Ecosphere
Environmental Services

District 10 Rangeland Vegetation Inventory Report

Prepared for:

BIA, Chinle Agency

Natural Resources

Durango, CO
Cortez, CO
Pagosa Springs, CO
Farmington, NM

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1. INTRODUCTION

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to conduct under-story rangeland vegetation inventories on approximately 250,000 acres of Land Management District 10, Tselani/Cottonwood Chapter, of the Chinle Navajo Agency. The BIA chose a professional, experienced firm, Ecosphere, to collect this data in order to eliminate bias within and between the agency and constituents. Field teams from Ecosphere collected species specific vegetation data including annual production, cover, and frequency. This data was used to calculate carrying capacity based on a forage value rating. Information derived from these calculations will be used to guide management decisions, including stocking rates. This report supplies the summarized results of the vegetation inventory as well as the background, methodology, and discussion necessary 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 10 as well as more comprehensive range management plans which 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). The BIA 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, also called communities, are locally organized entities similar to Counties and are the smallest political unit. District grazing committees consist of elected representatives from each community who are responsible for monitoring livestock grazing within their respective chapters. District grazing committees approve the carrying capacities of their districts, as discussed in the Navajo grazing Regulations Handbook. The periodic sampling of rangelands allows district grazing committees to evaluate the carrying capacity and resulting stocking rates of rangelands (Goodman 1982).

Individual grazing district committee members 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 of range management and resolving grazing disputes. According to the District Grazing Committee Policy and Procedure Manual, the district grazing committee members are responsible for attending district grazing committee meetings, as well as Chapter meetings, and for ensuring that permittees respect applicable laws, regulations and policies.

1.3 Grazing Overview

Timing of grazing, movement, 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. 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 in District 10 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

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. Knowledge of these resource issues that affect rangeland health and productivity is essential to any management plan. The results of this vegetative inventory quantify the current conditions of the rangelands on District 10. 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 (35) Major Land Resource Area (MLRA). The town of Chinle is located on the eastern edge of the project area. Cottonwood is located within the project area on the western side. The District 10 project area is mostly flat to rolling. It is bordered on the east by Highway 191 and on the south by Indian Route 251. Balakai Mesa forms the western boundary. Toadindaaska Mesa and Lohali Mesa were included in the project area in the northwest corner. The northern boundary runs due east from the north end of Lohali Mesa to Highway 191. The project area drains into a couple of reservoirs primarily from Balakai Wash and Cottonwood Wash.

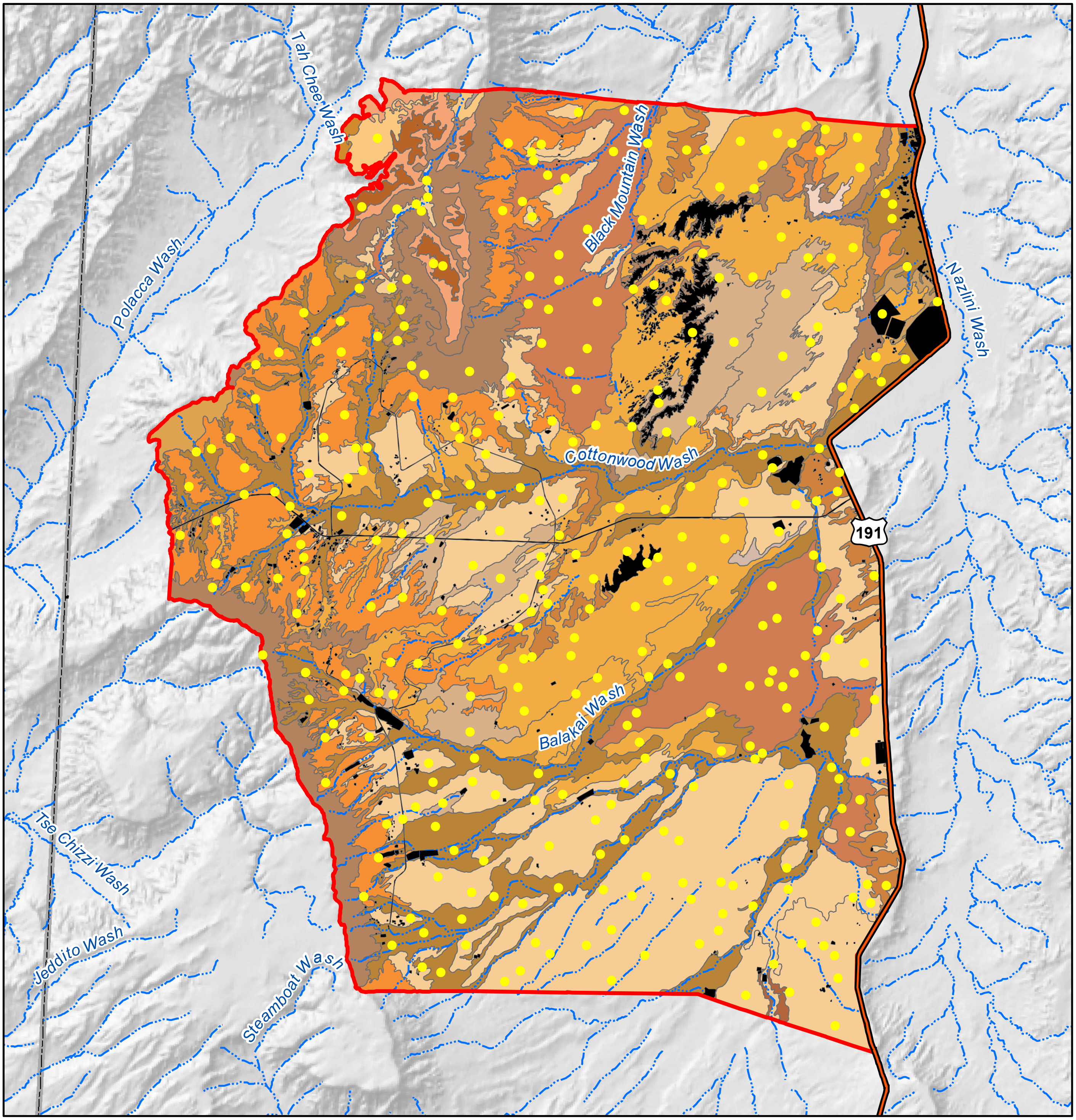
A map of the study area is provided on the following page.

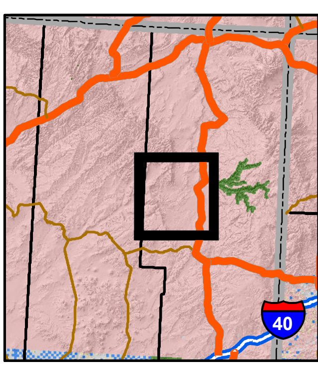
2.2 Geology

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, as well as volcanic remnants. The Colorado Plateau is primarily layers of sedimentary rock.

2.3 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 over estimated in the reconstruction factor, the total annual production estimate decreases. If precipitation is under estimated in the reconstruction factor, the total annual production estimate increases. Data was used from three precipitation gauges in and around the study area with complete datasets, Chinle O&M, Fluted Rock Lake and Toadindaaska Mesa. Several years of recent historical data were averaged as the baseline, or "normal" precipitation. The most recent water year was used to compare deviation from normal. The 2011 water year, the cumulative percent of normal at the time of the study was 77 to 97 percent of the historical average. The precipitation summary is included with the Excel data.





Transect Location
District 10 Boundary
Intermittent Stream
Perrenial Stream
Non Range Area
Limited Access
Highway
Major Road

0 1.5 3 6
Miles

1:250,000

Bureau of Indian Affairs

DISTRICT 10 RANGE PROJECT

APACHE COUNTY, ARIZONA
OVERVIEW MAP
FIGURE 1
10/13/2011

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UTM Zone 13 - NAD 83

2.4 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 which 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.

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.

Most of the inventory project area is located within the boundaries of a soil survey produced by the United States Department of Agriculture, Soil Conservation Service: Chinle Area, Parts of Apache and Navajo Counties, Arizona, and San Juan County, New Mexico (AZ713). However, this soil survey was not complete before the initiation of the study. Therefore, soil map units were not applied.

2.5 Range Sites

If the soil survey were complete, then ecological sites that are associated with soil map units could be utilized for range management. Until the soil mapping is finalized, and ecological site descriptions are written for the project area, range sites are used to differentiate soils and the potential production of plant communities associated with each range site. Range sites are named on the basis of the soils on which they are located and the purpose is to identify areas of different maximum potential production. Identification of range sites is primarily done by soils and edaphic (soil based) characteristics, as well as precipitation zones and possibly vegetation communities if the range site is in good condition. The different soils affect plant composition but as the range condition declines, the characteristic plant composition of each range site will deteriorate.

Transects in the study area were located on 18 range sites. A minimum of six transects was placed in each range site in order to provide sufficient data for analysis. The range sites and their acreage in the project area are listed below:

Range Site	Acres	Transects
Bad Lands	338.3	6
Bad Lands2	553.4	6
Clayey2	24,500.7	33
Loamy2	64,226.5	74
Loamy4	271.2	6
Loamy4a	1,647.1	6
Rough Broken2	21465.5	16
Saline Lowland2	38784.3	52
Sands2	12,973.5	15
Sandy2	42896.7	51
Shallow2	5349.8	9
Shallow4a	84.7	6
Steep Very Shallow2	254.0	6
Thin Breaks2	29,926.7	33
Thin Breaks3	1,364.8	6
Thin Breaks4a	1,365.9	6
Very Shallow2	349.47	6
Very Shallow4a	3,456.31	6
Subtotal Grazeable Rangeland	**249,808.7**	**343**
Thin Breaks	7.4	0
Non-Range42	0.1	0
Non-Usable	301.1	0
Non-Usable	44.2	0
Non-Usable2	256.5	0
Subtotal Non-grazeable, unsampled	**609.3**	**0**
Grand Total District 10 Study Area	**250,417.9**	**343**

Two range sites were missing written Range Site descriptions, the Badlands and the Steep Very Shallow 2. Rather than leave the transects in these range sites with no analysis, the Badlands2 range site characteristics were applied to Badlands, and Steep Very Shallow 5d,5e was substituted for the Steep Very Shallow 2. However, no criteria are set for judging condition class on the Badlands2 site or the Rough Broken sites.

3. METHODOLOGY

An inventory is the collection, assemblage, interpretation, and analysis of natural resource data for planning or other purposes. To satisfy the specific objectives for this inventory which include establishing a current carrying capacity of the rangelands, data were collected on ground cover, frequency, and forage production. The methods used to collect this data included protocols provided by the BIA modified to standards used in federally published Technical References.

The Statement of Work (SOW), provided by the BIA, described the study design and cited specific methodologies for data collection. The field methodology was based on the SOW and thefollowing technical references, with modifications approved by the BIA.

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. Updated.

3.1 Field Methodology

3.1.1 Transect Establishment

Transects consisted of a 200-ft straight line measured with an open reel tape placed flat and straight along the ground, as much as possible. Each transect was placed within a single range site. The transect azimuth 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. Vegetation attributes were read from ten plots at 20 foot intervals along the open reel tape starting at 20 feet, not at zero. 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 of the tape. The vegetative attributes measured at each transect were production, ground cover, and species frequency. Aspect, slope, surface soil texture, and notes were recorded in addition to the vegetative attributes.

3.1.2 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.

3.1.2.1 Establishing a Weight Unit

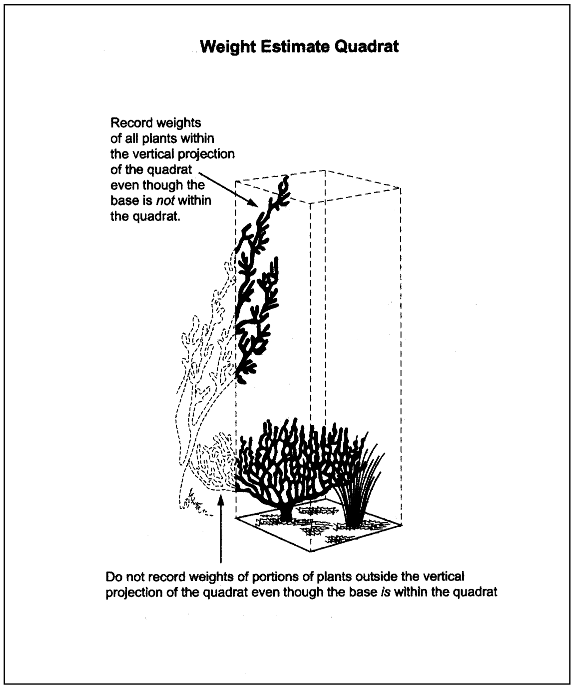
A weight unit is a part of a plant, an entire plant, or a group of plants of the same species used for estimation purposes. The weight unit method is an efficient means of estimating production. After weight units are established field teams can be very accurate in production estimation. The field team adhered to the following procedure for establishing weight units on individual species: identify a reasonable 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.

3.1.2.2 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 3-1). Prior to estimating and harvesting, two plots were chosen as representative plots for harvesting. On the harvested plots all species were estimated *in situ* and then harvested at ground level. In most cases, vegetation was so diverse and sparse that no two plots could effectively represent the species in the transect, especially forage species, with enough production to accurately calculate correction factors and air-dry weights. If important forage species were not well represented in the transect plots, then these species were estimated and clipped individually outside of the transect and recorded as representative plot 11. This method provides more data, and provides more accurate data for air dry weights. 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 date, species, transect 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 in the estimation of production (Estimation Correction Factor).

Figure 3-1 Weight Estimate Box

(Source: USDA NRCS 2003)



3.1.2.3 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 thoroughly 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.

3.1.2.4 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 10 percent, and barrel cacti 5 percent. A list of all plant species recorded during the inventory is included with the digital data provided with this report.

3.1.3 Frequency Data Collection

Frequency describes the abundance and distribution of species. Frequency measurements are an easy and efficient method for monitoring changes in a plant community over time. 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 are replaced by invaders and noxious weeds. The frequency and composition of preferred and desirable species compared to less valuable forage is an indication of the range condition. Frequency and composition results are included in the Excel data and in the Results section of this report.

3.1.4 Cover Data Collection

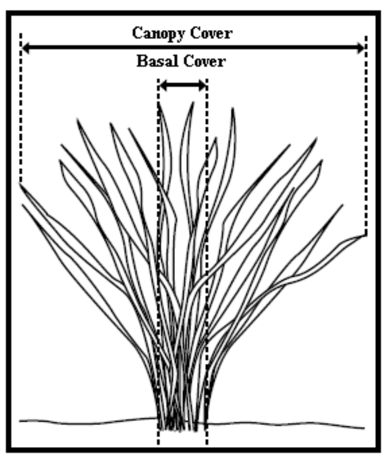
Ground cover measurements are used to quantify the amount of vegetation, organic litter, biological crusts, and exposed soil surface throughout an area. Cover is also important from a hydrologic perspective when examining basal and canopy cover of perennial and annual species and litter cover. This study measured understory vegetation—no trees were included in the cover data.

Cover data can assist in determining the proper hydrologic function of a site, as well as the biotic integrity of a site. Point-Intercept cover measurements are highly repeatable, and lead to more precise measurements than cover estimates using quadrants. For trend comparisons in herbaceous plant communities, basal cover is generally considered to be the most stable. Basal cover does not vary as much due to climatic and seasonal conditions (compared to canopy cover). Canopy cover can vary widely over the course of the growing season. The change in cover over the course of the growing season can make it hard to compare results from different portions of large areas where sampling takes several weeks or a few months. In the future, cover monitoring for each ecological site within each grazing unit should replicate the sampling time period from this baseline inventory.

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. The cover category is determined by the first interception at each of the pin points. A total of 40 measurements, or 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 (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). Ground 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 plant. Canopy Vegetation hits were recorded when the pin flag struck the area covered by the projection of the outermost perimeter of the natural spread of foliage of plants (Figure 3-2). 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 Results.

Figure 3-2 Vegetative Cover

(Source: Elzinga, Salzer and Willoughby 1998)



3.1.5 Soil Surface Texture Test

At most transects the A Horizon (top 0”-6”) of the soil surface was sampled to verify the assigned range site. 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.

3.2 Post-Field Methodology

After field data collection is complete, the data must be prepared and analyzed. All field data was downloaded into a database. Dry weights were measured and entered individually into the database, by each species on each transect. Calculations were applied to reconstruct the production data to the amount of vegetation that would occur in a "normal" year. These adjustments included utilization, climate, growth curve, and air dry weight corrections.

After the reconstruction factor calculation was complete for every species on every transect, the results were grouped by range sites, and the data analyzed. Analysis included condition class, available forage based on forage value and harvest efficiency factors, adjustments for slope and distance to water and finally, and carrying capacity.

3.2.1 Reconstructed Annual Production

The translation of a plot full of plants to a measure of available forage is achieved through a series of 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 a "normal" annual air-dry production weight 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 a 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. 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.

3.2.1.1 Estimation Correction Factor

The harvested plots provide the data for correction factors of estimated species weights from the field. Measured (harvested) weights of species were divided by their estimated weights 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* was estimated in a single plot 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.

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

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

3.2.1.2 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). 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 0.8888.

For species in a transect that were not clipped, an average %ADW was used, generated from the same species in the same range site. 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.

3.2.1.3 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% ungrazed then the amount of *Sporobolus airoides* estimated would represent only 90% 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.

3.2.1.4 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 growth curve estimatesthe 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% of the full production of that species for the year.

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 up until 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%) by the 31 days that occur the month of August. This calculation yields a rate of .35% per day. The number of days that have occurred up to that date (21) is multiplied by the daily rate (.35%) 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. The actual growth curve used in the analysis is included with the Excel data.

3.2.1.5 Percent Normal Production

The Percent Normal Production is directly affected by growing conditions. Precipitation amount and timing as well as temperature and their relationship have an impact on species production. Production varies each year depending on the favorability of growing conditions. Biomass production measurements from year to year are not accurate without accounting for percent of normal production influences. For this inventory the variation in precipitation was used as the value for percent of normal production. The factors of precipitation timing and temperature are extremely difficult factors to quantify and apply to biomass production because the impacts vary by individual species. Limited gauging station precipitation percentage was used in the calculations as the sole factor affecting the percent of normal production. Data was gathered from three gauging stations around the project area in District 10.

For this example, the water year was 102% of the average. Now, the reconstruction factor is complete:

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

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:

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

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

3.3.1.6 Conversion from Grams to Pounds per Acre

The conversion from the working unit of grams (per transect) into the application of pounds per acre is factored into the formula. 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). So, in this case the conversion factor equals one and therefore is not explicitly written into the equation. Hence, in the example, there were 78.74 pounds per acre of *Sporobolos airoides*. The value 78.74 represents the total reconstructed annual production of the species in pounds per acre.

3.2.2 Calculating Ground Cover

Ground cover was calculated by dividing the number of hits of a ground cover category (basal vegetation, canopy vegetation, gravel/rock, 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% for that transect. Cover data was averaged by ecological site within each community.

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

3.2.3 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%. Frequency of species on each transect is included in the electronic data with this report. Frequency of the three most common species to appear on transects within each community is presented in Section 4 Results.

3.2.4 Calculating Condition Class

Range site descriptions use condition classes (poor, fair, good and excellent) to indicate the present vegetation production as compared to the potential climax vegetation community. The climax community in a Range Site is similar to the Historic Climax Plant Community (HCPC) in Ecological Site descriptions.

Most range site descriptions contain a production table showing the expected pounds per acre of annual air dry forage in both favorable and unfavorable years. The table is further subdivided into the condition classes of poor, fair, good and excellent. These numbers represent the amount of forage per acre that a range site would produce in a given condition. To illustrate, the Loamy4a range site with an excellent condition class should produce 460 pounds of forage in a favorable year and 305 pounds in an unfavorable year. Averaged together, production becomes 382.50 pounds per acre. The favorable and unfavorable figures were averaged because the reconstruction factor in the species calculations has already factored in the percent of normal precipitation and growth.

The “Allowable Percent” represents the percent composition of each species that would be expected within an excellent condition class. All production for decreaser species is included, and no production from invader species is included. Increaser species are given a percentage allowable to be included in the total forage. For example, if on a Loamy4a Range Site the reconstructed weight of *Pleuraphis jamesii* was 200 pounds, it would comprise 52 percent of the plant community (200 divided by 382.5). However, *Pleuraphis jamesii* should not exceed 20 percent of the total or 76.5 pounds per acre (382.5 multiplied by 20%). The resulting 76.5 pounds per acre is the “Pounds Allowable”. No more than 76.5 pounds per acre is included in the total pounds allowable.

The sum of pounds allowable for each species resulted in a total pounds allowable of forage. The amount of this forage determines the condition class. In Loamy 4a a Poor condition class was assigned to transects with allowable forage production from 0 to 75 pounds per acre, a Fair condition class was assigned to transects with allowable forage production greater than 76 and up to 150 pounds per acre. For Good condition class the allowable forage was greater than 150 and up to 382.5 pounds per acre. Transects with more than 382.5 pounds per acre of allowable forage were assigned an Excellent condition class.

3.2.5 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. 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 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 10 range management currently allows for year round grazing so forage values are listed for the most conservative seasonal use.

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 emergency plants, with harvest efficiency applied.

3.2.6 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. Carrying capacities were calculated by the acreage of each range site within the project area.

Available forage, 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). This figure was chosen so that carrying capacities would be conservative. When calculating carrying capacity, only the winter forage value was used. This is because grazing permits in District 10 are issued on a year-long basis, not on a seasonal basis. If the higher spring or summer forage values were used, many areas would be overgrazed. For example, if a permitted area has enough palatable species available to support livestock in the spring and summer but there is less 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. Using the winter forage availability reduces overall carrying capacity but prevents overgrazing of the range resource during the season of least available forage. Range managers issuing permits in the

District 10 can use the transect data associated with the individual permit areas in order to more finely tune the carrying capacity. Range managers will need to adjust numbers based upon forage available throughout the year.

4. RESULTS

A total of 343 transects were located on District 10 study area, which includes extra transects completed in addition to those provided by the BIA. The attributes calculated from the data were total annual production, available forage, ground cover, and species frequency, as well as condition class. Each range site was analyzed for available forage production and stocking rate calculations. Carrying capacity was calculated in Animal Units Year Long. Summary carrying capacity was converted to sheep units in order to compare with range site recommendations. In addition to stocking rates and carrying capacity, the following sections discuss results forage by range site for ground cover, species frequency and composition, condition class, and available.

Overall results for the District 10 Tselani/Cottonwood project area include nearly half of all transects in a poor condition class, and a majority of transects (75 percent) in both Poor and Fair condition classes.

Range Site	Excellent	Good	Fair	Poor	N/A	Range Site Total
Badlands/Badands2 *					12	**12**
Clayey2			11	22		**33**
Loamy2	1	1	17	55		**74**
Loamy4			1	5		**6**
Loamy4a		2	1	3		**6**
Rough Broken2 *					16	16
SalineLowland2	16	3	10	23		**52**
Sands2			7	8		**15**
Sandy2		2	18	31		**51**
Shallow2	4	3	2			**9**
Shallow4a	3	1		2		**6**
Steep Very Shallow2**	3	2		1		**6**
Thin Breaks2	7	5	15	6		**33**
Thin Breaks3				6		**6**
Thin Breaks4a			1	5		**6**
Very Shallow2		1	5			**6**
Very Shallow4a	1		2	3		**6**
Condition Class Total	**35**	**20**	**90**	**167**	**28**	**343**

*No criteria are set for judging condition class on these range sites
**Based on criteria for Steep Very Shallow 5d, 5e

The total carrying capacity of the District 10 Tselani/Cottonwood project area, prior to reductions for slopes and distance to water, is 1,667.6 animal units year long (AUYL) or 6,670 sheep units year long. However, after reductions are made for areas of steep slopes, and for areas one or two miles from an identified water source, the carrying capacity decreases to 1,031 AUYL or 4,123.9 sheep units year long.

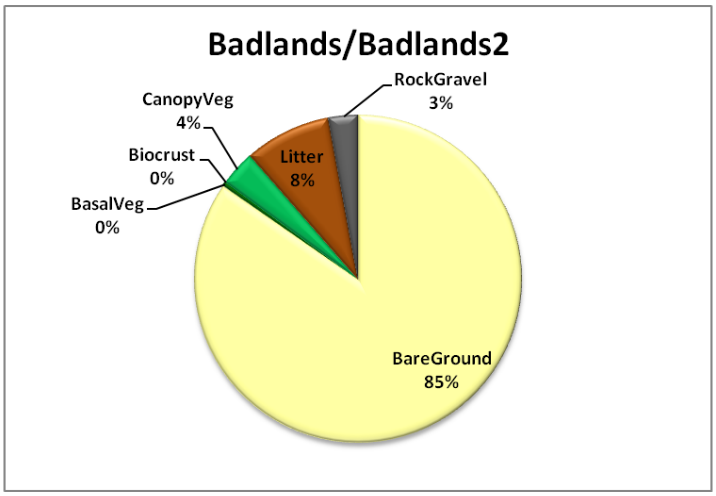
This represents a 38 percent reduction. Identification of more water sources, or adding more water sources in key areas, would significantly improve the carrying capacity.

Range Site	Before Reductions			After Reductions			
	Stocking Rate (Acres/ AUM)	Carrying Capacity (AUYL)	Carrying Capacity (SUYL)	Stocking Rate (Acres/ AUM)	Carrying Capacity (AUYL)	Carrying Capacity (SUYL)	% Reduction
Bad Lands	30.80	0.92	3.66	63.32	0.45	1.78	51.4%
Bad Lands2	25.11	1.84	7.35	110.61	0.42	1.67	77.3%
Clayey2	16.58	123.15	492.59	24.03	84.97	339.90	31.0%
Loamy2	10.33	518.05	2,072.20	15.46	346.16	1,384.64	33.2%
Loamy4	12.56	1.80	7.20	0.00	0.00	0.00	100.0%
Loamy4a	4.60	29.86	119.43	47.80	2.87	11.49	90.4%
Rough Broken2	7.70	232.25	929.01	20.26	88.30	353.19	62.0%
Saline Lowland2	12.57	257.19	1,028.77	16.25	198.90	795.60	22.7%
Sands2	14.98	72.18	288.73	29.74	36.35	145.41	49.6%
Sandy2	17.75	201.35	805.42	27.12	131.80	527.21	34.5%
Shallow2	15.70	28.39	113.57	20.23	22.04	88.15	22.4%
Shallow4a	7.41	0.95	3.81	286.51	0.02	0.10	97.4%
Steep Very Shallow2	14.40	1.47	5.88	14.40	1.47	5.88	0.0%
Thin Breaks2	14.03	177.71	710.86	22.23	112.17	448.69	36.9%
Thin Breaks3	16.89	6.73	26.93	36.59	3.11	12.43	53.8%
Thin Breaks4a	134.42	0.85	3.39	3461.84	0.03	0.13	96.1%
Very Shallow2	58.85	0.49	1.98	104.61	0.28	1.11	43.7%
Very Shallow4a	23.21	12.41	49.63	176.88	1.63	6.51	86.9%
Totals		**1,667.60**	**6,670.40**		**1,031.0**	**4,123.9**	**38.2%**

4.1 Badlands/Badlands2

On these range sites data was collected on 12 transects, six in each site. No range site description was provided for Badlands, so the transects were grouped with Badlands2. There are no criteria set for judging condition classes on the badlands sites. Carrying capacity for the 891.7 acres of both Badlands sites is 2.76 AUYL before reductions and 0.87 AUYL after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Badlands sites had the highest percentage of bare ground of all range sites.



The average plot frequency of species by forage value shows that Badlands sites had the lowest percentage of preferred species.

Forage Value	Frequency on Badlands	Frequency on Badlands2
Preferred	8%	10%
Desirable	40%	48%
Emergency	0%	0%
Injurious	5%	2%
Toxic	3%	5%
Unknown	8%	2%

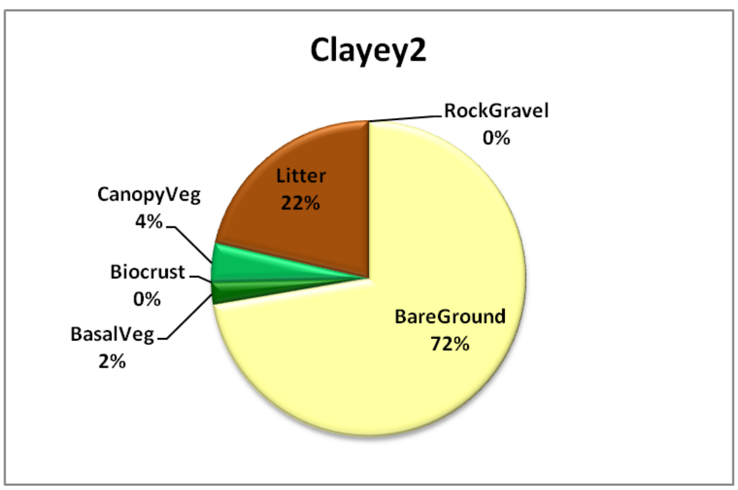
The three most common species to occur on Badlands transects included both a preferred species of grass, Indian rice grass, and the invasive Russian thistle.

Range Site	*Species*	Total # Transects	# Transects	%
Bad Lands	*Achnatherum hymenoides*	6	5	83%
Bad Lands	*Salsola tragus*	6	4	67%
Bad Lands	*Sporobolus* sp.	6	4	67%
Bad Lands	*Bouteloua gracilis*	6	3	50%
Bad Lands	*Chyrsothamnus greenei*	6	3	50%
Bad Lands	*Ericameria nauseosa*	6	3	50%
Bad Lands2	*Salsola tragus*	6	5	83%
Bad Lands2	*Achnatherum hymenoides*	6	4	67%
Bad Lands2	*Ericameria nauseosa*	6	4	67%
Bad Lands2	*Pleuraphis jamesii*	6	4	67%
Bad Lands2	*Bouteloua gracilis*	6	3	50%

4.2 Clayey2

Data was collected on 33 transects in Clayey2. Carrying capacity for the 24,500.7 acres of Clayey2 on the project area is 123.5 AUYL before reductions and 84.97 after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Clayey2 sites had a high percentage of bare ground.



The average plot frequency of species by forage value shows that Clayey2 also had one of the lowest percentages of preferred species.

Forage Value	Frequency
Preferred	8%

Desirable	31%
Emergency	1%
Injurious	1%
Toxic	3%
Unknown	2%

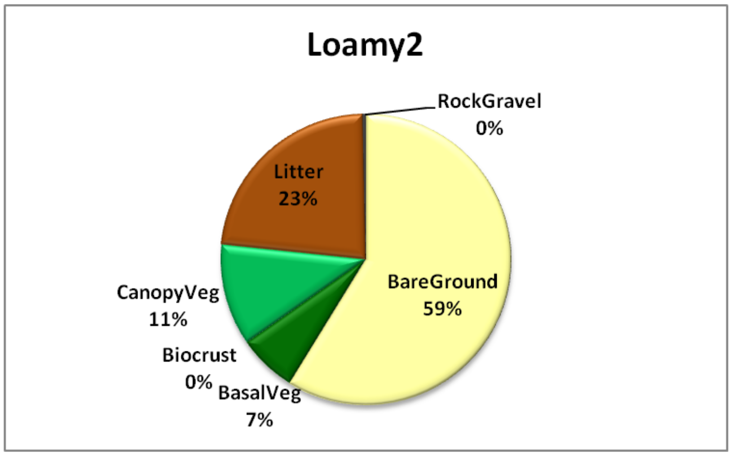
The three most common species to occur on Clayey2 transects included both a preferred species of grass, Indian rice grass, and the invasive Russian thistle.

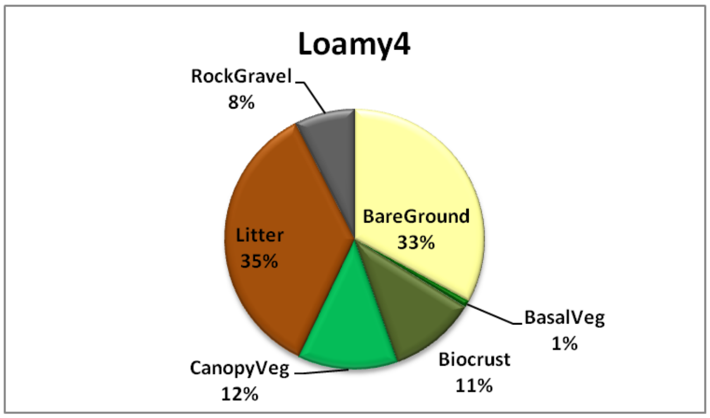
Species	Total # Transects	# Transects	%
Pleuraphis jamesii	33	31	94%
Salsola tragus	33	26	79%
Achnatherum hymenoides	33	9	27%
Gutierrezia sarothrae	33	9	27%

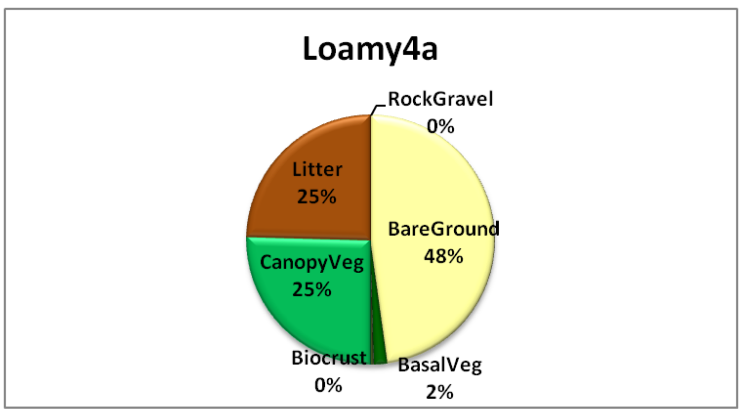
4.3 Loamy2, Loamy4, Loamy4a

Data was collected on 74 transects in Loamy2, and on six transects each in the Loamy4 and Loamy4a range sites. Carrying capacity for 64,226.5 acres of Loamy2 is 518.05 AUYL, reduced to 346.16 AUYL. Carrying capacity for 271.2 acres of Loamy4 is 1.80 before reductions, and zero after reductions due to a 100 percent reduction of acreage and forage available to livestock when slopes and distance to water are applied. Carrying capacity of the 1,647.1 acres of Loamy4a was reduced by 90.4 percent and was 29.86 AUYL before reductions and 2.87 after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Loamy2 had the highest percentage of basal vegetation hits, and Loamy4a had the highest percentage of canopy vegetation hits.







The average plot frequency of species by forage value shows that Loamy sites had high percentages of combined preferred and desirable species.

Forage Value	Frequency on Loamy2	Frequency on Loamy4	Frequency on Loamy4a
Preferred	12%	22%	22%

Desirable	52%	52%	43%
Emergency	4%	2%	0%
Injurious	2%	7%	8%
Toxic	6%	8%	7%
Unknown	4%	3%	5%

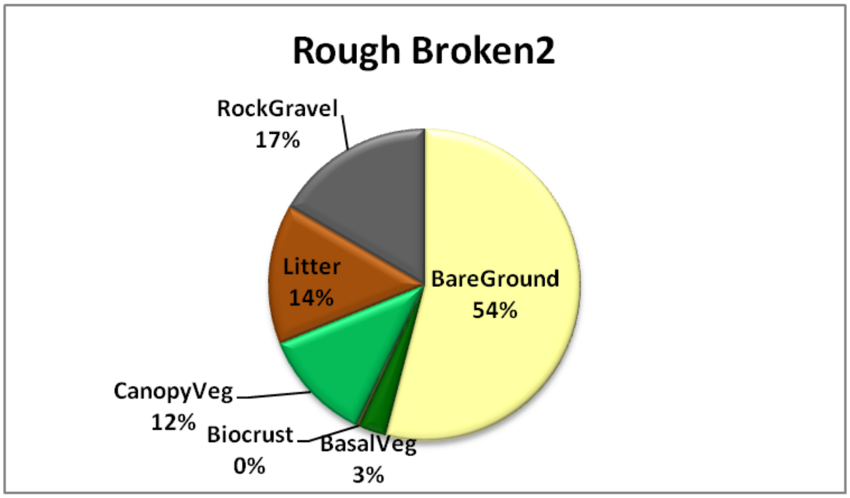
The three most common species to occur on Loamy transects include blue grama grass on all three sites, as well as snakeweed.

Range Site	*Species*	Total # Transects	# Transects	%
Loamy2	*Pleuraphis jamesii*	74	72	97%
Loamy2	*Bouteloua gracilis*	74	57	77%
Loamy2	*Gutierrezia sarothrae*	74	45	61%
Loamy4	*Bouteloua gracilis*	6	6	100%
Loamy4	*Chaetopappa ericoides*	6	6	100%
Loamy4	*Elymus elymoides*	6	5	83%
Loamy4	*Gutierrezia sarothrae*	6	5	83%
Loamy4	*Artemesia tridentata*	6	4	67%
Loamy4a	*Artemesia tridentata*	6	6	100%
Loamy4a	*Chaetopappa ericoides*	6	6	100%
Loamy4a	*Bouteloua gracilis*	6	5	83%
Loamy4a	*Elymus elymoides*	6	4	67%
Loamy4a	*Gutierrezia sarothrae*	6	4	67%

4.4 Rough Broken2

Data was collected on 16 transects in Rough Broken2. On the 21,465.5 acres of this range site carrying capacity is 232.25 AUYL before reductions and 88.30 after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of species by forage value shows that Rough Broken 2 had one of the highest percentages of preferred species.

Forage Value	Frequency
Preferred	25%
Desirable	49%
Emergency	8%
Injurious	3%
Toxic	8%
Unknown	16%

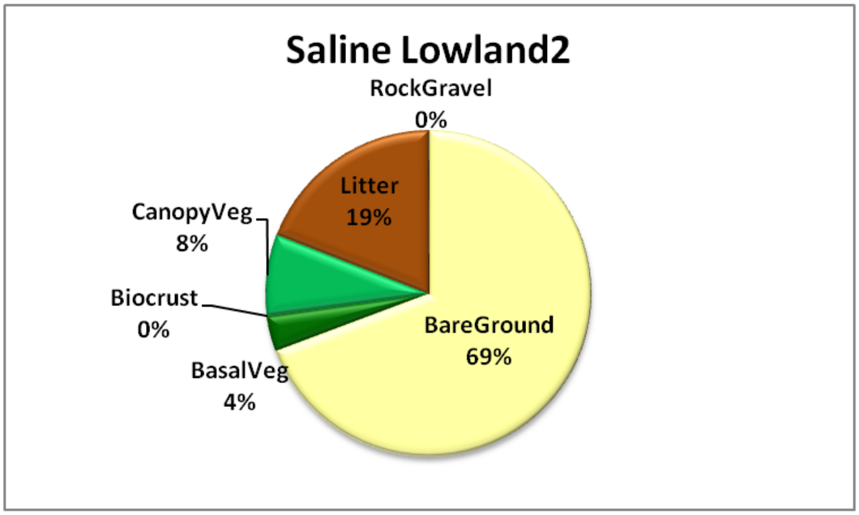
The three most common species to occur on Rough Broken2 transects included both a preferred species of grass, Indian rice grass, and the invasive Russian thistle. The most common species was snakeweed.

Species	Total # Transects	# Transects	%
Gutierrezia sarothrae	16	11	69%
Pleuraphis jamesii	16	11	69%
Achnatherum hymenoides	16	10	63%
Salsola tragus	16	7	44%

4.5 Saline Lowland2

Data was collected on 52 transects in Saline Lowland2. There are 38, 784.3 acres of this range site with a carrying capacity of 257.19 AUYL before reductions and 198.90 after. The percentage reduction was only 22.7 percent.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of species by forage value shows that Saline Lowland2 had a low combination of desirable and preferred species.

Forage Value	Frequency
Preferred	9%
Desirable	30%
Emergency	3%
Injurious	1%
Toxic	2%
Unknown	5%

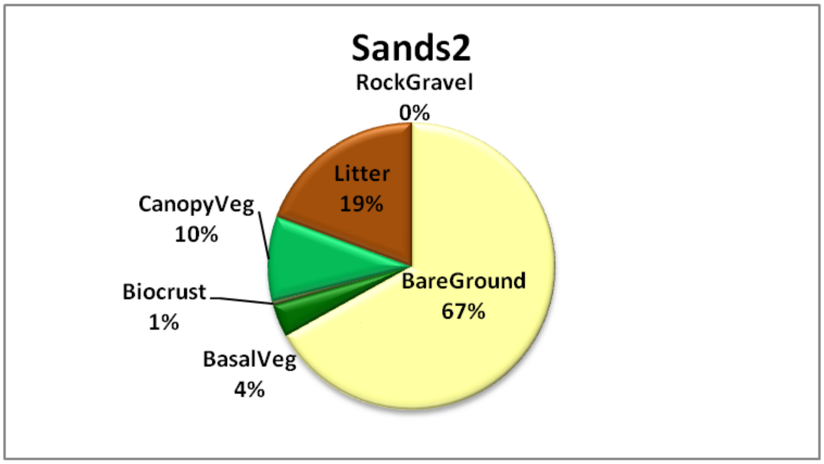
The three most common species to occur on Saline Lowland2 transects was Russian thistle, followed by galleta grass and alkali sacaton.

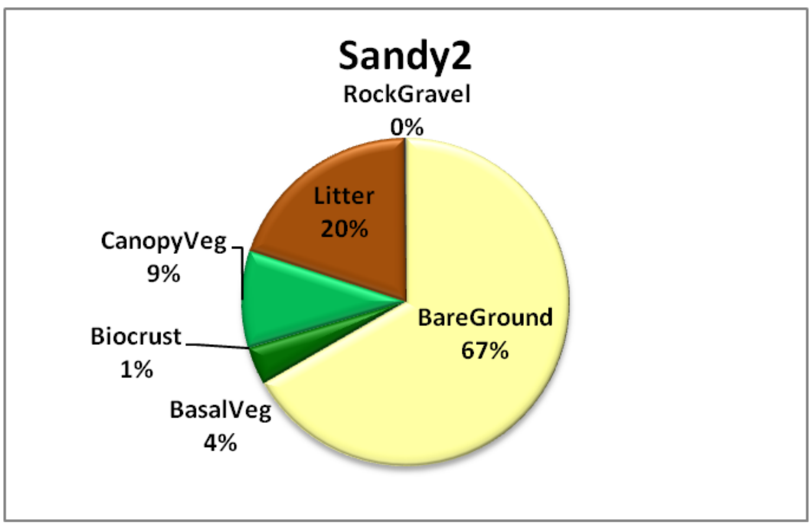
Species	Total # Transects	# Transects	%
Salsola tragus	52	34	65%
Pleuraphis jamesii	52	31	60%
Sporobolus airoides	52	22	42%

4.6 Sands2, Sandy2

On these range sites data was collected on 15 transects in Sands2 and 51 transects in Sandy2. On the 12,973.5 acres of Sands2, the carrying capacity is 72.18 AUYL before reductions and 36.35 after. The carrying capacity for 42,896.7 acres of Sandy2 is 201.35 AUYL before reductions and 131.80 after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Sands2 and Sandy2 range sites are very similar in ground cover composition.





The average plot frequency of species by forage value shows that Sands2 and Sandy2 sites had a good frequency of combined preferred and desirable forage species.

Forage Value	Frequency on Sands2	Frequency on Sandy2
Preferred	12%	12%
Desirable	55%	53%
Emergency	6%	3%
Injurious	1%	2%
Toxic	7%	6%

Unknown	9%	5%

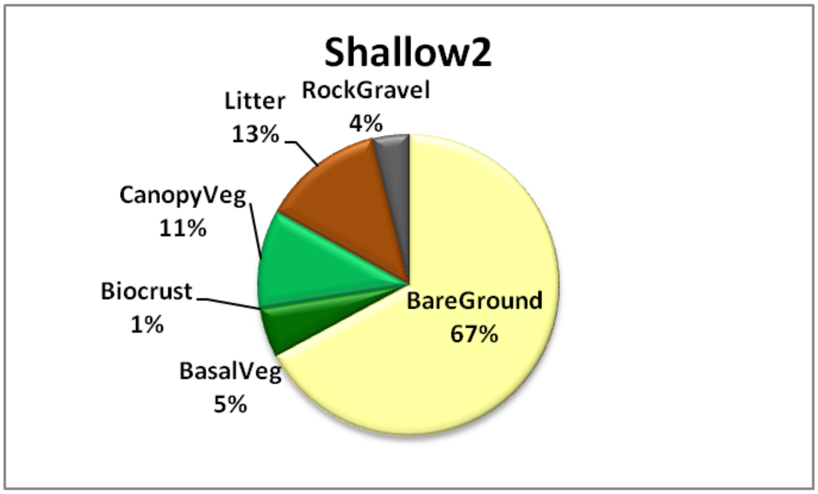
The three most common species to occur on Sands2 and Sandy2 transects included, on both sites, Indian rice grass and blue grama grass and galleta grass. Sandy2 also had a high composition of Russian thistle.

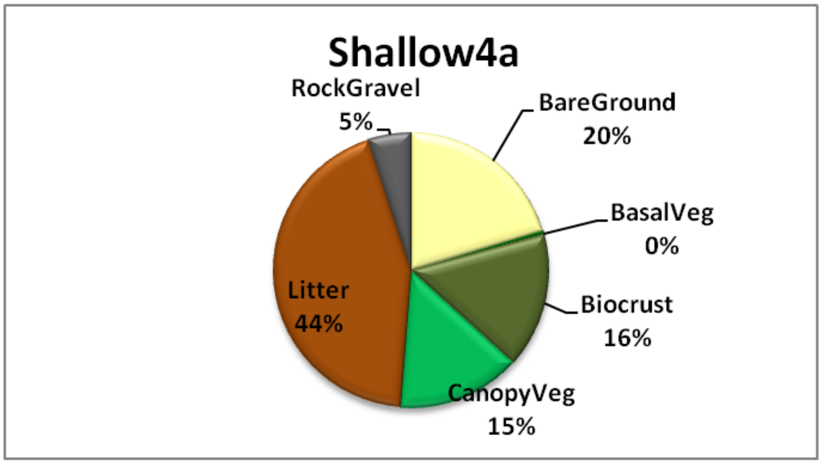
Range Site	*Species*	Total # Transects	# Transects	%
Sands2	*Achnatherum hymenoides*	15	14	93%
Sands2	*Bouteloua gracilis*	15	12	80%
Sands2	*Pleuraphis jamesii*	15	10	67%
Sandy2	*Pleuraphis jamesii*	51	44	86%
Sandy2	*Salsola tragus*	51	42	82%
Sandy2	*Achnatherum hymenoides*	51	40	78%
Sandy2	*Bouteloua gracilis*	51	40	78%

4.7 Shallow2, Shallow4a

On these range sites data was collected on 9 transects in Shallow2 and 6 transects in Shallow4a. There are 5,349.8 acres of Shallow2 and only 84.7 acres of Shallow4a. Carrying capacities are 28.39 AUYL for Shallow2 before reductions and 22.04 after with only a 22.4 percent reduction, and for Shallow4a 0.95 AUYL before and only 0.02 after due to a 97.4 percent reduction.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Shallow2 and Shallow4a were not very similar in ground cover composition. Shallow4a had one of the lowest percentages of bare ground and high percentages of biological soil crusts and litter. However, the sample size was only six transects.





The average plot frequency of species by forage value shows that Shallow2 had the highest frequency of desirable species, but also a high frequency of toxic species. Shallow4a had the highest frequency of preferred species of all the range sites.

Forage Value	Frequency on Shallow2	Frequency on Shallow4a
Preferred	19%	32%
Desirable	74%	40%
Emergency	10%	0%
Injurious	6%	7%
Toxic	9%	7%
Unknown	19%	5%

The three most common species to occur on Shallow2 included grasses in all transects, and in Shallow4a Big sage was the most common species. Due to the low number of transects in these range sites, many species tied for first, second and third most common.

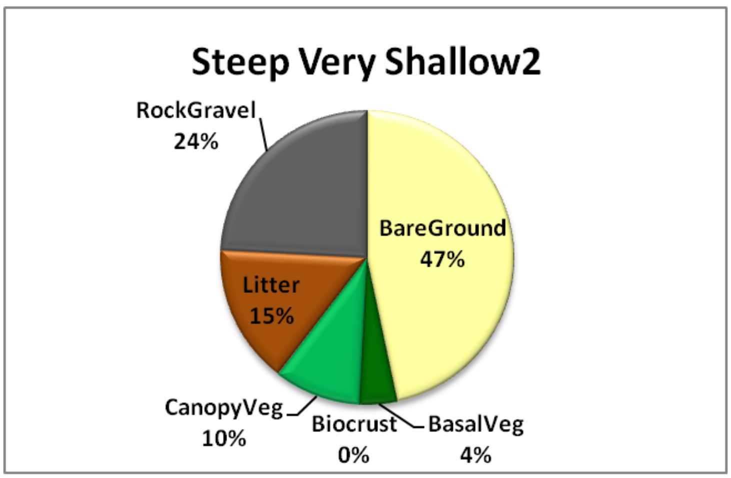
Range Site	*Species*	Total # Transects	# Transects	%
Shallow2	*Achnatherum hymenoides*	9	9	100%
Shallow2	*Pleuraphis jamesii*	9	9	100%
Shallow2	*Bouteloua gracilis*	9	8	89%
Shallow2	*Gutierrezia sarothrae*	9	8	89%
Shallow2	*Chaetopappa ericoides*	9	7	78%
Shallow2	*Chyrsothamnus greenei*	9	7	78%
Shallow2	*Ephedra viridis*	9	7	78%
Shallow4a	*Artemesia tridentata*	6	5	83%
Shallow4a	*Elymus elymoides*	6	5	83%

Shallow4a	*Gutierrezia sarothrae*	6	4	67%
Shallow4a	*Poa fendleriana*	6	4	67%
Shallow4a	*Bouteloua gracilis*	6	3	50%
Shallow4a	*Lesquerella sp.*	6	3	50%

4.8 Steep Very Shallow2

Data was collected on 6 transects in Steep Very Shallow2. There were only 254 acres of Steep Very Shallow2 and no reductions were necessary therefore the carrying capacity remains at 1.47 AUYL.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of species by forage value shows that Steep Very Shallow2 had few preferred species.

Forage Value	Frequency
Preferred	8%
Desirable	55%
Emergency	8%
Injurious	0%
Toxic	7%
Unknown	28%

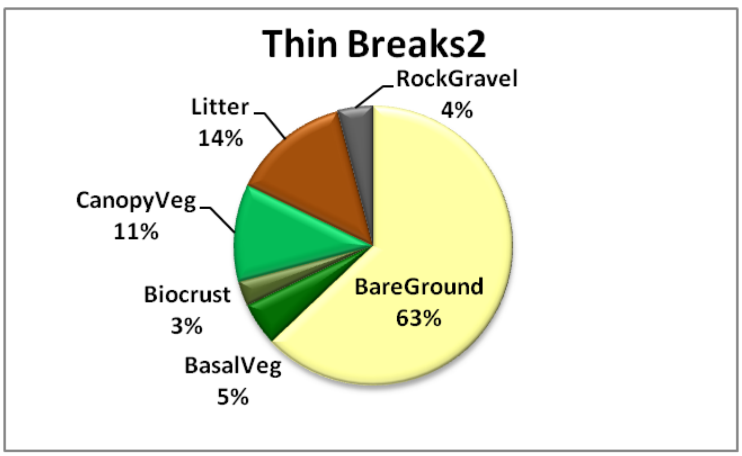
The three most common species to occur on Steep Very Shallow2 transects included galleta grass on all six transects, followed by blue grama and then forbs and shrubs.

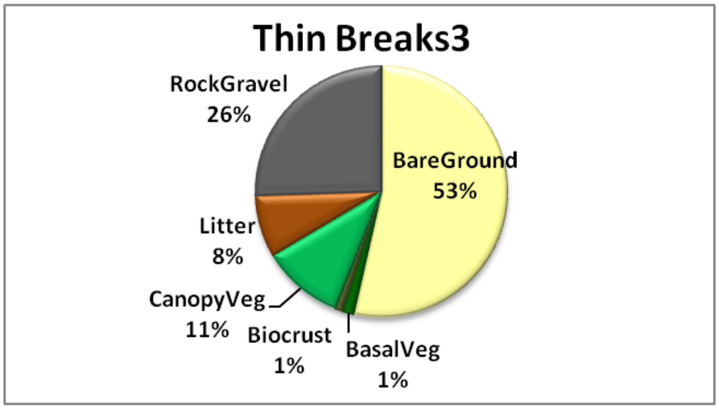
Species	Total # Transects	# Transects	%
Pleuraphis jamesii	6	6	100%
Bouteloua gracilis	6	5	83%
Chaetopappa ericoides	6	4	67%
Chamaesyce sp.	6	4	67%
Ephedra viridis	6	4	67%
Gutierrezia sarothrae	6	4	67%

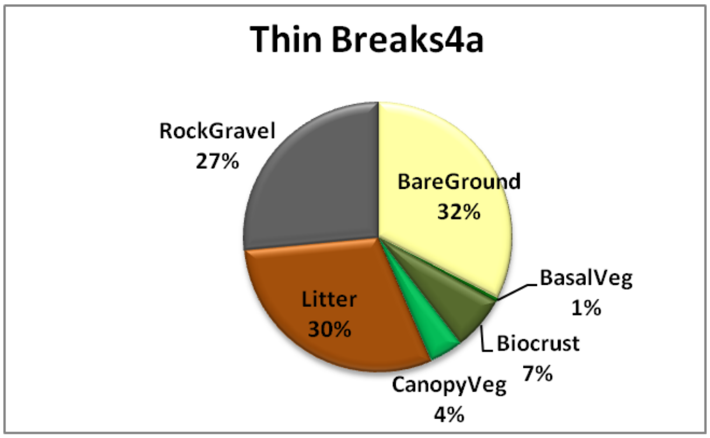
4.9 Thin Breaks2, Thin Breaks3, Thin Breaks4a

Data was collected on 33 transects in Thin Breaks2, and on six transects each in the Thin Breaks3 and Thin Breaks4a range sites. On Thin Breaks2 the carrying capacity is 177.71 AUYL before reductions and 112.17 after reductions on 29, 926.7 acres. On Thin Breaks3, the carrying capacity is 6.73 AUYL before reductions and 3.11 after on 1,364.8 acres. Thin Breaks4a has a carrying capacity of 0.85 AUYL before a 96.1 percent reduction, which results in a 0.03 AUYL carrying capacity over 1,365.9 acres.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Thin Breaks3 and Thin Breaks4a had the highest percentages of rock and gravel of all the range sites in the project area.







The average plot frequency of species by forage value shows that Thin Breaks2 had one of the highest frequencies of desirable species, but also of toxic species. Thin Breaks3 had the lowest frequency of desriable species.

Forage Value	Frequency on Thin Breaks2	Frequency on Thin Breaks3	Frequency on Thin Breaks4a
Preferred	20%	18%	18%
Desirable	65%	15%	28%
Emergency	7%	2%	2%
Injurious	3%	2%	7%
Toxic	9%	5%	7%
Unknown	19%	18%	13%

The three most common species to occur on Thin Breaks transects included Indian rice grass in all three sites. Half of the six sites in Thin Breaks3 had no production.

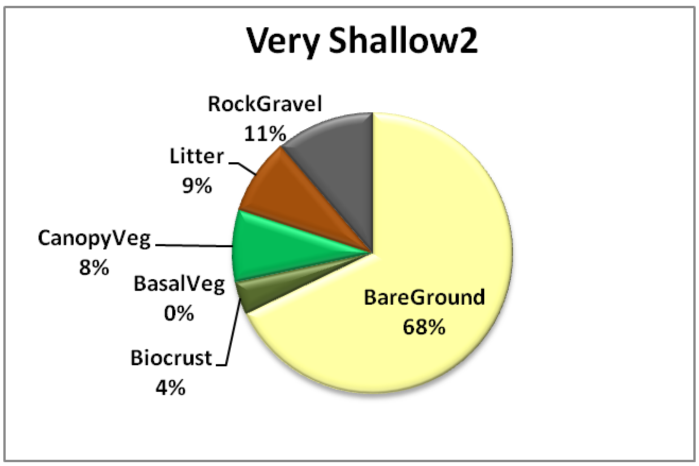
Range Site	*Species*	Total # Transects	# Transects	%
Thin Breaks2	*Achnatherum hymenoides*	33	30	91%
Thin Breaks2	*Gutierrezia sarothrae*	33	29	88%

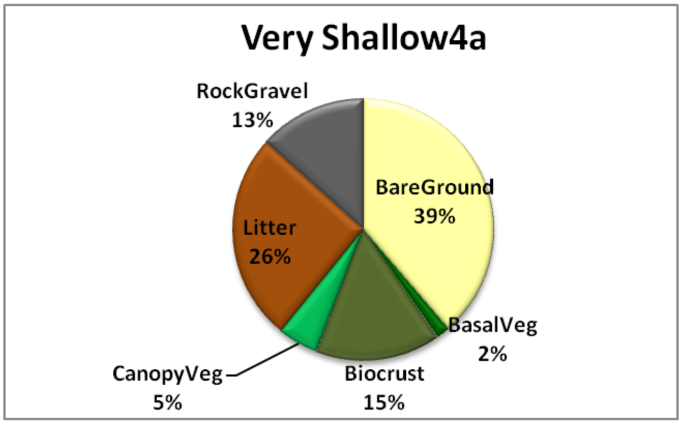
Thin Breaks2	*Bouteloua gracilis*	33	27	82%
Thin Breaks2	*Pleuraphis jamesii*	33	27	82%
Thin Breaks3	*Gutierrezia sarothrae*	6	3	50%
Thin Breaks3	*No Production*	6	3	50%
Thin Breaks3	*Achnatherum hymenoides*	6	2	33%
Thin Breaks3	*Artemisia bigelovii*	6	2	33%
Thin Breaks3	*Elymus elymoides*	6	2	33%
Thin Breaks3	*Purshia stansburiana*	6	2	33%
Thin Breaks3	*Salsola tragus*	6	2	33%
Thin Breaks4a	*Gutierrezia sarothrae*	6	4	67%
Thin Breaks4a	*Opuntia polyacantha*	6	4	67%
Thin Breaks4a	*Achnatherum hymenoides*	6	3	50%
Thin Breaks4a	*Cercocarpus montanus*	6	3	50%
Thin Breaks4a	*Elymus elymoides*	6	3	50%

4.10 Very Shallow2, Very Shallow4a

On these range sites data was collected on six transects each in the Very Shallow2 and Very Shallow4a range sites. Very Shallow2 covers 349.5 acres of the project area and has a carrying capacity of 0.49 AUYL before reductions, and 0.28 after reductions. There are 3,456.2 acres of Very Shallow4a with a carrying capacity of 12.41 AUYL before reductions and only 1.63 AUYL after reductions.

The transect dataset for ground cover by range site is large so it is provided with the electronic data for this study. An average ground cover is shown here. No ground cover percentages are included in the range site descriptions, however, the ground cover figures presented here can provide a baseline for determining trend in future studies. Very Shallow4a had a high percentage of biological soil crusts.





The average plot frequency of species by forage value shows that Very Shallow2 had the lowest frequency of preferred species, and Very Shallow4a had the highest frequency of toxic species of all the range sites.

Forage Value	Frequency on Very Shallow2	Frequency on Very Shallow4a
Preferred	8%	13%
Desirable	45%	32%
Emergency	2%	5%
Injurious	0%	10%
Toxic	0%	10%
Unknown	5%	13%

The most common species to occur on Very Shallow2 was invasive Russian thistle, and in Very Shallow 4a it was snakeweed. Due to the low number of transects in these range sites, many species tied for first, second and third most common.

Range Site	*Species*	Total # Transects	# Transects	%
Very Shallow2	*Salsola tragus*	6	4	67%
Very Shallow2	*Achnatherum hymenoides*	6	3	50%
Very Shallow2	*Ericameria nauseosa*	6	3	50%
Very Shallow2	*Pleuraphis jamesii*	6	3	50%
Very Shallow2	*Sporobolus airoides*	6	3	50%
Very Shallow4a	*Gutierrezia sarothrae*	6	6	100%
Very Shallow4a	*Opuntia polyacantha*	6	4	67%
Very Shallow4a	*Artemisia bigelovii*	6	3	50%
Very Shallow4a	*Bouteloua gracilis*	6	3	50%
Very Shallow4a	*Elymus elymoides*	6	3	50%

Very Shallow4a	*Ephedra viridis*	6	3	50%

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 condition class or 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

Local precipitation monitoring stations in the project area recorded higher than normal precipitation in 2010. However, 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 two miles from a water source can be considered ungrazable and that acreage should be removed from stocking rate calculations. Permitting in areas beyond two miles will lead to overgrazing and deterioration

Reductions for distance to water have been made on the geodatabase accompanying this study. BIA recommendations incude 100 percent stocking rates between zero and one mile from a water source, 50 percent stocking rate between one and two miles from the water source, and no grazing more than two miles from the water source.

If permittees are hauling water to their stock, this should be considered when determining stocking rates. Monitoring of the condition, addition, or loss of water sources should be updated in the geodatabase and resulting stocking rates.

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 for itself 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, farmland, 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. 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 10 project, the winter 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 District 10 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 could support more livestock but only during spring and summer. Range managers should adjust numbers based upon forage available throughout the year. 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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8. APPENDICES