District One
&
District Three, Unit Two

Vegetative Inventory Report

Prepared for:
Bureau of Indian Affairs
Western Navajo Agency

Prepared by:

Ecosphere Environmental Services

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Abstract

Ecosphere Environmental Services was contracted by the Bureau of Indian Affairs (BIA) to collect and compile vegetation data on Grazing District Three, Unit Two and parts of Grazing District One of the Western Navajo Agency. The BIA provided 396 transect locations in District Three, Unit Two and 406 transect locations in District One. Data collection in Grazing District Three, Unit Two occurred during July and August of 2006 and in Grazing District One during August and September of 2006. Measurements were taken for biomass production, ground cover, and species frequency. The data were analyzed to determine the carrying capacity of the range resource.

Data were analyzed by soil map units within each grazing compartment. Carrying capacities and recommended stocking rates were calculated by compartment using a forage value rating. Rangeland managers for the Western Navajo Agency who are familiar with the vegetation and conditions of the area provided forage values for all of the species encountered during the inventory. The data were aggregated by soil unit, and then calculated according to the acreage of each soil unit within each compartment. District Three, Unit Two contains three compartments, District One contains seven compartments. Results are presented by compartment.

Overall, the range resource was in moderately good condition. The District One study area appeared to be in slightly better condition than the District Three, Unit Two area with higher frequencies of decreaser plant species, less bare ground, and more available forage.

1.0 INTRODUCTION

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to conduct under-story rangeland vegetation inventories on parts of District One (District One) and District Three, Unit Two (District Three) of the Western Navajo Agency. Field biologists collected species specific vegetation data including annual production, cover, and frequency. This data was also used to calculate carrying capacity based on a local forage value rating. Information derived from these calculations can be used to guide management decisions, including stocking rates. This report supplies the results of the vegetation inventory as well as the background, methodology, and discussion necessary for management planning.

1.1 Purpose and Need

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

1.2 Affected Regulatory Entities

Livestock grazing permits are administered by the BIA Natural Resources Program in accordance with 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 Three and District One study area includes parts of four Chapters: Tuba City, Kaibeto, Gap and Red Lake/Tonalea.

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. Stocking rates, season of use, annual precipitation, soil types, location of water sources, and topography strongly influence the variety and quality of forage on rangelands. The results of this vegetative inventory quantify the current conditions of the rangelands on Districts One and Three. This information can be used to document future changes on the rangelands and assist with management decisions.

2.1 Geographic Setting

The project area is located within the Colorado Plateau (35) Major Land Resource Area (MLRA) and within two sub-resource areas, or Common Resource Areas (CRA), previously known as Land Resource Units. Differences between the CRAs occur in vegetation composition and precipitation averages. Most of the project area is located within the 35-2AZ Colorado Plateau Cold Desert Shrub CRA. The northern half of District One is located within the 35-3AZ Colorado Plateau Sagebrush – Grasslands CRA.

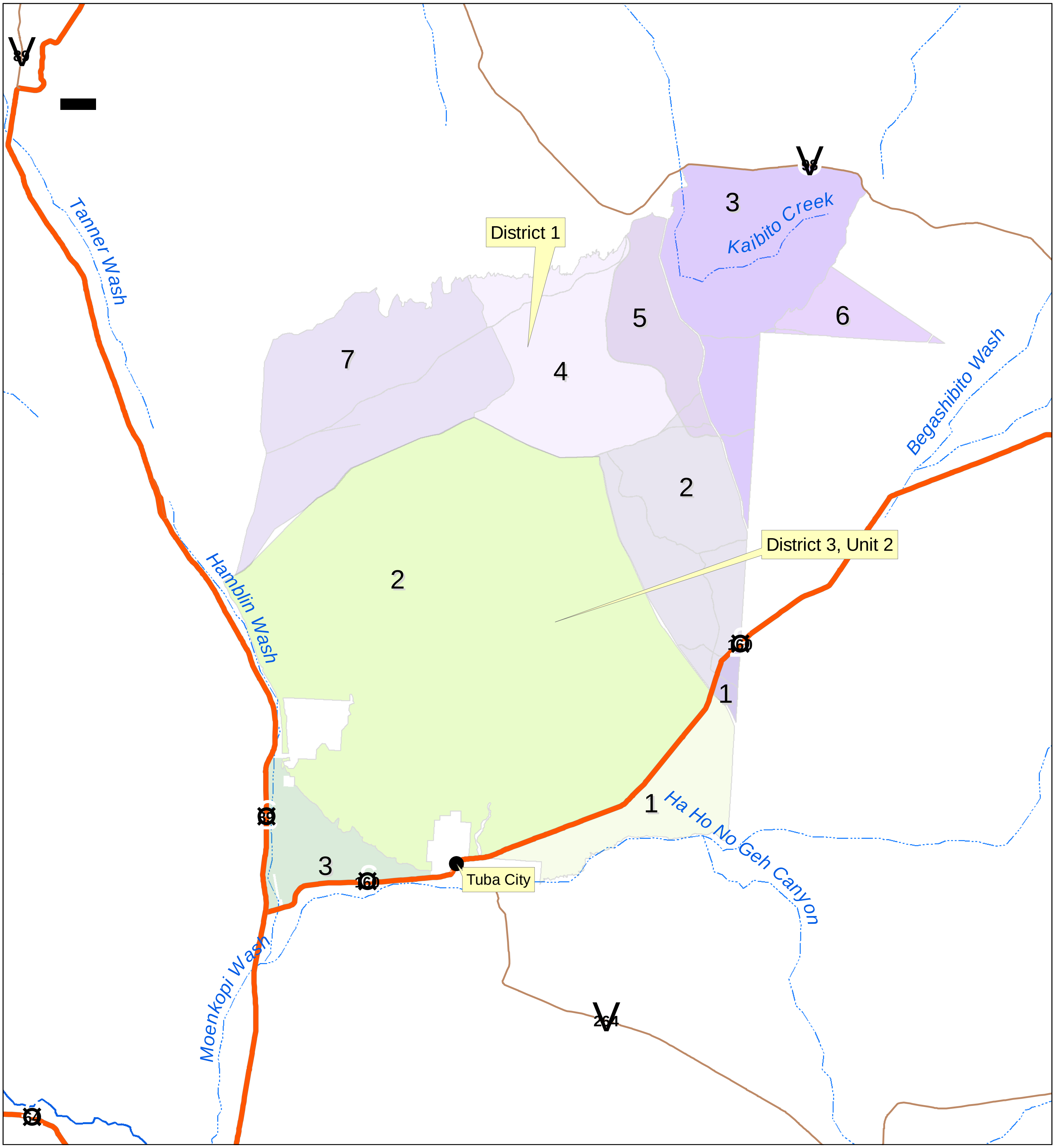
The study area surveyed is topographically diverse, ranging from the Echo Cliffs in the west, to White Mesa in the northeast corner, and Moenkopi to the south, with sand dunes and rock outcroppings scattered in between. Other prominent features include Wildcat Peak and Preston Mesa. The San Francisco Peaks are visible to the south near Flagstaff, and Black Mesa is the dominant land feature to the east.

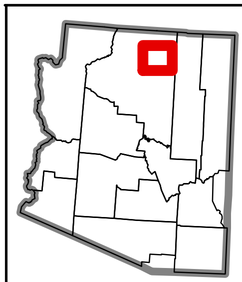
The study area is located in the vicinity of Tuba City, in Coconino County, Arizona. District Three, Unit Two is bounded by U.S. Highway 89 on the west, and U.S. 160 on the south. District One lies to the northeast of District Three, Unit Two and is bordered on the north by Highway 98. Tuba City is located approximately 78 miles north of Flagstaff and 75 miles southwest of Kayenta. The District Three study area contains three grazing Compartments. The District One study area contains seven grazing Compartments. A map of the Compartments and Districts of the study area is provided in Map 1 on the following page.

Acreages for each soil map unit, compartment and District study area were extracted from digital shapefiles provided by the Western Navajo Agency. The District Three, Unit Two study area covered 244,849.6 acres the majority of which is in compartment 2 (208,581.6 acres). Compartments 1 and 3 contain 21,168.9 and 15,099.1 acres, respectively. In the District One study area the total acreage is 204,044 acres distributed among seven compartments as follows: 1- 1,638.7 acres, 2- 35,879.8 acres, 3- 48,302.2 acres, 4- 37,831.2 acres, 5- 16,133.1 acres, 6- 8,639.2 acres, and 7- 55,619.8 acres.

2.2 Geology

The Colorado Plateau has been uplifted from its surroundings; during the uplift the rivers flowing across the plateau cut into the bedrock, forming impressive geologic features and scenery such as extensive rock outcrops, canyons, cliffs, as well as volcanic remnants.





District 3, Unit 2 and District 1 Study Area

BIA, Western Navajo Agency

Compartments	MAP 1
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	5/7/2008

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The southwestern portion of District Three, Unit Two borders the bare, clay hills of the Painted Desert within the Chinle Formation. A large portion of the study area is within the Glen Canyon Group, including the red rock formations which comprise the Echo Cliffs. Dinosaur tracks near Moenave are visible in the Triassic rocks of the Kayenta Formation. The Glen Canyon Group extends east almost to Tonalea, where it meets the San Rafael Group in which is located White Mesa. White Mesa, at the northeast corner of the study area, consists of late Jurassic sandstone. Wildcat Peak is of volcanic origin (Chronic 1983).

2.3 Soils

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

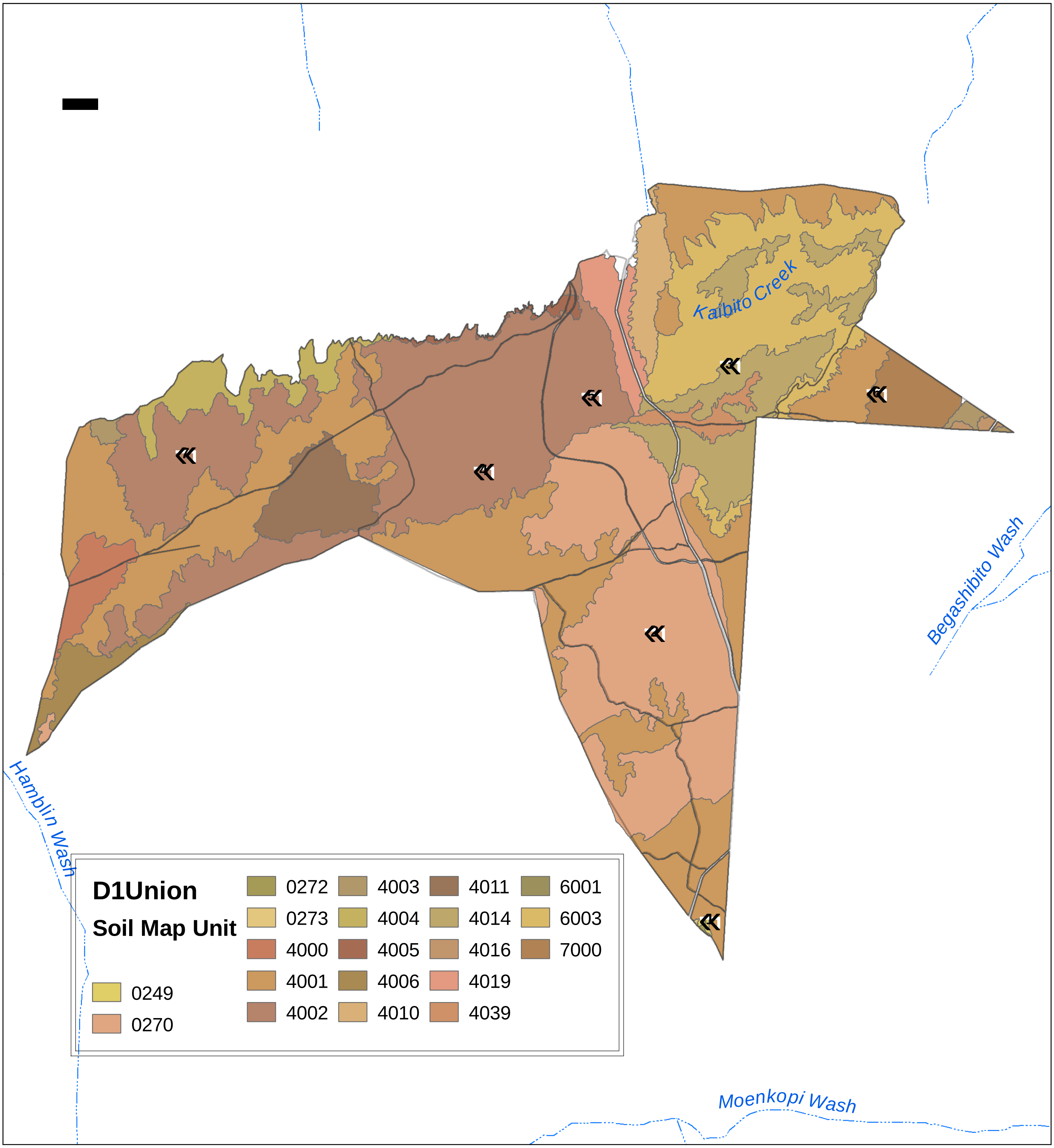
Biological soil crusts occur occasionally throughout the study area. Biological soil crusts are a complex mosaic of organisms that weave through the top few millimeters of soil, gluing loose particles together to stabilize and protect soil surfaces from erosive forces. Additionally, roughened soil surfaces created by biological crusts act to impede overland water flow, resulting in increased infiltration (Belnap et al. 2001). Biological soil crusts can provide a vital component for healthy, functioning soils.

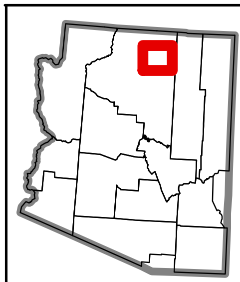
The inventory project area is located within the boundaries of two soil surveys produced by the United States Department of Agriculture, Soil Conservation Service. The Navajo Mountain Area, AZ, Parts of Apache, Coconino and Navajo Counties Soil Survey (AZ711) for District Three, Unit Two and the Little Colorado River Area, AZ, Parts of Coconino and Navajo Counties Soil Survey (AZ707) for District One. Soil mapping in these areas is not complete and the boundaries of the soil map units used for this study are subject to revisions (See Maps 2 and 3).

The soil surveys, when complete, are likely to be Order III mapped, including individual soil and plant components at association or complex levels (map units). Finer levels (soil types) are generally described, but not mapped. Each of the delineated map units contains multiple soil types within it. Each soil type is correlated with a specific ecological site. Order II mapping would delineate soil types within map units, and boundaries of ecological sites could be determined directly from the soil map. Ecological sites cannot be assigned directly from Order III map information because they are not delineated at a level equivalent to the individual components (soil types). In addition, the associated ecological site descriptions that correspond to soils in these particular surveys have not yet been developed. When the soil surveys and ecological site descriptions are complete and published, this information will become valuable for rangeland managers.

2.4 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 storms bring significant precipitation in





District 1 Study Area

BIA, Western Navajo Agency

Compartments and Soil Map Units	MAP 2
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	5/7/2008

UTAH COLO.
ARIZ. N. MEX.

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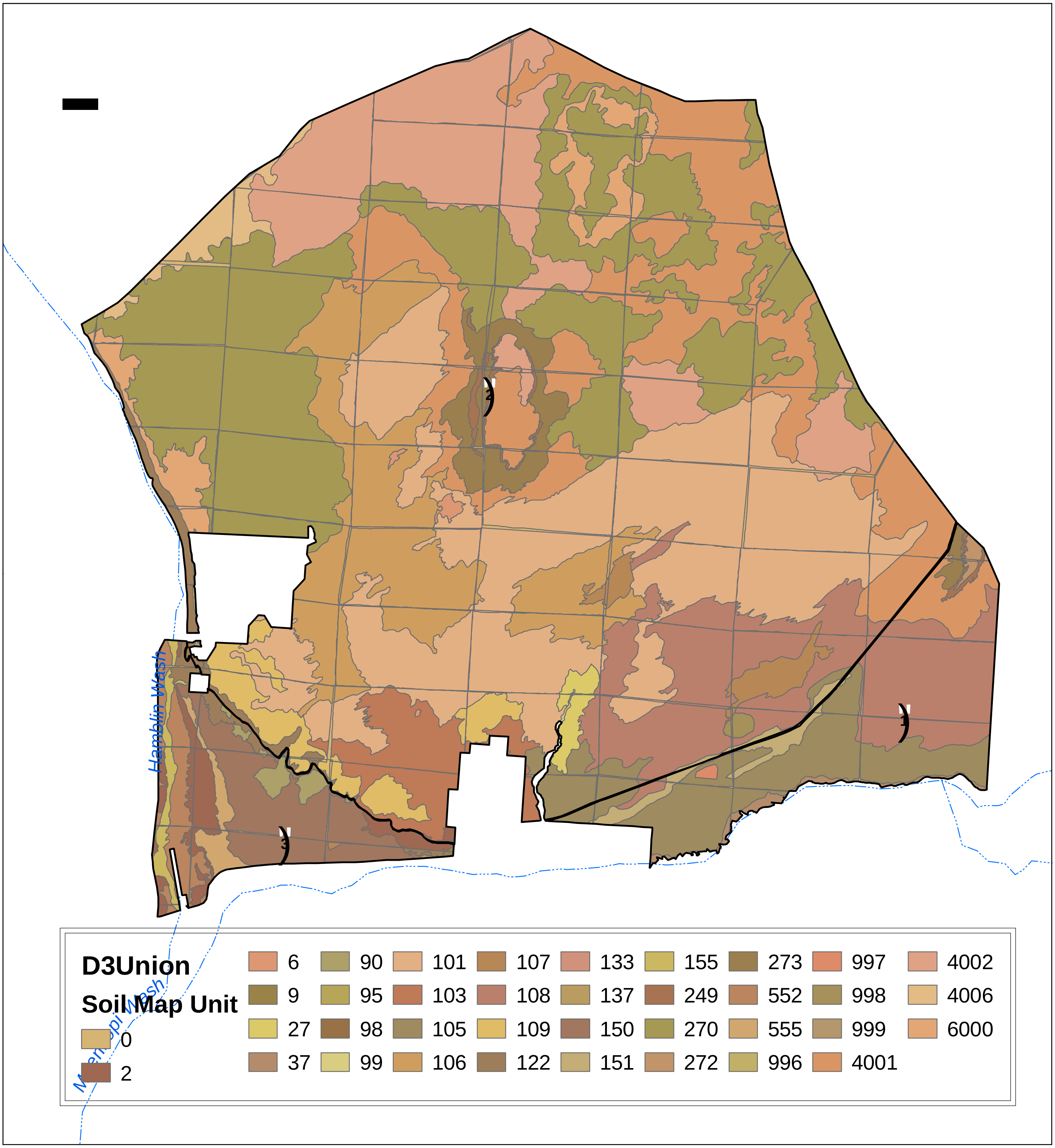

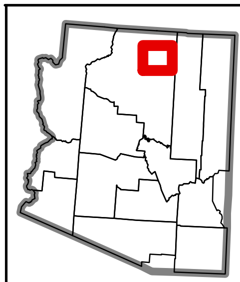

District 3, Unit 2

BIA, Western Navajo Agency

Compartments and Soil Map Units	**MAP 3**
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	**5/7/2008**

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the winter months and contribute to groundwater recharge. The region is dominated by drying southwesterly winds. The Colorado Plateau Cold Desert Shrub CRA is the driest CRA on the Colorado Plateau. Precipitation averages from five to nine inches annually. The mean annual temperature hovers around 50 to 55 degrees Fahrenheit. The Colorado Plateau Sagebrush – Grasslands CRA is generally higher in elevation with more moisture at ten to 14 inches per year.

2.5 Precipitation

Precipitation is a key variable affecting vegetation growth from year to year, and the effect of precipitation in any given year must be factored into biomass data collection. The Navajo Water Resources Department provided approximately six years of nearly complete precipitation data from gauging stations surrounding the inventoried area. The 2006 water year was compared to the previous five years of historical data. This five year historical average was the basis for comparison to “normal” precipitation levels. The data from the three stations closest to the study area in each District were combined to produce an average annual precipitation for the area. The average of three stations, instead of the single, closest station was used in order to account for localized, undocumented rain events that affect small portions of the rangeland. These precipitation data were used to correct vegetative production levels in 2006 to a level indicative of average precipitation. Overall in 2006, the study area was fairly consistent with the five year average. In District One, the 2006 water year was 104% of the five year average; District Three was 101% of normal.

These percentages provide a conservative reconstruction because the comparison “normal” value is calculated from only the previous five years and the previous five years have been droughty. A “normal” value calculated from 100 years of data would provide a more stable measure of precipitation norms, but only five years of reliable data was available for this location. The advantage of using a droughty five year average is that conservative estimates are factored into the reconstruction and the resulting stocking rates will also be somewhat conservative. The precipitation data are provided as Appendix A.

2.6 Plant Communities

The Colorado Plateau Cold Desert Shrub CRA (35-2AZ) is primarily rangeland on the Navajo Reservation. The general topography is rolling, and supports a fair amount of forage species. The Southwest Regional Gap Analysis Project (SWReGAP) has mapped vegetative landcover over the entire southwest area. The dominant landcovers in the study area include Colorado Plateau Blackbrush-Mormon-tea Shrubland, Inter-Mountain Basins Semi-Desert Shrub Steppe, Inter-Mountain Basins Active and Stabilized Dune, Southern Colorado Plateau Sand Shrubland, Inter-Mountain Basins Juniper Savanna and Colorado Plateau Pinyon-Juniper Woodland. The following descriptions and photos are provided from the landcover legend for the SWReGAP accessed at http://ftp.nr.usu.edu/swgap/index.html.

Colorado Plateau Blackbrush-Mormon-tea Shrubland (Photo 1.) occurs in the Colorado Plateau on benchlands, colluvial slopes, pediments or bajadas. Elevation ranges from 560-1650 m. Substrates are shallow, typically calcareous, non-saline and gravelly or sandy soils over sandstone or limestone bedrock, caliche or limestone alluvium. It also occurs in deeper soils on sandy plains where it may have invaded desert grasslands. The vegetation is characterized by extensive open shrublands dominated by *Coleogyne ramosissima* often with *Ephedra viridis*, *Ephedra torreyana*, or *Grayia spinosa*. Sandy portions may include *Artemisia filifolia* as codominant. The herbaceous layer is sparse and composed of graminoids such as *Achnatherum hymenoides*, *Pleuraphis jamesii*, or *Sporobolus cryptandrus*. This vegetation landcover occurs in the northwest corner of the study area.

Photo 1. Colorado Plateau Blackbrush-Mormon Tea Shrubland

Inter-Mountain Basins Semi-Desert Shrub Steppe (Photo 2.) typically occurs at lower elevations on alluvial fans and flats with moderate to deep soils. This semi-arid shrub-steppe is typically dominated by graminoids (>25% cover) with an open shrub layer. Characteristic grasses include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Distichlis spicata*, *Hesperostipa comata*, *Pleuraphis jamesii*, *Poa secunda*, and *Sporobolus airoides*. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include *Atriplex canescens*, *Artemisia tridentata*, *Chrysothamnus greenei*, *Chrysothamnus viscidiflorus*, *Ephedra* spp., *Ericameria nauseosa*, *Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. *Artemisia tridentata* may be present but does not dominate. The general aspect of occurrences may be either open shrubland with patchy grasses or patchy open herbaceous layer. Disturbance may be important in maintaining the woody component. Microphytic crust is very important in some stands. This vegetation landcover occurs primarily on the western half of the project area.

Photo 2. Inter- Mountain Basins Semi-Desert Shrub Steppe

Inter-Mountain Basins Active and Stabilized Dune (Photo 3.) occurs in Intermountain West basins and is composed of unvegetated to moderately vegetated (<10-30% plant cover) active and stabilized dunes and sandsheets. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe composed of *Achnatherum hymenoides*, *Artemisia filifolia*, *Artemisia tridentata* ssp. *tridentata*, *Atriplex canescens*, *Ephedra* spp., *Coleogyne ramosissima*, *Ericameria nauseosa*, *Prunus virginiana*, *Psoralidium lanceolatum*, *Purshia tridentata*, *Sporobolus airoides*, *Tetradymia tetrameres*, or *Tiquilia* spp. These dunes can be found in the central area of District Three, Unit Two.

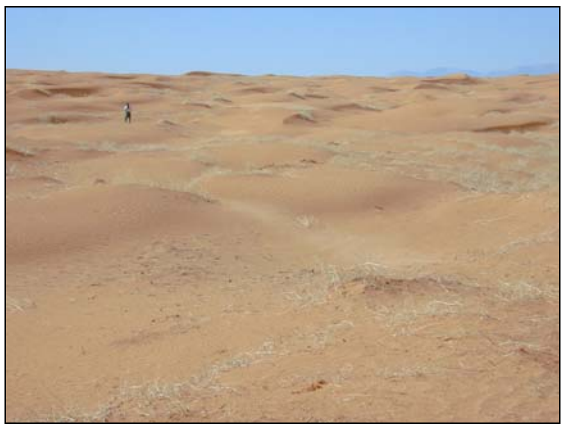


Photo 3. Inter- Mountain Basins Active and Stabilized Dune

Southern Colorado Plateau Sand Shrubland (photo 4.) is a large-patch ecological system found on the south-central Colorado Plateau in northeastern Arizona extending into southern and central Utah. It occurs on windswept mesas, broad basins and plains at low to moderate elevations (1300-1800 m). Substrates are stabilized sandsheets or shallow to moderately deep sandy soils that may form small hummocks or small coppice dunes. This semi-arid, open shrubland is typically dominated by short shrubs (10-30 % cover) with a sparse graminoid layer. The woody layer is often a mixture of shrubs and dwarf-shrubs. Characteristic species include *Ephedra cutleri*, *Ephedra torreyana*, *Ephedra viridis*, and *Artemisia filifolia*. *Coleogyne ramosissima* is typically not present. *Poliomintha incana*, *Parryella filifolia*, *Quercus havardii* var. *tuckeri*, or *Ericameria nauseosa* may be present to dominant locally. *Ephedra cutleri* and *Ephedra viridis* often assume a distinctive matty growth form. Characteristic grasses include *Achnatherum hymenoides*, *Bouteloua gracilis*, *Hesperostipa comata*, and *Pleuraphis jamesii*. The general aspect of occurrences is an open low shrubland but may include small blowouts and dunes. Occasionally grasses may be moderately abundant locally and form a distinct layer. Disturbance may be important in maintaining the woody component. Eolian processes are evident, such as pediceled plants, occasional blowouts or small dunes, but the generally higher vegetative cover and less prominent geomorphic features distinguish this system from Inter-Mountain Basins Active and Stabilized Dune. This sand shrubland covers most of the northern and eastern portions of the study area.


Photo 4. Southern Colorado Plateau Sand Shrubland

Inter-Mountain Basins Juniper Savanna (Photo 5.) is another widespread ecological system. It occupies dry foothills and sandsheets and is typically found at elevations ranging from 1500-2300 m. This system is generally found at lower elevations and more xeric sites than Colorado Plateau Piñon-Juniper Woodland. These occurrences are found on lower mountain slopes, hills, plateaus, basins and flats often where juniper is expanding into semi-desert grasslands and steppe. The vegetation is typically open savanna, although there may be inclusions of more dense juniper woodlands. This savanna is typically dominated by *Juniperus osteosperma* trees with high cover of perennial bunch grasses and forbs, with *Bouteloua gracilis, Hesperostipa comata*, and *Pleuraphis jamesii* being most common. In the southern Colorado Plateau, *Juniperus monosperma* or juniper hybrids may dominate the tree layer. Piñon trees are typically not present because sites are outside the ecological or geographic range of *Pinus edulis* and *Pinus monophylla*. This vegetation landcover occurs in the very northeast section of the study area.


Photo 5. Inter-Mountain Basins Juniper Savannah

Colorado Plateau Piñon-Juniper Woodland (Photo 6.) occurs in dry mountains and foothills of the Colorado Plateau region. It is typically found at lower elevations ranging from 1500-2440 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of piñon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. *Pinus edulis* and/or *Juniperus osteosperma* dominate the tree canopy. In the southern portion of the Colorado Plateau in northern Arizona and northwestern New Mexico, *Juniperus monosperma* and hybrids of Juniperus spp may dominate or codominate the tree canopy. *Juniperus scopulorum* may codominate or replace *Juniperus osteosperma* at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species include *Arctostaphylos patula*, *Artemisia tridentata*, *Cercocarpus intricatus*, *Cercocarpus montanus*, *Coleogyne ramosissima*, *Purshia stansburiana*, *Purshia tridentata*, *Quercus gambelii*, *Bouteloua gracilis*, *Pleuraphis jamesii*, or *Poa fendleriana*. This woodland is only found in the highest elevations of the northeast corner of the study area, as well as on Preston Mesa.


Photo 6. Colorado Plateau Piñon Juniper Woodland

A complete list of understory plant species found during the Vegetation Inventory is attached as Appendix B.

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 a current carrying capacity of the rangelands, data were collected on ground cover, frequency, and forage production. The methods used to collect this data included protocols provided by the BIA modified to standards used in Technical References. Data analysis methods were approved by the Natural Resources Conservation Service.

3.1 Pre-Field Methodology

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

3.1.1 Document Review

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

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

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

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

3.1.2 Pre-Work Conference

A pre-work conference was held on July 11 2006, in Tuba City, Arizona to discuss contract specifics, questions and concerns. BIA employees present at the conference included Mr. Casey Francisco, Contracting Officer Representative; Mr. Tony Robbins, Natural Resource Manager, Western Navajo Agency; and Ms. Deanna Benally, Spatial Analyst. Members of the Ecosphere team present at the conference included Ms. Alexis Watts, Project Manager; and Mr. Ike Wennihan, South Wind Conservation Inc., Natural Resource Specialist.

During the conference some technical issues regarding the SOW were clarified:

Ecosphere volunteered to collect additional data on an “eleventh plot.” 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 which suggests that plots 3 and 7 be clipped and the Technical References which state that the clipped plots should be representative plots. By estimating and harvesting an eleventh plot the field team can harvest most of the species that are estimated and accomplishes the same goal that the selection of representative plots accomplishes (an estimation correction factor).

It was agreed to harvest species at ground level.

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.

Finally, it was agreed that field biologists would begin data collection in the southern portion of the project area and work towards the north and northwest. District Three, Unit Two would be completed first, followed by District One.

3.1.3 Electronic Data Collection Protocol

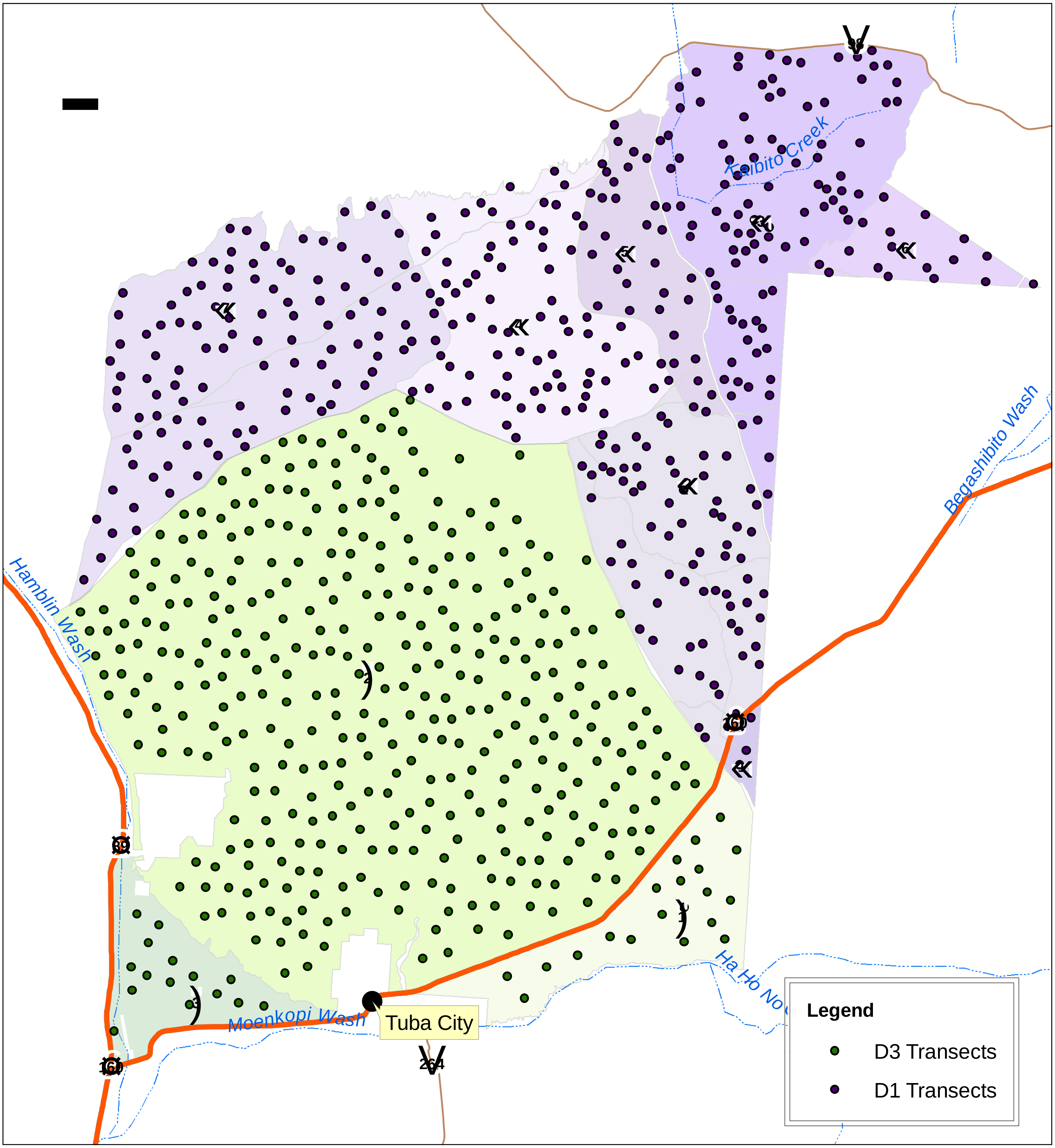
The use of electronic data recorders contributes to a higher quality product and more accurate data collection than paper data sheets with manual transfer to a digital database. Palm Zire 21 units were chosen for their black and white screens which are readable in outdoor daylight conditions. Ecosphere created a Pendragon software program specifically for the data parameters of this inventory. 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.

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. 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 between 25 July and 17 August, 2006 in District Three, Unit Two, and data was collected in District One between 28 August and 14 September, 2006. The BIA provided Ecosphere with predetermined transect locations (See Map 4). The Universal Transverse Mercator (UTM) coordinates of these transect locations were downloaded into hand held Global Positioning System (GPS) units. The GPS unit was used in combination with topographic maps to navigate by vehicle and foot to the transect locations. Transects were established within ten meters of the GPS coordinates, and usually within one or two meters. In District Three, Unit Two, all locations were previously scouted by the Bureau of Natural Resources staff to make sure they were located in accessible areas. In District One, most



District 3, Unit 2 and District 1 Study Area

BIA, Western Navajo Agency

Compartments and Transect Locations	MAP 4
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	5/7/2008

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locations were not previously scouted. Some transects were located in inaccessible canyons or adjacent to private residences. These transects were moved to suitable locations. The UTM coordinates of the new locations were recorded in the data recorders. A total of 31 transects were moved in District One.

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 attributes were read from ten plots at ten meter intervals along the transect bearing. Each plot was established at the toe of the final pace. The plots were measured with a square 9.6 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 notes were recorded 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.

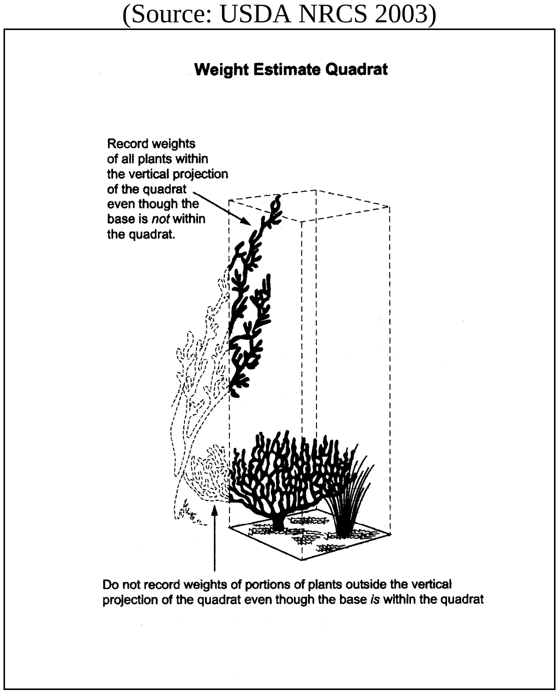
3.2.2.1 Establishing a Weight Unit

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 actual 9.6 ft^2 frame up to a height of 4.5 feet were estimated. Excluded were any plants and parts of plants outside of the box (Figure 3.2.1). 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, but 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 materials were collected and stored in paper bags labeled with tracking information including transect, date, species, and plot number. All of the harvested material was allowed to air-dry for ten days or more before re-weighing to convert from field (green) weight to air-dry weight (ADW). The purpose of the double sampling is to correct any variability in the estimation of production (Estimation Correction Factor).

Figure 3.2.1. 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 include in the vegetation measurements, the forage which has been consumed prior to the vegetation 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 team personnel were thoroughly trained and practiced in making ocular estimates of utilization of plants. An attempt was made to locate un-grazed plants near the transect. These un-grazed plants were assumed to approximately represent the species before grazing occurred. Ungrazed plants were used as a comparison to estimate grazed plants. Some re-growth may have occurred before the inventory period. However, if grazing patterns are undetectable on the plant, it is impossible to determine what re-growth, if any, may have occurred. The percentage of un-grazed plant remaining was recorded for each species on each transect.

3*.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. All cacti and yuccas were included in this category.

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

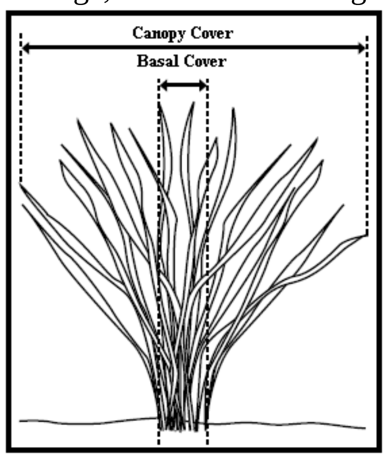
Frequency describes the abundance and distribution of species. Frequency measurements are an easy and efficient method for monitoring changes in a plant community over time. Frequency is the number of times a species is present in a given number of sampling units, usually expressed as a percentage. Electronic data collection allowed for easy and accurate collection of frequency data. The number of plots in which a species occurred on a transect was automatically entered 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 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 our 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 pin placement directly over (perpendicular to the ground) the corners of the quadrant frame as specified in Technical Reference 1734-4

Sampling Vegetation Attributes. Cover hits were recorded in the first category intercepted by the pin flag while vertically lowering the pin into position on the frame. 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 3.2.2). 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 the least biased and most objective of the three basic cover measures (Bonham1989).

Figure 3.2.2 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 C.

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:

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

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

3.3.2 Estimation Correction Factor

The harvested, or clipped, weights 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

3.3.3 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.

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

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.

$$\text{(estimated green weight(g) x correction factor) x \% ADW} = (80g \times 0.93) \times 0.67 = 49.85g$$

3.3.4 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*.

3.3.5 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 One and Three study area were constructed by Karlynn Huling, former Rangeland Conservationist for the Flagstaff, Arizona NRCS office. Growth curves are provided as Appendix D.

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.

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

The total annual production equation would now look like this:

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

3.3.6 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. In this example, the percent of normal precipitation was 68% of normal, so we assume that our figure of 57.10 grams is 68% of what would be expected during a normal year. To adjust, we divide the 57.10 grams by 0.68 to produce 83.97 grams of production in a normal year.

57.10g/ 68% = 83.97g = Reconstructed Weight

3.3.7 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 83.97 pounds per acre of *Sporobolos airoides*. The figure 83.97 represents the total reconstructed annual production of the species in pounds per acre.

3.3.8. 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 Compartment.

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

3.3.9. 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 compartment. The indicator species included the following:

Decreasers- *Achnatherum hymenoides, Bouteloua curtipendula, Bouteloua eriopoda, Pascopyrum smithii, Stipa comata*

Increasers- *Aristida purpurea, Atriplex confertifolia, Muhlenbergia pungens*

Invaders- *Astragalus* spp., *Chrysothamnus* spp., *Salsola kali*

Indicator species include increasers, decreasers and invaders. If a 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.

3.3.10 Calculating Forage Value Rating

The forage value rating indicates the composition of preferred and desirable forage species within a management unit. The forage value rating system involves assigning a forage value to each plant species in the management unit. The forage value of each plant species is defined by a particular type of livestock in terms of palatability or preference and the availability of the species for consumption.

The forage value system can also be used to determine stocking rates. After forage values are assigned to each plant species, a harvest efficiency factor is assigned to each forage value. From this, the amount of available forage in the management unit is calculated and incorporated into a stocking rate.

3.3.10.1 Assigning Forage Values

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, Western Navajo Agency. Rangeland managers from this 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. These forage values are specific to the Western Navajo Agency management area and do not necessarily reflect conventional forage values (Appendix F).

3.3.10.2 Forage Value Rating

The forage value rating of each analysis unit, in this case each soil map unit, was calculated using a specific formula based on the amount of preferred and desirable forage in that unit. The forage value rating of a particular area is a short term evaluation of the forage value at the time of measurement and is subject to change due to rapid events like fire, or slower events such as increased canopy cover. The forage value rating is not a similarity index. The forage value rating system is calculated as follows (NRCS 2003):

Forage Value Rating	Minimum Percentage
Very high	50 preferred + desirable = 90
High	30 preferred + desirable = 60
Moderate	10 preferred + desirable = 30
Low	Less than 10 preferred

3.3.10.3 Harvest Efficiency Factor and Available Forage

After assigning each plant species a forage value of preferred, desirable, undesirable, toxic or non consumed, then each forage group was 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 total 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 total forage. Standard harvest efficiencies were applied: 35% for preferred species, 25% for desirable species, and 15% for undesirable species (NRCS 2003). Nonconsumed and Toxic species were excluded from the calculations. The total forage multiplied by the harvest efficiency factor equals the available forage. A stocking rate was calculated from the amount of available forage.

3.3.10.4 Stocking Rates and Carrying Capacity Based on Available Forage

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 rates for District One and District Three were calculated using the available forage from the assigned forage values and harvest efficiency factors. Maximum stocking rates were derived from the preferred, desirable and undesirable production with an application of harvest efficiency factors. This available forage was translated into animal unit months (AUMs) at the rate of 790 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). Carrying capacities were calculated using the stocking rate and the acreage of each soil map unit within a compartment.

Some of the smaller soil map units do not contain any transects and therefore no stocking rate or carrying capacity could be calculated. In addition, there are very small amounts of “undefined” soil map unit acreage within each compartment. This is a result of the GIS soil layer that contains fragments of acreage in between polygons that were never accounted for in the attributes table provided with the shapefile. For both the unsampled soil map units and the “undefined” acreage an adjusted carrying capacity was produced using, where applicable, the stocking rate from the same soil map unit in another compartment of the same district, or the average of the stocking rates in the compartment for the “undefined” acreage.

The stocking rates and carrying capacities for each soil map unit within each compartment are provided in Section 4.0 Results.

3.3.11 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 forage value rating and indicator species composition.

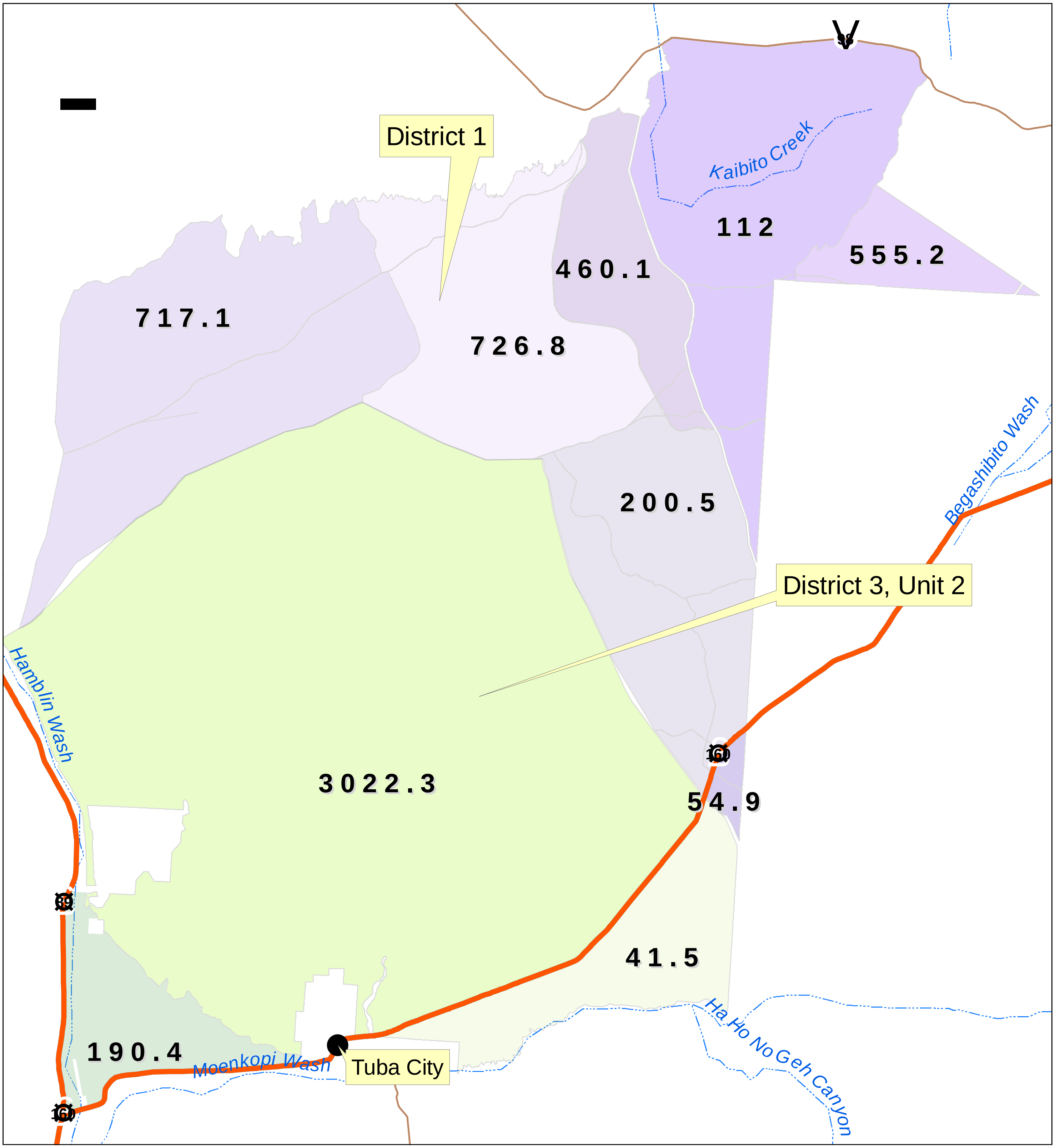
4.0 RESULTS

A total of 396 transects were located on District Three, Unit Two and 406 transects were located within the District One study area. The attributes calculated from the data were total annual production, vegetative and ground cover, species frequency, and apparent trend. Each District was analyzed by compartment, and using soil map units within those compartments for production and stocking rate calculations.

The results of the data analysis indicate varying conditions. In general, District One was in better condition than District Three. Specifically, the median stocking rate in District One was 88.1 acres per sheep unit year long, with a mean of 107.4, while the median stocking rate in District Three was 98.7 with a mean of 242.5. Within District One stocking rates by soil map unit ranged from 27.3 acres per sheep unit year long to 329.3 acres per sheep unit year long. In District Three the stocking rates ranged from 14.8 to 1322.2 acres per sheep unit year long. However, these rates are all from soil map units with three or fewer transects. The minimum and maximum stocking rates from soil map units with more than three transects in District One are 43.2 (n=18) and 215.6 (n=6) acres per sheep unit year long, and in District Three, 24.1 (n=5) and 458.8 (n=9) acres per sheep unit year long.

Total maximum recommended carrying capacity for District One was calculated at 2,788 sheep units year long, including adjustments for some soil map units. Total maximum recommended carrying capacity in District Three, Unit Two was 3,291 sheep units year long, including adjustments for some soil map units. Maximum carrying capacity is illustrated on Map 5 on the following page.

Results are summed by District, followed by complete results presented by compartment within each District. Of note in the production results is that the top three production species are presented so that range managers can quickly see whether production in a particular soil map unit consists of high quality forage species, or other less desirable species. Data are provided as Appendix E.



District 3, Unit 2 and District 1 Study Area

Recommended Maximum Carrying Capacity by Compartment
in Sheep Units Year Long

TUBA CITY AREA	Map 5
COCONINO COUNTY, ARIZONA	5/7/2008

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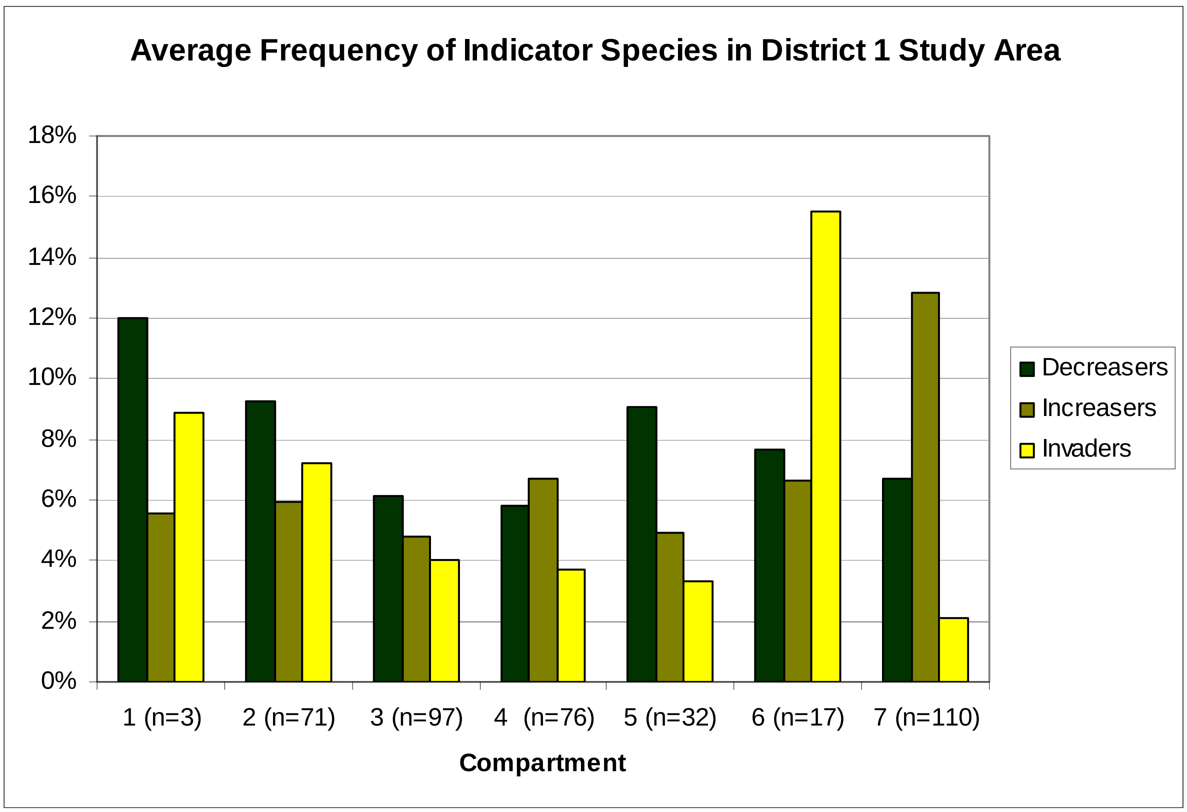
4.1 District One

In District One 406 transects were sampled. Of those 406 transects, Compartment 1 contained three transects, Compartment 2 contained 71 transect, Compartment 3 contained 97 transects, Compartment 4 contained 76 transects, Compartment 5 contained 32 transects, Compartment 6 contained 17 transects, and Compartment 7 contained 110 transects.

Species frequency percentages were averaged by compartment within each District study area. In the District One study area Compartment 1 has the highest frequency of increasers, followed by compartments 2 and 5. Compartment 5 also has one of the lowest frequencies of invaders and increasers. The lowest frequency of invaders was recorded in Compartment 7, but Compartment 7 has the highest frequency of increaser species. Compartment 6 has a very high frequency of invader species. Five of the seven compartments have a higher frequency of decreasers than increasers or invaders (Figure 4.1.1).

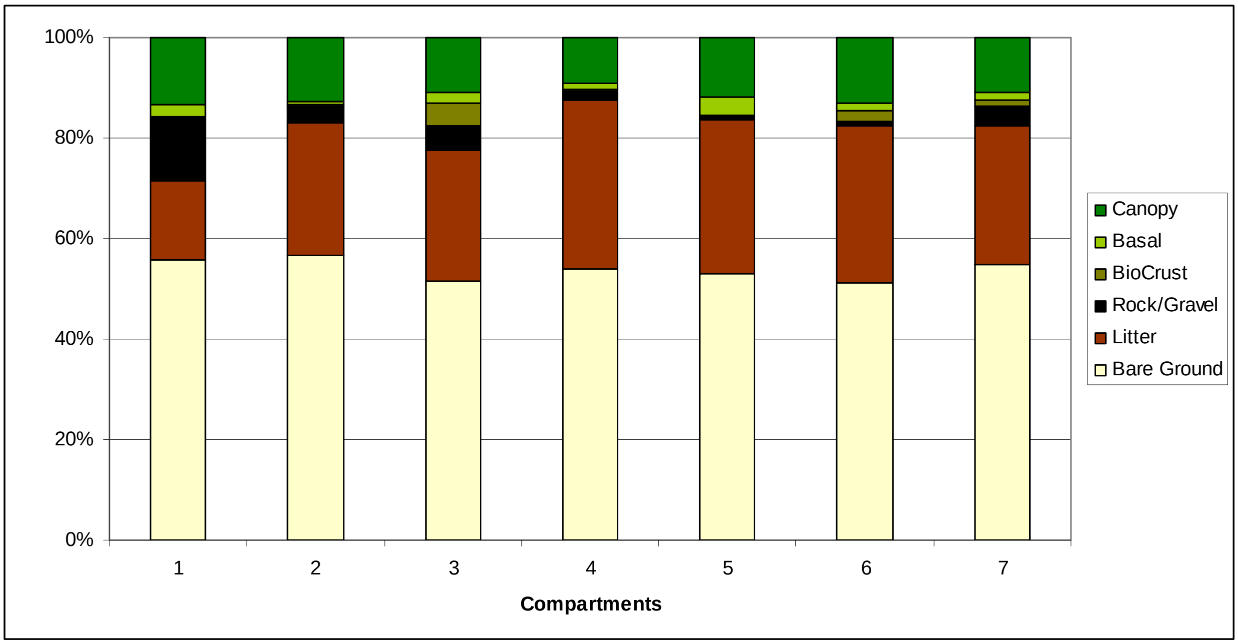
Figure 4.1.1 Frequency of Indicator Species in District One by Compartment



No reference data exists on ground cover for District One. This ground cover data provides baseline information (Appendix F). The most frequent ground cover was Bare Ground, with a total cover for the District1 study area of 54.4%. Bare ground was the largest proportion of ground cover in all compartments and was consistent with values between 51.2% and 56.7%. Litter was the next most common ground cover with a District average of 28.1%, including a low of 16% in Compartment 1 and a high of 33.6% in Compartment 4. Biological soil crusts had the smallest proportions and compartment 3 had a surprisingly large proportion with 4.7%. In

Compartment 1 no BioCrust was recorded, but the highest amount of Rock/Gravel, at almost 13%, was documented. The highest vegetative count was in Compartment 5, where the combination of Canopy and Basal vegetative cover reached over 15%. Compartment 5 had the highest percentage of basal vegetative cover; basal cover is a consistent attribute for monitoring cover. Compartment 2 had the lowest percentage of basal cover. Vegetative cover was highest in compartments 1 and 5 and lowest in compartment 4. Compartment 1 has a much higher proportion of rock/gravel and much lower proportion of litter than all other compartments. In general, ground cover throughout the district was dominated by bare ground, followed by litter, then vegetative cover and finally rock/gravel with very small proportions of biocrust (Figure 4.1.2).

Figure 4.1.2 Percentage Ground Cover by Compartment in the District One Study Area

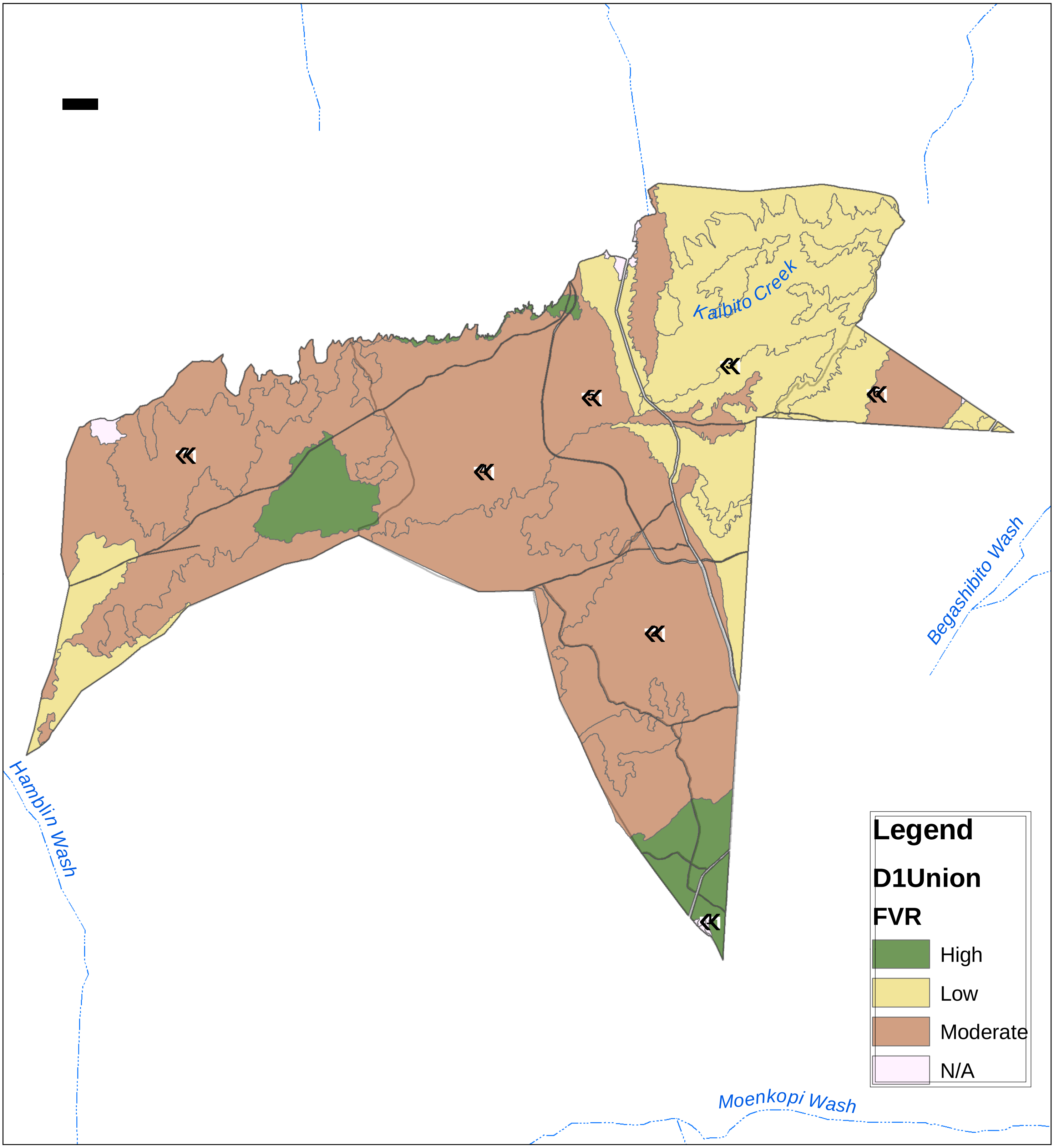


The total maximum recommended carrying capacity for District One is 2,827 sheep units year long. The adjusted maximum recommended carrying capacity for District One is 2788 sheep units year long. Adjustments were made to include the "undefined" acreage in each compartment by averaging the stocking rates within each compartment. Additionally, most compartments had soil map units for which no data was available, if data was available for the same soil map unit in another compartment, that stocking rate was applied. The calculated carrying capacity and the adjusted carrying capacity of each of the seven compartments in District One is provided in Table 4.1.1.

Table 4.1.1 Summary of District One Results

Compartment	No. of Transects	Acres	Carrying Capacity (SUYL)	Adjusted Carrying Capacity (SUYL)
1	3	1,638.7	54.9	54.9
2	71	35,879.8	555.2	561.3
3	97	48,302.2	726.8	728.5
4	76	37,831.2	460.1	463.7
5	32	16,133.1	200.5	202.0
6	17	8,639.2	112.0	112.2
7	110	55,619.8	717.1	721.9
District One Total	406	204,044.0	2,826.6	2787.7

Forage value ratings of soil map units for each compartment are illustrated on Map 6 on the following page.



District 1 Study Area

BIA, Western Navajo Agency

Forage Value Rating (FVR) by Soil Units	**MAP 6**
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	**5/7/2008**

UTAH COLO.
ARIZ. N. MEX.

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ENVIRONMENTAL SERVICES

4.1.1 District One, Compartment 1

In Compartment 1 there were only three transects. The data from these transects indicates a high frequency of decreaser species (12%), with 6% increaser and 9% invader species. Although only three transects were sampled the data shows one of the highest proportions of vegetative cover in the District (16% with 3% basal), and a low litter component (16%). Table 4.1.1.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 1.

Table 4.1.1.1 Compartment 1 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
249	84.9	N/A	N/A	N/A
272	40.0	N/A	N/A	N/A
273	15.1	N/A	N/A	N/A
4001	1,497.7	42%	77%	High
Undefined	0.9	N/A	N/A	N/A

Compartment 1 has a high frequency of decreaser species, a high percentage of vegetative cover and a high forage value rating, indicating an apparent trend toward the potential natural vegetation community (PNC).

The stocking rates derived from forage values and the carrying capacity for Compartment 1 are listed in Table 4.1.1.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top three species with the most production in this compartment included frosted mint (*Poliomintha incana*), blue grama grass (*Bouteloua gracilis*), and mormon tea (*Ephedra cutleri*).

Table 4.1.1.2 Compartment 1 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs/acre)
0	249	84.9	N/A	N/A	N/A	N/A	N/A
0	272	40.0	N/A	N/A	N/A	N/A	N/A
0	273	15.1	N/A	N/A	N/A	N/A	N/A
3	4001	1,497.7	27.3	54.9	POIN3,BOGR2,EPCU	274.6	69.5
0	Undefined	0.9	N/A	N/A	N/A	N/A	N/A
3		**1,638.7**		**54.9**			

This compartment has a low stocking rate of 27.3 acres per sheep unit year long allowing for a carrying capacity of 55 sheep units year long on less than 1,500 acres. However, transects were located in only one of the four soil map units within the compartment. There are an additional 140.9 acres (8.6% of the total acreage) that were excluded from the carrying capacity calculation that may be suitable for grazing and that would increase the carrying capacity of the compartment. On the other hand, these results for stocking rate have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are only initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

Finally, Table 4.1.1.3 provides descriptive statistics for the data from the three transects in Compartment 1.

Table 4.1.1.3 Descriptive Statistics for District One, Compartment 1

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	274.6	69.5
Standard Error	88.2	25.9
Median	341.2	80.8
Standard Deviation	152.8	44.9
Minimum	99.8	20.0
Maximum	382.8	107.7
Confidence Level (95%)	379.5	111.6
No. Transects	3	3

4.1.2 District One, Compartment 2

In Compartment 2 there were 71 transects. The data from these transects indicates a high frequency of decreaser species (9%), with 6% increaser and 7% invader species. The ground cover proportions in Compartment 2 include 14% vegetative cover. Table 4.1.2.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 2.

Table 4.1.2.1 Compartment 2 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
270	25,118.6	17%	51%	Moderate
4001	10,364.3	16%	52%	Moderate
Undefined	397.0	N/A	N/A	N/A

Compartment 2 has a higher frequency of decreaser species than increaser or invader species, a high percentage of vegetative cover and moderate forage value ratings, indicating an apparent trend toward the potential natural vegetation community (PNC).

The stocking rates derived from forage values and carrying capacity for Compartment 2 are listed in Table 4.1.2.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included Indian ricegrass (*Achnatherum hymenoides*), blue grama grass (*Bouteloua gracilis*), mormon tea (*Ephedra cutleri*), and snakeweed (*Gutierrezia sarothrae*).

Table 4.1.2.2 Compartment 2 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
47	270	25,118.6	65.4	383.9	GUSA2,EPCU,ACHY	145.1	29.0
24	4001	10,364.3	60.5	171.2	GUSA2,EPCU,BOGR2	160.2	31.3
0	Undefined	397.0	N/A	N/A	N/A	N/A	N/A
71		**35,879.8**		**555.2**			

Many transects were located in each of the two soil map units within the compartment allowing for confident interpretation of the results. Table 4.1.2.3 provides descriptive statistics for the data from the 71 transects in Compartment 2.

Table 4.1.2.3 Descriptive Statistics for District One, Compartment 2

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	150.2	29.8
Standard Error	8.0	2.1
Median	135.3	25.9
Standard Deviation	67.4	17.8
Minimum	29.9	7.2
Maximum	388.7	108.8
Confidence Level (95%)	16.0	4.2
No. Transects	71	71

This compartment has average stocking rates allowing for a carrying capacity of 555 sheep units year long. It would be possible in this compartment to divide the “undefined” acreage between the two other soil map units according the percentages of the total each soil map unit represents. This would produce 4.2 additional SUYL in unit 270 and 1.9 additional SUYL in unit 4001 for an adjusted maximum carrying capacity of 561 SUYL. The stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.1.3 District One, Compartment 3

In Compartment 3 there were 97 transects. The frequency of indicator species was very similar with 6% decreaser species, 5% increaser and 4% invader species. There is a high proportion of vegetative cover as well as biological soil in this compartment. Table 4.1.3.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 3.

Table 4.1.3.1 Compartment 3 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
270	1,350.2	0%	36%	Low
4001	9,679.0	7%	39%	Low
4010	3,256.2	16%	31%	Moderate
4014	12,250.1	7%	49%	Low
4019	874.0	0%	13%	Low
4039	1,550.9	11%	38%	Moderate
6001	2.9	N/A	N/A	N/A
6003	19,199.0	7%	30%	Low
Undefined	139.8	N/A	N/A	N/A

Compartment 2 has a slightly higher frequency of decreaser species than increaser or invader species, a high percentage of vegetative cover and beneficial biological soil crusts but low and moderate forage value ratings. The trend of this compartment is unapparent.

The stocking rates derived from forage values and carrying capacity for Compartment 3 are listed in Table 4.1.3.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included blue grama grass (*Bouteloua gracilis*), galleta grass (*Pleuraphis jamesii*), snakeweed (*Gutierrezia sarothrae*), several species of prickly pear cactus (*Opuntia* spp.), yuccas (*Yucca* spp.), big sagebrush (*Artemisia tridentata*) and Bigelow sagebrush (*Artemisia bigelovii*), and also Russian thistle (*Salsola kali*).

Table 4.1.3.2 Compartment 3 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
2	270	1,350.2	41.9	32.2	SAKAR,BOGR2,GUSA2†	442.1	45.2
18	4001	9,679.0	43.2	224.2	GUSA2,BOGR2,PLJA	237.8	43.9
7	4010	3,256.2	166.5	19.6	OPER,YUCCA,GUSA2*	58.7	11.4
34	4014	12,250.1	64.4	190.1	GUSA2,ARTR2,BOGR2	149.1	29.4
2	4019	874.0	98.5	8.9	OPER,PLJA,GUSA2	118.6	19.3
2	4039	1,550.9	60.1	25.8	GUSA2,ARBI3,BOGR2	166.4	31.5
0	6001	2.9	N/A	N/A	N/A	N/A	N/A
32	6003	19,199.0	84.9	226.1	OPUNT,GUSA2,OPER*	124.8	22.3
0	Undefined	139.8	N/A	N/A	N/A	N/A	N/A
97		**48,302.2**		**726.8**			

†Non-Native Invasive top production species
*Top 3 Production Species are Shrubs/Sub-Shrubs

Transects were located in all but two of the nine soil map units within the compartment, although three of those only contain two transects each. Soil map unit 270 has the most production but very little available forage due to the high percentage of Russian thistle. Table 4.1.3.3 provides descriptive statistics for the data from the 97 transects in Compartment 3.

Table 4.1.3.3 Descriptive Statistics for District One, Compartment 3

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	156.8	28.6
Standard Error	20.2	3.2
Median	80.2	16.8
Standard Deviation	198.8	31.6
Minimum	5.4	1.2
Maximum	1598.3	243.7
Confidence Level (95%)	40.1	6.4
No. Transects	97	97

This compartment has average to high stocking rates allowing for a carrying capacity of only 727 sheep units year long over 48,302.2 acres. One soil map units was not included in these calculations because no transects were located in that unit, but it accounts for only 2.9 acres. The “undefined” acreage in this compartment could be applied using an average of the stocking rates for the compartment. The average stocking rate is 79.9 acres per sheep unit year long, which would add 1.7 SUYL to the adjusted maximum carrying capacity making it 728.5, or 729 SUYL. These stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.1.4 District One, Compartment 4

In Compartment 4 there were 76 transects. The frequency of indicator species was trending toward increaser species with 6% decreaser species, 7% increaser and 4% invader species. There is a low proportion of vegetative cover and a higher than average proportion of litter. Table 4.1.4.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 4.

Table 4.1.4.1 Compartment 4 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
270	5,670.3	12%	31%	Moderate
4001	9,592.7	10%	54%	Moderate
4002	21,572.8	18%	44%	Moderate
4004	145.1	N/A	N/A	N/A
4005	660.5	42%	77%	High
4011	43.9	N/A	N/A	N/A
Undefined	146.0	N/A	N/A	N/A

Compartment 4 has slightly higher frequency of increaser species than decreaser species, a moderate percentage of vegetative cover and a majority of moderate forage value ratings. This compartment has an apparent trend slightly away from the PNC.

The stocking rates derived from forage values and carrying capacity for Compartment 4 are listed in Table 4.1.4.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included (*Gutierrezia sarothrae*), Mormon tea (*Ephedra cutleri*), Greene's rabbitbrush (*Chrysothamnus greeenei*), sand sagebrush (*Artemisia filifolia*) and three grass species: Indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*), and sand muhly (*Muhlenbergia pungens*).

Table 4.1.4.2 Compartment 4 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
13	270	5,670.3	70.8	80.1	GUSA2,EPCU,ACHY	150.2	26.8
18	4001	9,592.7	50.9	188.4	GUSA2,ARFI2,EPCU*	184.7	37.2
44	4002	21,572.8	114.3	188.8	GUSA2,EPCU,SPCR	79.9	16.6
0	4004	145.1	N/A	N/A	N/A	N/A	N/A
1	4005	660.5	228.3	2.9	EPCU,MUPU2,CHGR6	30.9	8.3
0	4011	43.9	N/A	N/A	N/A	N/A	N/A
0	Undefined	146.0	N/A	N/A	N/A	N/A	N/A
76		**37,831.2**		**460.1**			

*Top 3 Production Species are Shrubs/Sub-Shrubs

Transects were located in four of the seven soil map units within the compartment, and one of those units only contains one transect. The stocking rate for the map unit based on data from one transect is very high. Table 4.1.4.3 provides descriptive statistics for the data from all 76 transects in Compartment 4.

Table 4.1.4.3 Descriptive Statistics for District One, Compartment 4

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	116.1	23.1
Standard Error	9.0	1.9
Median	94.1	18.0
Standard Deviation	78.7	16.9
Minimum	14.9	2.8
Maximum	302.7	70.8
Confidence Level (95%)	18.0	3.9
No. Transects	76	76

This compartment has average to high stocking rates allowing for a carrying capacity of only 460 sheep units year long over 37,831.2 acres. Three soil map units were not included in these calculations because no transects were located in those units, and they account for 335 acres which may be suitable for grazing. Inclusion of these acres could increase the overall carrying capacity of the compartment. However, within other compartments the same soil map units contain transects. A stocking rate for soil map unit 4004 was available from compartment 7 for an additional 1.8 SUYL, and a stocking rate for soil map unit 4011 was also available from compartment 7 for an additional 0.5 SUYL. Also, an average stocking rate could be applied to the "undefined" acreage throughout the compartment for an additional 1.4 SUYL. These additions would bring the adjusted maximum carrying capacity up to 463.7 or 464 SUYL. But these stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.1.5 District One, Compartment 5

In Compartment 5 there were 32 transects. The frequency of indicator species showed a good frequency of decreaser species (9%), over increaser (5%) and invader species (3%). There is a very low proportion of rock or gravel cover and a higher than average proportion of basal vegetation cover. Table 4.1.5.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 5.

Table 4.1.5.1 Compartment 5 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
270	5,198.2	14%	41%	Moderate
4002	6,700.1	7%	30%	Low
4005	101.7	17%	55%	Moderate
4014	1,178.7	7%	60%	Low
4019	2,469.3	14%	58%	Moderate
4039	314.4	0%	28%	Low
6003	8.9	N/A	N/A	N/A
Undefined	161.9	N/A	N/A	N/A

The frequency of decreaser species over increaser and invader species is high; the percentage of vegetative cover, especially stable basal cover is excellent, but the forage value ratings are low to moderate. This compartment has an unapparent trend.

The stocking rates derived from forage values and carrying capacity for Compartment 5 are listed in Table 4.1.5.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included (*Gutierrezia sarothrae*), Mormon tea (*Ephedra cutleri*), yucca species (*Yucca* spp.) and four grass species: blue grama (*Bouteloua gracilis*), Indian ricegrass (*Achnatherum hymenoides*), galleta grass (*Pleuraphis jamesii*) and sand muhly (*Muhlenbergia pungens*).

Table 4.1.5.2 Compartment 5 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
12	270	5,198.2	48.0	108.3	GUSA2,EPCU,BOGR2	203.3	39.5
11	4002	6,700.1	108.8	61.6	GUSA2,ACHY,BOGR2	93.8	17.4
1	4005	101.7	247.6	0.4	YUCCA,MUPU2,EPCU	34.6	7.7
1	4014	1,178.7	115.7	10.2	GUSA2,BOGR2,ACHY	76.3	16.4
6	4019	2,469.3	215.6	11.5	GUSA2,ACHY,EPCU	40.0	8.8
1	4039	314.4	36.7	8.6	GUSA2,PLJA,BOGR2	290.9	51.7
0	6003	8.9	N/A	N/A	N/A	N/A	N/A
0	Undefined	161.9	N/A	N/A	N/A	N/A	N/A
32		**16,133.1**		**200.5**			

Transects were located in six of the eight soil map units within the compartment, but three of those units contain only one transect. Stocking rates from these units may not be as reliable as those from units with many transects. Table 4.1.5.3 provides descriptive statistics for the data from all 32 transects in Compartment 5.

Table 4.1.5.3 Descriptive Statistics for District One, Compartment 5

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	128.6	24.8
Standard Error	15.9	3.3
Median	106.1	19.7
Standard Deviation	90.0	18.7
Minimum	12.4	3.2
Maximum	303.7	91.4
Confidence Level (95%)	32.4	6.7
No. Transects	32	32

This compartment has a mix of stocking rates translating to a carrying capacity of 201 sheep units year long. Two soil map units were not included in these calculations because no transects were located in those units, and they account for 170.8 acres which may be suitable for grazing. A stocking rate for soil map unit 6003 could be applied from compartment 3 to add 0.1 SUYL, and an average stocking rate for compartment 5 could be applied to the “undefined” acreage adding 1.3 SUYL for an adjusted maximum carrying capacity of 202 SUYL. But these stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.1.6 District One, Compartment 6

In Compartment 6 there were 17 transects. There is an imbalanced proportion of invader species in this compartment, with 8% frequency of decreasers, a 7% frequency of increasers and a 15% frequency of invader species. The percentage of each ground cover is close to the average for the district with slightly higher litter and slightly less rock or gravel cover and average vegetative cover. Table 4.1.6.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 6.

Table 4.1.6.1 Compartment 6 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
4001	3,236.2	1%	18%	Low
4003	508.6	0%	11%	Low
4016	271.2	0%	46%	Low
6003	977.3	21%	39%	Moderate
7000	3,628.3	13%	45%	Moderate
Undefined	17.6	N/A	N/A	N/A

With a very high frequency of invader species, average vegetative cover, and low to moderate forage value ratings, this compartment indicates an apparent trend away from the PNC

The stocking rates derived from forage values and carrying capacity for Compartment 6 are listed in Table 4.1.6.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included (*Gutierrezia sarothrae*), Mormon tea (*Ephedra cutleri*), yucca species (*Yucca* spp.), prickly pear cacti (*Opuntia whipplei*), Russian thistle (*Salsola kali*), blue grama (*Bouteloua gracilis*), Indian ricegrass (*Achnatherum hymenoides*), and galleta grass (*Pleuraphis jamesii*).

Table 4.1.6.2 Compartment 6 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
6	4001	3,236.2	67.9	47.6	SAKAR,GUSA2,BOGR2†	309.3	27.9
1	4003	508.6	277.3	1.8	OPWH,SAKAR,PLJA	61.0	6.8
1	4016	271.2	107.2	2.5	GUSA2,BOGR2,ACHY	104.9	17.7
3	6003	977.3	46.2	21.1	YUCCA,EPCU,GUSA2*	214.2	41.0
6	7000	3,628.3	93.3	38.9	OPWH,GUSA2,EPCU*	101.2	20.3
0	Undefined	17.6	N/A	N/A	N/A	N/A	N/A
17		**8,639.2**		**112.0**			

†Non-Native Invasive top production species
*Top 3 Production Species are Shrubs/Sub-Shrubs

Seventeen transects were distributed among five of the six soil map units within the compartment; only two units contain more than three transects, and none contain more than six transects. Stocking rates from these units may not be as reliable as those from units with many transects. Table 4.1.6.3 provides descriptive statistics for the data from all 17 transects in Compartment 6.

Table 4.1.6.3 Descriptive Statistics for District One, Compartment 6

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	192.4	25.7
Standard Error	32.3	4.0
Median	211.3	20.3
Standard Deviation	133.0	16.5
Minimum	26.8	6.5
Maximum	535.4	68.1
Confidence Level (95%)	68.4	8.5
No. Transects	17	17

This compartment has a carrying capacity of 112 sheep units year long, and a mix of stocking rates. The highest stocking rates come from the two soil map units with only one transect of data. An additional 17.6 acres was not included in the carrying capacity calculations because no transects were located within that soil map unit. Inclusion of these acres using the average stocking rate for the compartment would add only 0.1 SUYL and would not change the recommended carrying capacity. These stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.1.7 District One, Compartment 7

In Compartment 7 there were 110 transects. This compartment has a 7% frequency of decreaser species and a much higher frequency of increasers (13%), but a low frequency of invader species (2%). With one quarter of the transects in the district falling within Compartment 7, the percentage of each ground cover for this compartment is nearly identical to the average for the district. Table 4.1.7.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 7.

Table 4.1.7.1 Compartment 7 Forage Value Ratings

Soil Map Unit	Acres	%P	%P+D	Forage Value Rating
270	202.4	26%	30%	Moderate
4000	3,211.6	3%	28%	Low
4001	19,305.0	12%	52%	Moderate
4002	18,483.7	14%	66%	Moderate
4003	482.9	N/A	N/A	N/A
4004	4,793.7	18%	68%	Moderate
4006	2,868.3	8%	59%	Low
4011	5,829.6	30%	62%	High
Undefined	442.6	N/A	N/A	N/A

There is a very high frequency of decreaser species, but a very low frequency of invaders, average vegetation cover, and variable forage value ratings, although the the soil map units with the most acreage have a moderate rating. The compartment has an unapparent trend.

The stocking rates derived from forage values and carrying capacity for Compartment 7 are listed in Table 4.1.7.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included Mormon tea (*Ephedra* spp.), Russian thistle (Salsola kali), snakeweed (*Gutierrezia sarothrae*), blue grama (*Bouteloua gracilis*), Indian ricegrass (*Achnatherum hymenoides*), and galleta grass (*Pleuraphis jamesii*), and sand muhly (*Muhlenbergia pungens*), also, on one transect, lemonscent (*Pectis* angustifolia) and blackbrush (*Coleogyne ramosissima*).

Table 4.1.7.2 Compartment 7 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
1	270	202.4	329.3	0.6	EPTO,PEAN,CORA	43.8	5.8
7	4000	3,211.6	98.3	32.7	SAKAR,GUSA2,PLJA†	174.9	19.3
34	4001	19,305.0	56.7	340.6	GUSA2,SPCR,BOGR2	162.6	33.5
38	4002	18,483.7	91.2	202.6	GUSA2,MUPU2,ACHY	94.4	20.8
0	4003	482.9	N/A	N/A	N/A	N/A	N/A
13	4004	4,793.7	80.5	59.5	EPCU,ARFI2,GUSA2*	102.8	23.5
4	4006	2,868.3	146.1	19.6	PLJA,CORA,BOGR2	75.2	13.0
13	4011	5,829.6	94.8	61.5	GUSA2,EPCU,BOGR2	83.4	20.0
0	Undefined	442.6	N/A	N/A	N/A	N/A	N/A
110		**55,619.8**		**717.1**			

†Non-Native Invasive top production species
*Top 3 Production Species are Shrubs/Sub-Shrubs

Of the nine soil map units within Compartment 7, two were not sampled, and one contained only one transect. Table 4.1.7.3 provides descriptive statistics for the data from all 110 transects in Compartment 7.

Table 4.1.7.3 Descriptive Statistics for District One, Compartment 7

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	119.1	24.4
Standard Error	7.9	1.6
Median	96.1	20.3
Standard Deviation	82.4	16.8
Minimum	6.0	1.2
Maximum	508.0	105.3
Confidence Level (95%)	15.6	3.2
No. Transects	110	110

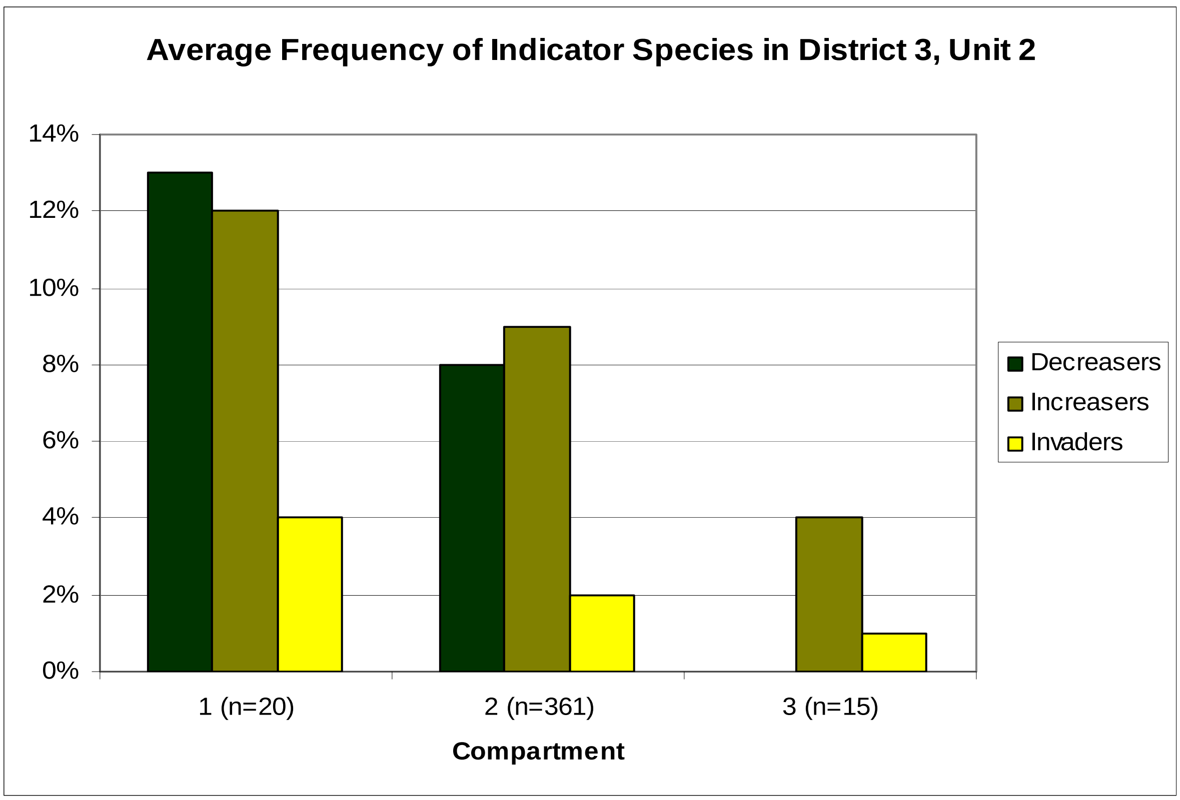
This compartment has a carrying capacity of 717 sheep units year long, resulting from moderate to high stocking rates. The highest stocking rate comes from the soil map unit with only one transect of data. An additional 925.5 acres was not included in the carrying capacity calculations because no transects were located within those two soil map units. Applying the stocking rate from soil map unit 4003 that was calculated in compartment 6 would add 1.7 SUYL. Averaging the stocking rates in compartment 7 for the “undefined” acreage would contribute 3.0 SUYL. The adjusted maximum carrying capacity would increase to 721.9, or 722 SUYL. But these stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.2 District Three, Unit 2

In District Three, Unit 2 396 transects were sampled. Of those 396 transects, Compartment 1 contained 20 transects, Compartment 2 contained 361 transect, and Compartment 3 contained 15 transects.

The species frequency percentages were averaged by compartment within each District study area. Compartment 1 has the highest frequency of increasers, followed by compartments 2, while compartment 3 had no decreaser species recorded. Compartment 1 also has the highest frequency of increasers and invaders. In District Three the proportion of decreaser species to increaser species was much closer than in District One where decreaser species were more frequent (Figure 4.2).

Figure 4.2.1 Frequency of Indicator Species in District Three by Compartment



No reference data exists on ground cover for District Three, Unit 2. This ground cover data provides baseline information (Appendix F). The most frequent ground cover, by far, was Bare Ground, with a total average cover for the District Three study area of 60.9%. Bare ground was the largest proportion of ground cover in all three compartments with values between 60.2% and 71%. Litter was the next most common ground cover with a District average of 19.1%, including a low of 16.8% in Compartment 1 and a high of 19.6% in Compartment 2. Biological soil crusts had the smallest proportions with less than 1% in all compartments. The highest vegetative count was in Compartment 2, where the combination of Canopy and Basal vegetative cover reached over 11%, the majority of which was canopy cover; all three compartments had less than 1% basal vegetation cover. In general, Compartments 2 and 3 were very similar, while compartment 1 had more bare ground and subsequently less biocrust, rock, and canopy cover than the other two compartments (Table 4.2.1).

Table 4.2.1 Percentage Ground Cover by Compartment in the District Three Study Area

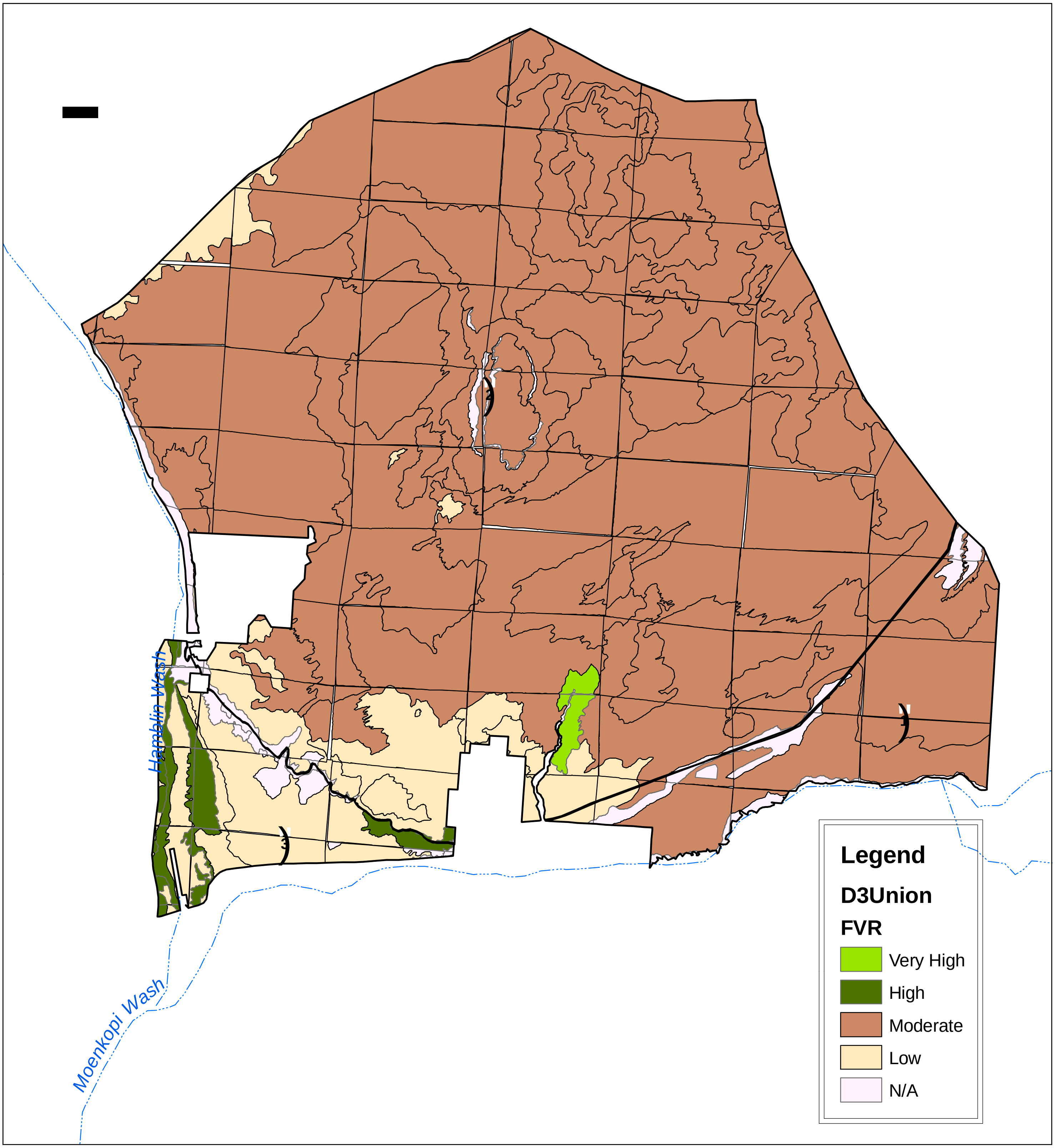
Compartment	**BioCrust**	**Rock/Gravel**	**Bare Ground**	**Litter**	**Basal**	**Canopy**	**Vegetation (Combined Basal and Canopy)**
1	0.1	3.5	71.0	16.8	0.6	8.0	8.6
2	0.7	8.3	60.2	19.6	0.7	10.5	11.2
3	0.7	8.7	61.0	18.9	0.6	10.1	10.7
District Average	0.7	8.5	60.9	19.1	0.6	10.2	10.8

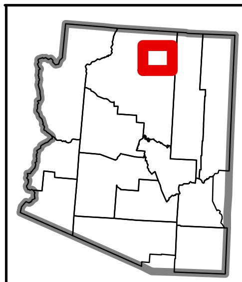
The total maximum recommended carrying capacity for District Three, Unit 2 is 3,254 sheep units year long. The adjusted maximum recommended carrying capacity for District Three is 3,291 sheep units year long. Adjustments were made to include the “undefined” acreage in each compartment by averaging the stocking rates within each compartment. Additionally, most compartments had soil map units for which no data was available, if data was available for the same soil map unit in another compartment, that stocking rate was applied. The calculated carrying capacity and the adjusted carrying capacity of each of the three compartments in District Three, Unit 2 is provided in Table 4.2.2.

Table 4.2.2 Summary of District Three, Unit 2 Results

Compartment	**No. of Transects**	**Acres**	**Carrying Capacity (SUYL)**	**Adjusted Carrying Capacity (SUYL)**
1	20	21,168.9	190.4	220.8
2	361	208,581.6	3,022.3	3026.9
3	15	15,099.1	41.5	43.4
District Three Total	396	244,849.6	3,254.1	3291.1

Forage value ratings of soil map units for each compartment are illustrated on Map 6 on the following page.





District 3, Unit 2

BIA, Western Navajo Agency

Forage Value Rating (FVR) by Soil Units	**MAP 7**
TUBA CITY AREA	
COCONINO COUNTY, ARIZONA	**5/7/2008**

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4.2.1 District Three, Compartment 1

In Compartment 1 there were 20 transects. This compartment has a 13% frequency of decreaser species, a close frequency of increasers (12%), but a low frequency of invader species (4%). Compartment 1 had 10% more bare ground than the district average. Table 4.2.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 1.

Table 4.2.1.1 Compartment 1 Forage Value Ratings

Soil Map Unit	**Acres**	**P%**	**P+D%**	**Forage Value Rating**
Undefined	114.8	N/A	N/A	N/A
37	627.3	N/A	N/A	N/A
105	8,997.1	23%	63%	Moderate
108	7,463.2	14%	66%	Moderate
151	1,205.9	N/A	N/A	N/A
249	214.6	11%	31%	Moderate
272	271.4	N/A	N/A	N/A
273	397.3	N/A	N/A	N/A
997	104.4	N/A	N/A	N/A
4001	1,773.0	N/A	N/A	N/A

There was a high frequency of both decreaser and increaser species and a low frequency of invader species in this compartment, and a very high percentage of bare ground with a low percentage of vegetative cover. Forage value ratings were moderate. This compartment may be trending slightly away from the PNC.

The stocking rates derived from forage values and carrying capacity for Compartment 1 are listed in Table 4.2.1.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included Mormon tea (*Ephedra* cutleri), snakeweed (*Gutierrezia sarothrae*), Indian ricegrass (*Achnatherum hymenoides*), and galleta grass (*Pleuraphis jamesii*), also, on one transect, hairy false goldenaster (*Heterotheca villosa*), Fendler's sandwort (*Arenaria fendleri*) and cryptanth (*Cryptantha crassisepala*).

Table 4.2.1.2 Compartment 1 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
0	Undefined	114.8	N/A	N/A	N/A	N/A	N/A
0	37	627.3	N/A	N/A	N/A	N/A	N/A
8	105	8,997.1	84.4	106.5	EPCU,PLJA,ACHY	105.6	22.5
11	108	7,463.2	89.3	83.5	GUSA2,PLJA,ACHY	96.1	21.2
0	151	1,205.9	N/A	N/A	N/A	N/A	N/A
1	249	214.6	698.8	0.3	HEVI4,ARFE3,CRCI3	20.2	2.7
0	272	271.4	N/A	N/A	N/A	N/A	N/A
0	273	397.3	N/A	N/A	N/A	N/A	N/A
0	997	104.4	N/A	N/A	N/A	N/A	N/A
0	4001	1,773.0	N/A	N/A	N/A	N/A	N/A
20		**21,168.9**		**190.4**			

Only three of the ten soil map units within Compartment 1 were sampled, and one of these contained only one transect. Table 4.2.1.3 provides descriptive statistics for the data from all transects in Compartment 1.

Table 4.2.1.3 Descriptive Statistics for District Three, Compartment 1

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	96.1	20.8
Standard Error	10.9	3.1
Median	87.4	18.4
Standard Deviation	48.9	13.7
Minimum	20.2	1.5
Maximum	229.5	62.9
Confidence Level (95%)	22.9	6.4
No. Transects	20	20

This compartment has a carrying capacity of 190 sheep units year long, resulting from high stocking rates. The highest stocking rate comes from the soil map unit with only one transect of data. Because only three soil map units contained transects, the carrying capacity applies to the acreage of those three units, which totals 16674.9 acres, or 78.8% of the 21,168.9 acres in the compartment. An additional 4,494.1 acres was not included in the carrying capacity calculations because no transects were located within those seven soil map units. Two of these soil map units had available data from compartment 2. Applying the stocking rates from compartment 2 to soil map units 273 and 4001 would add 3.9 and 25.9 SUYL, respectively. Averaging the stocking rates to apply to the undefined acres would add 0.6 SUYL for a total adjusted maximum carrying capacity of 220.8 or 221 SUYL. The stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops ((See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.2.2 District Three, Compartment 2

In Compartment 2 there were 361 transects. This compartment has a 8% frequency of decreaser species, a close frequency of increasers (9%), but a low frequency of invader species (2%). 2 had the highest canopy cover average in the district.Table 4.2.2.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 2.

Table 4.2.2.1 Compartment 2 Forage Value Ratings

Soil Map Unit	**Acres**	**P%**	**P+D%**	**Forage Value Rating**
Undefined	1,363.7	16%	44%	Moderate
2	144.0	N/A	N/A	N/A
6	274.5	2%	48%	Low
9	5.6	N/A	N/A	N/A
27	1,044.4	60%	93%	Very High
90	35.0	N/A	N/A	N/A
98	7.3	N/A	N/A	N/A
99	38.2	N/A	N/A	N/A
101	44,042.1	22%	54%	Moderate
103	5,647.3	2%	40%	Low
105	2,394.3	7%	24%	Low
106	20,042.0	19%	49%	Moderate
107	2,039.2	29%	69%	Moderate
108	13,217.4	12%	51%	Moderate
109	4,662.6	4%	24%	Low
122	1,788.4	N/A	N/A	N/A
150	4.3	N/A	N/A	N/A
151	382.5	N/A	N/A	N/A
249	787.3	N/A	N/A	N/A
270	48,013.2	29%	53%	Moderate
273	4,217.5	11%	44%	Moderate
996	5.0	N/A	N/A	N/A
998	280.4	23%	100%	Moderate
999	0.1	N/A	N/A	N/A
4001	27,844.2	23%	50%	Moderate
4002	22,929.4	27%	59%	Moderate
4006	2,228.3	2%	20%	Low
6000	5,143.4	16%	33%	Moderate

The frequency of increaser species is slightly higher than the decreaser species but the frequency of invader species is low. There is good vegetative cover and variable but mostly moderate forage value ratings. The trend of this compartment is not apparent.

The stocking rates derived from forage values and carrying capacity for Compartment 2 are listed in Table 4.2.2.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included snakeweed (*Gutierrezia sarothrae*), frosted mint (*Poliomintha incana*), desert twinbugs (*Dicoria brandegeei*), fineleaf hymenopappus (*Hymenopappus filifolius*), sand sage (*Artemisia filifolia*), Indian ricegrass (*Achnatherum hymenoides*), several rabbitbrush species (*Chrysothamnus* spp.), Mormon tea (*Ephedra cutleri*), galleta grass (*Pleuraphis jamesii*), greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), four winged saltbush (*Atriplex canescens*), blackbrush (*Coleogyne ramosissima*), and paperflower (*Psilostrophe cooperi*)

Table 4.2.2.2 Compartment 2 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
3	Undefined	1,363.7	231.5	5.9	GUSA2,POIN3,DIBR3	46.2	8.2
0	2	144.0	N/A	N/A	N/A	N/A	N/A
1	6	274.5	1322.2	0.2	HYFI,ARFI2,ACHY	11.1	1.4
0	9	5.6	N/A	N/A	N/A	N/A	N/A
1	27	1,044.4	14.8	70.7	POIN3,ARFI2,CHRYS9*	434.4	128.4
0	90	35.0	N/A	N/A	N/A	N/A	N/A
0	98	7.3	N/A	N/A	N/A	N/A	N/A
0	99	38.2	N/A	N/A	N/A	N/A	N/A
85	101	44,042.1	96.4	457.0	ARFI2,GUSA2,EPCU*	98.3	19.7
8	103	5,647.3	61.1	92.4	GUSA2,ATCO,CHNAA4*	184.6	31.0
2	105	2,394.3	56.0	42.8	CHNAA4,GUSA2,PLJA	207.3	33.9
39	106	20,042.0	98.7	203.1	GUSA2,ARFI2,POIN3*	94.3	19.2
5	107	2,039.2	24.1	84.6	SAVE4,ATCO,ATCA2*	364.3	78.6
20	108	13,217.4	85.1	155.2	SAVE4,ATCO,ATCA2*	119.4	22.3
3	109	4,662.6	270.1	17.3	GUSA2,CORA,PLJA	53.7	7.0
0	122	1,788.4	N/A	N/A	N/A	N/A	N/A
0	150	4.3	N/A	N/A	N/A	N/A	N/A
0	151	382.5	N/A	N/A	N/A	N/A	N/A
0	249	787.3	N/A	N/A	N/A	N/A	N/A
89	270	48,013.2	60.8	790.0	EPCU,GUSA2,ARFI2*	153.0	31.2
10	273	4,217.5	102.2	41.2	GUSA2,OPUNT,PLJA	94.1	18.5
0	996	5.0	N/A	N/A	N/A	N/A	N/A
1	998	280.4	405.2	0.7	ATCO,SAVE4	17.1	4.7
0	999	0.1	N/A	N/A	N/A	N/A	N/A
39	4001	27,844.2	68.4	407.0	GUSA2,EPCU,ARFI2*	135.5	27.7
45	4002	22,929.4	39.2	585.1	GUSA2,EPCU,BOGR2	220.7	48.4
3	4006	2,228.3	90.5	24.6	CORA,GUSA2,PLJA	219.3	21.0
7	6000	5,143.4	115.5	44.5	GUSA2,CHNAB3,PSCO2	99.8	16.4
361		**208,581.6**		**3022.3**			

*Top 3 Production Species are Shrubs/Sub-Shrubs

There are 28 soil map units in Compartment 2. Eleven of these, the smallest, were not sampled (3,197.8 acres or 1.5%). Three of these had only transect. Table 4.2.2.3 provides descriptive statistics for the data from all 361 transects in Compartment 2.

Table 4.2.2.3 Descriptive Statistics for District Three, Compartment 2

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	138.6	28.1
Standard Error	5.8	1.4
Median	106.0	20.1
Standard Deviation	111.0	26.4
Minimum	0.3	0.0
Maximum	651.8	165.6
Confidence Level (95%)	11.5	2.7
No. Transects	361	361

This compartment has a carrying capacity of 3022 sheep units year long, resulting from varying stocking rates. The highest stocking rates come from the soil map units with only one transect of data. An additional 3,197.8 acres was not included in the carrying capacity calculations because no transects were located within those soil map units. Applying stocking rates from the same soil map units in other compartments would add 1.0 SUYL to soil map unit 2, 0.0 (rounded) SUYL to soil map unit150 and 3.7 SUYL to soil map unit249. The total adjusted maximum recommended carrying capacity would be 3026.9 or 3027 SUYL. These stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

4.2.3 District Three, Compartment 3

In Compartment 3 there were 15 transects. This compartment had almost no decreaser species; the frequency amounted to 0% with only three Indian ricegrass plants. The frequency of increasers was quite low (4%) and there was an even lower frequency of invader species (1%). Compartment 3 contained 91% of the transects in the district, so the ground cover averages for the district are identical to those of Compartment 3. Table 4.2.3.1 shows the amount of Preferred (P) and Desirable (D) forage in Compartment 3.

Table 4.2.3.1 Compartment 3 Forage Value Ratings

Soil Map Unit	Acres	P%	P+D%	Forage Value Rating
Undefined	187.4	N/A	N/A	N/A
2	2,430.0	37%	70%	High
9	32.3	N/A	N/A	N/A
90	851.9	N/A	N/A	N/A
95	18.3	N/A	N/A	N/A
103	13.5	N/A	N/A	N/A
107	28.9	N/A	N/A	N/A
109	19.9	N/A	N/A	N/A
122	983.8	N/A	N/A	N/A
133	8.6	N/A	N/A	N/A
137	24.3	N/A	N/A	N/A
150	6,219.6	7%	50%	Low
155	932.7	75%	75%	High
552	2,288.4	0%	96%	Low
555	1,059.3	0%	69%	Low

With very few decreasers, average vegetative cover, and more low than high forage value ratings this compartment is probably trending away from the PNC.

The stocking rates derived from forage values and carrying capacity for Compartment 3 are listed in Table 4.2.3.2 in sheep units year long (SUYL). The reconstructed weight is the average measured field weight of the production from those transects, reconstructed to an average year of precipitation and factoring in growth curves, dry weights, and utilization. The available forage is the average weight of the production multiplied by a harvest efficiency factor according to forage value (See methods in Section 3.3). The top species with the most production in this compartment included Mormon tea (*Ephedra* cutleri), shadscale (*Atriplex confertifolia*), prickly pear species (*Opuntia* spp.), salt cedar (*Tamarix* sp.), saltgrass (*Distichlis spicata*), and also frosted mint (*Poliomintha incana*), wormwood (*Artemisia dranunculus*), Rusby's goldenbush (*Isochoma rusbyi*), sand dropseed (*Sporobolus cryptandrus*), gooseberryleaf globemallow (*Sphaeralcea grossulariifolia*), galleta grass (*Pleuraphis jamesii*) and snakeweed (*Gutierrezia sarothrae*).

Table 4.2.3.2 Compartment 3 Stocking Rates and Carrying Capacity

No. of Transects	Soil Map Unit	Acres	Stocking Rate (Acres/SUYL)	Carrying Capacity (SUYL)	Top 3 Production Species	Reconstructed Weight (lbs/acre)	Available Forage (P+D+U) (lbs./acre)
0	Undefined	187.4	N/A	N/A	N/A	N/A	N/A
2	2	2,430.0	142.9	17.0	EPCU,ATCO,OPUNT*	51.7	13.3
0	9	32.3	N/A	N/A	N/A	N/A	N/A
0	90	851.9	N/A	N/A	N/A	N/A	N/A
0	95	18.3	N/A	N/A	N/A	N/A	N/A
0	103	13.5	N/A	N/A	N/A	N/A	N/A
0	107	28.9	N/A	N/A	N/A	N/A	N/A
0	109	19.9	N/A	N/A	N/A	N/A	N/A
0	122	983.8	N/A	N/A	N/A	N/A	N/A
0	133	8.6	N/A	N/A	N/A	N/A	N/A
0	137	24.3	N/A	N/A	N/A	N/A	N/A
9	150	6,219.6	458.8	13.6	ATCO,TAMAR2,DISP	29.4	4.1
1	155	932.7	604.6	1.5	POIN3,ARDR4,ISRU2*	11.9	3.1
2	552	2,288.4	662.4	3.5	SPCR,ATCO,SPGR2	11.9	2.9
1	555	1,059.3	179.6	5.9	ATCO,PLJA,GUSA2	48.2	10.6
15		**15,099.1**		**41.5**			

*Top 3 Production Species are Shrubs/Sub-Shrubs

Only five of the fifteen soil map units within Compartment 3 were sampled, and two of these contained only one transect, two more contained only two transects, leaving the largest soil map unit with nine transects. Table 4.2.3.3 provides descriptive statistics for the data from all 15 transects in Compartment 3.

Table 4.2.3.3 Descriptive Statistics for District Three, Compartment 3

	Pounds Per Acre	
	Reconstructed	Available Forage
Mean	30.1	5.5
Standard Error	8.2	1.8
Median	20.9	3.1
Standard Deviation	31.9	7.1
Minimum	0.0	0.0
Maximum	101.8	26.2
Confidence Level (95%)	17.7	4.0
No. Transects	15	15

This compartment has a maximum carrying capacity of 42 sheep units year long, resulting from very high stocking rates. Because only five soil map units contained transects, the carrying capacity is more applicable to the acreage of those units which are also the largest unit and total 12,930 acres, or 85.6% of the 15,099.1 acres in the compartment. An additional 2,169 acres was not included in the carrying capacity calculations because no transects were located within those soil map units. Inclusion of these acres, from stocking rates in compartment 2 would add 0.2 SUYL to soil map unit 103, 1.2 SUYL to soil map unit107 and 0.1 SUYL to soil map unit 109, plus 0.5 SUYL to the “undefined” acreage using the average stocking rate for compartment 3. The adjusted recommended maximum carrying capacity would be 43.4 SUYL. However the stocking rates have not been adjusted for local conditions such as distance to water or ungrazeable areas of roads and rock outcrops (See Section 6.0) and are therefore initial stocking rate recommendations which are subject to change and may decrease the overall carrying capacity.

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, composition, and location of water, shelter and minerals (Heitschmidt 1991). The total forage 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 make adjustments for inclusion of these areas. An example of this would be to develop additional water sources in areas rarely visited by livestock due to a scarcity of water. 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 forage value data can be used to help determine how many animals should be allowed to graze in the given area, which is a crucial step. Low stocking rates benefit individual animals 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.

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 each grazing community should 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 soil units or compartments. 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.

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 deteriorating 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 local precipitation monitoring stations in the project area recorded about average precipitation compared to the previous five year average. However, on a longer time scale, precipitation levels throughout the Southwest are indicative of drought. In other words, the five year average used as "normal" comparison is likely still less than the 100 year average. By using the six year "normal" we used only the most reliable information, but also provided a conservative deviation from normal, thereby producing a conservative initial stocking rate which is appropriate under drought 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 and carrying capacities provided in the results. The provided stocking rates and carrying capacities should be used as a guide to be adjusted appropriately with consideration of a variety of factors including the forage value ratings applied to the data, the variability of precipitation, and distance to water sources, and the percentage of acreage with steep slopes.

6.1 Ecological Sites

Ecological sites are differentiated from each other based on significant differences in species and species groups of the characteristic plant community, and their proportional composition and production, as well as soil factors, hydrology and other differences in the overstory and understory plants due to variations in topography, climate and environmental factors or the response of vegetation to management. Each ecological site description (ESD) describes the historic climax plant community (HCPC) that was present during European settlement of North America. This community is considered to be best suited to the local suite of environmental factors and able to equilibrate itself in response to those factors. Many rangelands have undergone significant change to the degree that they are never expected to again display the characteristics of the HCPC. In their best condition, these rangelands would reach their potential natural community (PNC). PNCs may include non-native plant species and other factors which differentiate them from an HCPC on the same site.

After the soil surveys for the study area are complete, it will be possible to assign each transect to an ecological site and compare the vegetation on each transect to the HCPC for its corresponding ecological site. This process will allow range managers to compare the amount of production measured in this inventory to the potential production for each site.

Potential production is the expected production of a particular ecological site. The potential production of a site is usually provided in the published ecological site description (ESD) with the soil survey. The information in the ESD is based on field data collected in sites with similar soils, climate, water resources, vegetation and land use. Comparing measured total annual production to potential production 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 HCPC. This information is based on the field data collected for development of the ESD. Allowable production may include production from preferred, desirable, and undesirable forage species, as well as toxic plants such as *Astragalus* species. Care should be taken to examine the allowable quantity of these species in ESDs because they can influence the perceived forage available of the rangeland. Allowable production is much more indicative of range condition than total annual production. The most accurate picture of current conditions can be made by comparing allowable production to expected production from the climax plant community. This can be accomplished with a similarity index. When possible, it is recommended that management objectives include monitoring of allowable production and comparing that data to the expected climax community.

6.2 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

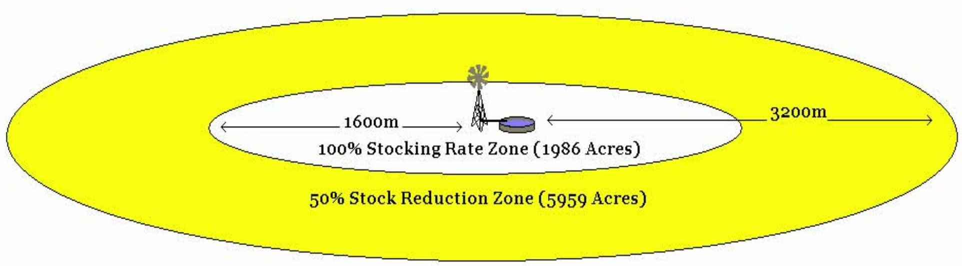
6.2.1 Stocking Rates during Drought

If there is very little precipitation during the winter and early spring numbers, stock numbers should not be permitted at the rate of a normal 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.

6.2.2 Distance to Water

Forage utilization generally increases with proximity to water sources. Livestock managers should consider the number and locations of water sources within a rangeland management unit and adjust stocking rates accordingly. Areas further than 3,200 meters from a water source can be considered ungrazable and that acreage should be removed from stocking rate calculations.
Livestock will rarely range more than 3,200 meters(m) from a water source. Holechek (1988) recommends no stocking rate reductions for the zone under 1,600 m from water, a 50% reduction for the zone 1,600 to 3,200 m from water and that the zone over 3,200 m from water be considered ungrazable (Figure 6.1). The area between 1,600 m and 3,200 m is 5,959 acres.

- Figure 6.1 Stocking Rate Reduction Zones at Water Sources



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

6.2.3 Other Considerations for Stocking Rate Selection

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

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

7.0 SUMMARY

The grazing lands of District One were in moderately good condition during the time of this vegetation inventory. In District Three, Unit Two, the data show that there are slightly less frequent decreaser species, more bare ground and less available forage than in District One, and overall the area is not improving.

Without a previous baseline or ecological site descriptions it is difficult to compare the current conditions to what might be expected on these rangelands. The data from this study will provide that comparative baseline for future management.

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.

7. REFERENCES AND LITERATURE CITED

Belnap, Jayne, et al. 2001. Biological Soil Crusts: Ecology and Management. Interagency Technical Reference 1730-2. Bureau of Land Management. Denver, CO.

Bonham, C. D. 1989. Measurements for Terrestrial Vegetation. New York, NY: John Wiley & Sons. *In* Elzinga, Caryl L., Daniel W. Salzer and John W. Willoughby. 1998. Measuring and Monitoring Plant Populations. Interagency Technical Reference 1730-1. Bureau of Land Management. Denver, Colorado.

Chronic, Halka. 1983.Roadside Geology of Arizona. Mountain Press Publishing Company. Missoula, Montana.

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

Division of Community Development(DCD), Navajo Nation. 2004. Chapter Images:2004.

Elzinga, Caryl L., Daniel W. Salzer and John W. Willoughby. 1998. Measuring and Monitoring Plant Populations. Interagency Technical Reference 1730-1. Bureau of Land Management. Denver, Colorado.

Goodman, James M. 1982. The Navajo Atlas: Environments, Resources, People and History of the Dine Bikeyah. University of Oklahoma Press. Norman, Oklahoma.

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

Heitschmidt, R. & J. Stuth (eds.). 1991. Grazing Management – An Ecological Perspective. Timber Press. Oregon

Holecheck, Jerry L. et al. 1999. Grazing Studies: What We've Learned. *Rangelands* 21(2).

Lowe, Charles H. 1985. Arizona's Natural Environment. University of Arizona Press.

Nations, Dale and Stump, Edmund. 1981. Geology of Arizona. Kendall/Hunt Publishing Company. Dubuque, Iowa.

United States Department of Agriculture, Natural Resources Conservation Service. Navajo Mountain Area, AZ, Parts of Apache, Coconino and Navajo Counties Soil Survey (AZ711), unpublished.

United States Department of Agriculture, Natural Resources Conservation Service. Little Colorado River Area, AZ, Parts of Coconino and Navajo Counties Soil Survey (AZ707), unpublished.

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

8. APPENDICES

Appendix A

Precipitation Data For District One Study Area and District Three, Unit Two Study Area, 2006

District One Stations	WATER YEAR (WY)	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
BODAWAY / GAP	2001	2.1	0.0	0.3	0.9	0.2	1.2	0.0	0.3	0.0	0.6	2.9	0.1
BODAWAY / GAP	2002	0.0	0.2	0.5	0.0	0.1	0.3	0.0	0.1	0.0	1.2	0.2	1.4
BODAWAY / GAP	2003	0.3	0.7	0.2	0.0	0.6	0.2	0.0	0.2	0.0	0.9	1.6	1.1
BODAWAY / GAP	2004	0.3	0.7	0.3	0.1	0.5	0.4	0.1	0.0	0.0	0.8	1.9	1.1
BODAWAY / GAP	2005	1.0	1.7	0.2	2.1	1.4	0.1	0.9	0.0	0.7	0.7	0.9	0.0
KAIBITO	2002	0.2	0.1	0.7	0.0	0.1	0.3	0.1	0.0	0.1	0.4	0.1	2.6
KAIBITO	2003	0.3	0.5	0.4	0.1	0.5	0.5	0.2	0.3	0.0	0.8	0.9	0.8
KAIBITO	2004	1.1	1.3	0.4	0.1	0.3	0.5	1.1	0.0	0.2	1.4	0.5	1.1
KAIBITO	2005	0.6	2.2	0.3	2.4	2.5	0.4	1.4	0.1	0.6	0.6	1.0	0.1
RED LAKE FARMS WX	2001	1.5	0.3	0.1	1.0	0.3	1.0	0.6	0.4	0.0	0.8	1.6	0.1
RED LAKE FARMS WX	2002	0.3	0.3	0.9	0.0	0.1	0.1	0.2	0.1	0.1	0.4	0.2	1.6
RED LAKE FARMS WX	2003	0.3	0.3	0.4	0.1	0.8	0.8	0.1	0.1	0.1	0.3	0.3	1.0
RED LAKE FARMS WX	2004	0.7	0.7	0.1	0.9	0.0	0.8	0.4	0.0	0.2	0.1	1.0	1.4
RED LAKE FARMS WX	2005	0.6	1.3	0.3	2.0	1.7	0.1	0.8	0.0	0.4	0.2	2.0	0.0
5 Year Averages	**AVG.**	**0.7**	**0.7**	**0.4**	**0.7**	**0.7**	**0.5**	**0.4**	**0.1**	**0.2**	**0.6**	**1.1**	**0.9**
Total (Avg. 5 yr to Date)		0.7	1.4	1.8	2.5	3.1	3.6	4.0	4.1	4.3	4.9	6.0	6.8

BODAWAY / GAP	2006	0.8	0.0	0.0	0.1	0.0	1.1	0.1	0.1	0.1	0.0	0.6	0.3
KAIBITO	2006	0.9	0.0	0.1	0.4	0.0	1.2	0.2	0.0	0.1	0.5	1.6	0.7
RED LAKE FARMS WX	2006	0.4	0.0	0.0	0.2	0.1	0.9	1.5	0.2	0.0	0.7	0.8	0.6
WY Averages	**AVG.**	**0.7**	**0.0**	**0.0**	**0.2**	**0.0**	**1.1**	**0.6**	**0.1**	**0.1**	**0.4**	**1.0**	**0.5**
Total (Avg WY) to Date		0.7	0.7	0.7	0.9	1.0	2.0	2.6	2.7	2.7	3.1	4.1	4.6
WY % Normal		**100%**	**48%**	**40%**	**38%**	**31%**	**57%**	**66%**	**65%**	**64%**	**64%**	**69%**	**68%**

District Three Stations	WATER YEAR (WY)	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
BODAWAY / GAP	2001	2.1	0.0	0.3	0.9	0.2	1.2	0.0	0.3	0.0	0.6	2.9	0.1
BODAWAY / GAP	2002	0.0	0.2	0.5	0.0	0.1	0.3	0.0	0.1	0.0	1.2	0.2	1.4
BODAWAY / GAP	2003	0.3	0.7	0.2	0.0	0.6	0.2	0.0	0.2	0.0	0.9	1.6	1.1
BODAWAY / GAP	2004	0.3	0.7	0.3	0.1	0.5	0.4	0.1	0.0	0.0	0.8	1.9	1.1
BODAWAY / GAP	2005	1.0	1.7	0.2	2.1	1.4	0.1	0.9	0.0	0.7	0.7	0.9	0.0
TUBA CITY O&M	2001	1.3	0.1	0.2	1.3	0.2	1.8	0.1	0.0	0.0	0.6	1.9	0.0
TUBA CITY O&M	2002	0.4	0.3	0.8	1.3	0.0	0.2	0.1	0.0	0.0	0.2	0.0	3.1
TUBA CITY O&M	2003	0.2	0.7	0.4	0.2	0.2	0.4	0.2	0.0	0.0	0.5	0.7	1.8
TUBA CITY O&M	2004	0.1	1.0	0.7	0.5	0.0	0.3	0.2	0.1	0.0	0.4	1.0	1.2
TUBA CITY O&M	2005	1.2	1.0	0.6	1.4	1.3	0.1	0.7	0.0	0.3	0.1	2.3	0.1
RED LAKE FARMS WX	2001	1.5	0.3	0.1	1.0	0.3	1.0	0.6	0.4	0.0	0.8	1.6	0.1
RED LAKE FARMS WX	2002	0.3	0.3	0.9	0.0	0.1	0.1	0.2	0.1	0.1	0.4	0.2	1.6
RED LAKE FARMS WX	2003	0.3	0.3	0.4	0.1	0.8	0.8	0.1	0.1	0.1	0.3	0.3	1.0
RED LAKE FARMS WX	2004	0.7	0.7	0.1	0.9	0.0	0.8	0.4	0.0	0.2	0.1	1.0	1.4
RED LAKE FARMS WX	2005	0.6	1.3	0.3	2.0	1.7	0.1	0.8	0.0	0.4	0.2	2.0	0.0
5 Year Averages	**AVG.**	**0.7**	**0.6**	**0.4**	**0.8**	**0.5**	**0.5**	**0.3**	**0.1**	**0.1**	**0.5**	**1.2**	**0.9**
Total (Avg. 5 yr to Date)		0.7	1.3	1.7	2.5	3.0	3.5	3.8	3.9	4.0	4.5	5.7	6.6
BODAWAY / GAP	2006	0.8	0.0	0.0	0.1	0.0	1.1	0.1	0.1	0.1	0.0	0.6	0.3
TUBA CITY O&M	2006	0.4	0.1	0.0	0.2	0.0	0.8	0.4	0.0	0.0	0.7	0.7	1.0
RED LAKE FARMS WX	2006	0.4	0.0	0.0	0.2	0.1	0.9	1.5	0.2	0.0	0.7	0.8	0.6
WY Averages	**AVG.**	**0.5**	**0.0**	**0.0**	**0.2**	**0.0**	**0.9**	**0.7**	**0.1**	**0.0**	**0.5**	**0.7**	**0.6**
Total (Avg WY) to Date		0.5	0.5	0.5	0.7	0.7	1.6	2.3	2.4	2.4	2.9	3.5	4.1
WY % Normal		**72%**	**40%**	**30%**	**28%**	**24%**	**47%**	**60%**	**61%**	**60%**	**64%**	**62%**	**62%**

Appendix B

	Harvest Efficiency Factor
Preferred	P
Desirable	D
Undesirable	U
Nonconsumed	N
Toxic	T

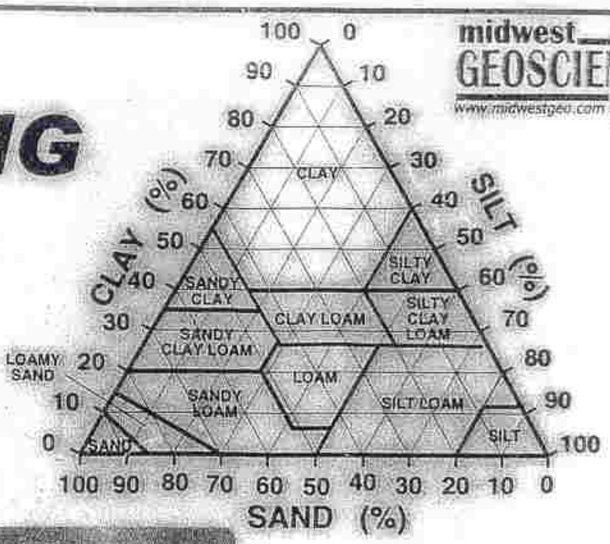
Code	Plant Name	Forage Value
ABFR2	Abronia fragrans Nut	N
ACHY	Achnatherum hymenoid	D
ALIN	Allionia incarnataL.	N
AMAL	Amaranthus albus L.	T
AMARA	Amaranthus L.	T
AMAC2	Ambrosia acanthicarpa	U
AMBRO	Ambrosia L.	U
AREA	Arenaria eastwoodiae	U
ARFE3	Arenaria fendleriGra	U
AROL	Aristida oligantha	P
ARPU9	Aristida purpureaNut	P
ARBI2	Artemisia biennis Willd.	P
ARBI3	Artemisia bigelovii	P
ARCA12	Artemisia campestris	P
ARDR4	Artemisia dracunculu	P
ARFI2	Artemisia filifolia	D
ARTEM	Artemisia L.	D
ARLU	Artemisia ludovician	P
ARTR2	Artemisia tridentata	D
ASTRA	Astragalus	T
ASCE	Astragalus ceramicus	T
ATCA2	Atriplex canescens(P	D
ATCO	Atriplex confertifol	D
BOBA2	Bouteloua barbataLag	P
BOCU	Bouteloua curtipendu	D
BOER4	Bouteloua eriopoda	D
BOGR2	Bouteloua gracilis(W	D
BRICK	Brickellia Ell.	U
BRRU2	Bromus rubens L.	U
BRTE	Bromus tectorum L.	U
EUFE3	Chamaesyce fendleri	U
EUGL13	Chamaesyce glyptospe	U
CHENO	Chenopodium	T
CHAL6	Chenopodium albescen	U
CHIN2	Chenopodium incanum	U
CHIN13	Chenopodium incisum	U
CHDE2	Chrysothamnus depres	U
CHGR6	Chrysothamnus greene	U
CHNAB3	Chrysothamnus nauseosa var. bigelovii	U
CHNAA4	Chrysothamnus nauseousus	U
CHRYS9	Chrysothamnus Nutt.	U
CHGR6	Chrysothamnus viscid	U
CORA	Coleogyne ramosissim	N
COPA26	Comandra pallida	T
COUM	Comandra umbellata(L	T
COWR2	Cordylanthus wrighti	N
CRYPT	Cryptanthus spp.	U
CRCI3	Cryptantha cinerea	U
CRFL5	Cryptantha flava (A.	U
CRFU	Cryptantha fulvocanes	U
CRYPT	Cryptantha Lehm. ex	U
CRMI	Cryptantha micrantha	U
DEOB	Descurainia obtusa(G	U
DIBR3	Dicoria brandegeeiGr	U
DICOR	Dicoria Torr. ex Gra	U
DIWI2	Dimorphocarpa wisliz	
DISP	Distichlis spicata	
ELEL5	Elymus elymoides (Ra	D
EPCU	Ephedra cutleri Peeb	P
EPTO	Ephedra torreyana	P
ERDI2	Eriastrum diffusum(G	U
ERAL4	Eriogonum alatum Tor	P
ERCE2	Eriogonum cernuum	P
ERDE6	Eriogonum deflexumTo	P
ERGO	Eriogonum gordoniiBe	U
ERLA3	Eriogonum lachnogynu	P
ERLE9	Eriogonum leptocladon	U
ERIOG	Eriogonum Michx.	U
EREL12	Erysimum elatum Nutt	U
EUFE2	Euphorbia fendleriTo	U
EUGI3	Euphorbia glyptosperma	N
EUGR3	Euphorbia gracillima	N
EUPHO	Euphorbia L.	N
EUPA6	Euphorbia parryi	U
EVNU	Evolvulus nuttallianus	
GILIA	Gilia Ruiz & Pavón	N
GUMI	Gutierrezia microcep	U
GUSA2	Gutierrezia sarothra	U
HASP3	Haplopappus spinulosus	U
HECO5	Heliotropium convolvulaceum	N

HEVI4	Heterotheca villosa	N
HYFI	Hymenopappus filifolius	N
HYMEN4	Hymenopappus L'Hér.	N
HYACA2	Hymenoxys acaulis(Pu	I
HYMEN7	Hymenoxys Cass.	I
HYRI	Hymenoxys richardson	I
IPGU	Ipomopsis gunnisonii	U
IPLO2	Ipomopsis longiflora	U
ISRU2	Isocoma rusbyi	?
KOAM	Kochia americana	U
LALA11	Lappula sp.	U
LEFR2	Lepidium fremontiiS.	U
LEPU	Leptodactylon pungens	N
LEIN3	Lesquerella intermed	N
LESQU	Lesquerella S. Wats.	N
LEER	Leucelene ericoides	N
LIAR3	Linum aristatum Enge	U
LIPEL2	Linum peranne L. var	U
LIIN2	Lithospermum incisum	U
LITHO3	Lithospermum L.	U
MACHA	Machaeranthera	U
MACA2	Machaeranthera canescens	N
MAGR2	Machaeranthera grindelioides	N
MENTZ	Mentzelia L.	N
MEPU3	Mentzelia pumila Nut	N
MOSQ	Monroa squarrosa	N
MUPU2	Muhlenbergia pungens	P
OENOT	Oenothera	P
OECA10	Oenothera caespitosa	P
OEDE2	Oenothera deltoides	P
OEPA	Oenothera pallida	P
OPUNT	Opuntia P. Mill.	U
OPPO	Opuntia polyacantha	U
OPWH	Opuntia whipplei	U
PAFI4	Parryella filifolia	U
PEAN	Pectis angustifolia	U
PEDIO	Pediocactus Britt.&	U
PEAM	Penstemon ambiguusTo	
PEPA8	Penstemon palmeriGra	
PENST	Penstemon Schmidel	
PEPUG2	Petradoria pumila v.	
PHACE	Phacelia Juss.	U
PHBR15	Phemeranthus brevicaulis	U
PHLOX	Phlox L.	N
PLPA2	Plantago patagonica	N
PLJA	Pleuraphia jamesiiTo	D
POIN3	Poliomintha incana(T	P
PORTU	Portulaca	
POHA5	Portulaca halimoides L.	
POOL	Portulaca oleraceae	N
PSCO2	Psilostrophe cooperi	N
PSILO3	Psilostrophe DC.	N

PSLA3	Psoralidium lanceolatum	N
PUST	Purshia stansburiana	P
PUTR2	Purshia tridentata(P	P
QUGA	Quercus gambelii Nut	U
QUTU2	Quercus turbinella Greene	N
REAR	Reverchonia arenaria	
SAKAR	Salsola Kali	
SAVE4	Sarcobatus vermiculatus	P
SEFI2	Senecio filifoliusNu	N
SENEC	Senecio L.	N
SEMU3	Senecio multilobatus	N
SESP3	Senecio spartioides	N
SPCO	Sphaeralcea coccinea	D
SPGR2	Sphaeralcea grossula	D
SPHAE	Sphaeralcea St.-Hil.	D
SPAI	Sporobolus airoides	D
SPCO4	Sporobolus contractu	D
SPCR	Sporobolus cryptandr	D
SPGI	Sporobolus giganteus	D
STEX	Stephanomeria exigua	U
STEPH	Stephanomeria Nutt.	U
STCO4	Stipa comata Trin.&	N
SUMO	Suaeda moquinii (Tor	N
TAMAR2	Tamarix L.	N
TECA2	Tetradymia canescens	N
TOAN	Townsendia annua Bea	N
TOWNS	Townsendia Hook.	N
TOIN	Townsendia incana	N
TROC	Tradescantia occiden	N
VUOC	Vulpia octoflora (Wa	P
WIRE	Wislizenia refracta	U
YUCCA	Yucca	U
YUAN2	Yucca angustissimaEn	U

Appendix C

USDA SOIL TEXTURING FIELD FLOW CHART



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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 → back to start) 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

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

Less than 2.5cm	2.5 to 5.0cm	Greater than 5.0cm
Is soil very sandy? YES → SANDY LOAM	Does soil feel very gritty? YES → SANDY CLAY LOAM	Does soil feel very gritty? YES → SANDY CLAY
NO	NO	NO
Is soil moderately sandy? YES → LOAM	Does soil feel slightly gritty? YES → SILTY CLAY LOAM	Does soil feel slightly gritty? YES → SILTY CLAY
NO	NO	NO
Does sample have little or no sand? YES → SILT LOAM	Does soil feel smooth? YES → CLAY LOAM	Does soil feel smooth? YES → CLAY

TEXTURE MODIFIERS
Fragment Content % by Volume

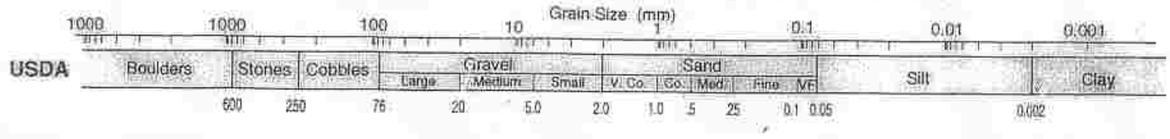
< 15%	No modifier
15% to <35%	Add modifer
36% to <60%	Add "very" with modifier
60% to 90%	Add "extremely" with modifier
>90%	No modifer; use Size Class only

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 D

Arizona CRA Growth Curves															
February 3, 2006															
		Prepared by Karlynn Huling													
Growth Curve Number	**Growth Curve Name**	**Jan %**	**Feb %**	**Mar %**	**Apr %**	**May %**	**Jun %**	**Jul %**	**Aug %**	**Sep %**	**Oct %**	**Nov %**	**Dec %**	**Total %**	**Description**
AZ3511	35.1 10-14" p.z. all sites	0	0	1	5	11	18	25	24	13	3	0	0	100	Growth begins in the spring and continues through the summer, most growth occurs during the summer rainy season.
AZ3521	35.2 6-10" p.z. all sites	0	1	9	20	27	14	10	11	5	3	0	0	100	Growth begins in the spring and continues through the summer, most growth occurs in the spring using stored winter moisture.
AZ3531	35.3 10-14" p.z. all sites	0	1	3	17	18	10	19	20	10	1	1	0	100	Growth begins in the spring and contines through the summer.
AZ3561	35.6 13-17" p.z. all sites	0	1	5	16	17	15	15	15	11	5	0	0	100	Growth begins in the spring and continues into the fall.
AZ3921	35.7 14-18" p.z. all sites	0	0	5	14	21	17	18	14	8	3	0	0	100	Growth begins in the spring and continues through the summer.
AZ3581	35.8 17-25" p.z. all sites	0	0	0	4	10	24	21	23	13	5	0	0	100	Growth begins in the spring, most growth occurs during the summer rainy season.
AZ3591	35.9 25-33" p.z. all sites	0	0	0	0	15	15	20	25	20	5	0	0	100	Growth begins in late spring and continues into the fall.