District Seven

Vegetative Inventory Report

Prepared for:
Bureau of Indian Affairs
Ft. Defiance Agency

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Abstract

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to collect and compile vegetation data on Grazing District Seven of the Ft. Defiance Agency. The BIA provided Ecosphere with 1,143 pre-determined transect locations and data were collected during the first week of December of 2005 and all of June and July of 2006. Data collected included measurements for biomass production, ground cover and species frequency. Data were grouped by four existing range units and analyzed by ecological sites within each of the range units to determine total annual production and similarity index or forage value rating as well as ground cover percentages and frequency of indicator species. Trend assessments were completed based on the results and analysis. The results of the survey will be used to monitor rangeland trends and adjust stocking rates.

Recommended stocking rates of ecological sites within the four range units ranged from 2.5 to 663.9 acres per sheep unit year long. The recommended initial carrying capacity of the entire study area in District Seven was 22,185 sheep units year long. Overall the District Seven rangelands are in poor condition.

1.0 INTRODUCTION

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to conduct rangeland vegetation inventories on District Seven of the Ft. Defiance Agency. Species specific vegetation data was measured, including annual production, cover, and frequency. These data were used to calculate carrying capacity and assess current range condition. Information derived from these calculations can be used to guide management decisions, including stocking rates. This report supplies the results of the inventory as well as the background, methodology, and discussion necessary for management planning.

1.1 Purpose and Need

The purpose of this inventory is to provide comparison 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 updated stocking rates as well as more comprehensive range management plans which are crucial for future rangeland health and productivity. The Ft. Defiance Agency has stated that the function of their grazing program is to restore the potential of the rangelands to the "maximum extent feasible." This can be accomplished by "establishing good range management principles and then ensuring such practices are continued (Ft. Defiance Agency, 2005, Statement of Work for Vegetation Survey on Ft. Defiance Agency- District 7, unpublished)."

1.2 Affected Regulatory Entities

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

1.2.1 BIA Agency Natural Resources Program

All livestock grazing permits are issued by BIA Natural Resources. Master livestock grazing records are also maintained by the BIA Natural Resources. The BIA is responsible for complying with all federal statutes, orders and regulations. According to the BIA, their obligation "is to protect and preserve the resources on the land, including the land itself, on behalf of the Indian landowners. Protection and preservation includes conservation, highest and best use, and protection against misuse of the property for illegal purposes. BIA will use the best scientific information available, and reasonable and prudent conservation practices, to manage trust and restricted Indian lands. Conservation practices must reflect local land management goals and objectives. Tribes, individual landowners, and BIA will manage Indian agricultural lands." A summary of the BIA Range Policy as stated in the Agricultural and Range Management Handbook (2003) is outlined in Figure 1.1.

Figure 1.1 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.
- Investigate accidental, willful, and/or incidental trespass on Indian agricultural land.
- Provide leadership, training, and technical assistance to Indian landowners and land users.
- Keep records that document the organization, functions, conduct of business, decisions, procedures, operations, and other activities undertaken in the performance of federal trust functions.
- Restrict the number of livestock grazed on Indian range units to the estimated grazing capacity of such ranges, and promulgate such other rules and regulations as may be necessary to protect the range from deterioration, prevent soil erosion, assure full utilization of the range, and like purposes.
- Ensure farming and grazing operations be conducted in accordance with recognized principles of sustained yield management, integrated resource management planning, and sound conservation practices.

1.2.2 District Grazing Committees

Districts, which are formally called Land Management Districts, were established in 1936 by the Soil Conservation Service (now the Natural Resource Conservation Service, or NRCS) and adopted by the BIA. There are 23 districts on the Navajo Nation. 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 are locally organized entities similar to Counties. District Grazing Committees consist of elected representatives from each Chapter who are responsible for monitoring livestock grazing within their respective chapters. The District Seven study area included parts of six Chapters; Whitecone, Dilcon, Teesto, Indian Wells, Jeddito and Low Mountain. Jeddito and Low Mountain are combined into one grazing unit and the part of Whitecone in the study area is included with Indian Wells unit. The areas of District Seven located on the Navajo Partitioned Lands were not included in this study.

1.2.3 Navajo Nation Department of Agriculture (NNDOA)

Individual Grazing District Committee members are elected officials who are directly accountable to their local chapters and administratively accountable to the Director of the NNDOA. The NNDOA is also responsible for annual livestock tallies to determine if permittees are in compliance with their permit. In addition, the NNDOA is responsible for resolving grazing disputes.

1.2.4. Navajo Nation Department of Justice

Many legal issues are attached to the use, transfer, and legality of grazing permits. The Navajo Nation Department of Justice may be called upon from time to time to determine if actions are in the best interests of the Navajo Nation. The Navajo Nation Department of Justice may also be called upon to determine if any actions infringe on the rights of individuals.

2.0 RESOURCE DESCRIPTIONS

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

2.1 History

The Colorado Plateau has always been a marginal resource for livestock production. “Many of the ranchers who have struggled with the semi-arid conditions of the area consider much of the Plateau to be a ’60-40 range.’ This is a range where a cow must have a mouth sixty feet wide and move at forty miles–per-hour to be able to find enough to eat. The Navajo Reservation is no exception to this rule and, if anything, conditions there are worse than in other locations on the Plateau (Grahame and Sisk 2002).”

The natural aridity of the Navajo Nation on the Colorado Plateau, concurrent with a regional warming trend, has been enhanced by a noticeable reduction of precipitation since 1966. “In recent years, the Navajo Nation has been experiencing drought conditions that may surpass the severity of all previous droughts in the 20th century (USGS 2005).” This drought, as well as the documented overgrazing which occurred on Navajo Nation rangelands, undoubtedly contributed to a shift from grass dominated landscapes to shrub dominated ones. This, in turn, reduced vegetative cover which decreased soil stability and is currently contributing to further erosion (USGS 2005).

During the last century livestock numbers on the Navajo Nation fluctuated greatly in cycles of overstocking followed by reactionary reduction programs. In 1936 the entire Navajo Nation was stocked well beyond the grazing capacity of the ranges, and grazing districts were established as a means to reduce the overgrazing. Later, these districts were further subdivided into units. Individuals were issued permits to graze their animals in specific grazing districts and range units (BIA 1971). District Seven contains four range units

The four range units in District Seven are associated with five Navajo Nation Chapters. The Low Mountain and Jeddito Chapters are combined into one range unit, and the other three range units/Chapters are Dilcon, Indian Wells and Teesto. The range units include the portions of the Chapters which are not located within the Navajo Partitioned Lands. The 2000 census population of the five Chapters in District Seven totaled 5,299.

2.2 Geographic Setting

District Seven is located in the southwest corner of the Navajo Nation in Arizona (Figure 2.1 in Appendix A). The town of Dilcon is located roughly in the center of the project area; approximately 40 miles north, northeast of the city of Winslow. Most of the District lies within Navajo County, while the northern portion, Balakai Mesa, is in Apache County. The elevation in the lower portion of the study area ranges from about 4800 feet to 6700 feet with Dilcon at 5962 feet. Balakai Mesa is higher at about 7000 up to 7400 feet.

The project area is located within the Colorado Plateau (35) Major Land Resource Area (MLRA) and within several sub-resource areas, or Common Resource Areas (CRA), previously known as Land Resource Units. The CRAs in District Seven are characterized by gently dipping sedimentary rocks with volcanic fields in places and a mesic soil temperature regime. Differences between the CRAs occur in vegetation composition and precipitation averages. Growth curve information, used to reconstruct plant biomass, is derived from these CRA averages. Precipitation averages of the four CRAs in District Seven are provided in Table 2.1 below. Figure 2.2 in Appendix A shows the four grazing units in District Seven along with the approximate CRA boundaries.

Table 2.1 Common Resource Areas in District Seven

CRA symbol	**CRA name**	**Annual Average Precipitation**
35.1	Colorado Plateau Mixed Grass Plains	10 to 14 inches
35.2	Colorado Plateau Shrub-Grasslands	6 to 10 inches
35.3	Colorado Plateau Sagebrush-Grasslands	10 to 14 inches
35.6	Colorado Plateau Piñon-Juniper-Sagebrush	13 to 17 inches

2.3 Geology

The Navajo Nation is located on the Colorado Plateau, a distinct geologic land form which 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 District Seven area is defined by the distinct landmarks of the Hopi Buttes. This cluster of small volcanoes erupted during the Pliocene. The volcanoes are surrounded by deposits of the Bidahochi formation which formed while ancient Lake Bidahochi existed in the basin of the District Seven area. The lake may have been fed by an ancestral Colorado River which at that time flowed southeast (Chronic 1983). The Wingate sandstone is also prominent in the District Seven area, exposed in colorful cliffs. Finally, the Jeddito/Low Mountain area of District Seven is a separate mesa, Balakai Mesa, higher in elevation than the rest of District Seven.

Drainages in the area are ephemeral and few, but include Coyote Wash and Pueblo Colorado Wash which flow southwest into the Little Colorado River.

2.4 Soils

Knowledge of the soil properties in a particular area is essential for predicting potential forage production. The application of soil survey information is what enables rangeland managers to provide estimates of forage production in a given area. Soils in the District Seven study area are primarily mesic semiarid and mesic arid soils. The Fruitland-Camborthids-Torrifluvents Association is shallow to deep, moderately coarse to moderately fine-textured, nearly level to hilly soils on upland plains. The Rudd-Bandera-Cabezon Association is shallow, gravelly, cobbly and stony, medium and fine-textured, undulating soils on plains and mesa tops and gently rolling to steep soils on cinder cones.

The inventory area is located within the boundaries of soil survey AZ 715, Ft. Defiance Area, AZ, Parts of Coconino and Navajo Counties (NRCS Unpublished). The study area contains 58 soil map units and 84 soil types and 37 different ecological sites.

2.5 Climate

The Colorado Plateau is quite arid. Most of the area follows a bi-seasonal weather regime characterized by summer and winter precipitation and fall and spring droughts. April, May and June tend to be the driest months. Precipitation occurs in the summer months in the form of heavy rain storms with limited infiltration. Less intense events bring precipitation in the winter months and contribute to groundwater recharge. The region is dominated by drying southwesterly winds.

2.6 Precipitation

An accurate precipitation monitoring system is essential to range management programs. Biomass production estimates are directly affected by precipitation measurements when reconstructing the plant community to an average precipitation year. If precipitation is over estimated in the reconstruction factor, the total annual production estimate will decrease. If precipitation is under estimated in the reconstruction factor, the total annual production estimate will increase.

Data from two active precipitation stations in District Seven were provided from the Navajo Nation Department of Water Resources (Figure 2.3 in Appendix A). The two stations have complete data for the past six years, but beyond six years the data is inconsistent or unavailable. Five years of historical data were used as a comparison, and the most recent water year was used for deviation from normal. The two sets of data were averaged together to produce an average precipitation percentage throughout the District. Precipitation data is included as Appendix B.

2.7 Plant Communities

The District Seven area is located in the upper Sonoran life-zone and is generally described as Great Basin Desert Scrub and Piñon-Juniper Woodland. “In northeastern Arizona, particularly in Navajo and Apache Counties, the formerly extensive plains grassland is now much reduced (Lowe 1985).” Major shrubs in the Great Basin desert are big sagebrush (*Artemisia tridentata*), blackbrush (*Coleogyne ramosissima*), and Mormon tea *(Ephedra cutleri*). Broom snakeweed (*Gutierrezia sarothrae*), rubber rabbitbrush (*Chrysothamnus nauseosus*) are also common. Prickly pear cactus *(Opuntia polyacantha*) and Whipple’s cholla *(Opuntia whipplei*) are the prominent cacti. Piñon pine *(Pinus edulis),* Utah juniper *(Juniperus osteosperma)* and one-seed juniper *(Juniperus monosperma)* are the characteristic species of piñon-juniper woodland. Below about 6500 feet in elevation, the piñon-juniper woodlands may be dominated by junipers, even occurring in pure stands. Blue grama *(Bouteloua gracilis)* remains one of the most important grass species in this vegetation community. A complete list of understory plant species found during the Vegetation Inventory is included in Appendix C.

3.0 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 the trend and 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 Technical References. Data analysis methods were approved by the Natural Resources Conservation Service.

3.1 Pre-Field Methodology

Before the initiation of field work, preparations were made to verify the protocol for field data collection. To begin this process Ecosphere reviewed the Statement of Work (SOW), provided by the BIA, which described the study design and specific methodologies for data collection.

3.1.1 Document Review

The SOW cited the following technical references which were reviewed by the Ecosphere team prior to the pre-work conference:

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

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

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

3.1.2 Pre-Work Conference

A pre-work conference was held on September 27, 2005, in Gallup, New Mexico, to discuss contract specifics, questions and concerns, make resolutions and clarifications, and discuss timelines of the project. The meeting was held concurrently with the pre-work conference for a Commercial Forest project and representatives from both areas were in attendance. BIA employees present at the meeting included Ms. Victoria Joe, Contracts Specialist; Mr. Jim Bydone, Contracting Officer Representative; Mr. Jonathan Martin, Navajo Regional Branch of Forestry; Mr. Jerome Willie, Natural Resource Manager, Ft. Defiance Agency; and Ms. Ladonna Carlisle, Navajo Region Rangeland Management Specialist. Members of the Ecosphere team present at the conference included Mr. Mike Fitzgerald, Principal; Ms. Alexis Watts, Project Manager; and Mr. Ike Wennihan, South Wind Conservation Inc., Natural Resource Specialist. The following concerns applied to the SOW for both projects.

3.1.2.1 Issues and Resolutions

The following issues and discrepancies were quickly resolved at the pre-work conference. Most of these involve contradictions between the data collection methods specified by the BIA in the SOW and the Technical References referred to in the SOW. Resolutions are a result of agreements based on the specific parameters of this inventory.

Issue # 1: Which plots will be harvested?
SOW Statements: "Plots 3 and 7 clip are to be the harvested plots" and "utilizing the double sample method (estimating and harvesting) as described in National Range and Pasture Handbook and Inventory and Monitoring (Technical Report 1734-7)."
Technical Reference Statement: The technical references all state that the plots to be harvested should be selected after weights have been estimated on all plots. Plots to be harvested should include most of the species that were estimated.
Resolution: Ecosphere volunteered to collect additional data on an "11th plot" for forage species that were not clipped in plots 3 or 7. Green weights would be both estimated and clipped for forage species that represented a significant percentage of the plant community (5-7 grams per transect). The additional data collection resolves the contradiction between the SOW and the Technical References. Estimating and harvesting additional species accomplishes the same goal as the selection of representative plots (an estimation correction factor).

Issue # 2: At what height will species be harvested?
SOW Statement: Anything rooted in the plot should be harvested to 1/2 inch above ground.
Technical Reference Statement: All technical references cited in the SOW specify to harvest all herbaceous plants originating in the plot at ground level.
Resolution: It was agreed to harvest species as close to the ground level as possible.

Issue #3: What is the harvest height on shrubs and larger plants?
SOW Statement: Shrubs rooted in or overhanging up to a height of 4 feet above the plot shall be included in the plot estimates and harvesting.
Technical Reference Statement: All technical references state that if harvesting forage production only, harvest to a height of 4.5 feet above the ground.
Resolution: It was agreed that the field team would use the frame for a 9.6 ft^2 plot size and an imaginary box 4.5 feet tall would be used over the plot.

Issue #4: What plot size do we need to use for large shrubs?
SOW Statement: "If the vegetation consists of large shrubs, larger plots must be used. The contractor must comply with National Range and Pasture Handbook, Chapter 4, Inventorying and Monitoring Grazing Land Resources."
Resolution: The BIA declared that the intent of the inventory was primarily to collect understory vegetation data and no larger plots would be necessary.

Issue #5: Which methodology will be used for cover data collection?
SOW Statements: "Frequency and cover data shall be collected and calculated in accordance to the guideline specified in Technical Reference 1734-4." and "40 Cover plots are sampled along each transect".

Resolution: The use of a modified pin/point frame allowed the 40 cover plots to be collected in a similar method to the Technical Reference 1734-4. A statement of agreement was made to use a pin flag in the four corners of the quadrant frame at each of the ten plot locations for a total of 40 hits.

Issue #6: Adhere fully to Technical Reference protocols or SOW?
SOW Statement: The statement of work also specifies the following: "The work shall comply with the standards applicable to each type of work and as listed in the individual sections of these specifications and as found in the Technical Reference Vegetation Attributes [1996] for the Double Sampling Methodology. The Contractor shall incorporate materials and applications with the same force and effect as when they were given in full text."
Technical Reference: The Technical Reference 1734-4 protocol for Double Sampling varies with plot harvesting as the other technical references did.
Resolution: This issue is resolved by the same resolution as Issue #1.

In summary,

- It was agreed that the field team would collect additional data on forage species by estimating and harvesting an "11th plot" to accomplish the same goal as the selection of representative plots.
- It was agreed that the field team would clip plots as close to the ground as possible.
- There was agreement to follow the National Range and Pasture Handbook (2003) protocol for harvesting plots to a height of 4.5', including all plants and parts of plant inside the frame and excluding all plants and parts of plants outside of the frame.
- It was agreed that cover data collection would be conducted as described in the SOW. Ecosphere would employ a modified version of the point/frame protocol described in the National Range and Pasture Handbook (2003).
- It was agreed that large shrub data would be collected only inside of quadrant plots, and that no larger plots were needed.

3.1.3 Electronic Data Collection Protocol

Ecosphere decided that the use of electronic data recorders would contribute to a higher quality product and more accurate data collection than paper data sheets with manual transfer to a digital database. Ecosphere chose Palm Zire 21 units for their black and white screens which are readable in outdoor daylight conditions. Ecosphere created a Pendragon software program specifically for the data parameters of this inventory based on data sheets and information provided in the SOW. The pairing of the Palm units with a custom Pendragon program ensured quality data collection with minimal errors. The Pendragon software allows data to be transferred directly into an MS Access database and MS Excel worksheets for consolidation, analysis, and calculations.

A data management protocol was created to ensure all data was securely entered, downloaded, and stored. Each field biologist's electronic data recorder was downloaded into a notebook computer at the end of each work day. Each field biologist submitted transect data daily to the Project Manager or Field Leader. The Project Manager or Field Leader reviewed the data for errors or discrepancies. The risk of data loss was eliminated by daily backup of data to both the notebook hard drive as well as an external storage device.

3.2 Field Methodology

3.2.1 Transect Establishment

Data collection in the field occurred in two separate phases; from 3 December through 7 December, 2005, and from 2 June through 27 July, 2006. The project was initiated in December of 2005 and quickly postponed by the BIA due to perceived decaying plant conditions. During the summer work period 51 of the transects completed in December were re-surveyed for a comparative analysis. The total number of transects was 1,142. Of those, 104 were surveyed in December and 1089 in the summer, and 51 were surveyed twice, for a total of 1,193 surveys.

The BIA provided Ecosphere with predetermined transect locations (Figure 2.3 in Appendix A). This sample set of locations was randomly distributed throughout the entire study area. The Universal Transverse Mercator (UTM) coordinates of these transect locations were downloaded into hand held Global Positioning System (GPS) units. The GPS units were used in combination with topographic maps to navigate by vehicle and foot to the transect locations. Transects were established within ten meters of the GPS coordinates, and usually within one or two meters. Some transects were located adjacent to private residences or in inaccessible areas such as slopes greater than 65 degrees. These transects were labeled inaccessible and were not surveyed. A total of three transects were labeled inaccessible, representing ¼ of 1% of the total number of transects.

Transects consisted of a paced, linear study design. An attempt was made to keep each transect within a single soil unit and vegetation community. The transect bearing was randomly determined by selecting a prominent distant landmark such as a mesa or lone tree. The transect bearing was read with a compass and recorded. Transects were then paced along the transect bearing. Vegetation attribute readings were taken from ten plots at ten meter intervals along the transect bearing. Each plot was established at the toe of the final pace. The plots were measured with a square 9.6 ft^2 quadrant frame. The 9.6 ft^2 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 noxious weed data were collected in addition to the vegetative attributes.

3.2.2 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.

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

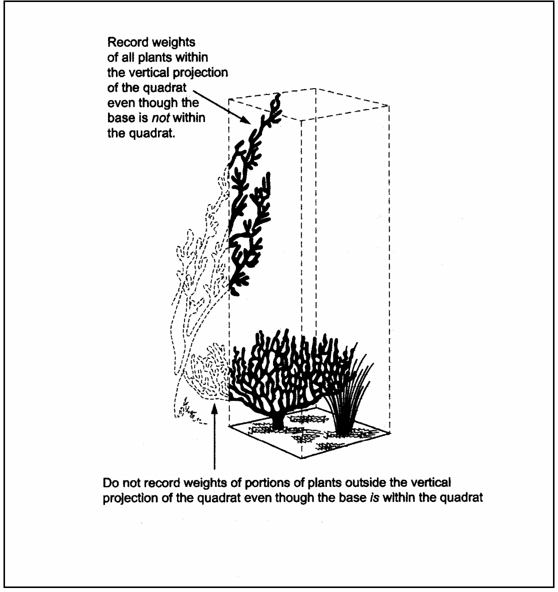
3.2.2.1 Establishing a weight unit

A weight unit is a part of a plant, an entire plant, or a group of plants of the same species used for estimation purposes. The weight unit method is an efficient means of estimating production. After weight units are established biologists 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.

3.2.2.2 Double Sampling Methodology (Estimating and Harvesting)

Production (in grams) was estimated by counting the weight units of each species in each plot. All plants and parts of plants inside an imaginary box outlined by the 9.6 ft^2 frame up to a height of 4.5 feet were estimated. Excluded were any plants and parts of plants outside of the box (Figure 3.1). On plots 3 and 7 forage species were estimated *in situ* and then harvested at ground level. In some cases, forage species representing a significant percentage of the composition of the species in a transect were not captured in plots 3 or 7. In such cases, if a species contributed five to seven grams or more of estimated production and was not harvested in plots 3 or 7, it was estimated and clipped individually and recorded as plot 11. Clipped biomass was weighed with a hand scale, and both estimated and harvested (green) weights were recorded. All harvested biomass was collected and stored in paper bags labeled with tracking information including transect, date, species, and plot number. All of the harvested material was allowed to air-dry for ten days or more before re-weighing to convert from field (green) weight to air-dry weight (ADW). The purpose of the double sampling is to correct any variability in the estimation of production (Estimation Correction Factor).

Figure 3.1 Weight Estimate Box
(Source: USDA NRCS 2003)



3.2.2.3 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 assist in the reconstruction of vegetation measurements by accounting for vegetation consumed prior to the inventory. With the Ocular Estimation Method, 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 biologists were thoroughly trained and practiced in making ocular estimates of utilization of plants. Data on the percentage of un-grazed plant remaining was recorded for each species on each transect. 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 nearly impossible to determine what re-growth, if any, may have occurred.

3.2.2.4 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.

3.2.2.5 No Clip List

The BIA approved a “No-Clip List” for the field methodology. This list included non-forage, toxic, and undesirable species. The No-Clip species were *Astragalus* spp., *Hordeum* spp., *Lupine* spp., *Senecio* spp., *Gutierrezia sarothrae, Muhlenbergia torreyi, Erodium cicutarium and*

Leucelene ericoides. These species were exempt from harvesting in the double sampling procedure. The “No-Clip List” species were estimated only. The weight that was estimated for these species was carried over to the assumed clipped weight for calculation purposes. At regular intervals the field team clipped these species and gathered green weights to calibrate their estimated weights.

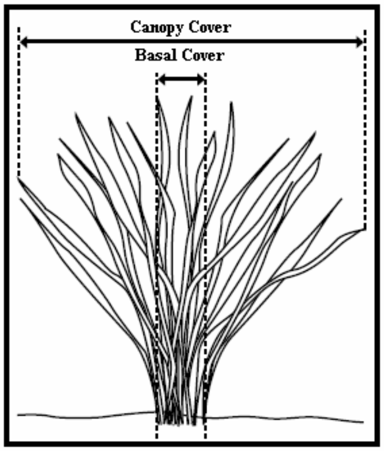
3.2.3 Frequency Data Collection

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. Electronic data collection allowed for easy and accurate collection of frequency data. The number of times a species occurred was automatically calculated by the custom software program when weights were estimated for the species.

3.2.4 Cover Data Collection

Cover in this study refers to ground cover and describes the percentage of ground which is covered by understory vegetation, organic litter, bare ground, rock and biological crust. The Point-Intercept method employed on this study consisted of a modified pin/point frame used at each plot along a transect using a sighting device (pin flag) in the four corners of the 9.6 ft^2 quadrant frame. Pin/point frames determine hits by recording the cover category intercepted by each of the pin points. A total of 40 hits were recorded from ten frame placements. Only the point of the pin flag was used to record a hit. Emphasis was placed on lowering the pin directly over (perpendicular to the ground) in the corners of the quadrant frame as specified in technical reference 1734-4 Sampling Vegetation Attributes (Coulloudon et al.1999). Cover hits fell into the following categories: Basal Vegetation, Canopy Vegetation, Litter, Bare Ground, Gravel/Stone, and Biological Crust. A Basal Vegetation cover hit was recorded when the pin flag struck the ground surface occupied by the basal portion of the plants. Canopy Vegetation hits were recorded when the pin flag struck an area of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants (Figure 3.2). Litter hits were recorded when the pin flag intercepted herbaceous or woody plant litter. Bare Ground was recorded when the pin flag struck bare ground free of litter, vegetation, gravel or stone, or any biological crusts. Gravel/Stone 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).

Figure 3.2. Vegetative Cover
(Source: Elzinga, Salzer and Willoughby 1998)



3.2.5 Soil Surface Texture Test

At each transect 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. The USDA Soil Texturing Field Flow Chart is attached as Appendix D. The soil surface texture information was used to assist in determining soil type and ecological site.

3.3 Post-Field Methodology

3.3.1 Calculating Production

The translation of a plot full of plants to a measure of pounds per acre is achieved through simple calculations. The formula, derived from technical reference 1734-7 Ecological Site Inventory (Habich 2001) and the National Range and Pasture Handbook (USDA NRCS 2003), reconstructs the measured weight of biomass to an annual air-dry production which accounts for physical, physiological, and climatological factors. The calculation uses the estimated green weight of a species multiplied by an estimation correction factor and then by the percent air dry weight (%ADW) of the species. This number is divided by the result of the utilization of the species multiplied by its 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 equation below:

$$\frac{\textbf{(estimated green weight(g) x correction factor) x \% ADW}}{\textbf{(un-utilized percentage x growth curve percentage)}} \quad \textbf{x (percent of normal precipitation)}$$

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

3.3.1.1 Estimation Correction Factor

The harvested or clipped plots provide the data for correction factors of estimated weights. 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 on plot 3 to weigh 50 grams (g), but the clipped weight was actually 45g, then all estimates of *Sporobolus airoides* for that transect would be multiplied by 0.90. If *Sporobolus airoides* was also estimated and clipped on plot 7 then the correction factor would be calculated by first summing the estimated weights in plots 3 and 7 and then summing the clipped weights in plots 3 and 7 before applying the same calculation. For example, if the estimated weight in plot 7 was 10g, and the clipped weight was 11g, then the sum of the estimated weights (60g) and the sum of the clipped weights (56g) would be calculated into a correction factor of 0.93. If the total estimated weight for estimates of *Sporobolus airoides* on all plots in this transect was 80g, the resulting corrected weight would be 74.4g as illustrated below.

$$\text{Correction Factor} = \frac{\text{Sum of Measured Weights on Clipped Plots}}{\text{Sum of Estimated Weights on Clipped Plots}} = \frac{56\text{g}}{60\text{g}} = 0.93$$

Thus, in the example: (estimated green weight(g) x correction factor) = 80g x 0.93 = 74.4g

3.3.1.2 Biomass ADW Conversion

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 a spreadsheet. 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 total annual production calculations. In the example above, the total green weight for *Sporobolus airoides* was 74.4g. If the dry weight was 50g, then the %ADW would be 0.67. For species in the transect which were not clipped (non-palatable/less palatable species) the %ADW defaulted to one.

$$\%\text{ADW} = \frac{\text{Dry Weight (lab)}}{\text{Green Weight(field)}} = \frac{50\text{g}}{74.4\text{g}} = 0.67\text{g}$$

At this point, continuing with the same example, all of the elements for the numerator of the equation are present: the estimated weight, the correction factor, and the %ADW. The estimated weight multiplied by the correction factor was 74.4g. Multiplied by the %ADW, the result would be 49.85g.

(estimated green weight(g) x correction factor) x % ADW = (80g x 0.93) x 0.67 = 49.85g

3.3.1.3 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*.

3.3.1.4 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. Production varies each year depending on the favorability of growing conditions. For example, if *Sporobolus airoides* was measured in a transect during September, that measurement represents only 97% of the full growth of that species. Another 3% would be added to account for potential growth. Growth curves for the CRAs in the District Seven area were constructed by Karlynn Huling, former Rangeland Conservationist for the Flagstaff, Arizona NRCS office.

At this point two of the elements in the denominator of the sample equation are present. The utilization multiplied by a growth curve, 90% multiplied by 97%, or 0.873.

$$\%\text{Utilization x }\%\text{Growth Curve} = 0.90 \text{ x } 0.97 = 0.873$$

The total annual production equation would now look like this:

$$\frac{(80\text{g x } 0.93) \text{ x } 0.43}{0.90 \text{ x } 0.97} = \frac{49.85\text{g}}{0.873} = 57.10\text{g}$$

3.3.1.5 Precipitation Deviation

Precipitation has a direct effect on annual production; therefore comparisons of production levels from year to year are not accurate without accounting for precipitation influences. Precipitation is factored into production by multiplying the total weight by the current water years' deviation from average precipitation.

The Navajo Water Resources Department provided six complete years of precipitation data from two gauging stations on District Seven. The 2006 water year was compared to the five previous years of historical data. Data prior to six years ago was inconsistent and was discarded from calculations. Data from the two gauging stations were averaged together. The 2006 water year (October 2005 through September 2006) was less than the average of the previous five years, and much of the precipitation for the 2006 water year fell in August. By the end of May of 2006 the precipitation reached only 28% of normal, and no precipitation fell during June so the figure stayed at 28% of normal. By the end of July precipitation had risen to 48% of normal. If the 28% average is used for the continuing example, then the 57.10 grams of total production would achieve a total annual reconstructed production of 203.93 grams.

57.10g/ 28% = 203.93g = Reconstructed Weight

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. However, in this case the conversion factor equals one and therefore is not explicitly written into the equation. The plot size, 9.6 ft^2, was repeated ten times in each transect, thereby creating 96 ft^2 of sampling area, which calculates into a 1:1 conversion (Coulloudon et al. 1999). Hence, in the example, there were 203.93 pounds per acre of *Sporobolos airoides*. The figure 203.93 represents the total reconstructed annual production of the species in pounds per acre.

3.3.2 Calculating Cover

Cover was calculated by dividing the number of hits of a 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 grouped by range unit.

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

3.3.3 Calculating Frequency

Electronic data collection allowed for easy and accurate collection of frequency data. Species frequency was automatically 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%. Indicator species were singled out for frequency analysis and averaged by range unit.

3.3.4 Assigning Ecological Sites

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

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

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

The soil type assignment/ ecological site assignment for each transect was based on interpretation of the current vegetative community compared to the expected HCPC, as well as soil stability test results and the map unit descriptions from the Soil Survey. The transect data was compared to the HCPC of each possible ecological site for that soil map unit. The data analysis is therefore based on an assumption that each transect was assigned the correct ecological site. The only way to make true determinations of soil type is by digging soil pits at each transect and verifying the soil type. In the absence of soil pit verification, the best option was to compare the HCPC to the vegetation found on the ground at each transect, and to utilize the soil surface data that was collected. All transects with multiple ecological site possibilities were assessed in this way. Some transects did not have enough information to discern between the ecological site possibilities. The available ecological sites in the District Seven area include:

FO35XF627AZ - Sandstone Upland 13-17"
FO35XF628AZ - Sandy Loam Upland 13-17"
FO35XF630AZ - Loamy Shallow 13-17"
RO35XA101AZ - Breaks 10-14"
RO35XA112AZ - Loamy Bottom 10-14"
RO35XA113AZ- Loamy Upland 10-14"
RO35XA117AZ - Sandy Loam Upland 10-14"
RO35XA119AZ – Shallow Loamy 10-14"
RO35XB201AZ- Mudstone/Sandstone Hills 6-10"
RO35XB202AZ - Clayey Wash 6-10"
RO35XB203AZ - Clay Loam Upland 6-10"
RO35XB209AZ - Loamy Wash 6-10"
RO35XB210AZ - Loamy Upland 6-10"
RO35XB215AZ - Sandstone/Shale Upland 6-10"
RO35XB216AZ - Sandy Wash 6-10"
RO35XB217AZ- Sandy Upland 6-10"
RO35XB219AZ- Sandy Loam Upland 6-10"
RO35XB220AZ - Shale Upland 6-10"
RO35XB237AZ- Clay Loam Terrace 6-10"
RO35XC315AZ - Sandy Upland 10-14"
RO35XC322AZ - Sandstone Upland 10-14" Shallow
RO35XF605AZ - Loamy Upland 13-17"

3.3.5 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. A similarity index was calculated for all transects that were assigned to ecological sites with available ESDs.

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 average 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 accounted for in the reconstruction process. This is the recommended and accepted method of calculating a similarity index.

To calculate a similarity index, each plant species found on a transect was compared to the ESD. The ESD has an assigned composition percentage for each species (or group of species) expected to occur in the HCPC. The percentage assigned to the species in the ESD is a percentage of the total annual production (average) expected for the site. 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 100 pounds/acre of blue grama
2) The ESD lists the allowable percentage of blue grama at 10% (average)
3) The ESD lists the total annual production (average) at 500 pounds/acre
4) Based on the information in the ESD, the “Allowable” production for blue grama was 50 pounds/acre.
5) No more than 50 pounds may be “allowed” to be counted towards the similarity index for the transect.
6) If the ESD had listed the allowable percentage of blue grama at 20% (average) then all 100 pounds (and no more) would have been “allowed” to be counted towards the similarity index for the transect.

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

3.3.6 Calculating Forage Value Rating

For those transects in which no ESD was available for a similarity index comparison, a forage value rating was calculated. The forage value rating indicates the composition of preferred and desirable forage species within a management unit. The value of species is defined by a particular type of livestock in terms of palatability or preference and the availability of the species. 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.
- 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.

A list of all species identified during the inventory process was forwarded to the BIA, Ft. Defiance Agency. Rangeland managers from the Ft. Defiance Agency assigned a forage value to each species using the definitions of preference groups provided above. Ecosphere used these values as assigned by the BIA. Some of the assigned forage values are unconventional, for example broom snakeweed *(Gutierrezia sarothrae)*, Russian thistle (*Salsola kali*) and prickly pear cactus (*Opuntia* spp.) were assigned as desirable species. These forage values are specific to the District Seven management area (Appendix C).

Each group of plants was then assigned a harvest efficiency factor. The harvest efficiency factor accounts for the amount of production consumed by grazers and generally averages 25% on rangelands with continuous grazing (NRCS 2003). 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. Rangeland managers at the BIA, Ft. Defiance Agency assigned harvest efficiency factors of 50% for preferred species, 35% for desirable species, and 5% for undesirable species. Nonconsumed and Toxic species were excluded from the calculations. Ecosphere used these harvest efficiency factors provided by the BIA to determine forage value ratings and stocking rates.

A stocking rate was calculated from the amount of production provided by preferred, desirable and undesirable plants. Additionally, a stocking rate was calculated exclusive of undesirable production in order to provide management options. For consistency, stocking rates were calculated by Forage Value Rating for the entire study area.

3.3.7 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.

Stocking rate recommendations are provided in some of the ESDs and are correlated with similarity indices and allowable production. This method of calculating stocking rates is no longer recommended by the NRCS. Stocking rates for District Seven were calculated using the Forage Value Rating and harvest efficiency factors. However when the ESD provided a recommended stocking rate, a stocking rate was calculated using this recommendation, in addition to the Forage Value Rating method. Maximum stocking rates were derived from the preferred and desirable, and undesirable production with an application of harvest efficiency factors. The pounds of preferred, desirable and undesirable forage was incorporated into animal unit months (AUMs) or 790.8 pounds of forage per month (NRPH 2003). The result was multiplied by 12 months to provide an animal unit year of forage and also multiplied by five to convert to sheep units (year long). Stocking rates based only on preferred and desirable production were also calculated to provide management options. These stocking rates are located on the forage value rating worksheets included with this report (Appendix E).

Carrying capacities were calculated using the stocking rate generated from the forage value rating. Carrying capacities were calculated by the acreage of each ecological site within a range 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 complex 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 soil unit "X" in the Teesto range unit, and 20% of the soil unit consists of soil "yy" while 80% consists of soil "zz", then soil "yy" is calculated as 40 acres, while soil "zz" is calculated as 160 acres. In addition, if minor soils were included in the soil complex, the percentage of minor soils was added to the major soil units to account for 100% of the acreage of the soil map unit complex.

The stocking rates and carrying capacities for each ecological site/soil type within each soil map complex are provided in Section 4.0 Results. Ecological sites/soil types are not mapped, however the soil complex is mapped so aggregated ecological site information is presented in the attached Ft. Defiance Soil Survey Maps. Stocking rates and carrying capacities by soil unit are provided in the Map Reference Table. Stocking rates should not be averaged across ecological sites within a soil map unit complex however, that is precisely what is illustrated on the attached Ft. Defiance Soil Survey Maps; stocking rates and carrying capacities by ecological site within a soil map complex were combined in order to represent them on a map.

3.3.8 Assessing Apparent Trend

Trend is a rating of the direction of change that may be occurring on a site. The plant community and the associated components of the ecosystem may be either moving toward or away from the historic climax plant community or some other desired plant community or vegetation state. Alternately, the trend may not be apparent. There are two common types of trend determination: apparent trend and measured trend. In order to determine a measured trend baseline data needs to be established for the area of assessment. Apparent trend is just a snapshot of what is apparently occurring on the site at the present time. For monitoring purposes it is important to develop a measured trend over time. Attributes for evaluating trend include composition changes, recruitment of young plants, plant vigor, and condition of soil surface. The most comprehensive and accurate way to measure trend is to evaluate all of these attributes. Apparent trend for this inventory was determined primarily by frequency and composition of HCPC plant. This was measured indirectly by comparison of the described HCPC to the current plant community and directly by indicator species frequency data. Indicator species include increasers, decreasers and invaders. If the current plant community is changing due to prolonged over grazing, the perennial species that are most sensitive to damage by grazing will decrease (decreaser species). Increaser species and invader species will replace the decreaser species as disturbance increases. This will lead to a change in species composition in a direction away from the climax community.

4.0 RESULTS

A total of 1,143 transects were located on District Seven. Data were not collected on three transects located on slopes greater than 65 degrees, or within the yard of private residences. The attributes analyzed from the data were total annual production (reconstructed), total allowable production, similarity index, ground cover, species frequency, and apparent trend. Each Chapter, or range unit, was analyzed by the ecological sites present within it. Several ecological sites were not sampled due to inefficiencies in the distribution of transect locations, but most of those ecological site areas were of small acreage. Data were summarized by range unit.

The results of this inventory indicate that most of the ecological sites are currently far from the climax community. Average similarity indices ranged from a low of one to a high of 33 percent. Initial stocking rate recommendations ranged from 2.5 to 663.9 acres per sheep unit year long.

The results of the data analysis indicate conditions very unlike the climax conditions expected for the District Seven project area. Many of the locations have transitioned into deteriorated states that may never be able to return to a climax state. In general, Low Mountain/Jeddito was in the best condition and Dilcon was in the worst condition, however none of the range units were in good range condition. Table 4.1 (on the following pages) shows the complete summary of results of the vegetation inventory by ecological site within each range unit. Key production species are noted so that range managers can quickly see whether production in a particular ecological site consists of high quality forage species, or other less desirable species. Maximum stocking rates were calculated by Forage Value Rating for all ecological sites, regardless of whether the Ecological Site Description provided a stocking rate, so that comparisons can be made of the two methods. Finally, the data for Forage Value Rating averages, and the resulting stocking rates and carrying capacities include data from the winter transect surveys because the results are for year round stocking.

The total District 7 maximum carrying capacity calculated by forage value rating from the results of this study was 22,185 sheep units year long. In comparison, the current carrying capacity is 31,220 sheep units year long.

Table 4.2 shows the percentage of understory ground cover by range unit. Low Mountain/Jeddito had the highest percentage of basal vegetative cover; basal cover is a consistent attribute for monitoring cover. Indian Wells had the lowest percentage of basal cover. Bare ground was the largest proportion of ground cover in all districts except Low Mountain/Jeddito which had a higher litter component. Biological soil crusts had the smallest proportions.

Table 4.2 Percentage Ground Cover by range unit/Chapter

Chapters	Biocrust	Rock/Gravel	Bare Ground	Basal	Canopy	Litter
Dilcon	0.11	10.04	49.76	0.82	3.79	35.48
IndianWells	0.28	9.35	49.42	0.53	4.37	36.05
LowMtn/Jeddito	1.16	5.91	33.89	1.46	8.22	49.36
Teesto	0.03	6.15	49.05	0.85	8.75	35.17
Grand Total	0.30	8.77	47.45	0.81	5.19	37.48

Table 4.3 shows the average frequency of indicator forage species by range unit over the District Seven study area. Indicator species were compiled from Range Site descriptions of the neighboring District Five area.

Table 4.3 Frequency of Indicator Species in District Seven

Indicator Species	Dilcon	IndianWells	LowMtn/Jeddito	Teesto
Decreasers				
Bouteloua eriopoda	1%	1%	0%	1%
Elymus elymoides	<0.5%	1%	19%	2%
Pascopyrum smithii	0%	<0.5%	3%	0%
Stipa comata	3%	3%	3%	6%
Increasers				
Atriplex confertifolia	6%	7%	1%	1%
Chrysothamnus nauseosus	3%	3%	1%	6%
Gutierrezia sarothrae	18%	18%	26%	21%
Muhlenbergia pungens	1%	2%	1%	2%
Invaders				
Astragalus spp.	<0.5%	1%	<0.5%	2%
Salsola kali	1%	7%	1%	<0.5%

Data has been analyzed to provide for the management of the four existing range units in District Seven, however prior to the initiation of field work, the District Seven area was divided into ten conceptual compartments utilizing existing fences and roads as boundaries. Should the BIA and Navajo Nation be able to change the livestock grazing permits to accommodate these ten compartments, livestock grazing in District Seven could be managed by these compartments that provide distinct boundaries. Each transect in the District Seven area was labeled according to the compartment in which it was located. Therefore, future studies could use the data from this inventory as baseline data on the compartments.

TABLE 4.1 Results Dilcon

Chapter	ESD#/ESD Name	Number of Transects	Reconstructed weight (lbs/acre)	Plant Community Production in Average Year (lbs/acre)	Pounds Allowable	Similarity Index	Acres	FVR Stocking Rate (Acres/Sheep Unit Year Long)	Carrying Capacity in Sheep Units (year long)	Trend	Key Species (highest production in order)	Notes
Dilcon	INACCESSIBLE	2	0	N/A	N/A	N/A			0			
	NO VEGETATION	11	0	N/A	N/A	N/A			0			
	NO ESD	34	415.6	N/A	N/A	N/A		663.9				
	RO35XA101AZ - Breaks 10 -14"	32	279.9	650	112.7	17	20,686	26.9	768	AWAY	EPCU, CHNAB3, PLJA	
	RO35XA113AZ - Loamy Upland 10-14"	42	232	650	68.3	11	14,845	33.2	446.6	AWAY	GUSA2, EPCU, PLJA	
	RO35XA117AZ - Sandy Loam Upland 10-14"	49	226.6	800	72.8	9	34,372	36.8	934.8	AWAY	GUSA2, CHNAB3, BOGR2	
	RO35XA118AZ - Sandy Upland 10-14"	1	62.6	525	46.8	9	121	141.5	0.9	AWAY	DESCU, GUSA2, BOGR2	
	RO35XA119AZ - Shallow Loamy 10-14"	4	201.5	650	57.6	9	5,724	36.2	158.1	AWAY	OPUNT, GUSA2, ARBI3	
	RO35XB201AZ - Mudstone/Sandstone Hills 6-10"	25	168.4	350	37.7	11	17,061	46.4	367.8	AWAY	ATCO, YUAN2, YUCCA	
	RO35XB202AZ - Clayey Wash 6-10"	4	179.9	2250	91.7	4	2,990	30.1	99.2	AWAY	ATCO, ATCA2, SPAI	
	RO35XB203AZ - Clay Loam Upland 6-10"	18	165.6	550	40.6	7	13,988	37.7	371.2	AWAY	ATCO, GUSA2, PLJA	
	RO35XB209AZ - Loamy Wash 6-10"	3	42.1	1450	11.2	1	2,222	128.6	17.3	AWAY	ATCO, SPAI, SPCR	
	RO35XB210AZ - Loamy Upland 6-10"	41	60.9	475	31.8	7	13,406	101.2	132.4	AWAY	GUSA2, PLJA, ATCO	
	RO35XB211AZ - Loamy Wash 6-10" Saline	1	293.4	1100	110.6	10	271	18.5	14.7	AWAY	ATCO, SPAI, PLJA	
	RO35XB215AZ - Sandstone/Shale Upland 6-10"	48	95.5	350	23.2	7	14,397	73.8	195.2	AWAY	ATCO, CHNAB3, PLJA	
	RO35XB216AZ - Sandy Wash 6-10"	13	71.8	875	31.8	4	6,520	84.7	76.9	AWAY	GUSA2, SPAI, CHNAA4	
	RO35XB217AZ - Sandy Upland 6-10"	14	51.7	400	23.1	6	9,273	122.8	75.5	AWAY	EPCU, ERLE9, PLJA	
	RO35XB219AZ - Sandy Loam Upland 6-10"	94	131.9	650	49.1	8	45,174	52.7	857.2	AWAY	CHNAB3, PLJA, ATCO	
	RO35XB220AZ - Shale Upland 6-10"	30	69	150	24.1	16	8,595	79.7	107.8	AWAY	ATCO, ATCA2, SPAI	
	RO35XB237AZ - Clay Loam Terrace 6-10"	4	232.8	500	58.6	12	1,212	26.6	45.5	AWAY	ATCO, PLJA, GUSA2	
	Badlands	0					7,101	0	0	N/A		
	Riverwash	0					2,017	0	0	N/A		
	Rock Outcrop	0					4,850	0	0	N/A		
	Water	0					9	0	0	N/A		
	RO35XA103 - (ESD Not Developed)	0					3,009	21.2	141.6	N/A	CHNAB3, GUSA2, BOGR2	Used Soil Unit 449 FVR
	RO35XA108 - (ESD Not Developed)	0					13	0	0	N/A		Not Sampled (Soil Unit 456)
	RO35XA123 - (ESD Not Developed)	0					12	0	0	N/A		Not Sampled (Soil Unit 456)
	RO35XB222 - Sandy Terrace 6-10"	0					81	0	0	N/A		Not Sampled (Soil Unit 337)
	RO35XB235 - (ESD Not Developed)	0					11,422	0	0	N/A		Not Sampled (Soil Units 343 and 344)
DILCON	**TOTAL**	**470**					**239,371**		**4810.6**			

TABLE 4.1 Results Indian Wells

Chapter	ESD#/ESD Name	Number of Transects	Reconstructed weight (lbs/acre)	Plant Community Production in Average Year (lbs/acre)	Pounds Allowable	Similarity Index	Acres	(Acres/Sheep Unit Year Long)	Carrying Capacity in Sheep Units (year long)	Trend	Key Species (highest production in order)	Notes
Indian Wells	NO ESD	39	338.08	N/A	N/A	N/A				N/A		
	NO VEGETATION	3	0	N/A	N/A	N/A				N/A		
	RO35XA101AZ - Breaks 10 -14"	37	314.37	650	88.9	14	21,227	21.4	991.7	AWAY	SPAI, ATCO, CHNAB3	
	RO35XA113AZ - Loamy Upland 10-14"	2	274.1	650	53.1	8	1,638	28.9	56.7	AWAY	SPAI, ATCO, CHNAB3	
	RO35XA117AZ - Sandy Loam Upland 10-14"	57	363.5	800	103	13	38,595	20.6	1870.2	AWAY	GUSA2, CHNAB3, CHGR6	
	RO35XA119AZ - Shallow Loamy 10-14"	18	371.9	650	105.26	16	12,864	18.7	686.1	AWAY	EPCU, GUSA2, PUST	
	RO35XB201AZ - Mudstone/Sandstone Hills 6-10"	11	226.07	350	41.06	12	7,091	27.8	254.9	AWAY	ATCO, SPAI, CHGR6	
	RO35XB202AZ - Clayey Wash 6-10"	7	166.03	2250	128.44	6	5,803	44.1	131.7	AWAY	SPAI, GUSA2, TAMAR2	
	RO35XB203AZ - Clay Loam Upland 6-10"	73	198.09	550	62.94	11	20,937	33	633.9	AWAY	GUSA2, SPAI, ATCO	
	RO35XB209AZ - Loamy Wash 6-10"	1	285.45	1450	254.59	18	4,289	19.8	217	AWAY	ATCA2, SAKAR, SPAI	
	RO35XB210AZ - Loamy Upland 6-10"	38	595.28	475	101.64	21	20,393	12.4	1638.8	AWAY	EPCU, GUSA2, CHNAB3	
	RO35XB215AZ - Sandstone/Shale Upland 6-10"	3	252.61	350	114.24	33	3,114	2.5	1251.4	Not Apparent	ATCO, SPAI, PLJA	
	RO35XB216AZ - Sandy Wash 6-10"	17	200.97	875	34.4	4	5,699	33	172.9	AWAY	ATCO, CHNAB3, ATCA2	
	RO35XB217AZ - Sandy Upland 6-10"	6	877.32	400	57.57	14	1,594	8.6	186.2	AWAY	EPCU, GUSA2, BOGR2	
	RO35XB219AZ - Sandy Loam Upland 6-10"	71	302.94	650	96.75	15	32,948	21.7	1516.1	AWAY	GUSA2, KRLA2, ATCA2	
	RO35XB220AZ - Shale Upland 6-10"	8	235.42	150	43.59	29	1,210	26.4	45.9	Not Apparent	ATCO, SPAI, PLJA	
	RO35XB237AZ - Clay Loam Terrace 6-10"	2	95.2	500	86	17	1,291	59.2	21.8	AWAY	SPAI, PLJA, GUSA2	
	Unspecified Badlands	1	9.92	N/A	N/A	N/A	14,848			N/A		*Only 1 transect
	Riverwash	0					534			N/A		
	RO35XA103 - (ESD Not Developed)	0					4,042	60.5	66.8	N/A	GUSA2, CHNAB3, PLJA	Used Soil Unit 449 FVR; All Shrubs/Sub-Shrubs
	RO35XA108 - (ESD Not Developed)	0					1,509	3.3	462.9	N/A	GUSA2, CHGR6, ATCA2	Used Soil Unit 456 FVR
	RO35XA123 - (ESD Not Developed)	0					1,365	3.3	418.8	N/A	GUSA2, CHGR6, ATCA2	Used Soil Unit 456 FVR
	RO35XB211 - Loamy Wash 6-10" Saline	0					830			N/A		Not Sampled (Soil Unit 342)
	RO35XB235 - (ESD Not Developed)	0					30			N/A		Not Sampled (Soil Unit 343)
	ROCK	0					4,825			N/A		
INDIAN WELLS	**TOTAL**	**394**					**206,676**		**10623.8**			

TABLE 4.1 Results Low Mountain/ Jeddito

Chapter	ESD#/ESD Name	Number of Transects	Reconstructed weight (lbs/acre)	Production in Average Year (lbs/acre)	Pounds Allowable	Similarity Index	Acres	(Acres/Sheep Unit Year Long)	Carrying Capacity in Sheep Units (year long)	Trend	Key Species (highest production in order)	Notes
Low Mtn/ Jeddito	Inaccessible	1	0	N/A	N/A	N/A				N/A		
	NO ESD	7	373.26	N/A	N/A	N/A				N/A		
	FO35XC322AZ - Sandstone Upland 10-14" Shallow	12	610.68	400	104.98	26	2,181	12.8	170.9	AWAY	CHGR6, AMUT, GUSA2	
	FO35XF627AZ - Sandstone Upland 13-17"	43	555.31	350	81.37	23	18,176	13.5	1348.2	AWAY	ARTR2, GUSA2, BOGR2	
	FO35XF628AZ - Sandy Loam Upland 13-17"	31	470.37	500	151.01	30	8,981	15.3	587.2	Not Apparent	ARTR2, GUSA2, PUST	
	FO35XF630AZ - Loamy Shallow 13-17"	2	175.95	300	38.67	13	15,909	38.2	416.3	AWAY	GUSA2, PENST, OPUNT	
	RO35XA101AZ - Breaks 10 -14"	5	1014.47	650	96.54	15	3,591	7.6	474.9	AWAY	CHGR6, ARTR2, ATCA2	
	RO35XA112AZ - Loamy Bottom 10-14"	2	616.08	1700	110.86	7	980	12.5	78.5	AWAY	ARTR2, GUSA2, CHGR6	
	RO35XA117AZ - Sandy Loam Upland 10-14"	22	582.49	800	102.73	13	13,099	12.7	1033.1	AWAY	GUSA2, ARTR2, CHGR6	
	RO35XC315AZ - Sandy Upland 10-14"	1	746.94	650	128.18	20	210	11.4	18.3	AWAY	ARTR2, CHGR6, GUSA2	
	RO35XF605AZ - Loamy Upland 13-17"	32	905.22	600	180.9	30	8,089	8.5	949.2	Not Apparent	ARTR2, GUSA2, BOGR2	
	FO35XC320	0					1,668			N/A		Not Sampled (Soil Unit 431)
	FO35XC323	0					4,792			N/A		Not Sampled (Soil Unit 430)
	RO35XA104	0					745			N/A		Not Sampled (Soil Units 423 and 426)
	RO35XC302	0					1			N/A		Not Sampled (Soil Unit 405)
	RO35XC313	0					773			N/A		Not Sampled (Soil Units 446 and 447)
	RO35XC317	0					388			N/A		Not Sampled (Soil Unit 446 and 466)
	RO35XC320	0					1			N/A		Not Sampled (Soil Unit 405 and 431)
	RO35XF608	0					2,840			N/A		Not Sampled (Soil Unit 475)
	ROCK	0					1,514			N/A		
LOW MTN/ JEDDITO	**TOTAL**	**158**					**83,937**		**5076.6**			

TABLE 4.1 Results Teesto

Chapter	ESD#/ESD Name	Number of Transects	Reconstructed weight (lbs/acre)	Plant Community Production in Average Year (lbs/acre)	Pounds Allowable	Similarity Index	Acres	(Acres/Sheep Unit Year Long)	Carrying Capacity in Sheep Units (year long)	Trend	Key Species (highest production in order)	Notes
Teesto	NO ESD	13	624.9	N/A	N/A	N/A						
	NO VEGETATION	3	0	N/A	N/A	N/A						
	RO35XA101AZ - Breaks 10 -14"	23	292.4	650	104.8	16	6,938	27.5	251.9	AWAY	EPCU, CHNAB3, CHGR6	
	RO35XA113AZ - Loamy Upland 10-14"	11	311.8	650	81.5	13	4,465	26	171.9	AWAY	GUSA2, BOGR2, CHNAB3	
	RO35XA117AZ - Sandy Loam Upland 10-14"	30	248.5	800	80.6	10	11,587	32.2	359.8	AWAY	CHNAB3, GUSA2, CHGR6	
	RO35XA119AZ - Shallow Loamy 10-14"	20	366.7	650	113	17	6,452	19.6	329.9	AWAY	EPCU, PUST, ARBI3	
	RO35XB201AZ - Mudstone/Sandstone Hills 6-10"	4	73.3	350	44.8	13	1,094	92.3	11.9	AWAY	PLJA, GUSA2, BOGR2	
	RO35XB202AZ - Clayey Wash 6-10"	1	49.3	2250	48.1	2	873	113.1	7.7	AWAY	PLJA, SPAI, KRLA2	
	RO35XB210AZ - Loamy Upland 6-10"	1	383.6	475	34.7	7	711	22.6	31.4	AWAY	GUSA2, BOGR2, PLJA	
	RO35XB215AZ - Sandstone/Shale Upland 6-10"	6	381.1	350	58	17	2,068	24.9	82.9	AWAY	CHNAB3, PLJA, GUSA2	
	RO35XB216AZ - Sandy Wash 6-10"	2	19.6	875	15.5	2	876	353.4	2.5	AWAY	GUSA2, ARFR4, PLJA	
	RO35XB217AZ - Sandy Upland 6-10"	10	177.7	400	47.1	12	4,244	43.4	97.8	AWAY	GUSA2, PLJA,YUAN2	
	RO35XB219AZ - Sandy Loam Upland 6-10"	47	116.5	650	63	10	16,790	65.6	255.8	AWAY	GUSA2, PLJA, YUAN2	
	Dune Land	0					53	0	0	N/A		
	Riverwash	0					96	0	0	N/A		
	Rock	0					1,734	0	0	N/A		
	RO35XA103 - (ESD Not Developed)	0					626	16.2	38.7	N/A	BOGR2, GUSA2, CHNAB3	Used Soil Unit 449 FVR
	RO35XA108 - (ESD Not Developed)	0					594	35.8	16.6	N/A	GUSA2, BOGR2, ARBI3	Used Soil Unit 456 FVR; Only 2 transects
	RO35XA123 - (ESD Not Developed)	0					538	35.8	15	N/A	GUSA2, BOGR2, ARBI3	Used Soil Unit 456 FVR; Only 2 transects
	RO35XB203	0					314	0	0	N/A		Not Sampled (Soil Unit 328)
	RO35XB209	0					645	0	0	N/A		Not Sampled (Soil Unit 326)
	RO35XB220	0					189	0	0	N/A		Not Sampled (Soil Unit 328)
	RO35XB235	0					684	0	0	N/A		Not Sampled (Soil Unit 344)
TEESTO	**TOTAL**	**171**					**61570.17**		**1674**			
DISTRICT SEVEN	GRAND TOTAL	**1193**					**591,554**		**22185**			

4.1 Dilcon

In the Dilcon range unit, data were collected on 470 transects. There are 22 ecological sites occurring in the Chapter, as well as badland areas, rock outcrops, riverwash, and water. There are 239,371 acres in the Dilcon Chapter range unit. The similarity indices ranged from one to 17 percent similarity to the expected historic climax plant community. The Dilcon Chapter was the largest chapter within the District Seven project and also had the poorest condition overall. The best stocking rate in the Dilcon Chapter was 18.5 acres per sheep unit year long, and the lowest was 663.9 acres per sheep unit year long. The Recommended carrying capacity is 4810.6 sheep units (year long) for the Dilcon Chapter. The trend for all ecological sites in Dilcon was moving away from the climax vegetation community and the range condition was poor. Shrubs and subshrubs constitute a large percentage of the total production in this area.

4.2 Indian Wells

In the Indian Wells range unit data were collected on 394 transects. There are 20 ecological sites within the Chapter, as well as badland areas, rock outcrops, and riverwash, covering 206,676 acres. Similarity indices ranged from four to 33 percent of the expected historic climax plant community. The maximum stocking rate for the Indian Wells Chapter varied from 2.5 acres per sheep unit year long for the Sandstone/Shale Upland Ecological Site, and 59.2 acres per sheep unit year long for the Clay Loam Terrace Ecological Site. The Recommended carrying capacity is 10623.8 sheep units (year long) for the Indian Wells Chapter. The trend for all ecological sites in Indian Wells is either moving away from the climax vegetation community or not apparent. The range condition was poor.

4.3 Low Mountain/ Jeddito

In the Low Mountain/Jeddito range unit data were collected on 158 transects. There are 17 ecological sites, as well as areas of bare rock, covering 83,937 acres. The highest similarity index for the entire District Seven project occurred in the Loamy Upland ecological site. Overall similarity indices varied from seven to 30 percent in similarity to the expected historic climax plant community. The maximum stocking rate was 38.2 acres per sheep unit year long for the Breaks Ecological Site. The minimum stocking rate was 7.6 acres per sheep unit year long for the Loamy Shallow Ecological Site. The Recommended carrying capacity is 5,076.6 sheep units (year long) for the Low Mountain/Jeddito Chapter. The trend for all ecological sites in the Low Mountain/Jeddito range unit is moving away from the climax vegetation community or not apparent. The range condition was poor to fair. Additionally, there were eight ecological sites in which no transects were located.

4.4 Teesto

In the Teesto range unit data were collected on 171 transects. The Teesto Chapter range unit covers 61,570 acres and includes 18 ecological sites as well as areas of dunes, riverwash and rock. The similarity indices ranged from two to 17% of the expected climax communities. All of the ecological sites are in poor condition. The maximum stocking rates were 19.6 acres per sheep unit year long for the Shallow Loamy ecological site ranging to 353.4 acres per sheet unit for the

Sandy Wash ecological site. The Recommended carrying capacity is 1674.0 sheep units (year long) for the Teesto chapter. The trend for all ecological sites in the Teesto range unit is moving away from the climax vegetation community and the range condition was poor.

4.5 Winter/Summer Comparison

In December of 2005, when this inventory was initiated, 104 transects were completed before it was decided that the degradation of plants would inhibit accurate data collection. The project was delayed until June of 2006. Unfortunately, there was almost no precipitation between December and June so the sampling conditions during the summer inventory were not improved. For comparison, 51 of the transects that were sampled (in compartment 6) in December were re-sampled in June. Although we predicted greater canopy cover, the results do not show this. We surmise that a lack of winter and spring precipitation contributed to the results, but a further comparison of the same 51 transects would provide more insight into the differences between sampling near the beginning of the growing season versus after the growing season.

Table 4.4 illustrates the results of frequency sampling on the 51 transects with the following indicator species used in all analyses:

Decreasers	BOER4	Bouteloua eriopoda
	ELEL5	Elymus elymoides
	PASM	Pascopyrum smithii
	STCO4	Stipa comata
Increasers	ATCO	Atriplex confertifolia
	CHNAA4	Chrysothamnus nauseosus
	GUSA2	Gutierrezia sarothrae
	MUPU2	Muhlenbergia pungens
Invaders	ASTRA	Astragalus spp.
	SAKAR	Salsola kali

Table 4.4 Percentage Species Frequency Comparison of Data Collected in Winter and Summer.

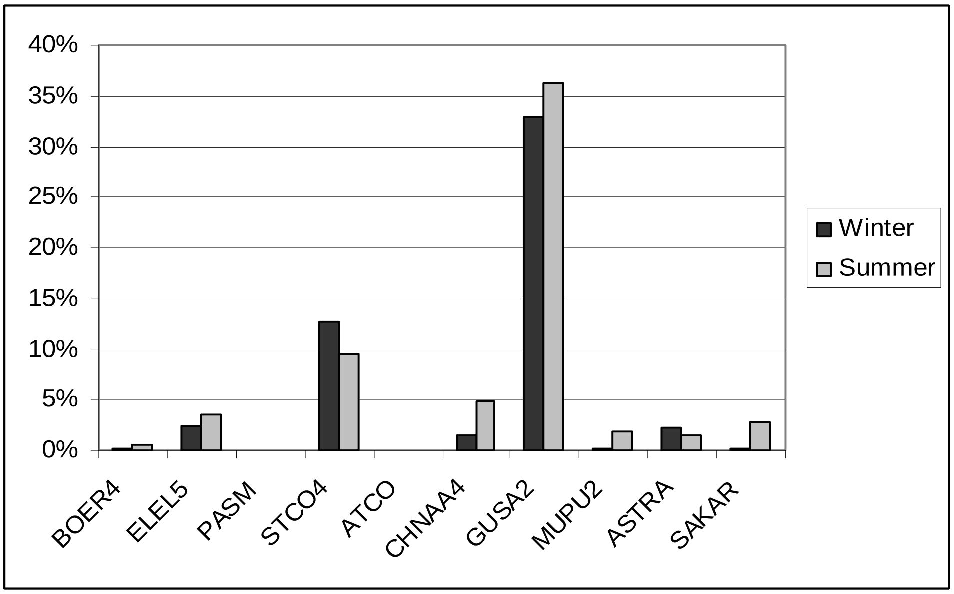
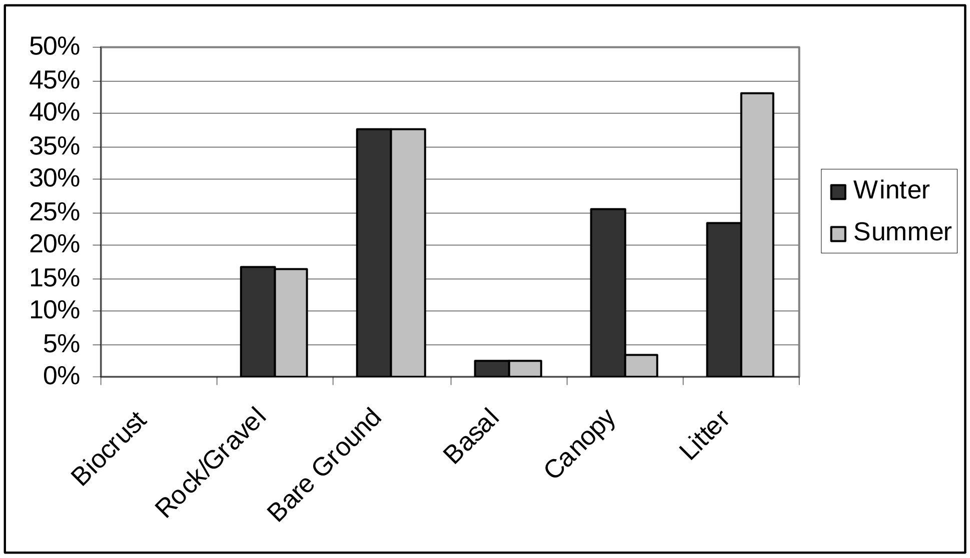


Table 4.5 shows the differences in percentage ground cover between the winter and summer sampling periods. Surprisingly, canopy cover was higher in winter, but again this is likely due to the lack of rainfall between the two sampling periods. The higher litter percentage in the summer sampling period may represent the decay of the canopy into litter. Unsurprisingly, basal vegetation cover is equal. Basal cover is a more stable vegetation indicator than canopy cover because it does not fluctuate seasonally.

Table 4.5 Percentage Ground Cover Comparison of Data Collected in Winter and Summer.



We calculated the complete production comparison between winter and summer transects in the same way as the overall District Seven transects. The information is included in Appendix E, however the results are not adequate for analysis due to the low sample size, of one transect, in many of the Ecological Sites. Table 4.6 illustrates the average productivity by Chapter which is a better comparison. In all cases, however, winter production was greater than summer production.

Table 4.6 Production Comparison of Data Collected in Winter and Summer.

Chapter	ESD#/ESD Name	Season	Reconstructed weight	Pounds Allowable	Reference Community Production in average year lbs/ac)	Average Similarity Index
DILCON	NO ESD	Summer	294.2			
DILCON	NO ESD	Winter	367.4			
DILCON	RO35XA101AZ - Breaks 10 -14"	Summer	509.4	151.9	650	23
DILCON	RO35XA101AZ - Breaks 10 -14"	Winter	227.3	172.4	650	27
DILCON	RO35XA113AZ - Loamy Upland 10-14"	Summer	465.8	87.9	650	14
DILCON	RO35XA113AZ - Loamy Upland 10-14"	Winter	118.0	59.7	650	9
DILCON	RO35XA117AZ - Sandy Loam Upland 10-14"	Summer	127.4	127.4	800	16
DILCON	RO35XA117AZ - Sandy Loam Upland 10-14"	Winter	95.7	74.1	800	9
DILCON	RO35XB216AZ - Sandy Wash 6-10"	Summer	236.8	31.6	875	4
DILCON	RO35XB216AZ - Sandy Wash 6-10"	Winter	205.4	54.7	875	6
INDIAN WELLS	RO35XA117AZ - Sandy Loam Upland 10-14"	Summer	329.8	118.5	800	15
INDIAN WELLS	RO35XA117AZ - Sandy Loam Upland 10-14"	Winter	206.0	79.2	800	10
INDIAN WELLS	RO35XA119AZ - Shallow Loamy 10-14"	Summer	280.6	84.0	650	13
INDIAN WELLS	RO35XA119AZ - Shallow Loamy 10-14"	Winter	195.5	28.7	650	4
TEESTO	NO ESD	Summer	547.9			
TEESTO	NO ESD	Winter	102.2			
TEESTO	RO35XA101AZ - Breaks 10 -14"	Summer	529.8	135.1	650	21
TEESTO	RO35XA101AZ - Breaks 10 -14"	Winter	142.7	80.6	650	12
TEESTO	RO35XA113AZ - Loamy Upland 10-14"	Summer	464.7	126.4	650	19
TEESTO	RO35XA113AZ - Loamy Upland 10-14"	Winter	144.8	39.5	650	6
TEESTO	RO35XA117AZ - Sandy Loam Upland 10-14"	Summer	191.9	92.6	800	12
TEESTO	RO35XA117AZ - Sandy Loam Upland 10-14"	Winter	132.0	70.2	800	9
TEESTO	RO35XA119AZ - Shallow Loamy 10-14"	Summer	590.1	142.1	650	22
TEESTO	RO35XA119AZ - Shallow Loamy 10-14"	Winter	133.2	71.2	650	11
TEESTO	RO35XB217AZ - Sandy Upland 6-10"	Summer	906.1	80.6	400	20
TEESTO	RO35XB217AZ - Sandy Upland 6-10"	Winter	209.4	52.0	400	13
TEESTO	RO35XB219AZ - Sandy Loam Upland 6-10"	Summer	142.4	104.5	650	16
TEESTO	RO35XB219AZ - Sandy Loam Upland 6-10"	Winter	126.3	111.3	650	17

While these comparisons provide an interesting view of the particular conditions during the two sampling periods, they should not be used as a definitive source of information because the lack of winter and spring precipitation was noticeable, even during the drought cycle, resulting in lower than average biomass production. Also, the transects were not permanently marked so the individual transect data is not comparable; the grouped data should be more accurate.

5.0 DISCUSSION

5.1 Grazing Overview

Movement of animals, timing of grazing, 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. Established grazing patterns are dictated by topography, plant distribution, and location of water, shelter and minerals (Heitschmidt 1991). Overall production of a given pasture or grazing unit does not necessarily reflect the amount of forage available to livestock. Therefore, it is important to recognize specific areas that restrict animals due to inaccessibility, long distances to water, steep slopes, or other factors. Once identified, production from these areas can be subtracted from the total or plans can be made to possibly include 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. Plant availability and composition also helps to determine where animals are likely to congregate.

After likely foraging patterns have been determined for a given area, production and similarity index 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 because there tend to be more available resources as a result of lowered competition with other animals. Conversely, high stocking rates can inhibit the individual, but the increase in animal 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.

Early season 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 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 the process continues, both the preferred and secondary plant species will be severely reduced and replaced with non-preferred or invasive species.

Overgrazing can be an awkward term when applied over an entire landscape. In most cases, plants that have been severely reduced by grazing can be found growing next to plants that have been left untouched. Therefore, it is more appropriate to view overgrazing at a species or individual level. Savory (1999) sums up overgrazing as "the grazing of roots." This is an apt description and refers to plants that are grazed severely during the growing season and then suffer additional losses due to grazing of re-growth during the same season. When this occurs, root growth essentially stops as energy reserves located in the roots and the lower portion of the plant are used for re-growth. The resulting energy depletion severely curtails new growth in the following season and often results in plant mortality.

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.

5.2 Frequency

On rangeland, regeneration of climax plant species maintains good range conditions. Grazing by too many animals (livestock and wildlife) or too heavy utilization by a few animals results in overuse, loss of vigor, and ultimately disappearance of the preferred and desirable plants. Deterioration of the range vegetation begins when less valuable forage species replace the desirable species. If deterioration continues, the less valuable forage species begin to be replaced by invaders and noxious weeds.

Frequency of preferred and desirable species can be monitored relatively easily by range technicians and managers as long as species are correctly identified. Monitoring the trend of key climax species is a recommended management objective. If frequency declines over time for key climax plants, then the range resource is being over utilized and negative impacts to the resource will result. If the frequency of key species increases over time, then the range resource and condition is recovering.

This report provides baseline data for frequency. Future studies should repeat the collection of species frequency data in order to compare with data collected on this inventory.

5.3 Ground Cover

Ground cover measurements are used to quantify ground cover of litter, biological crusts, and soil surface condition. Cover is also important from a hydrologic perspective when the variables of interest may include basal and canopy (foliar) cover of perennial and annual species and litter cover. This study measured understory vegetation; no trees were included.

Cover data can assist in determining the proper hydrologic function of a site, as well as the biotic integrity of a site. Point interception 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 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 the District Seven area should take place around June and July to replicate the sampling time period from this baseline inventory.

5.4 Production

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. Therefore, these determinations represent a productivity index. They are valuable for comparing the production of different Range Sites. Production data must be obtained at a time of year when measurements are valid for comparison with similar data from other years, other sites, and various conditions being evaluated.

The total annual production can be misleading. Total annual production includes production from all species of a plant community during a single year, including invasive, noxious, toxic, and non-forage species. Total annual production does not indicate the amount of forage available to livestock or other herbivores, or whether or not it is a climax plant species expected to occur. Total annual production is often measured in a monitoring program, but may not be the best vegetative attribute for which to manage. Total annual production is simply a baseline assessment of what is actually on the ground.

Potential production is the expected production of a particular ecological site. The potential production of a site is given in the ESD. The information in the ESD is based on field data collected in sites with similar soils, climate, water resources, vegetation and land use. Comparing current total annual production to potential production is very 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 historic climax plant community. 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 focus on monitoring allowable production and comparing that data to the expected climax community.

Those transects with no recorded vegetation were excluded from the results averages. The transects with no vegetation are associated with a particular ecological site, but the evidence for determining Ecological Site was too limited to make a determination. The exclusion of these transects slightly increases the estimated production levels of the area. There were 17 transects with no vegetation. Three each in Teesto and Indian wells, and 11 in Dilcon.

5.5 Drought

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 early seral states or irreversible states.

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.

The two local precipitation monitoring stations in the project areas recorded significantly reduced precipitation compared to the previous five year average. Precipitation levels throughout the Southwest are indicative of drought. Drought conditions are not optimal times for rangeland inventories, but also not unusual; the NRCS was collecting data on the same vegetative attributes as part of their National Resource Inventory during the same period of time with similar conditions.

6.0 RECOMMENDATIONS

The most important recommendation that can be made as a result of this inventory is to caution against the direct application of the stocking rates provided in the results. The provided stocking rates 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 variability of precipitation, and distance to water sources, and the percentage of acreage with steep slopes.

6.1 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

We highly advise that range managers using this data reassess the designations of forage values to individual species. Some of the species such as snakeweed (*Gutierrezia sarothrae*), cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), sandhill muhly (*Muhlenbergia pungens*), and prickly pear (*Opuntia* spp.) would not be considered desirable species by most range managers The values can be changed relatively easily in the Forage Value Rating spreadsheets provided as tools in this report. The forage value assignments clearly show their weakness in the results of the Low Mountain/Jeddito area. The initial stocking rates appear to be very high because much of the “available forage” in this area consists of big sagebrush (*Artemisia tridentata*), pricklypear and snakeweed. These species were assigned a “Desirable” forage value by BIA Range Managers. This assignment of desirable for these species artificially inflates the amount of forage available and thus lowers the number of acres per sheep unit year long. It should be noted that while big sagebrush may be a desirable or even a preferred species for sheep in woodland sites, over-allocation could occur when the amount of production of big sagebrush is far above its expected level. Managers should pay close attention to the contribution of shrubs to the total, desirable and preferred production amounts.

An alternative stocking rate was calculated on all Forage Value Rating spreadsheets. This alternative excludes undesirable species. It should be noted that it still includes those species labeled desirable by local range managers including snakeweed and Russian thistle, and prickypear cacti. We recommend that range managers examine those spreadsheets, as well as the notes provided in the summary of results spreadsheets that indicate primary composition of available forage.

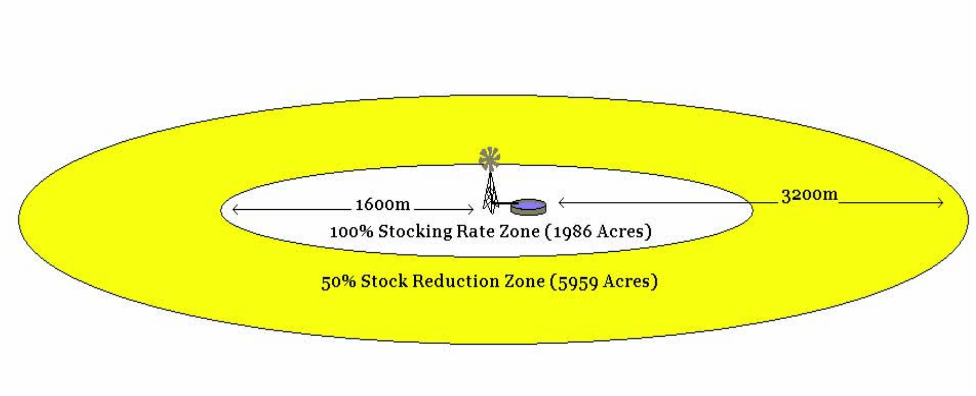
6.2 Stocking Rates during Drought

If there is very little precipitation during the winter and early spring numbers, stock numbers should not be permitted at the rate of an average years’ production. 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.

6.3 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.
Permanent and temporary water sources in District Seven are not currently mapped, or may be incompletely mapped. 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



All water sources in District Seven should be mapped, and designated as seasonal or permanent. 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.

6.4 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.

Transects were identified according to their location within ten compartments. The boundaries of these compartments were drawn by the BIA using roads, fences and other manageable boundaries. Currently, grazing permits are allocated by the four Chapter range units, but a switch to these ten compartments would provide for more efficient and measurable management of the grazing lands within District Seven. Because the raw transect data and calculations are provided with this report, and labeled by compartment, the baseline conditions of the ten compartments is retrievable by sorting the data accordingly.

7.0 SUMMARY

The grazing lands of District Seven varied from poor to fair condition during the time of this vegetation inventory. The results of the data analysis indicated conditions unlike the climax plant community conditions expected for the District Seven project area. Some of the locations have transitioned into deteriorated states that may never be able to return to a climax state.

Developing a flexible stocking program is vital for measuring improvement of the range resource and implementing flexible stocking rates is vital for maintenance and improvement of the range resource. A well planned and executed monitoring program will allow for adaptability in response to factors such as the ongoing drought. General management objectives should include increasing composition and species production to levels closer to a potential vegetation community.

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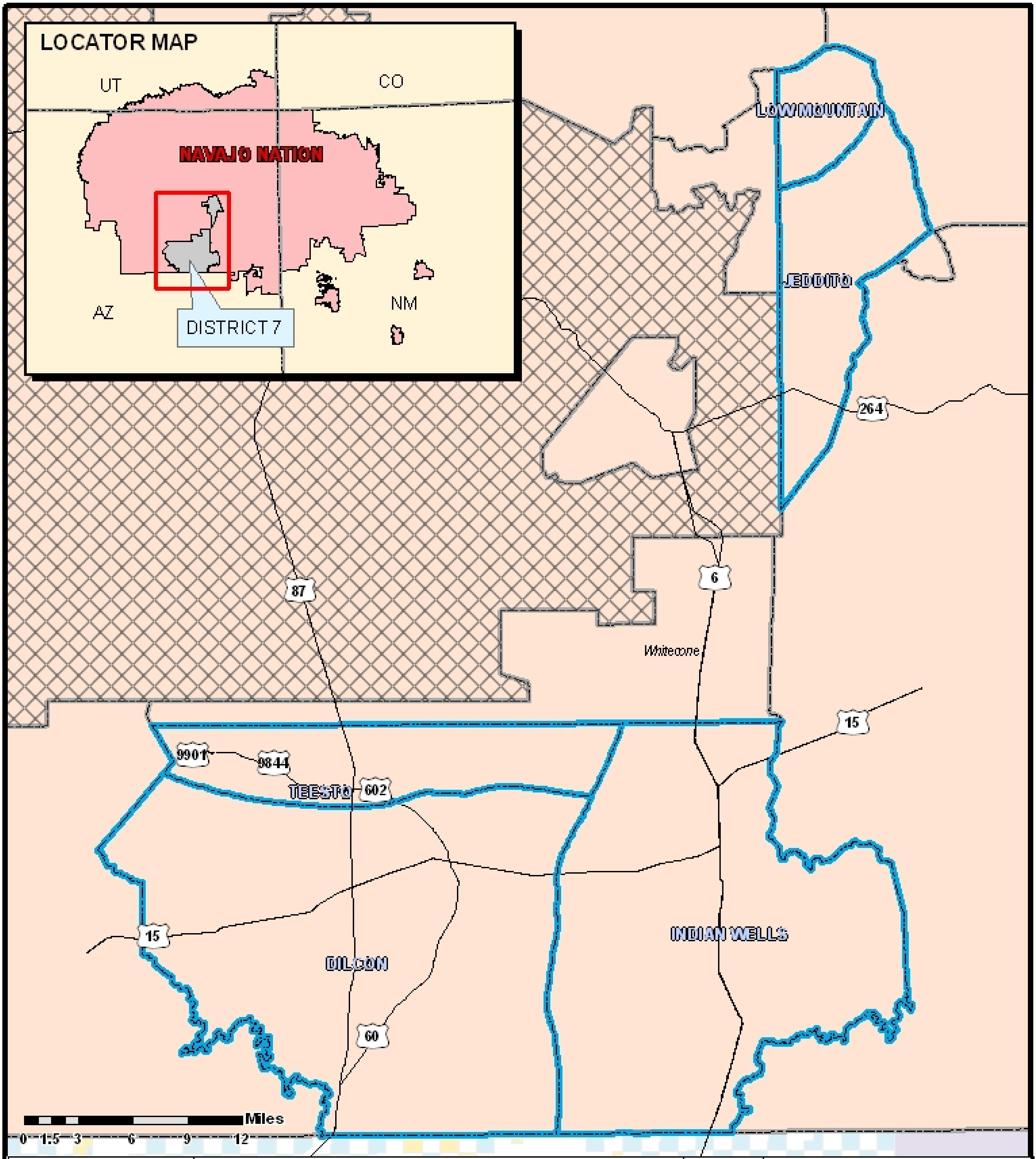
APPENDIX A



ECOSPHERE
ENVIRONMENTAL SERVICES

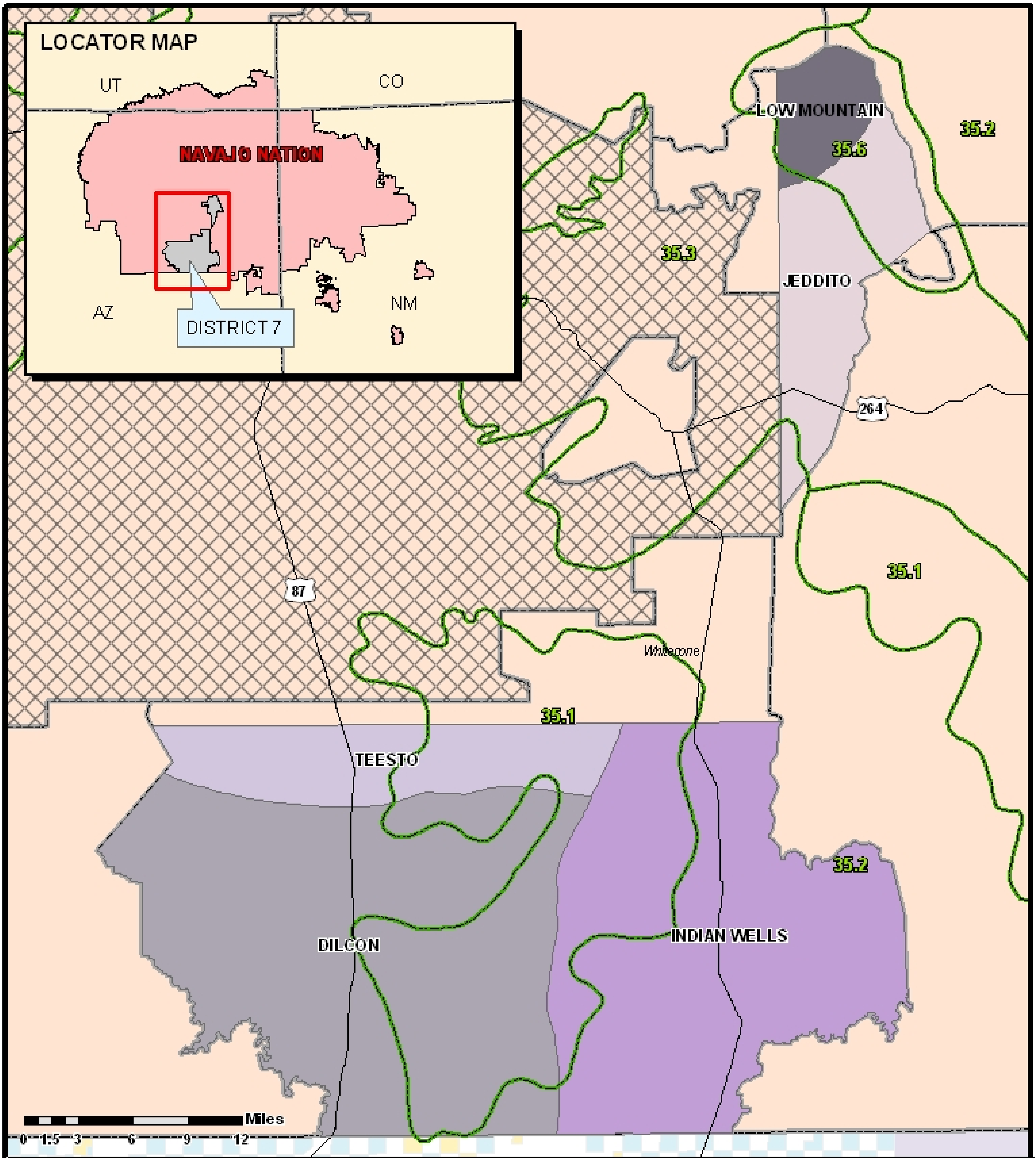
BUREAU OF INDIAN AFFAIRS

DISTRICT 7 VEGETATION INVENTORY

N

District 7 Chapters
Hopi Indian Reservation
Other Districts

VICINITY MAP	FIGURE 2.1
NAD 83 UTM ZONE 12 N	1:455,000
NAVAJO COUNTY AND APACHE COUNTY, ARIZONA	12/11/2007



ECOSPHERE
ENVIRONMENTAL SERVICES

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DISTRICT 7 VEGETATION INVENTORY

N

🟩 CRA
☒ Hopi Indian Reservation
☐ Other Districts

Range Units and Common Resource Areas

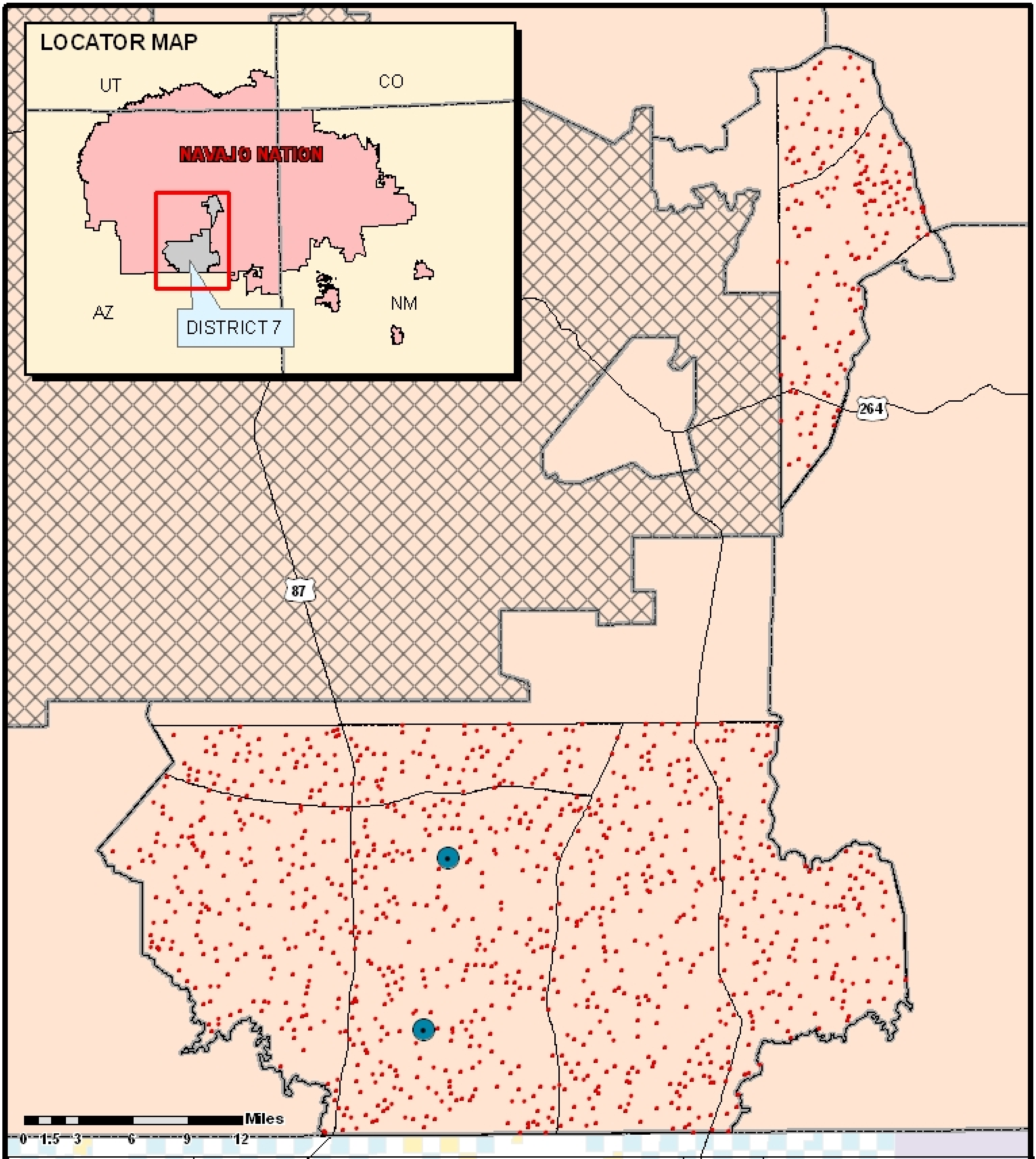
FIGURE 2.2

NAD 83 UTM ZONE 12 N

1:455,000

NAVAJO COUNTY AND APACHE COUNTY, ARIZONA

12/11/2007



ECOSPHERE
ENVIRONMENTAL SERVICES

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DISTRICT 7 VEGETATION INVENTORY

Precipitation Station and Transect Locations

NAD 83 UTM ZONE 12 N

NAVAJO COUNTY AND APACHE COUNTY, ARIZONA

FIGURE 2.3

1:455,000

12/11/2007

APPENDIX B

PRECIPITATION RAIN

DILKON O&M

WATER YEAR	STATUS	10	11	12	1	2	3	4	5	6	7	8	9	Total Of PRECIP
1988	Active	5.3												5.3
1989	Active	4.2						2.9						7.1
1990	Active	2.85							0		1.25			4.1
1991	Active	1.3			2.2	0	1.1			0.08	0.22			4.9
1992	Active				3.9		2.2			4.4		4.4	0.3	15.2
1993	Active		0.7	1.7	3.3	1.65	0		2.35	0.05		4.1	0.3	14.15
1994	Active	1.5	0.8	0.1	0	0.5	0.6	2.15		0.85	0.6	0.45	1.25	8.8
1995	Active		1.1	1			3.2	0.4	0.4		0.4	0.7	1	8.2
1996	Active	0.05	0.05	0.2	0.2	0.1			0.8		1		1.7	4.1
1997	Active						5.2			1				6.2
1998	Active					2.9	2.35					3.65	0.1	9
1999	Active	1.7			0.9						1.89		6.31	10.8
2000	Active								2.55		1.35	1.07	0	4.97
2001	Active	2.3	0.42	0.17	0.86	0.28	0.99	0.78	0.7	0.05	0.68	1.6	0.65	9.48
2002	Active	0.4	0.3	1.1	0	0.21	0.09	0.3	0.1	0	1.9	1.4	1.27	7.07
2003	Active	0.23	0.3	0.9	0.1	0.7	1.4	0.05	0.05	0.1	0.3	1.6	0.6	6.33
2004	Active	0.45	0.6	0.8	0.6	0.5	0.2	0.95	0	0.25	1.3	0.5	2.85	9
2005	Active	0.65	0.9	0.86	1.14	2.03	0.62	1.25	0	0.4	1.2	0.85	0.55	10.45
2006	Active	0.4	0	0.1	0.1	0	0.3	0.3	0	0.02	2.78			4
2007		1.6	0.13											1.73

RECIPITATION RAIN

WATER YEAR	STATUS	10	11	12	1	2	3	4	5	6	7	8	9	Total Of PRECIP
2007	Active			0.47										0.47

IGHLAND RIM DRIVE

WATER YEAR	STATUS	10	11	12	1	2	3	4	5	6	7	8	9	Total Of PRECIP
1998	Active												0	0
1999	Active	1.2			0.8						2.11		5.19	9.3
2000	Active				0.14						3.41	0.6	0.25	4.4
2001	Active	2.15	0.75	0.06	0.87	0.34	0.57	0.68	1.17	0	0.8	2.13	0.2	9.72
2002	Active	0.46	0	1	0	0.19	0.36	0.35	0	0	1.47	0.43	1.3	5.56
2003	Active	0.2	0.3	0.4	0.25	0.65	0.9	0.05	0.05	0	0.35	1.75	0.3	5.2
2004	Active	0.9	0.4	0.6	0.4	0.4	0.42	0.88	0	0.5	1.6	1.3	2	9.4
2005	Active	0.6	1.4	0.72	1.58	2.2	1.5	1.2	0	0.5	0.2	0.68	0.47	11.05
2006	Active	0.55	0.1	0	0.15	0	0.4	0.35	0.05	-0.05	0.2	2.7	0.35	4.8
2007	Active			0.5										0.5
2007		1.6	0											1.6

APPENDIX C

	Harvest Efficiency Factor
Preferred	50%
Desirable	35%
Undesirable	5%
Nonconsumed	0%
Toxic	0%

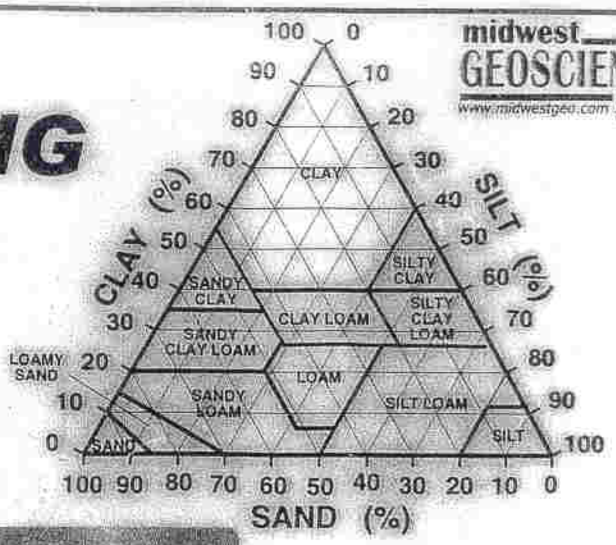
Code	Plant Name	Forage Value
ACHY	Achnatherum hymenoides	P
AGCRD	Agropyron cristatum	P
AMAC2	Ambrosia acanthicarpa	D
AMBRO	Ambrosia spp.	D
AMUT	Amelanchier Utahensis	D
ARABI2	Arabis spp.	U
ARBI3	Artemisia bigelovii	D
ARFE3	Arenaria fendlerii	D
ARFI2	Artemisia filifolia	D
ARFR4	Artemisia frigida	D
ARNO4	Artemisia nova	D
ARPU9	Aristida purpurea	U
ARTEM	Artemisia spp.	D
ARTR2	Artemisia tridentata	D
ASFU2	Astragalus fucatus	T
ASGL6	Asplenium glenniei	U
ASTRA	Astragalus spp.	T
ATCA2	Atriplex canescens	P
ATCO	Atriplex confertifolia	P
ATRIP	Atriplex spp.	D
ATSP2	Atriplex spinosa	D
BOER4	Bouteloua eriopoda	P
BOGR2	Bouteloua gracilis	P
BOUTE	Bouteloua spp.	P
BROMU	Bromus spp.	D
BRRU2	Bromus rubuns	D
BRTE	Bromus tectorum	D
CANU3	Calochortus nuttallii	D
CAREX	Carex spp.	D
CEMO2	Cercocarpus montanus	P
CHAMA15	Chamaesyce	U
CHDE2	Chrysothamnus depressus	T
CHENO	Chenopodium spp.	T
CHGR6	Chrysothamnus greene	U
CHGR6	Chrysothamnus viscid	U
CHGR6	Chrysothamnus greenii	U
CHNAA4	Chrysothamnus nauseosus	U
CHNAB3	Chrysothamnus nauseosus var. bige	U
CHRYS9	Chrysothamnus spp.	U
CHVI8	Chrysothamnus viscidiflorus	U

CIRSI	Cirsium spp.	U
CORYP	Coryphantha	U
COVI9	Coryphantha vivipara	N
COWR2	Cordylanthus wrightii	T
CRCR3	Cryptantha crassisepala	U
CRTE4	Croton texensis	U
CRYPT	Cryptantha spp.	U
DESCU	Descurainia spp.	U
ECHIN3	Echinocereus spp.	N
ELEL5	Elymus elymoides	D
EPCU	Ephedra cutleri	D
EPTO	Ephedra torreyana	D
EPVI	Ephedra viridis	D
ERAL4	Eriogonum alatum	U
ERCI6	Erodium cicutarium	D
ERIGE2	Erigeron spp.	U
ERIOG	Eriogonum spp.	U
ERION	Erioneuron spp.	U
ERLE9	Eriogonum leptoclaydon	U
ERPU8	Erionureon pulchellum	U
EUPA6	Euphorbia parryi	U
EUPHO	Euphorbia	U
EVLA	Evolvulus laetus	D
GAURA	Gaura spp.	U
GILIA	Gilia spp.	D
GILO2	Ipomopsis longiflora	D
GRSQ	Grindelia squarrosa	U
GUSA2	Gutierrezia sarothra	D
HEVI4	Heterotheca villosa	U
HIFE	Hieracium fendleri	D
HYACA2	Hymenoxys acaulis	U
HYFI	Hymenopappus filifolia	U
HYFL	Hymenopappus flavescens	U
HYMEN4	Hymenopappus	U
HYMEN7	Hymenoxys spp.	U
HYOD	Hymenoxys odorata	U
HYRI	Hymenoxys richardsonii	T
IPOMO2	Ipomopsis spp.	D
KOAM	Kochia americana	D
KOMA	Koeleria macrantha	D
KRLA2	Kraschenіnnikovia lanata	P
LAOC3	Lappula occidentalis	U
LEER	Leucelene ericoides	D
LEPU	Leptodactylon pungens	D
LERE3	Lesquerella rectipes	U
LESQU	Lesquerella	U
LIIN2	Lithospermum incisum	U
LINUM	Linum spp.	D
LITHO3	Lithospermum spp.	U
LOTUS	Lotus spp.	U
LUPIN	Lupine spp.	T
LYPA	Lycium pallidum	U
MACHA	Machaeranthera spp.	D
MENTZ	Mentzelia spp.	D
MIRAB	Mirabilis spp.	U
MOSQ	Monroa squarrosa	U
MUHLE	Muhlenbergia spp.	P
MUPU2	Muhlenbergia pungens	P
MUTO2	Muhlenbergia torreyi	D
OENOT	Oenothera spp.	D
OPPH	Opuntia phaeacantha	D
OPPO	Opuntia polyacantha	D
OPUNT	Opuntia spp.	D
OPWH	Opuntia whipplei	D
PAFI4	Parryella filifolia	D
PASM	Pascopyrum smithii	P
PENST	Penstemon spp.	P
PEPU7	Petradoria pumila	D
PEPUG2	Petradoria pumila ssp. Graminea	D
PHACE	Phacelia spp.	P
PHCR	Phacelia crenulata	P
PHLOX	Phlox spp.	D
PLIN3	Plantago insularis	P
PLJA	Pleuraphis jamesii	P
PLPA2	Plantago patagonica	D
POFE	Poa fendleriana	P
POIN3	Poliomintha incana	D
PORTU	Portulaca spp.	D
PSILO3	Psilostrophe spp.	U
PUST	Purshia stansburiana	P
PUTR2	Purshia tridentata	P
SAKAR	Salsola kali	D
SAVE4	Sarcobatus vermiculatus	D
SEDOJ	Senecio douglasii (flaccidus)	U
SEFI2	Senecio filifolius	T
SENEC	Senecio spp.	T
SOEL	Solanum elaeagnifolium	U
SPAI	Sporobolus airoides	P
SPCO	Sphaeralcea coccinea	D
SPCO4	Sporobolus contractus	P
SPCR	Sporobolus cryptandrus	P
SPFE	Sphaeralcea fendleri	P
SPGI	Sporobolus giganteus	P
SPHAE	Sphaeralcea	P
SPORO	Sporobolus	P
SPPA2	Sphaeralcea parvifolia	D
STCO	Stachys coccinea	D
STCO4	Stipa comata	P
STEX	Stephanomeria exigua	D
TECA2	Tetradymia canescens	U
VUOC	Vulpia octoflora	D
YUAN2	Yucca angustissima	U
YUBA	Yucca baccata	U
YUCCA	Yucca spp.	U

APPENDIX D

USDA SOIL TEXTURING FIELD FLOW CHART

midwest GEOSCIENCES group
www.midwestgeo.com



Remove any material larger than 2 mm in size and start with approximately 25g of sediment in palm. Add water dropwise and knead the soil to break down all aggregates. Stop adding water when soil is plastic and moldable.

Add dry sediment

Does soil hold together when squeezed? NO → Is soil too dry? (YES → add water) NO → Is sediment too wet? (YES → Add dry sediment) NO → SAND

YES

Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form the ribbon with uniform thickness and width. Allow the ribbon to extend over the forefinger, breaking from its own weight.

YES

Does the soil form a ribbon? NO → LOAMY SAND

YES

Is the ribbon less than 2.5cm long before breaking? >2.5 CM? → Is the ribbon from 2.5 to 5.0cm long before breaking? >5.0 CM? → Is the ribbon greater than 5.0cm long before breaking?

YES YES YES

Excessively wet a small pinch of soil in palm and rub with forefinger

Is soil very sandy? YES → SANDY LOAM
NO
Is soil moderately sandy? YES → LOAM
NO
Does sample have little or no sand? YES → SILT LOAM

Does soil feel very gritty? YES → SANDY CLAY LOAM
NO
Does soil feel slightly gritty? YES → SILTY CLAY LOAM
NO
Does soil feel smooth? YES → CLAY LOAM

Does soil feel very gritty? YES → SANDY CLAY
NO
Does soil feel slightly gritty? YES → SILTY CLAY
NO
Does soil feel smooth? YES → CLAY

TEXTURE MODIFIERS
Fragment Content % by Volume

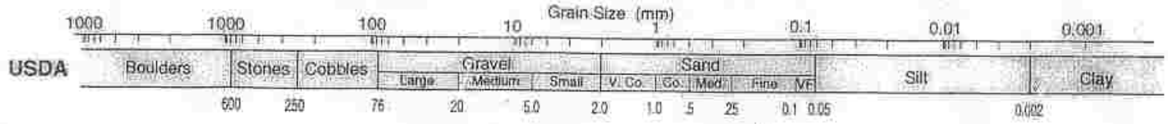
<15%	No modifier
15% to <35%	Add modifer
36% to <60%	Add "very" with modifier
60% to 90%	Add "extremely" with modifier
>90%	No modifer: use Size Class only

ROCK FRAGMENT MODIFIERS
Size Class & Quantity

Gravelly	>15% but <35% gravel
Fine Gravelly	>15% but <35% fine gravel
Medium Gravelly	>15% but <35% med. gravel
Large Gravelly	>15% but <35% large gravel
Very Gravelly	<35% but <60% gravel
Extremely Gravelly	>60% but <90% gravel
Cobbly	>15% but <35% cobbles
Very Cobbly	<35% but <60% cobbles
Extremely Cobbly	>60% but <90% cobbles
Stony	>15% but <35% stones
Very Stony	<35% but <60% stones
Extremely Stony	>60% but <90% stones
Bouldery	>15% but <35% boulders
Very Bouldery	<35% but <60% boulders
Extremely Bouldery	>60% but <90% boulders

COMPOSITIONAL TEXTURE MODIFIERS
Organic Class

Grassy	> 15% grassy fibers
Herbaceous	> 15% herbaceous fibers
Mossy	>15% moss fibers
Mucky	Minerals >10% but <17% fibers
Peaty	Minerals >10% but >17% fibers
Woody	>15% wood fragments or fiber



APPENDIX E.

(CD Attached)