District 8, Utah Rangeland Vegetation Inventory Report

Prepared for:

BIA, Western Navajo Agency Natural Resources

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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 Land Management District 8, Utah portion, of the Western Navajo Agency, plus Monument Valley Tribal Park (MVTP) which lies in both Utah and Arizona. Field teams collected species specific vegetation data including annual production, cover, and frequency. This data was also used to calculate carrying capacity based on a local forage value rating. Information derived from these calculations can be used to guide management decisions, including stocking rates. This report supplies the 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 8, Utah 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 periodic sampling of rangelands allows district grazing committees to evaluate the carrying capacity and resulting stocking rates of rangelands (Goodman 1982).

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.

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, 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

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 8, Utah and MVTP. 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 District 8 area is topographically rugged, including the mesas and outcrops on Monument Valley Tribal Park (MVTP), rolling shrublands, and canyon tributaries of the San Juan River. The area is bordered on the north by the San Juan River, to the east by Comb Ridge, the south by the Arizona state line (except for the portion of MVTP in Arizona) , and to the west by Nokai Mesa.

Few towns exist in the study area. Oljeta and Monument Valley in the south, and the settlement of Halchita in the north. Highway 163, the only paved road, runs northeast-southwest. A map of the study area and the six grazing compartments is provided in Map 1 on the following page.

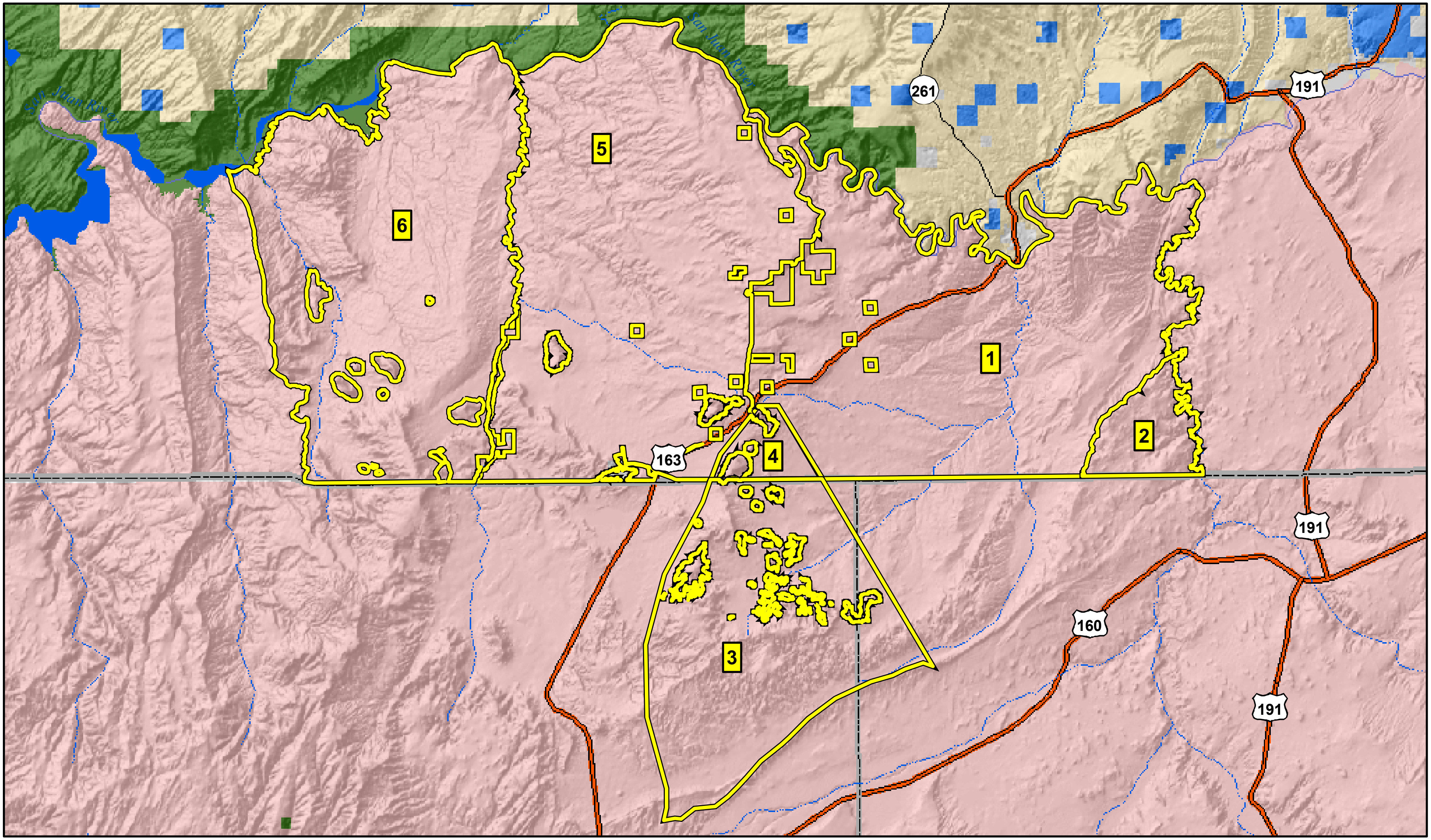
Acreages for each compartment were extracted from digital shapefiles provided by the Western Navajo Agency. The six compartments in the District 8, Utah study area covered 537,623.5 acres, distributed among six compartments as follows: 1- 147,166.6 acres, 2- 12,935 acres, 3- 82,700.1 acres, 4- 5,891.00 acres, 5- 157,079.3 acres, and 6- 131,851.4 acres.

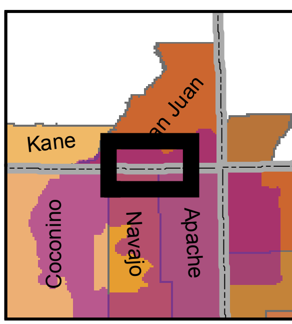
2.2 Geology

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. In the study area these sedimentary layers include sandstone formations of all ages; De Chelly sandstone, Organ Rock Tongue, Cedar Mesa Sandstone. There are also shale dominated formations and carbonate dominated formations of limestone or dolomite. Also present in the study area are unconsolidated eolian deposits of dune sand.

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





Bureau of Indian Affairs

DISTRICT 8 RANGE INVENTORY

OVERVIEW MAP

SAN JUAN COUNTY, UTAH,
NAVAJO AND APACHE COUNTIES, AZ

5/9/2011

0 2 4 8
Miles

Ecosphere
Environmental Services

Transect
Compartments

Owner

- Private
- State
- Bureau of Land Management
- National Park Service
- Tribal

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 from precipitation gauges in the study area were incomplete and therefore unusable. Data was used from the closes t stations with complete datasets, Chilchinbito and Dennehotso. Six years of historical data were averaged as the baseline, or “normal” precipitation. The most recent water year was used to compare deviation from normal. The 2010 water year was about 112 to 149 percent of the six year average.

The precipitation data are provided as Appendix A.

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.

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: the San Juan County, Utah, Navajo Indian Reservation Soil Survey (UT643). In Arizona, MVTP is located on the Navajo Mountain Area, AZ, Parts of Apache, Coconino and Navajo Counties Soil Survey (AZ711). The soil survey is Order III mapped, which means it includes soil and plant components at association or complex levels (called map units). Within the map units, finer levels (called soil types) are generally described, but not mapped. Each of the delineated map units contains multiple soil types within it. Each soil type is correlated with a specific ecological site. Order II mapping would delineate soil types within map units, and boundaries of ecological sites could be determined directly from the soil map. Ecological sites cannot be assigned directly from Order III map information because they are not delineated at that level.

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.

2.5 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 those factors. Many rangelands have undergone significant transitions to a state in which they are never expected to again display the characteristics of the HCPC. 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 directly associated with soil types. The determination of ecological site for each transect can be complicated due to inconsistencies of scale in the soil surveys. As described in Section 2.4, Soils, the Soil Survey was mapped at the soil complex scale (Order III), meaning that there are up to three soil types inside of a mapped soil complex. The smaller soil types are not mapped. Since each soil type has a single ecological site assigned to it, each map unit, has up to three unmapped ecological site possibilities.

Rangeland managers should be aware that maps of ecological sites are available on the NRCS Web Soil Survey website, however, the mapping is by dominant ecological site. Unfortunately, this may grossly misrepresent soil units. For example, in soil map units where the dominant soil type/ecological site is 60 percent of the soil map unit, then the other 40 percent of the soil unit would be mapped incorrectly. An analogy might use a basket of fruit in which there are six apples and four oranges. Using the dominant system, the entire basket of fruit would be labeled as apples. While the dominant ecological site map may be appropriate at a landscape level, it is not correct to use for rangeland management.

The assignment of a soil type and ecological site 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. In cases where the ESD was not developed, an educated guess was applied based on the ESD name, the soil map unit description, and the vegetation community in the area. 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. The ESDs in this report should not be relied upon for future studies, instead 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/.

Most of the ecological sites for the soils in the Arizona portion of MVTP are not assigned in the soil survey. There are 14 ecological sites from the rest ofDistrict 8, Utah study area transect sites in addition to badlands and rockoutcrops. These ecological sites are:

R035XY009UT Alkali Flat Greasewood
R035XY015UT Sandy Bottom (Fourwing Saltbush)

R035XY018UT Talus Slope (Blackbrush-Shadscale)
R035XY115UT Desert Sand (Sand Sagebrush)
R035XY118UT Desert Sandy Loam (Fourwing Saltbush)
R035XY121UT Desert Sandy Loam (Blackbrush)
R035XY126UT Desert Shallow Gypsum
R035XY130UT Desert Shallow Sandy Loam (Shadscale)
R035XY133UT Desert Shallow Sandy Loam (Blackbrush)
R035XY212UT Semidesert Sand (Fourwing Saltbush)
R035XY219UT Semidesert Sandy Loam (Black Grama)
R035XY236UT Semidesert Shallow Sandy Loam (Utah Juniper-Blackbrush)
R035XY324UT Upland Sand (Utah Pinon Juniper)

The following are brief descriptions of the ecological sites extracted from the ecological site descriptions, and accompanied by photos from transects located within those sites.

R035XY009UT -Alkali Flat Greasewood – This ecological site description is not available, it has not been written.

R035XY015UT - Sandy Bottom (Fourwing Saltbush) - This site occurs on flood plains, valley flats, channels, drainageways, and stream terraces at elevations between 3,800 to 6000 feet. The site receives a mean annual precipitation of 6 to 12 inches. The dominant plant aspect is fourwing saltbush (*Atriplex canescens*) and Indian ricegrass (*Achnatherum hymenoides*). Annual production at its highest potential similarity index is between 350 and 950 pounds per acre.

R035XY018UT- Talus Slope (Blackbrush-Shadscale) – Found only on talus slopes, this ecological site has an elevation range of 5,500 to 6400 feet. The site receives a mean of 7 to 12 inches of precipitation annually. It is described as having a plant community dominated by shadscale (*Atriplex confertifolia*) and Indian ricegrass. As the name implies, there may also be blackbrush (*Coleogyne ramosissima*). A low producing site, annual production could range between 75 and 300 pounds per acre at its highest potential similarity index.

R035XY115UT -Desert Sand (Sand Sagebrush) – Found only in sand drift areas, this site occurs between 3,000 and 5,000 feet elevation. It receives a mean annual precipitation of 6 to 9 inches annually. The dominant aspect of the plant community is Indian ricegrass and sand sagebrush (*Artemisia filifolia*). At is highest potential similarity index, the site may produce between 370 and 400 pounds per acre of production in an average year.

R035XY118UT- Desert Sandy Loam (Fourwing Saltbrush) - Located on gently sloping desert plains, mesas, stream terraces and broad valleys, sand sheets and drainageways on structural benches at elevations between 3,800 and 5,000 feet. It receives between 5 to 9 inches of precipitation annually. The plant community is dominated by fourwing saltbush and Indian ricegrass. At its highest potential similarity index the site could produce between 250 to 550 pounds per acre of air dry annual production.

R035XY121UT -Desert Sandy Loam (Blackbrush) – Found on mesas and benches at elevations between 3,000 and 5,000 feet. This ecological site receives between 6 to 9 inches of mean annual precipitation. The plant community is dominated by open stands of blackbrush with Indian ricegrass. The site can support between 400 and 450 pounds per acre of annual production in an average year at its highest potential similarity index.

R035XY126UT -Desert Shallow Gypsum - This ecological site description is not available, it has not been written.

R035XY130UT- Desert Shallow Sandy Loam (Shadscale) – Occuring on mesa tops, benches and cuesta scarps, this site receives only 6 to 9 inches of annual precipitation. It is found at elevations between 3,000 and 5,000 feet. The dominant plants include shadscale, Indian ricegrass and galleta grass (*Pleuraphis jamesii*). Annual production in air dry weight ranges between 75 and 400 pounds per acre, at its highest potential similarity index.

R035XY133UT Desert Shallow Sandy Loam (Blackbrush) – Located on dissected pediments, escarpments, ledges, hillslopes on structural benches, rolling ridges, dissected cuestas, structural benches, mesa tops, south facing hillsopes, and canyons. Found at elevations between 3,700 and 6,000 feet. Mean annual precipitation is between 6 to 10 inches annually. The ecological site is dominated by a blackbrush community with native grasses or invasive grasses may be present depending on the state. Annual production may reach between 195 and 315 pounds per acre at the sites highest potential.

R035XY212UT Semidesert Sand (Fourwing Saltbush) – This site occurs on dunes, sand sheets and structural benches between 4,200 and 6,700 feet in elevation. It receives 7 to 12 inches of mean annual precipitation. The plant community is dominated by fourwing saltbush but may transition to sand sagebrush. Annual production in air dry weight ranges between 291 and 600 pounds per acre, at its highest potential similarity index.

R035XY219UT Semidesert Sandy Loam (Black Grama) – Found on alluvial fans and valley flats at elevations between 4,500 and 5,700 feet. Mean annual precipitation is between 7 to 10 inches. The plant community is Indian ricegrass, galleta grass (*Pleuraphis jamesii*), fourwing saltbush and Mormon tea (*Ephedra* spp.). Annual production in air dry weight ranges between 221 and 541 pounds per acre, at its highest potential similarity index.

R035XY236UT- Semidesert Shallow Sandy Loam (Utah Juniper-Blackbrush)- This ecological site can be found on foothills, benches and mesa tops at elevations usually between 4,600 and 5,800 feet. Dominant plant species include Utah juniper (*Juniperus osteosperma*), Pinyon pine (*Pinus edulis*) as overstory, and blackbrush as understory. The sites that best fit the description are at 5,800 feet in elevation; at higher elevations the plant composition shifts with an increase in sagebrush and a decrease in blackbrush. Mean annual precipitation is variable, averaging 8 to 12 inches. The site produces 200 to 300 pounds per acre of annual production in an average year.

R035XY324UT- Upland Sand (Utah Juniper-Pinyon) – This site is found on stabilized dunes and sand sheets on structural benches; mesas; and hillslopes between 5,550 and 7,500 feet in elevation. Mean annual precipitation is between 12 and 16 inches. The overstory consists of Utah juniper and pinyon pine, with an understory dominated by Mormon tea, as well as grasses that will decrease as conditions deteriorate. Annual production may range between 252 pounds per acre of air dry weight in a low year, to 652 in a favorable year.

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 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. Updated.

The field methodology was based on the SOW and the technical references, with modifications approved by the BIA.

3.1 Field Methodology

3.1.1 Transect Establishment

Data collection in the field occurred between 8 September and 31 October, 2010. The BIA provided Ecosphere with predetermined transect locations. The Universal Transverse Mercator (UTM) coordinates of these transect locations were downloaded into hand held 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 on inaccessible canyon slopes or adjacent to private residences. These transects were moved to suitable locations within the same soil unit.

Transects consisted of a paced, linear study 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 azimuth. 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. The vegetative attributes measured at each transect were production, cover, and frequency. Aspect, slope, soil surface and notes were recorded in addition to the vegetative attributes.

3.1.2 Production Data Collection

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 includes the aboveground 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.

Weight is the most meaningful expression of the productivity of a plant community or an individual species. It has a direct relationship to feed units for grazing animals that other measurements do not have. Production is determined by measuring the annual aboveground growth of vegetation. Some aboveground growth is used by insects and rodents, or it disappears because of weathering before production measurements are made.

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.

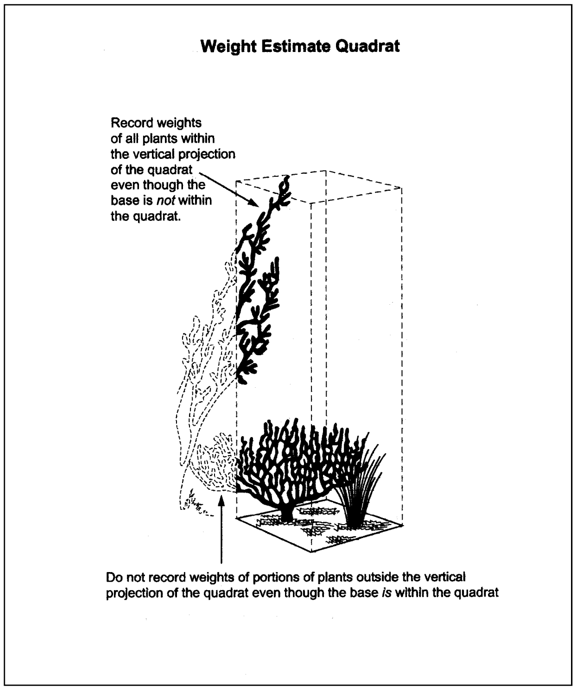
3.1.2.1 Establishing a Weight Unit

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: 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.

3.1.2.2 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 3.2.1). Two plots were chosen as representative plots for harvesting, plots 3 and 7. On the harvested plots all species were estimated *in situ* and then harvested at ground level. In many cases, vegetation was so diverse and widespread that no two plots could effectively represent the species, especially forage species. If important forage species were not represented in the harvested plots, then these species were 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 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. Also included is a list of scientific collections made during the data collection, under Ecosphere’s valid Navajo Nation permit.

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.

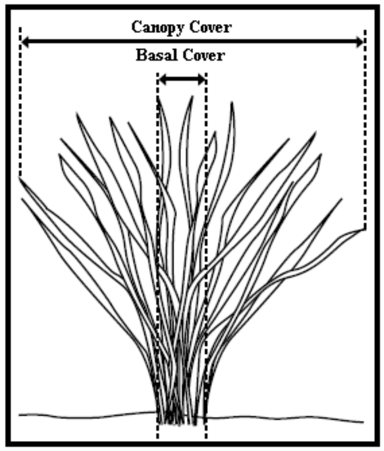
3.1.4 Cover Data Collection

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 (foliar) 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) over 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 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 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 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.

3.2 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 ecological sites within each community, and the data analyzed. Analysis included similarity indices, 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 pounds per acre 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 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* 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.

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

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). 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 0.8888.

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

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.

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. The 2010 water year data within the project area was not collected completely, so data was gathered from gauging stationsoutside the project area in District 8. It would provide more accuracy to the annual production if a more comprehensive record was available from local water stations.

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

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

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:

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

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.

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

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 five most common species to appear on transects within each community is presented in Section 4 Results.

3.2.4 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% 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 allowed pounds of each species was summed for each transect.

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. 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 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 8 range management currently allows for year round grazing so forage values are listed for each season, and the available forage is calculated for each season.

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% 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% for preferred plants, 25% for desirable, and 15% 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, for each season.

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.

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). When calculating carrying capacity, only the winter available forage was used. This is because grazing permits in District 8 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 8 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.

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% of the soil unit consists of soil type “yy” while 80% 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

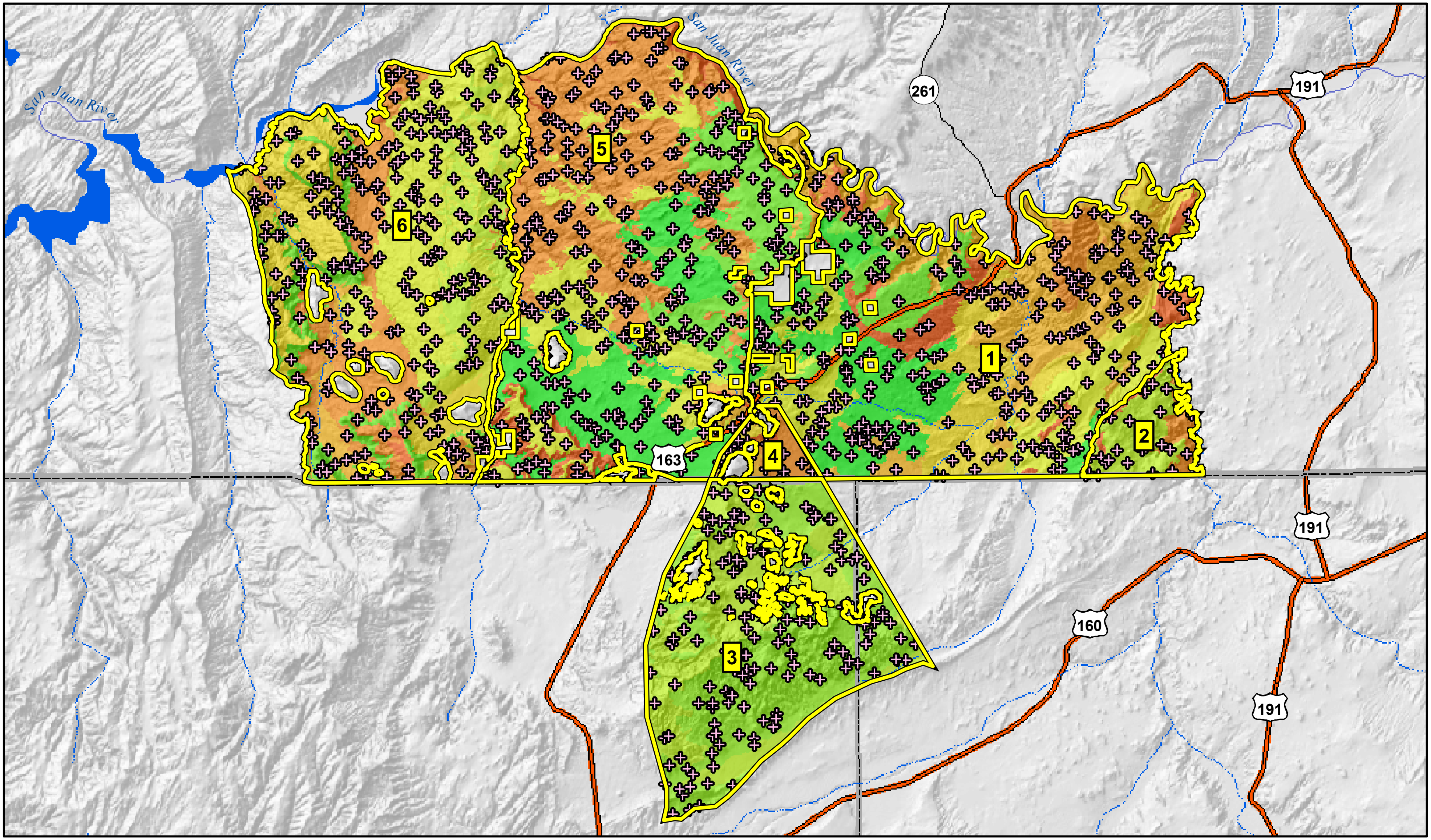
A total of 1092 transects were located on District Two, Utah and MVTP study area. Additional transect data was collected for a total of 1094 transects. The attributes calculated from the data were total annual production, available forage, vegetative and ground cover, and species frequency. Each District was analyzed by compartment, and using soil map units and ecological sites within those compartments for production and stocking rate calculations. Carrying capacity was calculated in Animal Units Year Long. The following sections discuss results for ground cover, species frequency and composition, similarity indices and available forage by ecological site within each compartment. No reductions were made for inaccessible areas in the project area such as slopes over 60 percent or areas greater than two miles from a water source.

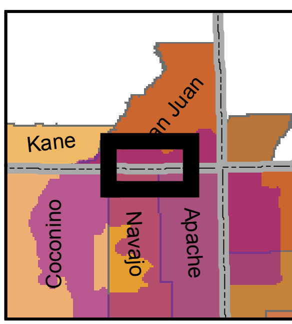
Compartment	Transects	Acres	Total Available Winter Forage (lbs)	Carrying Capacity (AUM)	Carrying Capacity (AUYL)
1	298	147,166.6	711,758.0	780.0	65.0
2	26	12,935.0	69,427.9	76.1	6.3
3	161	82,700.1	593,121.4	650.0	54.2
4	16	5,891.0	15,442.7	16.9	1.4
5	318	157,079.3	858,655.5	941.0	78.4
6	275	131,851.4	581,263.5	637.0	53.1
Total	1094	537,623.5	2,829,669.0	3,101.0	258.4

The random generation of transects produced a good coverage of the project area. Only a few soil map units were not sampled. The sum of the acres of those map units is shown in the table below. Less than 0.1% of the project area was unsampled.

Compartment	Acres	Acres Not Sampled	Percent Not Sampled
1	147,166.6	1.0	0.000693
2	12,935.0	327.9	2.5
3	82,700.1	0.0	0.0
4	5,891.0	198.5	3.4
5	157,079.3	0.0	0.0
6	131,851.4	0.0	0.0
Total	537,623.5	527.4	0.1

A map showing rates of winter available forage across the District 8, Utah and MVTP study area is provided on the following page.





Bureau of Indian Affairs

DISTRICT 8 RANGE INVENTORY

AVAILABLE FORAGE MAP

SAN JUAN COUNTY, UTAH,
NAVAJO AND APACHE COUNTIES, AZ

5/9/2011

0 2 4 8
Miles

Ecosphere
Environmental Services

Transect | Compartments

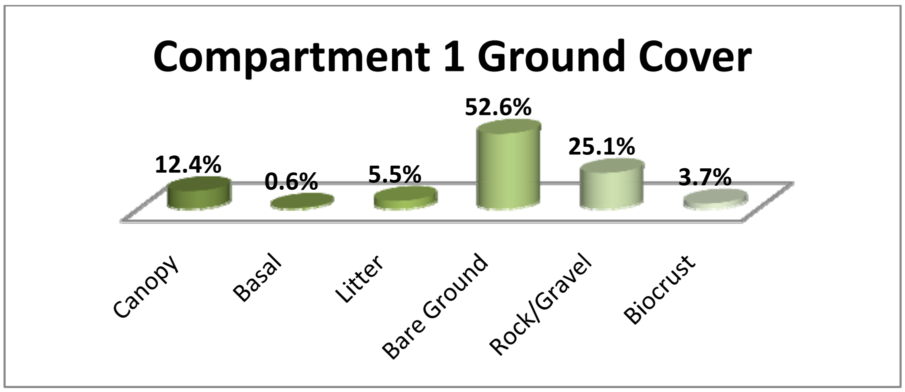
Available Forage (Winter lbs/acre)

0.0	4.1 - 6.1
0.1 - 1.9	6.2 - 7.2
2.0 - 2.6	7.2 - 7.3
2.7 - 3.6	7.3 - 8.2
3.7 - 4.0	8.2 - 8.4

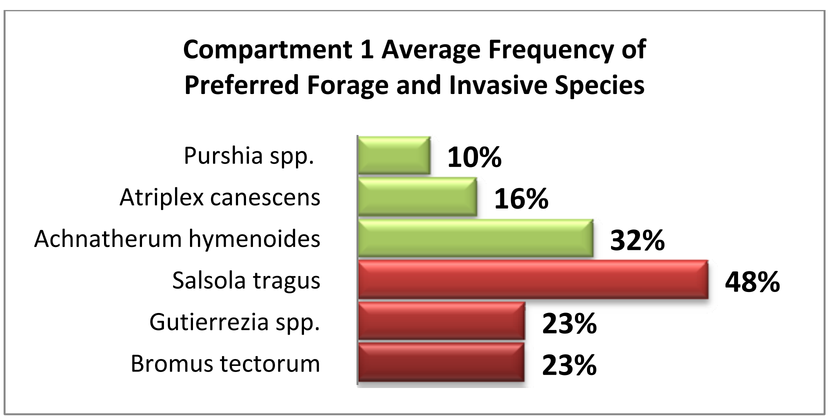
4.1 Compartment 1

In Compartment 1 data was collected on 298 transects. Rock, gravel and bare ground comprised the majority of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 1 was 10 percent. Although this is low, Compartment 1 did have several transects with similarity indices over the 50 percent; the highest was 60 percent. There were also transects with zero similarity.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. Currently, many of the ecological site descriptions are in draft form and do not have complete cover percentages. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here by Compartment can also provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common than preferred forage in Compartment 1. The invasive Russian thistle (*Salsola tragus*) was noticeably prevalent. This is often a sign of declining trend.



The five most common species to occur on transects included Russian thistle as the most common species on Compartment 1, occurring in 74 percent of all transects. The other top species include two forbs and two shrubs.

Species	Number of Transects	Percentage of Transects
Salsola tragus	220	74%
Abronia fragrans	197	66%
Ephedra spp.	164	55%
Chrysothamnus viscidiflorus	163	55%
Plantago patagonica	153	51%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 65 animal units year long on 147,166.6 acres based on *winter* forage availability. Only one acre was excluded from the carrying capacity calculation based on ecological site and soil map unit sampling.

Ecological Site	Badlands	NOT PROVIDED	R035XY009UT Alkali Flat Greasewood	R035XY015UT Sandy Bottom (Fourwing Saltbush)	R035XY018UT Talus Slope (Blackbrush-Shadscale)	R035XY115UT Desert Sand (Sand Sagebrush)	R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	R035XY121UT Desert Sandy Loam (Blackbrush)	R035XY126UT Desert Shallow Gypsum	R035XY130UT Desert Shallow Sandy Loam (Shadscale)	R035XY133UT Desert Shallow Sandy Loam (Blackbrush)
# of Transects	1	2	4	1	9	2	67	42	26	106	38
Reconstructed Weight (Lbs./Ac.)	87	289	251	242	94	547	412	241	182	203	265
Allowable Weight (Lbs./Ac.)	NA	NA	NA	133	37	43	27	54	NA	39	40
Total Production in Reference State (Lbs./Ac.)	NA	NA	NA	600	213	309	425	260	NA	255	220
Average Similarity Index (%)	NA	NA	NA	22%	17%	14%	6%	21%	NA	15%	18%
Available Spring Forage for Stocking Rate (Lbs./Ac.)	16	62	48	33	14	64	81	39	40	36	52
Available Summer Forage for Stocking Rate	5	4	18	28	9	12	19	13	7	11	15

(Lbs./Ac.)											
Available Fall Forage for Stocking Rate (Lbs./Ac.)	2	2	16	26	6	6	17	13	6	10	13
Available Winter Forage for Stocking Rate (Lbs./Ac.)	3	1	5	25	5	9	9	5	3	4	6

Because ecological sites are not mapped, analysis was calculated by ecological sites within soil map units based on percentage of ecological sites within each soil map unit. For management purposes, it may be useful to see the forage available and stocking rates by soil map units.

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
AnA	Aneth loamy fine sand, moderately alkali, 0 to 3 percent slopes	2894.0	13263.6	4.6	100.0	14.5
BA	Badland	603.0	1838.1	3.0	100.0	2.0
DMD	Deleco-Monue association, sloping	12639.2	92322.3	7.3	100.0	101.2
HmD	Hoskinnini-Rock outcrop complex, 2 to 8 percent slopes	9387.8	40576.9	4.3	100.0	44.5
LAG	Lithic Torriorthents-Typic Torriorthents-Rock outcrop association, steep	12741.2	38678.0	3.0	100.0	42.4
LLG	Lithic Torriorthents-Rock outcrop (limestone) complex, steep	5354.2	12947.8	2.4	100.0	14.2
MbD	Moenkopie sandy loam, 3 to 8 percent slopes	24405.7	94431.0	3.9	100.0	103.5
McF	Moenkopie-Rock outcrop complex, 8 to 25 percent slopes	15014.1	44424.0	3.0	100.0	48.7
NbC	Nakai very fine sandy loam, 2 to 6 percent slopes	26916.6	249598.4	9.3	100.0	273.5
NnD	Neskahi fine sandy loam, 2 to 6 percent slopes	12249.2	64299.7	5.2	100.0	70.5
PrE	Piute-Rock outcrop complex, 3 to 25 percent slopes	0.0	0.0	3.8	100.0	0.0
RO	Rock outcrop	645.6	0.0	0.0	100.0	0.0
RRG	Rock outcrop, sandstone-Lithic Torriorthents, association, steep	4017.8	7772.8	1.9	100.0	8.5

RSG	Rock outcrop-Moenkopie association, steep	7578.2	9163.0	1.2	100.0	10.0
RaE	Raplee very fine sandy loam, 2 to 12 percent slopes	11014.3	30695.0	2.8	100.0	33.6
SSD	Sogzie-Sheppard association, sloping	1.5	4.3	2.9	31.3	0.0
ShD	Sheppard fine sand, hummocky	1271.7	11743.0	9.2	100.0	12.9
w	Water	432.6	0.0	0.0	n/a	0.0

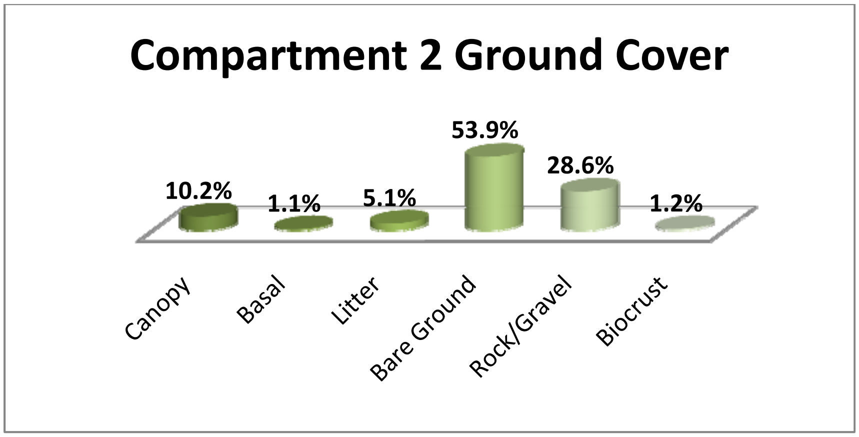
The production data for transects in compartment 1 were analyzed for descriptive statistics. The standard deviation was high, indicating a large variance in the data.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	261.30
Standard Error	16.37
Median	173.90
Standard Deviation	282.67
Minimum	9.61
Maximum	2,424.75
Sum	77,868.08
Confidence	32.23

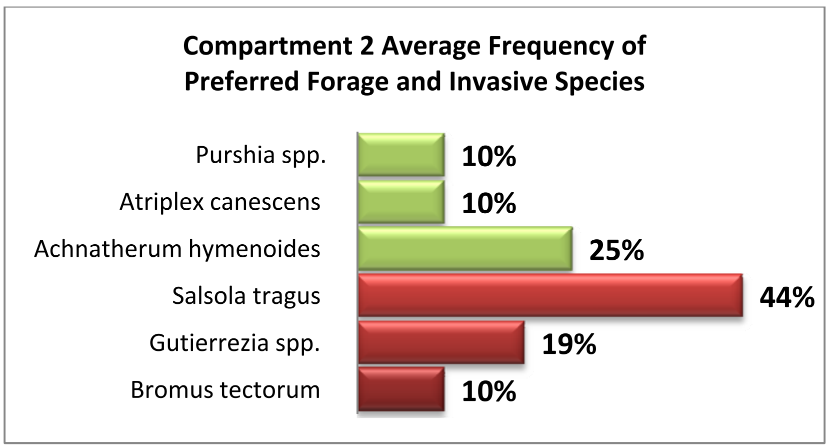
4.2 Compartment 2

In Compartment 2 there were 26 transects. Rock, gravel and bare ground comprised the majority of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 2 was 9 percent.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common that preferred forage in Compartment 2. This is often a sign of declining trend, however 25 percent frequency of Indian ricegrass (*Achnatherum hymenoides*) is high.



The five most common species to occur on transects in Compartment 2 included forbs, shrubs, and a preferred forage species, Indian ricegrass.

Species	Number of Transects	Percentage of Transects
Salsola tragus	17	68%
Sporobolus cryptandrus	15	60%
Ephedra spp.	14	56%
Achnatherum hymenoides	13	52%
Gutierrezia spp.	12	48%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 6.3 animal units year long on 12,935 acres based on *winter* forage availability. However,2.5 percent, or 327.9 acres, were not included in the carrying capacity calculation due to a lack of transects, or inadequate distribution of transects, on the soil map unit. On the other hand, these results have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads, steep slopes, and rock outcrop.

Ecological Site	R035XY015UT Sandy Bottom (Fourwing Saltbush)	R035XY115UT Desert Sand (Sand Sagebrush)	R035XY130UT Desert Shallow Sandy Loam (Shadscale)	Rock Outcrop
# of Transects	1	17	5	3
Reconstructed Weight (Lbs./Ac.)	992	337	126	268
Allowable Weight (Lbs./Ac.)	26	35	37	NA
Total Production in Reference State (Lbs./Ac.)	600	309	255	NA
Average Similarity Index (%)	4%	11%	14%	NA
Available Spring Forage for Stocking Rate (Lbs./Ac.)	241	63	12	57
Available Summer Forage for Stocking Rate (Lbs./Ac.)	11	26	11	3
Available Fall Forage for Stocking Rate (Lbs./Ac.)	11	25	11	4
Available Winter Forage for Stocking Rate (Lbs./Ac.)	1	7	1	3

Because ecological sites are not mapped, analysis was calculated by ecological sites within soil map units based on percentage of ecological sites within each soil map unit. For management purposes, it may be useful to see the forage available and stocking rates by soil map units.

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
AnA	Aneth loamy fine sand, moderately alkali, 0 to 3 percent slopes	39.4	0.0	0.0	0.0	0.0
LAG	Lithic Torriorthents-Typic Torriorthents-Rock outcrop association, steep	817.5	1084.8	1.3	64.7	1.2

RO	Rock outcrop	456.3	1298.5	2.8	100.0	1.4
RRG	Rock outcrop, sandstone-Lithic Torriorthents, association, steep	2612.5	5530.6	2.1	100.0	6.1
ShD	Sheppard fine sand, hummocky	9009.2	61514.0	6.8	100.0	67.4

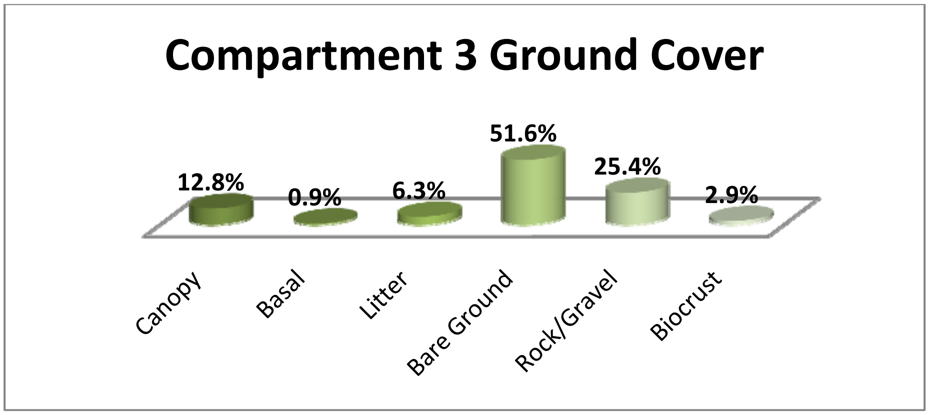
Descriptive statistics were applied to the transect production data in Compartment 2. The standard deviation was high, indicating a large variance in the data.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	313.59
Standard Error	62.30
Median	174.96
Standard Deviation	317.69
Minimum	0.00
Maximum	1,061.57
Sum	8,153.27
Confidence Level(95.0%)	128.32

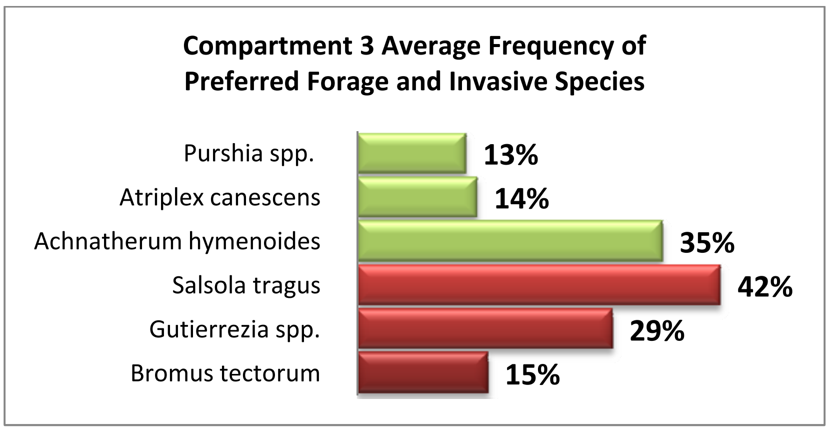
4.3 Compartment 3 (MVTP, Arizona)

In Compartment 3 data was collected on 161 transects. Rock, gravel and bare ground, as well as vegetative cover, comprised the majority of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 3 could not be calculated due to a lack of ecological site descriptions for the soil units in this compartment.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common that preferred forage in Compartment 3. This is often a sign of declining trend, however 35 percent frequency of Indian ricegrass (*Achnatherum hymenoides*) is high.



The single most common species to occur on transects in Compartment 3 was Russian thistle, however, in the top five most common species were also two forage species, Indian ricegrass and galleta grass (*Pleuraphis jamesii*).

Species	Number of Transects	Percentage of Transects
Salsola tragus	100	62%
Achnatherum hymenoides	93	58%
Gutierrezia	91	57%
Ephedra spp.	85	53%
Pleuraphis jamesii	81	50%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 54.2 animal units year long on 82,700.1 acres based on *winter* forage availability. All acres were included in the carrying capacity calculation. These results have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads, steep slopes, and rock outcrop.

Due to a lack of ecological sites in Compartment 3, no similarity index calculations were made. The rest of the calculations were completed: production data was calculated for available forage, and stocking rates and carrying capacity were calculated for the entire Compartment.

Ecological Site	None
# of Transects	161
Reconstructed Weight (Lbs./Ac.)	168
Allowable Weight (Lbs./Ac.)	NA
Total Production in Reference State (Lbs./Ac.)	NA
Average Similarity Index (%)	NA
Available Spring Forage for Stocking Rate (Lbs./Ac.)	27
Available Summer Forage for Stocking Rate (Lbs./Ac.)	11
Available Fall Forage for Stocking Rate (Lbs./Ac.)	9
Available Winter Forage for Stocking Rate (Lbs./Ac.)	7

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
Overall	N/A	82700.1	593121.4	7.2	100.0	650.0

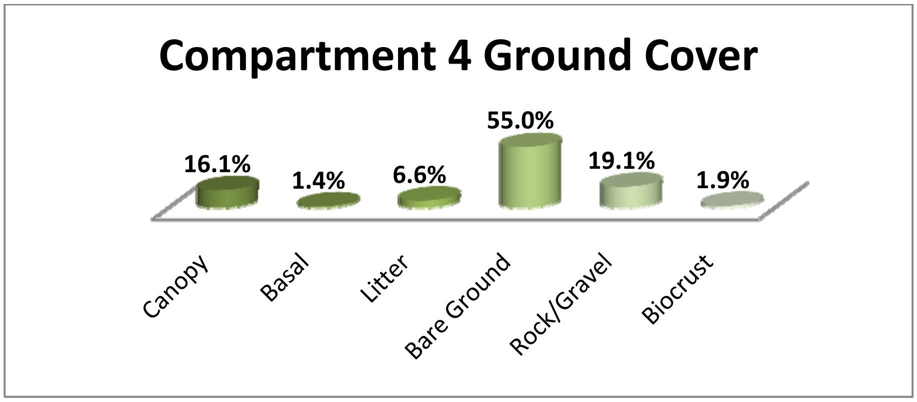
Descriptive statistics were applied to the transect production data in Compartment 3. The standard deviation was high, indicating a large variance in the data.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	168.10
Standard Error	17.44
Median	91.71
Standard Deviation	221.29
Minimum	0.00
Maximum	1,581.11
Sum	27,063.55
Confidence	34.44

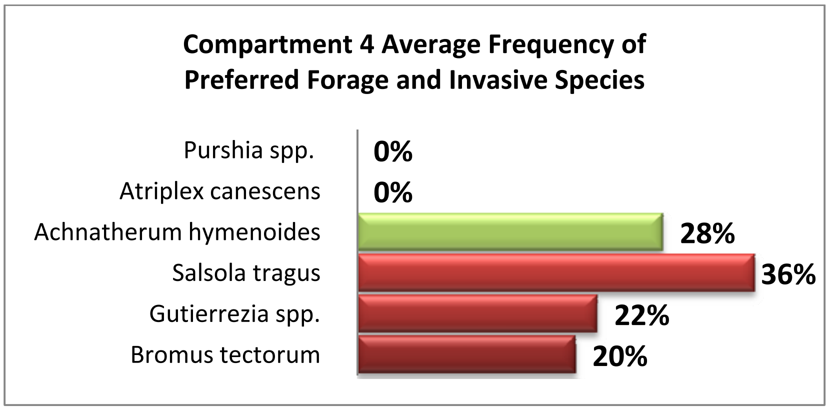
4.4 Compartment 4 (MVTP, Utah)

In Compartment 4 there were 16 transects. Bare ground, Rock/gravel as well as canopy vegetation comprised the majority of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 4 was only 8 percent.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common that preferred forage in Compartment 4. This is often a sign of declining trend. While there was less frequency of preferred shrubs, the 28 percent frequency of Indian ricegrass (*Achnatherum hymenoides*) is high.



The five most common species to occur on transects in Compartment 4 included two forage species, galleta grass and Indian ricegrass. Although Russian thistle is common, it does not represent as much of the composition of this Compartment as in other Compartments.

Species	Number of Transects	Percentage of Transects
Ephedra spp.	14	88%
Coleogyne ramosissima	12	75%
Pleuraphis jamesii	12	75%
Salsola tragus	11	69%
Achnatherum hymenoides	10	63%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 1.4 animal units year long on 5,891 acres, based on winter forage availability. However,3.4 percent, or 198.5 acres, were not included in the carrying capacity calculation due to a lack of transects, or inadequate distribution of transects, on the soil map unit. These results have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads, steep slopes, and rock outcrop.

Ecological Site	R035XY018UT Talus Slope (Blackbrush-Shadscale)	R035XY115UT Desert Sand (Sand Sagebrush)	R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	R035XY133UT Desert Shallow Sandy Loam (Blackbrush)	Unassigned
# of Transects	1	4	6	3	2
Reconstructed Weight (Lbs./Ac.)	17	72	288	222	82
Allowable Weight (Lbs./Ac.)	15	38	31	26	NA
Total Production in Reference State (Lbs./Ac.)	213	309	425	220	NA
Average Similarity Index (%)	7%	12%	7%	12%	NA
Available Spring Forage for Stocking Rate (Lbs./Ac.)	2	16	68	44	16
Available Summer Forage for Stocking Rate (Lbs./Ac.)	2	10	6	9	14
Available Fall Forage for Stocking Rate (Lbs./Ac.)	2	6	4	8	10
Available Winter Forage for Stocking Rate (Lbs./Ac.)	1	6	3	4	11

Because ecological sites are not mapped, analysis was calculated by ecological sites within soil map units based on percentage of ecological sites within each soil map unit. For management purposes, it may be useful to see the forage available and stocking rates by soil map units.

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
HmD	Hoskinnini-Rock outcrop complex, 2 to 8 percent slopes	1851.7	4665.7	2.5	100.0	5.1
LAG	Lithic Torriorthents-Typic Torriorthents-Rock outcrop association, steep	562.3	106.5	0.2	64.7	0.1
MhD	Monue-Sheppard complex, 1 to 12 percent slopes	1095.9	4426.6	4.0	100.0	4.9
NbC	Nakai very fine sandy loam, 2 to 6 percent slopes	2381.1	6243.9	2.6	100.0	6.8

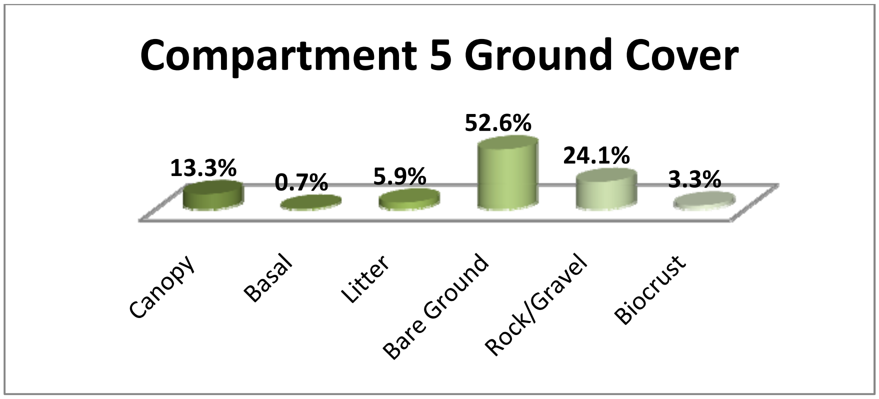
Descriptive statistics were applied to the transect production data in Compartment 4. The standard deviation was high, indicating a large variance in the data.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	179.10
Standard Error	62.55
Median	78.40
Standard Deviation	250.21
Minimum	17.08
Maximum	931.15
Sum	2,865.56
Confidence	133.33

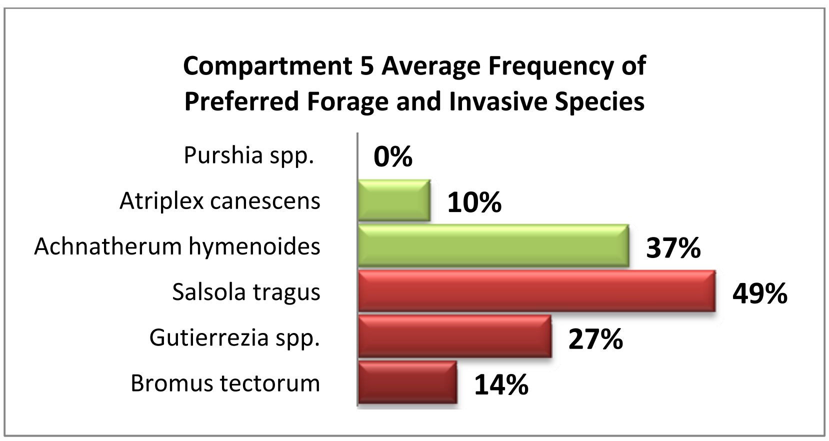
4.5 Compartment 5

In Compartment 5 there were 318 transects. Rock, gravel and bare ground comprised the majority of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 5 was only 8 percent.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common that preferred forage in Compartment 5. This is often a sign of declining trend, however 37 percent frequency of Indian ricegrass (*Achnatherum hymenoides*) is very high, and was the highest of all Compartments.



The five most common species to occur on transects in Compartment 5 Indian ricegrass as the most commonspecies by composition, tied evenly with snakeweed (*Gutierrezia* spp.). Also common was Russian thistle and galleta grasss, and blackbrush (*Coleogyne ramosissima*).

Species	Number of Transects	Percentage of Transects
Achnatherum hymenoides	217	66%
Gutierrezia spp.	217	66%
Salsola tragus	204	62%
Coleogyne ramosissima	169	51%
Pleuraphis jamesii	148	45%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 78.4 animal units year long on 157, 079.3acres based on *winter* forage availability. All acres were included in the carrying capacity calculation. These results have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads, steep slopes, and rock outcrop.

Ecological Site	NOT PROVIDED	R035XY015UT Sandy Bottom (Fourwing Saltbush)	R035XY018UT Talus Slope (Blackbrush-Shadscale)	R035XY115UT Desert Sand (Sand Sagebrush)	R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	R035XY121UT Desert Sandy Loam (Blackbrush)	R035XY130UT Desert Shallow Sandy Loam (Shadscale)	R035XY133UT Desert Shallow Sandy Loam (Blackbrush)	R035XY212UT Semidesert Sand (Fourwing Saltbush)	R035XY219UT Semidesert Sandy Loam (Black Grama)	Rock Outcrop	Unassigned
# of Transects	6	1	11	42	31	8	121	63	22	1	5	7
Reconstructed Weight (Lbs./Ac.)	368	326	55	492	327	347	125	148	603	304	75	245
Allowable Weight (Lbs./Ac.)	NA	64	15	30	24	38	19	32	34	94	NA	NA
Total Production in Reference State (Lbs./Ac.)	NA	600	213	309	425	260	255	220	425	381	NA	NA
Average Similarity Index (%)	NA	11%	7%	10%	6%	15%	7%	15%	8%	25%	NA	NA
Available Spring Forage for Stocking Rate (Lbs./Ac.)	84	11	9	100	52	57	17	20	138	74	7	44
Available Summer Forage for Stocking Rate (Lbs./Ac.)	7	10	6	16	14	23	5	6	44	70	2	17
Available Fall Forage for Stocking Rate (Lbs./Ac.)	7	13	4	15	15	28	5	6	40	70	1	15
Available Winter Forage for Stocking Rate (Lbs./Ac.)	7	10	1	8	10	16	4	4	12	7	1	10

Because ecological sites are not mapped, analysis was calculated by ecological sites within soil map units based on percentage of ecological sites within each soil map unit. For management purposes, it may be useful to see the forage available and stocking rates by soil map units.

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
DMD	Deleco-Monue association, sloping	21435.2	130583.5	6.1	100.0	143.1

DND	Deleco-Nakai-Rock outcrop association, sloping	3761.9	19155.6	5.1	100.0	21.0
HmD	Hoskinnini-Rock outcrop complex, 2 to 8 percent slopes	1593.4	4955.3	3.1	100.0	5.4
LAG	Lithic Torriorthents-Typic Torriorthents-Rock outcrop association, steep	10121.8	18938.2	1.9	100.0	20.8
MFD	Moepitz-Monue association, gently sloping	1373.7	19447.0	14.2	100.0	21.3
MhD	Monue-Sheppard complex, 1 to 12 percent slopes	31141.3	282228.9	9.1	100.0	309.3
NbC	Nakai very fine sandy loam, 2 to 6 percent slopes	1015.8	9724.9	9.6	100.0	10.7
OJD	Oljeto-Sheppard association, sloping	4326.0	58886.5	13.6	100.0	64.5
PrE	Piute-Rock outcrop complex, 3 to 25 percent slopes	1124.6	3221.2	2.9	100.0	3.5
RRG	Rock outcrop, sandstone-Lithic Torriorthents, association, steep	58003.2	132105.8	2.3	100.0	144.8
Rh	Riverwash	117.8	0.0	0.0	100.0	0.0
SSD	Sogzie-Sheppard association, sloping	11920.9	88431.0	7.4	100.0	96.9
ShD	Sheppard fine sand, hummocky	1791.0	14707.8	8.2	100.0	16.1
ShE	Sheppard fine sand, rolling	5925.7	48662.8	8.2	100.0	53.3
SkE	Sheppard fine sand, high rainfall, hummocky	3361.7	27606.9	8.2	100.0	30.3
w	Water	65.6	0.0	0.0	n/a	0.0

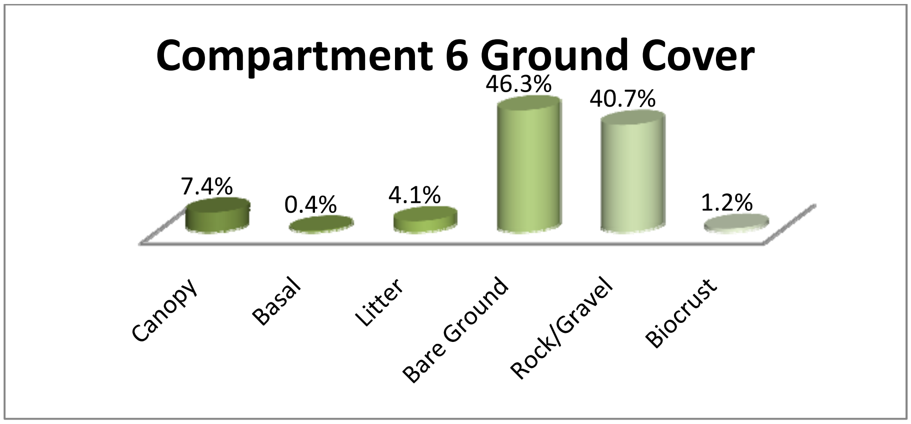
Descriptive statistics were applied to the transect production data in Compartment 3. The standard deviation was high, indicating a large variance in the data.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	242.99
Standard Error	18.71
Median	136.24
Standard Deviation	332.53
Minimum	0.89
Maximum	2,853.85
Sum	76,783.53
Confidence	36.80

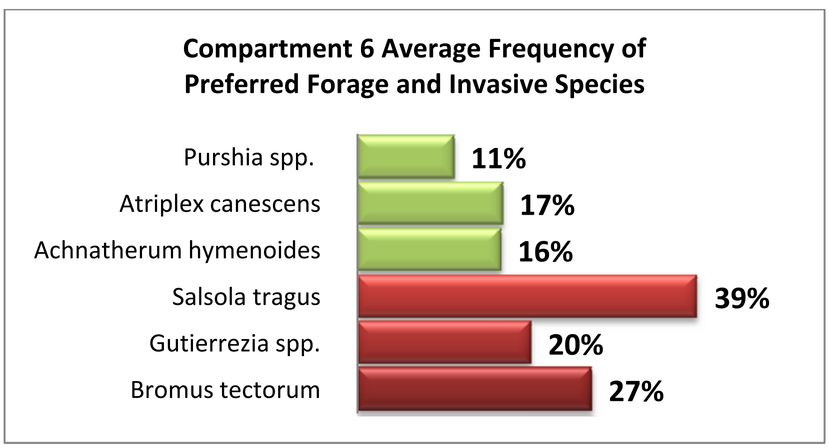
4.6 Compartment 6

In Compartment 6 there were 275 transects. Rock, gravel and bare ground comprised almost all of the ground cover. Invasive species were frequent. The median similarity index of all transects in Compartment 6 was the lowest of all compartments in the study area at 6 percent.

Ground cover was analyzed by ecological site so that comparisons could be made to the ground cover percentages in the written ecological site descriptions. The dataset for ground cover by ecological site is large so it is provided with the electronic data for this study. However, the ground cover figures presented here can provide a baseline for determining trend in future studies.



The average plot frequency of common invasive and preferred species shows that invasive species are far more common that preferred forage in Compartment 6. This is often a sign of declining trend.



The five most common species to occur on transects in Compartment 6 consisted of forbs and shrubs including invasive species snakeweed and Russian thistle.

Species	Number of Transects	Percentage of Transects
Gutierrezia spp.	163	60%
Salsola tragus	141	52%
Coleogyne ramosissima	139	51%
Ephedra torreyana	125	46%
Chamaesyce spp.	93	34%

Production results are calculated and presented by ecological site. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value as explained in Section 3.2.5. This compartment has a carrying capacity of 53.1 animal units year long on 131,851.4 acres based on *winter* forage availability. All acres were included in the carrying capacity calculation. These results have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads, steep slopes, and rock outcrop.

Ecological Site	NOT PROVIDED	R035XY015UT Sandy Bottom (Fourwing Saltbush)	R035XY018UT Talus Slope (Blackbrush-Shadscale)	R035XY115UT Desert Sand (Sand Sagebrush)	R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	R035XY121UT Desert Sandy Loam (Blackbrush)	R035XY130UT Desert Shallow Sandy Loam (Shadscale	R035XY130UT Desert Shallow Sandy Loam (Shadscale)	R035XY133UT Desert Shallow Sandy Loam (Blackbrush)	R035XY212UT Semidesert Sand (Fourwing Saltbush)	R035XY236UT Semidesert Shallow Sandy Loam (Utah Juniper-Blackbr	R035XY324UT Upland Sand (Utah Pinon Juniper)	Rock Outcrop	Unassigned
# of Transects	4	4	22	2	7	15	1	146	61	1	2	1	6	3
Reconstructed Weight (Lbs./Ac.)	33	61	121	60	176	156	123	109	90	918	51	234	117	80
Allowable Weight (Lbs./Ac.)	NA	16	20	23	30	32	5	22	18	15	32	37	NA	NA
Total Production in Reference State (Lbs./Ac.)	NA	600	213	309	425	260	255	255	220	425	275	452	NA	NA
Average Similarity Index (%)	NA	3%	10 %	7%	7%	12 %	2%	9%	8%	4%	12 %	8%	NA	NA
Available Spring Forage for Stocking	4	11	27	8	24	31	25	16	15	6	3	1	22	9

Rate (Lbs./Ac.)														
Available Summer Forage for Stocking Rate (Lbs./Ac.)	2	4	13	5	11	6	7	4	5	6	3	1	6	4
Available Fall Forage for Stocking Rate (Lbs./Ac.)	2	2	13	4	11	7	11	4	4	8	4	0	4	3
Available Winter Forage for Stocking Rate (Lbs./Ac.)	1	1	12	3	8	4	6	1	2	13	5	0	3	0

Because ecological sites are not mapped, analysis was calculated by ecological sites within soil map units based on percentage of ecological sites within each soil map unit. For management purposes, it may be useful to see the forage available and stocking rates by soil map units.

Soil Map Unit MUSYM	Soil Map Unit Name	Acres	Total Available Winter Forage Pounds	Available Winter forage Pounds Per Acre	Percent Surveyed	Carrying Capacity (AUM)
DND	Deleco-Nakai-Rock outcrop association, sloping	3134.0	11383.0	3.6	100.0	12.5
HaD	Hoskinnini very fine sandy loam, very shallow, 2 to 5 percent slopes	4012.4	8863.4	2.2	100.0	9.7
HmD	Hoskinnini-Rock outcrop complex, 2 to 8 percent slopes	19291.1	46870.4	2.4	100.0	51.4
LAG	Lithic Torriorthents-Typic Torriorthents-Rock outcrop association, steep	15280.7	113073.3	7.4	100.0	123.9
MhD	Monue-Sheppard complex, 1 to 12 percent slopes	1097.0	6510.0	5.9	100.0	7.1
NOC	Neskahi-Oljeto association, sloping	1187.6	4505.5	3.8	100.0	4.9
NkD	Nepalto very fine sandy loam, 2 to 8 percent slopes	3284.8	12462.1	3.8	100.0	13.7
OJD	Oljeto-Sheppard association, sloping	5829.2	20953.7	3.6	100.0	23.0
PcD	Pickrell loamy fine sand, 2 to 6 percent slopes	13270.3	81010.8	6.1	100.0	88.8
PrE	Piute-Rock outcrop complex, 3 to 25 percent slopes	383.3	954.5	2.5	100.0	1.0
PsE	Piute-Rock outcrop complex, high rainfall, 3 to 25 percent slopes	2165.9	5393.7	2.5	100.0	5.9
RRG	Rock outcrop, sandstone-Lithic Torriorthents, association, steep	44814.7	203095.9	4.5	100.0	222.6
RSG	Rock outcrop-Moenkopie association, steep	16561.0	65285.6	3.9	100.0	71.5
Rh	Riverwash	8.8	0.0	0.0	100.0	0.0

SaE	Shedado loamy very fine sand, 1 to 8 percent slopes	669.8	179.7	0.3	100.0	0.2
TrD	Trail loamy sand, 1 to 8 percent slopes	723.7	722.0	1.0	100.0	0.8

Descriptive statistics were applied to the transect production data in Compartment 6. The standard deviation was high, indicating a large variance in the data. The confidence interval in compartment 6 was the best of the study area, showing that the data are reliable.

Descriptive Statistics	Reconstructed Weight (Lbs./Ac.)
Mean	110.87
Standard Error	7.73
Median	68.19
Standard Deviation	128.24
Minimum	0.00
Maximum	917.55
Sum	30,488.99
Confidence	15.22

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

No precipitation gauging station in the District 8, Utah and MVTP study area had a complete data set for the year in which data was collected. 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.

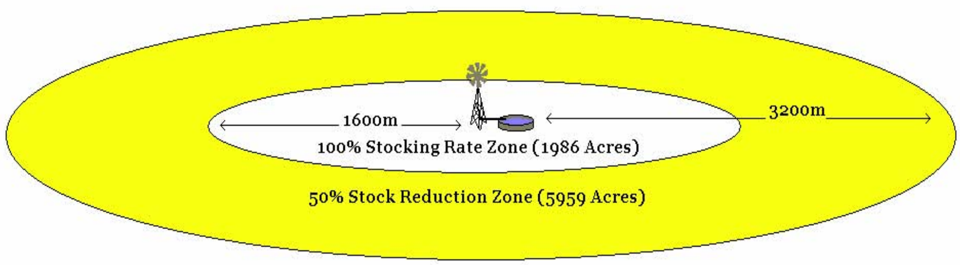
Drought is one of the biggest variables in Southwestern U.S. rangelands. Livestock operators must plan for drought as a normal part of the range-livestock business. Failure to prepare and manage before, during, and after drought conditions is probably one of the biggest reasons why range areas are in 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 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% reduction for the zone 1,600 to 3,200 m from water and that the zone over 3,200 m from water be considered ungrazable (Figure 6.1). The area between 1,600 m and 3,200 m is 5,959 acres.

Figure 6.1 Stocking Rate Reduction Zones at Water Sources



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 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, 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% for slopes from 11 to 30%. Slopes from 31 to 60% should have a 60% reduction in stocking rates and slopes beyond 60% 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 8 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 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 could support more livestock but only during spring and summer. 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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8. APPENDICES

Historical Precipitation Averages by Month
Navajo Nation Precipitation Data

Chilchinbito

Water Year	January	February	March	April	May	June	July	August	September	October	November	December
2002	0.01	0.10	0.20	0.15	0.05	0.00	0.76	0.00	2.65	0.05	0.30	0.29
2003	0.25	0.65	0.50	0.20	0.30	0.10	0.20	1.20	17.20	1.15	0.30	0.70
2004	0.75	0.70	0.10	0.95	0.05	0.00	1.10	1.20	2.40	0.25	0.70	0.75
2005	2.58	1.52	0.40	1.47	0.00	0.15	0.55	2.10	0.10	0.90	1.80	0.40
2006	0.00	0.10	1.00	0.75	0.15	0.30	0.75	3.72	1.03	1.10	0.00	0.10
2009	0.30	0.60	0.90	0.10	0.75	0.05	0.50	0.12	0.58	0.15	0.60	1.90
Historical	**0.65**	**0.61**	**0.52**	**0.60**	**0.22**	**0.10**	**0.64**	**1.39**	**3.99**	**0.60**	**0.62**	**0.69**
2010	2.05	1.3	0.8	0.6	0.1	0.15	2.45	0.9	0.62	0.3	0	1.6
2010 % of Normal	**154.6%**	**165.8%**	**164.3%**	**148.1%**	**149.9%**	**149.9%**	**189.0%**	**154.4%**	**102.3%**	**50.0%**	**24.7%**	**99.7%**

Dennehotso

Water Year	January	February	March	April	May	June	July	August	September	October	November	December
2001	0.55	0.30	0.20	0.00	0.94	0.24	0.10	0.80	0.30	1.90	0.26	0.14
2002	0.03	0.05	0.05	0.10	0.00	0.02	0.48	0.12	1.69	0.07	0.11	0.52
2003	0.12	0.65	0.57	0.13	0.05	0.01	0.17	0.69	0.67	0.72	0.21	0.15
2004	0.22	0.63	0.00	1.09	0.06	0.06	0.33	0.17	1.53	0.63	0.40	0.20
2005	1.22	1.05	0.05	0.57	0.08	0.07	0.20	1.20	0.33	1.23	1.35	0.48
2006	0.45	0.00	0.60	0.08	0.06	0.66	0.35	0.40	0.34	0.71	0.07	0.00
Historical	**0.43**	**0.45**	**0.25**	**0.33**	**0.20**	**0.18**	**0.27**	**0.56**	**0.81**	**0.88**	**0.40**	**0.25**
2010	1.01	0.72	0.62	0.07	0.18	0.2	0.12	2.03	0.67	0	0.3	0.7
2010 % of Normal	**102.7%**	**113.6%**	**126.5%**	**114.9%**	**113.4%**	**113.4%**	**108.2%**	**142.1%**	**132.5%**	**0.0%**	**23.5%**	**65.6%**

COMBINED

Month	January	February	March	April	May	June	July	August	September	October	November	December
Chilchinbito Historical Avg	0.65	0.61	0.52	0.6	0.22	0.1	0.64	1.39	3.99	0.6	0.62	0.69
Dennehotso Historical Avg	0.43	0.45	0.25	0.33	0.2	0.18	0.27	0.56	0.81	0.88	0.4	0.25
Two Station Historical Avg	**0.54**	**0.53**	**0.385**	**0.465**	**0.21**	**0.14**	**0.455**	**0.975**	**2.4**	**0.74**	**0.51**	**0.47**
Chilchinbito 2010	2.05	1.3	0.8	0.6	0.1	0.15	2.45	0.9	0.62	0.3	0	1.6
Dennehotso 2010	1.01	0.72	0.62	0.07	0.18	0.2	0.12	2.03	0.67	0	0.3	0.7
Two Station 2010 Avg	**1.53**	**1.01**	**0.71**	**0.335**	**0.14**	**0.175**	**1.285**	**1.465**	**0.645**	**0.15**	**0.15**	**1.15**
2010 Water Year Cumulative Percent of Normal	**131.9%**	**143.0%**	**148.0%**	**138.3%**	**134.4%**	**134.1%**	**149.3%**	**149.4%**	**111.8%**	**20.3%**	**24.0%**	**84.3%**