Ecosphere
Environmental Services

District 18
Vegetation Inventory Report

Prepared for:

Bureau of Indian Affairs
Ft. Defiance Navajo Agency

September 2011

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ABSTRACT

Ecosphere Environmental Services was contracted by the Bureau of Indian Affairs (BIA) to collect and compile vegetation data on Land Management District 18, of the Ft. Defiance Navajo Agency. Data were collected from 794 transects in six grazing units covering eight Communities during August, September, and October of 2010. Measurements were taken for biomass production, ground cover, and species frequency. The production data were analyzed to determine the carrying capacity of the range resource. Initial data analysis revealed an insufficient sample design, resulting in the under-sampling or lack-of-sampling in several soil map units and ecological sites. An additional 75 transects were sampled during July, 2011 to help with the largest data gaps and to include transects in designated range management units.

Carrying capacities and initial stocking rates were calculated using a forage value rating. Data were analyzed by ecological sites within each grazing unit. The stocking rate data were aggregated by soil map units within each grazing unit, and then carrying capacities were generated according to the acreage of each soil map unit within each grazing unit.

1. INTRODUCTION

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to conduct under-story rangeland vegetation inventories within six grazing units covering eight Communities in Land Management District 18 of the Ft. Defiance Navajo Agency. Field biologists collected species-specific vegetation data including annual production, ground cover, and species frequency. This data was used to calculate stocking rates based on a forage value rating. Information derived from these calculations can be used to guide management decisions. This report supplies the results of the vegetation inventory, as well as the background, methodology, and discussion and recommendations for management planning.

1.1 Purpose and Need

Baseline range condition data is critical to establishing quality range management practices. The purpose of the inventory was to provide baseline information about the existing range resource to enable resource managers and permittees to improve and/or maintain the condition of the range resource. The results of this inventory will enable recommendations for adjusted stocking rates in District 18 as well as more comprehensive range management plans that are crucial for future range productivity.

1.2 Regulatory Entities

The Navajo Nation Department of Agriculture (NNDOA) manages livestock grazing activities on the Navajo Nation primarily through District Grazing Committees. Livestock grazing permits are administered by the BIA Natural Resources Program in accordance with the Navajo Grazing Regulations (25 CFR §167). All three parties, BIA, NNDOA, and the Grazing Committees, coordinate their activities in an effort to utilize and manage the range resources.

1.2.1 BIA Agency Natural Resources Program

All livestock grazing permits are issued by BIA Natural Resources. Master livestock grazing records are also maintained by the BIA Natural Resources. The BIA is responsible for complying with all federal statutes, orders, and regulations. According to the BIA, their obligation “is to protect and preserve the resources on the land, including the land itself, on behalf of the Indian landowners. Protection and preservation includes conservation, highest and best use, and protection against misuse of the property for illegal purposes. BIA will use the best scientific information available, and reasonable and prudent conservation practices, to manage trust and restricted Indian lands. Conservation practices must reflect local land management goals and objectives. Tribes, individual landowners, and BIA will manage Indian agricultural lands.” A summary of the BIA Range Policy as stated in the Agricultural and Range Management Handbook (2003), is outlined below.

BIA Range Policy

- Comply with the American Indian Agricultural Resources Management Act of December 3, 1993, as amended
- Comply with applicable environmental and cultural resources laws.
- Comply with applicable sections of the Indian Land Consolidation Act, as amended.
- Unless prohibited by federal law, recognize and comply with tribal laws regulating activities on Indian Agricultural land, including tribal laws relating to land use, environmental protection, and historic and/or cultural preservation.
- Manage Indian agricultural lands either directly or through contracts, compacts, cooperative agreements, or grants under the Indian Self-Determination and Education Assistance Act, as amended.
- Administer land use as set forth by 25 CFR 162 – Leases and Permits and 25 CFR 167-Navajo Grazing Regulations.
- Seek tribal participation in BIA agriculture and rangeland management decision-making.
- Integrate environmental considerations into the initial stage of planning for all activities with potential impact on the quality of the land, air water, or biological resources.

1.2.2 District Grazing Committees

Districts, formally called Land Management Districts, were established in 1936 by the Soil Conservation Service (now called Natural Resource Conservation Service, or NRCS) and adopted by the BIA. The Navajo Nation is organized into 110 Chapters. Chapters, or Communities, are locally organized entities similar to Counties and are the smallest political unit. District Grazing Committees consist of elected representatives from each Community within a district who are responsible for monitoring livestock grazing within their respective chapters. District Grazing Committees approve the carrying capacities of their districts.

Individual Grazing District Committee members are elected officials who are directly accountable to their local chapters and administratively accountable to the Director of the Navajo Nation Department of Agriculture (NNDOA). The NNDOA is also responsible for annual livestock tallies to determine if permittees are in compliance with their permit. In addition, the NNDOA and the district grazing committees are responsible for enforcement and resolving grazing disputes. The periodic sampling of rangelands allows district grazing committees to evaluate the carrying capacity and resulting stocking rates of rangelands (Goodman 1982).

1.3 Grazing Overview

Timing of grazing, movement, and dispersal of livestock, and animal numbers are all factors that must be considered when optimizing livestock production. Prior to considering these factors, managers should first recognize animals' ability to efficiently harvest the nutrients present in their surroundings. This

requires an understanding of foraging behavior as influenced by an animal's environment. Grazing patterns are dictated by topography, plant distribution, composition, and location of water, shelter, and minerals (Heitschmidt 1991). The total forage production of a given pasture or grazing area does not necessarily reflect the amount of forage available to livestock. Therefore, it is important to recognize specific factors that restrict forage availability such as inaccessibility, long distances to water, steep slopes, or other factors. Once identified, production from these areas can be subtracted from the total or adjustments can be made for inclusion of these areas. An example of this would be to develop additional water sources in areas rarely visited by livestock due to a scarcity of water.

After likely foraging patterns have been determined for a given area, production and forage value data can be used to help determine how many animals should be allowed to graze in the given area, which is a crucial step. Low stocking rates benefit individual animals as more resources are available due to lowered competition with other animals. Conversely, high stocking rates can inhibit the individual animal, but the increase in total livestock production allows for greater, short-term gains for the producer. The final stocking-rate decision must take into consideration the ecosystem as a whole. Maintaining long-term viable rangelands provides for the continued health of livestock and long-term financial gains for producers or permittees. Viable rangelands also provide for the continued health of the local air, water, and other ecological resources.

Grazing during the initial growing season, and late season grazing at the time of seed development, can be very detrimental to plant vigor and root development. This will remain a problem for rangeland managers as long as livestock grazing permits are issued for year round grazing. However, Holecheck (1999) argues that stocking rate has a much greater impact on range condition than the season of use.

Stocking rates are correlated with the prevention of overgrazing. When livestock, wildlife, and feral horses graze and browse on a site, they each select their own preferred species. If the site is stocked too heavily and for too long a time, the desired forage species will become overgrazed. These preferred species are weakened and their mortality rate increases, resulting in a reduction of their percent composition on the site. If deterioration continues, the less valuable forage species are replaced by invaders and noxious weeds.
In general, managers should be aware that the final products of this inventory are subject to a variety of factors. The application of stocking rates to determine carrying capacity should be used with care and in context to seasonal, topographic, and behavioral factors.

2. RESOURCE DESCRIPTIONS

Knowledge of the resource issues that affect rangeland health and productivity is essential to any management plan. Stocking rates, season of use, annual precipitation, soil types, location of water sources, and topography strongly influence the variety and quality of forage on rangelands. The data from this vegetative inventory quantify the current conditions of the rangelands on District 18. This information can be used to document future changes on the rangelands and assist with management decisions.

2.1 Geographic Setting

The project area is located within the Colorado Plateau Major Land Resource Area (MLRA 35). The study area surveyed is topographically and ecologically diverse—ranging from the wooded foothills of the Chuska Mountains around 8,600 feet in elevation to the washes at less than 6,000 feet under the sandstone cliffs and sand dunes south of Interstate 40. In between are rolling hills, grasslands, scrublands, and bottomlands. The area is about twice as long as it is wide, and runs parallel to the Arizona and New Mexico state line.

The Communities included in the study area are Crystal, Sawmill, Red Lake, Fort Defiance, Sait Michaels, Oak Springs, Houck, and Lupton. The towns of Window Rock and Fort Defiance lie within the study area, and Route 12 runs north/south through the study area. The study area includes acreage within the Navajo Nation Commercial Forest. This acreage was inventoried in 2005 and was excluded from the current inventory. However, data from the 2005 Commercial Forest study was extracted and used to analyze Range Management Units (RMUs) whose boundaries included Commercial Forest acreage. A map of the study area which illustrates the six grazing units, eight Communities, and the included non-Commercial Forest acreage, is provided in Map 1 on the following page.

Ecosphere
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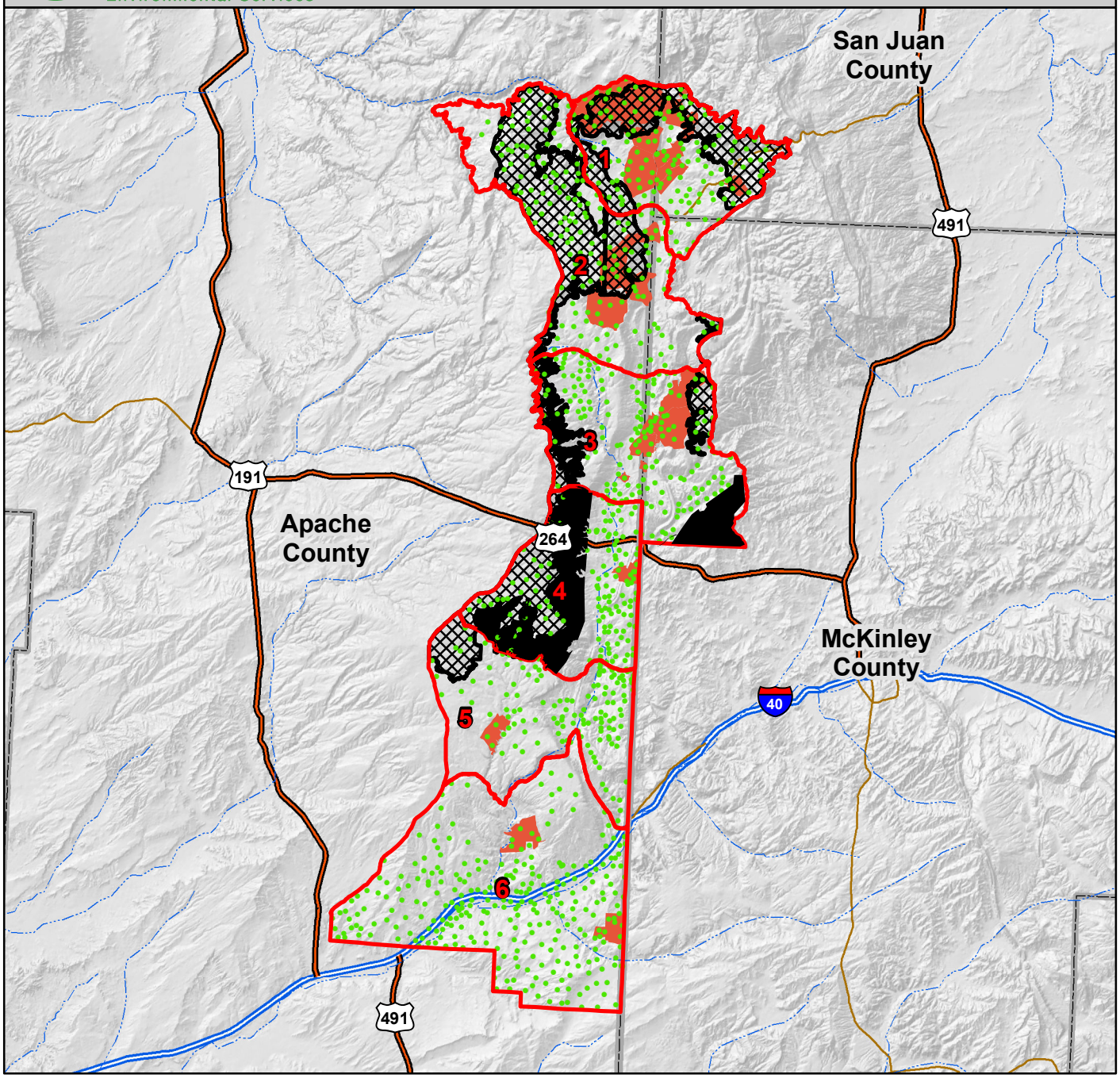
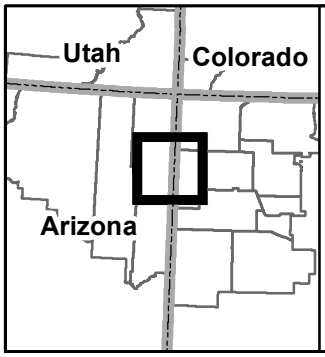
BIA Range Inventory





Limited Access
Highway
Major Road
Intermittent Stream
Transects
Grazing Unit
Commercial Forest
Excluded Area
RMU

0 5 10 20
Miles

1:700,000

DISTRICT 18

APACHE COUNTY, ARIZONA
SAN JUAN AND MCKINLEY COUNTIES
NEW MEXICO

OVERVIEW MAP

FIGURE 1

9/26/2011

UTM Zone 13 - NAD 83

Acreages for each grazing unit were extracted from digital shapefiles provided by the Ft. Defiance Agency. Due to the scale of mapping, occasional anomalies occur at the shapefile boundaries; the final acreage figures are consistent with soil survey boundaries. Table 1 shows acreages for the six grazing units including the acres of Commercial Forest that were not sampled, and the remaining non-Commercial Forest area that was sampled. This acreage includes RMUs within grazing district boundaries.

Table 1. District 18 Project Area Acres

Grazing Unit #	Grazing Unit Name	Total Acres	Commercial Forest Acres	Non-Commercial Forest Acres
1	CRYSTAL	74303.3	34066.9	40,236.4
2	RED LAKE/SAWMIL	112789.6	51080.4	61,709.3
3	FORT DEFIANCE	94618.9	11029.8	83,589.1
4	SAINT MICHAELS	75364.9	21463.3	53,901.6
5	OAKS SPRINGS	82463.4	7436.9	75,026.6
6	HOUCK/LUPTON	161080.2	0.0	161,080.2
	District 18	600620.4	125077.3	475,543.1

2.2 Geology

The Colorado Plateau is underlain primarily by relatively flat lying layers of sedimentary rock. The Colorado Plateau has been uplifted from its surroundings. During the uplift, the rivers flowing across the plateau cut into the bedrock, forming impressive geologic features and scenery such as extensive rock outcrops, canyons, cliffs, and volcanic remnants. Land Management District 18 is bordered by the Chuska Mountains in the northeast, the Defiance Plateau in the northwest, a Jurassic-era ridge to the east, and the southern portion below Interstate-40, which is primarily Pliocene continental rocks. Much of the underlying geology is sandstone from the Mesa Verde group, the San Rafael group, de Chelly sandstone, siltstone from the Chinle formation, and Mancos shale (USGS 2008).

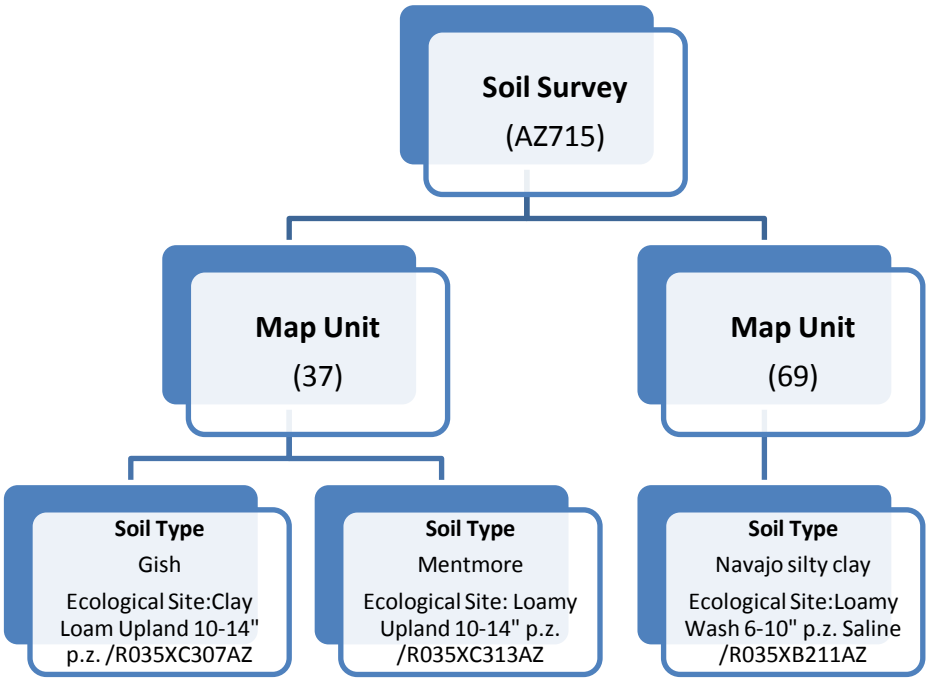
2.3 Soils

Knowledge of the soil properties in a particular area can help in predicting forage production. Soil properties such as texture, depth, moisture content, and capacity can dictate the type and amount of vegetation that will grow in that soil. The application of soil survey information is what enables rangeland managers to provide estimates of forage production in a given area.

The inventory project area is located almost entirely within the boundaries of a single soil survey produced by the United States Department of Agriculture, Soil Conservation Service, the Fort Defiance Area, Parts of Apache and Navajo Counties, Arizona and McKinley and San Juan Counties, New Mexico Soil Survey (AZ715). The soil surveys are Order III mapped at association or complex levels (also called soil map units). Finer levels (called soil types) are described, but not mapped. This is important to remember because each of the mapped soil units contains multiple soil types within it. We cannot spatially separate these finer levels (soil types) within the mapped units. The soil survey does describe the percentage of each soil type within a soil map unit, but not where the soil type is located within the soil map unit.

Each soil type is correlated with a specific ecological site. (See Section 2.6 for a description of ecological sites.) Ecological sites cannot usually be delineated or mapped directly from Order III map information because they are not associated with the soil map units, they are associated with the finer levels of unmapped soil types.

Furthermore, some of the associated ecological site descriptions that correspond to soils in these particular surveys are in draft form and have not yet been finalized. Soil surveys and ecological site descriptions are valuable for rangeland managers, as long as their limitations are understood. The following graph illustrates the hierarchy of *unmapped* soil types and their corresponding ecological sites within a *mapped* soil unit within a given soil survey. The examples in the graph are extracted from the soil survey used for this project.



It is worth noting that biological soil crusts occur occasionally throughout the study area. Biological soil crusts are a complex mosaic of organisms that weave through the top few millimeters of soil, gluing

loose particles together to stabilize and protect soil surfaces from erosive forces. Additionally, roughened soil surfaces created by biological crusts act to impede overland water flow, resulting in increased infiltration (Belnap et al. 2001). Biological soil crusts can provide a vital component for healthy, functioning soils.

2.4 Climate

The Colorado Plateau is quite arid. The average annual precipitation is 6 to 18 inches, although the project area generally receives 12 to 16 inches annual average. Most of the area follows a bi-seasonal weather regime characterized by summer and winter precipitation and fall and spring droughts. April, May, and June tend to be the driest months. Almost half of the precipitation occurs in the summer months from July through September, in the form of heavy rain storms with limited infiltration. Less intense storms bring significant precipitation in the winter months and contribute to groundwater recharge. The region is dominated by drying southwesterly winds. Temperatures average 46-49 degrees (F) annually, decreasing at the higher elevations.

2.5 Precipitation

An accurate precipitation monitoring system is essential to range management programs. Biomass production estimates are directly affected by precipitation measurements when reconstructing the plant community to a normal production year. If precipitation is overestimated in the reconstruction factor, the total annual production estimate decreases. If precipitation is underestimated in the reconstruction factor, the total annual production estimate increases.

Precipitation gauges are located throughout the Navajo Nation and data is managed by the Navajo Nation Division of Water Resources (NNDWR). The NNDWR provided ten years of precipitation data from several gauging stations in District 18. More details on the precipitation data are included in Section 3.3.2.3 Percent Normal Production.

2.6 Ecological Sites

An ecological site is a unique collection of the environmental factors responsible for its development, including characteristic soils, hydrology, and vegetation, all of which are interrelated (USDA NRCS 2010). The plant community on an ecological site is differentiated from other ecological sites by significant differences in species and species groups, and their proportional composition and production. Other factors include topography, climate, and environmental factors, or the response of vegetation to management.

Each ecological site description (ESD) describes the historic climax plant community (HCPC) that was present during European settlement of North America. This community is considered to be best suited to the local suite of environmental factors and able to equilibrate itself in response to those factors. Many rangelands have undergone significant change to the degree that they are never expected to

display the characteristics of the HCPC again. In their best condition, these rangelands would reach their potential natural community (PNC). PNCs may include non-native plant species and other factors which differentiate them from an HCPC on the same site.

Ecological sites are used to compare the rangeland in its best potential condition to the current condition measured during this study.

The ecological sites found at the District 18 study area transect locations are listed in Table 2. Those listed in **bold** were not yet developed and were unavailable at the time of the study.

Table 2. Ecological Sites in District 18 Study Area

1	**Clay Loam Flat 10-14" p.z. Sodic (R035XC309AZ)**
2	Clay Loam Upland 10-14" p.z. (R035XC307AZ)
3	Clayey Bottom 10-14" p.z. (R035XA104AZ)
4	Clayey Bottom 10-14" p.z. (R035XC305AZ)
5	Loamy Bottom 10-14" p.z. (R035XA112AZ)
6	Loamy Upland 10-14" p.z. (R035XC313AZ)
7	Loamy Upland 13-17" p.z. (R035XF605AZ)
8	Loamy Wash 6-10" p.z. Saline (R035XB211AZ)
9	Meadow 17-25" p.z. (R035XH821AZ)
10	Sandy Loam Upland 10-14" p.z. (R035XA117AZ)
11	Sandy Loam Upland 10-14" p.z. (R035XC317AZ)
12	Sandy Wash 6-10" p.z. (R035XB216AZ)
13	Shale Hills 10-14" p.z. (R035XC320AZ)
14	Shallow Loamy 10-14" p.z. (R035XC319AZ)
15	Shallow Loamy 13-17" p.z. (R035XF608AZ)
16	**Sandstone Upland 10-14" p.z. Shallow (JUOS) (F035XC322AZ)**
17	Sandstone Upland 13-17" p.z. (JUOS, PIED) (F035XF627AZ)
18	Sandy Loam Upland 13-17” p.z (JUOS, PIED) (F035XF628AZ)
19	Loamy Shallow 13-17” p.z. (PIED) (F035XF630AZ)
20	**Loamy Slopes 13-17”(PIED) (F035XF633AZ)**
21	**Breaks 13-17” (PIED) (F035XF629AZ)**
22	Sandstone Upland 17-25” p.z. (PIPO) (F035XH826AZ)
23	Sandy Loam Upland 17-25” p.z. (PIPO) (F035XH811AZ)
24	Loamy Upland 10-14" p.z (R035XA113AZ)
25	Sandy Upland 10-14" p.z. (R035XA118AZ)

26	**JUMO/ARTR-PUST/ACHY-HECO (F035XC323AZ)**
27	**JUMO-PIED/ARTR/ACHY-HECO (F035XF622AZ)**
28	**(F035XF602AZ) No name provided**
29	(F035XH818AZ) Sandy Loam 17-25" p.z. steep (PIPO, POTR5)
30	(F035XH827AZ) Sandstone Hills 17-25" (PIPO)
31	(FO35XH812AZ) Sandy Upland 17-25" (PIPO)
32	(R035XC302AZ) Sedimentary Cliffs 10-14"

The following are brief descriptions of the ecological sites extracted from the ecological site descriptions.

1. Clay Loam Flat 10-14" p.z. Sodic (R035XC309AZ)

The ecological site description was not developed during the data collection for this inventory. The site description was published in time for use in the analysis of the data.

This rangeland site occurs on alluvial flats, stream terraces, and valley floors at 5,900 to 6,700 feet in elevation. Slopes range from 0 to 8 percent. Soils are very deep and well drained. Soil surface textures ranges from loam to silty clay loam. The dominant plant community in the reference state is a grass-shrub mix dominated by *Pascopyrum smithii*, *Sporobolus airoides*, and *Atriplex canescens* with scattered *Sarcobatus vermiculatus*. Plant species most likely to invade on the site are cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola tragus*), rabbitbrushes (*Ericameria* spp., *Chrysothamnus* spp.) and annual weeds. Continous grazing on this ecological site will produce fewer preferred cool season grasses and more lower forage value grasses, forbs and shrubs.

2. Clay Loam Upland 10-14" p.z. (R035XC307AZ)

This site occurs as undulating plains and rolling hills. The site occurs in and upland position and does not significantly benefit from run-in moisture. Slopes range from 1 to 10 percent. Elevations range from 5,500 to 5,800 feet. The reference state plant community includes grasses with a small percentage of shrubs, half shrubs, and a canopy of *Juniperus* sp. trees. Dominant vegetation may include *Artemisia tridentata*, *Atriplex canescens*, *Bouteloua gracilis,* and *Pascopyrum smithii*. Other states may include shrubland with Juniper. Plant species most likely to invade or increase after continuous grazing and drought conditions are *Gutierrezia sarothrae, Salsola tragus, Cylindropuntia whipplei, Chrysothamnus greenii,* and *Ephedra cutleri*.

3. Clayey Bottom 10-14" p.z. (R035XA104AZ)

This site occurs in a bottom position with no entrenched channel. It benefits significantly from run-in moisture from adjacent areas. Landform includes alluvial flat. Soils are deep and have textures of fine sandy loam to clay. Slopes range from 0 to 5 percent, and elevations range from 5,500 to 6,500 feet. The reference community includes 70 to 80 percent grasses, 5 to 10 percent forbs and 10 to 15 percent

shrubs based on air dry weight. *Sporobolus airoides* dominates the plant community, with *Bouteloua gracilis* sub dominant. If the site is overgrazed, the *Sporobolus airoides* and *Bouteloua gracilis* will decrease along with *Pascopyrum smithii*, *Pleuraphis jamesii* and *Bouteloua curtipendula*. Likely to increase are *Aristida* spp., *Schedonnardus paniculatus*, *Muhlenbergia torreyi,* and inferior forbs and shrubs. State and transition models for this site are not yet developed.

4. Clayey Bottom 10-14" p.z. (R035XC305AZ)

This range site occurs in a bottom position with no entrenched channel, therefore it benefits from run-in moisture from adjacent areas. The soil of the site is deep—over 40 inches. Soil surface textures range from sandy clay loam to clay loam. Slopes range from 0 to 5 percent and elevations from 4,800 to 5,800 feet. Landforms include swales and stream terraces. This ecological site supports grassland interspersed with small amounts of shrubs in its reference state. Dominant vegetation may include *Atriplex canescens*, *Pascopyrum smithii,* and *Bouteloua gracilis*. Plant species most likely to increase or invade on this site when it deteriorates include *Artemisia tridentata*, *Ericameria* sp. and/or *Chrysothamnus* sp., *Gutierrezia sarothrae*, *Muhlenbergia richardsonis*, and annuals. State and transition models for this site are not yet developed.

5. Loamy Bottom 10-14" p.z. (R035XA112AZ)

This occurs in the bottom position of level to gently sloping flood plains with no entrenched channel. It benefits significantly from run-in moisture from adjacent areas. Slopes are always less than 5 percent. Elevation ranges from 5,500 to 6,500 feet. Landforms include flood-plain step and alluvial flat. Soils are deep, over 60 inches, with surface textures of fine sandy loam, sandy loam, loam, gravelly loam and sandy clay loam. The reference plant community is made up primarily of both cool and warm season grasses with a relatively small percentage of forbs and shrubs. Dominant vegetation may include *Atriplex canescens*, *Krascheninnikovia lanata*, *Pascopyrum smithii,* and *Muhlenbergia wrightii*. Plant species most likely to increase or invade on this site when it deteriorates include *Ericameria* sp. and/or *Chrysothamnus* sp., *Gutierrezia sarothrae*, annuals, cacti, and *Packera cana*. Continuous grazing during the winter and spring periods will decrease the cool season grasses, which are replaced by warm season, lower forage value grasses and shrubs. State and transition models for this site are not yet developed.

6. Loamy Upland 10-14" p.z. (R035XC313AZ)

This ecological site is found on fan terraces and the backslopes, footslopes, and summits of plateaus and mesas. The soil is deep to very deep with soil surface textures of fine sandy loam to loam. Slopes are predominantly 0 to 15 percent but can occasionally reach 30 percent. Elevations range from 4,800 to 5,800 feet. In its reference state, this site has a plant community consisting primarily of grasses with a moderate amount of shrubs. Dominant vegetation may include *Artemisia tridentata*, *Pascopyrum smithii,* and *Bouteloua gracilis*. Plants most likely to invade this site include *Artemisia tridentata*, *Gutierrezia sarothrae*, *Ericameria* sp. and *Chrysothamnus* sp., *Juniperus* sp., and annuals. State and transition models are in draft form for this site but include “snakeweed/annual grass/forb” and “snakeweed/exotic annual grass/annual forb”.

7. Loamy Upland 13-17" p.z. (R035XF605AZ)

This ecological site is found on stream terraces, draws, and fan terraces of undulating plateaus. The soil is deep to very deep with surface textures of loam and silt loam. Slopes range from 1 to 5 percent and elevations range from 5,500 to 7,000 feet. This site in its reference state is a grass-shrub mix. Dominant vegetation may include *Artemisia tridentata* ssp., *Bouteloua gracilis*, and *Pascopyrum smithii*. With severe disturbance, *Artemisia* sagebrush species will increase, along with *Gutierrezia sarothrae*, and *Vulpia octoflora,* and annual *Lupinus* sp. will invade. Other states for this site include "tree invaded, composite shrub/exotic annual grass/forb", and "tree invaded/composite shrub/exotic annual grass/forb".

8. Loamy Wash 6-10" p.z. Saline (R035XB211AZ)

This site occurs in a bottom position with no entrenched channel. It benefits significantly from run-in moisture from adjacent areas. Landforms include flood plains, alluvial fans, and playas. Soils are deep with surface textures of predominantly clay loam and clay, but with some other textures included. Slopes range from 0 to 5 percent and elevations from 4,500 to 5,500 feet. The reference community is primarily grasses and shrubs with a small percentage of forbs. Dominant vegetation may include *Atriplex canescens*, *Sporobolus airoides*, and *Pleuraphis jamesii*. Plant species most likely to invade or increase when the site deteriorates include *Alhagi maurorum*, *Sarcobatus vermiculatus*, *Atriplex confertifolia*, *Packera cana,* and annuals. State and transition models have not been developed for this site.

9. Meadow 17-25" p.z. (R035XH821AZ)

This site occurs on the toeslopes of undulating high plateaus and calderas. It has a seasonable water table at 2 to 3 feet. Soils are very deep with loam surface soil textures. Slopes range from 1 to 15 percent and elevations range from 8,400 feet to 9,200 feet. The reference state is a grass dominated with little bare ground meadow free of trees and shrubs, surrounded by ponderosa pine, and soils are wet for a majority of the year. Dominant vegetation may include *Pinus ponderosa*, *Symphoricarpos oreophilus*, *Quercus gambelii*, *Poa pratensis,* and *Carex duriuscula*. Drought and continuous heavy grazing may push reference state into an annual dominated state.

10. Sandy Loam Upland 10-14" p.z. (R035XA117AZ)

This ecological site occurs in an upland position on gently sloping plains or alluvial fans. It neither benefits significantly from run-in, nor experiences excessive runoff of moisture. Landforms include alluvial fans and plains. Soils are deep with surface textures of sandy loam to loamy sand. Slopes range from 0 to 10 percent, and elevations range from 5,500 to 6,500 feet. The reference state plant community is primarily war season grasses with some cool season grasses and half shrubs. Dominant vegetation may include *Atriplex canescens*, *Krascheninnikovia lanata*, *Bouteloua gracilis* and *Bouteloua eriopoda*. Other states include "exotic and shrub dominated", "juniper state", and "introduced exotics".

11. Sandy Loam Upland 10-14" p.z. (R035XC317AZ)

This site occurs on very deep well drained soils on terraces, hills, fans, and mesas. Soils are deep to very deep with surface textures of fine sandy loam, very fine sandy loam, and fine sand. Slopes range from 1

to 5 percent and elevations from 5,000 to 5,500 feet. Dominant vegetation in the historic climax plant community is primarily grasses such as *Achnatherum hymenoides* and *Hesperostipa comata,* with a small percentage of forbs and shrubs. Plant species most likely to invade or increase on this site when it deteriorates are *Gutierrezia sarothrae*, *Ericameria* sp., *Chrysothamnus* sp., and annuals. This ecological site has several known states and transition pathways.

12. Sandy Wash 6-10" p.z. (R035XB216AZ)

This site occurs in a bottom position with no entrenched channel. It benefits significantly from run-in moisture from adjacent areas. Slopes are less than 2 percent. Elevation ranges from 4,500 to 5,500 feet. Soils are deep. Textures are mixed but generally, the surface is loamy fine sand. Dominant species are primarily grasses with shrubs and trees, including *Populus fremontii*, *Atriplex canescens*, *Pascopyrum smithii,* and *Achnatherum hymenoides*. Plant species most likely to invade or increase when the site deteriorates are *Tamarix* sp., *Ericameria* sp. and *Chrysothamnus* sp., and *Salsola tragus*. State and transition models are yet to be developed.

13. Shale Hills 10-14" p.z. (R035XC320AZ)

This range site occurs in an upland position on footslopes, backslopes of canyon sides, and mesas. It does not benefit from run-in moisture and can be subject to significant runoff—especially where vegetation has deteriorated. Slopes range between 3 and 70 percent. Elevation ranges between 5,600 and 6,900 feet. Soils are shallow with surface textures of clay loam, clay, and very channery clay loam. The reference plant community includes a mixture of cool and warm season grasses with a fair percentage of forbs and shrubs. Dominant species may include *Atriplex confertifolia*, *Sporobolus airoides,* and *Pleuraphis jamesii*. Plant species most likely to invade or increase on this site when it deteriorates are *Pleuraphis jamesii, Bromus tectorum*, *Suaeda moquinii*, and annual forbs. Continuous livestock grazing use during winter and spring will decrease cool season grasses, which are replaced by lower forage value grasses and shrubs. State and transition models are yet to be developed.

14. Shallow Loamy 10-14" p.z. (R035XC319AZ)

This site occurs on gently rolling plateaus and structural benches. It includes the summits, backslopes, and toeslopes that are shallow to moderately deep (14 to 25 inches). Surface textures are usually loam but can also be fine sandy loam or sandy clay loam. The surface is usually gravelly. Slopes usually range between 1 and 15 percent, but may go as high as 25 percent. Elevations range between 4,500 and 6,000 feet. The reference plant community has a large component of warm season perennial grasses along with a smaller component of cool season perennial grasses. Mid shrubs are a large part of the community and *Artemisia tridentata* may comprise as much as one third of the total plant community. Dominant species include *Artemisia tridentata, Pleuraphis jamesii,* and *Bouteloua gracilis*. Other states may include" loss of perennial grasses", "invasion by exotics", and" introduced perennial grasses".

15. Shallow Loamy 13-17" p.z. (R035XF608AZ)

This ecological site is found on hills, plateaus, and mesas of limestone parent material. The soils are shallow and usually covered with gravel and small stones. Surface textures may be gravelly very fine

sandy loam to very gravelly loam. Slopes range from 1 to 15 percent and elevations range from 5,800 to 6,200 feet. The reference state plant community is a shrub-grass mix. With severe disturbance, *Bouteloua gracilis* and *Artemisia tridentata* will increase and *Bromus tectorum* and annual forbs will invade. Dominant species may include *Artemisia tridentata*, *Poa fendleriana,* and *Bouteloua gracilis*.

16. Sandstone Upland 10-14" p.z. Shallow (JUOS) (F035XC322AZ)

The ecological site description was not developed at the time of field data collection. The ecological site description was not published in time for analysis of this inventory.

This Forestland site occurs on shallow slopes of cuestas, benches, fan terraces and stabilized dunes of mesa and plateaus. Soils are shallow and well drained, with soil surface textures ranging from loamy fine sand to very channery loam. Depth to sandstone bedrock varies from 4 to 20 inches. Slopes range from 1 to 20 percent, elevations range from 5,000 to 6,800 feet. In the reference plant community, trees dominate the overstory, but grasses are common in the understory with a few perennial forbs and scattered shrubs. Continuous grazing in winter and spring will cause a decrease in high forage value cool season grasses. Dominant species may include *Juniperus osteosperma*, *Pinus edulis*, *Achnatherum hymenoides*, *Hesperostipa comata*, *Hesperostipa neomexicana*, *Bouteloua gracilis*, with *Artemisia bigelovii* and *Purshia stansburiana*.

17. Sandstone Upland 13-17" p.z. (JUOS, PIED) (F035XF627AZ)

This Forestland site consists of shallow to very shallow well-drained soils on plateaus and mesas. It is often located parallel to mesa and plateau rims, but can also be found on mesa tops where soils are shallow and rock outcrops common. This site receives runoff from sites with deeper soils above it. The site has high runoff potential so it will generate runoff to sites that lie below it. Slopes range from 1 to 35 percent, elevations range from 6,200 to 7,200 feet. Soil surface textures may be gravelly fine sandy loam, channery fine sandy loam, very fine sandy loam, or loam. In the reference plant community, trees dominate the overstory, but shrubs and grasses are common in the understory with 5-10 percent grasses, 5-10 percent shrubs, 1-5 percent forbs. Dominant species may include *Juniperus osteosperma*, *Pinus edulis*, *Artemisia tridentata*, *Ephedra viridis*, and *Poa fendleriana*. Other states include grass shrub dominated when most of the trees have been eliminated.

18. Sandy Loam Upland 13-17” p.z (JUOS, PIED) (F035XF628AZ)

This Forestland site is found on summit areas, treads of fan terraces on plateaus and footslopes of broad, stable landslides. The soils are deep to very deep with surface textures of very fine sandy loam and fine sandy loam. The slopes on the site range from 1 to 30 percent. Elevations range from 6,200 to 7,800 feet. Dominant species may include *Juniperus osteosperma, Pinus edulis, Artemisia tridentata, Purshia tridentata, Poa fendleriana,* and *Achnatherum hymenoides.* This woodland site has a canopy cover of 50 to 60 percent. Grasses make up 30-50 percent of the composition, forbs 5-10 percent, and shrubs 30-40 percent. Other phases can include a decreased overstory cover, grass, and shrub dominant, or a depauperate native understory usually arrived at by continuous heavy grazing. Other states include “introduction of exotic understory”, “heavy overstory/depauperate native understory”,

and “heavy overstory/mixed native and exotic understory”. Heavy overstory is usually a result of fire suppression and favorable climatic conditions.

19. Loamy Shallow 13-17” p.z. (PIED) (F035XF630AZ)

This Forestland site is found on summits of mesas, structural benches, and cuestas. The soils are shallow with surface textures of very flaggy, very fine sandy loam, and sandy clay. Slopes range from 5 to 45 percent. Elevations range from 6,300 to 8,500 feet. Dominant species may include *Pinus edulis, Juniperus osteosperma, Artemisia nova, Quercus gambelii, Poa fendleriana,* and *Bouteloua gracilis*. This woodland site in its reference state has an overstory dominated by *Pinus edulis*. The understory is dominated by shrubs 55 percent, then grasses 30 percent, followed by forbs 10 percent. Additional phases may include a grass and shrub dominant as a result of fire, and a depauperate native understory phase as a result of continuous heavy grazing. Other states include “introduction of exotic understory”, “heavy overstory/depauperate native understory”, and “heavy overstory/mixed native and exotic understory”. Heavy overstory is generally arrived at from fire suppression and favorable climatic conditions.

20. Loamy Slopes 13-17” (PIED) (F035XF633AZ)

The ecological site description has not been developed. No information is available.

21. Breaks 13-17” (PIED) (F035XF629AZ)

The ecological site description was not developed at the time of field data collection. The ecological site description was not published in time for analysis of this inventory.

This Forestland site is found on backslopes and escarpments of mesas and cuestas between 6,500 to 8,000 feet in elevation. Slopes range from 35 to 70 percent. Soils are shallow to moderately deep with surface textures of cobbly sandy loam and very cobbly clay loam. The reference state plant community is dominated by trees, with an understory of 25 percent grasses including *Poa fendleriana* and *Achnatherum hymenoides*. A few forbs at 5 percent including *Penstemon* spp. And *Astragalus* spp, and shrubs at 65 percent including *Cercocarpus montanus* and *Purshia tridentata*. State and transition models have not yet been developed for this site. Due to the steep slopes, the site is not good for livestock grazing.

22. Sandstone Upland 17-25” p.z. (PIPO) (F035XH826AZ)

This Forestland site is located on plateaus and mesas. Soils are typically shallow, with small inclusions of moderately deep soils. Surface textures are fine sandy loam and sandy loam. Slopes on the site range from 1 to 15 percent. The site is well drained and does not benefit significantly from run-on moisture from adjacent sites. Elevation ranges from 7,300 to 8,500 feet. The reference state plant community is dominated by mature Ponderosa pines. Shrubs are small, scattered, and make up less than 2 percent cover. Grass and forb species range from 5 to 30 percent cover. Other states include “no canopy, grass and forb dominated”. Dominant species may include *Pinus Ponderosa, Pinus edulis, Artemisia tridentata, Mahonia repens, Bouteloua gracilis,* and *Muhlenbergia Montana.*

23. Sandy Loam Upland 17-25" p.z. (PIPO) (F035XH811AZ)

This Forestland site is located on toeslopes, fan terraces, backslopes, and footslopes on stable landslides, plateaus, and mesas. Elevations range from 6,800 to 8,600 feet and slopes range from 1 to 15 percent. Soils are deep to moderately deep with soil surface textures of sandy loam, fine sandy loam, and loam. Soils with up to 25 percent content cobbles are common. The reference plant community includes a tree canopy cover of 40 to 55 percent with an understory of grasses, forbs, shrubs, and small trees. In the light overstory stage, Ponderosa pine seedlings are small and competing with grass, forbs, and shrubs. In the dense overstory stage, Ponderosa pine starts to shade and crown out grasses, forbs and most shrubs. Dominant species may include *Pinus ponderosa, Quercus gambelii, Artemisia tridentata, Bouteloua gracilis* and *Carex geophila*. Other states include "canopy removed, grass and forb dominated".

24. Loamy Upland 10-14" p.z (R035XA113AZ)

This ecological site occurs in an upland position as gently rolling plains, fans, and terraces. It neither benefits significantly from run-in nor experiences excessive loss of moisture from runoff. Slopes range from 0 to 30 percent. Elevations range from 5,500 to 6,500 feet. Soils are moderately deep or deep with surface textures of sandy loam to clay loam with various amounts of gravel on the surface. The reference plant community is composed primarily of warm season grasses with a small percentage of cool season grasses and half-shrubs. Phases include an increase of shrubs or more warm season dominated grasses. Dominant species may include *Juniperus osteosperma, Krascheninnikovia lanata, Atriplex canescens, Bouteloua eriopoda, Elymus elymoides*. Other states include a "juniper state" and "exotic and shrub dominated".

25. Sandy Upland 10-14" p.z. (R035XA118AZ)

This rangeland site occurs in an upland position as gently rolling plains and mesas. It neither receives a significant amount of run-in moisture nor experiences an excess of runoff moisture. Slopes run from 0 to 8 percent. Elevations range from 5,500 to 6,500 feet. Soils are deep and well-drained with surface textures of loamy sand or sand. Dominant species may include *Juniperus monosperma, Pinus edulis, Artemisia filifolia, Atriplex canescens, Achnatherum hymenoides,* and *Hesperostipa comata.* The reference state is native grassland composed primarily of cool season and warm season grasses with a small percentage of forbs and half-shrubs. Trees may be present but are widely scattered. Natural disturbances such as fire maintained the native grassland with a light overstory of woody vegetation. Phases include warm season dominant, and a larger component of shrubs. Other states include "introduced exotics-current potential", "shrub dominated state", "juniper state", and "juniper dominated".

26. (F035XC323AZ) No site name listed. Biological name: Juniperus osteosperma/Artemisia tridentata-Purshia stansburiana/Achnatherum hymenoides-Hesperostipa comata.

The ecological site description has not been developed. No information is available.

27. (F035XF622AZ) No site name listed. Biological name: Juniperus monosperma-Pinus edulis/Artemisia tridentata/Achnatherum hymenoides-Hesperostipa comata.

The ecological site description has not been developed. No information is available.

28. (F035XF602AZ) No site name listed. Biological name not listed.

The ecological site description has not been developed. No information is available.

29. (F035XH818AZ) Sandy Loam 17-25" p.z. steep (PIPO, POTR5)

This Forestland occurs on landforms of hills, mountain slopes and mountain valleys. Elevations range from 7,600 to 9,000 feet and slopes range from 25 to 90 percent. Soils can be shallow to very deep with soil surface textures of fine sandy loam, very flaggy loamy sand, very gravelly loam, and sandy loam. The reference plant community is dominated by tall trees of *Pinus ponderosa*, *Pseudotseuga menzeii* and *Populus tremuloides*, although north facing slopes may *includePicea pungens* and *Abies lasiocarpa*. Forbs and perennial grasses contribute light to medium cover. In other states, the canopy is removed and grasses, forbs and shrubs dominate. This site is suitable for summer grazing when the canopy is under 50 percent.

30. (F035XH827AZ) Sandstone Hills 17-25" p.z. (PIPO)

This Forest site is dominated by Ponderosa pine. It occurs on the slopes of plateaus and mesas. It is well drained and does not benefit significantly from run-in moisture from adjacent site and grasses, forbs. Slopes range from 15 to 35 percent. Elevations range from 7,300 to 8,500 feet. Soils are shallow to sandstone with surface textures of fine sandy loam; subsurface textures may be sandy clay loam and clay loam. The reference plant community includes dominant *Pinus ponderosa*, as well as *Pinus edulis*, *Pseuodotseuga menzeii* and *Quercus gambelii* in understory. Light to mid cover in forbs and perennial bunch grasses, primarily *Muhlenbergia montanus* and *Bouteloua gracilis*. Other phases and transitions may occur when mature canopy trees are removed through timber harvest or bark beetle infestation, resulting in higher production of grasses, forbs and some shrubs. Openings may be filled in by even aged stands of trees.

31. (FO35XH812AZ) Sandy Upland 17-25" p.z. (PIPO)

This ecological site occurs on the toeslopes of stable landslide areas, mountains and plateaus. Slopes are generally 1 to 15 percent but may reach as high as 25 percent. Elevations range from 7,600 to 8,600 feet. Soils are deep with surface textures of loamy fine sand, sand and fine sandy loam. The reference plant community includes a mature Ponderosa pine canopy with light cover in small shrubs, mid to high cover in perennial bunch grasses, and light to mid cover in forbs. Phases include a higher tree canopy cover, removal of Ponderosa canopy with grass and forb domination, and regeneration forming an even aged tight canopy of young trees. This ecological site is suitable for grazing during the summer and when tree canopy is less than 50 percent.

32. (R035XC302AZ) Sedimentary Cliffs 10-14" p.z.

This rangeland site occurs on steep canyon walls, small plateaus and breaks with excessive drainage. Slopes are greater than 30 percent. Elevations may range from 4,800 to 5,800 feet. Soils are shallow to very shallow with surface textures ranging from coarse to fine loams. The reference state a complex of trees, shrubs, forbs and grasses with a mixture of cool and warm season plants. Plants most likely to invade when the site deteriorates include *Artemisia tridentata*, *Gutierrezia sarothrae*, and *Juniperus* spp and cacti.

3. METHODOLOGY

The methods used to collect the data for this vegetation inventory included protocols provided by the BIA modified to standards used in federally published Technical References. The methodology used before, during and after field data collection are described in the following sections.

3.1 Pre-Field Methodology

Before the field work began for the inventory, preparations were made to establish a technically sound protocol for field data collection. To initiate the process the Statement of Work (SOW) was reviewed as were the technical references cited in the SOW, and a pre-work conference was held.

3.1.1 Document Review

Ecosphere reviewed the SOW provided by the BIA, which described the study design and specific methodologies for data collection. The SOW cited the following technical references:

Coulloudon, Bill, et al. 1999. Sampling Vegetation Attributes, Interagency Technical Reference 1734-4. Bureau of Land Management, Denver, Colorado.

Habich, E. F. 2001. Ecological Site Inventory, Technical Reference 1734-7. Bureau of Land Management, Denver, Colorado.

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2003. National Range and Pasture Handbook.

3.2 Field Methodology

3.2.1 Transect Establishment

Data collection in the field occurred between August **16** and October **19**, 2010. The BIA provided Ecosphere with predetermined transect locations. The Universal Transverse Mercator (UTM) coordinates of these transect locations were downloaded into handheld Global Positioning System (GPS) units. The GPS unit was used in combination with topographic maps to navigate by vehicle and foot to the transect locations. Transects were established within ten meters of the GPS coordinates, and usually within one or two meters. Some transects were located adjacent to private residences. These transects were moved to suitable locations within the same soil unit. The UTM coordinates of the new locations were recorded and are included with the GIS data set.

Transects consisted of a paced, linear 100 meter design. Each transect was placed within a single soil unit and vegetation community. The transect bearing was randomly determined by selecting a prominent distant landmark such as a mountain or lone tree. The transect azimuth was read with a compass and recorded. Transects were then paced along the transect azimuth. Vegetation attributes

were read from ten plots at ten meter intervals along the transect bearing. Each plot was established at the toe of the final pace. The plots were measured with a square 9.6 ft² quadrant frame. The 9.6 ft² plot is generally used in areas where vegetation density and production are relatively light (USDA NRCS 2003). Care was taken to avoid bias by establishing each plot using a consistent method, in this case always laying the frame to the right side. While pacing the transects, obstructions such as trees were avoided by sidestepping at 90° from the transect bearing and continuing to pace parallel to the transect. The original transect line was regained by sidestepping 90° in the opposite direction as soon as possible. Aspect, slope, soil surface, and relevant notes were recorded in addition to the vegetative attributes for each transect.

3.2.2 Production Data Collection

Production includes the above ground parts of all plants produced during a single growth year. Excluded are underground growth, production from previous years, and any increase in the stem diameter of shrubs. For the purposes of this study, production was measured as standing forage crop and reconstructed to peak standing crop. Standing forage crop is the total herbaceous and woody plant biomass present above ground and available to herbivores, while peak standing crop is the greatest amount of plant biomass above ground present during a given year (Coulloudon et al. 1999).

Production and composition of the plant communities were determined by a combination of estimating and harvesting (double sampling). Ecosphere followed the double sampling methodology of the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) modified to standards outlined in the SOW, and with modifications generated from the pre-work conference. This method is detailed in the following sections.

3.2.2.1 Establishing a Weight Unit

A weight unit is a part of a plant, an entire plant, or a group of plants of the same species used for estimation purposes. The weight unit method is an efficient means of estimating production. The field team adhered to the following procedure for establishing weight units on individual species: decide on a weight unit (in grams), visually select part of a plant, an entire plant, or a group of plants that will most likely equal this weight, harvest and weigh the plant material with a hand scale to determine actual weight, and repeat this process until the desired weight unit can be estimated with reasonable accuracy. The field team maintained proficiency in estimating by periodically harvesting and weighing to check estimates of production.

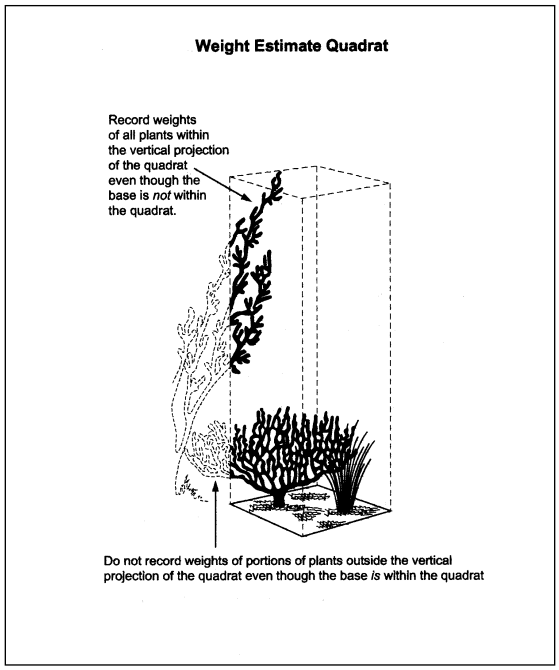
3.2.2.2 Double Sampling Methodology (Estimating and Harvesting)

Production (in grams) was estimated by counting the weight units of each species in each plot. All plants and parts of plants inside an imaginary box outlined by the actual 9.6 ft^2 frame up to a height of 4.5 feet were estimated. Excluded were any plants and parts of plants outside of the box (Figure 1). On plots 3 and 7, forage species were estimated *in situ* and then harvested at ground level. In some cases, forage species representing a significant percentage of the composition of the species throughout a transect

were not captured in plots 3 or 7. In such cases, if a species contributed ten grams or more of estimated production, but was not harvested in plots 3 or 7, a weight unit was estimated and clipped individually outside of the transect and recorded as plot 11. Clipped biomass was weighed with a hand scale, and both estimated and harvested (green) weights were recorded. All harvested materials were collected and stored in paper bags labeled with tracking information including transect, date, species, and plot number. All of the harvested material was allowed to air-dry for ten days or more before re-weighing to convert from field (green) weight to air-dry weight (ADW). The purpose of the double sampling is to correct any variability between the estimation of production and the actual weighed production. This results in an estimation correction factor which is calculated in the post-field methodology.

Figure 1. Weight Estimate Box

(Source: USDA NRCS 2003)



3.2.2.3 Sensitive Plants Protocol

Threatened, endangered, culturally important, or otherwise sensitive plants were never intentionally harvested for the purposes of this inventory. The weight of such plants was estimated, but the plants were not clipped. Cacti and yucca species were not clipped, their annual production was estimated using standard protocols as described in the National Range and Pasture Handbook (2003). Production for yuccas was considered 15 percent of total green weight. Cholla cacti production was considered 15 percent of active tissue, prickly pear ten percent, and barrel cacti five percent.

3.2.2.4 Ocular Estimates of Utilization

Utilization, or use, is the proportion of annual growth that has been consumed by grazing animals. The purpose of estimating utilization is to include in the vegetation measurements, the forage which has been consumed prior to the vegetation inventory. With the Ocular Estimation Method (Coulloudon et al. 1999a), utilization is determined by visual inspection of forage species. This method is reasonably accurate, commonly applied, and suited for use with both grasses and forbs. Field team personnel were trained and practiced in making ocular estimates of utilization of plants. An attempt was made to locate un-grazed plants near the transect. These un-grazed plants were assumed to approximately represent the species before grazing occurred. Ungrazed plants were used as a comparison to estimate grazed plants. Some re-growth may have occurred before the inventory period. However, if grazing patterns are undetectable on the plant, it is impossible to determine what re-growth, if any, may have occurred. The percentage of un-grazed plant remaining was recorded for each species on each transect.

3.2.3 Frequency Data Collection

Frequency describes the abundance and distribution of species. Frequency is the number of times a species is present in a given number of sampling units, usually expressed as a percentage. On rangeland, regeneration of desirable plants maintains good range conditions. Grazing by too many animals (livestock and wildlife), or heavy utilization by a few animals results in overuse, loss of vigor, and ultimately disappearance of the preferred and desirable plants. Deterioration of the range vegetation begins when less valuable forage species replace the desirable species. If deterioration continues, the less valuable forage species begin to be replaced by invaders and noxious weeds.

Frequency measurements are an easy and efficient method for monitoring changes in a plant community over time. Frequency was automatically recorded in the digital data each time a species was listed as occurring in a plot. Frequency data for every species is included in the data in Appendix A.

3.2.4 Cover Data Collection

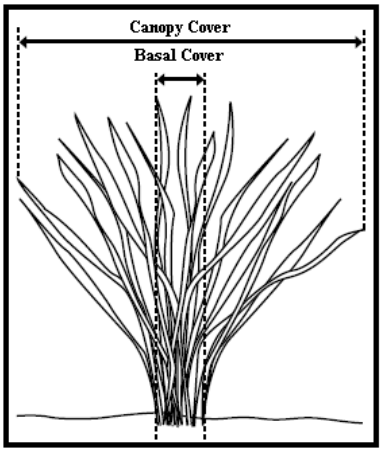
Ground cover measurements are used to quantify ground cover of litter, biological crusts, and soil surface condition. Cover is also important from a hydrologic perspective when the variables of interest may include basal and canopy (foliar) cover of perennial and annual species and litter cover. Cover data can assist in determining the proper hydrologic function of a site, as well as the biotic integrity of a site. For trend comparisons in herbaceous plant communities, basal cover is generally considered to be the most stable because while canopy cover can vary widely over the course of the growing season, basal cover does not vary as much due to climatic conditions.

The Point-Intercept method employed on this study consisted of a modified pin/point frame. At each plot along a transect a sighting device (pin flag) was placed in each of the four corners of the 9.6 ft^2 quadrant frame. Pin/point frames determine hits by recording the cover category intercepted by each of the pin points. A total of 40 hits were recorded from ten frame placements. Only the point of the pin

flag was used to record a hit. Emphasis was placed on lowering the pin directly over (perpendicular to the ground) in the corners of the quadrant frame as specified in technical reference 1734-4 Sampling Vegetation Attributes (Coulloudon et al.1999). Cover hits fell into the following categories: Basal Vegetation, Canopy Vegetation, Litter, Bare Ground, Rock/Gravel, and Biological Crust. A Basal Vegetation cover hit was recorded when the pin flag struck the ground surface occupied by the basal portion of the plants. Canopy Vegetation hits were recorded when the pin flag struck an area of ground covered by the projection of the outermost perimeter of the natural spread of foliage of plants (Figure 2). Litter hits were recorded when the pin flag intercepted herbaceous or woody plant debris. Bare Ground was recorded when the pin flag struck bare ground free of litter, vegetation, gravel or stone, or any biological crusts. Rock/Gravel was recorded when the pin flag intercepted gravel or stone free of vegetation. Measuring cover by points is considered one of the least biased and most objective cover measures (Bonham1989). Results of the ground cover data analysis are included in Section 4.0 Results.

Figure 2. Vegetative Cover

(Source: Elzinga, Salzer and Willoughby 1998)



3.2.5 Soil Surface Texture Test

At each transect in which there was a choice of soil types and ecological sites, the A Horizon (top 0”-6”) of the soil surface was sampled. The surface was cleared of debris to bare mineral soil. A small sample was analyzed using the USDA Soil Texturing Field Flow Chart. The flow chart uses a step-by-step procedure for estimating sand, silt, and clay content. The test also uses the ribbon method to determine the fraction of fine-grained particles within the sample. Field biologists assigned a texture class to the sample based on its tested content and ribbon characteristics.

3.3 Post-Field Methodology

The translation of a plot full of plants to a measure of pounds per acre is achieved through simple calculations. The formula, derived from technical reference 1734-7 Ecological Site Inventory (Habich

2001) and the National Range and Pasture Handbook (USDA NRCS 2003), reconstructs the measured weight of biomass to an annual air-dry production, which accounts for physical, physiological, and climatological factors.

First, the estimated green weight of a species is multiplied by an estimation correction factor, and then by the Reconstruction Factor. The Reconstruction Factor is the percent air-dry weight (%ADW) of the species divided by the result of the utilization multiplied by growth curve for that time of year and also multiplied by the percent of normal precipitation for the current water year during the time of data collection. This may be more easily understood with the formula below:

$$CorrectedGreenWeight\left(\frac{\%ADW}{(\%Utilization)(\%NormalPecipitation)(\%GrowthCurve)}\right)$$

The result is called the total reconstructed annual production. The details of each of the elements in this equation are explained in the following sections.

3.3.1 Estimation Correction Factor

The harvested or clipped plots provide the data for correction factors of estimated species weights from the field. Measured (clipped) weights of species were divided by the estimated weights of the same species in the same plots to establish a correction factor. This correction factor was then applied to all estimations of that species for the entire transect. For example, if *Sporobolus airoides* in plot 3 was estimated to weigh 10 grams (g), but the clipped weight was actually 9g, then all estimates of *Sporobolus airoides* for that transect would be multiplied by 0.90. If the total estimated weight for estimates of *Sporobolus airoides* on all plots in this transect was 80g, the resulting corrected weight would be 72g as illustrated below.

$$\textit{Correction Factor} = \frac{\textit{Sum of Measured Weights}}{\textit{Sum of Estimated Weights}} = \frac{9g}{10g} = 0.90$$

Thus, in the example: (estimated green weight(g) x correction factor) = 80g x 0.90 = 72g. The corrected green weight is 72 grams.

3.3.2 Biomass ADW Conversion

The air dry weight percentage is part of the Reconstruction Factor and accounts for the amount of water contained in the plants. The purpose is to remove the weight of water from the weight of the actual forage of the plant. All biomass from clipped plots was collected in paper bags with tracking information recorded on the bags (date, transect identification, plot number, and species). Clipped, or green, weights were immediately weighed with a hand scale, which was adjusted for the weight of the bag, and recorded. The paper bags filled with biomass were air-dried for a minimum of ten days. All bags were then weighed again and dry weights were recorded into the dataset. The weights after drying were

divided by the green weights to give a percent air dry weight (%ADW) in grams to be used in the Reconstruction Factor. In the example above, the green weight of the clipped biomass was 9g. If the dry weight in the lab was measured at 8g, then %ADW would be 0.888.

For species in a transect that were not clipped, an average %ADW was used, generated from the same species in the same community. In the case of remaining species the %ADW defaulted to one.

$$\%ADW = \frac{\text{Dry Weight (lab)}}{\text{Green Weight(field)}} = \frac{8g}{9g} = 0.8888$$

This value (0.8888) represents the numerator of the Reconstruction Factor. The three values in the denominator are explained below.

3.3.3 Utilization

The utilization estimate is applied to adjust for portions of plants which were not measured due to grazing of the plant prior to the survey. The default is 100 percent ungrazed. Grazed, or utilized, species were measured according to the average amount of plants which remained ungrazed in the vicinity of the transect. As an example, if *Sporobolus airoides* was recorded at a utilization factor of 90 percent ungrazed then the amount of *Sporobolus airoides* estimated would represent only 90 percent of the total amount of *Sporobolus airoides*.

Utilization = 0.9000

The total weight of the species in the transect is divided by 0.9 to bring the measured weight up to 100 percent.

3.3.4 Growth Curves

Growth curves are used to reconstruct the above-ground portion of a plant that has not yet reached its full growth potential for the season. The application of a growth curve accounts for the amount of forage which has not yet grown, and thus was not measured during the vegetation inventory. A measurement taken in June will be much less than a measurement of the same plant taken in September when the plant is nearing full growth. A growth curve calculates the average growth, by month, of plant species throughout the year within a specific region. For example, if *Sporobolus airoides* was measured in a transect during August, that measurement may represent only 88 percent of the full growth of that species.

Each growth curve entry was a pro-rated value according to the day of the month. For example, using the growth curve AZ3521, and a transect that was sampled August 21st, the first step would be to total the percentage of growth completed up to that date by adding up the monthly categories:

Feb (1%) +Mar(9%)+Apr(20%)+May(27%)+June(14%)+July(10%) for a subtotal of 81 percent of the growth curve completed before August.

Then, for the month of August, 21 days would need to be pro-rated and added to the total. The value is determined by dividing the percent of growth occurring in August (11 percent) by the 31 days that occur the month of August. This calculation yields a rate of .35 percent per day. The number of days that have occurred up to that date (21) is multiplied by the daily rate (.35 percent) for a total of 7.45 percent. This is added to the 81 percent that had occurred up to the end of July for a total of 88.45 percent of the growth curve completed.

Growth Curve = 0.8845

The growth curve for the example equation is 0.8845 percent. The total weight of the species in the transect is divided by 0.8845 to bring the measured weight up to 100 percent of growth for the year.

3.3.5 Percent Normal Production

The Percent Normal Production is directly affected by growing conditions. Precipitation amount and timing as well as temperature and their relations may have an impact on species production. Biomass production levels from year to year are not accurate without accounting for percent of normal production influences. We used the variation in precipitation as our percent of normal production. The factors of precipitation timing and temperature were not directly measured because they are extremely difficult factors to quantify and apply to biomass production since the impacts vary by individual species.

The Navajo Nation Water Resources Department provided ten years of precipitation data from several gauging stations in District 18. A water year is measured from October to September. Ideally, the 2010 water year would be compared to the average value of historical data from the previous ten consecutive years. However, for the gauging stations in District 18, there were several years of precipitation data that were incomplete and were disregarded for the analysis. For most of the precipitation gauges, the historical data consisted of water years 2001-2006 and sometimes 2009 if the data were complete.

Averaged data from a minimum of three gauging stations was applied to the transects in each grazing Unit. In Units 1 and 2, the following stations were used: Crystal Diversion, Crystal WX and NFPI. In management Units 3 and 4, the following gauging stations were used: Bonito ET, Blue Canyon Dam, Fort Defiance WMB, Coalmine Road, and Window Rock Zoo. Lastly, in management Units 5 and 6 there were three stations: Bowman's Park, Houck WX, and Lupton. The 2010 water year (October 2009 through September 2010) was higher than the historical average. The September 2010 cumulative water year for

Units 1 and 2 was 136 percent of normal, for Units 3 and 4 it was 113 percent of normal, and for Units 5 and 6 it was 138 percent of normal.

The 2011 water year data was incomplete for most precipitation stations, and therefore a group of only three gauging stations was averaged and applied to the entire District. Those stations were: Bonito ET, Coalmine Road, and Fort Defiance WMB. At the end of June, 2011, the percent of normal for these stations was 88.6%

The precipitation data is provided in Appendix C.

For our example calculation, we use a 109 percent of normal production. Now, our Reconstruction Factor is complete:

Reconstruction Factor = $\frac{0.8888}{(0.900 \times 1.02 \times 0.8845)} = 1.094$

The formula for the reconstruction factor, as explained above, is repeated here:

$$CorrectedGreenWeight\left(\frac{\%ADW}{(\%Utilization)(\%NormalPecipitation)(\%GrowthCurve)}\right)$$

When actual values from the example are inserted into the formula the equation becomes:

$$72g\left(\frac{0.8888}{0.900x1.02x0.8845}\right) = 72g \times 1.094 = 78.74g$$

The corrected green weight of *Sporobolos airoides* from the example above (72g) multiplied by the reconstruction factor (1.094) results in a total reconstructed annual production of 78.74 grams.

3.3.6 Conversion from Grams to Pounds per Acre

The conversion from the working unit of grams per transect into pounds per acre is factored into the formula. The conversion factor equals one and therefore is not explicitly written into the equation. The plot size, 9.6 ft^2, was repeated ten times in each transect, thereby creating 96 ft^2 of sampling area, which calculates into a 1:1 conversion (Coulloudon et al. 1999). Hence, in the example, there were 89.35 pounds per acre of *Sporobolos airoides*. The value 89.35 represents the total reconstructed annual production of the species in pounds per acre.

3.3.7 Calculating Cover

Cover was calculated by dividing the number of hits of a category (basal vegetation, canopy vegetation, rock/gravel, bare ground, litter, biological crust) by the total hits for the transect (40 hits). For example, if there were 20 hits of basal vegetation and 40 total hits, the percent cover for basal vegetation was 50 percent for that transect. Cover data was grouped by grazing unit. Cover data by ecological site can be compared to values in the ecological site descriptions. Cover data by grazing unit is useful only as a baseline or a snapshot of current conditions.

$$\frac{\text{20 “basal” hits/transect}}{\text{40 total hits/transect}} = 50\% \text{ Basal Cover}$$

3.3.8 Calculating Frequency

Species frequency was calculated when weights were estimated for the species in each plot. For example, if *Sporobolus airoides* occurred in six of the ten plots on a given transect, the frequency would be 60 percent. Frequency of species on each transect is included in the data in Appendix A. A list of all plant species recorded during the inventory is included as Appendix D. Also in Appendix D is a list of scientific collections made during the data collection.

3.3.9 Assigning Ecological Sites

Ecological sites are differentiated from each other based on significant differences in species and species groups of the characteristic plant community, and their proportional composition and production, as well as soil factors, hydrology, and other differences in the overstory and understory plants due to variations in topography, climate, and environmental factors or the response of vegetation to management. Each ecological site description (ESD) describes the historic climax plant community (HCPC) that was present during European settlement of North America. This community is considered to be best suited to the local suite of environmental factors and able to equilibrate itself in response to change factors. Some ESDs also describe transitional states of succession.

Ecological sites are directly associated with soil types. The determination of an ecological site for each transect was complicated due to inconsistencies of scale in the soil surveys. Each soil map unit (or complex) has multiple possible soil types within it. The Soil Survey was mapped at the soil complex scale (Order III), meaning that there up to three soil types inside of a mapped soil unit. The smaller soil types are not mapped. Each soil type has a single ecological site assigned to it. Therefore each soil unit, or map unit, has up to three ecological site possibilities.

“The type and size of map unit delineations, scale of data collection, sampling protocols, and date of the last inventory completed are all factors to consider when using existing soil surveys and rangeland inventories… [S]oil types, plant composition and production yield are representative for an area but may have significant dissimilar inclusions and/or change over time (BIA 2003).”

The soil type assignment/ecological site assignment for each transect was based on interpretation of the current vegetative community compared to the expected HCPC, as well as soil texture test results and the map unit descriptions from the Soil Survey. The transect data was compared to the HCPC of each possible ecological site for that soil map unit. In general, these ESDs represent the most up-to-date information available at the time of this study. It should be noted that they are also continually updated as new information is brought forth from field studies. For future studies, the most recent information should be collected from the NRCS. Approved and published ESDs are available on the internet at http://esis.sc.egov.usda.gov/.

3.3.10 Calculating Similarity Index

Each ecological site has a unique HCPC described in the ESD. The similarity index is a process of comparing the plant community that currently exists on the ground to the HCPC. The similarity index is expressed as a percentage. One hundred percent would mean that the current plant community is at its climax stage and represents 100 percent of what would be expected to be found on the site, while a lower percentage would indicate that the current vegetation community is dissimilar in species weight and composition from the HCPC. A similarity index was calculated for all transects that were assigned to ecological sites with available ESDs.

The plant community that is currently present on a site may never reach HCPC, but instead may have changed such that its final successional state would result in what is called a potential natural community, or PNC. The PNC, unlike the HCPC, is a result of natural disturbances and may include non-native species. For purposes of comparison the HCPC is used because this baseline has already been established for all ecological sites.

Each ESD lists a range of expected production for above-average years and below-average years for each species (or group of species) as well as the total annual production for the site. The median of the above-average and below-average is always used as the comparison production amount because all of the variable factors (such as above-average precipitation) have already been factored into the reconstruction process. This is the recommended and accepted method of calculating a similarity index. The sum total of these median values is used to compare the measured vegetation against the HCPC.

To calculate a similarity index, each plant species found on a transect was compared to the ESD. The ESD has an assigned production value for each species (or group of species) expected to occur in the HCPC. Production that is expected to occur in the ecological site (up to the maximum percent listed) is termed allowable production. If an individual species (or group of species) found on the transect is not listed in the ESD, no production is assigned or “allowed” from that species. For example:

1) A transect had 78.74 pounds/acre of *Sporobolus airoides*.
2) Based on the information in the ESD, the “Allowable” production for *Sporobolus airoides* is 50 pounds/acre.

3) No more than 50 pounds may be "allowed" to be counted towards the similarity index for the transect.
4) If the ESD had listed the allowable percentage of *Sporobolus airoides* at 200 pounds/acre, then all 78.74 pounds (and no more) would have been "allowed" to be counted towards the similarity index for the transect.

Thus, every species that occurred on the transect was compared against the ESD. If the species was not expected to occur in the ecological site, it was given a zero percent allowable production value. If the species was expected to occur on the site, it was assigned the maximum value "allowable" assigned in the ESD. The total pounds of each species was summed for the transect.

3.3.11 Calculating Available Forage

The forage value of a species is defined by a particular type of livestock in terms of palatability and the availability of the species. Only the values for common species are listed in the ecological site descriptions, however a comprehensive list of species from the Colorado Plateau area was developed by the Utah NRCS. This list was used to assign forage values to all species recorded in the data collection. The list is included with the data in digital data provided with this report. Species are grouped into five categories and each category is weighted accordingly. The five groups recognized by the National Range and Pasture Handbook (USDA NRCS 2003) are as follows:

- **Preferred** plants- These plants are abundant and furnish useful forage for a reasonably long grazing period. They are preferred by grazing animals. Preferred plants are generally more sensitive to grazing misuse than other plants and they decline under continued heavy grazing.
- **Desirable** plants- These plants are useful forage plants, although not highly preferred by grazing animals. They either provide forage for a relatively short period, or they are not generally abundant in the stand. Some of these plants increase, at least in percentage, if the more highly preferred plants decline.
- **Emergency** (or **Undesirable**) plants- These plants are relatively unpalatable to grazing animals, or they are available for only a very short period. They generally occur in insignificant amounts, but may become abundant if more highly preferred species are removed.
- **Nonconsumed** plants- These plants are unpalatable to grazing animals, or they are unavailable for use because of structural or chemical adaptations. They may become abundant if more highly preferred species are removed.
- **Toxic** plants- These plants are poisonous to grazing animals. They have various palatability ratings and may or may not be consumed. Toxic plants may become abundant if unpalatable and if the more highly preferred species are removed.

Species that can be injurious to livestock, regardless of their palatability, were also noted with the forage value.

In many cases, a species has more than one forage value according to the season of use. For example, *Poa fendleriana* is considered preferred in the spring, but desirable during the remainder of the year.

The District 18 range management currently allows for year round grazing so a single forage value is needed. For this inventory the *highest* value was chosen for each species. A more conservative estimate of the forage available could be made by using the lowest value.

3.3.11.1 Harvest Efficiency Factor

Each category of plants is assigned a harvest efficiency factor. The harvest efficiency factor accounts for production actually consumed by grazers and generally averages 25 percent on rangelands with continuous grazing (NRCS 2003). Not all annual production is available for livestock consumption due to trampling, loafing and other non-livestock factors such as loss to disease, insects or utilization by wildlife. Using NRCS guidelines, the harvest efficiency factors applied for this project were 35 percent for preferred plants, 25 percent for desirable, and 15 percent for undesirable/emergency plants. Nonconsumed and toxic species were excluded from the calculations. The harvest efficiency factor is applied to the amount of production within a management area and its purpose is to ensure watershed protection and sustainability of the range resource by limiting allocation of the available forage.

The available forage was calculated from the amount of production provided by preferred, desirable and undesirable/emergency plants, with harvest efficiency applied. Initial stocking rates were calculated from the available forage.

3.3.12 Initial Stocking Rates and Carrying Capacity

Stocking rate is the maximum number of kinds and classes of animals grazing a specific area of land for a specific period of time. Carrying capacity for rangeland management purposes defines the number of grazing animals (maximum stocking rate) that a specified area is able to support without depleting the forage resources of that area. Carrying capacity incorporates both domestic and wild grazing animals, and the capacity may vary annually in response to forage production.

Maximum stocking rates were derived from the preferred and desirable, and undesirable production with an application of harvest efficiency factors. The pounds of preferred, desirable, and emergency forage was incorporated into animal unit months (AUMs) or 912.5 pounds of forage per month (Ogle and Brazee 2009).

When assigning forage values to species found in the project area we used the highest forage value of any season. For example, *Bouteloua gracilis* is a desirable forage in the Spring and Summer but is only used as emergency forage in the Fall and Winter. Permits in District 18 are issued on a year-long basis. If we disregarded forage that is only available seasonally it would reduce overall stocking rate. The risk in treating this as a desirable species in a year-long grazing regime is overgrazing. Range managers issuing permits in the District 18 area need to use the transect data associated with the individual permit areas in order to more finely tune the carrying capacity. This includes looking at the seasons forage is

available, distance to water, slope within the permitted area, access, etc. For example, if a permitted area only has palatable species available to livestock in the Spring and Summer and there is no forage available during the Fall and Winter seasons, the area will likely be overgrazed at the end of the year and the resources could suffer permanent damage. Range managers will need to adjust numbers based upon forage available throughout the year.

Carrying capacities were calculated using the available forage. Carrying capacities were calculated by the acreage of each ecological site within a grazing unit. The soil units with which ecological sites are associated are not mapped. Therefore, acreage estimates for ecological sites were based on soil map unit descriptions. Soil map unit descriptions allocate percentages of the entire soil map unit to each individual soil component and therefore, for each ecological site within that soil map unit complex. For example, if there are 200 acres of the Mentmore soil unit, and 20 percent of the soil unit consists of soil type “yy” while 80 percent consists of soil type “zz”, then soil type “yy” is calculated as 40 acres, while soil type “zz” is calculated as 160 acres.

4. RESULTS

A total of 800 transects were located on the District 18 study area. It was discovered after the data were collected that 17 transects were located on Commercial Forest areas. Of those 17 transects, three were discarded due to their isolated locations and the remaining 14 were analyzed separately from the rest of the data. In the non-Commercial Forest area of District 18 six transects were in accessible areas (locked gates); data were collected for 777 transects. During analysis it became clear that there were discrepancies in the data caused by an inadequate random sample distribution. Several soil map units, ecological sites, and large tracts of land were not sampled. A GIS and statistical analysis provided the best placement for 75 additional transects in soil units that represented the most unsampled acres. The study area was analyzed by grazing unit, and ecological sites within those grazing units were analyzed for production and stocking rate calculations. Soil units were used as the unit of analysis for RMUs. Not all RMUs were sampled; certain range management units were removed from sampling based on the knowledge of D18 range managers in regards to fencing integrity and RMU status. Results for RMUs are provided in the RMU Addendum portion of this report.

For mapping purposes, the carrying capacities were calculated by soil map unit within each grazing unit. See accompanying Map Atlas.

The following table is a summary of results for the six grazing districts on the District 18 study area. The resulting stocking rates are initial rates that may require modification based on site-specific topography, current conditions and water sources.

Grazing Unit	Acres	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
1	25,845.3	126.0	3,568.3	7.2
2	55,362.2	60.4	3,662.8	15.1
3	64,687.3	74.2	5,260.0	12.3
4	30,637.0	70.1	2,354.9	13.0
5	73,150.1	68.4	5,482.3	13.3
6	155,159.6	106.2	18,056.1	8.6

4.1 Grazing Unit 1, Crystal

In Grazing Unit 1, 85 transects were used for analysis, including 35 transects from Commercial Forest within matching ecological sites. Fourteen ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 0 to 53.6 percent with a median of 24.7 percent similarity to the HCPC. There are 25,845.3 acres in this unit, excluding any

Commercial Forest areas. Twenty four soil units are represented in this unit, ranging from less than 11.6 acres to over 9,068 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

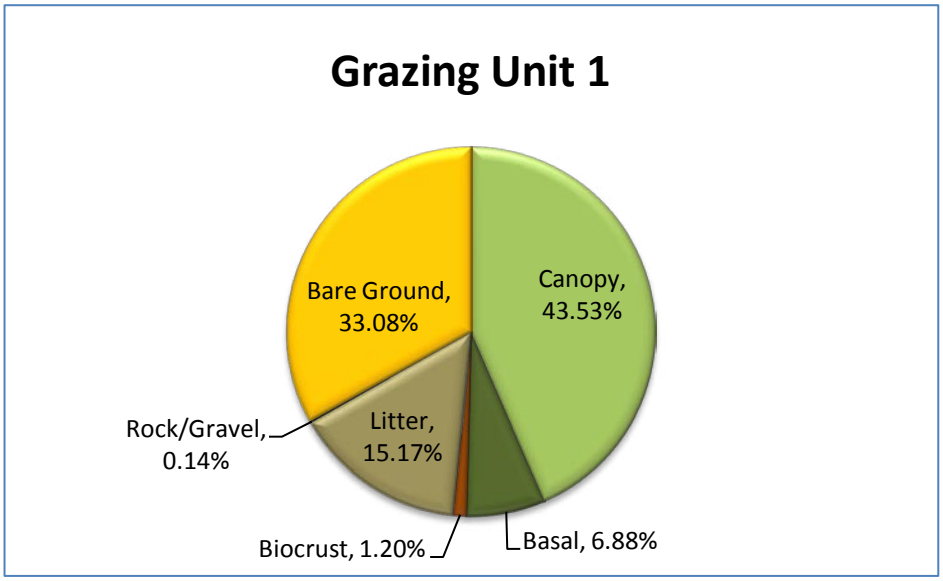
Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(R035XF605AZ) Loamy Upland 13-17"	696.3	192.7	152.4	6.0	71.8
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	379.5	25.5	85.8	10.6	127.7
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	100.84	95.99	24.00	38.0	456.3
(F035XF629AZ) Breaks 13-17" (PIED)	247.8	0.0	59.1	15.5	185.4
(F035XH811AZ) Sandy Loam Upland 17-25" (PIPO)	73.92	68.53	17.13	53.3	639.1
(F035XH818AZ) Sandy Loam 17-25" p.z. steep (PIPO, POTR5)	115.14	76.44	19.11	47.7	573.0
(F035XH826AZ) Sandstone Upland 17-25" (PIPO)	62.93	60.10	15.02	60.7	728.8
(FO35XH812AZ) Sandy Upland 17-25" (PIPO)	89.17	86.09	21.52	42.4	508.8
(R035XA112AZ) Loamy Bottom 10-14"	1449.1	52.6	362.5	2.5	30.2
(R035XA117AZ) Sandy Loam Upland 10-14"	805.7	201.1	106.0	8.6	103.3
(R035XC309AZ) Clay Loam Flat 10-14" Sodic	770.5	137.3	181.4	5.0	60.4
(R035XC313AZ) Loamy Upland 10-14"	990.5	203.6	267.1	3.4	41.0
(R035XF605AZ) Loamy Upland 13-17"	770.6	180.6	178.3	5.1	61.4
(R035XH821AZ) Meadow 17-25"	1273.9	128.2	264.1	3.5	41.5

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
102	459.8	7,144.3	15.5	7.8	58.7
114	1,208.0	228,776.6	189.4	250.7	4.8
120	38.3	1,157.8	30.3	1.3	30.1
125	1,373.0	362,577.6	264.1	397.3	3.5

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
130	976.4	15,644.0	16.0	17.1	56.9
131	114.9	1,333.2	11.6	1.5	78.7
132	50.1	-	-	-	-
137	19.5	2,070.2	106.0	2.3	8.6
27	1,225.7	184,164.6	150.3	201.8	6.1
3	11.6	919.3	78.9	1.0	11.6
32	245.7	18,278.0	74.4	20.0	12.3
4	1,094.6	79,789.3	72.9	87.4	12.5
51	259.8	5,259.9	20.2	5.8	45.1
52	38.3	730.6	19.1	0.8	47.8
54	371.7	6,573.0	17.7	7.2	51.6
55	880.4	15,014.5	17.1	16.5	53.5
74	9,068.1	1,610,569.0	177.6	1,765.0	5.1
75	1,514.3	169,890.8	112.2	186.2	8.1
76	126.9	6,472.7	51.0	7.1	17.9
77	17.2	218.7	12.7	0.2	71.8
78	2,547.8	452,514.1	177.6	495.9	5.1
86	3,568.5	85,636.7	24.0	93.8	38.0
90	584.6	106,052.3	181.4	116.2	5.0
99	50.1	1,347.4	26.9	1.5	33.9
Grazing Unit 1	**25,845.3**	**3,256,082.2**	**126.0**	**3,568.3**	**7.2**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.2 Grazing Unit 2, Red Lake and Sawmill

In Grazing Unit 2, 152 transects were used for analysis, including 86 transects from Commercial Forest within matching ecological sites. Sixteen ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 3.8 to 52.1 percent with a median of 26 percent similarity to the HCPC.There are 55,362.2 acres in this unit, excluding any Commercial Forest areas. Twenty two soil units are represented in this unit, ranging from 64 acres to over 11,000 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

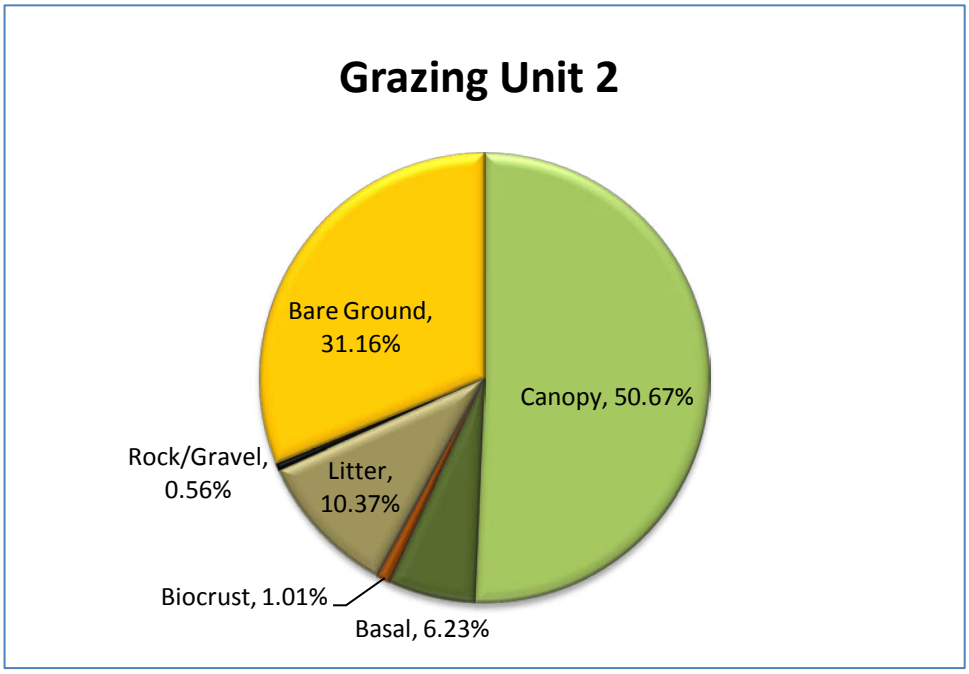
Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	65.52	60.53	15.13	60.3	723.6

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	60.31	59.09	14.77	61.8	741.2
(F035XH811AZ) Sandy Loam Upland 17-25" (PIPO)	86.92	70.55	17.64	51.7	620.9
(F035XH818AZ) Sandy Loam 17-25" p.z. steep (PIPO, POTR5)	29.20	28.55	7.14	127.8	1534.1
(F035XH826AZ) Sandstone Upland 17-25" (PIPO)	170.06	123.53	30.88	29.5	354.6
(F035XH827AZ) Sandstone Hills 17-25" (PIPO)	93.25	67.82	16.95	53.8	645.8
(R035XA104AZ) Clayey Bottom 10-14"	317.3	201.9	79.6	11.5	137.5
(R035XA112AZ) Loamy Bottom 10-14"	722.8	248.2	149.4	6.1	73.3
(R035XA117AZ) Sandy Loam Upland 10-14"	715.8	139.1	166.6	5.5	65.7
(R035XB211AZ) Loamy Wash 6-10" Saline	1020.6	164.7	227.3	4.0	48.2
(R035XC309AZ) Clay Loam Flat 10-14" Sodic	299.2	66.2	76.6	11.9	143.0
(R035XC313AZ) Loamy Upland 10-14"	737.0	243.1	148.2	6.2	73.9
(R035XC319AZ) Shallow Loamy 10-14"	357.8	161.3	88.5	10.3	123.7
(R035XC320AZ) Shale Hills 10-14"	601.9	32.6	85.2	10.7	128.6
(R035XF605AZ) Loamy Upland 13-17"	384.5	177.3	90.6	10.1	120.9
(R035XH821AZ) Meadow 17-25"	761.2	259.4	190.9	4.8	57.4

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
102		43,798.9	15.5	48.0	58.7
113		279.2	1.7	0.3	543.3
114		103,532.6	123.6		7.4
125		45,247.2	190.9	49.6	4.8
130		59,617.4	24.6	65.3	37.1
131		18,875.1	11.6	20.7	78.7
132		-	-	-	-
2		37,428.8	116.5	41.0	7.8
27		750,328.2	167.8		5.4
28		10,732.1	167.8	11.8	5.4
3		964,169.2	86.1		10.6
31		77,608.6	25.6	85.1	35.6
32		108,695.4	20.4		44.8
4		25,233.1	12.9	27.7	70.9
54		8,031.0	14.7	8.8	62.0
55		36,583.3	17.3	40.1	52.6
74		255,460.2	90.6		10.1
75		547,874.5	65.8		13.9
78		234,372.0	90.6		10.1

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
86		4,114.9	14.8	4.5	61.8
90	3,418.1	367,792.1	76.6	286.8	11.9
99		10,347.7	63.2	11.3	14.4
Grazing Unit 2		**3,342,329.4**	**60.4**		**15.1**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.3 Grazing Unit 3, Fort Defiance

In Grazing Unit 3, 149 transects were used for analysis, including 15 transects from Commercial Forest within matching ecological sites. Twenty one ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 0.1 to 51.9 percent with a median of 17 percent similarity to the HCPC.There are 64,687.3 acres in this unit, excluding any Commercial Forest areas. Thirty three soil units are represented in this unit, ranging from 3 acres to over 12,000 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

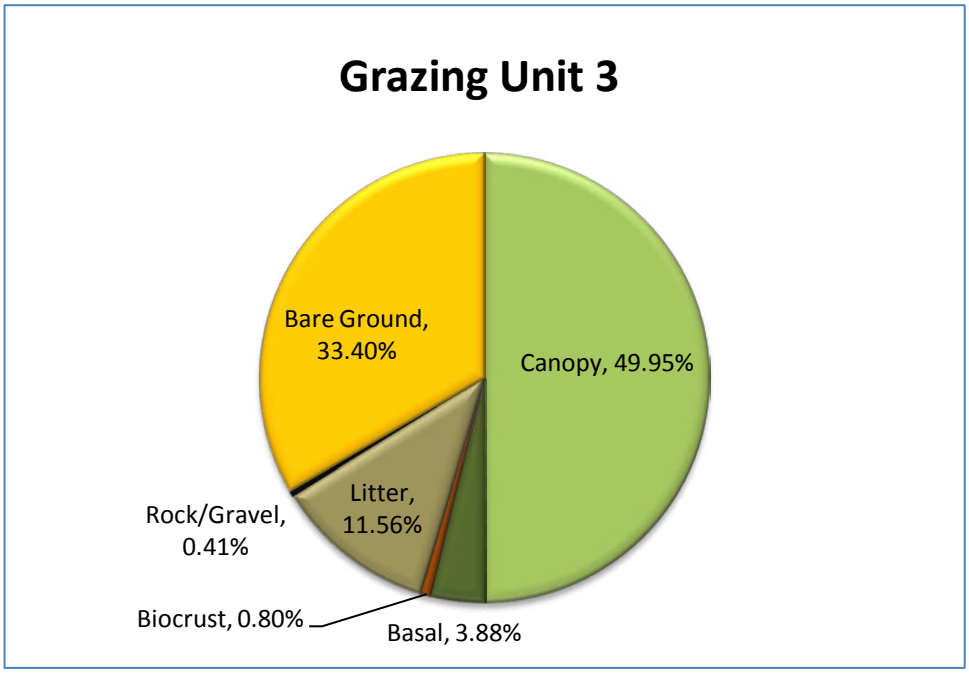
Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(F035XC322AZ) Sandstone Upland 10-14" Shallow (JUOS)	1587.5	0.0	86.2	10.6	127.0
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	550.7	34.7	151.7	6.0	72.2
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	70.04	69.57	17.39	52.5	629.6
(F035XF633AZ) Loamy Slopes 13-17" p.z (PIED)	80.6	0.0	13.6	66.9	803.0
(F035XH811AZ) Sandy Loam Upland 17-25"	116.27	84.49	21.12	43.2	518.4
(F035XH818AZ) Sandy Loam 17-25" steep (PIPO, POTR5)	24.90	24.90	6.22	146.6	1759.2
(F035XH826AZ) Sandstone Upland 17-25" (PIPO)	161.23	132.98	33.24	27.4	329.4
(F035XH827AZ) Sandstone Hills 17-25" (PIPO)	93.29	68.13	17.03	53.6	642.9
(R035XA104AZ) Clayey Bottom 10-14"	717.1	249.3	115.7	7.9	94.6
(R035XA112AZ) Loamy Bottom 10-14"	654.3	107.6	114.8	8.0	95.4
(R035XA117AZ) Sandy Loam Upland 10-14"	856.3	174.0	195.4	4.7	56.0
(R035XC302AZ) Sedimentary Cliffs 10-14"	111.1	106.8	24.6	37.0	444.3
(R035XC305AZ) Clayey Bottom 10-14"	400.1	216.9	88.8	10.3	123.3
(R035XC309AZ) Clay Loam Flat 10-14" Sodic	516.6	106.5	104.2	8.8	105.0
(R035XC313AZ) Loamy Upland 10-14"	728.4	172.4	155.0	5.9	70.7
(R035XC317AZ) Sandy Loam Upland 10-14"	859.1	82.5	192.9	4.7	56.8
(R035XC319AZ) Shallow Loamy 10-14"	294.1	179.2	72.4	12.6	151.2
(R035XC320AZ) Shale Hills 10-14"	145.9	32.1	21.8	41.9	502.8
(R035XF605AZ) Loamy Upland 13-17"	400.6	177.3	91.5	10.0	119.6
(R035XF608AZ) Shallow Loamy 13-17"	324.8	213.5	82.5	11.1	132.8
(R035XH821AZ) Meadow 17-25"	624.8	144.6	144.2	6.3	76.0

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
100		65,164.9	12.7	71.4	71.6
102		6,083.6	1.3	6.7	723.0
11		2,414.8	152.0	2.6	6.0
114		179,761.2	132.1		6.9
120		154,969.8	59.2		15.4
122		33,780.3	63.8	37.0	14.3
125		1,994.0	144.2	2.2	6.3
128		26,378.8	88.8	28.9	10.3
129		646.5	37.5	0.7	24.4
130		17,367.4	27.5	19.0	33.2
131		48,689.5	11.7	53.4	78.3
137		206,619.5	195.4		4.7
2		254,736.4	115.2		7.9
25	3.3	516.8	155.0	0.6	5.9
27		500,864.4	171.6		5.3
28	64.1	11,005.5	171.6	12.1	5.3
3		556,659.4	86.5		10.6
30		959.4	9.7	1.1	94.3
31		503,972.2	98.0		9.3
32		1,535,778.0	124.9		7.3
35		7,087.8	122.1	7.8	7.5
4		140,938.4	129.0		7.1
54		4,113.5	17.0	4.5	53.7
55		34,813.7	19.3	38.2	47.2
59		18,713.9	155.0	20.5	5.9
74		87,587.9	91.5	96.0	10.0
75		271,434.7	66.3		13.8
82		2,818.8	34.5	3.1	26.5
84		34,258.2	86.8	37.5	10.5
85		-	-	-	-
86		12,114.8	17.4	13.3	52.5
90	3,474.7	362,226.2	104.2	397.0	8.8
99		77,488.7	43.2	84.9	21.1
Grazing Unit 3		**4,799,732.9**	**74.2**		**12.3**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.4 Grazing Unit 4, Saint Michaels

In Grazing Unit 4, 127 transects were used for analysis, including 31 transects from Commercial Forest within matching ecological sites. Nineteen ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 0 to 51.2 percent with a median of 16 percent similarity to the HCPC.There are 30, 637 acres in this unit, excluding any Commercial Forest areas. Twenty five soil units are represented in this unit, ranging from 42 acres to over 4,200 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

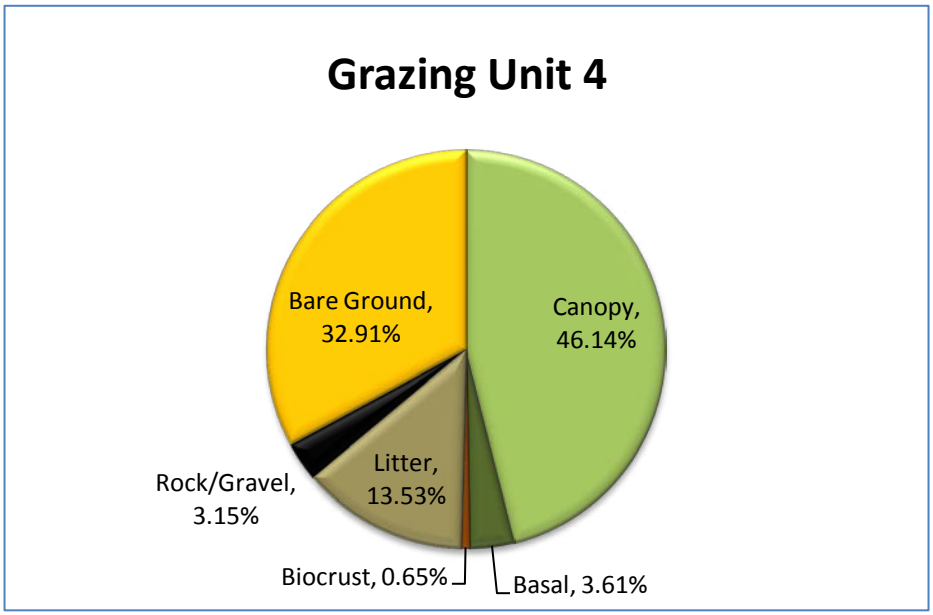
Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
"Doesn't Match Options"	1344.6	0.0	134.1	6.8	81.7
(F035XC322AZ) Sandstone Upland 10-14" Shallow (JUOS)	1589.6	0.0	375.4	2.4	29.2
(F035XF602AZ)	171.7	171.7	37.5	24.4	292.2
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	57.2	34.3	5.6	163.7	1964.5
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	188.84	60.03	15.01	60.8	729.7
(F035XF629AZ) Breaks 13-17" p.z. (PIED)	50.7	0.0	4.8	190.3	2283.3
(F035XH811AZ) Sandy Loam Upland 17-25"	64.14	51.36	12.84	71.1	852.8
(F035XH826AZ) Sandstone Upland 17-25" (PIPO)	98.74	84.82	21.20	43.0	516.4
(F035XH827AZ) Sandstone Hills 17-25" (PIPO)	62.19	46.73	11.68	78.1	937.2
(R035XA104AZ) Clayey Bottom 10-14"	1351.5	143.2	225.9	4.0	48.5
(R035XA112AZ) Loamy Bottom 10-14"	711.0	48.5	141.4	6.5	77.4
(R035XA117AZ) Sandy Loam Upland 10-14"	1117.1	71.5	166.4	5.5	65.8
(R035XB211AZ) Loamy Wash 6-10" Saline	662.9	12.0	121.1	7.5	90.4
(R035XB216AZ) Sandy Wash 6-10"	462.1	18.0	114.8	7.9	95.3
(R035XC309AZ) Clay Loam Flat 10-14" Sodic	827.5	90.1	178.8	5.1	61.3
(R035XC313AZ) Loamy Upland 10-14"	567.9	191.7	109.2	8.4	100.3
(R035XC317AZ) Sandy Loam Upland 10-14"	962.3	89.5	203.8	4.5	53.7
(R035XC319AZ) Shallow Loamy 10-14"	512.5	233.7	120.4	7.6	91.0
(R035XF605AZ) Loamy Upland 13-17"	577.8	221.5	95.7	9.5	114.4

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
100		5,321.9	12.7	5.8	71.6
102		3,090.5	1.3	3.4	723.0
114		341,798.4	182.2		5.0
120		16,085.7	7.6	17.6	120.0
122		17,498.3	63.8	19.2	14.3
129		82,156.3	37.5	90.0	24.4
131		790.9	8.0	0.9	114.2
2		256,397.6	181.2		5.0
26		39,715.0	112.3	43.5	8.1
27		571,644.6	150.6		6.1
28		27,436.4	150.6	30.1	6.1
30		6,894.7	9.7	7.6	94.2
31		19,579.6	20.6	21.5	44.4

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
32		56,255.6	13.4	61.6	68.2
37		24,790.4	101.5	27.2	9.0
4		2,868.4	4.7	3.1	192.6
55		1,874.8	13.9	2.1	65.7
59		297,821.2	109.2		8.4
69		6,077.0	121.1	6.7	7.5
74		231,488.9	95.7		9.5
75		19,731.6	68.5	21.6	13.3
78		4,052.4	95.7	4.4	9.5
86		4,286.0	15.0	4.7	60.8
90	2,127.5	380,327.4	178.8	416.8	5.1
99		111,167.4	164.9		5.5
Grazing Unit 4		**2,148,823.5**	**70.1**		**13.0**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.5 Grazing Unit 5, Oak Springs

In Grazing Unit 5, 130 transects were used for analysis, including 5 transects from Commercial Forest within matching ecological sites. Eleven ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 2.0 to 57.7 percent with a median of 25.5 percent similarity to the HCPC. There are 73,150.1 acres in this unit, excluding any Commercial Forest areas. Twenty soil units are represented in this unit, ranging from less than one acres to almost 19,000 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

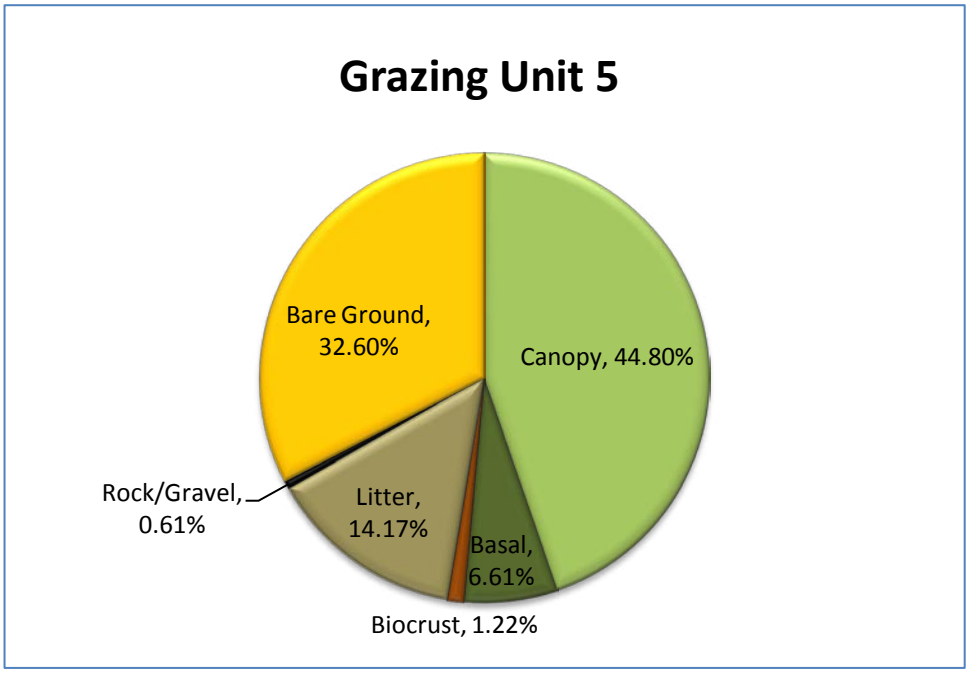
Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	605.1	124.6	122.8	7.4	89.2
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	440.3	182.7	99.7	9.2	109.9
(F035XH811AZ) Sandy Loam Upland 17-25" (PIPO)	191.2	29.9	30.3	30.1	361.1
(F035XH826AZ) Sandstone Upland 17-25" (PIPO)	264.7	58.1	55.8	16.3	196.2
(R035XA117AZ) Sandy Loam Upland 10-14"	878.6	104.4	214.7	4.3	51.0
(R035XC307AZ) Clay Loam Upland 10-14"	364.3	176.3	94.7	9.6	115.6
(R035XC313AZ) Loamy Upland 10-14"	665.7	233.3	138.1	6.6	79.3
(R035XC317AZ) Sandy Loam Upland 10-14"	655.1	114.1	157.8	5.8	69.4
(R035XC319AZ) Shallow Loamy 10-14"	229.0	143.8	51.2	17.8	214.0
(R035XF605AZ) Loamy Upland 13-17"	385.0	186.0	77.9	11.7	140.5
(R035XF608AZ) Shallow Loamy 13-17"	851.9	272.1	157.9	5.8	69.3

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
10	7,803.6	857,791.9	109.9		8.3
102	5,931.0	7,485.1	1.3	8.2	723.0
120	1,449.3	62,814.0	43.3	68.8	21.1
130	13,192.8	577,075.7	43.7		20.9
131	2,976.5	23,793.5	8.0	26.1	114.2
137	337.2	72,389.9	214.7	79.3	4.3
26	39.1	4,455.6	114.0	4.9	8.0
27	3,580.2	525,315.3	146.7		6.2
3	2,317.4	283,613.7	122.4		7.5
30	1,612.6	25,624.7	15.9	28.1	57.4
31	18,921.2	1,563,411.7	82.6		11.0
32	10,212.8	1,049,005.9	102.7		8.9
37	64.5	7,422.7	115.2	8.1	7.9
55	45.8	1,015.9	22.2	1.1	41.2
59	625.0	86,345.1	138.1	94.6	6.6
74	176.0	13,719.1	77.9	15.0	11.7
75	11,386.7	672,169.2	59.0		15.5
78	10.7	834.3	77.9	0.9	11.7
86	261.5	26,055.0	99.7	28.6	9.2
90	9.5	2,409.3	253.6	2.6	3.7
99	0.3	24.8	91.8	0.0	9.9
Grazing Unit 5	**73,150.1**	**5,002,571.1**	**68.4**		**13.3**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.6 Grazing Unit 6, Houck and Lupton

In Grazing Unit 6, 283 transects were used for analysis. Nineteen ecological sites were identified on transects in this unit. Similarity indices on each transect within an identified ecological site ranged from 0 to 56.5 percent with a median of 18.9 percent similarity to the HCPC. There are 155,159.6 acres in this unit. Thirty two soil units are represented in this unit, ranging from less than two acres to almost 46,000 acres.

Initial stocking rates are calculated by ecological site. As described in the methodology, each ecological site is associated with a soil type that is not mapped. Soil types are distributed throughout a mapped soil unit. The percentage of soil type in a soil map unit determines the number acres of a soil type and associated ecological site within a soil map unit. Available forage and initial stocking rates are calculated by ecological site, and combined into soil map units for spatial representation.

Reconstructed weight is the actual measured production. Total Allowable Weight is the production allowed to contribute to the similarity index. Available forage is calculated using forage preference values. Forage demand for one animal unit month (AUM) is 912.5 pounds, which multiplies to 10,950 pounds of forage demand year long.

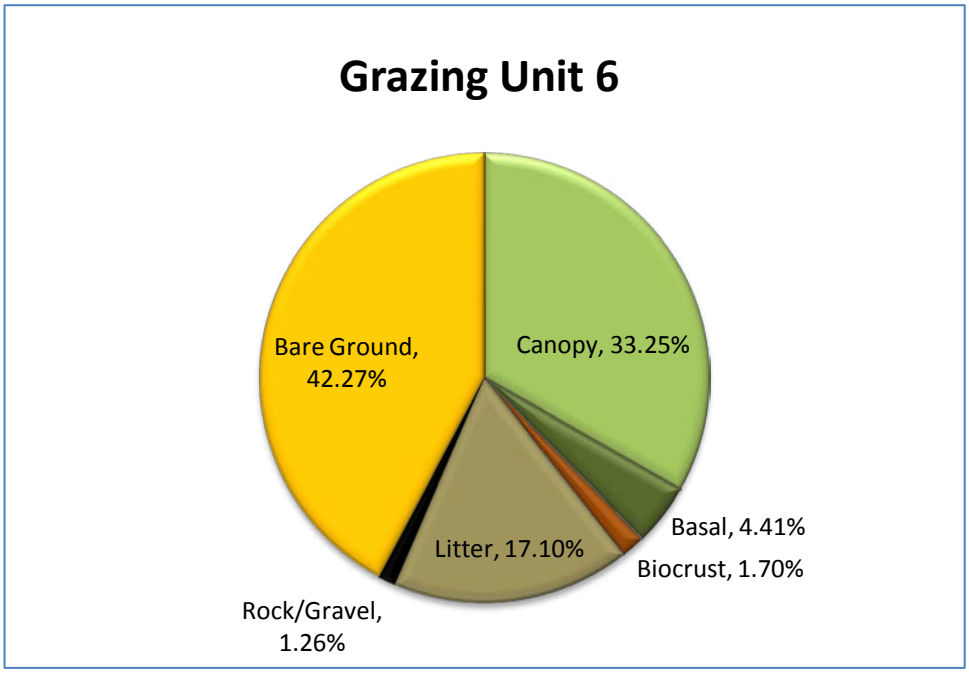
Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
"Doesn't Match Options"	732.6	23.2	150.8	6.1	72.6

Ecological Site Averages	Reconstructed weight	Total Allowable Weight	Available lbs/ac. for stocking rate	Acres/ AUM	Acres/AU Year Long
(F035XC322AZ) Sandstone Upland 10-14" p.z. Shallow (JUOS)	250.3	0.0	6.9	132.6	1590.7
(F035XC323AZ)	815.8	0.0	138.1	9.0	107.5
(F035XF622AZ)	191.0	191.0	46.5	19.6	235.7
(F035XF627AZ) Sandstone Upland 13-17" (JUOS, PIED)	322.9	33.0	33.5	27.2	326.6
(F035XF628AZ) Sandy Loam Upland 13-17" (JUOS, PIED)	554.7	141.3	110.1	8.3	99.5
(F035XF630AZ) Loamy Shallow 13-17" (PIED)	282.5	19.9	37.4	24.4	292.5
(R035XA104AZ) Clayey Bottom 10-14"	716.5	142.6	160.8	5.7	68.1
(R035XA112AZ) Loamy Bottom 10-14"	685.4	106.6	162.9	5.6	67.2
(R035XA113AZ) Loamy Upland 10-14"	743.8	134.0	161.9	5.6	67.6
(R035XA117AZ) Sandy Loam Upland 10-14"	642.3	155.0	124.7	7.3	87.8
(R035XA118AZ) Sandy Upland 10-14"	326.8	106.4	66.3	13.8	165.2
(R035XB216AZ) Sandy Wash 6-10"	394.1	140.1	92.0	9.9	119.0
(R035XC305AZ) Clayey Bottom 10-14"	1493.8	214.8	286.9	3.2	38.2
(R035XC309AZ) Clay Loam Flat 10-14" Sodic	1304.5	229.5	328.4	2.8	33.3
(R035XC313AZ) Loamy Upland 10-14"	614.8	159.5	110.0	8.3	99.6
(R035XC317AZ) Sandy Loam Upland 10-14"	593.9	130.2	109.9	8.3	99.7
(R035XC320AZ) Shale Hills 10-14"	670.9	67.5	35.8	25.5	306.3
(R035XF605AZ) Loamy Upland 13-17"	536.1	172.0	113.8	8.0	96.2

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
10	7,803.6	857,791.9	109.9		8.3
102	2,175.0	-	-	-	-
103	1,142.5	53,088.4	46.5	58.2	19.6
104	97.8	15,862.0	162.2	17.4	5.6
120	97.2	1,149.9	11.8	1.3	77.1
122	2,133.9	109,079.9	51.1		17.9
128	3,067.8	880,230.0	286.9		3.2
130	369.5	16,162.8	43.7	17.7	20.9
131	705.0	-	-	-	-
137	6,706.0	836,371.5	124.7		7.3
15	6,969.2	904,162.3	129.7		7.0
2	2,693.9	436,140.2	161.9		5.6
25	46.8	5,151.1	110.0	5.6	8.3

Soil Map Unit (MUSYM)	Acres	Total Available Forage	Stocking Rate (Acres/AUM)	Carrying Capacity (AUM)	Available Forage (Pounds/Acre)
26	265.7	24,886.2	93.7	27.3	9.7
27	2,072.1	227,793.9	109.9		8.3
31	40.8	1,444.0	35.4	1.6	25.8
32	6,077.3	209,337.5	34.4		26.5
4	744.3	21,211.9	28.5	23.2	32.0
55	888.7	15,157.3	17.1	16.6	53.5
59	1.8	201.3	110.0	0.2	8.3
6	5.0	-	-	-	-
74	924.9	105,250.7	113.8		8.0
75	9,845.2	769,519.8	78.2		11.7
77	213.4	17,104.2	80.1	18.7	11.4
78	198.7	22,608.5	113.8	24.8	8.0
80	45,961.0	6,776,605.9	147.4		6.2
84	14,746.2	1,948,761.6	132.2		6.9
86	17,697.2	1,948,300.4	110.1		8.3
87	400.6	23,345.6	58.3	25.6	15.7
90	3,430.0	1,128,764.7	328.4	1,237.0	2.8
97	58.6	-	-	-	-
99	17,579.9	249,436.6	14.2		64.3
Grazing Unit 6	**155,159.6**	**16,476,155.5**	**106.2**	**18,056.1**	**8.6**

Ground cover is not included in most of the ecological site descriptions for this study area. However, the ground cover figures presented here by Grazing Unit can provide a baseline for determining trend in future studies.



4.7 Commercial Forest Transects

Several transects were located on Commercial Forest areas. These areas were separated from the rest of the inventory. Four transects occurred in the Commercial Forest area of Grazing District 5, and ten transects occurred in the Commercial Forest area of Grazing District 2. Similarity indices on each of the ten transects in Grazing Unit 2 ranged from 5.7 to 34.8 percent with a median of 12.8 percent. The four transects in Grazing Unit 5 ranged from 6 to 13.8 percent, with a median of only 6.8 percent similarity to the HCPC.

There is no specific delineation of these areas for purposes of mapping and analysis.

Map Unit Symbol	Soil Map Unit Name

2	Aquima-Hawaikuh silt loams, 1 to 5 percent slopes
4	Atlatl-Nizhoni family-Rock outcrop complex 15 to 30 percent slopes
6	Badland-Claysprings family complex, 3 to 60 percent slopes

Ecological Site	Available lbs/ac. for stocking rate	Acres/AUM	Acres/Animal Unit (Year Long)
(F035XF630AZ) Loamy Shallow 13-17" p.z.	154.9	5.9	70.7
(R035XF605AZ) Loamy Upland 13-17" p.z.	86.2	10.6	127.0
(R035XC319AZ) Shallow Loamy 10-14" p.z.	62.8	14.5	174.3
(R035XH821AZ) Meadow 17-25" p.z.	67.3	13.6	162.7

5. DISCUSSION AND RECOMMENDATIONS

The most important recommendation that can be made as a result of this inventory is to caution against the direct application of carrying capacities provided in the results. The provided initial carrying capacities should be used as a guide to be adjusted appropriately with consideration of a variety of factors including the forage value ratings applied to the data, the seasonal palatability of forage, and the variability of precipitation.

5.1 Comparing Production

Potential production is the expected production of a particular ecological site. The potential production of a site is usually provided in the published ecological site description (ESD) with the soil survey. The information in the ESD is based on field data collected in sites with similar soils, climate, water resources, vegetation and land use. Comparing measured total annual production to potential production can be informative because it provides a measurable difference between current conditions and expected conditions.

Allowable production is production found on the ground at the site that was expected to occur in the HCPC. This information is based on the field data collected for development of the ESD. Allowable production may include production from preferred, desirable, and undesirable forage species, as well as toxic plants such as *Astragalus* species. Care should be taken to examine the allowable quantity of these species in ESDs because they can influence the perceived forage available of the rangeland. Allowable production is much more indicative of range condition than total annual production. The most accurate picture of current conditions can be made by comparing allowable production to expected production from the climax plant community. This can be accomplished with a similarity index. When possible, it is recommended that management objectives include monitoring of allowable production and comparing that data to the expected climax community.

5.2 Precipitation Data Collection

Because all production measurements are affected by annual precipitation, it is crucial that accurate precipitation data is applied to the production measurements. It would provide more accuracy to the annual production (and resulting stocking rates) if a more comprehensive record was available for multiple locations throughout the District. Managers should prioritize monthly data collection and record keeping in order to provide valid information to the district grazing committees.

5.3 Carrying Capacity and Stocking Rate Selection

"Although carrying capacity has important applications to management, shortcomings associated with its application should also be recognized. The primary complication in interpreting carrying capacity involves the incorporation of spatial and temporal variability. That is, both forage and animal intake are dynamic factors that vary according to site selection, time of sampling, species composition of the vegetation, utilization patterns, dietary preferences, livestock nutritive requirements, and resources available to the manager. Therefore, an evaluation of carrying capacity should be treated as a preliminary gauge to animal numbers for the management unit that will be revised in the light of monitoring information and immediate forage conditions." http://cals.arizona.edu/agnic/az/inventorymonitoring/carryingcapacity.html

5.3.1 Stocking Rates During Drought

Precipitation levels throughout the Southwest are indicative of drought. A ten year average used as "normal" comparison is likely still less than the 100 year average. A conservative initial stocking rate is appropriate under drought conditions. If there is very little precipitation during the winter and early spring numbers, stock numbers should not be permitted at the rate of a normal years' production. The same is true when an area endures several years of precipitation below normal levels.

The measure of forage production based upon a normal year allows managers to establish a "ceiling" or carrying capacity for their land. These measures should not be used to generate stocking rates when precipitation is below normal, especially during drought conditions. In a continuous grazing system, it is difficult to prepare for times of scarce moisture. Successful plans often implement a standard of light to moderate livestock numbers and adjust upwards as precipitation increases.

Range managers need to have the ability to increase stock numbers and reduce stock numbers based on current resource conditions. Ideally, permits would require an estimate of the current climate and production of the range resource at periodic intervals. Expected precipitation generally falls during late summer and winter, which would be good times to assess the rangelands. For example, if precipitation was below average during the winter, expected production in the spring and early summer will also be below average. The stock numbers should be adjusted promptly and accordingly. Further, the 2003 Navajo Nation Drought Contingency Plan (2003) clearly states that the reduction of animal numbers and improved range management is more likely to prevent overgrazing than providing supplemental feed and water.

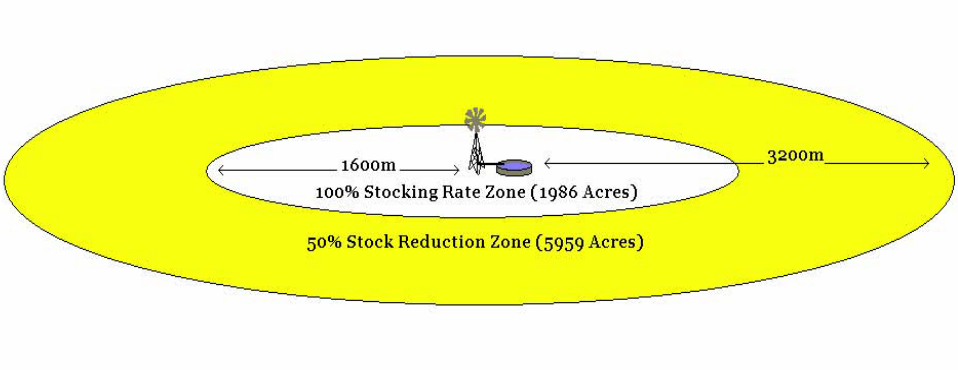
Drought is one of the biggest variables in Southwestern U.S. rangelands. Livestock operators must plan for drought as a normal part of the range-livestock business. Failure to prepare and manage before, during, and after drought conditions is probably one of the biggest reasons why range areas are in deteriorating or irreversible states.

5.3.2 Distance to Water

Forage utilization generally increases with proximity to water sources. Livestock managers should consider the number and locations of water sources within a rangeland management unit and adjust stocking rates accordingly. Areas further than 3,200 meters from a water source can be considered ungrazable, and that acreage should be removed from stocking rate calculations.

Livestock will rarely range more than 3,200 meters(m) from a water source. Holechek (1988) recommends no stocking rate reductions for the zone under 1,600 m from water, a 50 percent reduction for the zone 1,600 to 3,200 m from water. The zone over 3,200 m from water should be considered ungrazable (Figure 3). The area between 1,600 m and 3,200 m is 5,959 acres.

Figure 3. Stocking Rate Reduction Zones at Water Resources



Forage should be allocated only in areas within 3,200 m from a water source. Permitting in areas beyond 3,200 m will lead to overgrazing and deterioration. If permittees are hauling water to their stock, this should be considered when determining stocking rates. In these cases, utilization should be monitored more regularly at their grazing locations with permanent water sources (if any exist). Utilization should always be monitored within the 3,200 m from a water source. Care should be taken not to monitor utilization too close or too far from the water source to avoid skewed utilization data.

5.3.3 Other Considerations for Stocking Rate Selection

Control of livestock numbers (stocking rate) is the first and most important range management principle. As livestock graze, they reduce available forage both in quantity and quality, thereby changing the habitat and altering future animal/habitat relations. The timing and degree of forage utilization by animals are the principal controls over species composition and forage production in the manager's hands. Excessive forage utilization by livestock and/or wildlife reduces growth rates, weight gains, and animal values. "Coordination of forage utilization with forage growth through control of animal numbers usually determines the success or failure of other range practices and economic stability of the operation. This principle cannot be overemphasized" (Heady and Child, 1994). Numerous stocking rate experiments have shown that moderate and conservative stocking rates give greater long-term returns than does a high stocking rate. Long-term results include improved animal condition, additional wool

production, higher weaning weights, and correlated increased selling value. Wildlife directly competes with livestock for forage resources. Failure to account for wildlife in a management area when establishing a stocking rate will result in overgrazing and degradation of the resource.

Homesites, roads, and other unusable areas should be removed from the calculations of acres of rangeland. Inaccessible areas should also be removed from the total acreage calculations. Holecheck (1988) suggests that stocking rates should be reduced by 30 percent for slopes from 11 to 30 percent. Slopes from 31 to 60 percent should have a 60 percent reduction in stocking rates and slopes beyond 60 percent should be removed entirely from stocking rate calculations. In addition, areas of extensive bedrock should be removed from stocking rate calculations. If these areas are included in the total acreage available for grazing, then the areas that do contain available, accessible forage will be overgrazed.

5.4 Forage Values

The forage value of a species is not always constant throughout the year. However, for year-round grazing a single value is needed for calculations. For the District 18 project, the highest forage availability was used to calculate carrying capacity. For example, *Bouteloua gracilis* is a desirable forage in the spring and summer but only used as emergency forage in the fall and winter. Range managers issuing permits in the District1 8 area need to recognize species within the individual permit areas, and know their forage values, in order to more finely tune the stocking rates. For example, if a permitted area only has palatable species available to livestock in the spring and summer and there is no forage available during the fall and winter seasons, the area may be overgrazed during the fall and winter. Range managers should adjust numbers based upon forage available throughout the year. Forage values for a few species may be listed in the ESD's. The comprehensive list used to assign forage values for this inventory is included in the digital data with this report and should be referenced by rangeland managers to assess seasonal availability of forage.

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7. APPENDICES

Appendix A, Data

The data is available as Excel worksheets included electronically with this report.

Appendix B, Growth Curves

Arizona CRA Growth Curves
February 3, 2006
Prepared by Karlynn Huling, NRCS Arizona

Growth Curve Number	Growth Curve Name	Jan %	Feb %	Mar %	Apr %	May %	Jun %	Jul %	Aug %	Sep %	Oct %	Nov %	Dec %	Total %	Description
AZ3511	35.1 10-14" p.z. all sites	0	0	1	5	11	18	25	24	13	3	0	0	100	Growth begins in the spring and continues through the summer, most growth occurs during the summer rainy season.
AZ3521	35.2 6-10" p.z. all sites	0	1	9	20	27	14	10	11	5	3	0	0	100	Growth begins in the spring and continues through the summer, most growth occurs in the spring using stored winter moisture.
AZ3531	35.3 10-14" p.z. all sites	0	1	3	17	18	10	19	20	10	1	1	0	100	Growth begins in the spring and contines through the summer.
AZ3561	35.6 13-17" p.z. all sites	0	1	5	16	17	15	15	15	11	5	0	0	100	Growth begins in the spring and continues into the fall.
AZ3921	35.7 14-18" p.z. all sites	0	0	5	14	21	17	18	14	8	3	0	0	100	Growth begins in the spring and continues through the summer.
AZ3581	35.8 17-25" p.z. all sites	0	0	0	4	10	24	21	23	13	5	0	0	100	Growth begins in the spring, most growth occurs during the summer rainy season.
AZ3591	35.9 25-33" p.z. all sites	0	0	0	0	15	15	20	25	20	5	0	0	100	Growth begins in late spring and continues into the fall.

Appendix C, Precipitation as Percent of Normal

Grazing Units 1 and 2

Month	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-09	Nov-09	Dec-09
Little White Cone Historical	1.09	1.68	0.99	1.31	0.56	0.26	1.32	2.01	2.08	1.35	0.80	1.13
Crystal WX Historical	0.79	1.35	0.76	1.01	0.43	0.40	1.16	2.68	1.61	1.14	0.64	0.72
Crystal Diversion Historical	1.15	1.62	1.08	1.22	0.47	0.23	1.58	2.98	2.21	1.25	0.67	0.80
NFPI Historical	0.67	1.02	0.56	0.76	0.40	0.25	1.35	2.24	1.61	1.45	0.50	0.60
Historical Average	**0.93**	**1.42**	**0.85**	**1.08**	**0.46**	**0.29**	**1.35**	**2.48**	**1.88**	**1.30**	**0.65**	**0.81**
2010 Little White Cone	3.80	1.50	1.27	0.61	0.77	0.30	2.58	4.14	1.31	0.32	0.88	2.25
2010 Crystal WX	3.58	1.20	1.22	1.40	0.04	0.32	3.93	3.23	2.37	0.42	0.60	1.02
2010 Crystal Diversion	4.30	1.40	1.10	1.10	0.02	0.33	2.29	4.63	2.30	0.36	0.95	1.05
2010 NFPI	2.70	0.90	0.52	0.58	0.35	0.12	2.35	3.77	1.68	0.20	0.60	0.80
2010 Average	**3.60**	**1.25**	**1.03**	**0.92**	**0.30**	**0.27**	**2.79**	**3.94**	**1.92**	**0.33**	**0.76**	**1.28**
2010 Water Year Cumulative Percent of Normal	**161.7%**	**141.2%**	**138.3%**	**130.3%**	**126.2%**	**125.0%**	**137.0%**	**141.7%**	**136.2%**	**25.1%**	**55.6%**	**85.6%**

Grazing Units 3 and 4

Month	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-09	Nov-09	Dec-09	
Blue Canyon Dam Historical	0.64	1.17	0.74	0.80	0.13	0.64	1.83	1.99	2.39	0.82	0.74	0.78	
Fort Defiance WMB	0.86	0.99	0.68	0.63	0.74	0.42	1.88	1.82	1.71	0.91	0.44	0.79	
Coalmine Road	0.70	0.89	0.70	0.79	0.40	0.28	1.93	2.60	1.81	1.30	0.56	0.48	
Window Rock Zoo	0.91	0.97	0.82	0.73	0.52	0.26	1.18	2.26	1.86	1.07	0.86	0.63	
Combined Average	**0.78**	**1.00**	**0.74**	**0.74**	**0.45**	**0.40**	**1.70**	**2.17**	**1.94**	**1.02**	**0.65**	**0.67**	
2010 Blue Canyon Dam	3.40	1.10	0.55	0.68	0.00	0.20	2.07	3.23	1.85	0.28	0.62	1.25	
2010 Fort Defiance WMB	3.40	0.87	0.32	0.34	0.30	0.25	1.78	2.81	1.73	0.23	0.48	0.47	
2010 Coalmine Road	3.25	0.70	0.41	0.27	0.42	0.15	1.80	2.43	2.02	0.60	0.10	1.25	
2010 Window Rock Zoo	4.16	0.50	0.50	0.45	0.42	0.29	1.26	2.57	1.92	0.40	0.07	1.08	
Combined 2010 Average	**3.55**	**0.79**	**0.45**	**0.44**	**0.29**	**0.22**	**1.73**	**2.76**	**1.88**	**0.38**	**0.32**	**1.01**	
2010 Water Year Cumulative													
Percent of Normal	168.4%	146.6%	133.6%	123.7%	119.3%	115.3%	112.4%	115.6%	112.6%	36.9%	41.5%	72.8%	

Grazing Units 5 and 6

Month	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-09	Nov-09	Dec-09
Bowman Park Historical Avg.	0.98	1.65	1.24	0.85	0.37	0.42	1.23	2.22	1.48	1.09	1.03	1.47
Houck WX Historical Avg.	0.89	1.04	0.82	0.68	0.33	0.15	0.90	1.88	2.28	1.05	0.66	0.72
Lupton Historical Avg.	0.58	1.17	0.80	0.52	0.43	0.37	1.08	1.83	1.01	1.16	0.70	1.01
Three Station Histoical Average	**0.82**	**1.29**	**0.95**	**0.68**	**0.38**	**0.31**	**1.07**	**1.97**	**1.59**	**1.10**	**0.80**	**1.07**
Bowman Park 2010	4.38	1.90	0.38	0.62	0.35	0.10	1.75	5.30	1.75	0.40	0.42	2.00
Houck WX 2010	2.72	0.50	0.70	0.40	0.20	0.00	2.07	3.68	1.92	0.55	0.45	1.58
Lupton 2010	2.75	0.65	0.62	0.48	0.38	0.00	1.51	5.14	2.12	0.45	0.35	1.25
Three Station 2010 Average	**3.28**	**1.02**	**0.57**	**0.50**	**0.31**	**0.03**	**1.78**	**4.71**	**1.93**	**0.47**	**0.41**	**1.61**
2010 Water Year Cumulative Percent of Normal	152.6%	133.9%	122.1%	117.2%	115.3%	110.9%	117.8%	140.7%	138.1%	42.5%	46.1%	83.8%

2011 Data

Month	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-10	Nov-10	Dec-10
Bonito ET Historical	1.31	1.12	0.88	0.78	0.36	0.42	1.75	1.85	2.02	0.71	0.71	1.11
Coalmine Road Historical	0.93	0.85	0.50	0.73	0.42	0.29	1.76	2.09	1.69	0.88	0.41	0.89
Fort Defiance - WMB Historical	1.11	1.00	0.52	0.55	0.43	0.43	1.92	1.98	1.73	0.81	0.48	0.82
Historical Average	**1.12**	**0.99**	**0.63**	**0.69**	**0.40**	**0.38**	**1.81**	**1.97**	**1.81**	**0.80**	**0.53**	**0.94**
2011 Bonito ET	0.21	0.53	0.62	0.40	1.22	0.00	1.97			0.85	0.67	2.00
2011 Coalmine Road	0.25	0.70	0.44	0.59	0.79	0.05	1.95			0.80	0.15	1.15
2011 Fort Defiance WMB	0.28	0.63	0.50	0.68	1.06	0.03	3.85			0.99	0.31	1.32
2011 Average	**0.25**	**0.62**	**0.52**	**0.56**	**1.02**	**0.03**	**2.59**			**0.88**	**0.38**	**1.49**
2011 Water Year Cumulative Percent of Normal	**88.3%**	**82.5%**	**82.5%**	**82.3%**	**93.7%**	**88.6%**	**100.5%**			**110.1%**	**94.3%**	**120.8%**

Appendix D, Plant List and Collections

Collections made in the project area are listed in an Excel spreadsheet included with the data in Appendix A. Collections are stored in various herbariums, primarily the Navajo Nation Herbarium, located at the Deaver Herbarium in Flagstaff, Arizona under the care of the Navajo Nation botanist.

The following is a comprehensive list of the plant species recorded in transects during data collection in the project area.

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
ABRON	Abronia sp	N	Forb/herb		Desirable
ACMI2	Achillea millefolium	NI	Forb/herb	Perennial	Desirable
ACHY	Achnatherum hymenoides	N	Graminoid	Perennial	Preferred
ACHNA	Achnatherum sp				Preferred
ACRE3	Acroptilon repens	I	Forb/herb	Perennial	Emergency
AGCR	Agropyron cristatum	I	Graminoid	Perennial	Preferred
AGROP2	Agropyron sp				Preferred
ALLIU	Allium sp				Preferred
ALYSS	Alyssum sp				Unknown
AMAC	Amaranthus acanthochiton	N	Forb/herb	Annual	Desirable
AMAL	Amaranthus albus	I	Forb/herb	Annual	Desirable
AMBL	Amaranthus blitoides	I	Forb/herb	Annual	Desirable
AMARA	Amaranthus sp				Desirable
AMAC2	Ambrosia acanthicarpa	N	Forb/herb	Annual	Emergency
AMDU2	Ambrosia dumosa	N	Subshrub, Shrub	Perennial	Unknown
AMBRO	Ambrosia sp				Emergency
AMAL2	Amelanchier alnifolia	N	Tree, Shrub	Perennial	Unknown
ANSE4	Androsace septentrionalis	N	Forb/herb	Annual, Perennial	Emergency
ANTEN	Antennaria sp				Desirable
ARABI2	Arabis sp				Desirable
ARENA	Arenaria sp				Emergency
ARAR6	Aristida arizonica	N	Graminoid	Perennial	Emergency
ARLO16	Aristida longispica	N	Graminoid	Annual	Emergency
ARPU9	Aristida purpurea	N	Graminoid	Annual, Perennial	Emergency
ARIST	Aristida sp				Emergency
ARCA12	Artemisia campestris	N	Forb/herb	Perennial	Desirable
ARCA14	Artemisia carruthii	N	Forb/herb	Perennial	Desirable
ARDR4	Artemisia dracunculus	N	Subshrub,	Perennial	Preferred

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
			Forb/herb		
ARFI2	Artemisia filifolia	N	Subshrub, Shrub	Perennial	Desirable
ARFR4	Artemisia frigida	N	Subshrub	Perennial	Preferred
ARLU	Artemisia ludoviciana	N	Subshrub, Forb/herb	Perennial	Desirable
ARNO4	Artemisia nova	N	Subshrub, Shrub	Perennial	Preferred
ARTEM	Artemisia sp				Emergency
ARTR2	Artemisia tridentata	N	Tree, Shrub	Perennial	Desirable
ASCLE	Asclepias sp				Toxic
ASSU2	Asclepias subverticillata	N	Forb/herb	Perennial	Toxic
ASCA9	Astragalus calycosus	N	Forb/herb	Perennial	Toxic
ASHU2	Astragalus humistratus	N	Forb/herb	Perennial	Toxic
ASMO7	Astragalus mollissimus	N	Forb/herb	Perennial	Toxic
ASTRA	Astragalus sp				Toxic
ATCA2	Atriplex canescens	N	Shrub	Perennial	Preferred
ATCO	Atriplex confertifolia	N	Subshrub, Shrub	Perennial	NonConsumed
ATPO2	Atriplex powellii	N	Forb/herb	Annual	Preferred
AVFA	Avena fatua	I	Graminoid	Annual	Preferred
BADI	Bahia dissecta	N	Forb/herb	Annual, Biennial, Perennial	Unknown
BASSI	Bassia				Desirable
BOBA2	Bouteloua barbata	N	Graminoid	Annual	Preferred
BOER4	Bouteloua eriopoda	N	Graminoid	Perennial	Preferred
BOGR2	Bouteloua gracilis	N	Graminoid	Perennial	Desirable
BOSI2	Bouteloua simplex	N	Graminoid	Annual	Preferred
BRIN2	Bromus inermis	NI	Graminoid	Perennial	Preferred
BROMU	Bromus sp				Preferred
BRTE	Bromus tectorum	I	Graminoid	Annual	Preferred
CAGU	Calochortus gunnisonii	N	Forb/herb	Perennial	Preferred
CANU3	Calochortus nuttallii	N	Forb/herb	Perennial	Preferred
CALOC	Calochortus sp				Desirable
CAMIS	Camissonia sp				Unknown
CANU4	Carduus nutans	I	Forb/herb	Biennial, Perennial	NonConsumed
CAGE	Carex geophila	N	Graminoid	Perennial	Preferred
CAREX	Carex sp				Desirable
CAAN7	Castilleja angustifolia	N	Subshrub, Forb/herb	Perennial	Desirable
CALI4	Castilleja linariifolia	N	Subshrub, Forb/herb	Perennial	Desirable

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
CASTI2	Castilleja sp				Desirable
CENCH	Cenchrus sp				Injurious
CHER2	Chaetopappa ericoides	N	Subshrub, Forb/herb	Perennial	Desirable
CHAMA2	Chamaebatiaria sp				Unknown
CHER	Chamaerhodos erecta	N	Forb/herb	Biennial, Perennial	Desirable
CHCO2	Chamaesaracha coronopus	N	Subshrub, Forb/herb	Perennial	Unknown
CHAL11	Chamaesyce albomarginata	N	Forb/herb	Perennial	Unknown
CHFE3	Chamaesyce fendleri	N	Subshrub, Forb/herb	Perennial	Unknown
CHPA28	Chamaesyce parryi	N	Forb/herb	Annual	Unknown
CHAMA15	Chamaesyce sp				Unknown
CHAL7	Chenopodium album	NI	Forb/herb	Annual	Desirable
CHDE	Chenopodium desiccatum	N	Forb/herb	Annual	Desirable
CHGR2	Chenopodium graveolens	N	Forb/herb	Annual	Desirable
CHLE4	Chenopodium leptophyllum	N	Forb/herb	Annual	Preferred
CHENO	Chenopodium sp				Desirable
CHDE2	Chrysothamnus depressus	N	Subshrub	Perennial	Desirable
CHGR6	Chrysothamnus greenei	N	Shrub	Perennial	Desirable
CHVI8	Chrysothamnus viscidiflorus	N	Shrub	Perennial	Desirable
CIRSI	Cirsium sp				Injurious
CIWH	Cirsium wheeleri	N	Forb/herb	Perennial	Injurious
CLSE	Cleome sarrulata	N	Forb/herb	Annual	Desirable
CLEOM	Cleome sp				Desirable
COUMP	Comandra umbellata pallida	N	Subshrub, Forb/herb	Perennial	Emergency
COAR4	Convolvulus arvensis	I	Vine, Forb/herb	Perennial	Preferred
COCA5	Conyza canadensis	N	Forb/herb	Annual, Biennial	Desirable
CORA5	Cordylanthus ramosus	N	Forb/herb	Annual	Unknown
CORDY	Cordylanthus sp				Unknown
COWR2	Cordylanthus wrightii	N	Forb/herb	Annual	Unknown
COVI9	Coryphantha vivipara				Injurious
CROTO	Croton sp				Emergency
CRTE4	Croton texensis	N	Forb/herb	Annual	Emergency
CRCI3	Cryptantha cinerea	N	Subshrub, Forb/herb	Perennial	Emergency
CRCR3	Cryptantha crassisepala	N	Forb/herb	Annual	Emergency

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
CRFE3	Cryptantha fendleri	N	Forb/herb	Annual	Emergency
CRYPT	Cryptantha sp				Emergency
CUSCU	Cuscuta sp				Unknown
CYLIND	Cylindropuntia sp				Injurious
CYWH	Cylindropuntia whipplei	N	Shrub	Perennial	Injurious
CYMOP2	Cymopterus sp				Toxic
CYPER	Cyperus sp				Unknown
DESCU	Descurainia sp				Desirable
MACA2	Dieteria canescens	N	Forb/herb	Annual, Biennial, Perennial	Desirable
DIWI2	Dimorphocarpa wislizeni	N	Forb/herb	Annual	Unknown
DRCU	Draba cuneifolia	N	Forb/herb	Annual	Unknown
DRABA	Draba sp				Unknown
ECHIN3	Echinocereus sp				Injurious
ELEL5	Elymus elymoides	N	Graminoid	Perennial	Preferred
ELRE4	Elymus repens	I	Graminoid	Perennial	Preferred
EPTO	Ephedra torreyana	N	Subshrub, Shrub	Perennial	Desirable
EPVI	Ephedra viridis	N	Shrub	Perennial	Desirable
ERCI	Eragrostis cilianensis	I	Graminoid	Annual	Emergency
ERAGR	Eragrostis sp		Graminoid	Annual,Perennial	Desirable
ERNA10	Ericameria nauseosa	N	Shrub, Subshrub	Perennial	Desirable
ERCA2	Erigeron caespitosus	N	Forb/herb	Perennial	Desirable
ERDI4	Erigeron divergens	N	Forb/herb	Biennial	Desirable
ERFL	Erigeron flagellaris	N	Forb/herb	Biennial	Desirable
ERIGE2	Erigeron sp				Desirable
ERAL4	Eriogonum alatum	N	Subshrub, Forb/herb	Perennial	Preferred
ERCE2	Eriogonum cernuum	N	Forb/herb	Annual	Desirable
ERIN4	Eriogonum inflatum	N	Forb/herb	Annual, Perennial	Desirable
ERJA	Eriogonum jamesii	N	Subshrub, Forb/herb	Perennial	Desirable
ERMI4	Eriogonum microthecum	N	Subshrub, Shrub	Perennial	Desirable
ERNA4	Eriogonum natum	N	Forb/herb	Perennial	Desirable
ERRA3	Eriogonum racemosum	N	Subshrub, Forb/herb	Perennial	Preferred
ERIOG	Eriogonum sp				Desirable
ERSU5	Eriogonum subreniforme	N	Forb/herb	Annual	Desirable
ERCI6	Erodium cicutarium	I	Forb/herb	Annual, Biennial	Preferred
ERODI	Erodium sp				Preferred
ERCA14	Erysimum capitatum	N	Forb/herb,	Biennial,	Emergency

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
			Subshrub	Perennial	
ERYSI	Erysimum sp				Unknown
ESCOB	Escobaria sp				Injurious
ESVI2	Escobaria vivipara	N	Shrub	Perennial	Injurious
EUPHO	Euphorbia sp				Unknown
EVNU	Evolvulus nuttallianus	N	Subshrub, Forb/herb	Perennial	Unknown
FEROC	Ferocactus sp				Injurious
FOPUN2	Forestiera pubescens neomexicana	N	Shrub	Perennial	Unknown
GAILL	Gaillardia				Desirable
GAPI	Gaillardia pinnatifida	N	Subshrub, Forb/herb	Perennial	Desirable
GAYOP	Gayophytum sp				Unknown
GECA2	Geraea canescens	N	Forb/herb	Annual	Unknown
GERAN	Geranium sp				Desirable
GILIA	Gilia sp				Desirable
GRSQ	Grindelia squarrosa	N	Forb/herb	Annual, Biennial, Perennial	Emergency
GACO5	Guara coccinea	N	Subshrub, Forb/herb	Perennial	Desirable
GUMI	Gutierrezia microcephala	N	Subshrub, Shrub	Perennial	Unknown
GUSA2	Gutierrezia sarothrae	N	Subshrub, Shrub, Forb/herb	Perennial	Toxic
HEPA	Helianthella parryi	N	Forb/herb	Perennial	Unknown
HEAN3	Helianthus annuus	N	Forb/herb	Annual	Desirable
HEPE	Helianthus petiolaris	N	Forb/herb	Annual	Desirable
HEMU3	Heliomeris multiflora	N	Subshrub, Forb/herb	Perennial	Unknown
HECO26	Hesperostipa comata	N	Graminoid	Perennial	Preferred
HESPE11	Hesperostipa sp				Preferred
HEVI4	Heterotheca villosa	N	Subshrub, Forb/herb	Perennial	Desirable
HOLCU	Holcus sp				Unknown
HOJU	Hordeum jubatum	N	Graminoid	Perennial	Emergency
HYFI	Hymenopappus filifolius	N	Subshrub, Forb/herb	Perennial	Desirable
HYMEN4	Hymenopappus sp				Desirable
HYRI	Hymenoxys richardsonii	N	Subshrub, Forb/herb	Perennial	Desirable
HYMEN7	Hymenoxys sp				Desirable
IPOMO	Ipomoea				Unknown

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
IPLO	Ipomoea longifolia	N	Vine, Forb/herb	Perennial	Unknown
IPOMO2	Ipomopsis				Desirable
IPLO2	Ipomopsis longiflora	N	Forb/herb	Annual, Biennial	Desirable
JUNCU	Juncus sp				Desirable
KOSC	Kochia scopanum				Desirable
KOMA	Koeleria macrantha	N	Graminoid	Perennial	Preferred
KRLA2	Krascheninnikovia lanata	N	Subshrub, Shrub	Perennial	Preferred
LASE	Lactuca serriola	I	Forb/herb	Annual, Biennial	Preferred
LAOC3	Lappula occidentalis	N	Forb/herb	Annual, Biennial	Desirable
LEPID	Lepidium sp				Desirable
LEPU	Leptodactylon pungens				Emergency
LEMO3	Lesquerella montana	N	Forb/herb	Perennial	Desirable
LESQU	Lesquerella sp				Desirable
LIBU	Lilium bulbiferum	I	Forb/herb	Perennial	Unknown
LIPU11	Linanthus pungens	N	Forb/herb, Subshrub	Perennial	Emergency
LIWA4	Linanthus watsonii	N	Forb/herb, Subshrub	Perennial	Emergency
LILE3	Linum lewisii	N	Subshrub, Forb/herb	Perennial	Desirable
LIPU4	Linum puberulum	N	Forb/herb	Annual	Desirable
LINUM	Linum sp				Desirable
LITHO3	Lithospermum sp				Desirable
LOTUS	Lotus sp				Desirable
LOWR	Lotus wrightii	N	Forb/herb	Perennial	Desirable
LUAR3	Lupinus argenteus	N	Subshrub, Forb/herb	Perennial	Toxic
LUKI	Lupinus kingii	N	Forb/herb	Annual	Toxic
LYPA	Lycium pallidum	N	Shrub	Perennial	Desirable
MACA2	Machaeranthera canescens	N	Forb/herb	Annual, Biennial, Perennial	Desirable
MAGR10	Machaeranthera gracilis	N	Forb/herb	Annual	Desirable
MAGR2	Machaeranthera grindelioides	N	Subshrub, Forb/herb	Perennial	Desirable
MAPA	Machaeranthera parviflora	N	Forb/herb	Annual	Desirable
MAPI	Machaeranthera pinnatifida	N	Subshrub, Forb/herb	Perennial	Desirable
MACHA	Machaeranthera sp				Desirable
MATA2	Machaeranthera tanacetifolia	N	Forb/herb	Annual, Biennial	Emergency
MAFR3	Mahonia fremontii	N	Shrub	Perennial	Emergency

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
MARE11	Mahonia repens	N	Subshrub, Shrub	Perennial	Emergency
MANE	Malva neglecta	I	Forb/herb	Annual, Biennial, Perennial	Preferred
MAVU	Marrubium vulgare	I	Subshrub, Forb/herb	Perennial	Unknown
MELU	Medicago lupulina	I	Forb/herb	Annual, Perennial	Preferred
MESA	Medicago sativa	I	Forb/herb	Annual, Perennial	Preferred
MEDIC	Medicago sp				Preferred
MEOF	Melilotus officinalis	I	Forb/herb	Annual, Biennial, Perennial	Preferred
MELIL	Melilotus sp				Preferred
MESC	Menodora scabra	N	Subshrub, Forb/herb	Perennial	Unknown
MENOD	Menodora sp				Unknown
MESP3	Mentha longifolia	I	Forb/herb	Perennial	Unknown
MEAL6	Mentzelia albicaulis	N	Forb/herb	Annual	NonConsumed
MENTZ	Mentzelia sp				Emergency
MINA	Mimulus nanus				Unknown
MILI3	Mirabilis linearis	N	Subshrub, Forb/herb	Perennial	Unknown
MIMU	Mirabilis multiflora	N	Forb/herb, Subshrub	Perennial	Unknown
MOCE	Mollugo cerviana	I	Forb/herb	Annual	Unknown
MOPE	Monarda pectinata	N	Forb/herb	Annual	Unknown
MOSQ	Monroa squarrosa	N	Graminoid	Annual	Desirable
MUAS	Muhlenbergia asperifolia	N	Graminoid	Perennial	Desirable
MUMI	Muhlenbergia microsperma	N	Graminoid	Annual	Desirable
MUMI2	Muhlenbergia minutissima	N	Graminoid	Annual	Desirable
MUMO	Muhlenbergia montana	N	Graminoid	Perennial	Desirable
MUPU2	Muhlenbergia pungens	N	Graminoid	Perennial	Desirable
MURI	Muhlenbergia richardsonis	N	Graminoid	Perennial	Desirable
MUHLE	Muhlenbergia sp				Desirable
MUWR	Muhlenbergia wrightii	N	Graminoid	Perennial	Desirable
NADI	Nama dichotomum	N	Forb/herb	Annual	Unknown
OEPA	Oenenthera palida	N	Forb/herb	Biennial, Perennial	Emergency
OECA5	Oenothera cavernae	N	Forb/herb	Annual	Emergency
OECO2	Oenothera coronopifolia	N	Forb/herb	Perennial	Desirable
OENOT	Oenothera sp				Emergency
OPPH	Opuntia phaeacantha	N	Shrub	Perennial	Injurious

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
OPPO	Opuntia polyacantha	N	Shrub	Perennial	Injurious
ORLU	Orobanche ludoviciana	N	Forb/herb	Annual	Unknown
OROBA	Orobanche sp				Unknown
ORLU2	Orthocarpus luteus	N	Forb/herb	Annual	Desirable
ORPU2	Orthocarpus purpureoalbus	N	Forb/herb	Annual	Desirable
OXYTR	Oxytropis sp				Toxic
PACKE	Packera sp				Unknown
PAFI4	Parryella filifolia	N	Shrub	Perennial	Unknown
PASM	Pascopyrum smithii	N	Graminoid	Perennial	Desirable
PEAN	Pectis angustifolia	N	Forb/herb	Annual	Unknown
PEPA2	Pectis papposa	N	Forb/herb	Annual	Unknown
PECTI	Pectis sp				Unknown
PEBA2	Penstemon barbatus	N	Forb/herb	Perennial	Desirable
PELE9	Penstemon leonardii	N	Subshrub, Forb/herb	Perennial	Desirable
PELI2	Penstemon linarioides	N	Subshrub, Forb/herb	Perennial	Desirable
PEOP	Penstemon ophianthus	N	Forb/herb	Perennial	Desirable
PENST	Penstemon sp				Desirable
PHACE	Phacelia sp				Preferred
PHLO2	Phlox longifolia	N	Subshrub, Shrub, Forb/herb	Perennial	Desirable
PHYSA	Physalis sp				Unknown
PIMI7	Piptatherum micranthum				Unknown
PLLA	Plantago lanceolata	I	Forb/herb	Annual, Biennial, Perennial	Desirable
PLOV	Plantago ovata	N	Forb/herb	Annual	Desirable
PLPA2	Plantago patagonia	N	Forb/herb	Annual	Desirable
PLANT	Plantago sp				Desirable
PLJA	Pleuraphis jamesii	N	Graminoid	Perennial	Desirable
POFE	Poa fendleriana	N	Graminoid	Perennial	Preferred
POPR	Poa pratensis	NI	Graminoid	Perennial	Preferred
POA	Poa sp				Preferred
POIN2	Poliomintha incana				Unknown
POAV	Polygonum aviculare	I	Forb/herb	Annual, Perennial	Preferred
POVA	Polygonum aviculare				Unknown
PODO4	Polygonum douglasii	N	Forb/herb	Annual	Preferred
POLYG4	Polygonum sp				Unknown
POHA5	Portulaca halimoides	N	Forb/herb	Annual	Unknown

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
POOL	Portulaca oleracea	I	Forb/herb	Annual	Unknown
PORTU	Portulaca sp				Unknown
POTEN	Potentilla sp				Unknown
PSILO3	Psilostrophe sp				Unknown
PSTE5	Psoralidium tenuifloram	N	Forb/herb	Perennial	Desirable
PURSH	Purshia sp				Desirable
PUST	Purshia stansburiana	N	Tree, Shrub	Perennial	Preferred
PUTR2	Purshia tridentata	N	Shrub	Perennial	Desirable
QUPA4	Quercus x pauciloba	N	Tree, Shrub	Perennial	Injurious
RHTR	Rhus trilobata	N	Shrub	Perennial	Emergency
SACO8	Salsola collina	I	Forb/herb	Annual	Desirable
SAKA	Salsola kali				Desirable
SATR12	Salsola tragus	I	Forb/herb	Annual	Desirable
SALVI	Salvia sp				Unknown
SAAB	Sanvitalia abertii	N	Forb/herb	Annual	Unknown
SAVE4	Sarcobatus vermiculatus	N	Shrub	Perennial	Emergency
SCLER10	Sclerocactus sp				Injurious
SEER2	Senecio eremophilus	N	Subshrub, Forb/herb	Perennial	Toxic
SENEC	Senecio sp				Toxic
SESP3	Senecio spartioides	N	Subshrub, Forb/herb	Perennial	Toxic
SIDAL	Sidalcea sp				Unknown
SILEN	Silene sp				Desirable
SIAL2	Sisymbrium altissimum	I	Forb/herb	Annual, Biennial	Desirable
SIIR	Sisymbrium irio	I	Forb/herb	Annual	Desirable
SOEL	Solanum elaeagnifolium	N	Subshrub, Forb/herb	Perennial	Toxic
SOJA	Solanum jamesii	N	Forb/herb	Perennial	Toxic
SOLAN	Solanum sp				Toxic
SOLID	Solidago sp				Desirable
SPAM2	Sphaeralcea ambigua	N	Subshrub, Forb/herb	Perennial	Preferred
SPCO	Sphaeralcea coccinea	N	Subshrub, Forb/herb	Biennial, Perennial	Preferred
SPPA2	Sphaeralcea parvifolia	N	Subshrub, Forb/herb	Perennial	Preferred
SPHAE	Sphaeralcea sp				Preferred
SPGI	Sporobolos giganteus	N	Graminoid	Perennial	Desirable
SPAI	Sporobolus airoides	N	Graminoid	Perennial	Desirable
SPCO4	Sporobolus contractus	N	Graminoid	Perennial	Desirable

Symbol	Plant Name	Nativity	Growth Habit	Duration	Forage Value
SPRC	Sporobolus cryptandra				Desirable
SPCR	Sporobolus cryptandrus	N	Graminoid	Perennial	Desirable
SPORO	Sporobolus sp				Desirable
STAR10	Stenotus armerioides				Desirable
STPA4	Stephanomeria pauciflora	N	Subshrub, Forb/herb	Perennial	Unknown
STEPH	Stephanomeria sp				Unknown
SYMPH4	Symphyotrichum sp				Desirable
TAOF	Taraxacum officinale	NI	Forb/herb	Perennial	Preferred
TARAX	Taraxacum sp				Preferred
TECA2	Tetradymia canescens	N	Subshrub, Shrub	Perennial	Toxic
TELA	Teucrium laciniatum				Unknown
THME	Thelesperma megapotamicum	N	Forb/herb	Perennial	Unknown
THELE	Thelesperma sp				Unknown
THSU	Thelesperma subnudum	N	Forb/herb	Perennial	Unknown
TOEX2	Townsendia exscapa	N	Forb/herb	Perennial	Desirable
TOWNS	Townsendia sp				Desirable
TROC	Tradescantia occidentalis	N	Forb/herb	Perennial	Unknown
TRADE	Tradescantia sp				Unknown
TRDU	Tragopogon dubius	I	Forb/herb	Annual, Biennial	Preferred
TRTE	Tribulus terrestris	I	Forb/herb	Annual	Toxic
TRIFO	Trifolium sp				Preferred
TRWO	Trifolium wormskioldii	N	Forb/herb	Annual, Perennial	Preferred
TRWO4	Tripterocalyx wootonii				Unknown
VEBR	Verbena bracteata	N	Forb/herb	Annual, Biennial, Perennial	Unknown
VEMA	Verbena macdougalii	N	Forb/herb	Perennial	Unknown
VEEN	Verbesina encelioides	N	Forb/herb	Annual	Unknown
VIAM	Vicia americana	N	Vine, Forb/herb	Perennial	Preferred
VICIA	Vicia sp	N	Forb		Preferred
VUOC	Vulpia octoflora	N	Graminoid	Annual	Desirable
XANTH	Xanthium sp				Toxic
XAST	Xanthium strumarium	N	Forb/herb	Annual	Toxic
YUAN2	Yucca angustissima	N	Subshrub, Shrub, Forb/herb	Perennial	Injurious
YUBA	Yucca baccata	N	Subshrub, Shrub, Forb/herb	Perennial	Injurious
ZEMA	Zea mays	I	Graminoid	Annual	Unknown