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Forest Service

Southwestern
Region

Ecological Sustainability Report

Kiowa, Rita Blanca, Black Kettle, and McClellan Creek National Grasslands

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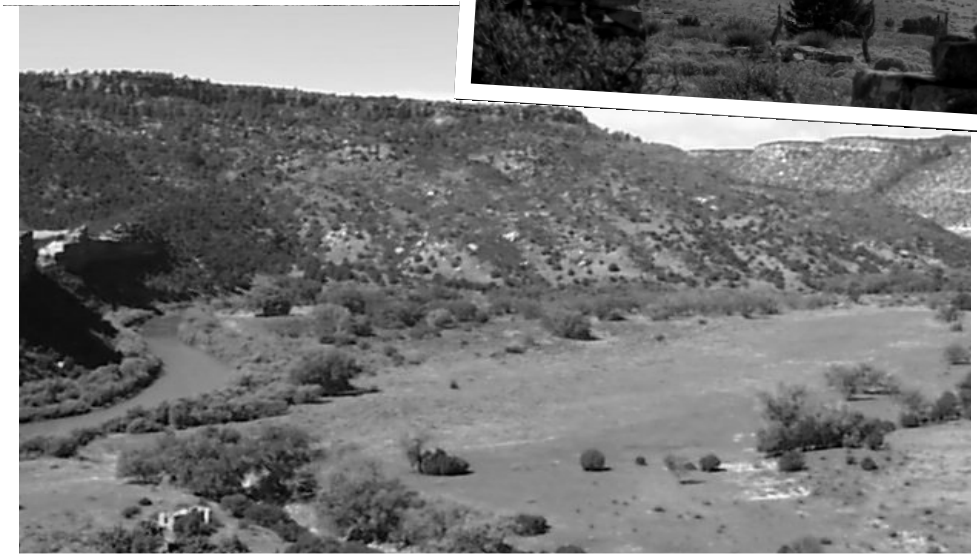
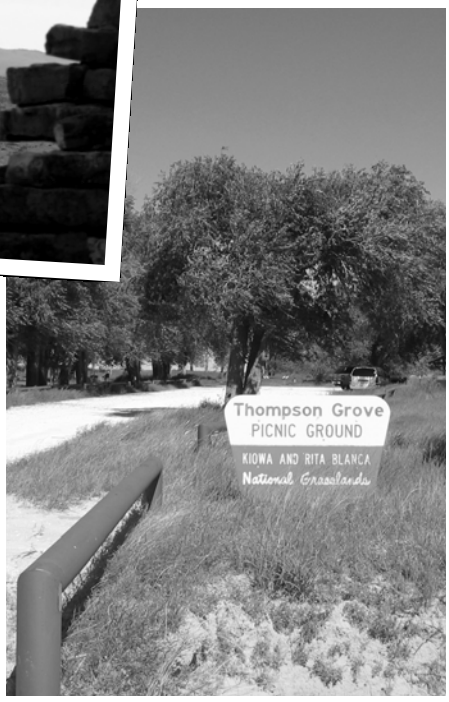

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Figure 1 National Grasslands Administered by the Cibola National Forest

1 Introduction

This report evaluates the ecological systems of the Kiowa, Rita Blanca, Black Kettle and McClellan Creek National Grasslands (hereafter referred to as the Grasslands) and the surrounding area. It will provide the information needed to determine areas needing revision in the existing Land and Resource Management Plan (the Plan), for the Cibola National Forest and Grasslands. It outlines and puts into context the relationship between the resources managed by the Grasslands and the broader ecological environment. The report is organized into two main sections, ecosystem diversity and species diversity. The ecosystem diversity section discusses conditions and trends in the vegetation communities and physical resources. Habitats for wildlife, fish and rare plants that exist within the Grasslands are discussed in the species diversity section.

The Grasslands are administered by the Cibola National Forest under the United States Department of Agriculture Forest Service. The Kiowa National Grassland is located in northeastern New Mexico, the Rita Blanca National Grassland is located in the panhandles of Oklahoma and Texas, the McClellan Creek National Grassland is located in the panhandle of Texas and the Black Kettle National Grassland is located in western Oklahoma (Figure 1). Table 1 shows each Grassland, the counties in which they are located and the total acres administered by the Forest Service.

Table 1 Grassland States and Counties

Grassland*	State	County
Kiowa (136,300 acres)	New Mexico	Harding Union Mora Colfax
Rita Blanca (93,000 acres)	Texas Oklahoma	Dallam Cimarron
Black Kettle (31,200 acres)	Oklahoma Texas	Roger Mills Hemphill
McClellan Creek (1,400 acres)	Texas	Gray

*Acreages are approximate

1.1 Planning Unit and Ecological Niche

The ecological niche of the Grasslands is defined by the unique land ownership pattern found across the administrative boundaries. It may best be described as a “checkerboard” land ownership pattern, as the units managed by the Grasslands are smaller parcels of land mostly surrounded by private land with the largest contiguous piece of land managed by the Grasslands being approximately 42,600 acres. The ecological niche of the Grasslands is described here in the context of the broader landscape, by examining subsections in the National Ecological Hierarchy, and in the context of the various ecological communities and processes that are represented within the Grasslands.

All four Grasslands are part of the larger Great Plains grassland ecosystem (Figure 2); however, each Grassland has unique characteristics which will be evaluated later in this report. This analysis was conducted using Potential Natural Vegetation Types (PNVTs) and existing mid-scale vegetation types found on the Grasslands[1]. PNVTs are coarse-scale groupings of ecosystem types that share similar geography, vegetation, and historical disturbances such as fire, drought, and native herbivory (Vander Lee and Smith 2005). The PNVTs used for this analysis were summarized from the Terrestrial Ecological Unit Inventory data for the Grasslands[2]. There are seven PNVTs found on the Grasslands. A comparison between PNVTs and existing vegetation was used to show the departure from reference conditions.

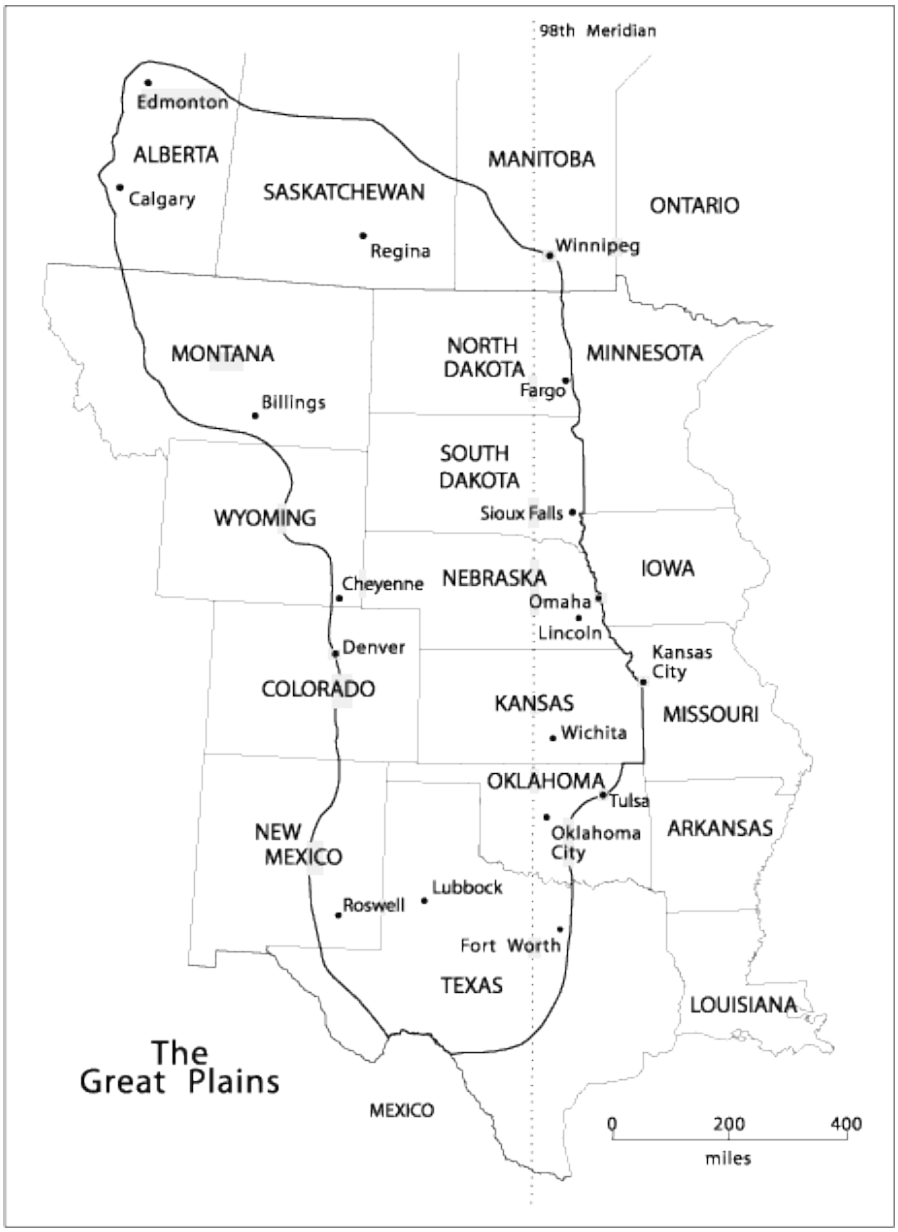

Figure 2 Great Plains (UNMC 2007)

[1] Mid-scale vegetation types were determined using satellite data and are mapped at the scale of 1:100,000. The mid-scale vegetation inventory for all National Grasslands analyzed in this report was conducted in 2005 and 2006 (USDA Forest Service 2006a).

[2] The Terrestrial Ecological Unit Inventory referenced in this document is specific to the Cibola National Forest National and Grasslands and is a classification of ecological types. It maps terrestrial ecological units based on soil types and existing vegetation (USDA Forest Service 2006b).

Table 2 shows the PNVTs found on the Grasslands and the associated current vegetation type (based on Mid-Scale Vegetation Inventory) (USDA Forest Service 2006a).

Table 2 Potential Natural Vegetation and Associated Existing Vegetative Units Found on the Grasslands

Potential Natural Vegetation Type	Associated Existing Dominant Vegetation Types
Black Kettle and McClellan Creek National Grasslands*	
Mixed Grass Prairie - 11,400 acres	Mixed bluestem grassland Grama grassland Sparsely vegetated/bare/developed
Shinnery Oak – 19,100 acres	Shinnery oak grassland Mixed bluestem grassland Shelterbelts
Mixed Hardwood Riparian – 2,000 acres	Forested floodplains and draws
Kiowa and Rita Blanca National Grasslands*	
Shortgrass Prairie – 182,000 acres	Grama grassland Grama w/Juniper grassland Grama w/Shrub grassland Grama/Feathergrass grassland Mixed bluestem grassland Sparsely vegetated/bare/developed
Sand sagebrush – 22,700 acres	Sand sagebrush dunes Grama grassland Mixed bluestem grassland
Piñon-Juniper Woodlands (w/Ponderosa pine) – 23,200 acres	Juniper Canyons Oak Canyons Piñon Canyons Grama grasslands Mixed bluestem grasslands Ponderosa pine
Cottonwood-Willow Riparian – 1,400 acres	Cottonwood-willow riparian River Canyon Bottoms Playas and Ephemeral Draws

*Acreages are approximate

Table 3 gives a general description of the vegetation types found on the Grasslands. Maps displaying the different PNVTs for each Grassland can be found in Appendix A. Existing dominant vegetation maps in Appendix A, display the vegetative units found on the Grasslands.

Table 3 Existing Vegetative Unit Descriptions

Mid-Scale Vegetation Type	General Description
Mixed bluestem grassland	Includes a variety of mixed grasses, little or big bluestem, sand sage, western wheatgrass and Indian grass. May have a hardwood component.
Shinnery Oak	Low-growing shinnery oak shrubs that are generally no more than 3 to 5 feet high. Shinnery oak shrubs commonly grow in small clusters, or "motts", that grow no more than 15 feet high and are less than 1/2 acre in size. Herbaceous understory included grasses and forbs.
Mixed Hardwood Riparian	Bottomland forests consisting of cottonwood, American elm, hackberry, and walnut.
Bare Soil/Sparsely Vegetated	Bare soil, disturbed areas, and developed areas
Grama grassland	Include a variety of mixed grasses, such as blue grama, buffalograss, galleta, and threeawn.
Grama/Feathergrass	Includes a variety of grama grasses with New Mexico feathergrass and threeawn included.
Grama with Shrubs	Grama grass communities with a shrub component, consisting of oak, mountain mahogany, squawbush and sumac.
Grama with Juniper	Grama grass communities with juniper and piñon pine.
Juniper Canyons	Consists of one-seed juniper and gamble oak in canyons. Occur mainly on South-facing, steeper slopes.
Oak Canyons	Consists of gambel oak and mountain mahogany. Occur mainly on North-facing slopes of gentler sloping canyon walls.
Piñon Canyons	Consists of piñon, juniper and oak. Piñon occurs interspersed with junipers and oaks on canyon sides and along canyon rim.
Cottonwood-Willow/Ephemeral Draws	Consists of cottonwood, willows, grama grasses, wheatgrass, and Apache plume. Found is areas along permanent and ephemeral water systems, such as bottomlands, marshes, and floodplains. These areas are adjacent to and near drainages, creeks, and lakes.
Playas	Consists of alkali sacaton, saltgrass and other riparian vegetation, including sedges and rushes. Playas are hollow, bowl-shaped depressions that are dependent on rainfall and surface runoff for the water they impound; may be dry for years at a time.

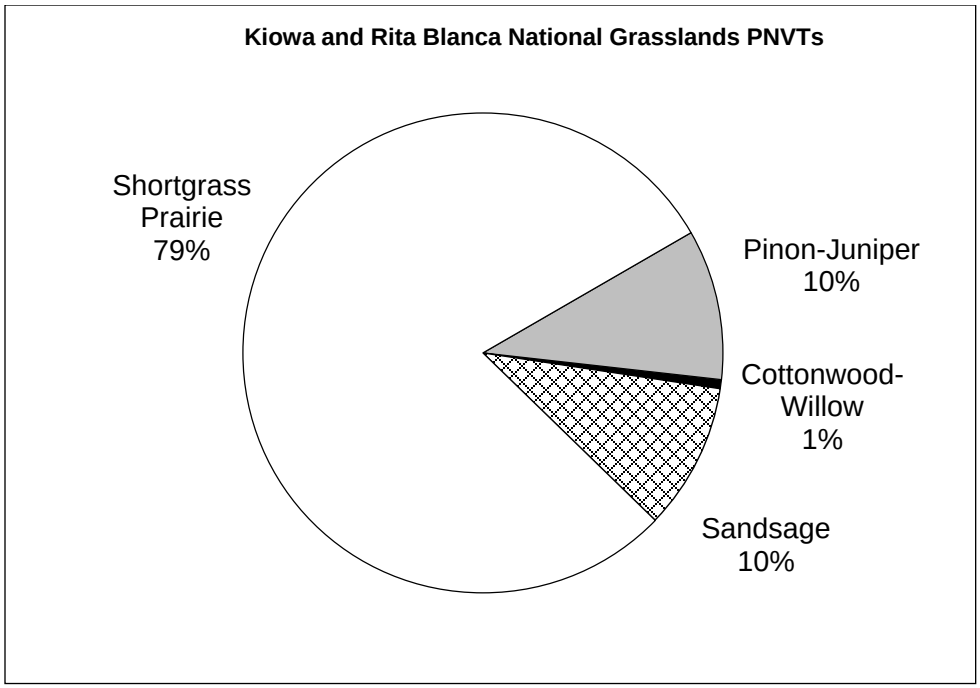

Figure 3 Relative abundance of PNVTs on the Kiowa and Rita Blanca National Grasslands.

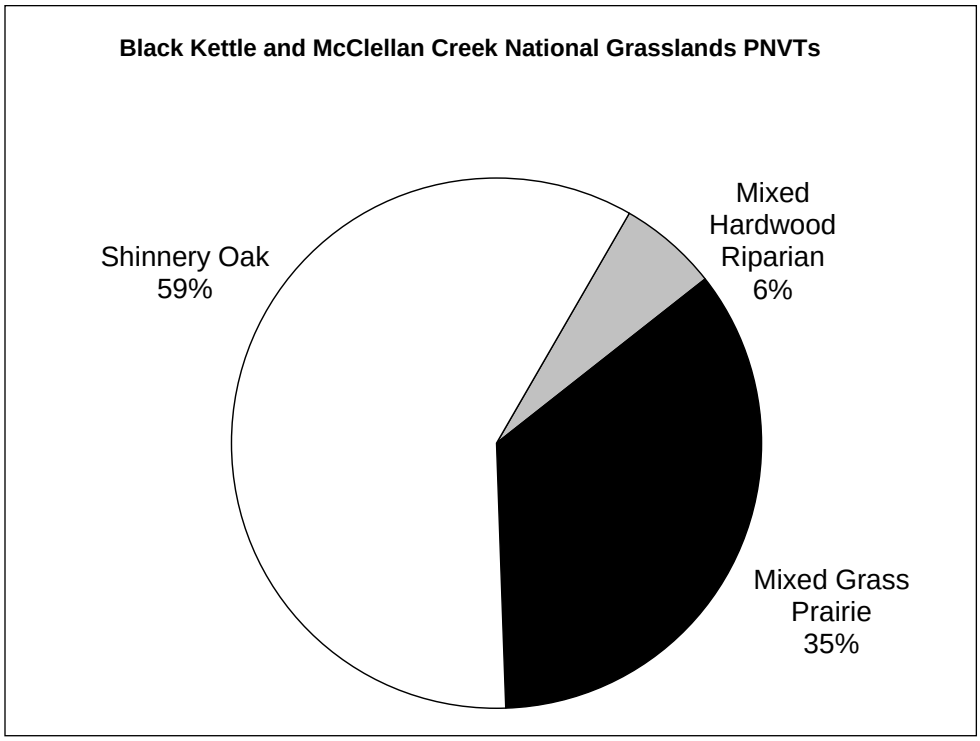

Figure 4 Relative Abundance of PNVTs on the Black Kettle and McClellan Creek National Grasslands

As the Grasslands have a checkerboard pattern of land ownership across the landscape, they form "islands" of restored grassland ecosystems surrounded by agricultural fields. Much of the land surrounding the Grasslands was once native prairie that has since been converted to agricultural fields. This makes the Grasslands and the PNVTs found within them important ecologically. While the Grasslands lack the large contiguous pieces of vegetation needed for many wildlife species, they provide crucial habitat features that may not be present on surrounding lands.

1.2 Surrounding Landscape

1.2.1 Terrestrial Units

Using the National Hierarchical Framework of Ecological Units (Cleland et. al. 1997) an ecological sustainability analysis of the landscapes surrounding the Grasslands was completed using the Section and Subsection units. This broad-scale analysis was done to set the context for the contributions the Grasslands make to ecological sustainability. Most of the analysis was done at the Subsection level. The Grasslands lie within four Sections and six Subsections.

Ecological Sections are characterized according to features and attributes such as landform, vegetation, surface water, and others. The Grasslands fall within four of these sections shown on the Ecoregion Sections Map in Appendix A as:

- Southern High Plains;
- Northern Texas High Plains;
- Texas High Plains; and
- South Central and Redbed Plains (Redbed Plains).

Collectively, the four sections mentioned above total over 65 million acres. The Grasslands make up less than 2% of these total acres. The majority of the land within these sections is privately-owned agriculture or crop land. Irrigated agriculture areas used for cropland are used mainly to farm soybeans, corn, or alfalfa. The main crops grown through dry-farming are winter wheat, beans, small grains, or sorghum. Much of the remaining vegetation is either shortgrass or mixed grass prairie, however, as the majority of the land ownership is private, most of these acres are used as rangeland for grazing cattle (Pennsylvania State University 2006). Table 4 describes the landforms, elevation, precipitation, vegetation, and land uses of the ecological Sections found on the Grasslands.

Table 4 Descriptions of Ecological Sections Found on the Grasslands (Avers and McNab 1994, McNab et. al. 2005)

Southern High Plains	
Typical Landforms	Smooth plains, small tablelands
Elevation	2,600 to 4,000 feet
Precipitation	Ranges from 15-25 inches
Predominant Vegetation	Short to mid-height grasslands (blue grama, buffalograss, hairy grama, little bluestem)
Surface Water	Low density of small, low volume, low intensity intermittent streams. Cimarron and North Canadian Rivers pass through.
Land Use	Natural vegetation has been converted to agricultural crops and range for cattle grazing on about 90% of the area.
Northern Texas High Plains	
Typical Landforms	Gently to moderately rolling plains dissected by narrow intermittent stream valleys
Elevation	1,500 – 5,500 feet
Precipitation	Ranges from about 15-25 inches
Predominant Vegetation	Shinnery oak, mixed grass prairie with little bluestem and sideoats grama, open to dense stands of broadleaved deciduous shrubs
Surface Water	Canadian River and other perennial and intermittent streams. Water disappears and reappears through sandbeds.
Land Use	Livestock grazing is common. Most productive sites have been converted to crop farming.
Texas High Plains	
Typical Landforms	Broad, extensive flat plains
Elevation	2,600 to 6,500 feet
Precipitation	15 to 22 inches annually
Predominant Vegetation	Shinnery oak, Bunch grasses with a sparse shrub layer, short grasses (blue grama and buffalograss), sagebrush, mesquite, yucca
Surface Water	Low density of small, intermittent streams with low volume and velocity. Canadian and Red Rivers pass through. Playa lakes are common in the western part of the Texas High Plains.
Land Use	About 90% converted to agricultural crops or

	pasture.
South Central and Redbed Plains	
Typical Landforms	Mostly irregular plains, with low mountains, smooth plains and tablelands
Elevation	1,600 to 3,000 feet
Precipitation	20 to 30 inches annually
Predominant Vegetation	Medium-tall grasslands with sparse tree cover, Shinnery oak, Grasses include sand bluestem, little bluestem, sand sagebrush.
Surface Water	Low density of small to medium intermittent streams and associated rivers, with a low volume of water flowing at low velocity. Major rivers include the Washita, Canadian and Red.
Land Use	About 90% converted to agricultural crops or pasture.

The Grasslands lie within six Subsections. Ecological Subsections are similar to Sections in that they are characterized according to features and attributes such as landform, vegetation, surface water; however, they are smaller in size and are more useful in planning at a smaller scale. Those within which the Grasslands lie are the Canadian River Canyon and Hills Woodland, Canadian-Cimarron Breaks, Caprock High Plains Grassland, Red Prairie, Sandy-Smooth High Plains and Southern South Central and Red Bed Plains. A map displaying the six subsections found on the Grasslands can be found in Appendix A. Table 5 displays the relative abundance of the existing general vegetation types within each of these Subsections (Fisher and Gregory 2001, Parker et. al. 2003, and Lowry et. al. 2005).

Table 5 Relative Abundance of Subsection Vegetation Types

Section →	**Northern Texas High Plains**		**South Central and Red Bed Plains**	**Texas High Plains**		**Southern High Plains**
Subsection* → PNVTs ↓	**Canadian-Cimarron Breaks (McClellan Creek)**	**Red Prairie (Black Kettle)**	**Southern and South Central Red Bed Plains (Black Kettle)**	**Caprock High Plains (Kiowa and Rita Blanca)**	**Canadian River Canyon and Hills Woodland (Kiowa)**	**Sandy Smooth High Plains (Kiowa and Rita Blanca)**
Agriculture	15%	24%	45%	8%	2%	26%
Shortgrass Prairie	12%	4%	1%	62%	54%	48%
Mixed Grass Prairie	41%	27%	43%	16%	6%	13%
Shinnery Oak		7%				
Mixed Hardwood Riparian	2%	1%	1%			
Cottonwood-Willow Riparian			1%	2%	1%	2%
Sand sagebrush	8%	3%	3%	8%	5%	4%
Piñon-Juniper				1%	15%	4%
Herbaceous Riparian	3%	1%				1%
Bare	1%	1%				
Mesquite (with other species)	16%	28%	3%	2%	9%	2%
Salt Cedar	2%	1%				
Chihuahuan Desert Vegetation				1%	5%	
Oak Savannah					2%	
Tallgrass Prairie		1%				
Redcedar/Oak		2%	2%			
Cliffs					1%	

*A blank cell means that vegetation type does not occur within or makes up <1% of a subsection.

Using LANDFIRE Rapid Assessment Fire Regime Departure data[3], an assessment of current conditions for common PNVTs on the surrounding landscape was conducted to determine the similarity of the Grasslands to the surrounding landscape. Each Subsection was evaluated using the vegetation types listed for each Subsection in Table 5. Fire regime departure delineates a continuous index of zero to 100 (percent departure from reference conditions). The higher the percentage of departure from the natural fire regime for a given vegetation type, the more likely it is that vegetation type is not within the reference condition for composition and structure. For this report, fire regime departure was categorized into five groups: 0-20%; 21-40%; 41-60%; 61-80%; and 81-100%, departed from natural fire regimes.

Table 6 displays the Subsections, the PNVTs on both the Grasslands and that Subsection and the category of highest percent departed (for example, within Canadian-Cimarron Breaks Subsection, the majority of the shortgrass prairie vegetation is 21-40% departed from its natural fire regime).

Table 6 Departure from Natural Fire Regimes by Subsection and Potential Natural Vegetation Type (PNVT)

Section →	**Northern Texas High Plains**		**South Central and Red Bed Plains**	**Texas High Plains**		**Southern High Plains**
Subsection* → PNVTs ↓	**Canadian-Cimarron Breaks (McClellan Creek)**	**Red Prairie (Black Kettle)**	**Southern and South Central Red Bed Plains (Black Kettle)**	**Caprock High Plains (Kiowa and Rita Blanca)**	**Canadian River Canyon and Hills Woodland (Kiowa)**	**Sandy Smooth High Plains (Kiowa and Rita Blanca)**
Mixed Grass Prairie	21-40%	61-80%	21-40%	61-80%	21-40%	21-40%
Shortgrass Prairie	21-40%	81-100%	21-40%	61-80%	61-80%	61-80%
Shinnery Oak		61-80%				
Piñon-Juniper				61-80%	61-80%	61-80%
Cottonwood-Willow Riparian			21-40%	81-100%	61-80%	81-100%
Mixed Hardwood Riparian	41-60%	81-100%	21-40%			
Sand sagebrush	41-60 and 81-100%	61-80%	41-60%	61-80%	61-80%	81-100%

[3] Fire regime departure is defined as a continuous measure describing the degree of departure from the reference fire regime (Hann and Bunnell 2001). This departure results in changes to one (or more) of the following ecological components: vegetation characteristics (species composition, structural stages, stand age, canopy closure, and mosaic pattern); fuel composition; fire frequency, severity, and pattern; and other associated disturbances (such as insect and disease mortality, grazing, and drought).

* A blank cell means that vegetation type does not occur within or makes up <1% of a subsection.

Agriculture was not included in the table above, however it makes up a portion of each Subsection. Since agriculture is a complete conversion from the natural vegetative cover, the departure from the natural fire regime is 100%.

1.2.2 Aquatic/Airshed Units

Aquatic: Aquatic units are known as watersheds. Watersheds are delineated based on the direction that a raindrop would runoff. Watersheds can be almost any size ranging from a few acres to thousands of square miles as in the case of the entire Mississippi River Basin. The mid-sized watersheds, approximately 40,000 to 250,000 acres, were selected to analyze the Grasslands. This size of watershed is known as a 5th level hydrologic unit. This is four steps down from the Arkansas, White, Red Region, 1st level hydrologic unit, in which the Grassland units are contained. The Grasslands are contained within 26 - 5th level hydrologic unit watersheds. The majority of the Grasslands units fall within eight 5th code Hydrologic Unit Code watersheds, as displayed in Table 7 and shown on the Watersheds map in Appendix A. Three of those watersheds have at least a 15% overlap with Grasslands units, as shown as bolded text in Table 7.

Table 7 Watersheds in which the Grasslands Fall Including Areas in National Forest System (NFS) Ownership and Other (Primarily Private) Ownership

Sub-basin Name	Watershed Name	Ownership		Total Area (acres)
		NFS		
		%	Acres	
Washita Headwaters (111300301)	Foss Reservoir-Washita River (05)	0.1%	187	155,393
	Cyclone Creek (04)	0.1%	104	111,410
	Lower Washita River (03)	4.8%	12,536	259,340
	Upper Washita River (02)	8.2%	17,260	210,114
Upper North Fork Red (11120301)	McClellan Creek (02)	0.6%	1,411	242,370
Coldwater (11100103)	Frisco Creek (04)	1.1%	2,899	276,092
	Upper Coldwater Creek (02)	10.1%	25,004	248,136
	Headwaters Coldwater Creek (01)	**25.6%**	54,591	212,985
Upper Beaver (11100101)	Town of Texhoma-Beaver River (08)	0.3%	511	173,395
	Town of Kerrick-Beaver River (06)	0.5%	537	108,815
	Near Boise City-Beaver River (05)	0.1%	174	116,816
	Town of Boise City (04)	0.3%	474	185,625
	Seneca Creek-Corrumpa Creek (03)	7.9%	13,071	165,384
	Seneca Creek (02)	3.7%	6,968	185,991

Sub-basin Name	Watershed Name	Ownership		Total Area (acres)
		NFS		
		%	Acres	
Lower Canadian-Deer (11090201)	Hackberry Creek-Canadian River (02)	0.4%	598	135,514
Middle Canadian-Spring (11090106)	Boggy Creek-Canadian River (08)	0.3%	579	225,938
Carrizo (11090104)	Trabajo Creek-Carrizo Creek (04)	1.1%	2,964	274,330
	Town of Sedan (03)	0.6%	515	80,213
Rita Blanca (11090103)	Perico Creek (03)	2.7%	4,273	157,964
	Sand Draw (02)	**21.3%**	30,228	142,034
	East Rita Blanca Creek (01)	7.9%	8,236	104,426
Ute (11080007)	Tequesquite Creek (05)	12.4%	20,773	168,193
	Carrizo Creek-Canadian River (02)	18.5%	17,813	96,511
	Alamocita Creek-Ute Creek (02)	0.5%	1,272	247,214
Upper Canadian (11080003)	**Carrizo Creek-Canadian River (05)**	**12.1%**	26,748	221,741
	Sauz Creek-Canadian River (03)	5.5%	12,375	223,880

Overall, there appears to be representative miles of stream and acreage in waterbodies on the Grasslands based on total acreage in the watersheds. However, the numbers tend to vary greatly in a given watershed. For example, the Grasslands in the Upper Washita River watershed have almost 15 percent of the perennial stream miles in the watershed (Table 8) but represent only about 8 percent of the area of the watershed. Conversely, the Grasslands in the Headwaters of Coldwater Creek watershed represent about 25 percent of the area of the watershed, but have no perennial streams and only 2 percent of the perennial lakes or ponds.

Table 8 Percentage of Perennial Streams, Intermittent Streams and Perennial Lakes or Ponds on National Forest System Land in the Watersheds in which the Grasslands Fall

Sub-basin Name	Watershed Name	Perennial streams on NFS	Intermittent streams on NFS	Perennial lakes/ponds on NFS
Washita Headwaters (111300301)	Foss Reservoir-Washita River (05)	0.0%	0.2%	0.0%
	Cyclone Creek (04)	0.0%	0.2%	0.0%
	Lower Washita River (03)	7.5%	7.1%	1.6%
	Upper Washita River (02)	14.8%	11.2%	13.4%
Upper North Fork Red (11120301)	McClellan Creek (02)	2.8%	0.6%	0.0%
Coldwater (11100103)	Frisco Creek (04)	0.0%	0.5%	0.7%
	Upper Coldwater Creek (02)		7.1%	5.3%
	Headwaters Coldwater Creek (01)	0.0%	20.0%	2.1%
Upper Beaver (11100101)	Town of Texhoma-Beaver River (08)		0.0%	0.0%
	Town of Kerrick-Beaver River (06)		0.0%	0.0%
	Near Boise City-Beaver River (05)	0.0%	2.6%	0.0%
	Town of Boise City (04)	0.0%	2.1%	0.0%
	Seneca Creek-Corrumpa Creek (03)	3.0%	9.3%	1.8%
	Seneca Creek (02)	3.8%	4.5%	0.9%
Lower Canadian-Deer (11090201)	Hackberry Creek-Canadian River (02)	0.5%	1.1%	0.1%
Middle Canadian-Spring (11090106)	Boggy Creek-Canadian River (08)	2.2%	0.2%	14.3%
Carrizo (11090104)	Trabajo Creek-Carrizo Creek (04)	0.0%	0.5%	0.0%
	Town of Sedan (03)		0.0%	0.0%
Rita Blanca (11090103)	Perico Creek (03)	0.0%	1.3%	0.0%
	Sand Draw (02)	0.0%	13.8%	7.0%
	East Rita Blanca Creek (01)		6.2%	0.9%
Ute (11080007)	Tequesquite Creek (05)		15.1%	41.8%

Sub-basin Name	Watershed Name	Perennial streams on NFS	Intermittent streams on NFS	Perennial lakes/ponds on NFS
	Carrizo Creek-Canadian River (02)	0.0%	0.9%	0.0%
	Alamocita Creek-Ute Creek (02)		15.1%	2.4%
Upper Canadian (11080003)	Carrizo Creek-Canadian River (05)	4.3%	16.4%	3.9%
	Sauz Creek-Canadian River (03)	7.7%	7.4%	0.9%

Airshed: The Kiowa National Grassland is in the Canadian River airshed as delineated by the New Mexico Environment Department for the purposes of smoke management[4]. The remaining Grassland units are not in a delineated airshed only because Texas and Oklahoma have not delineated any airshed other than around non-attainment areas. All four National Grasslands, however are in the larger regional watershed around the Canadian River and would therefore likely be in similar airsheds as the Kiowa National Grassland. Air quality standards for Class I areas, primarily larger Wilderness areas, are more stringent than the National Ambient Air Quality Standards (NAAQS) because they allow for no degradation of air quality (i.e. Class II air quality attainment areas which only need to meet state and national air quality standards). The nearest Class I areas to the Kiowa and Rita Blanca National Grasslands are the Pecos Wilderness and the Wheeler Peak Wilderness about 60 miles to the west on the Santa Fe and Carson National Forests, respectively, in New Mexico. Wichita Mountains Wilderness Class I area in the Wichita Peak Wildlife Refuge in Oklahoma is about 70 miles southeast of the Black Kettle and McClellan Creek National Grasslands.

1.3 Comparison of the National Grasslands to Surrounding Landscape

The Grasslands have a combined total acreage of approximately 261,900 acres. The Sections they overlap have a combined total acreage of 62,870,000 acres and the Subsections they overlap have a combined total acreage of 32,740,000 acres. This means the Grasslands make up approximately less than one percent of the landscape in the six Subsections within which the Grasslands lie. However, by looking at the PNVTs and comparing the amount of each found on the Grasslands and within the Sections and Subsections, there are some ecosystems that stand out in terms of relative abundance (Table 5). Most of the land surrounding the Grasslands and land within the Sections and Subsections is in private ownership. Land ownership within the Grasslands administrative boundaries is as follows: 73% Private; 24% Forest Service; and 3% State. Lands that are in private ownership are used primarily for agriculture, croplands or rangeland for grazing of domestic livestock (McNab et. al. 2005).

1.4 Important Ecosystems

The analysis of the Subsections was based on structural and composition classes within each Subsection and compared to reference condition. Composition and structure of the PNVTs on the Grasslands that are representative of the surrounding landscape may have characteristics that make them different and

[4] Airshed is defined as a "geographic area based on watershed boundaries that, because of topography, meteorology, and/or climate, are frequently affected by the same air mass" (New Mexico Environment Department Air Quality Bureau 2005).

may contribute more to ecological sustainability within these areas as well. In comparing the Grasslands to the surrounding landscape, there are two PNVTs that are similar to or representative of the surrounding landscape. These are mixed grass prairie and piñon-juniper. The remaining PNVTs, shortgrass prairie, shinnery oak, mixed hardwood riparian, cottonwood-willow and sand sagebrush, have more presence on the Grasslands in comparison to the surrounding landscape and Subsections. Management of these five PNVTs on the Grasslands that are underrepresented within the surrounding landscape is key to maintaining ecological sustainability. They may provide key wildlife habitat components or special features that have diminished on surrounding lands.

2 Ecosystem Diversity

2.1 Terrestrial Systems

This section summarizes the current and historical conditions, along with current management and projected trends for the Grasslands. Analyses were conducted for vegetation (prevalent ecosystems) and soil.

Vegetation Composition and Structure of PNVTs, Current Conditions, Reference Conditions and Projected Future Conditions and Trends and Current vegetative conditions on the Grasslands were derived using the mid-scale inventory information. Within each PNVT, mid-scale information was synthesized and grouped into successional classes based on vegetative composition and structure[5]. Current vegetative conditions are shown for both the surrounding landscape and the Grasslands themselves in terms of presence on the landscape. This also allows the relative abundance of a PNVT on the Grasslands to be shown in comparison to the surrounding landscape. They are displayed in terms of the Grasslands (Planning Unit) and surrounding landscape (Sections and Subsections).

Reference conditions were determined using various ecological models, based on the appropriateness and similarity to the potential natural vegetation types (PNVTs). Models used in this analysis were either LANDFIRE Rapid Assessment Models or LANDFIRE National models or Fire Regime Condition Class Models. When describing the reference conditions, comparisons between the current condition and reference condition are based on composition and structure only. The historical extent of a certain PNVT is discussed, but not offered for comparison to current condition.

The projected future condition and trends and comparison to current and reference conditions section describes current management trends and the effect continuation of those trends would have on the Grasslands PNVTs. It also describes whether or not continuation of current trends will move the PNVT toward the described reference conditions, if the PNVT is not already within reference condition. Future conditions are described only for the Grasslands as the Forest Service cannot affect management of lands off of the Grasslands.

For the mixed grass prairie and shinnery oak PNVT, modeling was conducted to determine the reference condition percentages using the appropriate Vegetation Dynamics Development Tool models. This modeling resulted in a range of variation for the reference conditions, which is why there is range listed for these PNVTs and none of the others.

2.1.1 **Mixed Grass Prairie**

Current Condition: Mixed grass prairie covers approximately 11,300 acres or 35% of the Black Kettle and McClellan Creek National Grasslands. In the early stage, 1-3 years post-fire, there are more forbs and diversity of species before little bluestem regains dominance. After

[5] Succession is defined as the gradual process of change in an ecosystem brought about by the progressive replacement of one community by another in a definite order until a stable community (i.e. climax community) is established over a period of time. Successional classes are the different stages found during ecological succession.

approximately three years, the grasses become the dominant species. Perennial grasses on the red-shale soils are primarily blue grama, hairy grama, little bluestem, and purple three awns. About 10% of the areas are covered in forbs and 10% in woody species. Table 9 displays the current composition and structure on the Grasslands of vegetation within the mixed grass prairie PNVT.

Table 9 Current Composition and Structure of the Mixed Grass Prairie PNVT

Successional Class Structure and Composition	Percent
Early: 1-3 years postfire. Resprouting grasses especially post-rain. Species include blue grama, buffalograss, hairy grama, sideoats grama and little bluestem.	35%
Mid/Late: Greater than 3 years post-fire. Lower diversity of forbs and lower productivity. Woody species may encroach in the absence of fire.	65%

The mixed grass prairie PNVT is found within all four Sections of the National Hierarchical Framework of Ecological Units, comprising between 10-37 % of those Sections. The mixed grass prairie PNVT is characterized by mixed grass to tall grass prairie found on moderate to gentle slopes and is dominated by one or some of the following species: big bluestem; little bluestem; western wheatgrass; sideoats grama and blue grama. This PNVT may also include areas that are dominated by low structure grasses and forbs. Table 10 depicts the subsections and grasslands mixed grass prairie PNVT percent.

Table 10 Percent of Subsection and Grasslands within Subsection in Mixed Grass Prairie PNVT

Subsection	% Subsection in Mixed Grass Prairie PNVT	% of Grasslands within Subsection in Mixed Grass Prairie PNVT
Canadian-Cimarron Breaks	41%	69%
Southern South Central and Red Bed Plains	44%	46%
Red Prairie	28%	6%

Contribution to Sustainability and Spatial Niche: The Subsections, Canadian-Cimarron Breaks and Red Prairie, have disproportionate total percentages of mixed grass prairie compared to the percentage of mixed grass prairie on the Grasslands within those Subsections. The McClellan Creek boundary overlaps the Canadian-Cimarron Breaks Subsection and the disproportionately larger percentage of mixed grass on McClellan Creek is due to the small size of this unit and the lack of PNVT diversity considering the topography and overall landscape constraints. The disproportionately small percentage of mixed grass prairie within the Red Prairie Subsection and Black Kettle boundary overlap is largely due to the soil types in this area of the Grasslands that are more conducive to other PNV types. While it may appear that management of the mixed grass prairie on the Grasslands is not a priority due to its overrepresentation on private land, much of all mixed grass prairie off of the Grasslands is highly departed from its reference condition due to historical agricultural practices and land use. This makes the native mixed grass prairie located on the Black Kettle and McClellan Creek National Grasslands important, as it has a high contribution to the overall ecological sustainability.

Reference Condition Planning Unit: F.W. Albertson (as quoted in Finch 2004) described the mixed-grass prairie just before the turn of the 20th century:

- "The vast majority of the land was native prairie. It was neither broken for cultivation nor overgrazed by livestock. Short grasses and low growing broad-leafed herbaceous plants occupied the hilltops. Many of the hills were dotted with bunches of little bluestem and in the favored areas such as buffalo wallows, sideoats grama and big bluestem were common. The hillsides were occupied primarily by big and little bluestem, sideoats grama, Indian grass and panic grass. All but the little bluestem and sideoats grama were dominant on the lowlands."

Dr. Albertson also noted that severe droughts and dust storms of the 20th century that were magnified by cultivating these dry lands also occurred before 1900 (Finch 2004). The mixed grass prairie also had less mesquite than what occurs today (Finch 2004). The mixed grass prairie experienced more frequent and higher intensity fires compared to the shortgrass prairie (Finch 2004).

The reference conditions for the mixed grass prairie were distributed as demonstrated in Table 11. Reference conditions were based on the LANDFIRE Rapid Assessment Model for shortgrass/mixed grass prairie (Bell et. al. 2005). Current condition is shown for comparison.

Table 11 Reference Conditions for the Mixed Grass Prairie

Successional Class Structure and Composition	Current Percent	Reference Percent[6]
Early: 1-3 years postfire. Resprouting grasses especially post-rain. Species include blue grama, buffalograss, hairy grama, sideoats grama and little bluestem.	35%	0-57%
Mid/Late: Greater than 3 years post-fire. Lower diversity of forbs and lower productivity. Woody species may encroach in the absence of fire.	65%	33-100%

The mixed grass prairie that occurs on soils that are of a loamy, red-shale type are currently close to the reference or are within reference conditions.

Projected Future Condition and Trends: Prescribed fire and livestock grazing are used to mimic natural processes. Prescribed burning tends to increase the amount of forbs within the mixed-grass prairie, to maintain or to move the PNVT toward reference conditions.

2.1.2 Shortgrass Prairie

Current Condition: Shortgrass prairie covers approximately 181,900 acres (or 79%), of the Kiowa and Rita Blanca National Grasslands. The shortgrass prairie PNVT typically occurs on plains and draws, or on gently rolling uplands of the southern Great Plains. Elevations range from 3,500-6,800 ft. Precipitation ranges from 12 to 20 inches, and occurs predominantly during the summer. Vegetation is mainly shortgrass dominated by blue grama, needle-and-thread, buffalograss, and galleta, with intermingled forbs and scattered half-shrubs. Post-fire early successional stages are dominated by resprouts and seedlings of grasses and post-fire associated forbs covering approximately 2% of this PNVT. Species include blue grama and

[6] Percentages are given as a range due to the dynamic nature of grassland ecosystems. There may be fluctuations throughout the year due to disturbance regimes. Range of percentages will be used in describing all PNVTs reference condition.

buffalograss. The mid-open stage covers approximately 90% of the PNVT with less than 35 percent herb cover that is low to medium height. The main grasses are blue grama and buffalograss. The mid-closed stage covers about 8% of this PNVT with greater than 35 percent herb cover. Again the main grass species are blue grama and buffalograss.

Livestock grazing is conducted in accordance with most recent environmental analyses utilizing an adaptive management approach taken by monitoring use and conditions on the ground, then adjusting as conditions change. Prescribed fire is applied, but on a small scale and generally not within the historical fire regime of 5-10 years. Removal of shrubs and trees encroaching onto the shortgrass prairie is occurring where access is adequate.

Playa lakes are a feature often occurring within the shortgrass prairie. They are shallow depressions that occur primarily in the High Plains region (Haukos and Smith 2003). There are approximately 19,000 playas scattered throughout the Southern High Plains with another 6,000 in adjacent states (The Handbook of Texas Online 2006). Playa vegetation occasionally occurs depending on the frequency of water retention and the size and depth of the playa. Where shoreline vegetation occurs, it typically consists of buffalograss, western wheatgrass, sideoats grama, alkali sacaton, and blue grama. Maps of locations of playa lakes found on the Grasslands can be found in Appendix A. Table 12 displays the current composition and structure the shortgrass prairie PNVT.

Table 12 Current Composition and Structure of the Shortgrass Prairie PNVT

Successional Class Structure and Composition	Percent
Early - Dominated by resprouts and seedlings of grasses and associated forbs. Species include blue grama and buffalograss.	2%
Mid Open -Less than 35 percent herb cover. Low to medium height. Main grasses are blue grama and buffalograss.	90%
Mid Closed - Greater than 35 percent herb cover. Main grass species are blue grama and buffalograss.	8%

The shortgrass prairie can be found in all four Sections that overlap the Grasslands. It comprises anywhere from 1% - 43% of these sections. There are two Subsections that overlap the Grasslands and encompass the shortgrass prairie PNVT. Table 13 shows the amount of the Grasslands in each Subsection in the shortgrass prairie PNVT.

Table 13 Percent of Subsection and Grasslands within Subsection in Shortgrass Prairie PNVT

Subsection	% Subsection in Shortgrass Prairie PNVT	% of Grasslands within Subsection in Shortgrass Prairie PNVT
Caprock High Plains Grassland	64%	53%
Sandy-Smooth High Plains	48%	87%

Contribution to Sustainability and Spatial Niche: The Subsections, Caprock High Plains Grassland and Sandy-Smooth High Plains, overlap the Rita Blanca and the Eastern units of Kiowa Grasslands boundaries. Both Subsections have disproportionate total percentages of shortgrass prairie compared to the percentage of shortgrass prairie on the Grasslands within those Subsections. The disproportionately smaller percentage of shortgrass on the Grasslands

compared to Caprock High Plains Grassland is due to topography proportion discrepancies. The 1.89 million total acres of the Caprock High Plains Grasslands encompasses Eastern Kiowa and the far Western portion of Rita Blanca Grasslands that are not representative of shortgrass prairie percentage of 79% over the total Kiowa Rita Blanca administrative boundary. Agriculture practices off of the grasslands that favor irrigation farming over cattle grazing addresses the disproportionately larger percentage of shortgrass prairie on the Grasslands boundary overlap with the Sandy-Smooth High Plains Subsection.

Currently, there is less shortgrass prairie across the landscape than found historically. Shortgrass prairie located off the Grasslands is highly departed from the historical condition. Therefore, the shortgrass prairie located within the National Grassland units is important and has a high contribution to the overall ecological sustainability.

Reference Condition Planning Unit: A departure analysis was conducted to determine whether this PNVT is within its reference condition and can be found in Appendix F. Historically, the shortgrass prairie was dominated by large expanses of blue grama mixed with buffalograss, with smaller amounts of galleta, New Mexico feathergrass, needle-and-thread, little bluestem, sideoats grama and western wheatgrass (The Nature Conservancy 2007, Finch 2004). Playas were formed and maintained through a combination of dissolution of subsurface basin material and the deflating action of strong prairie winds sweeping across the landscape (Haukos and Smith 2003, The Handbook of Texas Online 2006). Most of the playa lakes on Grasslands units have remained unmodified and appear to have the size, structure, composition and function that they were perceived to have had historically. Reference conditions utilized in analyzing playa lakes were pulled from Terrestrial Ecological Unit Inventory (TEUI) data and based on the potential vegetation for those units.

The shortgrass prairie is within the reference condition as a whole for the PNVT as demonstrated in Table 14. Reference conditions were based on the LANDFIRE Rapid Assessment Model for Shortgrass Prairie (Green et. al. 2005). Current condition is shown again for comparison.

Table 14 Reference Conditions for the Shortgrass Prairie

Successional Class Structure and Composition	Current Percent	Reference Percent
Early: Dominated by resprouts and seedlings of grasses and post-fire associated forbs. Species include blue grama and buffalograss.	2%	5%
Mid-Open: Less than 35 percent herb cover. Low to medium height. Main grasses are blue grama and buffalograss.	90%	65%
Mid-Closed: Greater than 35 percent herb cover. Main grass species are blue grama and buffalograss.	8%	30%

Projected Future Condition and Trends: Current management trends are stable and will keep this PNVT within its reference conditions. Conditions to create a greater proportion of late-structural stage and a greater proportion of early-successional stage conditions are projected conditions and trends.

2.1.3 **Shinnery Oak**

Current Condition: This ecosystem covers approximately 18,900 acres (or 59%), of the Black Kettle and McClellan Creek National Grasslands. The composition and structure of shinnery oak areas varies across the landscape due to historical agricultural practices of deep plowing. About 45% of the shinnery oak PNVT is in the early-mid-open, post-fire to three years post-fire regime and dominated by tallgrasses in shallower and more stable sandsheet areas. Grass cover is dominant with rapid recovery of shinnery oak resprouts. The late-closed successional class structure and composition stage occurs in the 3 to 10 year post-fire time frame. Shinnery cover is mostly dominant although grasses remain co-dominant on about 55% of the PNVT. Most shinnery oak stands on the Grasslands are burned on a 2 to 9 year cycle with the intent to maintain grass cover within the oak for wildlife habitat diversity and to mimic historical conditions. While the vertical structure of shinnery oak fluctuates frequently, the horizontal expanse or range of shinnery oak has not increased since the mid-19th century (Peterson and Boyd 1998). The rate of spread for shinnery oak is very slow, with edges of stands spreading up to 30 ft in 50 yrs (Peterson and Boyd 1998). Table 15 displays the current composition and structure the shinnery oak PNVT.

Table 15 Current Composition and Structure of the Shinnery Oak PNVT

Successional Class Structure and Composition	Percent
Early/Mid-Open: Dominated by tallgrasses in shallower and more stable sandsheet areas. Grass cover dominant with rapid recovery of shin-oak resprouts.	45%
Late-Closed: Three to ten years post-fire. Shinnery cover mostly dominant although grasses remain co-dominant.	55%

Structurally, the areas of deep plowed shinnery oak are close to the reference condition of shinnery oak but the composition of plants is different. These areas are dominated by little bluestem and have a small shrub and forb component with little or no shinnery oak present.

Current livestock grazing within the shinnery oak system is relatively light, with utilization levels retaining at least 50% of the current year's growth of vegetation, by weight, of forage species. Most shinnery oak stands on the unplowed areas are burned on a 2 to 9 year cycle with the intent to maintain grass cover within the oak for wildlife habitat diversity and to mimic historical conditions.

The shinnery oak PNVT can be found in two of the four Sections that overlap the Grasslands. It comprises 1% of the Texas High Plains Section and 2% of the Northern Texas High Plains Section. There are two Subsections that overlap the Grasslands and encompass the shinnery oak PNVT. Table 16 shows the amount of the Grasslands in each Subsection in the shinnery oak PNVT.

Table 16 Percent of Subsection and Grasslands within Subsection in Shinnery Oak PNVT

Subsection	% Subsection in Shinnery Oak PNVT	% of Grasslands within Subsection in Shinnery Oak PNVT
Red Prairie	<1%	90%
Southern South Central and Red Bed Plains	8%	49%

Contribution to Sustainability and Spatial Niche: The Subsections, Red Prairie and Southern South Central and Red Bed Plains, have overlapping boundaries with Black Kettle Grasslands. Both Subsections have disproportionate total percentages of shinnery oak compared to the Black Kettle Grassland due to agricultural practices that removed the shinnery oak species component. Currently, there is a much larger amount of the shinnery oak PNVT on Grasslands than in the surrounding landscape. This makes the contribution of the shinnery oak located within the Grasslands important to the overall ecological sustainability.

Reference Condition Planning Unit: Historically, the shinnery oak PNVT covered about 1 million acres in Oklahoma, 3.5 million acres in Texas, and 1.5 million acres in New Mexico (Peterson and Boyd 1998). Big bluestem, sand bluestem, Indiangrass, switchgrass, giant dropseed, plains bristlegrass, cane bluestem, and sideoats grama are among the grasses found in this ecosystem (Peterson and Boyd 1998). Both midgrass and tallgrass components and oak are well adapted to most fire regime variations (Peterson and Boyd 1998). The shinnery oak ecosystem contained a diverse mix of grasses and forbs along with the prevalent shinnery oak. The fire return interval for shinnery oak ecosystems is not well known, however, there are commonalities between the herbaceous compositions and fuel ignitions sources between shinnery oak and tallgrasses (Boyd and Bidwell 2002). This suggests that the fire return interval would have been similar to that of the tallgrass, which is between 5-10 years (Boyd and Bidwell 2002). The reference conditions for shinnery oak were distributed as demonstrated in Table 17. Reference conditions were based on the LANDFIRE Rapid Assessment Model for Shinnery Oak – Mixed Grass (Terrell 2005). Current condition is shown again for comparison.

Table 17 Reference Conditions for Shinnery Oak

Successional Class Structure and Composition	Current Percent	Reference Percent
Early/Mid-Open: Postfire to three years post-fire. Dominated by tallgrasses in shallower and more stable sandsheet areas. Grass cover dominant with rapid recovery of shin-oak resprouts.	45%	4-43%
Late/Closed: Three to ten years post-fire. Shinnery cover mostly dominant although grasses remain co-dominant.	55%	58-96%

The shinnery oak PNVT is within reference condition overall and has a slightly higher percent in the early/mid-open stage and slightly less in the late-closed stage than occurred historically.

Projected Future Condition and Trends: Under current management, the areas of unplowed shinnery oak are expected to remain close to the current condition. Prescribed burning and controlled grazing move this PNVT toward reference conditions that have the shinnery oak

composition fully recovering its vertical structure within 2 to 4 years after a fire (Harrell et. al. 2001). The horizontal expanse or range of shinnery oak does not fluctuate by current management, and the areas of the shinnery oak PNVT will remain fairly constant on the Grasslands with the composition and structure trends toward reference. Grassland managers will continue to manage with livestock grazing and prescribed fire to select for shrubs and woody plants including shinnery oak, sand sagebrush and Oklahoma plum and yucca to move the deep plowed areas as close as possible to a historical shinnery oak structure conditions.

2.1.4 Piñon-Juniper

Current Condition: This vegetation type covers approximately 21,700 acres (or 10%), of the Kiowa and Rita Blanca National Grasslands. In the piñon-juniper PNVT, juniper trees make up the overstory, with piñon pine mixed in with annual and perennial grasses, forbs and shrubs found in the understory (Vanderlee and Smith 2005). Juniper species include one-seed juniper and Rocky Mountain juniper. Common understory species include blue grama, big bluestem, wolftail, vine mesquite, sideoats grama, Indian ricegrass, four-wing saltbush, mountain mahogany, sumac, oak, and winterfat in the understory. There are also small, narrow "stringers" of ponderosa pine trees in the moist draws, hill slopes and canyon scarp slopes. The current condition was derived using the mid-scale data inventory. Because structure cannot be determined using the mid-scale vegetation inventory for this PNVT, all the tree classes were lumped together. Table 18 displays the current structure the piñon-juniper PNVT.

Table 18 Current Structure of the Piñon-Juniper PNVT

Successional Class Structure and Composition	Current Percent
Early: Open with grasses, forbs, seedlings and saplings. Usually occurs postfire. Seedlings are less than 4.5 ft. in height.	12%
Mid/Late: A mix of piñon and juniper trees in a variety of classes with varying canopy cover. Mid-development classes averages 10% of the PNVT in relative abundance and has dense canopy cover (31-70%) of pole size trees (5-9" in diameter) and very little understory. 25% of the PNVT will have pole size trees with a mixed shrub/herbaceous understory and canopy cover ranges from 0-30%. 35% of the PNVT will have late development with medium size trees (9-21" in diameter) and canopy cover of 0-40%. 10% of the PNVT will have dense, old growth characteristics with medium size trees and canopy cover of 41-70%.	88%

The piñon-juniper PNVT can be found in three of the four Sections that overlap the Grasslands. It comprises 6% of the Southern High Plains Section, 3% of the Texas High Plains and 1% of the Northern Texas High Plains Section. There are three Subsections that overlap the Grasslands and encompass the piñon-juniper PNVT. Table 19 shows the amount of the Grasslands in each Subsection in the piñon-juniper PNVT.

Table 19 Percent of Subsection and Grasslands within Subsection in Piñon-Juniper PNVT

Subsection	% Subsection in Piñon-Juniper PNVT	% of Grasslands within Subsection in Piñon-Juniper PNVT
Caprock High Plains Grasslands	1%	0%
Canadian River Canyon and Hills Woodland	14%	87%
Sandy-Smooth High Plains	4%	7%

Contribution to Sustainability and Spatial Niche: On the Kiowa Grasslands, almost all of the piñon-juniper can be found within the Canadian River Canyon and Hills Woodland Subsection. The disproportionate percentage of the piñon-juniper PNVT on the Grasslands compared to the Subsections is due to the Grasslands administrative boundary encompassing a piñon-juniper PNVT dominated landscape, whereas the Canadian River Canyon and Hills Woodland Subsection is not dominated by piñon-juniper.

Currently, there is approximately the same amount of piñon-juniper across the landscape as was historically, in terms of relative abundance. Since the majority of the piñon-juniper found off the Grasslands is highly departed from the reference condition, the contribution the Grasslands make to ecological sustainability for the piñon-juniper PNVT is important.

Reference Condition Planning Unit: Because structure cannot be determined using the mid-scale vegetation inventory for this PNVT, all the tree classes were lumped together. This means that there may be some structural components of the PNVT that are not within the reference condition that will need to be addressed with management activities. This will be determined at the project level. A departure analysis was conducted to determine whether this PNVT is within its reference condition and can be found in Appendix F.

On a regional scale, it is uncertain whether the present extent and structure of piñon-juniper woodlands are characteristic of its historical flux or whether the current occupancy and structure now exceed its range of natural variation (Gottfried et al. 1995). Much of what is now piñon-juniper woodland may have once been mostly juniper savannah, dominated by grasses and forbs and containing no more than 4-6 trees per acre (Brockway et. al. 2002a). By studying pollen, packrat middens, and archeological sites, scientists have been able to determine that juniper expanded down mountain slopes and into drier communities during times of increased moisture (Brockway et al. 2002a). Historical conditions facilitated periodic surface fires that maintained open stands of piñon-juniper with low tree densities and abundant grasses, forbs and shrubs in the understories (Brockway et al. 2002a).

Major ecological changes occurred in the Southwest with the arrival of Anglo-European settlers and their large herds of cattle and sheep and coincidental droughts in the late 1800s and mid-1900s (Gottfried et al. 1995). During the past 150 years, juniper trees increased in distribution and density and invaded historical grasslands (Brockway et al. 2002b). Pre-settlement fire frequencies ranged from 15-25 years, normally killing juniper trees less than 50 years old (Brockway et al. 2002b). The reference conditions for piñon-juniper were distributed as demonstrated in Table 20. Reference conditions were based on the LANDFIRE Biophysical Setting Model – Colorado Plateau Pinyon-Juniper Woodland (Babler 2006). Current condition is shown again for comparison.

Table 20 Reference Conditions for Piñon-Juniper

Successional Class Structure and Composition	Current Percent	Reference Percent
Early: Open with grasses, forbs, seedlings and saplings. Usually occurs postfire. Seedlings are less than 4.5 ft. in height.	12%	10%
Mid/Late: A mix of piñon and juniper trees in a variety of classes with varying canopy cover. Mid-development classes averages 10% of the PNVT in relative abundance and has dense canopy cover (31-70%) of pole size trees (5-9" in diameter) and very little understory. 25% of the PNVT will have pole size trees with a mixed shrub/herbaceous understory and canopy cover ranges from 0-30%. 35% of the PNVT will have late development with medium size trees (9-21" in diameter) and canopy cover of 0-40%. 10% of the PNVT will have dense, old growth characteristics with medium size trees and canopy cover of 41-70%.	88%	90%

The piñon-juniper PNVT located on the Grasslands is within the reference condition based on the above comparison.

Projected Future Condition and Trends: Thinning and burning projects are used to improve diversity in the understory and restore fire-adapted piñon-juniper woodlands. These treatments have successfully maintained a more diverse understory of grasses and forbs in piñon-juniper woodlands. Woodland areas have become more open although they have retained their mid to late seral stage structure including old growth characteristics of large-diameter trees, snags, and down logs.

Through the continued use of prescribed burning, regeneration of trees is expected to remain within the reference condition.

Continuation of current management trends is expected to keep the piñon-juniper PNVT in its current state, which is within reference conditions.

2.1.5 Cottonwood Willow

Current Condition: This vegetation type covers approximately 1,370 acres (or 1%), of the Kiowa and Rita Blanca National Grasslands. The cottonwood willow PNVT vegetation is a diverse mosaic of riparian forests, shrublands, streamside marshes, and barren alluvial surfaces. Larger river systems are dominated by gallery forests. Dominant species are Fremont cottonwood, narrowleaf willow, apache plume, western wheatgrass, and hackberry. Vegetation is dependent upon periodic flooding. Native Americans also had a strong influence on vegetation composition and structure by favoring edible plants (e.g., mesquite), collecting fuel wood, and burning to flush animals and increase accessibility to open water and agricultural fields. The current condition was derived using the mid-scale data inventory. Because structure cannot be determined using the mid-scale vegetation inventory for this PNVT, all the tree classes were lumped together. Table 21 displays the current structure the cottonwood-willow PNVT.

Table 21 Current Composition and Structure of the Cottonwood-Willow PNVT

Successional Class Structure and Composition	Percent
Early: This class is typically shrub/seedling dominated, but grasses may co-dominate.	16%
Mid: Vegetation composition includes tall shrubs and small trees (willows & cottonwoods). Late: This class represents the mature, large cottonwood and willow riparian woodlands.	84%

The cottonwood-willow PNVT can be found in two of the four Sections that overlap the Grasslands. It comprises 1% of the Southern High Plains Section and 1% of the South Central and Red Bed Plains Section. There are two Subsections that overlap the Grasslands and encompass the cottonwood-willow PNVT. Table 22 shows the amount of the Grasslands in each Subsection in the cottonwood-willow PNVT.

Table 22 Percent of Subsection and Grasslands within Subsection in Cottonwood-Willow PNVT

Subsection	% Subsection in Cottonwood-Willow PNVT	% of Grasslands within Subsection in Cottonwood-Willow PNVT
Canadian River Canyon and Hills Woodland	1%	3%
Caprock High Plains Grassland	2%	1%
Sandy Smooth High Plains	2%	0%
Southern and South Central High Plains Grassland	2%	0%

Contribution to Sustainability and Spatial Niche: Currently, there is much less cottonwood-willow across the landscape than appeared historically. The Subsections that do have cottonwood-willow are highly departed from the historical condition. The cottonwood-willow located within the Kiowa and Rita Blanca National Grasslands is within the reference condition, making it an important ecosystem and important to sustaining ecological sustainability.

Reference Condition Planning Unit: Riparian areas currently dominated by woody species were historically dominated by the same woody species, primarily cottonwood and willows. The regeneration of these woody species requires the presence of bare moist alluvial surfaces that are laid down during infrequent high-intensity floods. Structural diversity of semiarid woody riparian systems reaches a maximum after approximately 90 years (Skagen et. al. 2005). The reference conditions for cottonwood-willow were distributed as demonstrated in Table 23. Reference conditions were based on the LANDFIRE Biophysical Setting Model for North American Warm Desert Riparian Systems (Grove et. al 2005). Current condition is shown again for comparison.

Table 23 Reference Conditions for Cottonwood-Willow

Successional Class Structure and Composition	Current Percent	Reference Percent
Early: This class is typically shrub/seedling dominated, but grasses may co-dominate.	16%	20%
Mid (25%): Vegetation composition includes tall shrubs and small trees (willows & cottonwoods). Late(55%): This class represents the mature, large cottonwood and willow riparian woodlands.	84%	80%

The cottonwood-willow located within the Kiowa and Rita Blanca National Grasslands is within the reference condition.

Projected Future Condition and Trends: Because structure cannot be determined using the mid-scale vegetation inventory for this PNVT, all the tree classes were lumped together. This means that there may be some structural components of the PNVT that are not within the reference condition that will need to be addressed with management activities. This will be determined at the project level. A departure analysis was conducted to determine whether this PNVT is within its reference condition and can be found in Appendix F.

Current management trends of treating invasive species within the riparian systems, specifically salt-cedar, will help reduce the amount of invasives found in the cottonwood-willow PNVT. By removing salt-cedar from the Canadian River system in Mills Canyon, more of the PNVT will move into the mid successional class. This will increase vegetation on stream banks and stabilize slopes. Areas along Perico and Sauz Creeks periodically flood which helps keep some of this PNVT within the early successional class.

Under current management, this PNVT is expected to remain within the reference condition. There are disruptions to the natural hydrologic processes off of the Grasslands that prevent this PNVT from functioning fully as it did historically.

2.1.6 **Mixed Hardwood Riparian**

The mixed hardwood riparian areas that are found on the Black Kettle and McClellan Creek National Grasslands are there due to soil movement during the Dust Bowl area. Topsoil blew into these low-lying areas followed by upstream damming, creating areas that would not have been present historically. However, as this PNVT is present now, current management is conducted in ways conducive to keeping this PNVT intact. Under current management, this PNVT is expected to remain in its current state.

Current Condition: This vegetation type covers approximately 1,946 acres (or 6%), of the Black Kettle and McClellan Creek National Grasslands. The hardwood bottomlands have an overstory of cottonwood, elm, black walnut, soapberry, hackberry, and persimmon. Primary understory species include buckbrush, buttonbush, Virginia creeper, and Japanese brome where the overstory is thick and little bluestem in a more open overstory. A large percentage of the bottomland is sub-irrigated, with standing water during the wetter periods of the year. The exclusion of fire and the lack of disturbance have led to overcrowding of the hardwoods and the invasion of eastern red cedar in some locations. The current condition was derived using the mid-scale data inventory. Because structure cannot be determined using the mid-scale

vegetation inventory for this PNVT, all the tree classes were lumped together. Table 24 displays the current structure the mixed hardwood riparian PNVT.

Table 24 Current Composition and Structure of the Mixed Hardwood Riparian PNVT

Successional Class Structure and Composition	Percent
Early: Pioneer tree and shrub species of cottonwoods and willows. Herbaceous understory of sedges in wet areas. In this early stage, most of the area is bare sand. Dominated by young canopy of tree saplings and shrubs. Species would include indigo bush and various grass, sedges, and rushes.	13%
Mid: This stage develops as the stand starts to mature. This community tends to be partially opened, with scattered cottonwoods and willows. The shrub layer is poorly developed and often consists of widely scattered patches of dogwood. The understory vegetation is highly variable with wild rye, and muhlys. In wetter, more shaded areas Virginia creeper, nettles, and poison ivy would exists. Late: This class is a mature, late seral closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood, box elder, hackberry, walnut and elm. Understory species composed of Virginia creeper, and poison ivy. Found along the upper terrace that has been protected from most flood events, except for rare high intensity flooding.	87%

The mixed hardwood riparian PNVT can be found in two of the four Sections that overlap the Grasslands. It comprises 2% of the Northern Texas High Plains Section and 1% of the South Central and Red Bed Plains Section. There are three Subsections that overlap the Grasslands and encompass the mixed hardwood riparian PNVT. Table 25 shows the amount of the Grasslands in each Subsection in the mixed hardwood riparian PNVT.

Table 25 Percent of Subsection and Grasslands within Subsection in Mixed Hardwood Riparian PNVT

Subsection	% Subsection in Mixed Hardwood Riparian PNVT	% of Grasslands within Subsection in Mixed Hardwood Riparian PNVT
Canadian-Cimarron Breaks	2%	31%
Red Prairie	2%	4%
Southern South Central and Red Bed Plains	1%	5%

Contribution to Sustainability and Spatial Niche: The disproportionate percent of mixed hardwood riparian on McClellan Creek Grasslands compared to the Canadian-Cimarron Breaks is due to the abundance of the PNVT located along a relatively small reach of McClellan Creek within the administrative boundary of the Grassland. The mixed hardwood riparian PNVT areas off of the Grasslands are outside of the reference condition. The Black Kettle and McClellan Creek National Grasslands hold a fairly large portion of this PNVT within the Canadian-Cimarron Breaks subsection, making this an important ecosystem.

Reference Condition Planning Unit: Because structure cannot be determined using the mid-scale vegetation inventory for this PNVT, all the tree classes were lumped together. This means that there may be some structural components of the PNVT that are not within the reference

condition that will need to be addressed with management activities. This will be determined at the project level. A departure analysis was conducted to determine whether this PNVT is within its reference condition and can be found in Appendix F. The reference conditions for the mixed hardwood riparian vegetation type were distributed as demonstrated in Table 26. Reference conditions were based on the LANDFIRE Rapid Assessment Model for Great Plains Floodplain (Cunningham and Ortman 2005). Current condition is shown again for comparison.

Table 26 Reference Condition for Mixed Hardwood Riparian

Successional Class Structure and Composition	Current Percent	Reference Percent
Early: Pioneer tree and shrub species of cottonwoods and willows. Herbaceous understory of sedges in wet areas. In this early stage, most of the area is bare sand. Dominated by young canopy of tree saplings and shrubs. Species would include indigo bush and various grass, sedges, and rushes.	13%	20%
Mid (25%): This stage develops as the stand starts to mature. This community tends to be partially opened, with scattered cottonwoods and willows. The shrub layer is poorly developed and often consists of widely scattered patches of dogwood. The understory vegetation is highly variable with wild rye, and muhlys. In wetter, more shaded areas Virginia creeper, nettles, and poison ivy would exist. Late (55%): This class is a mature, late seral closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood, box elder, hackberry, walnut and elm. Understory species composed of Virginia creeper, and poison ivy. Found along the upper terrace that has been protected from most flood events, except for rare high intensity flooding.	87%	80%

The mixed hardwood riparian areas that are found on the Black Kettle and McClellan Creek National Grasslands are there due to soil movement during the Dust Bowl creating areas that would not have been present historically. Consequently there is not an appropriate reference condition for a departure from reference condition determination.

Projected Future Condition and Trends: The current management is conducted in ways conducive to keeping this PNVT intact and it is expected to remain in its current state.

2.1.7 Sand sagebrush

Current Condition: The sand sagebrush PNVT vegetation type covers approximately 22,651 acres (or 8 %), of the Grasslands. Sand sagebrush (sand sagebrush) occurs with perennial grasses such as little bluestem, blue grama, sand bluestem, and sand dropseed. It usually occurs on dunes, hills and other deep, well-drained sandy soils. Elevational range for sand sagebrush over its whole range is given as 2,000 to 6,000 feet. Annual precipitation for the shortgrass prairie, which includes sand sagebrush as a major shrub, ranges from 11.8 to 21.7 inches. The growing period for sand sagebrush in the southern Great Plains is from February to November (Brown and Smith 2000). Table 27 displays the current structure the sand sagebrush PNVT.

Table 27 Current Composition and Structure of the Sand sagebrush PNVT

Successional Class Structure and Composition	Percent
Post-fire: Dominated by resprouts and seedlings of grasses and forbs. Low to medium height with variable canopy cover. This type typically occurs where fires burn relatively hot.	1%
Mid-Open: Less than 35% herb cover. Medium to tall height.	69%
Mid-Closed: Greater than 35% herb cover. Medium to tall height.	30%

The Sand sagebrush PNVT can be found in all four Sections that overlap the Grasslands. It comprises 4% of the Southern High Plains, 3% of the Texas High Plains, 7% Northern Texas High Plains Section and 2% of the South Central and Red Bed Plains Section. There are two Subsections that overlap the Grasslands and encompass the sand sagebrush PNVT. Table 28 shows the amount of the Grasslands in each Subsection in the sand sagebrush PNVT.

Table 28 Percent of Subsection and Grasslands within Subsection in Sand sagebrush PNVT

Subsection	% Subsection in Sand sagebrush PNVT	% of Grasslands within Subsection in Sand sagebrush PNVT
Caprock High Plains Grassland	1%	46%
Sandy-Smooth High Plains	4%	6%

Contribution to Sustainability and Spatial Niche: The 1.89 million total acres of the Caprock High Plains Grassland Subsection overlaps the Rita Blanca and the Eastern units of Kiowa Grasslands boundaries. The Caprock High Plains Grassland total percentage of sand sagebrush PNVT is disproportionate to the percentage on the Grasslands within those Subsections. Eastern Kiowa and the far Western portion of Rita Blanca Grasslands are disproportionate to the 10% sand sagebrush PNVT found over the total Kiowa Rita Blanca administrative boundary as well. The disproportionately larger percentage of sand sagebrush on the Eastern Kiowa and far Western portion of Rita Blanca that overlap the Caprock High Plains Grasslands is due to topography, landuse, conversion to agriculture and management practices.

Currently, there is much less of the sand sagebrush PNVT across the landscape than was historically present due to massive soil movement that occurred during the dust bowl. These areas of the surrounding landscape that are sand sagebrush are highly departed from the reference condition. Sand sagebrush keeps the soil stable and help prevent further soil movement; therefore, they are important on the Grasslands. This makes the sand sagebrush PNVT on the Kiowa and Rita Blanca National Grasslands an important ecosystem and important to ecological sustainability.

Reference Condition Planning Unit: Historically, sand sagebrush areas included tall, warm season grasses such as prairie sandreed, sand bluestem and switchgrass, with blue grama in the understory. Cool season grasses and forbs such as needle-and thread and sun sedge were common. Sand sagebrush shrubs stabilize light sandy soils from wind erosion and can co-exist with herbaceous (grass) species by protecting them in heavily grazed conditions (Davis and Bonham 1979). The reference conditions for the Sand sagebrush vegetation type were distributed as demonstrated in Table 29. Reference conditions were based on the Fire Regime

Condition Class Model for Prairie Grassland 1 (Sand sagebrush-Bluestem Prairie) (Hann 2003). Current condition is shown again for comparison.

Table 29 Reference Conditions for Sand sagebrush

Successional Class Structure and Composition	Current Percent	Reference Percent
Early: Dominated by resprouts and seedlings of grasses and forbs. Low to medium height with variable canopy cover.	5%	1%
Mid-Open: Less than 35% herb cover. Medium to tall height.	69%	55%
Mid-Closed: Greater than 35% herb cover. Medium to tall height.	30 %	44%

Currently, the sand sagebrush prairie is within the reference condition as a whole for the PNVT.

Projected Future Condition and Trends: A departure analysis was conducted to determine whether this PNVT is within its reference condition and can be found in Appendix F. Due to massive soil movement that occurred during the Dust Bowl, there is currently more of the sand sagebrush vegetation type on the Grasslands than was present historically (TEU data). These areas are necessary to keep the soil stable and help prevent further soil movement; therefore, they are important on the Grasslands. Management activities will continue to maintain these areas. Prescribed burning is used in the PNVT, but presently only about 500 acres is burned every 3-5 years. Livestock grazing is done during the winter months to limit the impact to soils. No livestock grazing is conducted during the growing season in the sand sagebrush. Continuation of current management trends maintains the reference conditions.

2.2 Vegetative Disturbances

Historically, natural disturbance was a regular component of all of the PNVTs found on the Grasslands. These disturbances, including wildfire, grazing, and climatic events, had notable effects on the Grasslands vegetation (including composition and structure). In addition to these events, hardwood riparian areas were periodically affected by flooding. Though their frequency and intensity have shifted as a result of settlement and management, these historical natural disturbances continue to influence the composition and structure of the Grassland PNVTs. In addition, invasive species and motorized and off-road travel are now recognized as having disturbance-like effects on the Grasslands vegetation.

These various disturbances and their current and historical (reference) conditions are described below. Where possible, descriptions of the projected future conditions and trends for these vegetative disturbances are also included.

2.2.1 Fire

Current Conditions: Fire is the most significant disturbance process in sustaining plains grassland ecosystems. Grassland fires release nutrients into the soil, which stimulates nutrient cycling and soil productivity (Brockway et al. 2002a). Grassland fires reduce the establishment of woody trees and shrubs, which helps maintain a more resilient grassland composition and structure (Brockway et al. 2002a, Ford 2003). The encroachment of woody species that threatens plains grasslands in the region is not only the result of over 100 years of fire suppression, but also the planting of shelterbelts and other tree species during the early years of grasslands restoration in the 1940s.

Grasslands managers have increasingly used prescribed burns to eliminate the excess of woody trees and shrubs, including invasive trees like black locust and eastern red cedar, improve the diversity of structural stages, and restore fire-adapted ecosystems. Over the past 10-12 years, approximately 80% of the Black Kettle and McClellan Creek National Grasslands have been burned, with some units burned two to four times, and about 2% of the Kiowa and Rita Blanca National Grasslands units have been burned, mostly in the piñon-juniper ecosystem (GIS Geodatabase – Prescribed Fire History 2007). In addition, approximately 7,300 acres burned in wildfires on all four Grasslands in the ten years from 1995 to 2005. The 2006 wildfire season was especially unique due to prolonged drought and burned over 3,700 acres of Black Kettle, 1,500 acres of McClellan Creek and 850 acres of the Kiowa and Rita Blanca National Grasslands (GIS Geodatabase – Fire History 2007). Prescribed fire and wildfire maps are located in Appendix A.

Reference Conditions: Historically, lightning-caused fires and fires set by Indian Tribes burned across extensive areas of the plains grasslands, and ecosystems adapted to these periodic fires (Finch 2004). The plains grasslands had a historical fire regime of 3 to 10-years (Wright and Bailey 1982). This was disrupted by Euro-American settlements in the late 1800s (Wright and Bailey 1982), mainly by over-grazing and fire suppression (Finch 2004). Contemporary residential development and growth led to widespread fire suppression, with roads often serving as fuel breaks. Fire suppression caused increases in trees and other woody vegetation while reducing the abundance of fire-adapted native grasses (McPherson 2000; Coppedge et al. 2001; Finch 2004).

Projected Future Conditions and Trends: The Forest Service's emphasis on prescribed burning throughout the Grasslands will increase in the amount of acres burned and continue mimic historical fire regimes, improving the structural diversity of each PNVT toward its reference condition. Figure 5 shows the acreage per year treated using prescribed burns.

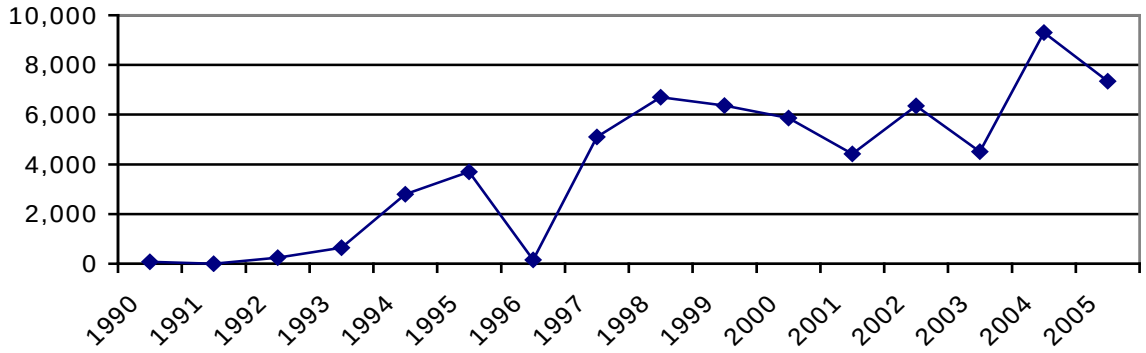

Figure 5 Acres Prescribed Burned on the Kiowa, Rita Blanca, Black Kettle and McClellan Creek National Grasslands, 1990-2005 (GIS Geodatabase – Prescribed Fire History 2007).

2.2.2 Grazing

Current Conditions: Cattle grazing occurs on over 96% of the Grasslands. Flexible stocking rates are set according to the season and vegetative conditions, with a minimum 30-day

growing season recovery period on the Black Kettle National Grassland and 60-day recovery period on the Kiowa and Rita Blanca National Grasslands.

Reference Conditions: Grazing by herbivores such as bison played a very important role in the development of the current grazing-adapted grasslands (Finch 2004). Unconfined herds of bison in the 1800s moved over extensive grasslands year-round, reducing grass cover and changing the dominance of certain plant species (Finch 2005). Blue grama and buffalograss tend to increase under continuous grazing, while warm season big- and little bluestem and cool-season grasses decrease with grazing pressure (The Nature Conservancy 1998). A prolonged drought in the mid-19th century, coupled with hunting pressure and competition with domestic livestock for riparian winter grazing, brought the bison to the brink of extinction (Finch 2005). Prairie dogs once inhabited millions of acres of the Great Plains and played an important role in modifying grasslands and providing habitat for numerous species (Finch 2004). Prairie dog grazing has been observed to reduce effective vegetative ground cover in drier PNVTs and potentially contributes to accelerated erosion, soil compaction (USDA Forest Service 1991) and declined soil productivity, especially during periods of drought. Herbivory can directly reduce vegetative cover, affect a change in vegetation species which may have reduced root holding and soil trampling by large ungulate trail creation, all of which can lead to accelerated erosion rates.

Projected Future Conditions and Trends: The Forest Service has adopted an adaptive management approach and completed an environmental analyses and Allotment Management Plans on every active grazing allotment on the Grasslands. The adaptive management approach now in place allows for adjustments in numbers of livestock and seasons of use through the annual operating permit system in order to respond to changing conditions and achieve management objectives. The intensity of livestock grazing is substantially lower on the Grassland units than on adjacent private lands, averaging half the stocking rate found on private land (UNM-BBER 2005). Current livestock management trends indicate that grazing on the Grasslands is currently sustainable.

2.2.3 **Invasive Species**

Current Conditions: Invasive species disrupt natural ecosystem functions and negatively affect both ecological and socio-economic conditions (Finch 2004). Invasive species can displace desirable native species, reduce the quality of wildlife habitat, damage sensitive riparian and watershed areas, increase wildfire risk, and increase erosion (Fletcher 1998, Finch 2004). The displacement of native species causes a decline in opportunities for land use and land values (Finch 2004). Invasive species cause major modifications in ecological processes and soil microflora, affecting nutrient cycling and decomposition rates (Finch 2004). Changes to grassland habitat by non-native species introduction can be beneficial to some game species such as whitetail deer and Rio Grande turkey and tree dependant bird species that can utilize the altered habitat.

The following list shows some invasive and/or non-native plants found so far on Grasslands units, and there are likely other species not yet inventoried (GIS Geodatabase – Invasive Plant 2007):

- Black locust
- Eastern redcedar
- Jointed goatgrass
- Hoary cress
- Scotch thistle
- Musk thistle
- Bull thistle
- Prickly sowthistle
- Cheatgrass
- Johnson cress
- Mesquite
- Salt-cedar
- Siberian elm
- Russian olive
- Kochia
- Russian thistle

Maps displaying invasive species by Grassland are located in Appendix A.

Reference Conditions: Historically, there were no invasive species found on the Grasslands.

Projected Future Conditions and Trends: Over the past decade, Grasslands managers have greatly increased the emphasis on preventing and controlling invasive plants, by: developing cooperative agreements with adjacent landowners to actively control invasive plants on "both sides of the fence"; engaging in cooperative interagency programs such as the salt-cedar control project along the Canadian River; conducting some small-scale control treatment for invasive species; and developing environmental analyses needed to implement more invasive plant control projects. These management activities will help to move all PNVTs closer to their reference conditions.

2.2.4 **Climate**

Current Conditions: The Grasslands experience extreme fluctuations in climate conditions and extreme weather events such as prolonged droughts, flooding, hail, blizzards, tornadoes, and dust storms (Bragg 1995, The Nature Conservancy 1998). Precipitation has a significant influence on ecological conditions and processes in the Great Plains (The Nature Conservancy 1998). Evaporation typically exceeds precipitation and water is the primary factor limiting vegetative growth and the type of vegetation a site will support (Finch 2004). Native grasslands are extremely well adapted to tolerate and resist the impacts from drought, fire and grazing (Weaver 1954, Finch 2004). Great Plains grassland soils and vegetation vary depending upon their location along the east-west moisture gradient (Figure 6). Grasslands average annual precipitation ranges from about 14 inches (Kiowa) to 29 inches (Black Kettle); average annual temperature ranges from about 50° F (Kiowa) to 59° F (Black Kettle) (DAYMET 2010).

Reference Conditions: The Grasslands evolved with severe droughts and other extreme climatic events, along with grazing and fire. Native grasslands are extremely well-adapted to tolerate and resist the impacts from drought, fire, and grazing (Weaver 1954, Finch 2004).

Projected Future Conditions and Trends: Joyce et al. (2001) predict that the Great Plains will become warmer and wetter; the combined effect will increase evapotranspiration and water stress on plants. Impacts of climate change on grasslands may include the invasion of woody species as a function of increased CO_2 concentration and a change in seasonal precipitation

patterns (Brown et al. 1997, Morgan et al. 2007). Both of these factors favor the establishment of vegetation with the C_3 photosynthetic pathway such as woody shrubs at the expense of warm season perennial C_4 species of grasses (Bazzaz and Carlson 1984, Patterson and Flint 1990, Johnson et al. 1993).

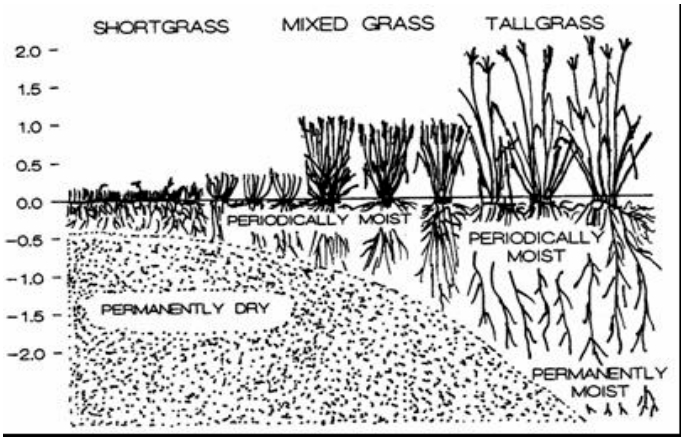

Figure 6 Effect of Moisture on Soil Differences in the Great Plains

2.2.5 Floods

Current Conditions: While some local, small-scale flooding occurs, there is a general lack of flood disturbance. This is attributed to the extensive flood control efforts in areas outside the Grasslands.

Reference Conditions: The entire range of flood magnitudes contributed to ecological processes such as nutrient cycling, recruitment and species composition (Finch 2004). Two to ten-year events primarily impacted herbaceous vegetation and 7-50 year events resulted in patchy removal of shrubs and saplings. 50+-year events removed stands of larger trees. Cottonwoods returned to pole size within 10 years of disturbance. Cottonwood is considered mature around 60 years. Flooding resulted in scouring, sedimentation and regeneration of cottonwood and other riparian species.

2.2.6 Motorized Travel and User-Created Roads

Current Conditions: On the Kiowa and Rita Blanca National Grasslands, off-road driving is not prohibited and is particularly prevalent in the popular hunting areas. Most of the Kiowa and Rita Blanca National Grasslands are not highly desired by off-road driving enthusiasts because of the mixed ownership pattern, abundance of fences, and relatively even and homogenous terrain. However, where the off-road driving and user-created roads are prevalent, such as in the Mills Canyon and Uplands, use has resulted in a loss of vegetative productivity and species diversity, long-term soil compaction and erosion, water quality degradation, and impacts to scenery, historical resources and other social values.

The Black Kettle and McClellan Creek National Grasslands prohibit driving off designated roads or trails so effects of off-road motorized travel on ecological sustainability are not an issue on that District. Transportation maps can be found in Appendix A.

Reference Conditions: Historically, there was no motorized travel on the Grasslands.

2.3 Soils

The Terrestrial Ecological Unit Inventory (TEUI) is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems also known as ecological types delineated and numbered in ecological units. TEUI was used throughout the soils analysis. Within National Forest System boundaries, TEU data is available at scales finer than subsections. The TEUI provides seamless coverage and descriptive information of terrestrial ecological units at the land unit (Landtype Phase) level (1:24,000) within the boundaries of the Grassland. The Ecological Units (and soils) are derived from the Ecological Unit Inventory, the TEUI of the Grasslands, (Strenger et al. 2007). It is the only seamless mapping of vegetation and soils available across the Grasslands that include field visited, validated and correlated sites with a stringent Regional and National protocol stemming from decades of work. The TEUI data is roughly equivalent to a Natural Resource Conservation Service (NRCS) soil survey with more emphasis placed on recognizing the soil, vegetation, landform and climatic relationships.

Differences in ecosystem properties, including soil and vegetation, can occur within short distances. Generally, small vegetation types smaller than about 10 to 40 acres were not mapped and are included in larger TEUI map units. Individual map units were based on data collected across the Grassland and may or may not represent landscape existing conditions and potential plant community as depicted in the TEUI. Overall accuracy of mapping and information provided by the TEUI is considered reliable at the Landtype Phase scale. There are 47 different terrestrial ecological map units and 13 different landforms on the Grasslands. A map unit is a collection of areas defined and named in terms of their landform, soil, vegetation, and climate components. Each map unit differs in some respect from all others in a survey area and is unique.

2.3.1 Current Condition

The Forest Service is required to manage lands in ways that minimize soil erosion and loss of topsoil in order to maintain long-term soil productivity. The loss of topsoil and productivity during the Dust Bowl era was extreme. Restoration management practices on the Grasslands over the past several decades have resulted in tremendous improvement in soil stability and vegetative recovery. A few units on the Black Kettle National Grassland that were heavily plowed in the past do not appear capable of recovering to their productivity potential, although the soils are grass-covered and stabilized. A few units on Kiowa and Rita Blanca National Grasslands adjacent to towns or other private developments are heavily impacted by invasive plant populations that are seriously reducing soil productivity and vegetative diversity (USDA Forest Service 2007a pg. 26-30; USDA Forest Service 2007b pg. 20-23). These soils are not likely to be fully restored to full productivity and native grassland vegetation due to continued spread of invasive plants and other impacts from adjacent lands.

Authorized activities on the Grasslands units that contribute to a long-term loss of soil productivity include recreation developments, oil-gas operations, roads, and caliche extraction pits. These constitute small, localized areas scattered across large landscapes. After authorized activities are completed, the Forest Service requires the disturbed acreage to be rehabilitated to restore soil productivity. Activities conducted by the Forest Service have gone through an environmental analysis process in accordance with the National Environmental Policy Act (NEPA) and the NEPA documents indicate that none of the projects would result in a significant impact to soil productivity or other soil conditions.

When conducted as planned, prescribed burns do not typically pose a risk to sustaining soil conditions. Prescribed burns are ignited under very specific climate and fuel moisture conditions so that grass will reemerge more quickly than it does after a typical wildfire event. The faster green-up results in less wind-driven soil erosion. Also, prescribed burns reduce the fuel loads so that subsequent wildfires that burn through those areas do not burn as hot or cause as much soil damage. Research on prescribed

burning overall effects in the ecosystems found on the Grasslands will help to ensure that these general "rules" hold true throughout the different PNVTs and terrestrial ecological units.

The only public land use activity causing unacceptable impacts to soil conditions is the unmanaged motorized vehicle use and the resulting unauthorized roads and trails this off-road driving creates. This use has resulted in degraded soil conditions and a loss of soil productivity, particularly in Mills Canyon. There are currently over 200 miles of roads, including unauthorized roads on soils with the potential for severe erosion.

2.3.2 **Erosion Hazard**

The Terrestrial Ecological Unit Inventory (TEUI) indicates places where there is a "severe erosion hazard" (USDA Forest Service 2006b). Severe erosion hazard means predicted soil loss rates have a high probability of reducing site productivity if all the vegetation is removed from the area and it experiences heavy rainfall or similar events. Areas with this rating are typically not severely eroding currently or expected to experience serious erosion under current ecological conditions and management trends but they are more susceptible to erosion if disturbed.

The process of soil erosion is variable and dependant on many soil factors and disturbance. Once disturbance causes the protective vegetative layer to be removed, the soil is susceptible to erosion and can occur above tolerable limits on soil with moderate or severe erosion hazards. A rating of slight indicates that removal of vegetation will not cause soil loss above the threshold, i.e. the maximum possible soil loss modeled would not exceed tolerable erosion rates (T), (Strenger et al. 2007). Threshold values vary by soil type and roughly equate to the point where annual soil renewability or soil productivity is sustained. Erosion rates higher than T cause a loss of soil surface horizons and soil productivity. Conversely, erosion rates less than T allow for the soil to naturally regenerate enough and do not cause a loss of soil productivity. A rating of moderate indicates that rates of soil loss will result in lowering of site productivity (modeled soil loss exceeds T). A rating of severe indicates that rates of soil loss have a high probability of lowering site productivity (modeled soil loss exceeds T). Areas that have excessive fuel loadings on soils with moderate or severe erosion hazard pose a risk of appreciable watershed degradation following wildfires. Erosion hazard is an indicator of the potential for soil loss given the loss of all ground cover. Current erosion hazard is similar to historical erosion hazard because it compares tolerable soil loss to potential soil loss (soil loss occurring when the vegetative ground cover is removed).

The following PNVTs have appreciable areas of severe erosion hazard: mixed grass prairie, piñon-juniper and shortgrass prairie (Table 30). Where disturbances or lack of disturbances, such as a lack of fire, has caused high fuel loadings, canopy covers and high departures from natural soil and vegetative conditions, there is high risk of watershed degradation following wildfires. Other PNVTs have fewer areas of soils with high erosion hazard but where they do exist, wildfire could have similar negative consequences on the watershed including soil productivity and sediment delivery or flooding. Similarly any activity that significantly reduces ground cover, e.g. prairie dog towns, could have negative effects including loss of soil productivity especially on soils with a severe erosion hazard. It is important to recognize that effective vegetative ground cover is essential, as indicated by satisfactory soil condition, to protect against compaction, removal of surface organic matter, accelerated erosion and sustain soil productivity.

Table 30 Erosion Hazard by PNVT

Erosion Hazard						
	Slight		Moderate		Severe	
PNVT	%	Acres	%	Acres	%	Acres
Mixed Grass Prairie	0.0%	0	65.2%	7358	34.8%	3932
Shortgrass Prairie	5.7%	10,288	65.8%	119,771	28.5%	51,931
Shinnery oak	0.0%	0	100.0%	19,033	0.0%	0
Piñon-Juniper	6.0%	0	47.1%	10931	46.8%	10858
Cottonwood-Willow	100.0%	1370	0.0%	0	0.0%	0
Mixed Hardwood Riparian	76.2%	1491	23.8%	465	0.0%	0
Sand sagebrush	25.7%	5812	74.3%	16,839	0.0%	0
Total		**19,987**		**174,397**		**66,722**

2.3.3 **Soil Condition**

Soil condition is an analysis of the primary soil functions evaluated were soil hydrology, soil stability and nutrient cycling (USDA Forest Service 199b). Numerous onsite soil condition assessments were made, and existing field notes were analyzed to classify and extrapolate soil condition across the Grasslands. Individual map units were based on data collected across the Grassland and may or may not represent soil condition at any given point on the landscape. Many differences in soils and related disturbances can occur within short distances. Overall accuracy of mapping and information provided by the TEUI and soil condition protocol is considered reliable at the ecological unit or landscape level.

Classes used for Soil Condition are Satisfactory, Impaired, Unsatisfactory and Inherently Unstable. The following are definitions describe each class:

Satisfactory: Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.

Impaired: Indicators signify a reduction in soil function. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. An impaired category indicates there is a need to investigate the ecosystem to determine the cause and degree of decline in soil functions. Changes in land management practices or other preventative measures may be appropriate.

Unsatisfactory: Indicators signify that a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs or recover from impacts. Unsatisfactory soils are candidates for improved management practices or restoration designed to recover soil functions.

Inherently Unstable: These soils have natural erosion exceeding tolerable limits. Based on calculations Hillslope Erosion Model these soils are eroding faster than they are renewing themselves but are functioning properly and normally.

Table 31 displays Grassland Soil Condition by PNVT with acreage and relative extent and percent contributions throughout the PNVT total extent.

Table 31 Grassland-Wide Soil Condition by PNVT

PNVT	Soil Condition								Grassland PNVT Total	
	Satisfactory		Impaired		Unsatisfactory		Inherently Unstable			
	%	Acres	%	Acres			%	Acres	% in PNVT	Acres
Mixed Grass Prairie	93%	10,496	7%	794	0	0	0	0	4.3%	11,290
Shortgrass Prairie	54%	98,208	46%	83,782	0	0	0	0	69.5%	181,990
Shinnery oak	15%	2855	85%	16,178	0	0	0	0	7.3%	19,033
Piñon-Juniper	76%	17,599	24%	5594	0	0	0	0	8.9%	10,522
Cottonwood-Willow	100%	1370	0%	0	0	0	0	0	0.5%	1,370
Mixed Hardwood Riparian	100%	1956	0	0	0	0	0	0	0.7%	1,956
Sand sagebrush	26%	5812	74%	16,839	0	0	0	0	8.6%	22,651
Total		**135,441**		**126,043**		**0**		**0**	**100.0%**	**261,485**
Total as Grassland Percent	**52%**		**48%**		**0.0%**		**0.0 %**			

Contribution to Sustainability: About 52 percent of the Grassland is in satisfactory condition and about 48 percent is in impaired condition (Table 31).

More than 90 percent of the mixed hardwood riparian, mixed grass prairie, and cottonwood-willow riparian PNVTs are in satisfactory refined soil condition. Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.

Conversely, the greatest proportion of impaired soil conditions are found in the shinnery oak PNVT. This PNVT only totals to about seven percent of the Grassland aerial extent but there is a much larger amount of the shinnery oak PNVT on the Grasslands than in the surrounding landscape. The shinnery oak PNVT, which is all on one terrestrial ecological unit, is impaired due to a combination of historical plowing on inclusions within of the map unit which resulted in changes in the topsoil; sandy, nutrient-poor soils; and non-native eastern red cedar encroachment.

A considerable portion of the piñon-juniper, sand sagebrush and shortgrass prairie PNVTs also have impaired soil conditions. Indicators signify that there has been a reduction in soil function. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation.

The impaired terrestrial ecological units in the piñon-juniper PNVT are likely in this category due to high portions of bare soil and current and natural soil loss greater than tolerable. Both

terrestrial ecological units have low re-vegetation potential, but appear to be in good condition otherwise.

In the sand sagebrush PNVT, the terrestrial ecological units appeared to be impaired because of a high proportion of bare soil.

There are many impaired TEUs in the shortgrass prairie PNVT so there are also many potential reasons for the impairments. TEUs 803, 807, 808, 814, 818 and 853 all have a high proportion of bare soil which is erodible and hinders soil hydrology functioning. TEUs 814 and 818 also have natural soil loss greater than tolerable soil loss. Some of the TEUs also have a low re-vegetation potential due to high alkalinity which indicates potential problems with soil nutrients.

Maintaining satisfactory soil condition is important in maintaining long-term soil productivity which is essential in sustaining ecosystem diversity. Impaired soil conditions have resulted in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation. Much of the current soil condition is an artifact of the Dust Bowl era erosion and deposition. These changes significantly altered soil structure, texture and horizonation. Most soils negatively affected during the Dust Bowl have yet to develop into productive grassland soils found prior to the 1930s.

2.4 Soil Loss

The TEUI identified soil loss by ecological map unit and is primarily based on soil properties modeled using the Hillslope Erosion Model (HEM) (Anderson 1988). A separate resource characteristic analysis will be conducted in this report evaluating Forest-wide soil condition based on three soil functions including ability of soil to resist erosion, ability of the soil to infiltrate water and ability of the soil to recycle nutrients.

Ratings used for Soil Loss are Satisfactory, Unsatisfactory, and Unsuited. A Satisfactory rating denotes that the current erosion rate is less than the soil erosion rate tolerable threshold (T) and that a low level of erosion is occurring, representing maintenance of soil productivity. An Unsatisfactory rating denotes a high level of erosion (more than T), representing continued loss of soil productivity. An Unsuited rating represents inherently unstable soil types that, even with optimal ground cover, soil loss would exceed T. TEUI units with Unsuited ratings are typically on steep slopes or sandy soils with low natural cover and are naturally prone to high rates of erosion.

Soil loss rates for natural, current, and tolerable are listed in the TEUI. Soil loss is defined as the predicted net average soil loss from a site due to erosion. Conditions on the ground when the TEUI was mapped indicate that 60% of the TEUI map units have a current soil loss rate either equal to or below the predicted natural soil loss potential, as in the predicted soil loss under natural conditions. Thirty percent of the TEUI map units have current soil loss rates exceeding natural soil loss rates but less than tolerable soil loss rates. These two conditions are in the satisfactory category for soil loss condition. The tolerable soil loss rate is the rate of soil loss that can occur while sustaining inherent soil productivity (Strenger et al. 2007). Ten percent of the TEU map units have soil loss rates where both natural and current soil loss rates are above the tolerable amount and unsuited. This is an unstable state, but given this is the natural soil loss condition, management activities on the Grasslands are not contributing to the soil loss (Strenger et al. 2007).

Table 32 displays soil loss by PNVT acreage and relative extent and percent contributions throughout the PNVT total extent. PNVT is a product of the Terrestrial Ecological Unit Inventory and is listed for each map unit.

Table 32 Soil Loss by PNVT

Soil Loss								
PNVT	**Satisfactory**		**Unsatisfactory**		**Unsuited**		**Grassland PNVT Total**	
	% In PNVT	**Acres**	**% In PNVT**	**Acres**	**% In PNVT**	**Acres**	**% on Grassland**	**Acres**
Mixed Grass Prairie	65.8%	7425	0%	0	34.2%	3865	4.3%	11,290
Shortgrass Prairie	89.8%	163,490	0%	0	10.2%	18,501	69.5%	181,990
Shinnery oak	100%	19,033	0%	0	0%	0	7.3%	19,033
Piñon-Juniper	87.7%	20348	0%	0	12.3%	2845	8.9%	10,522
Cottonwood -Willow	100%	1370	0%	0	0%	0	0.5%	1370
Mixed Hardwood Riparian	100%	1956	0%	0	0%	0	0.7%	1956
Sand sagebrush	100%	22,651	0%	0	0%	0	8.6%	22,651
Total [7]		**236,273**		**0**		**25,681**	**98.8%**	**261,954**
Percent of Grassland	**90.2%**		**0%**		**9.8%**			

Contribution to Sustainability: About 90 percent of the Grassland has a satisfactory soil loss rating, none of the Grassland has an unsatisfactory soil loss rating, and about 10 percent has an unsuited soil loss rating (Table 32). All of the mixed hardwood riparian, piñon-juniper, cottonwood-willow riparian, sand sagebrush, and shinnery oak PNVTs are in satisfactory soil loss condition. This indicates that on-site soil loss is within threshold limits and is not reducing the ability of the soil to maintain long-term soil productivity. Conversely, the greatest areas of unsuited soil loss are found in the shortgrass prairie PNVT. Proportionally, the mixed grass prairie PNVT has the most area in an unsuited soil loss, about 35 percent. Soil erosion may be occurring beyond its threshold and the soil is at risk of not maintaining long-term soil productivity. Maintaining satisfactory soil loss is important in maintaining long-term soil productivity, which is crucial in sustaining ecosystem diversity. Unsatisfactory soil loss results in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation.

2.4.1 Disturbances and Processes

The following is a list and analysis of disturbances that occur on the Grasslands affecting all identified soil resource characteristics including soil condition, soil loss, soil productivity and organic matter.

[7] Percentages do not total to 100 because water makes up a percentage of the area but is not considered a PNVT.

Herbivory: Cattle graze throughout most PNVTs. High levels of ungulate (livestock and pronghorn) and prairie dog grazing has been observed to reduce effective vegetative ground cover in drier PNVTs and potentially contributes to accelerated erosion, soil compaction (USDA Forest Service 1991) and declined soil productivity (especially during periods of drought). Herbivory can directly reduce vegetative cover, affect a change in vegetation species which may have reduced root holding, and trample soil in trails, all of which can lead to accelerated erosion rates.

Drought: The Grasslands have recently experienced several years of drought (roughly since about 1999) with occasional normal levels of seasonal moisture. Reduced precipitation results in reduced vegetative growth, reduced surface organic matter and productivity and ineffective vegetative ground cover putting the soil at risk of accelerated erosion and compaction during storm events and subsequent loss of soil productivity. As vegetation dries out, there is increased risk of wildfire spread and subsequent accelerated erosion and watershed degradation.

Flooding: Flooding affects the riparian PNVTs, as well as unmapped streamcourses throughout all the PNVTs. Flooding may cause localized soil loss in the stream channel, streambanks and floodplains if not well protected with deep rooted vegetative ground cover. Frequent flooding is a natural process and disturbance within these PNVTs. Flash flooding can occur in perennial, intermittent and ephemeral streams in all PNVTs, especially in large watersheds where short duration, high intensity storms occur. Maintaining native vegetation described in the Potential Plant Community of the TEUI provides channel stability, functional riparian areas and good water quality for wildlife and aquatic species.

Fire Regime: With the exclusion of wildfire throughout most PNVTs in the last 70 years, fuel loading has increased in woodland and forest PNVTs resulting in high risk of accelerated erosion, loss of soil and vegetative productivity, and sediment transport to connected streams following wildfires in areas with moderate and high erosion hazard on the Grassland. High levels of sediment can reduce fishery and aquatic habitat and those species that rely on it for their survival.

2.4.2 **Reference Condition**

Reference conditions for the Grasslands were developed using information in the TEUI database.

Erosion Hazard: Soils identified as unsuited are inherently unstable soils and would have had natural erosion above tolerable thresholds, regardless of natural or anthropogenic disturbances. This is likely the case unless some areas were disturbed intensively during the Dust Bowl era. Herbivory, such as ungulate and prairie dog grazing, has been observed to reduce effective vegetative ground cover in the vegetative basal area and litter, cause surface soil compaction, especially when the soil is wet and contribute to causing accelerated soil loss (USDA Forest Service 1991) and declined soil productivity. Previous to 1935, there is little documentation of range condition on public lands (USDA Forest Service 1991). It is not known to what degree Native American agricultural practices, including burning and cultivation may have had on soil loss but it is probable that when soils with high erosion hazard where burned and farmed, accelerated erosion resulted from storm events. Natural flood disturbance would have had limited affect on the extent of soil loss only causing accelerated erosion adjacent to stream channels or floodplains. Drought may have reduced the amount of protective vegetative ground cover resulting in accelerated erosion.

Soil Condition: Very little quantitative data exists to measure historical soil condition. However, some qualitative and quantitative inferences can be made and estimated providing

insight into historical soil condition primarily using knowledge about present disturbances and their effect on erosional processes, soil compaction and nutrient cycling. Historical conditions analyzed here generally estimate Pre-European settlement conditions unless otherwise noted.

Historically or pre-European settlement and without human-caused disturbances, soil loss, soil compaction and nutrient cycling would have been within functional limits to sustain soil function and maintain soil productivity for most soils. However, during cyclic periods of drought and local areas of overgrazing caused by buffalo, there were areas that experienced some soil problems. Since there were no political boundaries historically, soil condition was similar on similar soil types throughout the range of the PNVT both within and outside of the Grassland.

Prior to the Dust Bowl era much of the land area currently in an impaired soil condition was in a satisfactory condition. It is not possible to predict if this was indeed the case and to what extent this may have been the conditions historically.

Soil Loss: No quantitative data exists to measure historical soil loss. However, some qualitative and quantitative inferences can be made and estimated providing insight into historical soil loss condition primarily using knowledge about present disturbances and their effect on erosional processes. Historical conditions analyzed here generally estimate pre-European settlement conditions unless otherwise noted.

Historically or pre-European settlement and without extensive human-caused disturbances, soil loss and consequently, the soil loss condition, would have been below threshold values and therefore in satisfactory soil loss condition where not unsuited or inherently unstable. Since there were no political boundaries historically, soil loss would have been similar on similar soils throughout the range of the PNVT both within and outside of the Grasslands. It is unknown how much of the unsuited or inherently unstable land, prior to the Dust Bowl era, was in a satisfactory soil loss condition.

2.4.3 **Disturbances and Processes**

The following is a list and analysis of historical disturbances that may have occurred on the Grassland affecting soil characteristics and ecosystem diversity.

Herbivory: Very little range condition data is available before 1935 (USDA Forest Service 1991). However the General Terrestrial Ecological Survey (GTES) shows that from 1902 – 1987 that, as more livestock numbers and acres were grazed, range condition (and therefore soil condition) declined and, as fewer number and acres were grazed, range condition and trend improved (USDA Forest Service 1991). Domestic livestock grazing was not present historically or before European settlement, but bison were known to graze the Grassland and were reported to denude grass in some areas.

Drought: Cyclic drought patterns are known to have occurred throughout the last few centuries as evidenced through tree ring studies. The worst drought on record occurred in 1892-1893 when 50 -75 % of range animals perished or shipped to market (USDA Forest Service 1991). The first assessments of range condition were made by untrained observers in the late 1800's. These explorers contained optimistic assessments of large amounts of forage, but equally ominous warnings of areas denuded of grass by bison and drought (USDA Forest Service 1991).

Flooding: Streambanks were vegetated with native riparian species providing for greater streambank stability and little soil erosion and sediment delivery. The Canadian River likely had cottonwood and willow on the banks rather than tamarisk.

Fire Regime: Fuel loading or fuel build-ups were historically much lower than current conditions in woodland and grassland PNVTs and consequently did not pose as high a risk to accelerated soil loss and sediment delivery.

Plowing: Homesteaders plowed under native vegetation to cultivate much of the land that is now part of the National Grasslands. This exposed these soils to wind and water erosion and the lack of rainfall led to crop failures causing this condition to be maintained for long periods of time. This soon let to what is now know as the Dust Bowl era and is one of the reasons many of these soils/terrestrial ecological units are impaired today.

2.4.4 Projected Future Conditions and Trends and Comparison to Current and Reference Conditions

The Grasslands will always contain some small, scattered patches of bare soil that "blow in the wind" similar to natural erosion events that occurred historically, such as in prairie dog colonies, playa lake beds, and recently burned wildfire sites. Since 1971, over 100 wildfires have burned over 17,000 acres on the Grasslands (GIS Geodatabase – Fire History 2007). All areas have recovered to acceptable levels of soil stability and vegetative cover. The number of active oil-gas wells and other developments that would reduce site productivity is not expected to significantly increase on Grasslands units over the next 10-20 years.

Soil productivity is likely to improve after the 2005 Travel Management Rule is fully implemented and motorized travel routes and areas are designated[8]. Given the potential for livestock grazing activities to affect soil conditions and plant communities and productivity in a TEU, continued monitoring and adaptive management is needed to maintain and continue to improve soil condition. Predicted increases in air temperatures in the southern Great Plains may reduce soil organic matter affecting productivity, water-holding capacity and carbon storage in the soil (Joyce et al. 2001).

Erosion hazard and soil condition values indicate that there is a potential for soil productivity and soil erosion to be limited. Soil loss is rated relatively well given the erosion hazard and soil condition ratings. Current management trends are keeping soil productivity stable or slightly improving, even given damage done during the Dust Bowl era.

2.5 Aquatic Systems and Niche

A comparison of the Grasslands to the surrounding landscape for aquatic properties was described earlier in this report in section 1.2.2.1.

Overall, there appears to be representative miles of stream and acreage in waterbodies on the Grasslands based on total acreage in the watersheds. However, the numbers tend to vary greatly in a given watershed. For example, the Grasslands in the Upper Washita River watershed have almost 15 percent of the perennial stream miles in the watershed (Table 8) but represent only about 8 percent of the area of the watershed. Conversely, the Grasslands in the Headwaters of Coldwater Creek watershed represent about 25 percent of the area of the watershed, but have no perennial streams and only 2 percent of the perennial lakes or ponds.

[8] The 2005 Travel Management Rule (36 CFR 294) requires National Forest and Grassland to establish a designated motorized trail system for all units.

Playa lakes are a feature often occurring within the shortgrass prairie. They are shallow depressions that occur primarily in the High Plains region (Haukos and Smith 2003). There are approximately 19,000 playas scattered throughout the Southern High Plains with another 6,000 in adjacent states (The Handbook of Texas Online 2006). The Grasslands units include approximately 903 acres of playa lakes, mostly on the Kiowa and Rita Blanca National Grasslands (GIS Geodatabase – Water Body 2007). The playas only source of water is from rainfall events, and a significant amount of collected water is lost through evaporation, transpiration, and infiltration (Haukos and Smith 2003). The playa lakes on the Grasslands typically remain dry for most of the year and may remain dry for several years depending on precipitation (Playa Lakes Joint Venture 2006). When they contain water they become an important water and food resource for migratory birds and other wildlife. Playa ecosystems serve as biological refugia and critical sites of biodiversity (Haukos and Smith 2003). Water collected in playas also serves as a recharge point for the Ogallala Aquifer. Playa vegetation occasionally occurs depending on the frequency of water retention and the size and depth of the playa. Where shoreline vegetation occurs, it typically consists of buffalograss, western wheatgrass, sideoats grama, alkali sacaton, and blue grama. Maps of locations of playa lakes found on the Grasslands can be found in Appendix A.

2.5.1 Surface Water and Associated Riparian

The following section outlines the current and reference conditions and current management for the aquatic systems of the Grasslands.

Current Condition: The following surface water and riparian vegetation occurs on the Grasslands units, and additional water and riparian resources occur on adjacent private and state lands (GIS Geodatabase – Waterbodies and Streams 2007):

- 32 miles of perennial (mostly year-round) streams, with 60% on the Kiowa and Rita Blanca National Grasslands and 40% on the Black Kettle and McClellan Creek National Grasslands
- 3,400 acres of riparian area and 40 acres of playa lakes (shallow depressions that remain dry between rain events), and
- 1,300 acres of water in reservoirs, lakes, and ponds (at normal pool levels).

Over the past 20 years, water quality on the Grasslands has been relatively good. Some surface water has been polluted to a certain extent, most notably the Washita River that runs through a portion of the Black Kettle and is on the most recent list of water quality impaired streams in Oklahoma (Oklahoma Department of Environmental Quality 2004). Those reaches of the Washita are below water quality standards for pathogens (E. coli, enterococcus and fecal coliform), sulfates and turbidity. The source of impairment is not yet known. Of the approximately 51 miles of the Washita River that run in the Black Kettle National Grassland's administrative boundary, less than two miles go through Grasslands units.

The 16 miles of the Canadian River on the Kiowa National Grassland is not listed as water quality impaired according to New Mexico state standards (New Mexico Water Quality Control Commission 2004). However, a recent Stream Health Assessment noted that the reaches on the Grassland were degraded primarily due to the effects of tamarisk invasion, including lack of down woody debris in the riparian area and stream channel (Haan and Thornton 2004). Additionally the report noted that watershed conditions upstream of the Grasslands were degraded and likely affecting the reaches of the Canadian River on the Grasslands primarily through increased sedimentation. Additionally several of the numerous user-created roads and trails created by visitors to Mills Canyon are along and across the river, contributing to stream sedimentation, chemical pollution, and other unacceptable riparian and water quality impacts.

Stream and riparian condition analyses conducted during the environmental analysis process for continuation of current cattle grazing strategies, oil-gas operations and other authorized activities on Grasslands units have not indicated a significant impact or a risk to water quality or riparian conditions. In fact, most projects were specifically designed to improve water, riparian and soil conditions. There are 20- to 50-year-old oil and gas wells in riparian areas on the Lake Marvin and McClellan units; however, they are in compliance with environmental protection laws. For current and future oil-gas operations, the Forest Service requires oil-gas wells to be located outside the riparian corridor.

The water quality in the reservoirs on Black Kettle National Grasslands is not tested by the Forest Service, but none are on the impaired water lists for New Mexico, Oklahoma, or Texas. Drinking water at developed recreation sites is tested routinely and meets water quality standards. Dams now located on most stream channel throughout the Grasslands limit the potential for flooding and significantly reduce the peak flow of high intensity rainfall events. This alters the hydrology enough to change patterns of regeneration of species such as cottonwood and willow and allows tamarisk and other invasive species to continue to invade new areas and flourish in other areas. Likewise limiting the peak flow of floods reduces the sediment carrying capacity of streams and the floodplain deposition that historically occurred.

Reference Condition: Prior to the Dust Bowl era, water quality was very good except immediately after large fires, drought or bison grazing or during extreme flood events. Though there were no standards historically all streams would have met current water quality standards baring the rare events described above.

There were lower peak flow events, even on un-dammed reaches, compared to current conditions due to better watershed conditions. These conditions encouraged infiltration and groundwater recharge rather than fast runoff and overland flow. Higher ground water levels resulted in streams running longer into the growing season.

Playas were formed and maintained through a combination of dissolution of subsurface basin material and the deflating action of strong prairie winds sweeping across the landscape (Haukos and Smith 2003, The Handbook of Texas Online 2006). Most of the playa lakes on Grasslands units have remained unmodified and appear to have the size, structure, composition and function that they were perceived to have had historically. Reference conditions utilized in analyzing playa lakes were pulled from Terrestrial Ecological Unit Inventory (TEUI) data and based on the potential vegetation for those units.

Projected Future Conditions and Trends and Comparison to Current and Reference Conditions: Climate patterns in this region have a pronounced affect on watershed conditions and trends. Extreme temperatures and heat stress events in the southern Great Plains are expected to increase (Joyce et al. 2001). Along with this change, water demand for irrigation of grass and grain crops is expected to increase at least 50 percent over current use.

Long-term impairments to watershed conditions are expected to occur as a result of the conversion of native grasslands to farming and ranching operations on private lands, including large irrigation and chemical applications. There are also risks associated with industrial livestock grazing and oil and gas development.

There are no agricultural or industrial operations on the Grasslands units, which are managed to support native grasslands habitat and other ecosystems. Recent authorized activities occurring on the Grasslands units do not appear to be impairing watershed conditions. In evaluating NEPA documents, monitoring reports, and resource condition assessments for the Grasslands, activities such as livestock grazing, oil and gas development, recreation site development,

thinning, and prescribed burning have been conducted in a manner that avoids or mitigates significant adverse impacts. The one unauthorized activity that currently poses a risk to watershed conditions is unmanaged motorized vehicle use and the resulting "user-created" roads and trails. Motor vehicle use on the Black Kettle and McClellan Creek National Grasslands was limited to designated routes since 1990, but motor vehicle use has not yet been regulated on the Kiowa and Rita Blanca National Grasslands.

Over the past several decades watershed conditions have been dramatically improved, especially compared to the extremely degraded condition they were in during the 1940s and 50s following the Dust Bowl era. Conservation practices across the southern Great Plains, and notably in the McClellan Creek drainage, has resulted in a substantial increase in infiltration and groundwater recharge and a subsequent reduction in surface runoff and associated sedimentation. The reduced water level in the McClellan Creek reservoir has been attributed to a high amount of sediment build-up in the reservoir, continued drawdown of groundwater and the previously mentioned conservation efforts which limit that amount of water reaching the reservoir.

Management trends are improving the Canadian River's water quality and riparian conditions. Over the past ten years the Forest Service initiated improvement actions along the River including closing off-road vehicle trails and moving camping units away from the floodplain, removing cattle grazing on the largest riparian unit and limiting grazing in other parts of the riparian area, allowing fallen trees to create pools in the stream, and proposing salt-cedar control treatments as part of the interagency Canadian River salt-cedar control program. There are currently 40-50 miles of road in riparian areas on the Grasslands, including unauthorized user-created roads. Thus, the main risk to water quality on Grasslands units is expected to be from those roads located along streams and in riparian areas. Additionally dams located on most drainages will limit flooding and the associated hydrologic processes.

2.5.2 Groundwater Quality/Quantity

Current Condition: Groundwater, which is stored in water-bearing underground formations called aquifers, is an important factor in contributing to social, economic, and ecological conditions. On Grasslands units, it is mostly used to provide water for livestock and wildlife, and on private lands it is additionally used for drinking water and irrigation. Except for the Mills Canyon portion of Kiowa National Grassland, which is over the Canadian River aquifer, and a small portion of Black Kettle units over the Washita Alluvium aquifer the Grasslands lie over what is considered the Central High Plains aquifer which contains parts of New Mexico, Oklahoma, Texas, Colorado and Kansas (Becker et al. 2002).

In 1999 ground water quality was tested at 74 wells throughout the central High Plains aquifer. Over half of the samples showed signs of human-caused nitrate contamination and three of the wells had nitrate levels above the national standard of 10 milligrams per liter (Becker et al. 2002). A few samples also had concentrations of lead, manganese and uranium above the standards. These standards are known as the Maximum Contaminant Levels or Secondary Maximum Contaminant Levels. Nine samples contained detectable levels of volatile organic compounds and 18 samples contained one or more pesticide. None of the samples containing pesticides exceeded the standard and the samples containing pesticides were primarily taken from the Kansas portion of the aquifer (Becker et al. 2002).

Reference Condition: Prior to the Dust Bowl era, water quality was very good except immediately after large fires, drought or bison grazing or during extreme flood events. Though there were no standards historically all streams would have met current water quality standards

baring the rare events described above. There were lower peak flow events, even on un-dammed reaches, compared to current conditions due to better watershed conditions. These conditions encouraged infiltration and groundwater recharge rather than fast runoff and overland flow. Higher ground water levels resulted in streams running longer into the growing season.

Projected Future Conditions and Trends and Comparison to Current and Reference Conditions: Groundwater depletion and drawdown have been ongoing concerns in the prairie grasslands eco-region. Within the Grasslands administrative boundary, approximately 1,500 water wells, about 80%, are on state and private land and 380 water wells, 20%, are on Forest Service-managed land.

There is minimal data available on the conditions of the smaller aquifers, but data on the High Plains aquifer indicates that it has experienced extreme draw down over the last 50 years (McGuire 2004). Pumping water for irrigation, municipal water supplies and other uses far exceeds the recharge ability of the aquifer (McGuire 2004). This drawdown may cause some wells and springs used to manage livestock grazing and distribution to go dry. Also, the cost associated with drilling deeper wells is becoming a constraint to meeting the demand for water sources.

The continued reduction in available water is expected to impact wildlife populations and the ability of permittees to properly manage their livestock. While this situation impacts management on the Grasslands, management activities on the Grasslands contribute a minor amount to this problem because ground water use is limited primarily to livestock watering and drinking water at recreation sites. The predicted increase in water demand for irrigation (Joyce et al. 2001) and population growth will likely put additional strain on the ground water levels in the High Plains and other aquifers under the Grasslands.

2.6 Airsheds

2.6.1 Air Quality

Current Condition: Nationally, air quality standards are directed by the Clean Air Act (CAA) (42 U.S.C. s/s 7401 et seq.). The CAA identifies the roles of Federal and State government in maintaining healthy air quality. Air quality issues addressed by the CAA include:

- Movement of air pollution
- Permits
- Enforcement
- Deadlines and
- Public participation

The Clean Air Act also defines standards to protect human and environmental health; those areas that meet these standards are defined as “attainment areas”; those that do not are referred to as “non-attainment areas”. The CAA directs the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment.

The CAA delegates responsibility for implementation and enforcement of Clean Air Act regulations to the states. Many states augment the regulations of the CAA with additional regulations. Within the 3 states containing the Kiowa, Rita Blanca, Black Kettle and McClellan Creek National Grasslands there are lower air quality thresholds for sulfur compounds, carbon

monoxide, and nitrogen oxide in New Mexico (Table 33). Texas and Oklahoma ambient air quality standards are similar to the NAAQS. None of the states has air quality monitoring in the area of the National Grasslands because there are few activities in the area to emit primary pollutants and there are relatively few people living in these area to be affected by adverse air quality conditions. Nonetheless the air quality data that has been collected in these areas, usually by national monitoring networks or at regional airports, indicates that there is not a concern for air quality conditions in these areas except from dust storms and wildland fires.

Of the three states that contain the Grasslands, only New Mexico has identified Airsheds. Texas and Oklahoma reference their air quality based on the county or descriptions of non-attainment or maintenance areas.

The Kiowa National Grassland is located within the Canadian River Airshed. Based on the EPA's April 2005 non-attainment designations for the six criteria pollutants, the Canadian River Airshed is in attainment for all six pollutants. There are no facilities listed by the EPA AirData 1990 and 1999 Facility Emissions Reports for Criteria Pollutants in the 3 counties in New Mexico that contain the Kiowa National Grassland (US EPA 1990, US EPA1999).

The Black Kettle, McClellan Creek and Rita Blanca National Grasslands are split between Texas and Oklahoma. Based on the Environmental Protection Agency's April 2005 non-attainment designations for the six criteria pollutants, the associated counties covering the Black Kettle and Rita Blanca National Grasslands are in attainment for all six pollutants[9]. As of 1999 there are a total of 62 facilities listed on the EPA AirData Facility Emissions Report for the counties in Oklahoma and Texas on which the Rita Blanca, Black Kettle and McClellan Creek National Grasslands are located (US EPA 1999). The number in Cimarron County, OK increased from 2 in 1990 to 4 in 1999 (US EPA 1990, US EPA 1999). There are no facilities listed in Dallam County Texas. The number of facilities remained steady from 1990 to 1999 in Gray County Texas with 17 and 16 respectively. Hemphill County Texas had an increase in facilities listed from 1990 to 1999 from 11 to 16. Roger Mills County Oklahoma saw the biggest increase in facilities on the list with only 4 in 1990 and 26 in 1999. The large number of facilities on this list helps to explain some of the higher levels of criteria pollutants in these counties relative to others with fewer or no polluting facilities.

There have been several amendments to the Clean Air Act (in 1990 and 1997) and states of New Mexico, Texas and Oklahoma air regulations since the implementation of the Cibola Land and Resource Management Plan (Table 33).

[9] The Environmental Protection Agency sets standards for six common, or criteria, air pollutants: ozone, nitrogen dioxide, particulate matter, sulfur dioxide, lead and carbon monoxide. These pollutants are considered indicators of air quality.

Table 33 Summary of key changes made to the Clean Air Act, state air quality regulations (NM, OK & TX) since the implementation of the Cibola LRMP

States				
CAA Amendments	**New Mexico**	**Oklahoma**	**Texas**	**FS Handbook**
1997 amendment to the PM2.5 and ground level Ozone standards. The implementation of the Regional Haze Rule.	Title 20, Ch. 2, Part 3, 1995. Changes to the states Ambient Air Quality Standards. The Grassland must make sure projects do not exceed these limits.	Just starting their Smoke Management Plan required by EPA.	Texas Emissions Reduction Plan (SB 5) in 2001.	2580 R3 Supplement.
2001 the modification for the states to develop Smoke Management Plans that would allow for exclusion of an exceedance if a state had a plan.	Title 20, Ch.2,Part 65, 2003. Smoke Management Plan. The Grassland must follow to apply for a permit to burn.		Smoke Management Plan is the Burning Protocol.	

The significant changes that affect the Grasslands are the PM2.5 and Ozone regulation, the Regional Haze ruling, the development of Oklahoma's Smoke Management Plan and Texas Emissions Reduction Plan. The changes in these regulations require that the Grasslands provide documentation that they are not exceeding any of the new limits. At this time, there are no specific actions the Grasslands need to take other than working with the state of Oklahoma on the development of the Smoke Management Plan.

Reference Condition: The reference condition used for this analysis is the air quality standards that are currently in place for each state. National Ambient Air Quality Standards (US EPA 2006)

Carbon monoxide (CO) is a colorless, tasteless, odorless gas produced primarily by motor vehicles. Other sources include wood-burning stoves, fireplaces, wildland fires and industries that process metals or manufacture chemicals. High CO concentrations can occur in large urban areas and mountain valleys. CO is poisonous at high levels and can damage the heart and central nervous system.

Lead in the air exists primarily as particulates. The major source used to be gasoline, but is currently metals processing. Other sources are waste incinerators, utilities, and lead-acid battery manufacturers. Lead particularly affects young children and infants, and is found at high levels in urban and industrial areas. Lead deposits on soil and water, and can harm other animals.

Nitrogen Dioxide (NO_2) has a reddish-orange-brown color and a pungent odor. Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary sources are motor vehicles, electric utilities, and other industrial, commercial, and residential operations that burn fuels. Some nitrogen dioxide is emitted by wildland fires. NO_2 is easily converted to nitrates, a major component of acid rain, contributing to impacts on vegetation, visibility and soil and water quality. Nitrogen dioxide also impairs human health.

Ozone is an unstable gas composed of three oxygen atoms, and it has a characteristic odor. Ozone forms when hydrocarbons and nitrogen oxides chemically react in sunlight. Motor vehicle exhaust and industrial emissions, gasoline vapors, chemical solvents and natural sources emit NOX and the volatile organic compounds that help to form ozone. Ozone can trigger a variety of health problems including permanent lung damage after long-term exposure. It can also damage plants and ecosystems.

Particulate Matter (PM) consists of particles of solid or semi-solid materials in the atmosphere. Most human-made particles are 0.1 to 10 micrometers in diameter. Particulates 10 micrometers can cause respiratory problems, while larger particulates tend to settle out of the air. Particulates 2.5 micrometers are generally created during combustion and are the major cause of visibility impairment. These fine particles move over long distances by wind and then settle on ground or water. High PM concentrations are often associated with large urban areas or mountain valleys where dust, smoke, and emissions are common. Health effects of PM include: respiratory problems, decreased lung function, asthma, chronic bronchitis, irregular heartbeat, nonfatal heart attacks, and premature death in people with heart or lung disease.

Sulfur dioxide (SO_2) is a colorless gas that easily dissolves in water to form acid. It is a major pollutant throughout the world and potentially carcinogenic. The main source is burning fossil fuels, but diesel fuel and gasoline also contribute to sulfur dioxide in the air.

Table 34 National and New Mexico Ambient Air Quality Standards (New Mexico AAQS not listed are not stated, the same or slightly higher than NAAQS)

Pollutant	Averaging Times	National Primary Standards	National Secondary Standards	New Mexico Standards
Carbon Monoxide	8-hour [1]	9 ppm (10 mg/m3)	None	8.7 ppm
	1-hour [1]	35 ppm (40 mg/m3)	None	13.1 ppm
Lead	Quarterly Avg.	1.5 µg/m3	Same as Primary	
Nitrogen Dioxide	Annual (Arith. Mean)	0.053 ppm (100 µg/m3)	Same as Primary	0.053
	24-hour	----------	----------	0.10 ppm
Particulate Matter (PM10)	Annual [2] (Arith. Mean)	revoked	----------	
	24-hour [3]	150 µg/m3		
Particulate Matter (PM2.5)	Annual [4] (Arith. Mean)	15.0 µg/m3	Same as Primary	
	24-hour [5]	65 µg/m3		
Ozone	8-hour [6]	0.08 ppm	Same as Primary	
Sulfur Oxides	Annual (Arith. Mean)	0.03 ppm	----------	0.02 ppm
	24-hour [1]	0.14 ppm	----------	0.10 ppm
	3-hour [1]	----------	0.5 ppm (1300 µg/m3)	

1) Not to be exceeded more than once per year.
2) Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM10 standard in 2006 (effective December 17, 2006).
3) Not to be exceeded more than once per year on average over 3 years.
4) To attain this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.
5) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).
6) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

Reference condition: Reference conditions on the Grasslands were in attainment of the standards with the exception of short-term events such as rare dust storms or smoke from a large-scale grassland fire. Reference conditions are considered to be prior to pre-European

settlement of the area. The Dust Bowl era caused degradation to air quality and conditions have greatly improved.

Projected Future Conditions and Trends: Management activities on the Grasslands do not cause long term changes in air quality and meet state and federal air quality standards. This attainment of air quality standards is expected to continue into the future.

The regional emissions data were obtained from the 2002 Visibility Improvement State and Tribal Association of the Southeast (VISTAS) base case emissions database by county. Based on emission data from 1999 to 2002 for four of the six criteria pollutants, the overall trend is a decrease in pollutants in the three counties covering the Kiowa National Grassland (VISTAS 2005). The projected trend out to 2018 indicates a continued decrease in the four criteria pollutants except particulate matter PM10 and PM2.5. It is not clear at this time why there are slight increases, but these increase are slight and do not exceed NAAQS or state standards. To date there have been no documented exceedances of the NAAQS due to National Grassland activities. This trend is expected to continue over the next five to ten years.

Based on emission data from various local, state and federal sources for 1999 to 2002 for the four criteria pollutants, the overall trend is a decrease in the counties covering the Black Kettle and Rita Blanca National Grasslands. The projected trend out to 2018 using the Forest Services Emissions Tool[10] shows a continued decrease in the four criteria pollutants except NOX in Roger Mills County, Oklahoma and CO and SO_2 in Gray County, Texas. These increases along with increases in NH_3 and volatile organic carbons may be due to a projected increase in oil and gas development or higher levels of urbanization in these counties. To date there have been no documented violations of the NAAQS in the counties the Black Kettle, McClellan Creek or Rita Blanca National Grasslands cover due to Grassland activities. This trend is expected to continue over the next five to ten years.

Prescribed fire is the most notable land management activity that takes place on the Grasslands that has implications on air quality; however, this does not contribute adversely to air quality. All projects, including prescribed burns, must meet State air quality standards and smoke management plans once finalized (USDA Forest Service 1999a, USDA Forest Service 2000).

Air quality is carefully considered where prescribed burning activities could affect neighboring land uses (USDA Forest Service 1999a, USDA Forest Service 2000). Likewise, grassland and ecosystem productivity is not negatively affected by regional air quality. This is still true given an increase in prescribed burning in the last decade on the Grasslands (Figure 7).

[10] The Forest Service Emissions Tool was developed to view emission inventory results. http://webcam.srs.fs.fed.us/why_monitor.htm

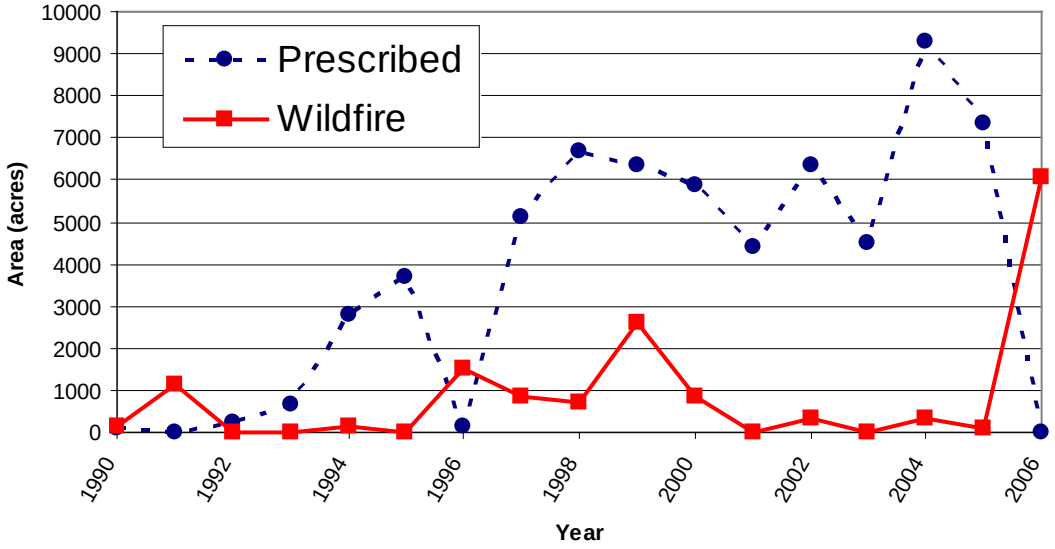

Figure 7 Area Burned in Prescribed and Wildfires* on the Kiowa, Rita Blanca, Black Kettle and McClellan Creek National Grasslands from 1990 through 2006.

*Wildfire acreages are the sum of recorded wildfires. Typically only wildfires greater than 10 acres are recorded.

Comparison of Current, Reference, and Projected Future Conditions: Currently, the Grasslands are meeting the air quality standards as outlined for each state. Since the reference and current conditions are the same, the Grasslands are within the reference conditions for air quality. Continuation of current management trends will keep the Grasslands within the reference conditions, since the only management trend affecting air quality is prescribed burning, and the Forest Service is required to meet State air quality standards during implementation of these burns. The increases in facilities listed on the EPA Air Data Facility Emissions Reports especially in Roger Mills County, Oklahoma may indicate that in the future off-site emissions may have increase effects on the Grasslands' ecosystems (US EPA 1999). However, given the current superior air quality in the area these increases in emissions may not have substantial effects on the ecosystems.

2.7 Summary of Major Findings

The Grasslands are contributing to ecological sustainability within each resource analyzed in this report. Four out of the seven PNVTs found on the Grasslands have greater representation on the Grasslands in comparison to the surrounding landscape. These are the shinnery oak, mixed hardwood riparian, cottonwood-willow and sand sagebrush PNVTs.

All of the vegetation types are within their HRV condition, and continuation of management trends is expected to maintain that condition. The following table depicts the current condition of the vegetation.

Table 35 Grasslands Vegetation Historical Range of Variability										
Vegetation Type	0-33% = No Departure from HRV or within HRV								34-67% = Moderately Departed	67-100% = Severely Departed
	0	5	10	15	20	25	30	33		
Mixed Grass Prairie		★								
Shinnery Oak						★				
Shortgrass Prairie					★					
Pinyon Juniper	★									
Cottonwood Willow Riparian	★									
Mixed Hardwood Riparian			★							
Sand Sagebrush			★							

Some of the vegetation types, while close to reference conditions within the HRV overall, may not be able to make a full recovery to the lower percentages of departure from reference conditions. These include the shinnery oak areas that were once deeply plowed, as well as formerly cultivated old field sites in shortgrass prairie. The deep plowing practices on shinnery oak eliminated the species from some areas during the Dust Bowl era, and recovery does not readily occur. Soil movement that occurred during the Dust Bowl era also created conditions that facilitated mixed hardwood riparian establishment, a vegetation type not historically found on the Grasslands. Consequently determining a departure from reference condition for mixed hardwood riparian on Black Kettle and McClellan Creek is a comparison of riparian woody vegetation structure and composition HRV from other areas. Some areas within the cottonwood-willow riparian may not have the capacity to fully recover to the lower percentages of departure from reference condition due to the disruption of natural hydrologic processes on and off of the Grasslands. While the structure and composition state of HRV may not be fully achievable on some areas within the shinnery oak, shortgrass prairie, and the mixed hardwood riparian and cottonwood willow riparian vegetation types, the continuation of select management practices should maintain these areas within HRV.

Over the past several decades watershed conditions have been dramatically improved, especially compared to the extremely degraded condition they were in during the 1940s and 50s following the Dust Bowl era. Conservation practices across the southern Great Plains, and notably in the McClellan Creek drainage, has resulted in a substantial increase in infiltration and groundwater recharge and a subsequent reduction in surface runoff and associated sedimentation.

All areas of the Grasslands have recovered to acceptable levels of soil stability and vegetative cover. The number of active oil-gas wells and other developments that would reduce site productivity is not expected to significantly increase on Grasslands units over the next 10-20 years. Soil productivity is likely to greatly improve after the 2005 Travel Management Rule is fully implemented and motorized travel is limited to designated travel routes. Predicted increases in air temperatures in the southern Great Plains may reduce soil organic matter affecting productivity, water-holding capacity and carbon storage in the soil (Joyce et al. 2001).

The Grasslands are meeting the air quality standards as outlined for each state. Since the reference and current conditions are the same, the Grasslands are within the reference conditions for air quality. Continuation of current management trends will keep the Grasslands within the reference conditions, since the only management trend affecting air quality is prescribed burning, and the Forest Service is required to meet State air quality standards during implementation of these burns.

3 Species Diversity

An analysis of ecological sustainability must include consideration of both ecosystem and species diversity. To better capture the ecological sustainability of the Grasslands, a hierarchical approach was used to analyze species diversity on the Grasslands. A list of plant, macro-lichen, bird, insect, and animal species was developed from species recognized by Federal or State agencies as Threatened or Endangered, or that are known to have some population or habitat issue and occur in the Plan area. Ecosystem habitat and habitat associations were identified for these species. This information was integrated with species diversity status and population and habitat trend information to conduct an analysis of risks to these species and their habitat.

3.1 Species Lists

A comprehensive list of species (including plant, macro-lichen, bird, insect, and animal species) that have population or habitat concerns and that are found in Texas, New Mexico, and Oklahoma was developed. This list includes 1,652 species at the time of this writing (Appendix B), and was developed using:

- Lists maintained under the Ecological Services Agency of the U.S. Fish and Wildlife Service (US FWS 2007a, US FWS 2007b, US FWS 2007c),
- Species ranks maintained by NatureServe (US FWS 2007b),
- New Mexico, Texas, and Oklahoma State T& E lists (NMDGF 2006a, ODWC 2007, TPWD 2007a),
- New Mexico, Texas, and Oklahoma priority Comprehensive Wildlife Conservation Strategy, (CWCS), species,
- Species for which there are local concerns resulting from declines in habitat, population, and/or distribution (ODWC 2005, NMDGF 2006b, TPWD 2007b),
- Species that are of high public interest, and
- Species that have emerging issues (such as invasive species).

Using this comprehensive list as a starting point, an analysis was conducted to develop a second list of those species that warrant consideration in the Grasslands Plan revision (Table 35). This list includes 39 species that meet all of the following criteria:

- The species currently has populations and/or habitat within the Plan area,

- The species is known to have population or habitat concerns (e.g., small or decreasing population, limited habitat, etc.), and
- The species may be affected by Forest Service management actions.

3.1.1 Species and Habitat Associations

The species included in (Table 35. Species for Consideration in Plan Revision and Habitat Association) were organized according to their associated Vegetation Types and the Grasslands on with they occur Some species, however, are not associated with a vegetation type, but rather, are dependent on unique habitat features (such as Playa Lakes, aquatic or riverine wetlands, etc. The species habitat associations were used to assess the status of species and severity of risk to ecosystem characteristics.

Table 36 Species for Further Consideration in Plan Revision and Habitat Association

#	Common Name	Ranger District	Habitat or Vegetation Type
1	Lesser prairie-chicken	Black Kettle	Mixed Grass Prairie and Shinnery Oak
1	Lesser prairie-chicken	Kiowa-Rita Blanca	Sand sagebrush
2	Plains Leopard Frog	Kiowa-Rita Blanca	Ponds and Playas, Cottonwood-Willow Riparian
2	Plains Leopard Frog	Black Kettle	Aquatic Lakes
3	Black-tailed prairie dog	Kiowa-Rita Blanca	Shortgrass Prairie
4	Mountain plover	Kiowa-Rita Blanca	Shortgrass Prairie
5	Swift fox	Kiowa-Rita Blanca	Shortgrass Prairie
6	Bald eagle	Kiowa-Rita Blanca	Shortgrass Prairie, Cottonwood-Willow Riparian,
6	Bald eagle	Black Kettle	Aquatic Lakes
7	Dotted Checkerspot	Kiowa-Rita Blanca	Sand sagebrush, Shortgrass Prairie
8	Conchas Crayfish	Kiowa-Rita Blanca	Rivers
9	Arkansas River Shiner	Black Kettle	Rivers
10	Suckermouth minnow	Kiowa-Rita Blanca	Rivers
11	Largemouth bass	Black Kettle	Rivers, Aquatic Lakes
12	Interior least tern	Black Kettle	Rivers
13	American avocet	Kiowa-Rita Blanca	Ponds and Playas
14	Arid Land Ribbon Snake	Kiowa-Rita Blanca	Cottonwood-Willow Riparian
15	Great Plains narrow-mouth toad	Kiowa-Rita Blanca	Cottonwood-Willow Riparian
16	Hobomok Skipper	Kiowa-Rita Blanca	Cottonwood-Willow Riparian
17	Red-headed woodpecker	Kiowa-Rita Blanca	Cottonwood-Willow Riparian
17	Red-headed woodpecker	Black Kettle	Mixed Hardwood Riparian
18	Spellenberg's Groundsel	Kiowa-Rita Blanca	Shortgrass Prairie, Piñon-Juniper
19	Alpine Fever-few	Kiowa-Rita Blanca	Shortgrass Prairie
20	Greene milkweed	Kiowa-Rita Blanca	Shortgrass Prairie
21	One-flowered Milkvetch	Kiowa-Rita Blanca	Shortgrass Prairie, Piñon-Juniper
22	Burrowing Owl	Kiowa-Rita Blanca	Shortgrass Prairie
23	Rhena Crossline Skipper	Kiowa-Rita Blanca	Shortgrass Prairie
24	Ferruginous hawk	Kiowa-Rita Blanca	Shortgrass Prairie

#	Common Name	Ranger District	Habitat or Vegetation Type
25	Andean prairie-clover	Kiowa-Rita Blanca	Shortgrass Prairie
26	Grasshopper sparrow	Kiowa-Rita Blanca	Shortgrass Prairie, Sand sagebrush
27	Scaled quail	Kiowa-Rita Blanca	Shortgrass Prairie, Sand sagebrush
28	Long-billed curlew	Kiowa-Rita Blanca	Shortgrass Prairie, Ponds and Playas
28	Long-billed curlew	Black Kettle	Mixed Grass Prairie
29	Panhandle Spurge	Kiowa-Rita Blanca	Sand sagebrush
30	Panhandle Spurge	Kiowa-Rita Blanca	Piñon-Juniper
31	Zone-tailed hawk	Kiowa-Rita Blanca	Piñon-Juniper
32	Greene milkweed	Kiowa-Rita Blanca	Piñon-Juniper
33	Northern bobwhite	Black Kettle	Shinnery Oak, Mixed Grass Prairie
34	Rio Grande turkey	Black Kettle	Shinnery Oak, Mixed Hardwood Riparian, Mixed Grass Prairie
35	Grasshopper sparrow	Black Kettle	Shinnery Oak, Mixed Grass Prairie
36	Bell's vireo	Black Kettle	Mixed Hardwood Riparian
37	Rocky Mountain Dagger	Kiowa-Rita Blanca	Caves-Cliffs-Rock Outcrops
38	Horrid Herrickia	Kiowa-Rita Blanca	Caves-Cliffs-Rock Outcrops
39	Ambersnail	Kiowa-Rita Blanca	Other Wetlands

3.1.2 Summary of major findings

Initially, 1,654 species with population or habitat concerns in Texas, Oklahoma, and New Mexico were considered for Grasslands Plan revision. This list was then narrowed down to just those species that occur on the Cibola National Grasslands and then screened further to a list of 39 species that includes only those that have known populations or habitat within the Plan area, have known population or habitat concerns, and may be affected by Forest Service management. These species were sorted according to the PNVT or unique habitat feature with which they are associated. Each of the PNVTs on the Grasslands, along with some unique habitat features (e.g., wetland or riverine), have adequate representation from species on the List of Species for Consideration in Plan Revision to warrant management consideration.

4 Integration of Ecosystem and Species Diversity Status and Risk Assessment

Based on known threats to ecosystem diversity on the Grasslands, assessments of risk to ecosystem diversity and those species identified for Consideration in Plan Revision (Table 35) were conducted.

The risk assessment process was initiated by first determining the threats to composition, structure and processes that create or sustain the various vegetation types found on the Grasslands. To determine whether or not these threats were resulting in risk to ecosystem diversity, each PNVT was considered in terms of the PNVTs projected trend toward (or away from) its reference condition and the potential of any existing or potential threats to influence that projected trend.

The risk assessment also included an analysis of each species' population dynamics and relationship to habitat and threats to that habitat. This analysis resulted in the development of "Overall Risk Summary" statements for each species on the list of Species for Consideration in Plan Revision. Those species considered to be at risk regarding the likelihood that the species will experience negative population

and distribution consequences were assessed further and a "Conclusion" statement reflected the "Status" of the at risk species.

4.1 Threats to Ecosystem Diversity

Those activities that have the potential to change the composition, structure and processes that create or sustain an ecosystem, including terrestrial and aquatic, away from its reference condition are considered threats to ecosystem diversity. A comprehensive list of potential threats to ecosystem diversity was developed, including 28 potential anthropogenic (human caused) and five potential natural threats to ecosystem diversity (Table 36). Each potential threat was analyzed to 1) determine whether or not the threat could affect ecosystem structure, composition, and processes and 2) whether or not the threat is under the Forest Service's control and ability to influence or remove the threat with management actions.

Table 37 Potential Threats to the Ecosystem Diversity of the Grasslands

Potential Threats:	Affects:		Administration:	
Anthropogenic	**Structure/ Composition**	**Process**	**Agency Control**	**Mgt. Response**
Mining (caliche)	Yes	Yes	Yes	Yes
Oil/Gas development	Yes	Yes	Yes	Yes
Water withdrawal	No	No	No	No
Wind farms	Yes	Yes	Yes	Yes
Fuelwood collection	Yes	No	Yes	Yes
Livestock grazing	Yes	Yes	Yes	Yes
Hunting-gathering	No	No	Yes	Yes
Solid waste	No	No	No	No
Sewage/septic waste	No	No	No	No
Agriculture (conversion to cropland)	Yes	Yes	No	No
Dam/Impoundments/flood control (small earthen dams)	Yes	Yes	Yes	Yes
Fire Management	Yes	Yes	Yes	Yes
Groundwater depletion	Yes	Yes	No	No
Urban development	Yes	Yes	No	No
Herbicide use	Yes	No	Yes	Yes
Vegetation treatments	Yes	Yes	Yes	Yes
Toxic waste contamination	Yes	Yes	No	No
Transportation infrastructure	Yes	Yes	Yes	Yes
Exotic and/or invasive species	Yes	Yes	Yes	Yes
Fire Suppression	Yes	Yes	Yes	Yes
Flooding (dams/impoundments)	Yes	Yes	No	No
Off-highway vehicle use	Yes	Yes	Yes	Yes
Recreation	No	No	Yes	Yes
Scientific research	No	No	Yes	Yes
Agricultural chemicals	Yes	Yes	No	No
Groundwater contamination	No	No	No	No
Powerplants and Industry	No	No	No	No

Natural				
Wildfire	Yes	Yes	No	Yes
Drought	Yes	Yes	No	No
Herbivory	Yes	Yes	Yes	Yes
Flooding	Yes	Yes	No	No
Insects/Disease	Yes	Yes	No	No

These potential threats were further assessed to determine how they affect the sustainability or function of various ecosystem characteristics, including PNVT, water, soil and air (Appendix C).

Only those threats that are under the authority of the Forest Service and those that the Forest Service has the ability to control or influence with management were considered in the risk assessment. Threats that were outside of the Forest Service's ability to control or influence with management were not considered.

4.2 Risk Assessment to Ecosystem Diversity

4.2.1 Terrestrial

The ecosystem diversity risk assessment was conducted by first considering the ecosystem characteristics at risk and then determining a departure from reference condition for each PNVT. Sections within this Ecological Sustainability Report were referenced and departure from reference condition for the PNVT, fire frequency, soil impairment, and soil loss, along with species association and niche contribution to sustainability was determined. The following list identifies the location of the information used for (Table 37).

- PNVT is the Potential Natural Vegetation Type
- Mid-scale vegetation departure references the Ecological Sustainability Report, Appendix F. PNVT Departure from Historical Conditions.
- LANDFIRE Rapid Assessment Fire Regime Departure data is an assessment of current conditions for common PNVTs on the surrounding landscape referencing Ecological Sustainability Report, Table 6. Departure from Natural Fire Regimes by Subsection and Vegetation Type.
- Soil condition percent impaired information is from the Ecological Sustainability Report, Table 31, Grassland-wide Soil Condition by PNVT.
- Soil Loss percent unsuited information is derived from t the Ecological Sustainability Report, Table 32, Soil loss by PNVT
- Species information reference is the Species Diversity Section 3 of the Ecological Sustainability Report, Table 35.
- Spatial Niche contribution to sustainability information was determined from the Contribution to Sustainability-Spatial Niche conclusion for each ecosystem characteristic.

Table 38 Severity of Departures from Reference Condition Considering Multiple Resources

	Vegetation		Soils		Species	Niche
PNVT	**Mid-scale vegetation Departure**	**LANDFIRE % Departure[1]**	**Soil Condition (% impaired)**	**Soil Loss (% unsuited)**	**Number of T&E, SOC, and SOI associated**	**Contribution to sustainability**
Mixed Grass Prairie	Within reference condition	21% - 40%	7% impaired	34% unsuited	4	High
Short Grass Prairie	Within reference condition	61% - 80%	46% impaired	10% unsuited	18	High
Shinnery oak	Within reference condition	61% - 80%	100% impaired	0% unsuited	3	High
Piñon-juniper	Within reference condition	61% - 80%	24% impaired	12% unsuited	4	Moderate
Cottonwood willow	Within reference condition	81% - 100%	0% impaired	0% unsuited	6	High
Mixed hardwood riparian	Within reference condition	41% - 60%	0% impaired	0% unsuited	3	Moderate
Sand sagebrush	Within reference condition	61% - 80%	74% impaired	0% unsuited	8	High

[1] The % departure from LANDFIRE was for the PNVTs as a whole throughout all the subsections (millions of acres), not just on the National Grasslands .The grey shaded blocks are departures from reference above 50%

No characteristics were determined trend away from reference or show significant departure from multiple resources overall. No ecosystem characteristic was determined to have a negative outcome or be at risk and no risk assessment was performed[11]. The shinnery oak PNVT, which is all on one terrestrial ecological unit, is impaired due to a combination of historical plowing on inclusions within of the map unit which resulted in changes in the topsoil; sandy, nutrient-poor soils; and non-native eastern red cedar encroachment. The effects of past plowing is stable while the encroachment is currently being managed resulting in a trend toward reference for shinnery oak as far as soil condition is concerned. In the sand sagebrush PNVT, the terrestrial ecological units appeared to be impaired because of a high proportion of bare soil. This condition is typical of this PNVT and is stable. Levels

[11] In some instances, an ecosystem characteristic (for example, ground water quantity) was identified as being outside of, and trending away from, its reference condition. However, the causes for this condition and trend were found to be outside of the Forest Service's control (for example, due to aquifer drawdown).

of unsuited soil loss rating for all PNVTs are primarily the result of activities during and effects of the Dust Bowl era and are stable with very slow trends toward reference.

4.2.2 **Aquatic**

The aquatic ecosystem diversity risk assessment was conducted by first considering the aquatic biota, water quality, riparian condition, and wetland condition. Sections 2.4.1 Surface Water and Associated Riparian and 2.4.2 Groundwater Quantity/Quality within this Ecological Sustainability Report were referenced and departure from reference condition was then determined for the three watersheds that have at least a 15% overlap with the Grasslands units.

Over the past several decades watershed conditions have been dramatically improved, especially compared to the extremely degraded condition they were in during the 1940s and 50s following the Dust Bowl era. Conservation practices across the southern Great Plains have resulted in a substantial increase in infiltration and groundwater recharge and a subsequent reduction in surface runoff and associated sedimentation.

No significant departure from current conditions relationship to reference or future conditions to reference was determined for surface water, associated riparian, and wetland or for groundwater quantity and quality under forest service control.

4.3 Species Risk Assessment

A species risk assessment was conducted by processing each species on the List of Species for Further Consideration in Plan Revision (Table 35) through an assessment of various habitat and population factors and threats[12]. Natural history and population information was gleaned from the references used in the screening process and from Cibola National Grasslands biologists; State of OK, TX, and NM biologists; and the US Fish and Wildlife Service biologists. The results of this process provided a numerical ranking of the risk to each species. Those species found to be at high risk were further assessed for their likelihood of being affected by four population and distribution scenarios (Appendix E Status of Species).

The risk assessment process included the following steps:

- Habitat factors within the plan area boundaries (per FSH 1909.12 Land Management Planning Handbook, Chap. 40, Sec. 43.26) were assessed for each species, according to PNVT. For those species with habitat on multiple PNVTs, separate risk assessments were run for each habitat type. Each of the habitat factors were assessed in terms of the historical, current, and projected future trends. As a way of synthesizing the overall habitat status for the species on a specific PNVT, the average "score" for the current condition and projected trend was calculated and a status statement for the species habitat developed. The habitat factors considered in the assessment included:
    - Amount: The percentage of the Plan area that is specific to a particular PNVT habitat.
        - *High* quantity of habitat encompasses $\geq$ 50% of the total Plan area.
        - *Moderate* quantity indicates habitat is restricted to between < 50% and $\geq$ 5% of the total Plan area.
        - *Low* quantity indicates that habitat is limited to < 5% of the total Plan area.
    - Quality: The availability of key habitat features in the Plan area boundary.

[12] To assess the habitat, population and threat factors for each species, the Forest Service's Southwestern Regions' Ecological Sustainability guidance was followed and tables were adapted to reflect assessment and ranking processes (Ecological Sustainability Version 5.1, 10/10/2006, Status of Species, Table 6, Table 7).

        - A *high* quality habitat has adequate representation of all PNVT successional stages and includes plentiful of key habitat feature availability (i.e. nesting sites, roost trees, brood habitat, etc.).
        - A *moderate* quality rating indicates that key habitat features are present and but are not all readily available.
        - A *low* quality rating indicates that key habitat features are not always present and not all available.
    - Distribution: The distribution of habitat features across a PNVT within the Plan area boundary.
        - *Even* habitat distribution indicates that habitat is dispersed broadly across the PNVT.
        - *Restricted* habitat distribution describes PNVTs where habitat is localized to specific areas.
        - *Highly* fragmented habitat describes PNVTs where habitat is isolated and separated by distance or barriers.
    - Habitat processes: Those processes (e.g., grazing, fire, flooding, etc.) that create or sustain the habitat within the Plan area boundary.
        - *Functioning* habitat indicates that the processes are extant within the PNVT.
        - *Disrupted* habitat indicates that not all processes are extant within the PNVT.
- Population factors were considered at the scale at which biological populations of the species operate (per FSH 1909.12 Land Management Planning Handbook, Chap. 40, Sec. 43.26). Each of the population factors were assessed in terms of the historical, current, and projected future trends. As a way of synthesizing the overall population status for the species on a specific PNVT, the average "score" for the current condition and projected trend was calculated and a status statement for the population factors developed. The population factors included in the assessment included:
    - Population distribution: Interaction within the population.
        - *High isolation* describes a population that is separated by barriers and or distance.
        - *Moderate isolation* indicates that the population is separated but has interaction on a limited basis.
        - *High interaction* describes a population that interacts regularly across its range.
    - Population size: Size of population, relative to individual species dynamics.
        - A *large* population indicates that the species has great numbers relative to the individual species dynamic.
        - A *moderate* population indicates that the species population number is not large or is limited.
        - A *small* population describes a species whose population number is very limited.
    - Species population stability: Current changes to the species population.
        - *Gaining* describes species whose populations are growing.
        - *Stable* describes species whose population sizes are not changing.
        - *Declining* describes species whose populations are decreasing.

  - Species diversity: Phenotypic, ecological, and genetic diversity.
    - *High diversity* describes species with vigorous population diversity dynamics.
    - *Moderate diversity* describes species with stable diversity dynamics.
    - *Low diversity* describes species with decreasing diversity opportunities.

- "Other threats" including risks to the PNVT and other known threats such as invasive species, disease, etc. to the species were identified and the severity (how bad the negative outcome may be) and the likelihood (the probability of a negative outcome) of the threats were analyzed.
  - Severity: How a species population or habitat would respond to a threat and was evaluated to determine the degree the species would be impacted.
    - *High severity* indicates that the threat will affect the species population in a critical negative manner.
    - *Moderate severity* indicates the threat impacts would be severely negative.
    - *Low severity* indicates that the threat impacts are chronic.
  - Likelihood: The probability of a negative outcome from a threat to the species population or habitat.
    - *High* likelihood indicates that the threat will have an imminent negative outcome.
    - *Moderate* likelihood indicates that odds are even that the threat will produce a negative outcome.
    - *Low* likelihood indicates that the probability of negative outcomes due to the threat is possible but not imminent.
- Descriptions of key biological interactions were developed, where they exist, for each species.
- To determine the overall risk to each species, an overall score was calculated by averaging the habitat, population, risk, severity and likelihood scores. Each species was then determined to be at high (average score of 1 to 1.5), moderate (average score of 1.51 to 2), or low (average score over 2.1) risk.
- Status Summary statements were developed to describe the overall current and projected status for the species on a particular PNVT.
- Risk Summary statements were developed to capture the potential severity and likelihood of the known threats on the species' population and habitat.
- Lastly, for those species determined to be at high risk, the likelihood of the species population dynamics being affected by four key consequence scenarios[13] was determined.

Of the 39 Species assessed for threats to population or distribution, five species were found to be facing a high risk (Table 38) and were further assessed to be facing high and moderate risks to one of the consequence scenarios (Table 39).

[13] The four consequence scenarios considered (per the Forest Service's Southwestern Regions' Ecological Sustainability guidance, Version 5.1, 10/10/2006, Status of Species, Table 7) included: 1) widespread decline of population in the Plan area and new isolation of populations within the Plan area; 2) widespread population decline, but without isolation of populations; 3) localized population decline that may be accompanied by some minor restrictions in population interactions, and 4) populations and their distribution are stable or improving.

Table 39 Species at High Risk to their Population or Distribution

Common Name	Ranger District	Habitat Type	Overall Average	Overall Risk Rating
Lesser prairie-chicken	Black Kettle	Mixed Grass Prairie and Shinnery Oak	1.19	High
Plains Leopard Frog	Kiowa-Rita Blanca	Ponds and Playas	1.35	High
Lesser prairie-chicken	Kiowa-Rita Blanca	Sandsage	1.44	High
Black-tailed prairie dog	Kiowa-Rita Blanca	Shortgrass Prairie	1.47	High
Plains Leopard Frog	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.47	High
Mountain plover	Kiowa-Rita Blanca	Shortgrass Prairie	1.49	High
Swift fox	Kiowa-Rita Blanca	Shortgrass Prairie	1.51	High

Table 40 Species at Risk and Consequences

Species	Threats Specific to the Species	Likelihood of Consequence
Lesser prairie-chicken[1] (Kiowa/Rita Blanca and Black Kettle National Grasslands)	**Sand sagebrush and Shinnery oak and Mixed Grass Prairie Vegetation:** **Invasive species**; Red cedar and black locust encroachment alter habitat requisites. **Contiguous habitat**; Fragmentation that creates areal expanse <8,000 acres that can result from agriculture expansion and oil and gas development, transportation infrastructure and etc. reduce desirable habitat conditions for lesser prairie chicken. **Obstructions;** Wind farms, fences, trees, etc. create avoidance areas for the lesser prairie chicken.	Moderate likelihood of localized population declines that may be accompanied by some minor restrictions in population interactions
Plains leopard frog (Kiowa and Rita Blanca National Grasslands)	**Cottonwood willow/riparian and Ponds and Playas PNVT:** Riparian habitat is limited and is ephemeral on Kiowa/Rita Blanca. **Agriculture;** Increased agriculture on private land both within the administrative boundary and outside of it creates total type conversion and loss of habitat. Loss of water developments and overflow pits associated with ranching which could house the plains leopard frog will be lost or abandoned when type converting to agriculture. **Disease;** Chytridiomycosis known as *Bd* fungus weakens and usually kills amphibians by disrupting necessary skin functions such as water and salt transfer.	Moderate likelihood of widespread declines in population in the plan area, and new isolation of populations within the area

Species	Threats Specific to the Species	Likelihood of Consequence
	Contiguous habitat; Fragmentation from agriculture type conversion from ranching. Those remaining overflow pits, if left available, further fragment and isolate populations. **Predation;** Bullfrog predation on tadpoles and heron and coyote predation on all life stages of plains leopard frog.	
Black-tailed prairie dog (Kiowa/Rita Blanca)	**Short grass prairie PNVT:** **Disease;** Outbreaks of Sylvatic Plague every five to ten years occur within and outside the administrative boundary where black-tailed prairie dogs towns exist. **Contiguous habitat;** Fragmentation and habitat loss from increased agricultural conversion on adjacent private lands. **Predation;** Poisoning and target shooting of black-tailed prairie dogs.	Moderate likelihood of widespread declines in population in the plan area, and new isolation of populations within the area
Mountain Plover	**Shortgrass prairie PNVT:** **Invasive Species;** Habitat change due to tree and shrub encroachment. **Disease;** Outbreaks of Sylvatic Plague every five to ten years occur within and outside the administrative boundary where black-tailed prairie dogs towns exist. The loss of prairie dog towns, limits mountain plover ideal nesting conditions. **Contiguous habitat;** Fragmentation and habitat loss from increased agricultural conversion on adjacent private lands.	Moderate likelihood of widespread declines in population and new isolation for Mountain plover on Shortgrass Prairie in the Kiowa-Rita Blanca Ranger District.
Swift Fox	**Shortgrass prairie PNVT:** **Invasive Species;** Habitat change due to tree and shrub encroachment. **Disease;** Outbreaks of Sylvatic Plague every five to ten years occur within and outside the administrative boundary where black-tailed prairie dogs towns exist. The loss of prairie dog towns, limits swift fox dens and escape opportunities. **Contiguous habitat;** Fragmentation and habitat loss from increased agricultural conversion on adjacent private lands. **Predation;** Coyote predation and competition are	High likelihood of localized population declines that may be accompanied by some minor restriction in population interactions for Swift fox on Shortgrass Prairie in the Kiowa-Rita Blanca Ranger District.

Species	Threats Specific to the Species	Likelihood of Consequence
	limiting factors on swift fox.	

[1]Due to either a very small or absent population of lesser prairie chickens on Cibola National Grasslands, likelihood consequence scenarios remain difficult to project.

4.4 Summary of Species at High Risk on the Grasslands

4.4.1 Lesser prairie-chicken

There are no known existing lesser prairie-chicken populations on the Kiowa or Rita Blanca Grasslands or on adjacent private lands. Where sand sagebrush habitat exists on the Kiowa and Rita Blanca Grasslands, it does not occur in contiguous blocks large enough to provide for a population of lesser prairie-chicken. Ideal lesser prairie-chicken habitat is considered to be about 25,000 contiguous acres and is subject to quality and vegetative composition needed for the species. Agriculture conversion of sand sagebrush habitat on adjacent private lands within and outside of the administrative boundary continues to increase. Some agriculture is beneficial to the lesser prairie-chicken (depending on the crop), but as agriculture increases, native habitat is lost. There are minimal obstructions on sand sagebrush due to programs that keep fences to a minimum. Homesteads that have trees are extremely scattered, not very abundant and do not appear to be expanding. Sand sagebrush on the Kiowa and Rita Blanca National Grasslands is not at risk from tree encroachment.

4.4.2 Plains leopard frog

The limiting factors impacting plains leopard frog on the Kiowa and Rita Blanca National Grasslands are the existence of wetland habitat and predation. Due to the semi-arid nature of the area, nearly all natural surface waters are ephemeral and of short duration. The plains leopard frog uses anthropogenic impoundments that, in some cases, create permanent bodies of water. Predation by bullfrog on the plains leopard frogs in permanent water is potentially severe due to bullfrog biennial maturation giving second season bullfrog tadpoles a distinct advantage over plains leopard frog tadpoles.

4.4.3 Black-tailed prairie dog

The Rita Blanca National Grassland lost greater than 95% of its black-tailed prairie dog population in less than a year (2004) to Sylvatic plague. Several large contiguous blocks of habitat within the administrative boundary prevent total isolation of part of the black-tailed prairie dog complex on the Kiowa and Rita Blanca National Grasslands although the increase in agriculture on private lands within and outside of administrative boundary will create total isolation from other distant black-tailed prairie dog colonies.

4.4.4 Mountain Plover

Limiting factors impacting the mountain plover within the short grass habitat type is the availability of ideal nesting cover. The close cropped vegetation associated with prairie dog towns is ideal nesting cover for mountain plover. Agriculture conversion on adjacent private lands within and outside of the administrative boundary continues to increase, further limiting mountain plover habitat. Plague effects to Black-tailed prairie dog communities has direct negative impacts to mountain plover.

4.4.5 Swift fox

Limiting factors impacting the swift fox within the short grass habitat type is the availability of escape cover and den sites often associated with prairie dog towns. Without escape areas and den site opportunities the swift fox is subject to predation largely from coyotes. Agriculture conversion on adjacent private lands within and outside of the administrative boundary continues to increase, further

limiting swift fox habitat. Plague effects to Black-tailed prairie dog communities has direct negative impacts to swift fox.

Table 41 Status of Species/Risk Assessment Ranking

Common Name	Ranger District	Habitat Type	[1]H/P/R score	Overall Risk Rating
Lesser prairie-chicken	Black Kettle	Mixed Grass Prairie	1.19	High
Lesser prairie-chicken	Black Kettle	Shinnery Oak	1.19	High
Plains Leopard Frog	Kiowa-Rita Blanca	Ponds and Playas	1.35	High
Lesser prairie-chicken	Kiowa-Rita Blanca	Sand sagebrush	1.44	High
Black-tailed prairie dog	Kiowa-Rita Blanca	Shortgrass Prairie	1.47	High
Plains Leopard Frog	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.47	High
Mountain plover	Kiowa-Rita Blanca	Shortgrass Prairie	1.49	High
Swift fox	Kiowa-Rita Blanca	Shortgrass Prairie	1.51	High
Northern bobwhite	Black Kettle	Shinnery Oak	1.56	Moderate
Bald eagle	Kiowa-Rita Blanca	Shortgrass Prairie	1.59	Moderate
Arid Land Ribbon Snake	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.63	Moderate
Conchas Crayfish	Kiowa-Rita Blanca	Rivers	1.64	Moderate
Arkansas River Shiner	Black Kettle	Rivers	1.66	Moderate
Suckermouth minnow	Kiowa-Rita Blanca	Rivers	1.67	Moderate
Great Plains narrowmouth toad	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.69	Moderate
Largemouth bass	Black Kettle	Rivers	1.69	Moderate
Bell's vireo	Black Kettle	Mixed Hardwood Riparian	1.75	Moderate
Greene milkweed	Kiowa-Rita Blanca	Shortgrass Prairie	1.77	Moderate
Bald eagle	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.80	Moderate
Dotted Checkerspot	Kiowa-Rita Blanca	Sand sagebrush	1.81	Moderate
Dotted Checkerspot	Kiowa-Rita Blanca	Shortgrass Prairie	1.81	Moderate
American avocet	Kiowa-Rita Blanca	Ponds and Playas	1.81	Moderate
Interior least tern	Black Kettle	Rivers	1.84	Moderate
One-flowered Milkvetch	Kiowa-Rita Blanca	Shortgrass Prairie	1.88	Moderate
Panhandle Spurge	Kiowa-Rita Blanca	Piñon-Juniper	1.88	Moderate
Spellenberg’s Groundsel	Kiowa-Rita Blanca	Shortgrass Prairie	1.88	Moderate
Alpine Fever-few	Kiowa-Rita Blanca	Shortgrass Prairie	1.88	Moderate
Rocky Mountain Dagger	Kiowa-Rita Blanca	Caves-Cliffs-Rock Outcrops	1.88	Moderate
Burrowing Owl	Kiowa-Rita Blanca	Shortgrass Prairie	1.88	Moderate
Northern bobwhite	Black Kettle	Mixed Grass Prairie	1.88	Moderate
Zone-tailed hawk	Kiowa-Rita Blanca	Piñon-Juniper	1.92	Moderate
Long-billed curlew	Kiowa-Rita Blanca	Ponds and Playas	1.92	Moderate
Rhena Crossline Skipper	Kiowa-Rita Blanca	Shortgrass Prairie	1.93	Moderate

Common Name	Ranger District	Habitat Type	[1]H/P/R score	Overall Risk Rating
One-flowered Milkvetch	Kiowa-Rita Blanca	Piñon-Juniper	1.94	Moderate
Panhandle Spurge	Kiowa-Rita Blanca	Sand sagebrush	1.94	Moderate
Spellenberg's Groundsel	Kiowa-Rita Blanca	Piñon-Juniper	1.94	Moderate
Ambersnail	Kiowa-Rita Blanca	Other Wetlands	1.94	Moderate
Hobomok Skipper	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	1.96	Moderate
Ferruginous hawk	Kiowa-Rita Blanca	Shortgrass Prairie	1.97	Moderate
Andean prairie-clover	Kiowa-Rita Blanca	Shortgrass Prairie	2.00	Moderate
Scaled quail	Kiowa-Rita Blanca	Sand sagebrush	2.00	Moderate
Red-headed woodpecker	Black Kettle	Mixed Hardwood Riparian	2.03	Moderate
Bald eagle	Black Kettle	Aquatic Lakes	2.06	Moderate
Red-headed woodpecker	Kiowa-Rita Blanca	Cottonwood-Willow Riparian	2.13	Low
Rio Grande turkey	Black Kettle	Mixed Grass Prairie	2.13	Low
Scaled quail	Kiowa-Rita Blanca	Shortgrass Prairie	2.19	Low
Rio Grande turkey	Black Kettle	Mixed Hardwood Riparian	2.19	Low
Largemouth bass	Black Kettle	Aquatic Lakes	2.19	Low
Rio Grande turkey	Black Kettle	Shinnery Oak	2.25	Low
Long-billed curlew	Kiowa-Rita Blanca	Shortgrass Prairie	2.38	Low
Long-billed curlew	Black Kettle	Mixed Grass Prairie	2.44	Low
Grasshopper sparrow	Black Kettle	Mixed Grass Prairie	2.50	Low
Plains Leopard Frog	Black Kettle	Aquatic Lakes	2.50	Low
Horrid Herrickia	Kiowa-Rita Blanca	Caves-Cliffs-Rock Outcrops	2.56	Low
Grasshopper sparrow	Kiowa-Rita Blanca	Shortgrass Prairie	2.56	Low
Greene milkweed	Kiowa-Rita Blanca	Piñon-Juniper	2.69	Low
Grasshopper sparrow	Black Kettle	Shinnery Oak	2.69	Low
Grasshopper sparrow	Kiowa-Rita Blanca	Sand sagebrush	2.69	Low

[1]H/P/R score column is the Current and Trend Habitat factors, Population factors, and Risks to a species average. High Risk is a score of 1 to 1.5. Moderate risk is over 1.51 to 2. Low risk is a score over 2.1

5 Summary of Ecological Sustainability

The ecological sustainability of the Grasslands is a culmination of ecosystem characteristics assessment, including PNVT, soil, water and air, and species diversity and status. Based on the ecosystem and species risk assessment findings described above, the Grasslands contribute to the ecological sustainability within each resource analyzed in this report.

Four out of the seven PNVTs found on the Grasslands have greater representation on the Grasslands in comparison to the surrounding landscape. These are the shinnery oak, mixed hardwood riparian, cottonwood-willow and sand sagebrush PNVTs. Mixed grass and shortgrass prairie have less

representation on the Grasslands in comparison to the surrounding landscape and piñon-juniper is equally represented.

All of the vegetation types are within their HRV condition, and continuation of management trends is expected to maintain that condition.

Some of the vegetation types, while close to reference conditions within the HRV overall, may not be able to make a full recovery to the lower percentages of departure from reference conditions. These include the shinnery oak areas that were once deeply plowed, as well as formerly cultivated old field sites in shortgrass prairie. The deep plowing practices on shinnery oak eliminated the species from some areas during the Dust Bowl era, and recovery does not readily occur. Soil movement that occurred during the Dust Bowl era also created conditions that facilitated mixed hardwood riparian establishment, a vegetation type not historically found on the Grasslands. Consequently determining a departure from reference condition for mixed hardwood riparian on Black Kettle and McClellan Creek is a comparison of riparian woody vegetation structure and composition HRV from other areas. Some areas within the cottonwood-willow riparian may not have the capacity to fully recover to the lower percentages of departure from reference condition due to the disruption of natural hydrologic processes on and off of the Grasslands. While the structure and composition state of HRV may not be fully achievable on some areas within the shinnery oak, shortgrass prairie, and the mixed hardwood riparian and cottonwood willow riparian vegetation types, the continuation of select management practices should maintain these areas within HRV.

Over the past several decades watershed conditions have been dramatically improved, especially compared to the extremely degraded condition they were in during the 1940s and 50s following the Dust Bowl era. Conservation practices across the southern Great Plains, and notably in the McClellan Creek drainage, have resulted in a substantial increase in infiltration and groundwater recharge and a subsequent reduction in surface runoff and associated sedimentation. The conditions of the unique habitat features found on the Grasslands, such as playa lakes, riverine and wetland associations on the Kiowa and Rita Blanca Grasslands and aquatic or riverine and wetland associated habitats on the Black Kettle Grasslands, have also been dramatically improved. Overall, the Grasslands are similar to the surrounding landscape in respect to miles and acreage of waterbodies. Groundwater depletion is occurring, though this depletion is outside of the agency’s control, it has the potential to affect Grasslands management.

All areas of the Grasslands have recovered to acceptable levels of soil stability and vegetative cover. In terms of soil productivity, about 52 percent of the soils on the Grasslands are in satisfactory soil condition while about 48 percent are impaired. In terms of soil loss, about 90% of the soils on the Grasslands are in satisfactory condition with the remaining 10% considered unsuited inherently unstable. The number of active oil-gas wells and other developments that would reduce site productivity is not expected to significantly increase on Grasslands units over the next 10-20 years. Soil productivity is likely to greatly improve after the 2005 Travel Management Rule is fully implemented and motorized travel is limited to designated travel routes. Predicted increases in air temperatures in the southern Great Plains may reduce soil organic matter affecting productivity, water-holding capacity and carbon storage in the soil (Joyce et al. 2001).

The Grasslands are meeting the air quality standards as outlined for each state. Since the reference and current conditions are the same, the Grasslands are within the reference conditions for air quality. Management activities on the Grasslands do not cause long term changes in air quality and meet state and federal air quality standards. This attainment of air quality standards is expected to continue into the future.

Of the species identified for further consideration in Plan Revision, lesser prairie-chicken, plains leopard frog, black-tailed prairie dog, mountain plover, and swift fox were assessed to be at high risk on cottonwood/willow riparian, shinnery oak, sand sagebrush and mixed and shortgrass prairie PNVTs.

The risks to these species were found to be the threats derived from fragmentation, disease, predation, and invasive species.

5.1 Ecosystem Management Opportunities and Constraints

When looking to identify resource management opportunities and constraints, two key factors should be considered: the current status and trend of an ecosystem and the effects of current management activities on that status and trend. Using these considerations and recognizing the importance of other ecosystem characteristics, such as, soil, water, air and habitat, each PNVT and habitat feature found on the Grasslands was reviewed to identify general management opportunities and constraints for the Grasslands.

5.1.1 Mixed Grass Prairie

Condition: Mixed grass prairie covers approximately 11,300 acres or 35% of the Black Kettle and McClellan Creek National Grasslands. Prescribed fire and livestock grazing are used to mimic natural processes. Prescribed burning increases the amount of forbs within the mixed-grass prairie. In the early stage, 1-3 years post-fire, there are more forbs and diversity of species before little bluestem regains dominance. After approximately three years, the grasses become the dominant species. Perennial grasses on the red-shale soils are primarily blue grama, hairy grama, little bluestem, and purple three awns. About 10% of the areas are covered in forbs and 10% in woody species.

Trends: The mixed grass prairie PNVT areas will be managed with livestock grazing and prescribed fire to maintain the reference conditions.

Departure from Reference: The natural areas of mixed grass prairie are within reference conditions.

Contribution to Sustainability and Management opportunities and constraints: Currently, there is more mixed grass prairie on the landscape, specifically off the Grasslands, than was present historically largely due to the past and current agriculture practices. While it may appear that management of the mixed grass prairie on the Grasslands is not a priority due to its overrepresentation on the landscape, much of the mixed grass prairie off of the Grasslands is highly departed from reference conditions. This makes the native mixed grass prairie located on the Black Kettle and McClellan Creek National Grasslands important, as it has a high contribution to the overall ecological sustainability.

5.1.2 Shortgrass Prairie

Condition: Shortgrass prairie covers approximately 181,900 acres, or 79%, of the Kiowa and Rita Blanca National Grasslands. The shortgrass prairie PNVT typically occurs on plains and draws, or on gently rolling uplands of the southern Great Plains. Vegetation is mainly shortgrass dominated by blue grama, needle-and-thread, buffalograss, and galleta, with intermingled forbs and scattered half-shrubs. Post fire early successional stages are dominated by resprouts and seedlings of grasses and post-fire associated forbs covering approximately 2% of this PNVT. Species include blue grama and buffalograss. The mid-open stage covers approximately 90% of the PNVT with less than 35 percent herb cover that is low to medium height. The main grasses are blue grama and buffalograss. The mid-closed stage covers about 8% of this PNVT with greater than 35 percent herb cover. Again the main grass species are blue grama and buffalograss. Livestock grazing is conducted in accordance with most recent environmental analyses utilizing an adaptive management approach taken by monitoring use

and conditions on the ground, then adjusting as conditions change. Prescribed fire is applied, but on a small scale and generally not within the historical fire regime of 5-10 years. Removal of shrubs and trees encroaching onto the shortgrass prairie is occurring where access is adequate.

Trends: Current management trends are stable and will keep this PNVT within its HRV reference conditions.

Departure from Reference: Currently, the shortgrass prairie is within the HRV reference condition for the PNVT.

Contribution to Sustainability and Management opportunities and constraints: Currently, there is less shortgrass prairie across the landscape than found historically. These areas of shortgrass prairie located off the Grasslands are highly departed from the historical condition. Therefore, the shortgrass prairie located within the National Grassland units is important and has a high contribution to the overall ecological sustainability. There is a management opportunity to create a greater proportion of late-structural stage conditions, which may require more rest or grass-banking. Likewise, prescribed fire may be used to create a greater proportion of early-successional stage conditions.

5.1.3 Shinnery Oak

Condition: This vegetation type covers approximately 18,900 acres (or 59%), of the Black Kettle and McClellan Creek National Grasslands. About 45% of the shinnery oak PNVT is in the early-mid-open, post-fire to three years post-fire regime and dominated by tallgrasses in shallower and more stable sandsheet areas. Grass cover is dominant with rapid recovery of shin-oak resprouts. The late-closed successional class structure and composition stage occurs in the 3 to 10 year post-fire time frame. Shinnery cover is mostly dominant although grasses remain co-dominant on about 55% of the PNVT. Most shinnery oak stands are burned on a 2 to 9 year cycle with the intent to maintain a co-dominant canopy cover of grasses intermixed with shinnery oak for wildlife habitat diversity and to mimic historical conditions. Current livestock grazing within the shinnery oak system is relatively light, with utilization levels retaining at least 50% of the current year's growth of vegetation, by weight, of forage species. Livestock grazing utilizes an adaptive management approach during the dormant season.

Trends: Prescribed burning and controlled grazing move this PNVT toward reference conditions that have the shinnery oak composition fully recovering its vertical structure within 2 to 4 years after a fire. The horizontal expanse or range of shinnery oak does not fluctuate by current management and the area of the shinnery oak PNVT will remain fairly constant on the Grasslands with the composition and structure trends toward reference.

Departure from Reference: The current condition of shinnery oak is within the HRV reference condition.

Contribution to Sustainability and Management opportunities and constraints: The Black Kettle Grassland contains a large portion of the shinnery oak found within the Red Prairie and Southern South Central and Redbed Plains Subsections. Both Subsections have disproportionately smaller total percentages of shinnery oak compared to the Black Kettle Grassland due to agricultural practices that removed much of the shinnery oak species component. Currently, there is a much larger amount of the shinnery oak PNVT on the Grasslands than in the surrounding landscape. This makes the management of the shinnery oak

located within the Grasslands important because of its contribution to the overall ecological sustainability.

5.1.4 **Piñon-Juniper**

Condition: This vegetation type covers approximately 21,700 acres or 10%, of the Kiowa and Rita Blanca National Grasslands. The current condition includes the early successional stage that occurs post-fire and covers about 12% of the PNVT with open areas of grasses, forbs, seedlings less than 4.5 ft. in height and saplings. The mid-late successional stage covers about 88% of the PNVT and includes a mix of piñon and juniper trees in a variety of classes with varying canopy cover. Mid-development classes averages 10% of the PNVT in relative abundance and have dense canopy cover, 31-70%, of pole size trees 5-9" in diameter, and very little understory. Twenty five % of the PNVT will have pole size trees with a mixed shrub-herbaceous understory and canopy cover ranges from 0-30%. Thirty five % of the PNVT will have late development with medium size trees, 9-21" in diameter and canopy cover of 0-40%. Ten % of the PNVT will have dense, old growth characteristics with medium size trees and canopy cover of 41-70%. Stands of piñon-juniper that are overstocked and encroaching onto the shortgrass prairie are being treated using thinning and prescribed burning. Currently, the level of treatment is approximately 500-900 acres of thinning a year, followed by 1,000 to 1,800 acres of burning.

Trends: Through the continued use of prescribed burning and thinning projects, woodland areas have become more open although they have retained their mid to late seral stage structure including old growth characteristics of large-diameter trees, snags, and down logs. Continuation of current management trends is expected to keep the piñon-juniper PNVT in its current state, which is within reference conditions.

Departure from Reference: The piñon-juniper PNVT is within the HRV reference condition.

Contribution to Sustainability and Management opportunities and constraints: There is approximately the same amount of piñon-juniper across the landscape as was historically, in terms of relative abundance. Continued and increased, where appropriate, burning will help encourage this PNVT toward reference condition. Since the majority of the piñon-juniper found off the Grasslands is highly departed from the reference condition, the contribution the Grasslands make to ecological sustainability for the piñon-juniper PNVT is important.

5.1.5 **Cottonwood Willow Riparian**

Condition: This vegetation type covers approximately 1,370 acres or 1%, of the Kiowa and Rita Blanca National Grasslands. The early successional class is represented on about 16% of this PNVT and is typically shrub-seedling dominated, but grasses may co-dominate. The mid and late successional class covers about 84% of this PNVT. The mid vegetation composition includes tall shrubs and small trees such as willows and cottonwoods. Late successional class represents the mature, large cottonwood and willow riparian woodlands. Current management activities are targeting non-native, invasive species in riparian areas, specifically, salt-cedar. These activities are encouraging establishment of needed mid-successional conditions.

Trends: By removing salt-cedar from the Canadian River system in Mills Canyon, more of the PNVT will move into the mid successional class. This will increase vegetation on stream banks and stabilize slopes. Areas along Perico and Sauz Creeks periodically flood which helps keep

some of this PNVT within the early successional class. Under current management, this PNVT is expected to remain within the HRV reference condition.

Departure from Reference: The cottonwood-willow areas located within the Kiowa and Rita Blanca National Grasslands are within the HRV reference condition**.**

Contribution to Sustainability and Management opportunities and constraints: Currently, there is much less cottonwood-willow across the landscape than appeared historically and those areas present on the landscape that do have cottonwood-willow are highly departed from the historical condition. The cottonwood-willow areas located within the Kiowa and Rita Blanca National Grasslands are within the reference condition, making it an important ecosystem and important to sustaining ecological sustainability. On-going non-native invasive species control will benefit regeneration and establishment of native cottonwood and willows. However, flood control and impoundments upstream of Grassland units can reduce flooding and in turn negatively affect cottonwood and willow recruitment. Current management trends of treating invasive species within the riparian systems, specifically salt-cedar, will help reduce the amount of invasive species found in the cottonwood-willow PNVT.

5.1.6 **Mixed Hardwood Riparian**

Condition: This vegetation type covers approximately 1,946 acres or 6% of the Black Kettle and McClellan Creek National Grasslands. The early successional stage represents approximately 13% of this PNVT with pioneer tree and shrub species of cottonwoods and willows with an herbaceous understory of sedges in wet areas. In this early stage, most of the area is bare sand dominated by a young canopy of tree saplings and shrubs. Species would include indigo bush and various grass, sedges, and rushes. The mid and late successional stage covers the remaining 87% of this PNVT. In the mid stage developing stands start to mature. This community tends to be partially open with scattered cottonwoods and willows. The shrub layer is poorly developed and often consists of widely scattered patches of dogwood. The understory vegetation is highly variable with wild rye, and muhlys. In wetter, more shaded areas, Virginia creeper, nettles, and poison ivy are present. In the late class is a mature, late seral, closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood, box elder, hackberry, walnut and elm. Understory species include Virginia creeper and poison ivy found along the upper terrace that has been protected from most flood events except for rare high intensity flooding.

Trends: Under current management, this PNVT is expected to remain in its current state.

Departure from Reference: The mixed hardwood riparian areas that are found on the Black Kettle and McClellan Creek National Grasslands are there due to soil movement during the Dust Bowl Era. Topsoil blew into these low-lying areas followed by upstream damming, creating areas that would not have been present historically. Consequently there is not an appropriate reference condition for a departure from HRV reference condition determination.

Contribution to Sustainability and Management opportunities and constraints: Currently, areas off of the National Grasslands that represent the mixed hardwood riparian PNVT are outside of mixed hardwood riparian structure and composition ideals. The Black Kettle and McClellan Creek National Grasslands hold a fairly large portion of this PNVT within the Canadian-Cimarron Breaks subsection, making this an important ecosystem. The most important management activity occurring within the mixed hardwood riparian is the removal of invasive species eastern redcedar and black locust. Management activities are limited by the conditions

currently found within the mixed hardwood riparian. Overcrowded, thicket like conditions compounded with stream impoundments are preventing large disturbance events, such as, fire and flooding from developing conditions that would have led to early successional stage classes and regeneration of woody species. The removal of invasive woody species such as, eastern redcedar and black locust, would help with the re-establishment of native hardwood species, such as cottonwood, willow, elm, hackberry, and ash. However, as this PNVT is present now, current management is conducted in ways conducive to keeping this PNVT intact

5.1.7 Sand sagebrush

Condition: The sand sagebrush PNVT vegetation type covers approximately 22,651 acres or 8 % of the Grasslands. One percent of this PNVT is a post-fire successional class dominated by resprouts and seedlings of grasses and forbs with low to medium height having a variable canopy cover. This class typically occurs where fires burn relatively hot. The mid-open successional stage represents 69% of this PNVT that has less than 35% herb cover, medium to tall in height. Mid-closed stage represents about 39% of the PNVT area with greater than 35% herb cover, medium to tall in height. Prescribed burning is currently being used at a rate of approximately 500 acres every three-five years. Livestock grazing occurs during the winter months to limit the impact to soils and no livestock grazing occurs during the growing season.

Trends: Continuation of current management trends will maintain sand sagebrush in the HRV reference condition.

Departure from Reference: The sand sagebrush PNVT is within the HRV reference condition.

Contribution to Sustainability and Management opportunities and constraints: Currently, there is much less of the sand sagebrush PNVT across the landscape than was historically present due to massive soil movement that occurred during the dust bowl. These areas of the surrounding landscape that are sand sagebrush are highly departed from the reference condition. Sand sagebrush keeps the soil stable and help prevent further soil movement; therefore, they are important on the Grasslands. This makes the sand sagebrush PNVT on the Kiowa and Rita Blanca National Grasslands an important ecosystem and important to ecological sustainability. Management activities will continue to maintain these areas. An increase in prescribed burning activities would help move more of the area into needed early- and mid-successional classes.

5.1.8 Soil

Condition: About 90% of the Grassland is in satisfactory soil loss, none of the Grassland is in an unsatisfactory soil loss and about 10% is in an unsuited soil loss. All of the mixed hardwood riparian, piñon-juniper, cottonwood-willow riparian, sand sagebrush, and shinnery oak PNVTs are in satisfactory soil loss. This indicates that on-site soil loss is within threshold limits and is not reducing the ability of the soil to maintain long-term soil productivity. Conversely, the greatest areas of unsuited soil loss conditions are found in the shortgrass prairie PNVT. Proportionally, the mixed grass prairie PNVT has the most area in an unsuited soil loss condition, about 35%. Soil erosion may be occurring beyond its threshold and the soil is at risk of not maintaining long-term soil productivity.

Trends: Restoration management practices over the past several decades have resulted in tremendous improvement in soil stability and vegetative recovery. A few units on the Black Kettle National Grassland that were heavily plowed in the past do not appear capable of recovering their productivity potential, although the soils are grass-covered and stabilized. A

few units on Kiowa and Rita Blanca National Grasslands adjacent to towns or other private developments are heavily impacted by invasive plant populations that are seriously reducing soil productivity and vegetative diversity. These too are not likely to be fully restored to full productivity and native grassland vegetation due to continued spread of invasive plants and other impacts from adjacent lands.

Departure from Reference: Soils found on the Grasslands are altered due to soil movement during the Dust Bowl area creating areas that would not have been present historically. Consequently there is not an appropriate reference condition or a departure from reference condition determination.

Contribution to Sustainability and Management opportunities and constraints: There are no management activities occurring on the Grasslands that are targeted specifically to soil productivity or soil loss. However, all management activities that are implemented must be conducted in a manner that does not contribute to loss of long-term soils productivity there are activities or conditions off of the Grasslands that affect Grassland soils. If populations of invasive species off of Grassland units are not controlled, they will continue to spread onto the Grasslands, posing management problems.

5.1.9 Perennial Streams, Reservoirs, Lakes, Ponds and Playa Lakes

Condition: The following surface water and riparian vegetation occurs on the Grasslands units and additional water and riparian resources occur on adjacent private and state lands (based on TEUI data):

- 32 miles of perennial, mostly year-round, streams, with 60% on the Kiowa and Rita Blanca National Grasslands and 40% on the Black Kettle and McClellan Creek National Grasslands
- 3,400 acres of riparian area and 40 acres of playa lakes that are shallow depressions that remain dry between rain events
- 1,300 acres of water in reservoirs, lakes, ponds and rivers at normal pool levels

Water quality conditions were extremely degraded during and immediately following the Dust Bowl era. These conditions have been dramatically improved by intentionally minimizing or avoiding any adverse effects from Grassland management activities. Impoundments are maintained and inspected for safety. Recreation surrounding the reservoirs, lakes and ponds does cause some minor erosion and contribute some sediment into the waterbodies. Likewise roads contribute some sediment into streams. Typically grazing activities are managed to limit erosion and trampling along perennial streams, but watering of livestock does contribute some sediment into waterways.

Trends: Conditions of most streams, reservoirs, lakes, and ponds are trending towards reference conditions.

Departure from Reference: Though there were no standards historically all streams would have met current water quality standards. There were lower peak flow events, even on un-dammed reaches, compared to current conditions due to better watershed conditions. These conditions encouraged infiltration and groundwater recharge rather than fast runoff and overland flow. Higher ground water levels resulted in streams running longer into the growing season. No significant departure from current conditions relationship to reference or future conditions to

reference was determined for perennial streams, reservoirs, lakes, and ponds under forest service control.

Contribution to Sustainability and Management opportunities and constraints: On the Black Kettle and McClellan Creek National Grasslands, unmanaged off highway vehicle use currently poses a risk to watershed conditions. The patchwork land ownership limits the ability of land management activities on the National Grasslands to have a large effect on water quality and streamflow. Benefits to stream health on Grasslands units can be negated by poor management on nearby private land. The mixed land ownership also presents an opportunity to work with partners and local land owners to address water quality and stream channel issues. On the Kiowa and Rita Blanca National Grasslands, invasive species, such as, salt-cedar, and unmanaged off highway vehicle use currently pose risks to watershed conditions. Invasive species are being controlled when and where they are found to be affecting streamflow and water quality. Grazing activities are altered when playa lakes have water. Likewise playa lakes are protected from "pitting," an activity that modifies the water holding capacity of a playa. Land management on adjacent private property could allow invasive species to re-invade riparian areas being treated. Additionally, impoundments can affect flooding which limits recruitment of riparian vegetation.

Overall, the Grasslands are similar to the surrounding landscape in respect to miles and acreage of waterbodies. Groundwater depletion is occurring; though this depletion is outside of the agency's control, it has the potential to affect Grasslands management.

5.1.10 **Air**

Condition: None of the three states, New Mexico, Texas and Oklahoma, containing the Kiowa, Rita Blanca, Black Kettle and McClellan Creek National Grasslands has air quality monitoring in the area of the National Grasslands. Nonetheless the air quality data that has been collected in these areas, usually by national monitoring networks or at regional airports, indicates that there is not a concern for air quality conditions in these areas except from dust storms and wildland fires.

Trends: The management trend affecting air quality is prescribed burning. The Forest Service is required to meet State air quality standards during implementation of burns and all management activities that are implemented must be conducted in a manner that does not lead to long-term non-attainment.

Departure from Reference: Currently, the Grasslands are meeting the air quality standards as outlined for each state. Since the reference and current conditions are the same, the Grasslands are within the reference conditions for air quality. The increases in facilities listed on the EPA Air Data Facility Emissions Reports especially in Roger Mills County, Oklahoma may indicate that in the future off-site emissions may have increase effects on the Grasslands' ecosystems (US EPA 1999). However, given the current superior air quality in the area these increases in emissions may not have substantial effects on the ecosystems.

Contribution to Sustainability and Management opportunities and constraints: Prescribed burning must be done with respect to state and national air quality standards and appropriate burn permits must be obtained prior to implementation. There are potential threats to air quality that occur off of the Grasslands and outside of Forest Service control, however, they do not affect management of the Grasslands.

6 References Cited

Anderson, M.G., *editor*. 1988. Modeling geomorphological systems. John Wiley and Sons, New York. 458 pages.

Avers, P. E. and W. H. McNab. 1994. Ecological subregions of the United States: Section Descriptions, United States Department of Agriculture Forest Service, Ecosystem Management, Washington D.C., USA.

Bazzaz, F.A. and R.W. Carlson. 1984. The response of plants to elevated CO_2 (carbondioxide). Competition among an assemblage of annuals at two levels of soil moisture (Amaranthus retroflexus, Plygonum pensylvanicum, Ambrosia artemisiifolia, Abutilon theophrasti).Oecologia 62: 196-198.

Becker, M.F., B.W. Ruce, L.M. Pope, and W.J. Andrews. 2002. Ground-Water Quality in the Central High Plains Aquifer, Colorado, Kansas, New Mexico, Oklahoma, and Texas, 1999. USGS Water-Resources Investigations Report 02-4112. 64 pp.

Bell, Gary, Delbert Bassett, and Zollnet, Doug. 2005. LANDFIRE Rapid Assessment Reference Condition Model. Southern Short/Mixed Grass Prairie Potential Natural Vegetation Group.

Biery, Ed, Kara Painter, William Baker and Barry Johnson. 2005. LANDFIRE Rapid Assessment Reference Condition Model. Pinyon Juniper – Mixed Fire Regime Potential Natural Vegetation Group.

Boyd, C. S. and T. G. Bidwell. 2002. Effects of prescribed fire on Shinnery Oak (Quercus havardii) plant communities in Western Oklahoma. Restoration Ecology 10(2):324-333.

Bragg, T. B. 1995. Climate, soils and fire: the physical environment of North American grasslands. In: K. Keeler and A. Joern, eds. The changing prairie. Oxford Univ. Press, New York.

Brockway, D. G., R. G. Gatewood, and R. B. Paris. 2002a. Restoring fire as an ecological process in shortgrass prairie ecosystems: initial effects of prescribed burning during the dormant and growing seasons. Journal of Environmental Management 65:135-152.

Brockway, D. G., R. G. Gatewood, and R. B. Paris. 2002b. Restoring grassland savannas from degraded piñon-juniper woodlands: effects of mechanical overstory reduction and slash treatment alternatives. Journal of Environmental Management 64:179-197.

Brown, J. H., T.J. Valone, C.G. Curtin. 1997. Reorganization of an arid ecosystem in response to recent climate change. Proceedings of the National Academy of Sciences (USA) 94: 9729- 9733.

Brown, James K.; Smith, Jane Kepler, eds. 2000. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Cleland, D. T., P. E. Avers, W. H. McNab, M. E. Jensen, R. G. Bailey, T. King, and W. E. Russell. 1997. National Hierarchical Framework of Ecological Units. Published in Boyce, M.S. and A Haney, ed. 1997. Ecosystem Mangament Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, Connecticut. pp. 181-200.

Coppedge, B.R.; Engle, D.M., Fuhlendorf, S.D., Masters, R.E.; and Gregory, M.S. 2001. Landscape cover type and pattern dynamics in fragmented southern Great Plains grasslands, USA. Landscape Ecology. Vol. 16: 677-690.

Cunningham, George R, and John Ortman. 2005. LANDFIRE Rapid Assessment Reference Condition Model. Great Plains Floodplain Potential Natural Vegetation Group.

Davis III, J. H. and Bonham., C. D. 1979. Interference of sand sagebrush canopy with needle and thread. – Journal of Range Management 32: 384–386.

DAYMET. U.S. Data Center. http://www.daymet.org/ (accessed August 22, 2010).

Dhillion, S. S. & M. Mills. 1999. The sand shinnery oak (Quercus havardii) communities of the Llano Estacado: history, structure, ecology, restoration. In R. Anderson, J. Fralish, and J. Baskin, editors. Savannas, barrens, and rock outcrop plant communities of North America. Cambridge University Press, New York.

Finch, Deborah M., Editor. 2004. Assessment of grassland ecosystem conditions in the Southwestern United States. Volume 1. General Technical Report RMRS-GTR-135-vol. 1. Fort Collins, CO: United States Department of Agriculture Forest Service, Rocky Mountain Research Station.

Finch, Deborah M., Editor. 2005. Assessment of grassland ecosystem conditions in the Southwestern United State. Volume 2. General Technical Report RMRS-GTR-135-vol. 2. Fort Collins, Colorado: United State Department of Agriculture Forest Service, Rocky Mountain Research Station.

Fisher, William L. and M. S. Gregory. 2001. The Oklahoma GAP Analysis Project.

Fletcher, R. 1998. Cibola National Forest Range of Natural Variability. United States Department of Agriculture Forest Service, Southwestern Region.

Ford, Paulette. 2003. Steppe plant response to seasonal fire. Pages 1125-1131 in Proceedings of the VIIth International Rangelands Congress. 26 July – 1 August 2003, Durban, South Africa.

Gottfried, G. J., T. W. Swetnam, C. D. Allen, J. L. Betancourt, and A. L. Chung-MacCoubrey. 1995. Pinyon-juniper woodlands. Pages 95-132 in Ecology, Diversity, and Sustainability of the Middle Rio Grande Basin. Fort Collins, Colorado: United States Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-268.

Green, Gale, Wayne Robbie and William Baker. 2005. LANDFIRE Rapid Assessment Reference Condition Model. Shortgrass Prairie Potential Natural Vegetation Group.

Grove, Janet, Holly Richter, and Jony Cockman. 2005. LANDFIRE Biophysical Setting Model. North American Warm Desert Riparian Systems.

Haan, D. and C. Thornton. 2004. Canadian River Tamarisk Control Project: Stream Health Assessment. T.E.A.M.S Enterprise Unit, US Forest Service. 18 pp.

The Handbook of Texas Online. http://www.tsha.utexas.edu/handbook/online/ (accessed July 8, 2006).

Hann, Wendel J. and D.L. Bunnell. 2001. Fire and land management planning and implementation across multiple scales. International Journal of Wildland Fire. 27 pp.

Hann, Wendel. Fire Regime Condition Class Interagency Handbook Reference Conditions. 2003. PRAR1 Prairie Grassland (Sand sagebrush-Bluestem Prairie) Natural Vegetation Group.

Harrell, Wade C. Samuel.D. Fuhlendorf, and Terrance.G. Bidwell. 2001. Effects of prescribed fire on sand shinnery oak communities. Journal of Range Management 54: 685–690.

Haukos, D.A. and L. Smith 2003. Past and future impacts of wetland regulations on playa ecology in the southern Great Plains. Wetlands 23:577-589.

Johnson, H.B., H.W. Polley, and H.S. Mayeux. 1993. Increasing CO2 and plant-plant interactions: effects on natural vegetation. *Vegetatio* 104/105: 157-170.

Joyce, L. A., D. Ojima, G. A. Seielstad, R. Harriss and J. Lackett. 2001. Chapter 7: Potential Consequences of Climate Variability and Change for the Great Plains. In: Climate Change Impacts on the Unites States: The Potential Consequences of Climate Variability and Change. National Assessment Synthesis Team. Report for the US Global Climate Change Research Program, Cambridge University Press, Cambridge UK. 620 pp.

Lowry, J. H, Jr., R. D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O'Brien, T. Sajwaj, K. A. Thomas, W. Rieth, S. Schrader, D. Schrupp, K. Schulz, B. Thompson, C. Velasquez, C. Wallace, E. Waller and B. Wolk. 2005. Southwest Regional Gap Analysis Project: Final Report on Land Cover Mapping Methods, RS/GIS Laboratory, Utah State University, Logan, Utah.

McGuire, V. L. 2004. Water-Level Changes in the High Plains Aquifer, Predevelopment to 2002, 1980 to 2002, and 2001 to 2002. US Geological Survey Fact Sheet 2004-3026. 5 pp.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2005. Description of ecological subregions: sections of the coterminous United States. Washington, DC: U.S. Department of Agriculture, Forest Service. 80p.

McPherson, G.R. 2000. Invasive plants and fire: integrating science and management. In. K.E.M. Galley and T.P. Wilson (eds.). Proceedings of the invasive species workshop: the role of fire in the control and spread of invasive species. Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL.

Morgan, J.A., D.G. Milchunas, D.R. LeCain, M. West, and A.R. Mosier. 2007. Carbon dioxide enrichment alters plant community structure and accelerates shrub growth in the shortgrass steppe. Proceedings of the National Academy of Sciences (USA) 104: 14724-14729.

The Nature Conservancy. 1998. The Central Shortgrass Prairie Ecoregional Conservation Plan. Colorado Field Office.

The Nature Conservancy. 2007. A Biodiversity and Conservation Assessment of the Southern Shortgrass Prairie Ecoregion. Southern Shortgrass Prairie Ecoregional Planning Team, The Nature Conservancy, San Antonio, TX.

New Mexico Department of Game and Fish (NMDGF). 2006a. Threatened and Endangered Species of New Mexico - Final 2006 Biennial Review and Recommendations. http://www.wildlife.state.nm.us/conservation/threatened_endangered_species/documents/06BiennialReview_000.pdf (accessed September 27, 2007).

New Mexico Department of Game and Fish (NMDGF). 2006b. Comprehensive Wildlife Conservation Strategy (CWCS) for New Mexico. http://fws-nmcfwru.nmsu.edu/cwcs/New_Mexico_CWCS.htm (accessed September 27, 2007).

New Mexico Environment Department Air Quality Bureau. 2005. New Mexico Smoke Management Program Guidance Document May 25, 2005. 25 pp. plus appendices.

New Mexico Water Quality Control Commission. 2004. 2004-2006 State of New Mexico Integrated Clean Water Act §303(d)/§305(b) Report. Gary King (ed). Santa Fe NM. 541 pp.

Oklahoma Department of Environmental Quality. 2004. The State of Oklahoma 2004 Water Quality Assessment Integrated Report. 369 pp.

Oklahoma Department of Wildlife Conservation (ODWC). 2005. Oklahoma's Comprehensive Wildlife Conservation Strategy. http://www.wildlifedepartment.com/cwcs.htm (accessed September 27, 2007).

Oklahoma Department of Wildlife Conservation (ODWC). 2007. Oklahoma's Endangered Species http://www.wildlifedepartment.com/endanger2.htm (accessed September 27, 2007).

Parker, Nick C., K. Allen, K. Arnold, R. Baker, R. Bradley, G. Cameron, S. Haskell, E. Holt, and E. Zimmerman. 2003. The Texas GAP Analysis Project.

Patterson, D.T. and E.P. Flint. 1990. Implications of increasing carbon dioxide and climate change for plant communities and competition in natural and managed ecosystems. Pages 83- 110 in B.A. Kimball, N.J. Rosenberg, L.H. Allen, G.H. Heichel, C.W. Struber, D.E. Kissel, S. Ernst (eds.), Impact of carbon dioxide, trace gases, and climate change on global agriculture. American Society of Agronomy Special Publication No. 53.

Pennsylvania State University. 2006. Soil Information for Environmental Modeling and Ecosystem Management Website. http://www.soilinfo.psu.edu/soil_lrr (accessed January 22, 2007).

Playa Lakes Joint Venture Website. http://www.pljv.org/ (accessed September 6, 2006).

Peterson, R. S. and C. S. Boyd. 1998. Ecology and management of sand shinnery communities: a literature review. General Technical Report RMRS-GTR-16. Fort Collins, Colorado: United States Department of Agriculture Forest Service, Rocky Mountain Research Station.

Seastedt, T.R. 1995. Soil Systems and nutrient cycles of the North American prairie. Pages 157-174 In A. Joern and K.H. Keeler (editors) The changing prairie: North American grasslands. Oxford University Press, New York, New York.

Skagen, S.K., R. Hazlewood, and M.L. Scott. 2005. The importance and future condition of western riparian ecosystems as migratory bird habitat. In: Ralph, C.J., and T.D. Rich, (eds.). Bird conservation

implementation and integration in the Americas: Proceedings of the Third International Partners in Flight Conference, 2002 March 20-24, Asilomar, California, Volume 2. General Tech. Report PSW-GTR-191. Albany, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station. p. 52

Strenger, S., S. Sebring, W. Robbie, F. Escobedo, C. Vaandrager, V. Andrew, E. Brooks, C. Krasine, B. Nielsen, and R. Fletcher. 2007. Terrestrial Ecosystems Survey of the Cibola National Forest and National Grasslands. USDA Forest Service, Southwestern Region. 696 pp.

Terrell, Bennie and Doug Zollner. 2005. LANDFIRE Rapid Assessment Reference Condition Model. Shinnery Oak – Mixed Grass Potential Natural Vegetation Group.

Texas Parks and Wildlife Department (TPWD). 2007a. Rare, Threatened, and Endangered Species of Texas by County. http://www.tpwd.state.tx.us/landwater/land/maps/gis/ris/endangered_species.phtml (accessed September 27, 2007).

Texas Parks and Wildlife Department (TPWD). 2007b. Texas Priority Species List. http://www.tpwd.state.tx.us/business/grants/wildlife/cwcs/media/IV.pdf (accessed September 27, 2007).

University of Nebraska Medical Center (UNMC). http://www.unmc.edu/emergency/greatplainsmap.htm (accessed March 23, 2007).

University of New Mexico Bureau of Business and Economic Research (UNM-BBER). 2005. Socioeconomic Assessment of the Region 3 National Grasslands.

USDA Forest Service. 1991. General Terrestrial Ecosystem Survey (GTES). Southwestern Region. 188 pp.

USDA Forest Service. 1999. Forest Service Handbook 2509.18 – Soil Management Handbook – R3 Supplement.

USDA Forest Service. 1999a. Geographic Area Assessment Kiowa and Rita Blanca National Grasslands, Cibola National Forest. Version 1, September 30, 1999. Paginated by chapter.

USDA Forest Service. 1999b. Soil Management Handbook. Forest Service Handbook Southwestern Region supplement 2509.19-99-1. 8 pp.

USDA Forest Service. 2000. Geographic Area Assessment Black Kettle and McClellan Creek National Grasslands, Cibola National Forest. Version 1, August 14, 2000. Paginated by chapter.

USDA Forest Service. 2006a. Cibola National Forest and Grasslands Mid-scale Vegetation Inventory Data.

USDA Forest Service. 2006b. Cibola National Forest and Grasslands Terrestrial Ecological Unit Inventory.

USDA Forest Service. 2007a. Environmental Assessment for Invasive Plant Management. Cibola National Forest, Black Kettle Ranger District, Cheyenne, Oklahoma. 98 pp.

USDA Forest Service. 2007b. Final Environmental Impact Statement for Canadian River Tamarisk Control. Cibola National Forest, Harding and Mora Counties, New Mexico. 102 pp.

US Environmental Protection Agency (US EPA). 1990. US EPA AirData Facility Emissions Report – Criteria Air Pollutants. http://iaspub.epa.gov/airsdata/ (accessed June 12, 2006).

US Environmental Protection Agency (US EPA). 1999. US EPA AirData Facility Emissions Report – Criteria Air Pollutants. http://iaspub.epa.gov/airsdata/ (accessed June 12, 2006).

US Environmental Protection Agency (US EPA). 2006. National Ambient Air Quality Standards. http://www.epa.gov/air/criteria.html (accessed June 12, 2006).

US Fish and Wildlife Service (US FWS). 2007a. All Listed and Sensitive Species in New Mexico. http://www.fws.gov/southwest/es/newmexico/SBC_view_all.cfm (accessed September 27, 2007).

US Fish and Wildlife Service (US FWS). 2007b. Endangered Species Lists – Lists for Arizona, New Mexico, Oklahoma and Texas. http://www.fws.gov/southwest/es/EndangeredSpecies/lists/default.cfm (accessed September 27, 2007).

US Fish and Wildlife Service (US FWS). 2007c. Federally Listed Threatened and Endangered Species in Oklahoma. http://www.fws.gov/southwest/es/oklahoma/spplist.htm (accessed September 27, 2007).

Vander Lee, B. and R. Smith. 2005. Ecological and Biological Diversity of National Forests in Region 3.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS) data last updated 9.9.2005 on http://webcam.srs.fs.fed.us/emissions/ using the Emissions Tool last updated on 9.9.2005 developed by Bill Jackson

Weaver, J.E. 1954. North American Prairie. Chicago, IL: Lakeside Press, R.R. Donnelley and Sons Co.

Wright, H. A. & Bailey, A. W., 1982. Fire ecology. John Wiley and Sons, New York, NY. 501 pp.

7 Geographic Information System (GIS) Data Location

All GIS data is from 2007 and can be accessed by contacting the Cibola National Forest's Supervisor's Office.

Playa Lakes Data

- USFS-R3_UTM13 Geodatabase
    - Water
        - Water Body

Prescribed Fire Data

- Other Cibola Data Geodatabase
    - Fire
        - Prescribed Fire History

Wildfire Data

- USFS-R3_UTM13 Geodatabase
    - Fire Management
        - Fire History

Invasive Species

- USFS-R3_UTM13 Geodatabase
    - Vegetation
        - Invasive Plants

Aquatic Data

- USFS-R3_UTM13 Geodatabase
    - Water
        - Waterbody
        - Stream

Soils Data

- NRIS
    - Legend
        - Properties
            - Interpretation