District 13 Vegetation Inventory

Burnham, Nenahnezad, San Juan, Upper Fruitland Communities

Prepared for:

Bureau of Indian Affairs
Northern Navajo Agency
Natural Resources

2014

Ecosphere Environmental Services

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

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ABBREVIATIONS/ACRONYMS

ADW	air-dry weight
AUM	animal unit month
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
Ecosphere	Ecosphere Environmental Services
ESD	ecological site description
ft^2	square foot
g	grams
GPS	global positioning system
HCPC	historic climax plant community
lb	pound
LMD	Land Management District
MLRA	Major Land Resource Area
NAPI	Navajo Agricultural Products Industry
NNDOA	Navajo Nation Department of Agriculture
NNDWR	Navajo Nation Division of Water Resources
NRCS	Natural Resource Conservation Service
PNC	potential natural community
RMU	range management units
SOW	statement of work
USDA	United States Department of Agriculture

ABSTRACT

Ecosphere Environmental Services was contracted by the Bureau of Indian Affairs (BIA) to collect and compile vegetation data on portions of Land Management District (LMD) 13, specifically in the Burnham, Nenahnezad, San Juan and Upper Fruitland communities of the Northern (Shiprock) Navajo Agency. The overall project area was approximately 398,285 acres. Data were collected from 561 transect locations during September of 2014. Measurements were taken for biomass production, ground cover, and species frequency. The data were analyzed to determine the carrying capacity of the range resource as well as the similarity to the historic climax plant community.

Data were analyzed by soil map units and ecological sites within 18 analysis units consisting of 3 communities (Burnham, Upper Fruitland and Nenahnezad/San Juan combined), and 8 range management units (RMUs) with several internal pastures. Carrying capacities and recommended stocking rates were calculated by analysis unit using available forage. The data were aggregated by ecological site and then analyzed according to the acreage within each soil within each analysis unit. Spatial analyses of slopes and distances to water sources were layered onto the data to improve stocking rate applications.

Overall, the similarity of the ecological sites in the study area to their historical potential ranged from 0 to 67 percent. Carrying capacity is less than the current permitted numbers.

1. Introduction

Ecosphere Environmental Services (Ecosphere) was contracted by the Bureau of Indian Affairs (BIA) to conduct under-story rangeland vegetation inventories on 24 analysis units within the Burnham, Nenahnezad, San Juan and Upper Fruitland communities in the Northern (Shiprock) Navajo Agency. Species-specific vegetation data measurements included annual production, cover, and frequency. This data was also used to calculate carrying capacity based on available forage production. 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 the study area as well as more comprehensive range management plans that are crucial for future range productivity.

1.2 Regulatory Entities

The Navajo Nation Department of Agriculture (NNDOA) manages livestock grazing activities on the Navajo Nation primarily through District Grazing Committees. Livestock grazing permits are administered by the BIA Natural Resources Program in accordance with the Navajo Grazing Regulations (25 CFR §167). The BIA and the District 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 including measuring the carrying capacity of the range resource. 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” (2003a). A summary of the BIA Range Policy as stated in the Agricultural and Range Management Handbook (2003a) is outlined below.

BIA Range Policy

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

1.2.2 District Grazing Committees

Districts, which are formally called Land Management Districts, were established in 1936 by the Soil Conservation Service (now called Natural Resource Conservation Service, or NRCS) and adopted by the BIA. The periodic sampling of rangelands allows district grazing committees to evaluate the carrying capacity and resulting stocking rates of rangelands (Goodman 1982).

The Navajo Nation is organized into 110 Chapters. Chapters, also called communities, are locally organized entities similar to counties and are the smallest political unit. District grazing committees consist of elected representatives from each community who are responsible for monitoring livestock grazing within their respective chapters. District grazing committees approve the carrying capacities of their districts, as discussed in *Navajo Reservation Grazing Handbook and Livestock Laws* published in 1967 by the Navajo Tribal Council.

Individual grazing district committee members 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 permit holders are in compliance with their permit. In addition, the NNDOA and the district grazing committees are responsible for enforcement of range management and resolving grazing disputes. According to the Navajo Nation Code, Title 3, Subchapter 5, the district grazing committee members are responsible for attending district grazing committee meetings, as well as Chapter meetings, and for ensuring that permit holders respect applicable laws, regulations, and policies. The District Grazing Committee must approve all stocking rates for grazing permits issued by the BIA and "adjust livestock numbers to carrying capacity of ranges in such a manner that the livestock economy of the Navajo Nation is preserved."

1.3 Grazing Overview

Timing of grazing, movement and dispersal of livestock, and livestock numbers are factors that must be considered when optimizing livestock production. Prior to considering these factors, managers need 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 area does not necessarily reflect the amount of forage available to livestock; therefore, it is important to recognize specific factors restricting forage availability such as inaccessibility (fences), long distances to water, or steep slopes. Once identified, total forage production can be adjusted for these inaccessible areas. An example of a management strategy that would result from this type of analysis would be to develop additional water sources in areas rarely visited by livestock because of the long distance to water. Section 6.5 explains how fencing can be used to more accurately manage forage production.

After likely foraging patterns have been ascertained, production and forage value data can be used to help determine the number of animals that could sustainably graze in a given pasture. Stocking rates are a trade-off between short-term and long-term benefits. Low stocking rates benefit individual animals, as more resources are available due to lowered competition with other animals. Conversely, high stocking rates can inhibit individual animals, but the increase in total livestock production allows for greater short-term gains for the producer. The final stocking rate decision must consider the ecosystem as a whole. Maintaining long-term viable rangelands provides for the continued health of livestock and long-term financial gains for producers or permittees. Viable rangelands also provide for the continued health of the local air, water, and other ecological resources.

Stocking rates are correlated with the prevention of overgrazing. When livestock, wildlife, and feral horses graze and browse on a site, each selects its own preferred species. If the site is stocked too heavily and for too long a time, the desired forage species will become overgrazed. These preferred species are weakened and their mortality rate increases, resulting in a reduction of their percent composition on the site. If deterioration continues, invaders and noxious weeds replace the less valuable forage species.

Plant vigor and root development can be adversely affected when grazing occurs during initial plant growth or during seed 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 rates have a much greater impact on range condition than the season of use.

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 and carrying capacity to grazing areas should be used with care and in context to dynamic seasonal, topographic, and behavioral factors.

2. RESOURCE DESCRIPTIONS

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

2.1 Geographic Setting

The study area is located within the Colorado Plateau (35) Major Land Resource Area (MLRA). The study area surveyed is characterized by extensive badlands and unique rock formations.

District 13 is located in San Juan County, New Mexico. Topography is broken and rough but total elevations do not range widely, only from about 5,200 to about 6,000 feet. The Chaco River forms the western and southern boundaries of the study area. The San Juan River forms the northern boundary, and the eastern boundary parallels highway 371. The Hogback is located just outside the western boundary. Many large washes, including Hunter Wash and Cottonwood Wash, bisect the study area.

A map of the study area (Figure 2-1) is provided in the map on the following page.

Acreages for each compartment were extracted from digital shapefiles provided by the BIA, Northern Navajo Agency. Some areas were removed from the study because they were predominantly badlands with little forage, were under jurisdiction of the Navajo Agricultural Products Industry (NAPI) or Navajo Mine lease, or were otherwise determined as non-range areas (a total of 179,929.8 acres not including steep slopes). Using these shapefiles and the soil survey boundaries, the 18 analysis units covered 218,355.1 acres.

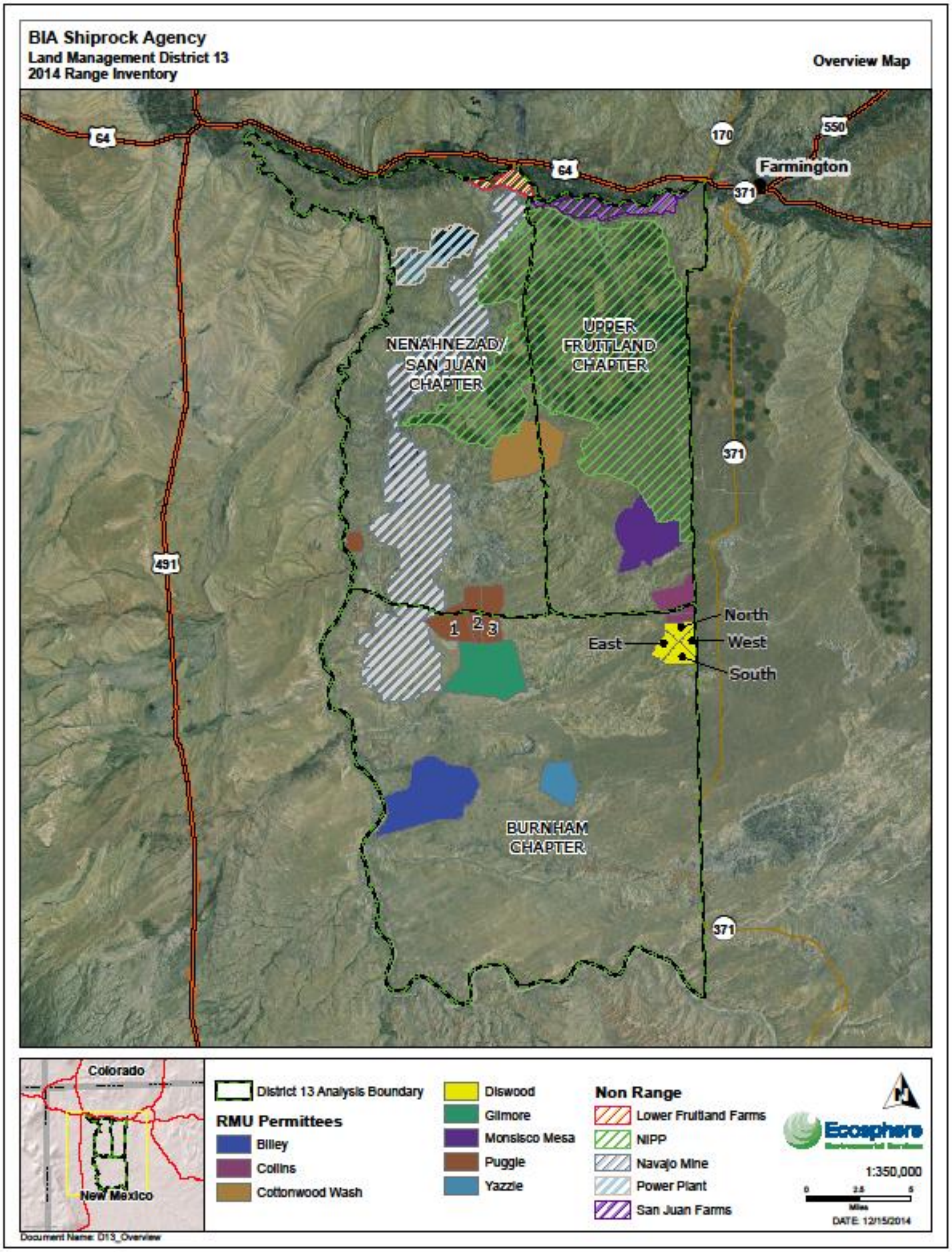


Figure 2-1. Overview Map of Study Area

2.2 Precipitation

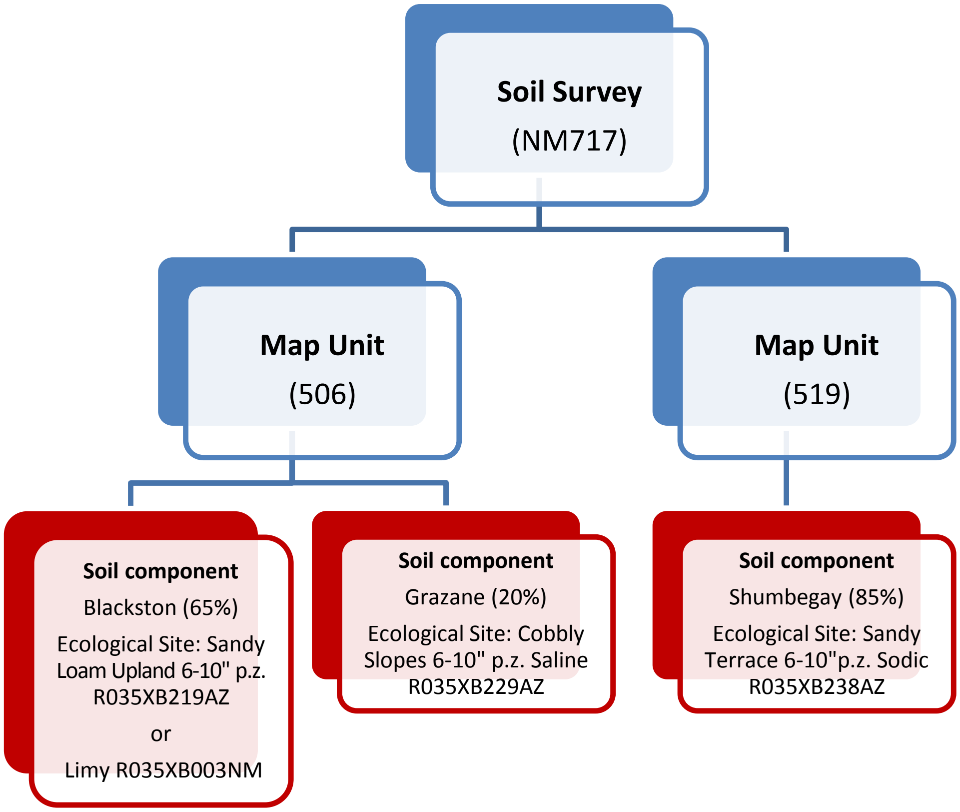
An accurate precipitation monitoring system is essential to range management programs. Biomass production estimates are directly affected by precipitation measurements when reconstructing the plant community to a normal production year. If precipitation is over estimated in the reconstruction factor, the total annual production estimate decreases. If precipitation is under estimated in the reconstruction factor, the total annual production estimate increases. Precipitation gauges are located throughout the Navajo Nation and data are managed by the Navajo Nation Division of Water Resources (NNDWR). The NNDWR provided 14 years of precipitation data averaging all of the gauging stations in Shiprock Agency. The gauging stations are widespread and vary from mountainous areas to the San Juan River area and, therefore, provide a regional average not specific to the study area. The precipitation data are provided as Appendix A.

2.3 Soils

Knowledge of the soil properties in a particular area can help predict forage production. Soil properties such as texture, depth, moisture content, and capacity can dictate the type and amount of vegetation that will grow in that soil. The application of soil survey information enables rangeland managers to provide estimates of forage production in a range unit. According to the Agricultural and Range Management Handbook, “the type and size of map unit delineations, scale of data collection, sampling protocols, and date of the last inventory completed are all factors to consider when using existing soil surveys and rangeland inventories” (USDOI BIA 2003b).

This vegetation inventory study area is located within the boundaries of two soil surveys produced by the United States Department of Agriculture (USDA), Natural Resources Conservation Service: Soil Survey of San Juan County, New Mexico, Eastern Part (UT618) and Soil Survey of Shiprock Area, Parts of San Juan County, New Mexico and Apache County, Arizona (NM717). Each soil survey is Order III mapped, which means it includes soil and plant components at association or complex levels (called map units). Within the map units, finer levels (called soil types) are generally described, but not mapped. Each of the delineated map units contains multiple soil components within it, and the major soil components are correlated with a specific ecological site. Order II mapping would delineate soil types within map units, and boundaries of ecological sites could be determined directly from the soil map. Ecological sites cannot be assigned directly from Order III map information because they are not delineated at that level.

Soil surveys and ecological site descriptions are valuable for rangeland managers, as long as their limitations are understood. Figure 2-2 illustrates the hierarchy of *unmapped* soil components and their corresponding ecological sites within a *mapped* soil unit within a given soil survey. The examples in the chart are extracted from one of the soil surveys used for this project. The soil survey and map units (indicated in blue) are mapped. The soil components and correlated ecological sites (indicated in red) are unmapped.



Notes: p.z. = precipitation zone.

Figure 2-2. Soil Survey Hierarchy

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

3. ECOLOGICAL SITES

Ecological sites are differentiated from each other based on significant variances in species and species groups of the characteristic plant community and their proportional composition and production. Additional determining factors include soils, hydrology, and other differences in the overstory and understory plants due to distinctions 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. Many rangelands have undergone significant transitions to the point that they are never again expected to display the characteristics of the HCPC. In their best condition, these rangelands would instead reach their reference or potential natural community (PNC). PNCs may include non-native plant species and other factors, which differentiate them from an HCPC on the same site.

Ecological sites are directly associated with soil components. The determination of ecological site for each transect was complicated due to inconsistencies of scale in the soil surveys. As described in Section 2.3, the soil survey was mapped at the soil complex scale (Order III), meaning there are up to three soil components inside a mapped soil complex. The soil components are not mapped. Since each major soil component has a single ecological site assigned to it, the map unit has up to three unmapped ecological site possibilities. Therefore, ecological sites cannot be mapped directly from Order III soil map information because they are not correlated with the soil map units; ecological sites are correlated with the finer levels of unmapped soil components.

Rangeland managers should be aware that maps of ecological sites are available on NRCS Web Soil Survey website (USDA NRCS 2014e). The mapping, however, is by dominant ecological site. Unfortunately, this may grossly misrepresent soil units. For example, in soil map units where the dominant soil component/ecological site is 60 percent of the soil map unit, then the other 40 percent of the soil unit would be mapped incorrectly. An analogy might be a basket of fruit containing six apples and four oranges. Using the dominant system, the entire basket of fruit would be labeled as apples. While the dominant ecological site map may be appropriate at a landscape level, it is usually too coarse to use with rangeland management of pastures. In most cases of rangeland fieldwork, it is possible to provide field staff with descriptions of the dominant ecological site, as well as descriptions for non-dominant soil components and ecological sites. A decision regarding which ESD best fits a given transect can then be made based upon field examination of soils and the plant community.

For this inventory soil components and ecological sites for each transect were assigned primarily using soil profile and texture test results and the map unit descriptions from the soil survey, supplemented with interpretation of the current vegetative community compared to the expected HCPC. In cases where the ESD was not developed, no ESD was assigned. Generally, the ESDs represent the most up-to-date information available at the time of this study. It should be noted that they also are continually updated as new information is brought forth from field studies. The ESDs in this report should not be relied upon for future studies; instead the most recent information should be collected from the NRCS. Approved and published ESDs are available on the internet at http://esis.sc.egov.usda.gov/.

The ecological sites from the study area are listed below followed by representative photographs of ecological sites that contained transects, with transect identified. Some sites had only one transect located within the ecological site. Many ecological sites contained no transects, especially those with few acres and these ecological sites have no representative photographs A total of 17 transects could not be assigned to an ecological site due to a lack of information in the soil map unit descriptions.

Table 3-1. Ecological Sites in the Study Area

ID	ESD	Description	Number of Transects	Acres (By proportion in Soil Map Unit)
1	R035XA130NM	Shale Hills	7	6,861.2
2	R035XB001NM	Loamy	18	6,592.0
3	R035XB002NM	Sandy	136	23,825.3
4	R035XB003NM	Limy	22	7,726.2
5	R035XB004NM	Clayey	1	250.9
6	R035XB005NM	Salt Flats	56	38,001.2
7	R035XB006NM	Shallow	25	9,525.0
8	R035XB007NM	Deep Sand	140	46,212.2
9	R035XB009NM	Shale Hills	0	102.5
10	R035XB016NM	Clay Loam Terrace (sodic) 7-10"	2	775.7
11	R035XB017NM	Cobbly Slopes 6-10"	3	886.2
12	R035XB021NM	Loamy Upland 7-10	4	221.7
13	R035XB022NM	Loamy Upland sodic	8	2,776.6
14	R035XB024NM	Saline Bottom 6-10"	1	130.8
15	R035XB028NM	Sandy Bottom 6-10"	4	742.1
16	R035XB030NM	Sandy Loam Upland 6-10"	7	3,017.6
17	R035XB033NM	Sandy Loam Upland 6-10" sodic	3	168.9
18	R035XB034NM	Sandy Terrace 6-10" sodic	6	915.9
19	R035XB035NM	Sandy Upland 6-10"	51	22,302.0
20	R035XB204AZ	Sandstone Upland 6-10" p.z.	15	10,015.0
21	R035XB267AZ	Sandy Loam Upland 6-10" p.z. Limy	2	333.8
22	R035XB268AZ	Shale Hills 6-10" p.z.	8	3,683.1
23	R035XB269AZ	Loamy Bottom 6-10" p.z. Perennial	0	133.9
24	R035XB270AZ	Porcelanite Hills 6-10" p.z.	1	1,218.7
25	R035XB271AZ	Loamy Upland 6-10" p.z. Saline-Sodic	0	50.3
26	R035XB272AZ	Loamy Bottom 6-10" p.z. Perennial, Saline	2	129.9
27	R035XB273AZ	Sandy Bottom 6-10" p.z.	0	271.8
28	R035XB274AZ	Sandy Loam Upland 6-10" p.z. Saline	17	6,219.2
29	R035XB277AZ	Siltstone Upland 6-10" p.z. Limy	3	50.3
30	R035XC328AZ	Cobbly Slopes 10-14" p.z.	2	505.0

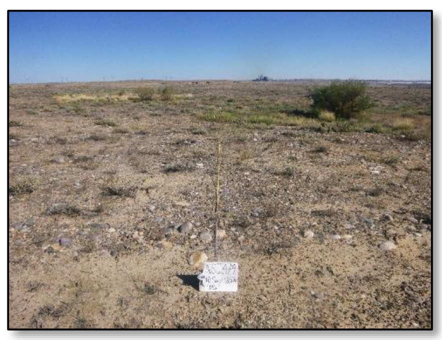
ID	ESD	Description	Number of Transects	Acres (By proportion in Soil Map Unit)
		Badland		14,694.7
		DuneLand		1,476.3
		Marshes		13.4
		Riverwash		1,731.5
		RockOutcrop		6,710.2
		Slickspots		8.7
		Water		75.0

Notes: p.z. = precipitation zone

1. R035XA130NM Shale Hills

Transects UF_528 and UF_39131

2. R035XB001NM Loamy



Transects BILL_020 and NSJ479

3. R035XB002NM Sandy


Transects BURN_223 and BILL_019

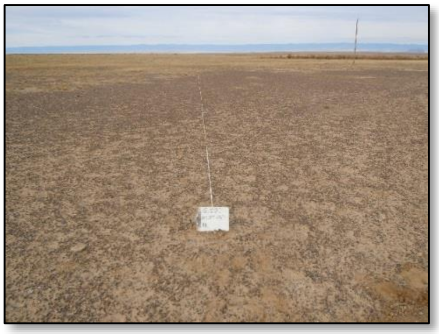
4. R035XB003NM Limy


Transects UF_534 and NSJ_460

5. R035XB004NM Clayey

Transect CW_357

6. R035XB005NM Salt Flats




Transects G_001 and NSJ_444

7. R035XB006NM Shallow


Transects UF_392 and UF_520

8. R035XB007NM Deep Sand

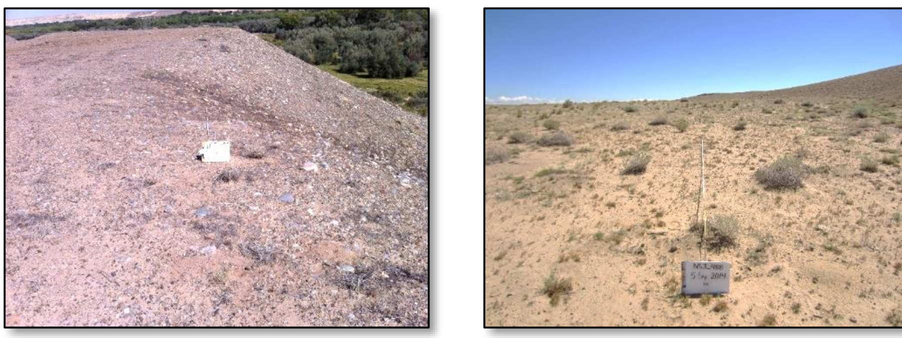

Transects BILL_010 and NSJ_420

9. R035XB009NM Shale Hills No transects were located in this ecological site. Approximately 102 acres of this ecological site is present in the study area.

10. R035XB016NM Clay Loam Terrace (sodic) 7-10"

Transect NSJ_466 and NSJ_467

11. R035XB017NM Cobbly Slopes 6-10"



Transects NSJ_ 485 and NSJ_488

12. R035XB021NM Loamy Upland 7-10”

Transects NSJ_482 and NSJ_500

13. R035XB022NM Loamy Upland sodic

Transects BURN_122 and BURN_153

14. R035XB024NM Saline Bottom 6-10"

Transect BURN_138

15. R035XB028NM Sandy Bottom 6-10"

Transects BURN_108 and BURN_99

16. R035XB030NM Sandy Loam Upland 6-10"

Transect NSJ_471 and NSJ_473

17. R035XB033NM Sandy Loam Upland 6-10" sodic

Transects BURN_124 and BURN_240

18. R035XB034NM Sandy Terrace 6-10" sodic

Transects BURN_137 and BURN_140

19. R035XB035NM Sandy Upland 6-10"

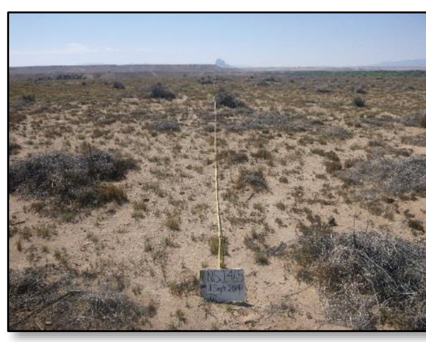
Transects BURN_133 and BURN_060

20. R035XB204AZ Sandstone Upland 6-10" p.z.

Transects BURN_096 and BURN_067

21. R035XB267AZ Sandy Loam Upland 6-10" p.z. Limy

Transects NSJ_417 and NSJ_465

22. R035XB268AZ Shale Hills 6-10" p.z.

Transects BURN_256 and BURN_243

23. R035XB269AZ Loamy Bottom 6-10" p.z. Perennial. No transects were located in this ecological site. Approximately 134 acres of this ecological site is present in the study area.

24. R035XB270AZ Porcelanite Hills 6-10" p.z.

Transect BURN_135

25. R035XB271AZ Loamy Upland 6-10" p.z. Saline-Sodic No transects were located in this ecological site. Approximately 50 acres of this ecological site is present in the study area.

26. R035XB272AZ Loamy Bottom 6-10" p.z. Perennial, Saline

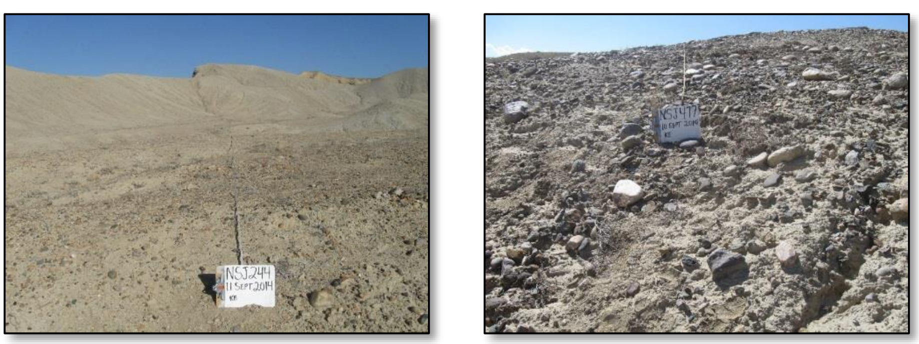
Transects NSJ_245 and NSJ_425

27. R035XB273AZ Sandy Bottom 6-10" p.z. No transects were located in this ecological site. Approximately 272 acres of this ecological site is present in the study area.

28. R035XB274AZ Sandy Loam Upland 6-10" p.z. Saline

Transects BURN_ 102 and BURN_241

29. R035XXB277AZ Siltstone Upland 6-10" p.z. Limy



Transects NSJ_244 and NSJ_477

30. R035XC328AZ Cobbly Slopes 10-14" p.z.

Transects NSJ_461 and NSJ_462

4. METHODOLOGY

The methods used to collect this data included protocols provided by the BIA and modified to standards used in federally published technical references. The Statement of Work (SOW), provided by the BIA to Ecosphere, described the study design and cited specific methodologies for data collection (Coulloudon et al. 1999a; Habich 2001; USDA NRCS 2003). The field methodology was based on the SOW and the technical references, with modifications approved by the BIA.

4.1 Field Methodology

4.1.1 Transect Establishment

Data collection in the field occurred between 1 September and 19 September. The BIA provided Ecosphere with predetermined transect locations. The Universal Transverse Mercator 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.

Transects consisted of a 200-foot line measured with an open reel tape placed flat and straight along the ground and stretched taut as much as possible. Using field maps and topography as a guide, each transect was placed within a single soil unit and vegetation community. The transect azimuth was randomly determined by selecting a prominent distant landmark, such as a mountain or lone tree. In some cases with no obvious landmark, a pen or pencil was tossed in the air to determine the random direction. The transect azimuth was read with a compass and recorded. The 200-foot tape was then extended along the transect azimuth. Vegetation attributes were recorded from ten plots at 20-foot intervals along the open reel tape. The plots were measured with a square 9.6-foot (ft^2) quadrant frame. The 9.6 ft^2 plot is generally used in areas where vegetation density and production are relatively light (Habich 2001). Care was taken to avoid bias by establishing each plot using a consistent method, in this case always laying the frame to the right side of the tape. The vegetative attributes measured at each transect were production, ground cover, and species frequency. Aspect, slope, soil texture, and notes were recorded. All plant species names were consistent with the USDA Plants Database (USDA NRCS 2014b).

4.1.2 Production Data Collection

Production is determined by measuring the weight of annual aboveground growth of vegetation because it has a direct relationship to feed units for grazing animals. 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 aboveground and available to herbivores. The peak standing crop is the greatest amount of plant biomass aboveground present during a given year (Coulloudon et al. 1999a). 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 using the USDA double sampling methodology with a combination of estimating and harvesting. For this survey, Ecosphere followed the double sampling methodology of the USDA, the NRCS modified standards outlined in the SOW, and the modifications generated from the pre-work conference. The double sampling method is detailed in the following sections.

4.1.2.1 Establishing a Weight Unit

A weight unit is a part of a plant, an entire plant, or a group of plants of the same species used to assess production. A weight unit is created by visually selecting part of a plant, an entire plant, or a group of plants that will most likely equal a particular weight. For example, a fist-sized clump of healthy, un-grazed Indian ricegrass (*Achnatherum hymenoides*) may be visually estimated to equal 10 grams (g). This clump of grass is then harvested and weighed with a hand scale to determine actual weight. This process is repeated until 10g of Indian ricegrass can be visually estimated with accuracy. After weight units are established, field teams can accurately estimate production. The field team maintained proficiency by regularly harvesting and weighing to check estimates of production.

4.1.2.2 Double Sampling Methodology (Estimating and Harvesting)

Production (in grams) was estimated by counting the weight units of each species in each plot. All plants and parts of plants inside a quadrant outlined by the 9.6 ft^2 frame up to a height of 4 feet were estimated by the field team (Figure 4-1). Plants outside the quadrant were excluded from the weight estimate. Two plots on each transect were chosen for harvesting. On the harvested plots, all species were estimated *in situ* and then harvested at ground level (¼ inch stubble height).

In many cases, vegetation in the transect was diverse and widespread, so two plots could not effectively represent all species. Furthermore, Ecosphere has determined, through several years of data collection and analysis, that intermittently occurring species are under-represented in the harvested material. In an effort to include more species in the harvested material, a weight unit of any species that contributed 10g or more of estimated production on the transect, but did not occur in the two selected harvested plots, was estimated and harvested individually outside of the transect. This was called a calibration sample.

Harvested 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 10 days or more before re-weighing to convert from green weight to air-dry weight (ADW). The purpose of the double sampling was to correct any variability between the estimation of production and the actual weighed production. This was accomplished by using an estimation correction factor, which is calculated in the post-field data processing.

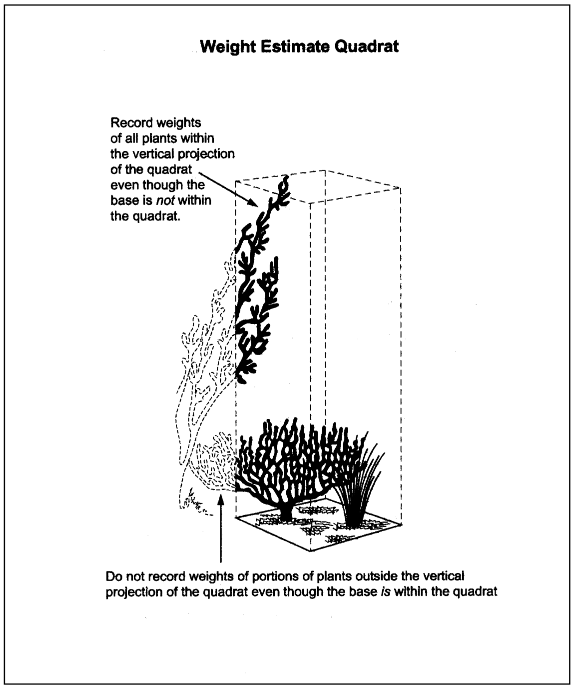


Figure 4-1. Weight Estimate Box

Source: Coulloudon et al. 1999a

4.1.3 Large Shrub Plots

Extended plots were established when the vegetation consisted of "large" shrubs. Neither the SOW or the National Range and Pasture Handbook (USDA NRCS 2003) adequately define the large shrub plot methodology. However, Ecosphere understands that the purpose of the large shrub plots is to capture the production of larger shrubs that are widely distributed and are too wide to be adequately measured within the 9.6 ft^2 frame.

Two extended plots were established at every transect containing shrubs. Shrubs were defined by USDA Plants Database (USDA NRCS 2013) and in addition to all woody shrubs, included all cacti and yucca. In cases where a species had potential to be a shrub or subshrub, the species in question was placed into a single category (shrub or subshrub) based on the growth form observed in the study area. The shrub species as defined for this project are included in the Plant List in Appendix B. Two extended square plots (0.1 acre) were measured from fixed locations along the 200 foot tape, and only the production weight of new growth on shrub species inside those plots was estimated. The shrub species were not estimated in the ten regular plots.

4.1.3.1 Ocular Estimates of Utilization

Utilization 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 that has been consumed prior to the vegetation inventory. With the Ocular Estimation Method (Coulloudon et al. 1999a), utilization is determined by visual inspection of forage species. This method is reasonably accurate, commonly applied, and suited for use with 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 represent the species approximately before grazing occurred. Un-grazed 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.

4.1.3.2 Sensitive Plants Protocol

Threatened, endangered, culturally important, or otherwise sensitive plants were estimated rather than harvested for the purposes of this inventory. Weights for cacti and yucca species were estimated using standard protocols as described in the Bureau of Land Management (BLM) Technical Reference 1734-7 (Habich 2001). The recommended values are as follows: 10 percent of total weight for prickly pear (*Opuntia* spp.), five percent for barrel-type cacti (*Ferocactus* spp., *Sclerocactus* spp., and *Echinocereus* spp.), 15 percent for cholla cacti (*Cylindropuntia* spp. and *Grusonia* spp.), and 15 percent for yuccas (*Yucca* spp.). A list of all plant species recorded during the inventory is included as Appendix B.

4.1.4 Frequency Data Collection

Frequency describes the abundance and distribution of species. Frequency measurements are an easy and efficient method for monitoring changes in a plant community over time. Frequency is the number of times a species is present in a given number of sampling units, usually expressed as a percentage.

On rangeland, regeneration of desirable plants maintains good range conditions. Grazing by too many animals (livestock and wildlife) or heavy utilization by a few animals results in overuse, loss of vigor, and disappearance of the preferred and desirable plants. Deterioration of range vegetation begins when less valuable forage species replace the desirable species. If deterioration continues, invaders and noxious weeds replace the less valuable forage species. The frequency and composition of preferred and desirable species compared to less valuable forage is used as an indication of range condition.

4.1.5 Cover Data Collection

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

Ground cover data can assist in determining the soil stability and proper hydrologic function and biotic integrity of a site. For trend comparisons in herbaceous plant communities, basal cover is generally considered to be the most stable because it does not vary as much from climatic and seasonal conditions (compared to canopy cover). Canopy cover can vary widely over the course of the growing season, which can make it difficult to compare results from different portions of a large area where sampling takes weeks or months. For this reason, future ground cover monitoring for each ecological site within each grazing unit should replicate the sampling period from this baseline inventory.

The line-point intercept method employed on this study is described in *Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems* (Herrick et al. 2005). There are 50 point measurements spaced evenly (every 4 feet) along a 200–foot measuring tape anchored securely at each end. At each point along the transect, a sighting device (pin flag) was placed perpendicular to the ground along the measuring tape. Three layers of point intercept were recorded as the pin flag was dropped into place: Top Canopy, Lower Canopy, and Soil Surface. The first cover category is determined by the first plant interception of the pin flag. The species of plant that the pin flag hits is recorded as the "Top Canopy." If no plants are intercepted, "None" is recorded. Up to three additional species intercepted by the pin flag below the top canopy are recorded as "Lower Canopy" layers. If herbaceous or woody litter is intercepted, this is recorded as a lower canopy layer. "Soil Surface" is recorded as either the base of a plant species (See Figure 4.2) or one of the following categories: Rock, Bedrock, Embedded Litter, Duff, Moss, Lichen Crust, or Soil. Bare ground occurs only when the Top Canopy is "None" and there are no Lower Canopy layers, and the Soil Surface is "Soil." Measuring cover by points is considered one of the least biased and most objective cover measures (Bonham 1989). Results of the ground cover data analysis are included in Section 5 Results.

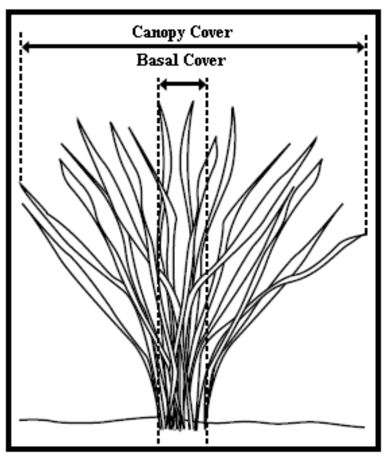


Figure 4-2. Vegetative Cover

Source: Elzinga, Salzer, and Willoughby 1998

4.1.6 Soil Surface Texture Test

At each transect, a small soil pit was dug to expose the soil profile. At diagnostic soil horizons, samples were analyzed using the USDA Soil Texturing Field Flow Chart. The Flow Chart uses a systematic 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. The field crew assigned a texture class to the sample based on its tested content and ribbon characteristics. The results of the soil sample determined or confirmed the soil component using Map Unit Descriptions from the Soil Survey as the primary reference.

4.1.7 Rangeland Health

Rangeland health was evaluated using the qualitative guidelines from the Interagency Technical Reference 1734-6, *Interpreting Indicators of Rangeland Health* (Pellant et al. 2005). The purpose is to measure the degree to which current rangeland conditions are different from what is expected to be there. The current rangeland conditions are compared to a reference state in the ESD. There are 17 condition indicators (such as water flow patterns, soil surface resistance to erosion, invasive plants, etc.) that are combined to evaluate three rangeland health attributes (biotic integrity, hydrologic function, soil and site stability). Not all ecological site descriptions have reference sheets for the 17 indicators, so rangeland health was evaluated only for those sites with reference sheets.

4.2 Post-Field Methodology

After all field data were collected, the data were downloaded into a database. Harvested biomass was air dried for 10 days, and dry weights were entered individually into the database for each species on each transect. This initial field dataset was adjusted to compare the collected production data to the amount of vegetation that would occur in a “normal” year. These adjustments included factors for utilization, climate, growth curve, and ADW.

After the production estimates were “normalized” for every species on every transect, results were grouped by ecological sites within each analysis unit. Further analyses included similarity indices, available forage based on forage value and harvest efficiency factors, stocking rates, and carrying capacity.

4.2.1 Reconstructed Annual Production

Pounds per acre were estimated from field data through a series of calculations derived from technical reference 1734-7 Ecological Site Inventory (Habich 2001) and the National Range and Pasture Handbook (USDA NRCS 2003). This methodology reconstructs the measured weight of biomass to a “normal” annual air-dry production weight that accounts for physical, physiological, and climatological factors. First, the field-estimated green weight of a species was multiplied by an estimation correction factor and then by a reconstruction factor. The reconstruction factor is the percent ADW of the species divided by the product of the utilization, normal precipitation for the current water year, and growth curve for that time of year, as shown in the formula below:

$$\textit{Corrected Green Weight} = \frac{\textit{(\% ADW)}}{\textit{(\% Utilization) (\% Normal Precipitation) (\% Growth Curve)}}$$

The result of multiplying the green weight of a species by the reconstruction factor is the “total reconstructed annual production.” Details of each of the elements in this equation are described in the following sections.

4.2.1.1 Estimation Correction Factor

The harvested plots provide the data for correction factors of estimated species weights from the field. Measured (harvested) weights of species were divided by the estimated weights of the same species in the same plot to establish a correction factor. This correction factor was then applied to all estimations of that species for the entire transect. For example, if alkali sacaton (*Sporobolus airoides*) was estimated to weigh 10g but the harvested weight was measured as 9g, then all estimates of alkali sacaton for that transect were multiplied by a correction factor of 0.90 as presented below:

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

If the total estimated weight for alkali sacaton on all plots in this transect was 80g, the resulting corrected estimated green weight (g) x correction factor = 80g x 0.90 = 72g. The corrected green weight is 72g.

4.2.1.2 Biomass ADW Conversion

The ADW percentage is part of the reconstruction factor and accounts for the amount of water contained in the plant. The purpose is to remove the weight of water from the weight of the actual plant forage. All biomass collected from harvested plots was placed in paper bags; tracking information (date, transect identification, plot number, and species) was recorded on the bags. Harvested, or green, weights were immediately obtained 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 10 days. All bags were then weighed again, and dry weights were recorded into the dataset. After drying, the weights were divided by the green weights to give a percent ADW in grams to be used in the reconstruction factor. In the example in Section 4.3.1.1, the green weight of the harvested biomass was 9g. If the dry weight in the lab was measured at 8g, then the percent ADW would be 0.89.

$$\%\ \textit{ADW} = \frac{\textit{Dry Weight (lab)}}{\textit{Green Weight (field)}} = \frac{8g}{9g} = 0.89$$

This value (0.89) represents the numerator of the reconstruction factor. The three values in the denominator are explained in the following sections. (Note: For species in a transect that were not harvested, an average percent ADW was used that was generated from the same species in the same analysis unit. In the case of remaining species, the percent ADW defaulted to 1.)

4.2.1.3 Utilization

The utilization estimate is applied to adjust for portions of plants that were not measured due to grazing of the plant prior to the survey. The default is 100 percent un-grazed. Grazed or utilized species were measured according to the average amount of plants that remained un-grazed near the transect. For example, if alkali sacaton was recorded at a utilization factor of 90 percent un-grazed, then the amount of alkali sacaton estimated would represent only 90 percent of the total.

Utilization = 0.9

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

4.2.1.4 Growth Curves

Growth curves are used to reconstruct the aboveground 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 that has not yet grown and, thus, was not measured during the vegetation inventory. A weight measurement taken in June would normally be less than a measurement of the same plant taken in September, when the plant is nearing full growth. A growth curve calculates the average growth by month of plant species throughout the year within a specific region. For example, if alkali sacaton was measured in a transect during August, that measurement may represent only 88 percent of the full growth of that species.

Growth curves typically are presented in an ecological site description. However, many of the ESDs in the survey area did not have growth curves or had incorrect growth curves. If the growth curve in the ESD was determined to be incorrect, then the ESD was replaced with the most suitable growth curve in the same common resource area, if possible.

The growth curves used in this analysis are associated with the Common Resource Areas (CRAs) found within the project. A CRA is a subdivision of an MLRA and is defined by soils, climate, and landscape conditions. Three CRAs—35.2, 35.3, and 35.6—were found to be present in the project region. The charts below show the percent production by month for each CRA growth curve.

Percent production by month in AZ3521, 35.2, 6-10” p.z. (all sites) growth curve.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	9	20	27	14	10	11	5	3	0	0

Percent production by month in AZ3531, 35.3, 10-14” p.z. (all sites) growth curve.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	3	17	18	10	19	20	10	1	1	0

Percent production by month in AZ3561, 35.6, 13-17” p.z. (all sites) growth curve.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	5	16	17	15	15	15	11	5	0	0

Note: p.z. = precipitation zone

Each growth curve entry was a pro-rated value according to the day of the month. To illustrate, assume that a transect located in CRA 35.2 was sampled August 21. The first step in the growth curve analysis is to estimate, using growth curve AZ3521, the percentage of growth completed up to that date by adding up the preceding monthly categories as illustrated below:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	1%	9%	20%	27%	14%	10%	11%	5%	3%	0%	0%

Then, for the month of August, 21 days would need to be prorated and added to the total. The value is determined by dividing the percent of growth occurring in August (11 percent) by the 31 days that occur during the month of August. This calculation yields a rate of 35 percent per day. The number of days that have occurred up to that date (21) is multiplied by the daily rate (35 percent) for 7.35 percent. This is added to the 81 percent that had occurred up to the end of July for a total of 88.35 percent of the growth curve completed. The growth curve value for the example sample collected on August 21 is 0.8835.

Growth Curve = 0.88

Therefore, the total weight of the species reported in that transect is divided by 0.88 to bring the measured weight up to 100 percent of growth for the year.

4.2.1.5 Percent Normal Production

The Percent Normal Production in a sample area is directly affected by the relationship between growing conditions, especially precipitation amount, timing of precipitation, and temperature. Production varies each year depending on the favorability of these growing conditions. Biomass production measurements from year to year are not accurate without adjusting production to a "normal" year. The factors of precipitation, timing, and temperature are extremely difficult factors to quantify and apply to biomass production because the impacts vary by species. For this inventory, the variation in precipitation was used as the value for normal production percentage. All precipitation gauges in Northern (Shiprock) Navajo Agency were used in the calculations to determine the percent of normal production. The 13 years prior to 2014 were averaged and used as an historic comparison. The 2014 water year was 93 percent of the average, or just under "normal." It should be taken into consideration that the current long-term drought has been in effect longer than the 13 years of averaged "normal" condition.

For the example calculation, the water year was 102 percent of the average.

Percent Normal Production = 1.02

The total weight of the species in the transect is divided by 1.02 to bring the measured water year down to 100 percent. Normalizing the precipitation to an average year helps to prevent over-allocating forage.

4.2.1.6 Reconstruction Equation

Using the example carried through the previous sections, Ecosphere began with an estimated green weight (in the field) of 80g of alkali sacaton, multiplied by the estimation correction factor for a corrected green weight of 72g. This corrected green weight of 72g was then multiplied by the reconstruction equation:

$$\textit{Reconstruction Equation} = \frac{0.89}{(0.90 \times 1.02 \times 0.88)} = 1.10$$

The formula for the reconstruction equation, as explained earlier in Section 4.2.1, is repeated here:

$$\textit{Corrected Green Weight} = \frac{(\%\ ADW)}{(\%\ Utilization)\ (\%\ Normal\ Precipitation)\ (\%\ Growth\ Curve)}$$

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

$$72g \times \frac{0.89}{0.90 \times 1.02 \times 0.88} = 72g \times 1.10 = 79.20g$$

The corrected green weight from the example above (72g) multiplied by the reconstruction factor (1.10) results in a total reconstructed annual production of 79.20g.

4.2.1.7 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 also factored into production estimates. The plot size, 9.6 ft^2, was repeated ten times in each transect, thereby creating 96 ft^2 of sampling area. The sampling area size accounts for the conversion from grams to pounds (453.59 grams per pound) and ft^2 to acres (43,560 ft^2 per acre), which calculates into a 1:1 conversion (Coulloudon et al. 1999a). Therefore, in this case the conversion factor equals one and is not explicitly included into the total reconstruction annual production equation. Hence, in the example, there were 79.20 pounds per acre of alkali sacaton. The value 79.20 represents the total reconstructed annual production of the species in pounds per acre.

4.2.2 Calculating Ground Cover

Ground cover calculation categories were measured in terms of top canopy, basal cover, and bare soil surface. Fifty ground cover point intercepts were measured, so ground cover categories were divided by 50 and the result was multiplied by 100 to estimate a percentage of ground cover for each transect. For example, if 30 hits were recorded for bare ground, the percent bare ground on that transect would be 60 percent.

$$\frac{30\ \text{“bare ground” hits}}{50\ \text{total hits}}\ X\ 100 = 75\%\ \text{bare ground}$$

It is important to note that bare ground refers to situations where soil was the only substrate present. A lack of foliar or basal cover in conjunction with duff, litter, rock, or bedrock is not considered bare ground. This is because true bare soil has less soil stability than duff, litter, rock, or bedrock. Cover data was averaged by analysis unit.

4.2.3 Calculating Frequency

Species frequency was measured when weights were estimated for all species in each production plot using the intensive method (Herrick et al. 2005). For example, if alkali sacaton occurred in six of the ten plots on a given transect, the frequency would be 60 percent. Frequency of species by plot on each transect is included in the database of production data with this report in digital format. Frequency of the five most common species (including large shrubs) to occur on transects within each analysis unit is presented in Section 5.

4.2.4 Calculating Similarity Index

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

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

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

The similarity index for this vegetation inventory was calculated by comparing the estimated production value for each plant species to the ESD. The ESD has an assigned production value for each species (or group of species) expected to occur in the reference community. Production that is expected to occur in the ecological site (up to the maximum percent listed) is termed “allowable production.” If an individual species (or group of species) is not listed in the ESD, no production is assigned or “allowed” from that species. For example, a transect had 79.20 pounds/acre of alkali sacaton. Based on the information in the ESD, the allowable production for alkali sacaton is 50 pounds/acre. No more than 50 pounds may be allowed for toward the similarity index for the transect. If the ESD had listed the allowable percentage of alkali sacaton at 200 pounds/acre, then all 79.20 pounds (and no more) would have been allowed to be counted toward the similarity index for the transect.

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

4.2.5 Calculating Available Forage

The forage value of a species is defined in terms of palatability and availability, as they apply to a particular type of livestock. ESDs list only the values for common plant species; however, the Utah NRCS developed a comprehensive list of species from the Colorado Plateau area. This list was the primary source used to assign forage values to all species recorded in the survey. The list is included with the digital Excel data for this report. The plant list in Appendix B includes the forage values for the least palatable season for different livestock (sheep, goats, cattle). Species are grouped into categories, and each category is weighted according to palatability. The categories recognized by the National Range and Pasture Handbook (USDA NRCS 2003) have been amended to include both toxic and injurious notations in addition to palatability and are as follows:

- **Preferred** plants – These plants are abundant and furnish useful forage for a reasonably long grazing period. They are preferred by grazing animals. Preferred plants are generally more sensitive to grazing misuse than other plants, and they decline under continued heavy grazing.

- **Desirable** plants – These plants are useful forage plants, although not highly preferred by grazing animals. They either provide forage for a relatively short period, or they are not generally abundant in the stand. Some of these plants increase, at least in percentage, if the more highly preferred plants decline.

- **Emergency** (or **Undesirable**) plants – These plants are relatively unpalatable to grazing animals, or they are available for only a very short period. They generally occur in insignificant amounts, but may become abundant if more highly preferred species are removed.

- **Nonconsumed** plants – These plants are unpalatable to grazing animals, or they are unavailable for use because of structural or chemical adaptations. They may become abundant if more highly preferred species are removed.

Toxic plants (denoted in tables and in the database with a superscript t) – 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.

Injurious plants (denoted in tables and in the database with a superscript i) – These plants are physically harmful to grazing animals. Specifically, these plants usually have spines or thorns that irritate the mouths or lower legs of domestic livestock. They may be utilized during seasons when they don’t present serious harm, so these plants also have a palatability rating.

Many species have more than one forage value according to the season of use. For example, muttongrass (*Poa fendleriana*) is considered preferred by sheep in the spring, but only desirable during the remainder of the year. Northen Navajo agency currently allows for year-round grazing, so a single forage value is needed. The lowest seasonal forage value was chosen for each species as a conservative estimate of the forage available and to avoid overgrazing during times of the year when forage palatability is lowest. Ecosphere used forage values during the least palatable season, usually fall or winter, for sheep. Available forage for cattle would need to be calculated separately.

Each forage group is assigned a harvest efficiency factor. The harvest efficiency factor accounts for production that is actually consumed by grazers. Not all annual production is available for livestock consumption due to trampling, loafing, and other non-livestock factors such as loss to disease, insects, or utilization by wildlife. The harvest efficiency factor is applied to the amount of production within a management area, and its purpose is to ensure watershed protection and sustainability of the range resource by limiting allocation of the available forage.

The harvest efficiency factor generally averages 25 percent on rangelands with continuous grazing (USDA NRCS 2003). Using NRCS guidelines, the harvest efficiency factors applied for this project were 35 percent for preferred plants, 25 percent for desirable species, and 15 percent for undesirable/emergency plants. Non-consumed as well as any toxic and injurious species, regardless of their forage value, were excluded from the calculations.

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

4.2.6 Grazing Area Adjustments

The amount of actual land available for grazing was quantified using geographic information systems (GIS) files from the BIA. Home sites, farmland, and roads were buffered and removed from the total acreage available for livestock grazing. Roads were buffered 1.5 to 15 meters from their center line. Washes and streams were also given a ten foot buffer.

Based on livestock behavior, carrying capacity was adjusted to account for distance to water and the steepness of slopes. Distance to water and slope percent were adjusted incrementally (Table 4-1) Slopes up to ten percent had no reduction in carrying capacity; moderate slopes had a 30 percent reduced carrying capacity, while steep slopes had a 60 reduction in carrying capacity. Slopes that are greater than 60 percent are generally inaccessible to livestock and were excluded from the available grazing acres.

Table 4-1. Distance to Water Reduction and Slope/Reductions

Distance to Water/ Reduction	Slope/Reduction
0-1 Mile/0%	0-10%/0%
1-2 Miles/50%	11-30%/30%
>2 Miles/100%	31-60%/60%

Distance to Water/ Reduction	Slope/Reduction
	>60%/100%

Livestock will rarely range more than two miles from a water source Holechek (1988). Areas further than 2 miles from a water source can be considered un-grazeable and that acreage should be removed from stocking rate calculations. Permitting in areas beyond two miles will lead to overgrazing and deterioration. However, if permittees are hauling water to their stock, this should be considered when adjusting carrying capacity.

BIA recommendations include 100 percent stocking rates and carrying capacity between zero and one mile from a water source, 50 percent between one and two miles from the water source, and no grazing more than 2 miles from the water source (Table 4-2).

Water sources included windmill and artesian well data supplied by the BIA and wetland data created by Ecosphere for the Navajo Nation Wetland Mapping Project. Monitoring of the condition, addition, or loss of water sources should be continually updated in the geodatabase and resulting stocking rates.

4.2.7 Initial Stocking Rates and Carrying Capacity

The initial stocking rate and carrying capacities were calculated by the percentage of ecological sites within each analysis unit (compartment or RMU). Carrying capacity for rangeland management purposes is defined as the number of grazing animals that a specified area can support without depleting the forage resources. Carrying capacity may vary annually in response to forage production.

The calculations for carrying capacity are run in a GIS model to calculate the percentage of each ecological site of each soil map unit within each grazing unit. Soil map units that had no transects were not included in the GIS analysis. Carrying capacity numbers are derived by dividing the stocking rate by the total acreage of a given ecological site within an analysis unit.

Stocking rates represent the number of acres needed to support one sheep unit for 1 year. For this project, yearlong numbers are derived from a BIA-approved animal unit month (AUM) of 790 pounds per acre. The AUM is multiplied by 12 months and the result is divided by the animal unit equivalent in order to derive the amount of forage necessary to support one sheep for a year. The stocking rate is determined by dividing this number by the average amount of available forage in each ecological site within an analysis unit. Table 4.2 is an example calculation for sheep using an available forage amount of 100 pounds per acre.

Table 4-2. Example Stocking Rate Calculation

Description	Calculation
AUM multiplied by 12 months = Amount of forage needed to support one animal unit for a year.	(790 x 12) = 9,480 lbs per acre
Amount of forage needed to support one animal unit for a year divided by sheep forage equivalent of AUM (4) = Amount of forage to support one sheep for a year.	9,480/4 = 2,370 lbs per acre
Amount of forage needed to support one sheep for a year/available forage = Number of acres necessary to provide the yearly forage amount for one sheep (stocking rate).	2,370/100 lbs per acre = 23.7 acres per year

Notes: AUM = animal unit month; lbs = pounds.

By law (25 CFR §167), the sheep forage equivalent of one animal unit in Northern Navajo Agency is four sheep. In other words, 790 pounds of forage can support one animal unit per month, or four sheep for a month, as shown in Figure 4.3.

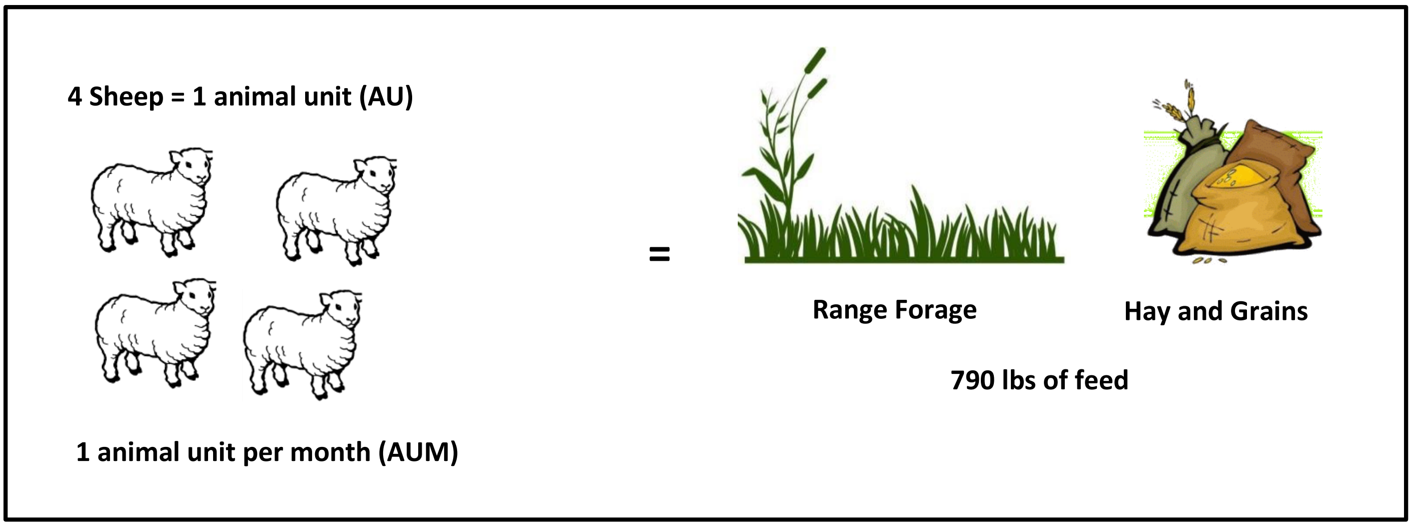


Figure 4-3. Amount of forage to support 1 animal unit (AU).

5. RESULTS

A total of 561 transects were located on the study area in District 13, which included the communities of Burnham, Nenahnezad, San Juan, and Upper Fruitland. The attributes collected at each transect were total annual production, ground cover, and species frequency. From the production data, forage production and initial stocking rates were calculated by ecological sites and soil types in soil map units within each analysis unit (3 communities and 15 pastures in 7 RMUs).

The total size of the study area is 398,284.9 acres. Areas that were considered non-range were removed from the analysis; these included 180,339.5 acres of roads, home sites, mine lands, agricultural lands, and water as well as acres of steep slopes over 60 percent which are considered inaccessible to livestock. That leaves only 217,945.4 grazeable acres in the study area. Of these acres, 16,434 could not be analyzed due to a lack of transects within the ecological sites in each analysis unit.

The results of the data analysis indicate the carrying capacity of the range resource is currently exceeded. In the study area 10, 505 sheep units year long are currently permitted. Initial calculations show the slope adjusted carrying capacity to be 1,419 sheep units for the entire study area. Sections 5 and 6 discuss which areas are in relatively good or poor condition, and how to improve the range resource.

5.1 Study Area Summary Results

The results of this study have been broken down into the following categories: carrying capacity, initial stocking rates, available forage, ground cover, and species frequency. An initial description of each category is presented below, followed by a more detailed analysis of each analysis unit (community and RMU and pasture).

Initial Stocking Rates and Carrying Capacity

In general, the derived stocking rates reflect an accurate depiction of available forage. However, in some cases only one transect was located in an ecological site. If the single transect happened to have extra high or extra low production, the resulting high or low stocking rate was applied to all acres of the ecological site within the analysis unit. In these situations, it may be necessary to gather additional data prior to adjusting animal numbers.

Results include the number of transects in each ecological site in each analysis unit. Sites without transects, and therefore no carrying capacity, can be identified and range managers can collect site-specific data in those areas in order to assess the available forage and calculate carrying capacity. The areas are also visible on the accompanying maps.

A carrying capacity is not evenly dispersed across an analysis unit; therefore, it is important to examine the stocking rates of each ecological site to determine which areas may be able to tolerate more livestock and which areas may be exceeding the carrying capacity.

Available Forage Production

Available forage is the portion of the total reconstructed production classified as preferred, desirable, and emergency forage (excludes toxic, injurious and non-consumed plants). Available forage is used to calculate stocking rates. Forage production is low to moderate throughout the study area. The highest average production of available forage is in the Diswood East pasture (45 pounds [lbs]/acre), followed by the Monsisco Mesa RMU (43 lbs/acre), and the Yazzie RMU (37.5 lbs/acre). The remaining units average about 16 lbs/acre. The highest producing ecological sites are R035XB016NM in the Nenahnezad/San Juan Community, R035XB002NM in the Yazzie RMU and Diswood South pasture, R035XB005NM in the Diswood East and Diswood North pastures, and R035XB001NM in the Upper Fruitland Community and the Monsisco Mesa RMU.

The ecological site table, in the results section for each analysis unit, presents available forage values and the number of transects for each ecological site, as well as the initial grazeable acres, initial and adjusted stocking rates and carrying capacities.

Frequency and Composition

A list of the most commonly encountered species by transect and the top contributors of biomass production is included in the results section of each analysis unit. The individual species frequency data (by the ten plots within each transect) are included in the electronic database. Several species are repeatedly found in the top five of the frequency and composition data for most of the analysis units. These include James' galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), prickly Russian thistle (*Salsola tragus*), blue grama (*Bouteloua gracilis*), and alkali sacaton (*Sporobolus airoides*).

Ground Cover

Ground cover values provide a baseline for determining the trend in future studies. An average of all ground cover data for the Land Management District 13 study area is included for comparison (Figure 5-1). The most represented ground cover category across the study area is bare ground. The highest percentage of bare ground is found in the Nenahnezad and Burnham communities with the majority of active erosion being in the southern third of the Burnham community, especially in the vicinity of Hunter Wash. Bare ground is of particular concern in the study area as the prevalence of sandy and clayey soils increases the likelihood of both wind and water erosion.

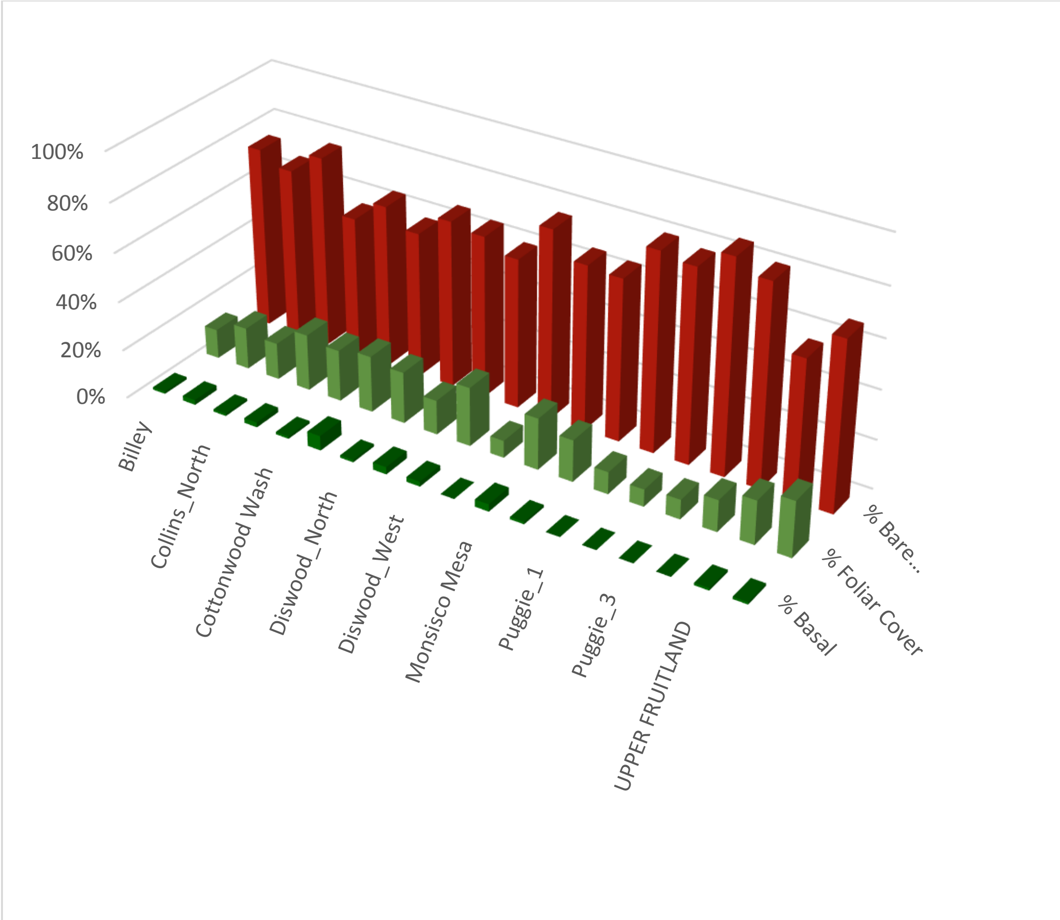


Figure 5-1. Cover Results for Study Area

Rangeland Health

The 17 Indicators of Rangeland Health are explained in Interagency Technical Reference 1734-6, *Interpreting Indicators of Rangeland Health*. The purpose is to measure the degree to which current rangeland conditions are different from what is expected to be there. The current rangeland conditions are compared to a reference state in an appropriate ecological site description. Reference sheets were only available on 28 of the transects in the project area, all of which were in Burnham and Nenahnezad/San Juan communities. The 17 Indicator data for each transect is included in the electronic data with this report. Averages of each indicator within an ecological site are presented in charts for the Burnham and Nenahnezad/San Juan results sections.

Results by Analysis Unit

The following section provides a brief discussion of the results and current plant communities found in each analysis unit. This is followed by a plate displaying acreage summaries, cover calculations, similarity index, and initial and adjusted carrying capacity for each ecological site. Maps are also included of each area, showing soils, transect locations, slopes and distance to water.

5.2 Communities

The communities of Burnham, Upper Fruitland, and Nenahnezad/San Juan combined were analyzed separately and did not include data from transects inside RMUs.

5.2.1 Burnham

Ecological Site Summary

The Burnham community is the largest analysis unit in the study area and contains large areas of grassland, numerous badland sites, and several large washes. It has 154,067 grazeable acres and 279 transects in 17 ecological sites. This includes two transects (BURN_117 and BURN_328) that could not be correlated with an ecological site due to poor soil mapping or soil descriptions and 7 transects that had no correlated ecological site in the soil survey (BURN_008, BURN_098, BURN_271, BURN_273, BURN_300,BURN_320, BURN_328 and BURN_334).

The most productive ecological site, in terms of available forage, is the R035XB028NM site. This is a sandy bottom site and can be found along Chaco and Hunter Wash in the southern portion of the community. Soils tend to be deep, well-drained and can be strongly alkaline. The reference plant community contains a mix of cool and warm-season grasses and a moderate shrub component. Dominant species include western wheatgrass (*Pascopyrum smithii*), alkali sacaton (*Sporobolus airoides*), Indian ricegrass (*Achnatherum hymenoides*), spineless horsebrush (*Tetradymia canescens*), and fourwing saltbush (*Atriplex canescens*). Disturbance factors lead to invasions by non-native species such as salt cedar (*Tamarix ramosissima*), cheatgrass (*Bromus tectorum*), and prickly Russian thistle (*Salsola tragus*). Native species that tend to increase following disturbance include rubber rabbitbrush (*Ericameria nauseosa*) and thrift mock goldenweed (*Stenotus armerioides*). Available forage is currently being supplied mainly by alkali sacaton, Indian ricegrass, James' galleta (*Pleuraphis jamesii*), coyote willow (*Salix exigua*), and rubber rabbitbrush. Some amount of site deterioration has occurred given the presence of prickly Russian thistle and the abundance of rubber rabbitbrush. Although salt cedar was not measured in this study, its presence was noted in the sampled areas.

One of the largest ecological sites, and the one with the highest carrying capacity, is the R035XB035NM site. This site occurs on sandy upland areas and is most prevalent in the southern portion of the Burnham community, south of Hunter Wash. Soils tend to be deep sand and the reference plant community is made up primarily of grasses like Indian ricegrass, James' galleta, and dropseed (*Sporobolus* spp.). Shrubs and forbs are not as common but can include globemallow (*Sphaeralcea* spp.), rose heath (*Chaetopappa ericoides*), Cutler's jointfir (*Ephedra cutleri*), broom snakeweed (*Gutierrezia sarothrae*), Greene's rabbitbrush (*Chrysothamnus greenei*), and fourwing saltbush. Site degradation leads to invasions/increases of flatspine bur ragweed (*Ambrosia acanthicarpa*), annual mustards, sandhill muhly (*Muhlenbergia pungens*), and Greene's rabbitbrush. At this time, most forage is being produced by James' galleta, rubber rabbitbrush, sand sagebrush (*Artemisia filifolia*), and tall dropseed (*Sporobolus contractus*). Transect data recorded that sandhill muhly is quite abundant and a fair amount of annual mustards were also found in the sampled plant community.

Several ecological sites are currently producing very low amounts of available forage, especially the badland and R035XB024NM sites. There is no written description for badlands, but even without disturbance, these areas tend to have little vegetation and cannot sustain more than low intensity grazing pressure. The R035XB024NM site is associated with saline bottoms. One transect fell within this site and is located in the upper reaches of Hunter Wash. Soils tend to have a high clay component and are moderately sodic and mildly to moderately alkaline. The reference plant community contains mostly grasses with a minor component of shrubs and forbs. Representative species include alkali sacaton, James' galleta, bottlebrush squirreltail (*Elymus elymoides*), mound saltbush (*Atriplex obovata*), and fourwing saltbush. As the site deteriorates, the plant community loses perennial grasses and annual grasses and forbs increase. The sampled location is dominated by black greasewood (*Sarcobatus vermiculatus*) with prickly Russian thistle, Mojave seablite (*Suaeda moquinii*), and a small amount of alkali sacaton in the understory.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Burnham community are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 91% of all transects)
2. James' galleta (*Pleuraphis jamesii*) (occurred on 78% of all transects)
3. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 72% of all transects)
4. blue grama (*Bouteloua gracilis*) (occurred on 40% of all transects)
5. false buffalograss (*Monroa squarrosa*) (occurred on 39% of all transects)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (15,838 lbs/acre)
2. prickly Russian thistle (*Salsola tragus*) (12,686 lbs/acre)
3. alkali sacaton (*Sporobolus airoides*) (6,662 lbs/acre)
4. sandhill muhly (*Muhlenbergia pungens*) (4,461 lbs/acre)
5. blue grama (*Bouteloua gracilis*) (3,096 lbs/acre)

Ground Cover

Bare Ground is the most commonly encountered category of ground cover in the Burnham community and the percentage is slightly below the study area average. Foliar cover and Basal cover are slightly above average. Wind and water erosion are severe at about 17 percent of all transect locations.

Rangeland Health

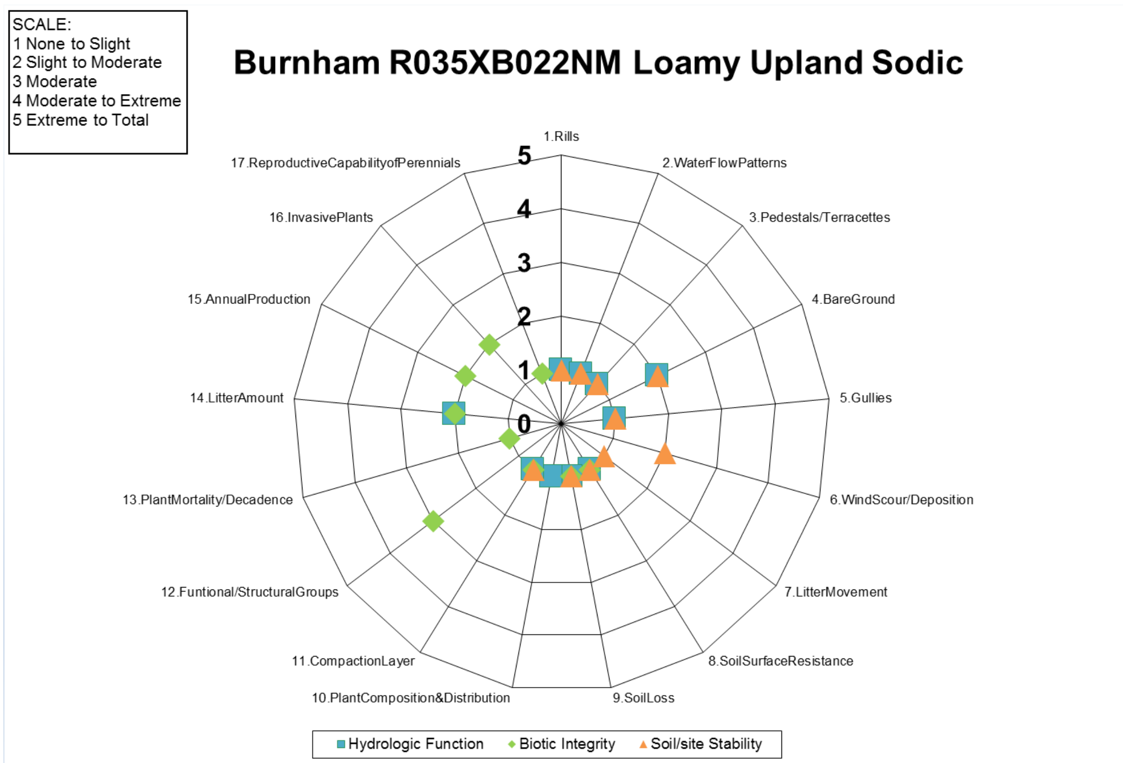
In Burnham there were three ecological sites with reference sheets for the 17 Indicators of Rangeland Health. There were 24 transects in these ecological sites. Most transects (15) were located in the R035XB204AZ Sandstone Upland 6-10" p.z. site. Only one transect was located in the R035XB022NM

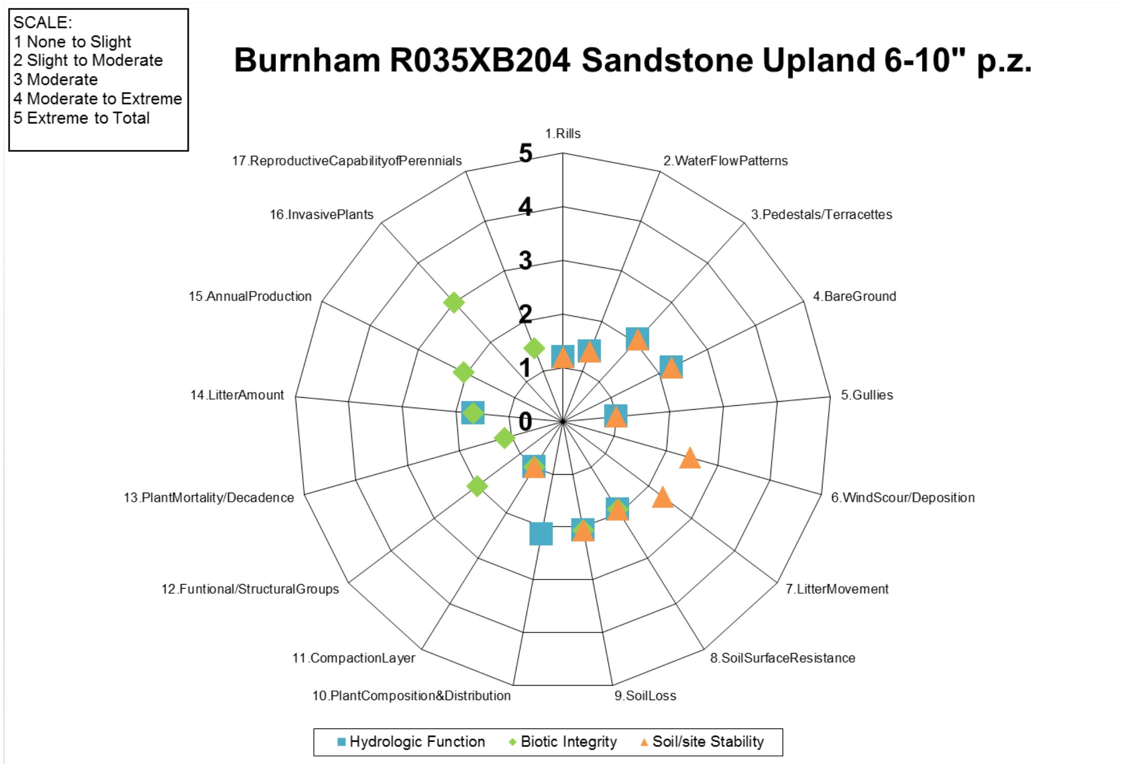
Loamy Upland sodic site, and eight transects were located in the R035XB268 Shale Hills 6-10" p.z. site. Table 5-1 shows the degree of departure from the reference community for each rangeland health attribute.

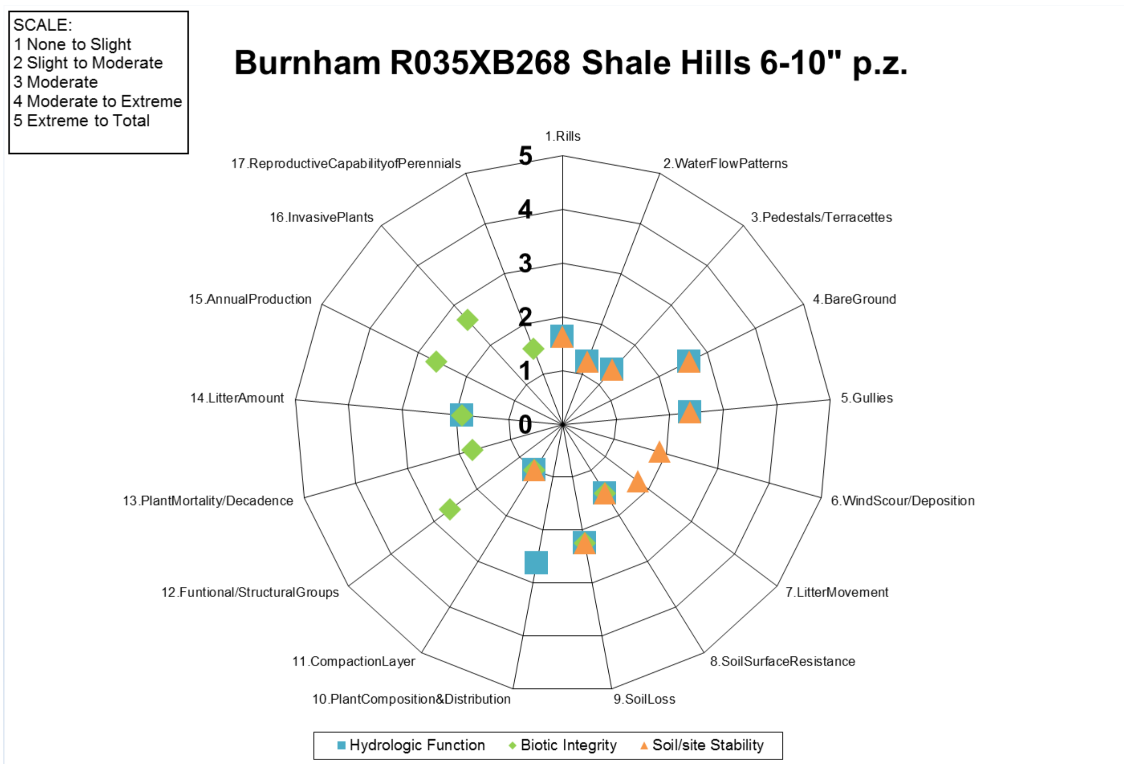
Table 5-1. Rangeland Health in Burnham

Ecological Site	Soil and Site Stability	Hydrological Function	Biotic Integrity
R035XB022NM Loamy Upland sodic	None to Slight	Slight to Moderate	Slight to Moderate
R035XB204AZ Sandstone Upland 6-10" p.z.	Slight to Moderate	Slight to Moderate	Slight to Moderate
R035XB268AZ Shale Hills 6-10" p.z.	Slight to Moderate	Slight to Moderate	Slight to Moderate

Data for the 17 indicators for each ecological site is included in the following graphs by ecological site.




SCALE:
1 None to Slight
2 Slight to Moderate
3 Moderate
4 Moderate to Extreme
5 Extreme to Total
Burnham R035XB204 Sandstone Upland 6-10" p.z.
1.Rills
2.WaterFlowPatterns
3.Pedestals/Terracettes
4.BareGround
5.Gullies
6.WindScour/Deposition
7.LitterMovement
8.SoilSurfaceResistance
9.SoilLoss
10.PlantComposition&Distribution
11.CompactionLayer
12.Funtional/StructuralGroups
13.PlantMortality/Decadence
14.LitterAmount
15.AnnualProduction
16.InvasivePlants
17.ReproductiveCapabilityofPerennials
0
1
2
3
4
5
Hydrologic Function
Biotic Integrity
Soil/site Stability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3 Moderate
4 Moderate to Extreme
5 Extreme to Total
Burnham R035XB268 Shale Hills 6-10" p.z.
1.Rills
2.WaterFlowPatterns
3.Pedestals/Terracettes
4.BareGround
5.Gullies
6.WindScour/Deposition
7.LitterMovement
8.SoilSurfaceResistance
9.SoilLoss
10.PlantComposition&Distribution
11.CompactionLayer
12.Funtional/StructuralGroups
13.PlantMortality/Decadence
14.LitterAmount
15.AnnualProduction
16.InvasivePlants
17.ReproductiveCapabilityofPerennials
0
1
2
3
4
5
Hydrologic Function
Biotic Integrity
Soil/site Stability

Analysis Unit BURNHAM

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		154,067.30
Non-Grazeable Acres	Developed	206.84
	Hydro	1,247.62
	Roads	817.93
	Slope >60%	114.94
	Soils	23,610.52
Grazeable Acres		128,069.45

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	0.0
Maximum	67.0
Median	14.0

Summary of Cover by Analysis Unit

Foliar Cover	16.69%
Bareground	68.93%
Basal	1.88%

Results by Ecological Site in Sheep Units Year Long

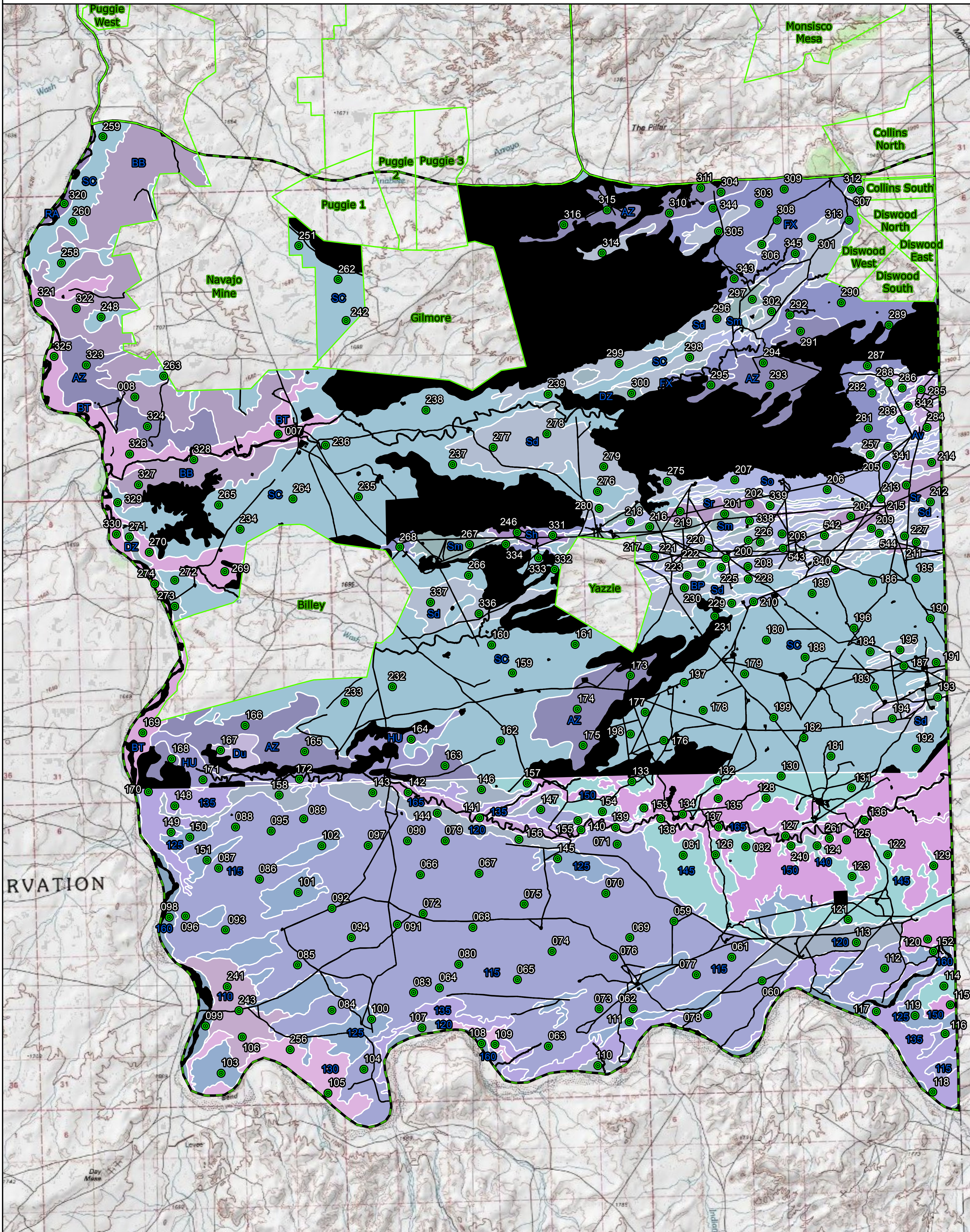
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	67	15.91	25,535.49	148.96	171.43	171.42	122.39
R035XB002NM Sandy	65	21.24	13,232.70	111.58	118.59	118.57	63.17
R035XB035NM Sandy Upland 6-10"	45	26.00	21,735.89	91.15	238.46	238.45	90.17
R035XB005NM Salt Flats	24	27.43	20,470.40	86.40	236.93	236.92	181.23
R035XB204AZ Sandstone Upland 6-10" p.z.	15	18.41	9,978.39	128.73	77.51	77.47	21.58
R035XB274AZ Sandy Loam Upland 6-10" p.z. Saline	12	17.19	5,454.43	137.87	39.56	39.55	4.64
R035XB268AZ Shale Hills 6-10" p.z.	8	9.78	3,683.06	242.33	15.20	15.10	9.35
R035XB022NM Loamy Upland sodic	8	22.91	2,776.56	103.45	26.84	26.83	17.05
R035XB034NM Sandy Terrace 6-10" sodic	6	17.78	906.22	133.30	6.80	6.75	5.74
R035XB003NM Limy	6	42.60	3,645.59	55.63	65.53	65.52	41.25
Dune land	4	5.93	695.94	399.66	1.74	1.72	1.04
R035XB028NM Sandy Bottom 6-10"	3	93.69	561.76	25.30	22.20	22.17	6.52
R035XB033NM Sandy Loam Upland 6-10" sodic	3	20.03	168.91	118.32	1.43	1.36	0.99
R035XB001NM Loamy	2	6.58	2,605.21	360.18	7.23	7.22	2.39
R035XB006NM Shallow	2	3.16	2,101.28	750.00	2.80	2.69	1.31
R035XB030NM Sandy Loam Upland 6-10"	2	6.30	1,643.49	376.19	4.37	4.35	1.77
Riverwash	2	43.46	348.21	54.53	6.39	6.38	1.08
R035XB270AZ Porcelanite Hills 6-10" p.z.	1	18.36	1,218.71	129.08	9.44	9.34	7.49
R035XB024NM Saline Bottom 6-10"	1	0.61	129.46	3,885.25	0.03	0.00	0.00
R035XA130NM Shale Hills	0		1,733.41				
R035XB016NM Clay Loam Terrace (sodic) 7-10"	0		551.36				
Rock outcrop	0		2,508.95				
Badland	0		6,498.99				

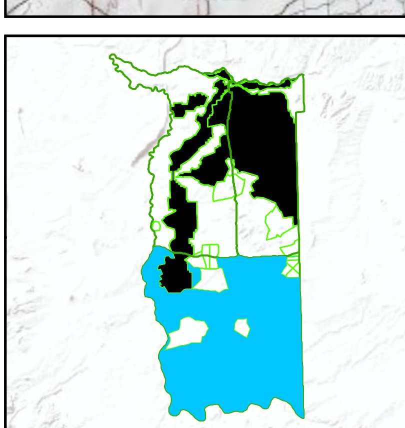
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 154,067
Grazeable Acres*: 128,069
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
1052 Sheep

Burnham Chapter





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 1 2 4
Miles

1:115,000

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

Date: 1/5/2015

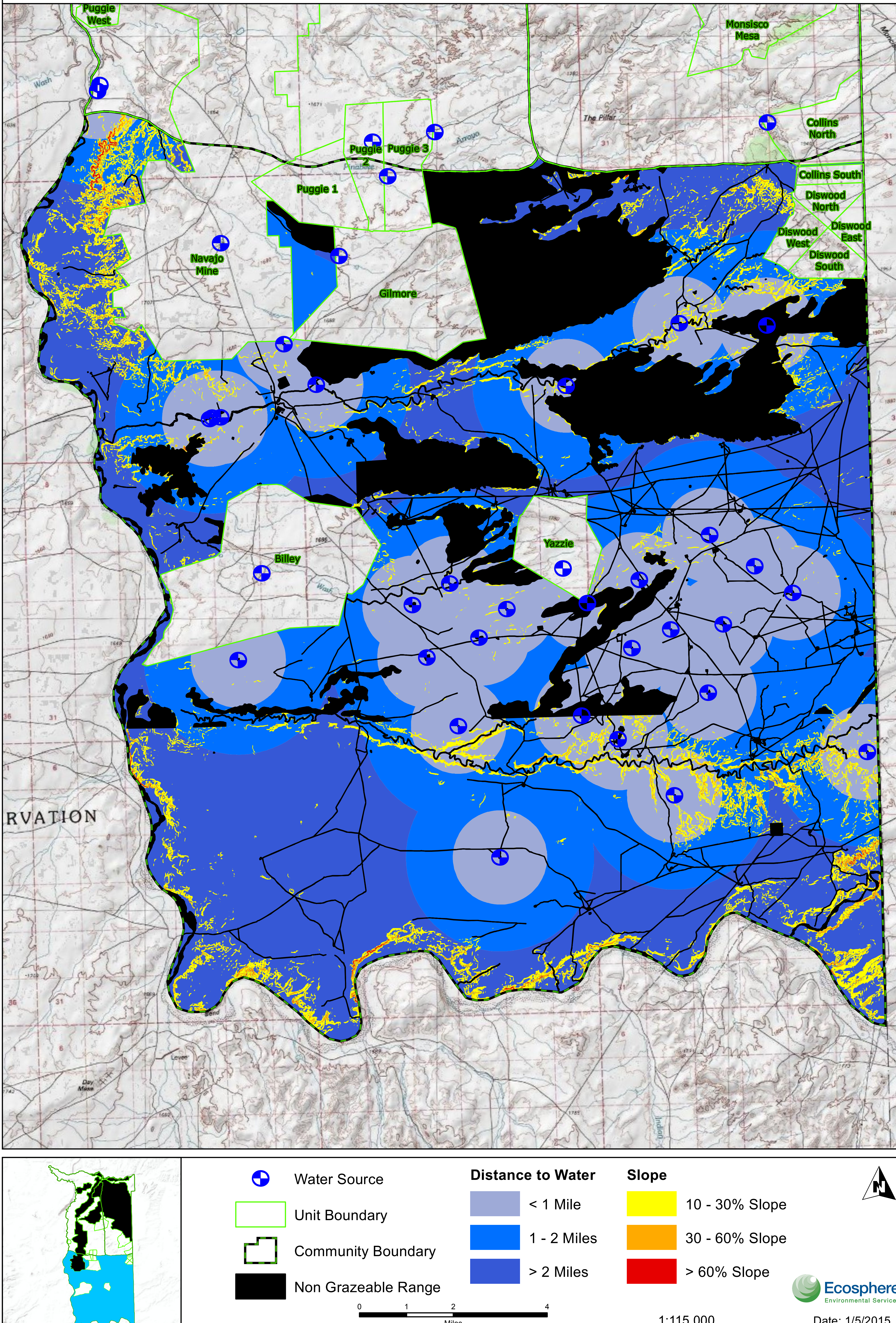
Document Name: P11X17_Soils_Initial_Comm

2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 154,067
Grazeable Acres*: 128,069
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
474 Sheep

Burnham Chapter



Coordinate System: NAD 1983 UTM Zone 12N

1:115,000

Ecosphere Environmental Services

Date: 1/5/2015

Document Name: P11X17_Slope_AdjCC_Comm

5.2.2 Nenahnezad/San Juan

Ecological Site Summary

The Nenahnezad/San Juan communities take in the benches above the San Juan River and extend south through a region of grasslands and badlands. It is bounded on the west by Chaco Wash. There are 97 transects in 17 ecological sites, which includes two transects (NSJ_441 and NSJ_442) that could not be correlated with an ecological site due to poor soil mapping or soil descriptions and 4 transects that had no correlated ecological site in the soil survey (NSJ_421, NSJ_426, NSJ_440 and NSJ_495). The combined Nenahnezad/San Juan analysis unit contains 71,086 acres of grazeable land.

The R035XB016NM site is relatively small, but currently has far more available forage than any other site. This site is associated with clay loam terraces and was sampled at two locations along the edge of Chaco Wash in the northwest corner of the community. Soils tend to be loams and clay loams and are very deep and well-drained. The representative plant community is characterized by both grasses and shrubs with a minor component of forbs. Common species include alkali sacaton (*Sporobolus airoides*), James' galleta (*Pleuraphis jamesii*), Powell's saltweed (*Atriplex powellii*), and mound saltbush (*Atriplex obovata*). With deterioration, the plant community tends to have a greater abundance of annual weeds and black greasewood (*Sarcobatus vermiculatus*). The sampled locations recorded alkali sacaton and slender wheatgrass (*Elymus trachycaulus*) as being the primary contributors to available forage. Weedy, wetland-associated species are also common and include foxtail barley (*Hordeum jubatum*), rough cocklebur (*Xanthium strumarium*), barnyard grass (*Echinochloa crus-galli*), burningbush (*Bassia scoparia*) and Douglas' knotweed (*Polygonum douglasii*).

The second highest amount of available forage was found in the R035XB272AZ site. This site is found in loamy bottoms with soils ranging from sandy loam to clay loam. The reference plant community is comprised mostly of grasses with scattered shrubs in the overstory. Dominant species include saltgrass (*Distichlis spicata*), alkali sacaton, foxtail barley, fourwing saltbush (*Atriplex canescens*), and rubber rabbitbrush (*Ericameria nauseosa*). As the site declines, species like salt cedar (*Tamarix ramosissima*), prickly Russian thistle (*Salsola tragus*), and black greasewood tend to invade or increase. At this time, black greasewood and prickly Russian thistle are dominant in the plant community, but the perennial grass alkali sacaton is also a main component. Although not abundant, the toxic forb, saltlover (*Halogeton glomeratus*) is also present.

The highest carrying capacity is associated with the R035XB007NM site. This is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush, and sand sagebrush (*Artemisia filifolia*). Most available forage is currently being produced by Indian ricegrass, alkali sacaton, and James' galleta. Prickly Russian thistle is well established within the plant community at this time.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Nenahnezad/San Juan community are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 89% of all transects)
2. James' galleta (*Pleuraphis jamesii*) (occurred on 57% of all transects)
3. saltlover (*Halogeton glomeratus*) (occurred on 43% of all transects)
4. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 43% of all transects)
5. false buffalograss (*Monroa squarrosa*) (occurred on 37% of all transects)

Species by Weight

1. prickly Russian thistle (*Salsola tragus*) (17,369 lbs/acre)
2. alkali sacaton (*Sporobolus airoides*) (3,452 lbs/acre)
3. saltlover (*Halogeton glomeratus*) (2,092 lbs/acre)
4. James' galleta (*Pleuraphis jamesii*) (798 lbs/acre)
5. black greasewood (*Sarcobatus vermiculatus*) (632 lbs/acre)

Ground Cover

The percentage of bare ground in the Nenahnezad/San Juan analysis unit is a little below the study area average, while basal cover is average, and foliar cover is slightly above average. Most of the more advanced erosion is taking place along the western edge of the analysis unit, just adjacent to Chaco Wash.

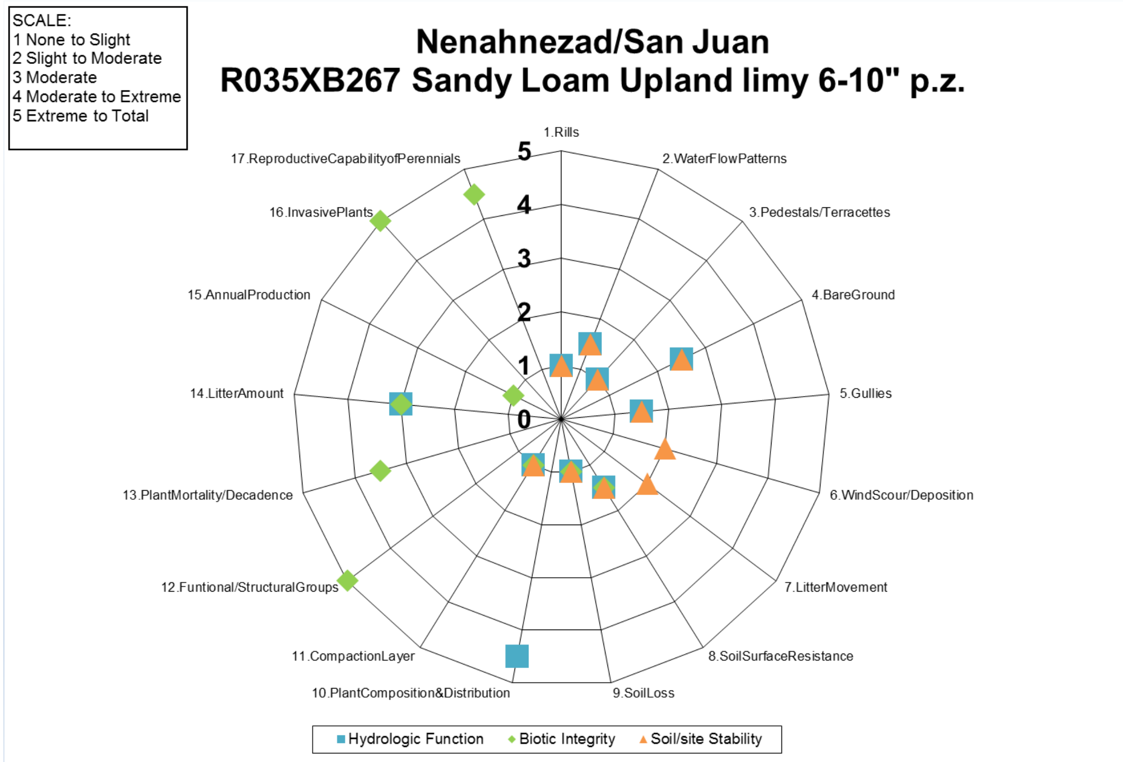
Rangeland Health

In Nenahnezad/San Juan there were two ecological sites with reference sheets for the 17 Indicators of Rangeland Health. There were two transects in each of the ecological sites. Table 5-2 shows the degree of departure from the reference community for each rangeland health attribute.

Table 5-2. Rangeland Health in Nenahnezad/San Juan

Ecological Site	Soil and Site Stability	Hydrological Function	Biotic Integrity
R035XB267AZ Sandy Loam Upland 6-10" p.z. Limy	Slight to Moderate	Slight to Moderate	Moderate
R035XC328AZ Cobbly Slopes 10-14" p.z.	Slight to Moderate	Slight to Moderate	Slight to Moderate

Data for the 17 indicators for each ecological site is included in the following graphs.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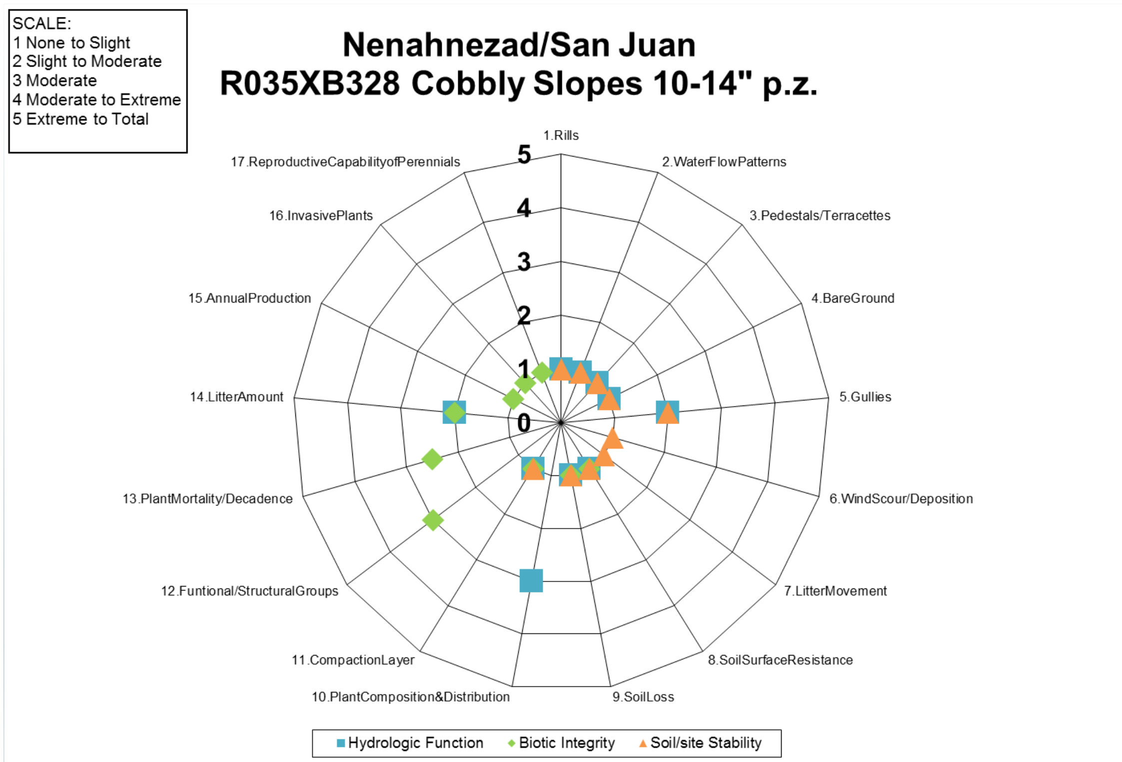
3 Moderate
4 Moderate to Extreme
5 Extreme to Total
Nenahnezad/San Juan
R035XB267 Sandy Loam Upland limy 6-10" p.z.
1.Rills
2.WaterFlowPatterns
3.Pedestals/Terracettes
4.BareGround
5.Gullies
6.WindScour/Deposition
7.LitterMovement
8.SoilSurfaceResistance
9.SoilLoss
10.PlantComposition&Distribution
11.CompactionLayer
12.Funtional/StructuralGroups
13.PlantMortality/Decadence
14.LitterAmount
15.AnnualProduction
16.InvasivePlants
17.ReproductiveCapabilityofPerennials
0
1
2
3
4
5
Hydrologic Function
Biotic Integrity
Soil/site Stability


SCALE:
1 None to Slight
2 Slight to Moderate
3 Moderate
4 Moderate to Extreme
5 Extreme to Total
Nenahnezad/San Juan
R035XB328 Cobbly Slopes 10-14" p.z.
1.Rills
2.WaterFlowPatterns
3.Pedestals/Terracettes
4.BareGround
5.Gullies
6.WindScour/Deposition
7.LitterMovement
8.SoilSurfaceResistance
9.SoilLoss
10.PlantComposition&Distribution
11.CompactionLayer
12.Funtional/StructuralGroups
13.PlantMortality/Decadence
14.LitterAmount
15.AnnualProduction
16.InvasivePlants
17.ReproductiveCapabilityofPerennials
0
1
2
3
4
5
Hydrologic Function
Biotic Integrity
Soil/site Stability

Analysis Unit NENAHNEZAD/SAN JUAN

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		71,086.02
Non-Grazeable Acres	Developed	1,968.88
	Hydro	1,179.82
	Roads	767.08
	Slope >60%	125.36
	Soils	21,706.79
Grazeable Acres		45,338.10

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	0.0
Maximum	47.0
Median	4.0

Summary of Cover by Analysis Unit

Foliar Cover	17.05%
Bareground	65.98%
Basal	0.60%

Results by Ecological Site in Sheep Units Year Long

Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB005NM Salt Flats	16	2.89	8,879.12	820.07	10.83	10.81	6.38
R035XB007NM Deep Sand	13	7.16	7,140.44	331.01	21.57	21.54	11.49
R035XB002NM Sandy	12	7.56	2,864.47	313.49	9.14	9.09	3.98
R035XB006NM Shallow	7	9.96	4,846.57	237.95	20.37	20.27	12.38
R035XB035NM Sandy Upland 6-10"	6	3.41	566.12	695.01	0.81	0.76	0.76
R035XB274AZ Sandy Loam Upland 6-10" p.z. Saline	5	9.74	764.79	243.33	3.14	2.93	2.40
R035XB003NM Limy	5	6.61	2,257.72	358.55	6.30	6.25	3.71
R035XB030NM Sandy Loam Upland 6-10"	5	2.85	1,374.13	831.58	1.65	1.64	1.55
R035XB021NM Loamy Upland 7-10	4	2.22	221.74	1,067.57	0.21	0.18	0.18
R035XB001NM Loamy	3	0.02	1,958.15	118,500.00	0.02	0.00	0.00
R035XB017NM Cobbly Slopes 6-10"	3	3.39	886.19	699.12	1.27	1.07	0.90
R035XB277AZ Siltstone Upland 6-10" p.z. Limy	3	2.88	50.32	822.92	0.06	0.00	0.00
R035XB016NM Clay Loam Terrace (sodic) 7-10"	2	214.34	224.39	11.06	20.29	20.25	14.24
R035XB272AZ Loamy Bottom 6-10" p.z. Perennial, Saline	2	47.80	129.92	49.58	2.62	2.62	2.62
Riverwash	2	12.62	1,093.84	187.80	5.82	5.81	4.38
R035XC328AZ Cobbly Slopes 10-14" p.z.	2	1.10	261.72	2,154.55	0.12	0.00	0.00
R035XB267AZ Sandy Loam Upland 6-10" p.z. Limy	2	0.28	333.83	8,464.29	0.04	0.00	0.00
Dune land	1	13.34	323.06	177.66	1.82	1.81	1.48
R035XB028NM Sandy Bottom 6-10"	1	11.62	180.35	203.96	0.88	0.85	0.64
R035XB271AZ	0		50.32				
R035XB034NM Sandy Terrace 6-10" sodic	0		9.67				
R035XB024NM Saline Bottom 6-10"	0		1.38				
R035XB004NM Clayey	0		20.21				
R035XA130NM Shale Hills	0		594.38				
Water	0		65.21				
R035XB273AZ	0		271.76				
R035XB269AZ	0		131.55				
R035XB009NM	0		71.63				
Marshes	0		13.42				

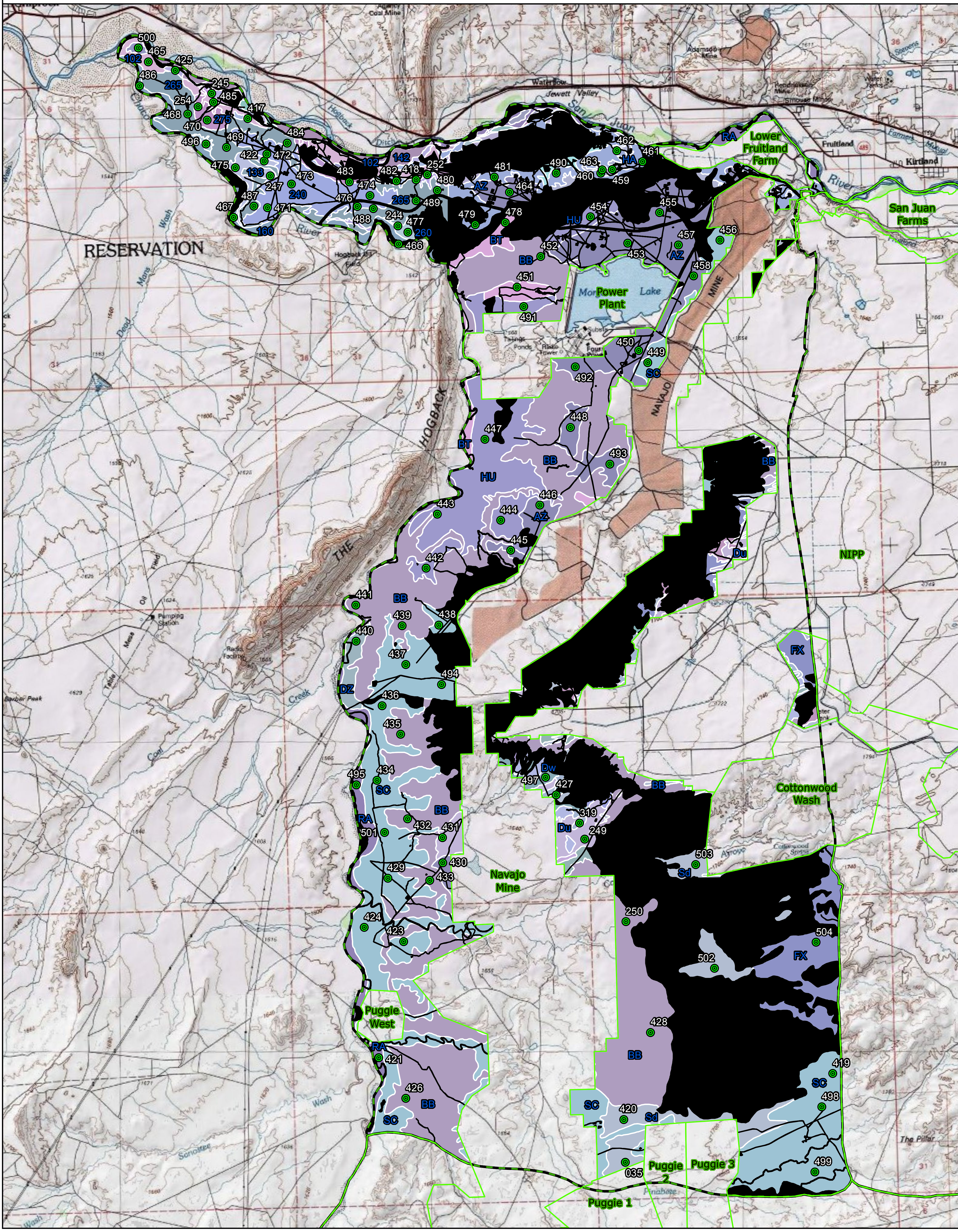
Badland	0		6,606.18				
R035XB204AZ Sandstone Upland 6-10" p.z.	0		36.63				
Rock outcrop	0		3,234.25				

2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 71,086
Grazeable Acres*: 45,338
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
107 Sheep

Nenahnezad/ San Juan Chapter



Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

Ecosphere Environmental Services

0 1 2 4
Miles

1:115,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

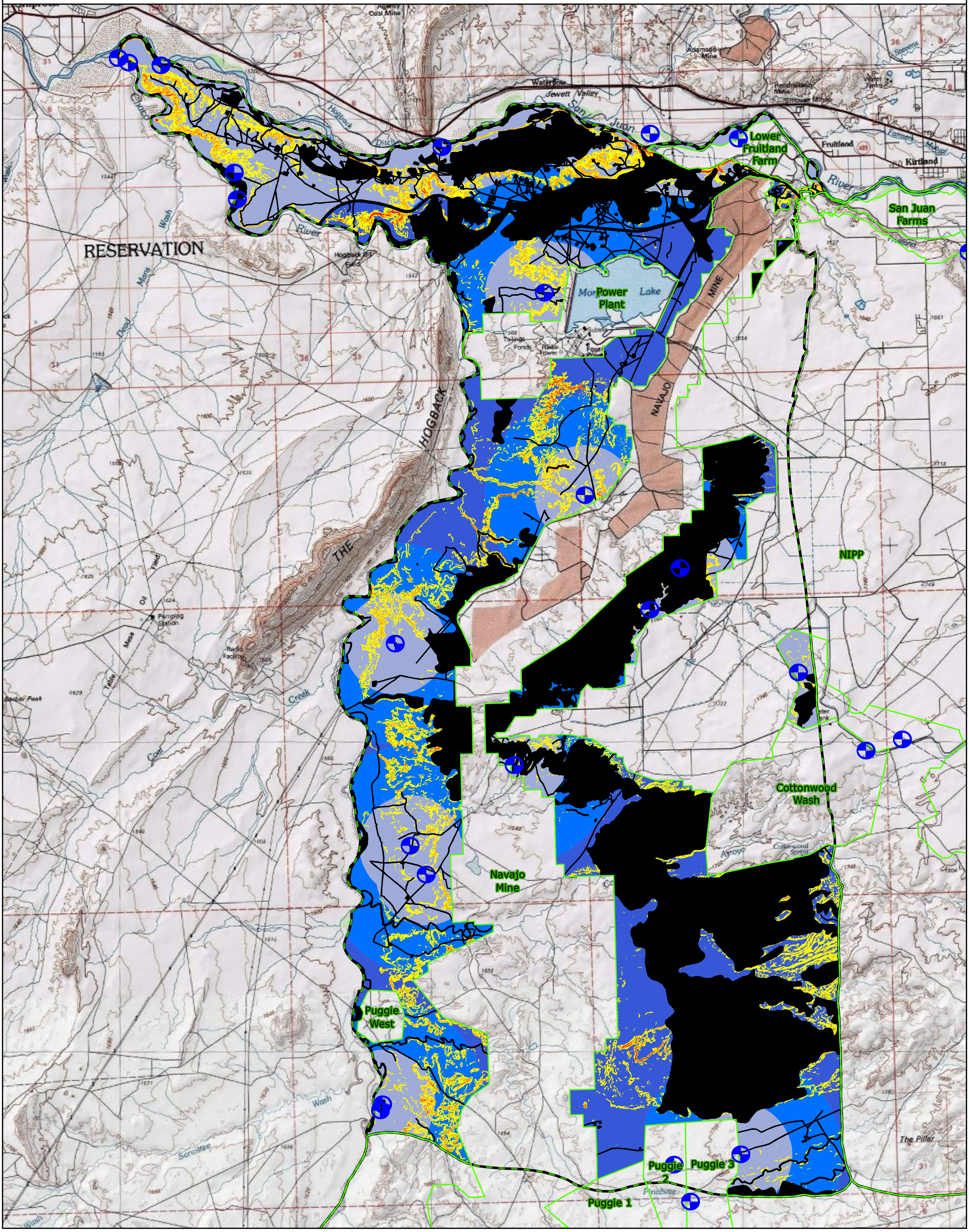
Document Name: P11X17_Soils_Initial_Comm

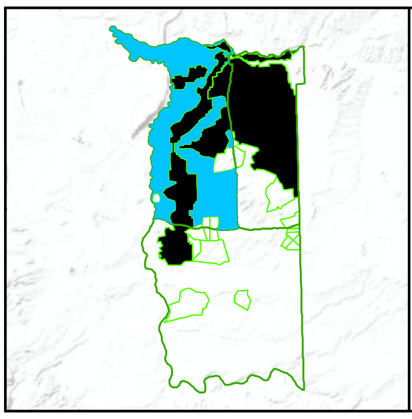
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 71,086
Grazeable Acres*: 45,338
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 55 Sheep

Nenahnezad/ San Juan Chapter





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 1 2 4
Miles

Ecosphere Environmental Services

1:115,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P11X17_Slope_AdjCC_Comm

5.2.3 Upper Fruitland

Ecological Site Summary

The Upper Fruitland community is bordered on the north by the San Juan River, U.S. Highway 371 on the east, and Road N 4062 to the west. Much of this region is occupied by agricultural land belonging to the NAPI. Rangeland consists mostly wooded breaks in the north, badlands to the south, and shrub/grasslands in the central region. This community contains 29,625 grazeable acres and 63 total transects in 6 ecological sites.

Available forage is highest in the R035XB001NM site which is a loamy site with moderately deep/deep, well-drained soils. Perennial grasses dominate the reference plant community while shrubs and forbs make up only a minor component of the site. Common species include James' galleta (*Pleuraphis jamesii*), Indian ricegrass (*Achnatherum hymenoides*), needle and thread (*Hesperostipa comata*), and bottlebrush squirreltail (*Elymus elymoides*). Prolonged grazing pressure will eventually convert the site to shrubland with numerous forbs in the understory. The field survey found that the current community is dominated by James' galleta with a fair amount of Cutler's jointfir (*Ephedra cutleri*) in the overstory. Needle and thread and prickly Russian thistle (*Salsola tragus*) make up a small portion of the sampled plant community.

The second largest site, R035XB002NM, has the highest carrying capacity. This is a sandy site with deep, well-drained soils and is primarily located in the southern portion of the community. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass, dropseed (*Sporobolus* spp.), needle and thread, and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush (*Atriplex canescens*), winterfat (*Krascheninnikovia lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase and the site eventually shifts towards a shrub/subshrub dominated plant community. Production is currently being driven by perennial grasses like James' galleta, Indian ricegrass, alkali sacaton (*Sporobolus airoides*), and needle and thread. Shrubs are not particularly abundant at this time, but prickly Russian thistle has become established in the plant community. The long awns on needle and thread can be injurious to livestock when the plant dries out and as a result, production values are not counted towards available forage. However, when green, this grass does serve as a valuable forage species. The noxious, toxic weed saltlover (*Halogeton glomeratus*) was found on two transects.

Carrying capacity and available forage are lowest for the R035XB006NM site. This is a shallow site found along the breaks leading down to the San Juan River. Soils range from sandy loams to clay loams, and the reference plant community is a mix of shrubs and grasses with the most prominent species being Indian ricegrass, James' galleta, needle and thread, buckwheat (*Eriogonum* spp.), winterfat, Cutler's jointfir, and fourwing saltbush. Site deterioration leads to an initial increase in shrubs followed by a shrub dominated community with large areas of bare ground. At this time, this site appears to be in a fairly degraded state. A small amount of James' galleta and alkali sacaton is present, but most production is from shrubs like jointfir (*Ephedra* spp.) and fourwing saltbush and numerous annual forbs. Saltlover was found on four of the ten transects in this ecological site.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Upper Fruitland community are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 78% of all transects)
2. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 78% of all transects)
3. James' galleta (*Pleuraphis jamesii*) (occurred on 73% of all transects)
4. Torrey's jointfir (*Ephedra torreyana*) (occurred on 52% of all transects)
5. western tansymustard (*Descurainia pinnata*) (occurred on 48% of all transects)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (2,670 lbs/acre)
2. prickly Russian thistle (*Salsola tragus*) (1,769 lbs/acre)
3. Indian ricegrass (*Achnatherum hymenoides*) (1,635 lbs/acre)
4. needle and thread (*Hesperostipa comata*) (753 lbs/acre)
5. Utah serviceberry (*Amelanchier utahensis*) (376 lbs/acre)

Ground Cover

The percentage of bare ground in the Upper Fruitland community is one of the lowest in the study area, but still makes up over half of the total cover. Basal cover is average, and foliar cover is slightly above average. Active erosion is occurring on 30 percent of the transects, which are mostly located in the breaks found in the northwest corner of the community.

Analysis Unit **UPPER FRUITLAND**

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		29,624.48
Non-Grazeable Acres	Developed	79.50
	Hydro	362.28
	Roads	321.80
	Slope >60%	167.23
	Soils	7,099.17
Grazeable Acres		21,594.50

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	0.0
Maximum	61.0
Median	13.0

Summary of Cover by Analysis Unit

Foliar Cover	17.56%
Bareground	56.63%
Basal	0.67%

Results by Ecological Site in Sheep Units Year Long

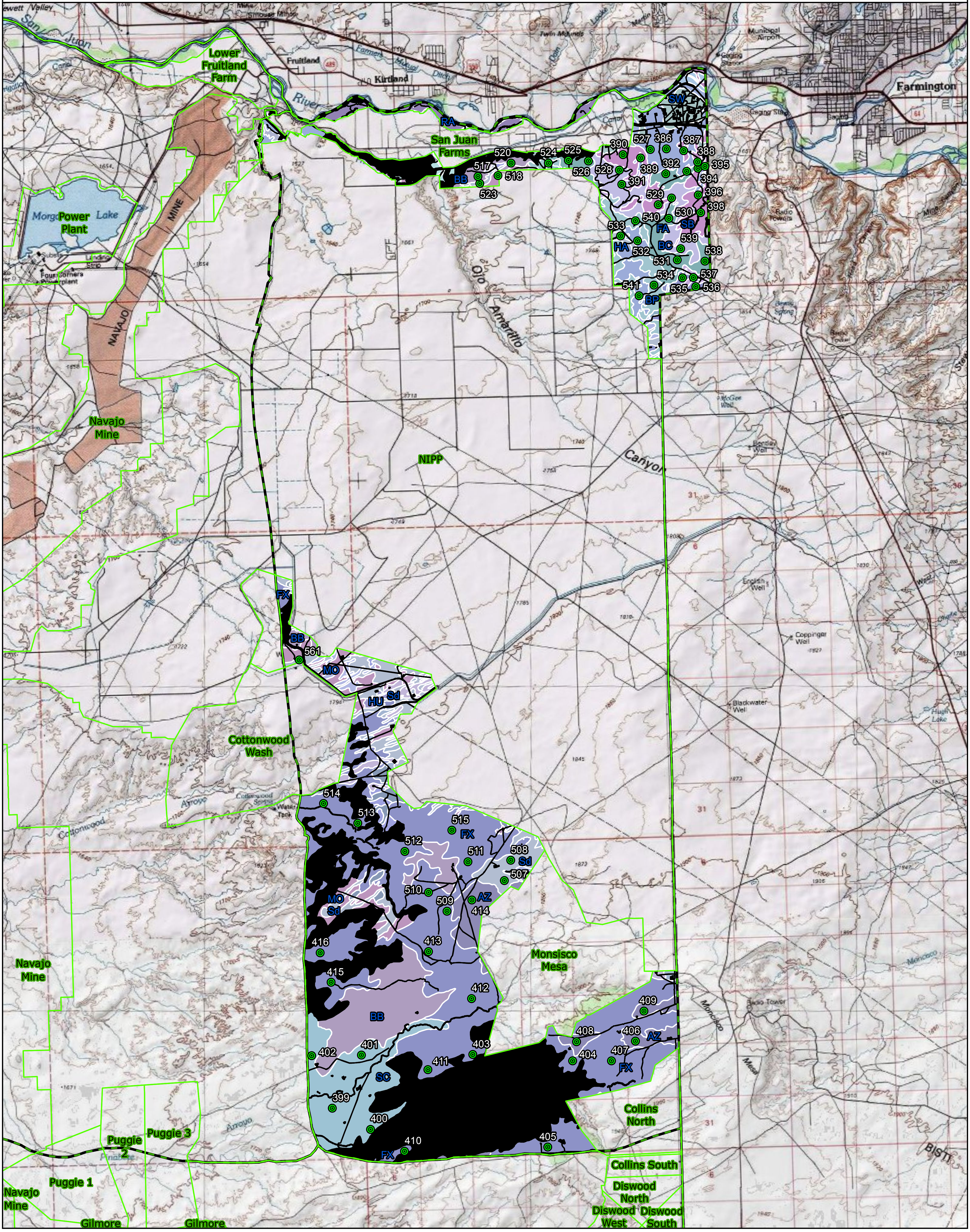
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	20	14.75	5,399.39	160.68	33.60	33.53	7.56
R035XB002NM Sandy	18	30.84	4,562.15	76.85	59.36	59.30	15.86
R035XB006NM Shallow	10	7.93	1,961.03	298.87	6.56	6.47	1.25
R035XB003NM Limy	8	13.57	1,293.66	174.65	7.41	7.32	0.72
R035XA130NM Shale Hills	6	19.74	3,098.98	120.06	25.81	25.72	4.77
R035XB001NM Loamy	1	45.74	1,042.99	51.81	20.13	20.04	5.74
Slickspots	0		8.73				
R035XB009NM	0		30.84				
Rock outcrop	0		920.89				
Badland	0		1,497.26				
Water	0		9.80				
Dune land	0		16.01				
R035XB004NM Clayey	0		170.94				
R035XB005NM Salt Flats	0		1,221.10				
R035XC328AZ Cobbly Slopes 10-14" p.z.	0		243.29				
Riverwash	0		282.33				
R035XB269AZ	0		2.33				

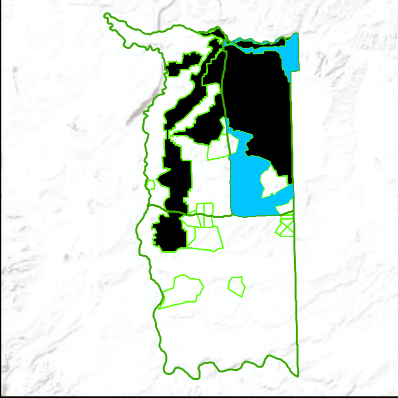
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 29,624
Grazeable Acres*: 21,595
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
153 Sheep

Upper Fruitland Chapter





Transect Location

Non Grazeable Range

Unit Boundary

Soil Map Units

Community Boundary

0 1 2 4
Miles

1:110,000

Date: 1/5/2015

Ecosphere Environmental Services

Coordinate System: NAD 1983 UTM Zone 12N

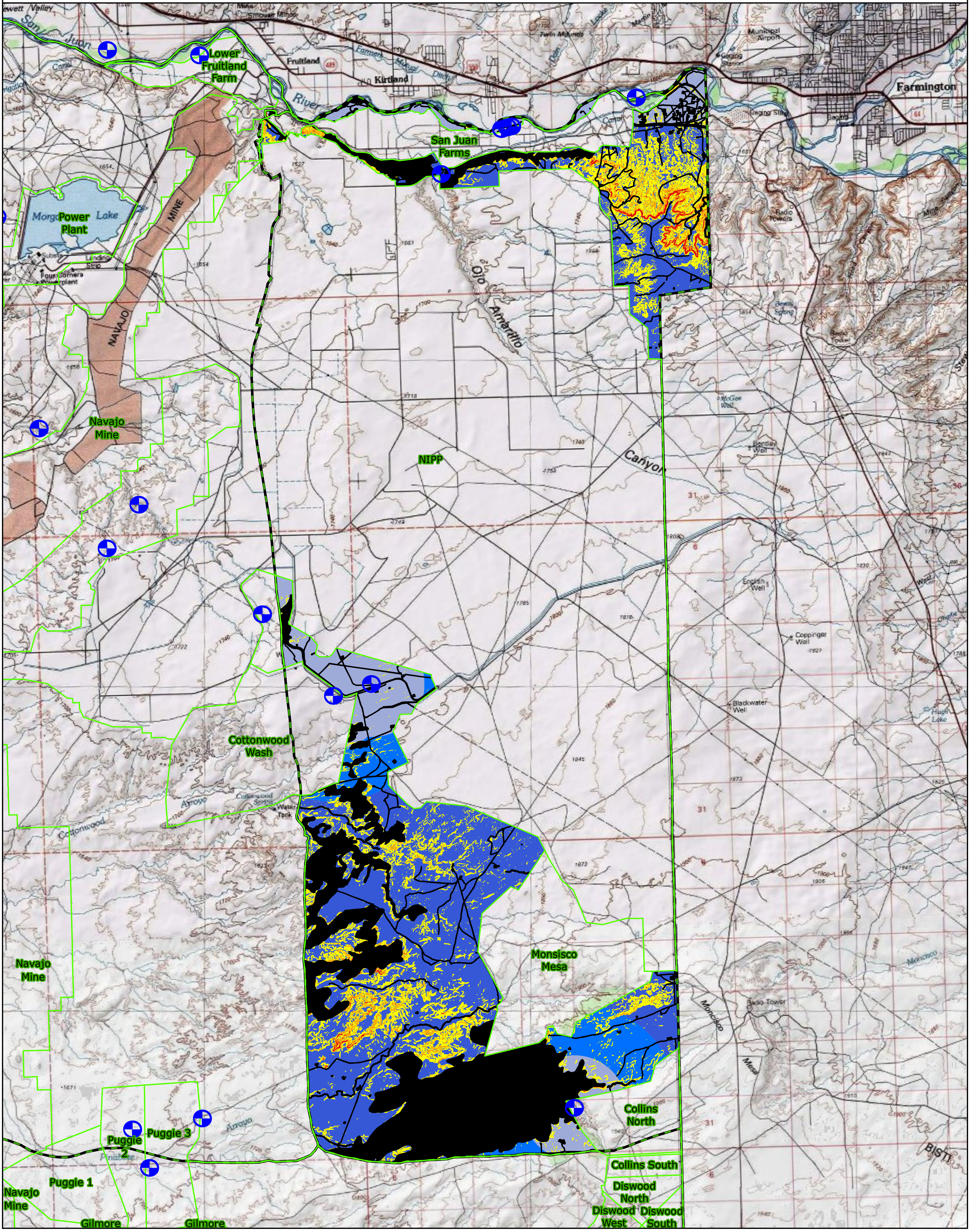
Document Name: P11X17_Soils_Initial_Comm

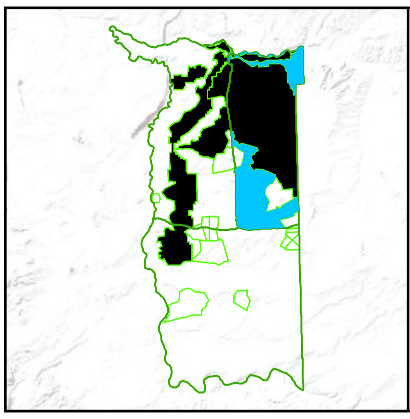
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 29,624
Grazeable Acres*: 21,595
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
27 Sheep

Upper Fruitland Chapter





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 1 2 4
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:110,000

Ecosphere Environmental Services

Date: 1/5/2015

5.3 Range Management Units

Range Management Units were analyzed separately from the community data.

5.3.1 Billey

Ecological Site Summary

The Billey RMU is located in an area of rolling hills in the eastern side of the Burnham community. This RMU contains 14 transects in four ecological sites and 6,280 grazeable acres.

The smallest ecological site, R035XB002NM, also has the highest amount of available forage. However, this is relative, as forage is scarce throughout the unit. This ecological site is a sandy site with deep, well-drained soils. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), needle and thread (*Hesperostipa comata*), and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush (*Atriplex canescens*), winterfat (*Krascheninnikovia lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase, and the site eventually shifts towards a shrub/subshrub dominated plant community. The current plant community is marked by large expanses of bare ground in an area of sand dunes. The most abundant species is prickly Russian thistle (*Salsola tragus*), but some dune stabilization is occurring around small clumps of Torrey's jointfir (*Ephedra torreyana*) and perennial grasses like James' galleta (*Pleuraphis jamesii*), Indian ricegrass, and alkali sacaton (*Sporobolus airoides*).

Carrying capacity is highest in the R035XB007NM site. This is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass, dropseed, alkali sacaton, globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush, and sand sagebrush (*Artemisia filifolia*). Shrubs, cacti, and forbs all increase following continuous grazing pressure. At the time of the survey, the highest producing species was prickly Russian thistle, followed by alkali sacaton, James' galleta, and Indian ricegrass.

The R035XB005NM site has the lowest amount of available forage but because of its large size has a relatively high carrying capacity. The site occurs within salt flats and has sodium-affected soils that are usually deep, but can be shallow in areas associated with the Huerfano soil component. Shrubland with perennial grasses in the shrub interspaces typifies the reference plant community. Unmanaged grazing often leads to a shrub-dominated site with mainly annual forbs and grasses making up the herbaceous understory. Currently, shrubs are not prevalent, but non-woody species are also scarce. Of the two transects in this site, one contains only trace amounts of perennial grasses, and the most abundant species is the toxic forb saltlover (*Halogeton glomeratus*). The second transect was located in a moderately productive stand of alkali sacaton, and no saltlover was encountered.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Billey RMU community are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 100% of all transects)
2. alkali sacaton (*Sporobolus airoides*) (occurred on 71% of all transects)
3. James' galleta (*Pleuraphis jamesii*) (occurred on 57% of all transects)
4. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 50% of all transects)
5. purple threeawn (*Aristida purpurea*) (occurred on 36% of all transects)

Species by Weight

1. prickly Russian thistle (*Salsola tragus*) (429 lbs/acre)
2. alkali sacaton (*Sporobolus airoides*) (268 lbs/acre)
3. saltlover (Halogeton glomeratus) (241 lbs/acre)
4. James' galleta (*Pleuraphis jamesii*) (144 lbs/acre)
5. Broom snakeweed (*Gutierrezia sarothrae*) (84 lbs/acre)

Ground Cover

The percentage of bare ground in the Billey RMU is over 70 percent, and the percent of foliar cover is below average. Active erosion is occurring on 30 percent of the transects, which are mostly located in the breaks found in the northwest corner of the community. Only one transect in the unit is currently showing evidence of severe erosion, but the high amount of bare ground makes this area at risk for future erosion problems, especially wind erosion.

Analysis Unit: Billey

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		6,991.27
Non-Grazeable Acres	Developed	3.98
	Hydro	31.55
	Roads	22.72
	Slope >60%	0.38
	Soils	607.72
Grazeable Acres		6,324.91

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	0.0
Maximum	19.0
Median	7.0

Summary of Cover by Analysis Unit

Foliar Cover	12.43%
Bareground	74.00%
Basal	0.57%

Results by Ecological Site in Sheep Units Year Long

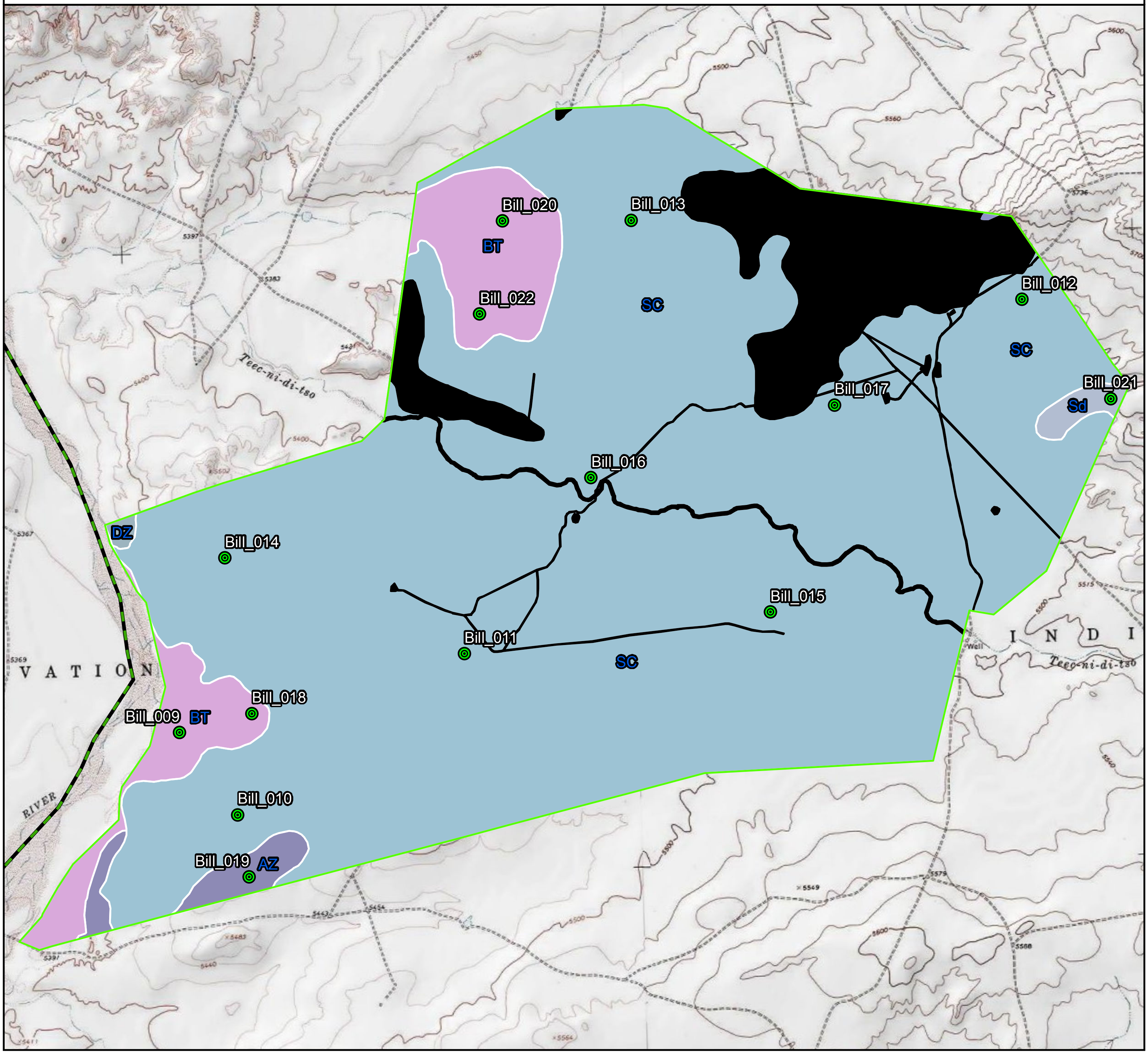
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	7	9.34	2,602.22	253.75	10.26	10.25	7.65
R035XB001NM Loamy	4	7.49	315.92	316.42	1.00	0.99	0.59
R035XB005NM Salt Flats	2	6.12	3,328.23	387.25	8.59	8.58	6.47
R035XB002NM Sandy	1	10.24	33.51	231.45	0.14	0.10	0.01
R035XB003NM Limy	0		35.15				
R035XA130NM Shale Hills	0		0.50				
Dune land	0		9.76				

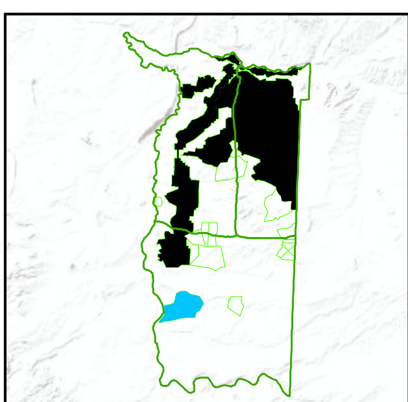
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 6,991
Grazeable Acres*: 6,325
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 20 Sheep

Burnham Chapter, Billey





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:40,000

Ecosphere
Environmental Services

Date: 1/5/2015

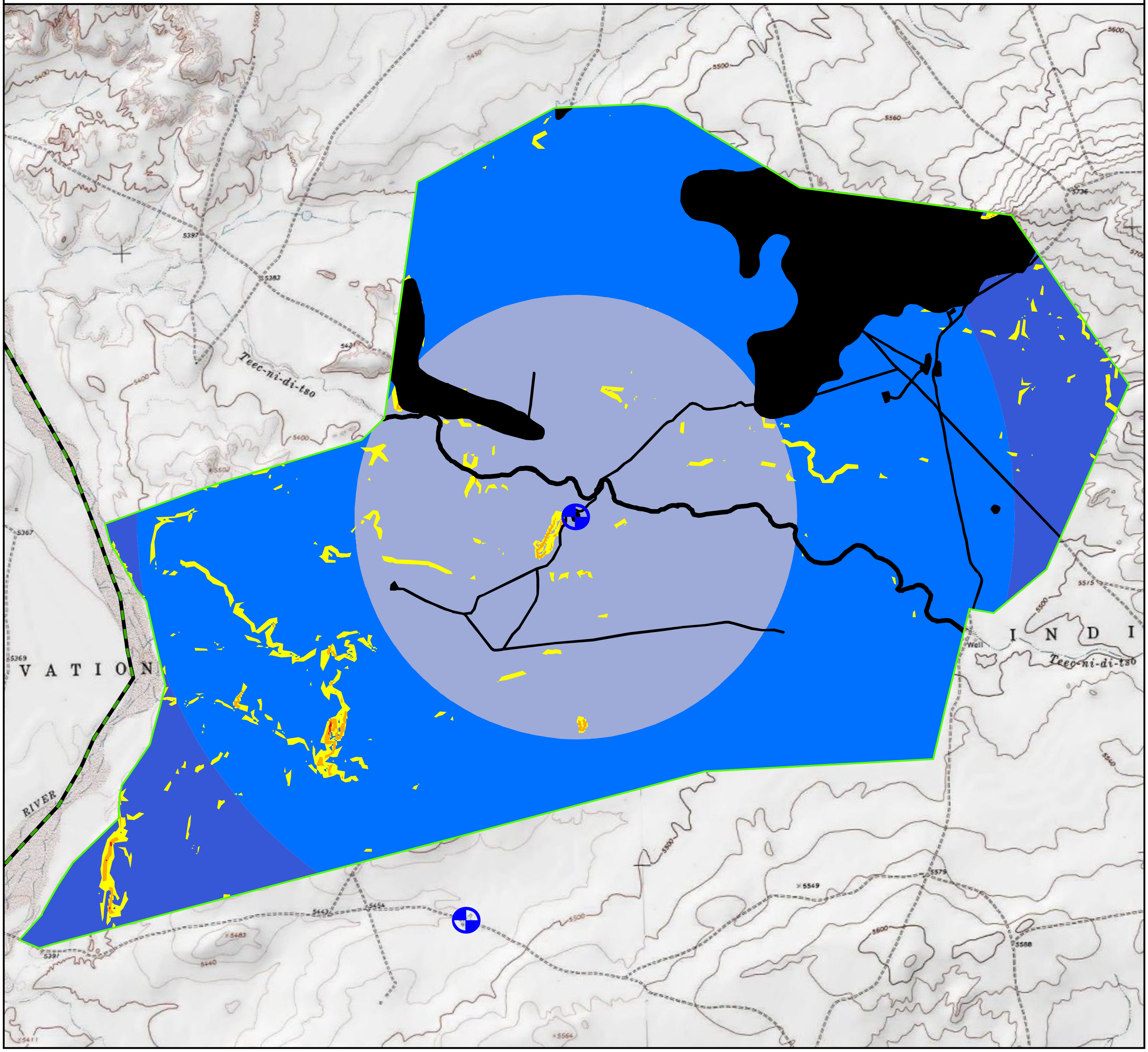
Document Name: P8X11_Soils_InitialCC_D13

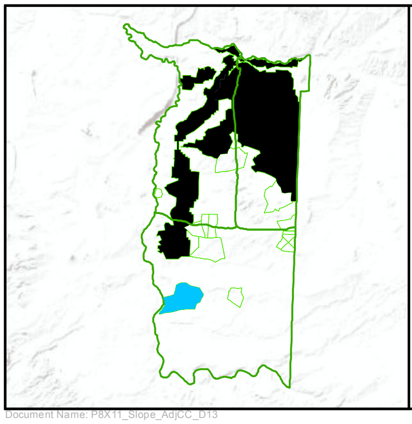
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 6,991
Grazeable Acres*: 6,325
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 12 Sheep

Burnham Chapter, Billey





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

1:40,000

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

5.3.2 Collins

Ecological Site Summary

The Collins RMU is located in the northwest corner of the Burnham Community and southeast corner of the Upper Fruitland community in an area of grassland and badlands. This RMU has two pastures with a total of 13 transects, four in the south pasture and nine in the north pasture. The south pasture has 360 grazeable acres with two ecological sites, and the north pasture has 1,688 grazeable acres with three ecological sites. The R035XB005NM and R035XB007NM sites are present in both pastures, while the larger north pasture also contains the R035XB002NM site.

Available forage is highest in both pastures in the R035XB005NM ecological site. Shrubland with perennial grasses in the shrub interspaces typifies the reference plant community. Unmanaged grazing often leads to a shrub-dominated site with mainly annual forbs and grasses making up the herbaceous understory. Species composition is somewhat differentiated between the two pastures with needle and thread (*Hesperostipa comata*), James' galleta (*Pleuraphis jamesii*), and blue grama (*Bouteloua gracilis*) being dominant in the north pasture. The south pasture also has a fair amount of blue grama and James' galleta, but other dominants include Indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*), and sandhill muhly (*Muhlenbergia pungens)*.

The R035XB007NM site is relatively productive in the Collins South pasture and relatively unproductive in the north pasture. This is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass, dropseed (*Sporobolus* spp.), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush (*Atriplex canescens*), and sand sagebrush (*Artemisia filifolia*). Prolonged, unmanaged grazing can lead to a shrub dominated site with large areas of bare ground and few perennial grasses. As with the R035XB005NM site, some of the main grasses in the north pasture are needle and thread and James' galleta. Needle and thread is not counted as a forage species in this analysis as it has the potential to be injurious to livestock once the seedheads dry out. However, its presence indicates that the site is in fairly good shape and this grass does provide good forage during the early summer months. Prevalent species in the south pasture include Indian ricegrass, blue grama, James' galleta, sandhill muhly, and sand dropseed.

The R035XB002NM site is exclusive to the Collins North pasture. This is a sandy site with deep, well-drained soils. The reference plant community is dominated by grasses, especially Indian ricegrass, dropseed, and needle and thread. When present, common shrubs tend to be fourwing saltbush and Cutler's jointfir (*Ephedra cutleri*). Shrubs and forbs tend to increase following uncontrolled grazing. Dominant species in the current plant community include needle and thread, James' galleta, and blue grama.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Collins North and South pastures are listed below:

Frequently Encountered Species

1. James' galleta (*Pleuraphis jamesii*) (occurred on 92% of all transects)
2. broom snakeweed (*Gutierrezia sarothrae*) (occurred on 92% of all transects)
3. blue grama (*Bouteloua gracilis*) (occurred on 77% of all transects)
4. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 77% of all transects)
5. Greene's rabbitbrush (*Chrysothamnus greenei*) (occurred on 77% of all transects)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (510 lbs/acre)
2. needle and thread (*Hesperostipa comata*) (411 lbs/acre)
3. blue grama (*Bouteloua gracilis*) (371 lbs/acre)
4. Indian ricegrass (*Achnatherum hymenoides*) (147 lbs/acre)
5. sandhill muhly (*Muhlenbergia pungens*) (80 lbs/acre)

Ground Cover

Both the north and south pastures of the Collins RMU consist largely of stabilized sand dunes. The loose nature of the soil make these areas highly susceptible to wind erosion. At this time, erosion was observed to be only slight to moderate at the transects, but erosion could become problematic in the north pasture in particular due to the high percentage of bare ground (north pasture = 78%, south pasture = 57%). However, the percentage of bare ground in the south pasture is well below the study area average. The percent of foliar coverage in the south pasture is also well above average.

Analysis Unit Collins_North

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		1,687.55
Non-Grazeable Acres	Developed	0.69
	Hydro	4.36
	Roads	15.92
	Slope >60%	0.02
	Soils	123.27
Grazeable Acres		1,543.29

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	13.0
Maximum	27.0
Median	18.0

Summary of Cover by Analysis Unit

Foliar Cover	14.67%
Bareground	77.56%
Basal	0.89%

Results by Ecological Site in Sheep Units Year Long

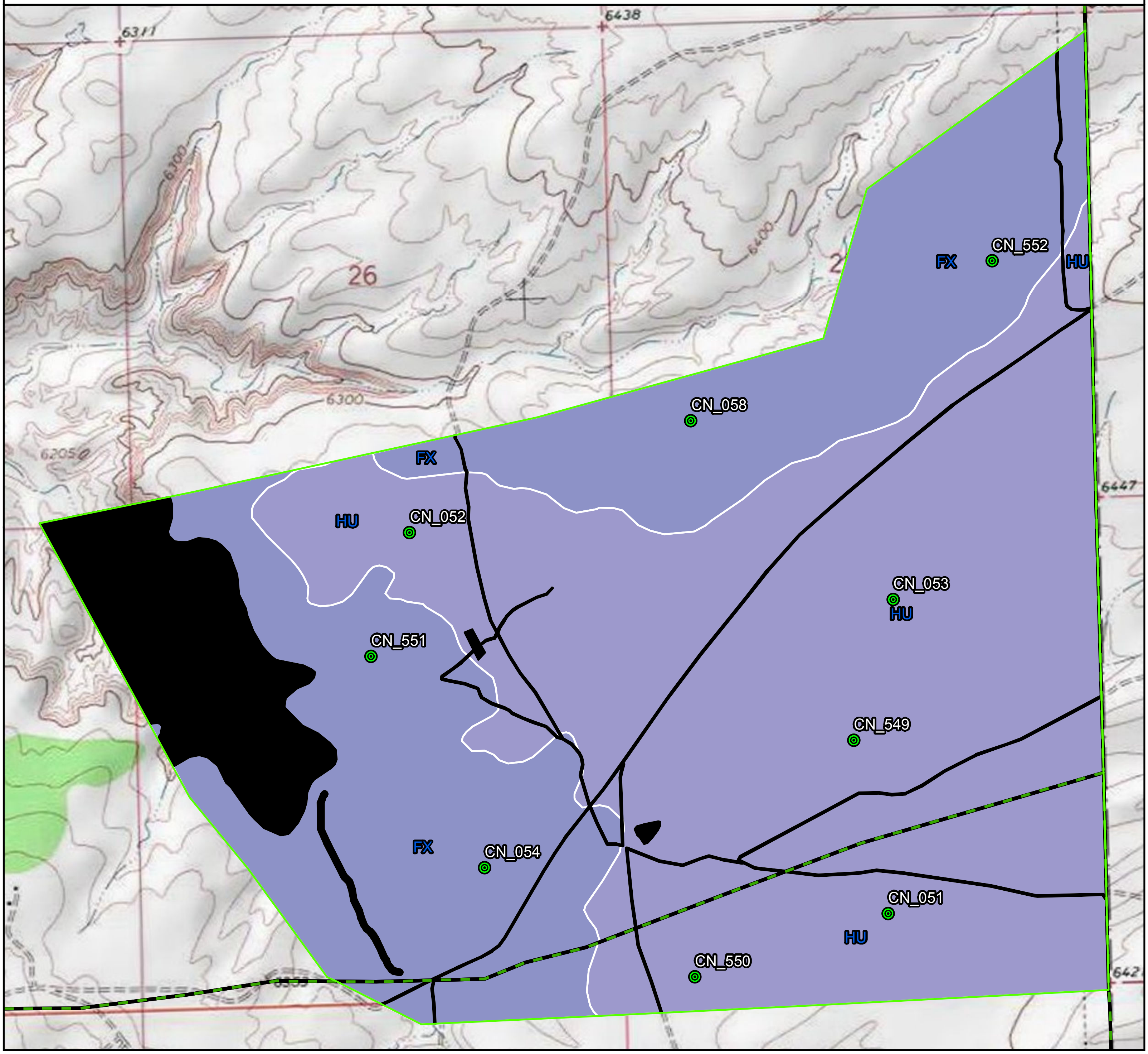
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB005NM Salt Flats	5	14.84	942.90	159.70	5.90	5.90	4.33
R035XB007NM Deep Sand	2	4.79	158.00	494.78	0.32	0.27	0.22
R035XB002NM Sandy	2	7.17	252.80	330.54	0.76	0.71	0.57
R035XA130NM Shale Hills	0		189.60				

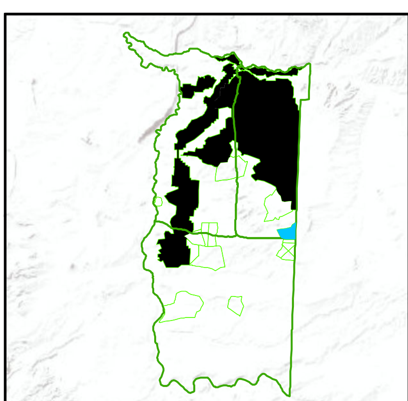
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,688
Grazeable Acres*: 1,543
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 7 Sheep

Upper Fruitland Chapter, Collins North





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

1:18,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

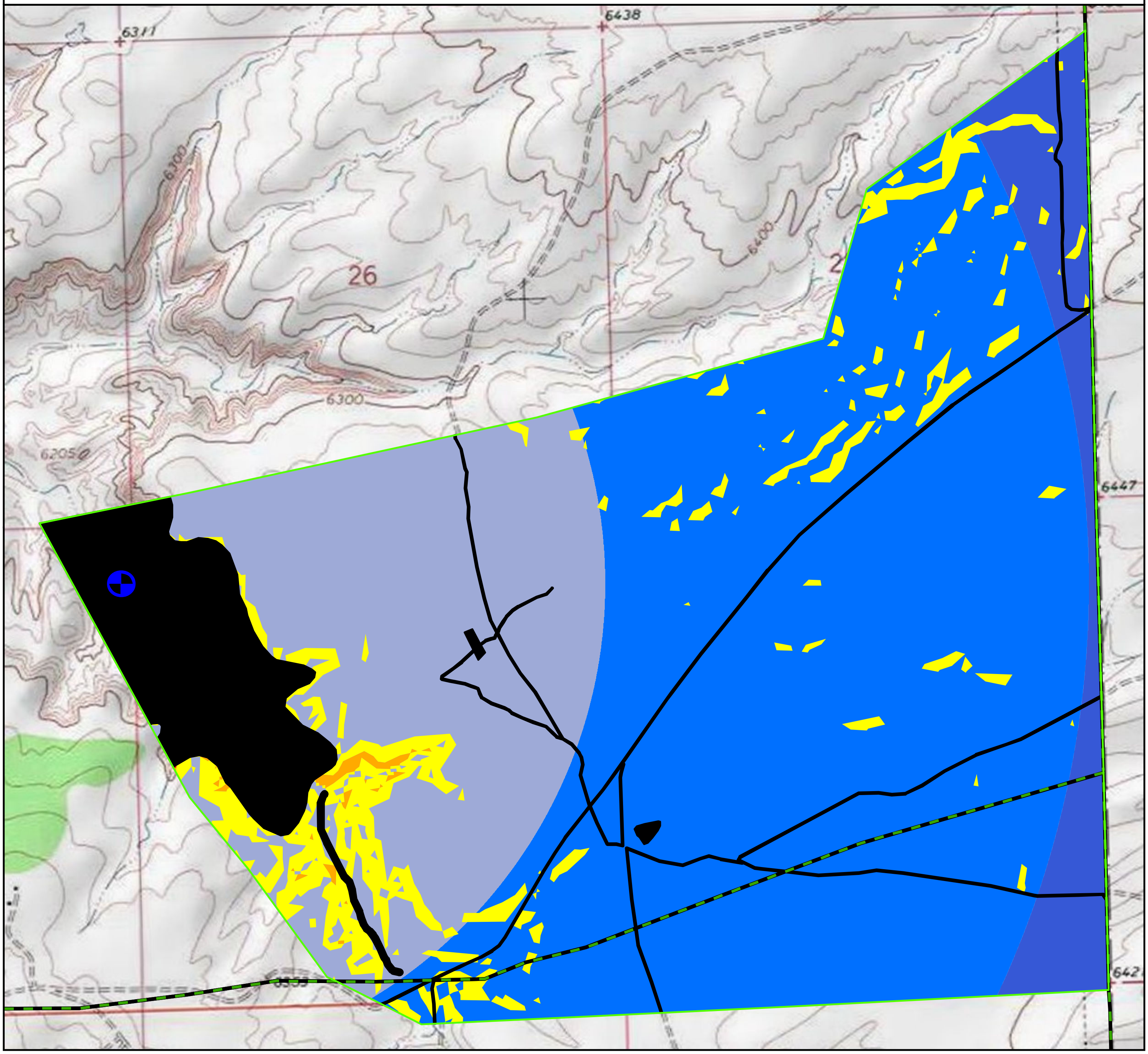
Document Name: P8X11_Soils_InitialCC_D13

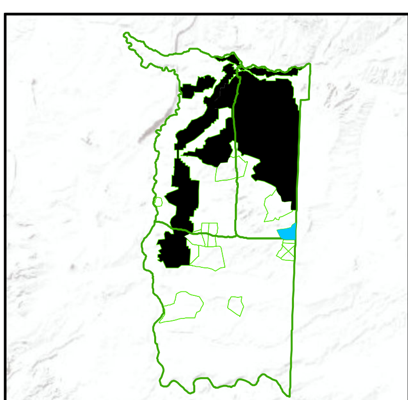
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,688
Grazeable Acres*: 1,543
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 4 Sheep

Upper Fruitland Chapter, Collins North





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
- < 1 Mile
- 1 - 2 Miles
- > 2 Miles

Slope
- 10 - 30% Slope
- 30 - 60% Slope
- > 60% Slope

0 0.25 0.5
Miles

1:18,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit | Collins_South

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		359.97
Non-Grazeable Acres	Developed	0.00
	Hydro	0.00
	Roads	1.84
	Slope >60%	0.00
	Soils	0.00
Grazeable Acres		358.12

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	19.0
Maximum	39.0
Median	32.0

Summary of Cover by Analysis Unit

Foliar Cover	23.00%
Bareground	57.50%
Basal	2.50%

Results by Ecological Site in Sheep Units Year Long

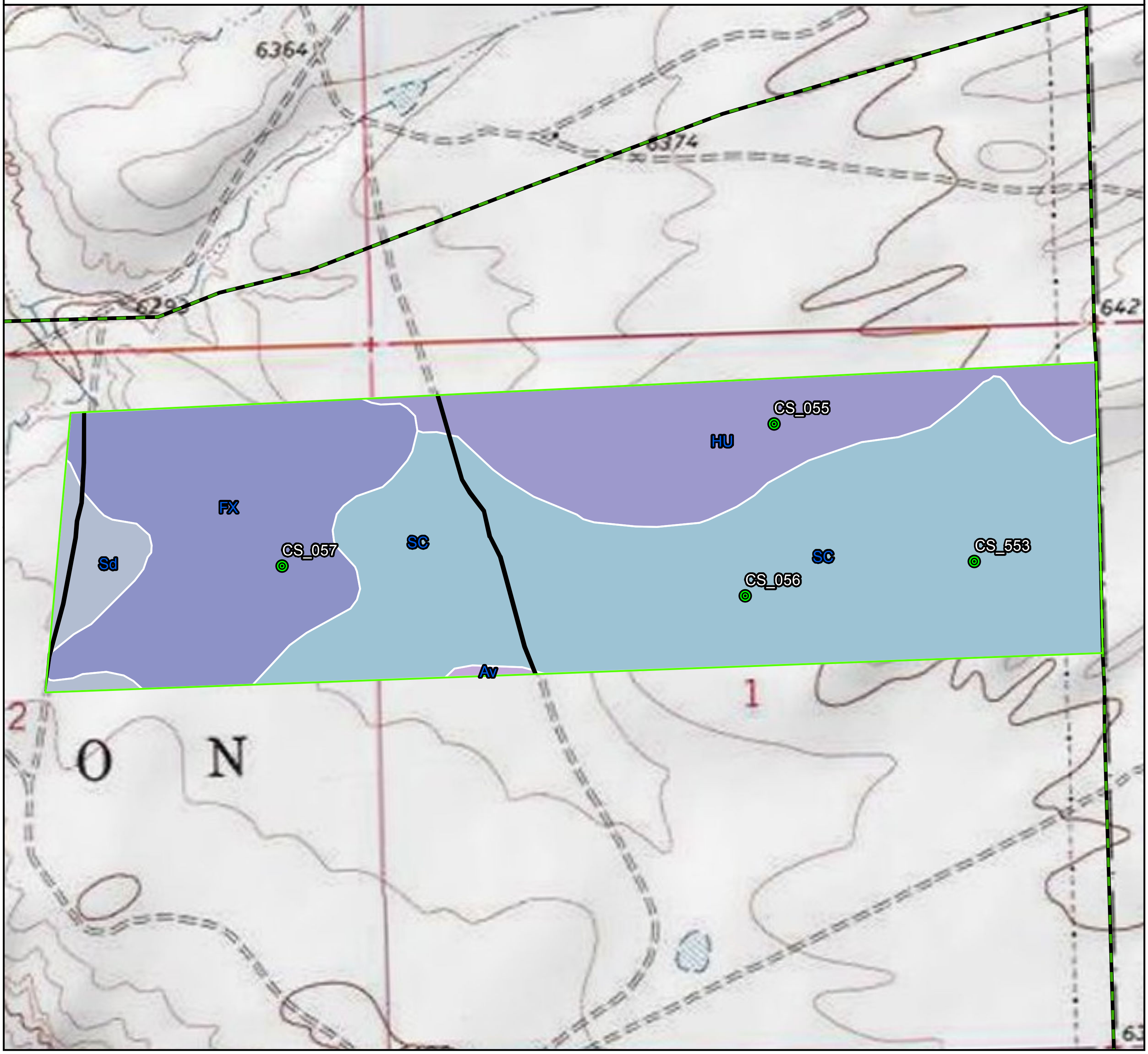
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	3	20.70	116.03	114.49	1.01	1.01	0.00
R035XB005NM Salt Flats	1	27.26	174.80	86.94	2.01	2.01	0.00
R035XB003NM Limy	0		0.92				
R035XB002NM Sandy	0		39.08				
R035XA130NM Shale Hills	0		27.29				

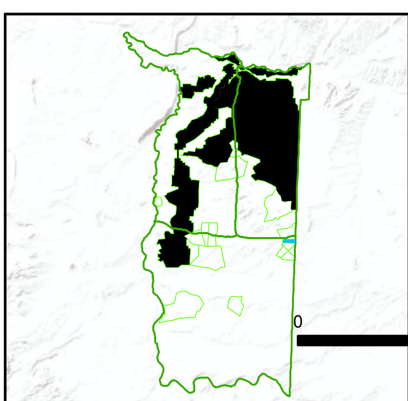
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 360
Grazeable Acres*: 358
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 3 Sheep

Burnham Chapter, Collins South





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

1:12,000

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

Date: 1/5/2015

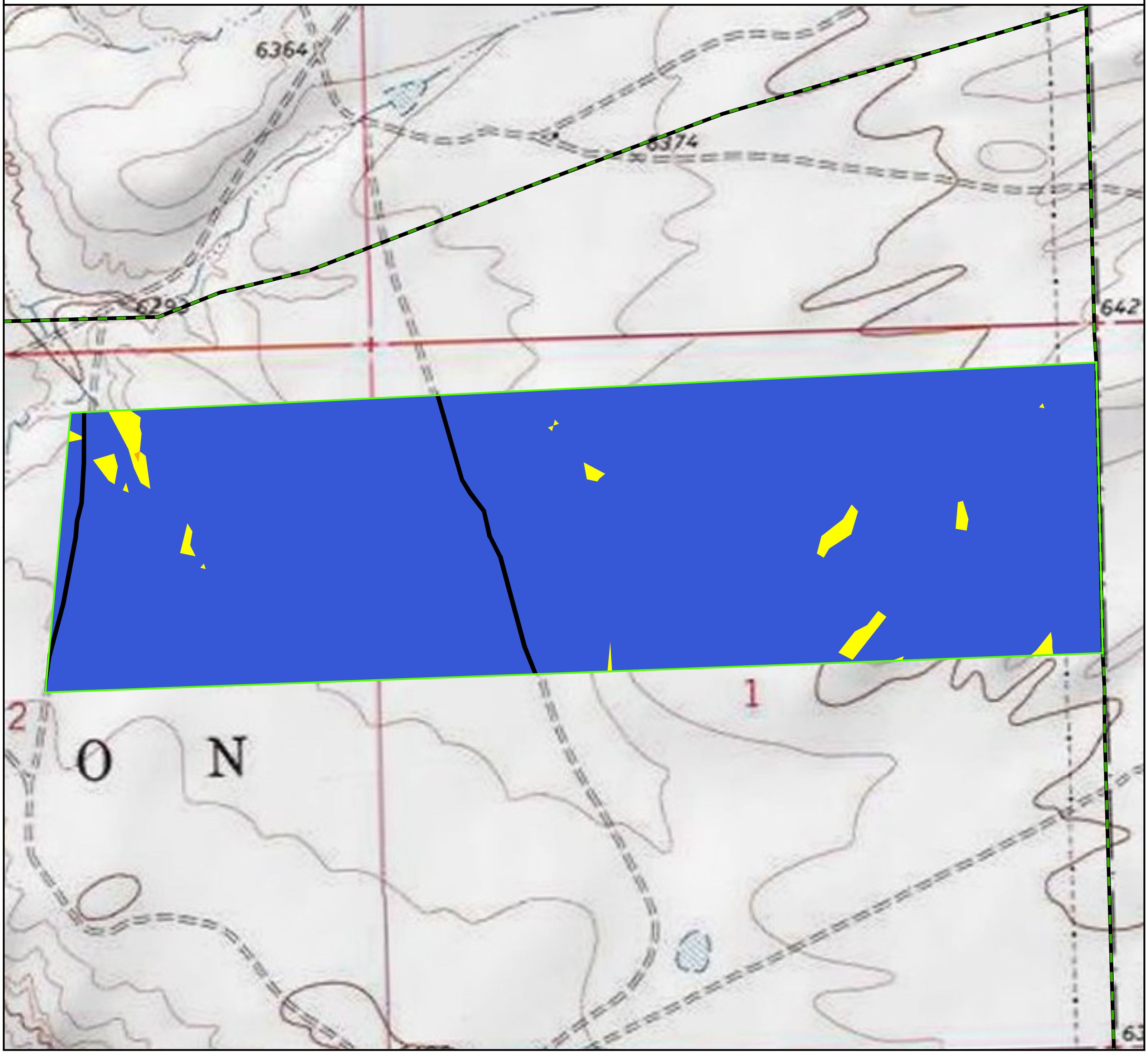
Document Name: P8X11_Soils_InitialCC_D13

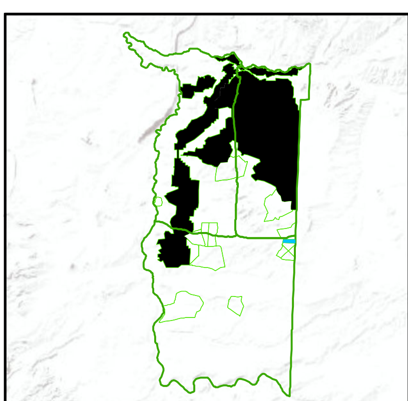
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 360
Grazeable Acres*: 358
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
0 Sheep

Burnham Chapter, Collins South





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:12,000

Ecosphere
Environmental Services

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

5.3.3 Cottonwood Wash

Ecological Site Summary

The Cottonwood Wash RMU is mostly on the central east side of the Nenahnezad/San Juan Community, but also crosses over into the central west side of the Upper Fruitland Community. Cottonwood Wash runs across the southern part of the RMU and much of the western half of the unit consists of badlands. This RMU has 22 transects in five ecological sites and 4,873 grazeable acres. Two transects have no correlation to an ecological site in the soil survey (CW_348 and CW_349). Available forage is highest in both the R035XB006NM and R035XB002NM ecological sites.

The R035XB006NM site is a shallow site found mostly along the northern edge of the unit. Soils range from sandy loams to clay loams, and the reference plant community is a mix of shrubs and grasses with the most prominent species being Indian ricegrass (*Achnatherum hymenoides*), James' galleta (*Pleuraphis jamesii*), needle and thread (*Hesperostipa comata*), buckwheat (*Eriogonum* spp.), winterfat (*Krascheninnikovia lanata*), Cutler's jointfir (*Ephedra cutleri*), and fourwing saltbush (*Atriplex canescens*). Site deterioration leads to an initial increase in shrubs followed by a shrub dominated community with large areas of bare ground. At this time, Cutler's jointfir is the only commonly encountered shrub in the plant community. Some deterioration has occurred as seen by the abundance of prickly Russian thistle (*Salsola tragus*). Dominant grasses include Indian ricegrass, sandhill muhly (*Muhlenbergia pungens*), and James' galleta.

The R035XB002NM site is a sandy site with deep, well-drained soils. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass, dropseed (*Sporobolus* spp.), needle and thread, and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush, winterfat, and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase, and the site eventually shifts towards a shrub/subshrub dominated plant community. Currently, shrubs are abundant in pockets, but are not widespread within the site. However, prickly Russian thistle is a main component of the community and is contributing 60 percent of the total biomass. Certain perennial grasses are also fairly common and include James' galleta, tall dropseed (*Sporobolus contractus*), mesa dropseed (*Sporobolus flexuosus*), and Indian ricegrass.

Available forage is lowest in the R035XB001NM site. This is a loamy site with moderately deep/deep, well-drained soils. Perennial grasses dominate the reference plant community while shrubs and forbs make up only a minor component of the site. Common species include James' galleta, Indian ricegrass, needle and thread, and bottlebrush squirreltail (*Elymus elymoides*). Prolonged grazing pressure will eventually convert the site to shrubland with numerous forbs in the understory. The single transect associated with this site fell within a wind-scoured area with little species diversity. Production is highest from James' galleta, followed by prickly Russian thistle. Trace amounts of sandhill muhly and cryptantha (*Cryptantha* sp.) were also detected.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Cottonwood Wash RMU are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 100% of all transects)
2. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 91% of all transects)
3. James' galleta (*Pleuraphis jamesii*) (occurred on 82% of all transects)
4. Cutler's jointfir (*Ephedra cutleri*) (occurred on 68% of all transects)
5. cryptantha (*Cryptantha sp.*) (occurred on 45% of all transects)

Species by Weight

1. prickly Russian thistle (*Salsola tragus*) (4,267 lbs/acre)
2. James' galleta (*Pleuraphis jamesii*) (811 lbs/acre)
3. Indian ricegrass (*Achnatherum hymenoides*) (506 lbs/acre)
4. sandhill muhly (*Muhlenbergia pungens*) (319 lbs/acre)
5. tall dropseed (*Sporobolus contractus*) (258 lbs/acre)

Ground Cover

The percent of bare ground in the Cottonwood Wash RMU is slightly below the project area average; basal cover is average, and foliar cover is above average. Erosion is slight to moderate overall, but two transects are experiencing more severe erosion. Wind erosion is more problematic in this unit than water erosion due to the prevalence of light, sandy soils.

Analysis Unit Cottonwood Wash

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		4,872.91
Non-Grazeable Acres	Developed	7.38
	Hydro	50.09
	Roads	20.69
	Slope >60%	0.76
	Soils	1,687.04
Grazeable Acres		3,106.95

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	2.0
Maximum	38.0
Median	11.5

Summary of Cover by Analysis Unit

Foliar Cover	20.55%
Bareground	65.55%
Basal	1.18%

Results by Ecological Site in Sheep Units Year Long

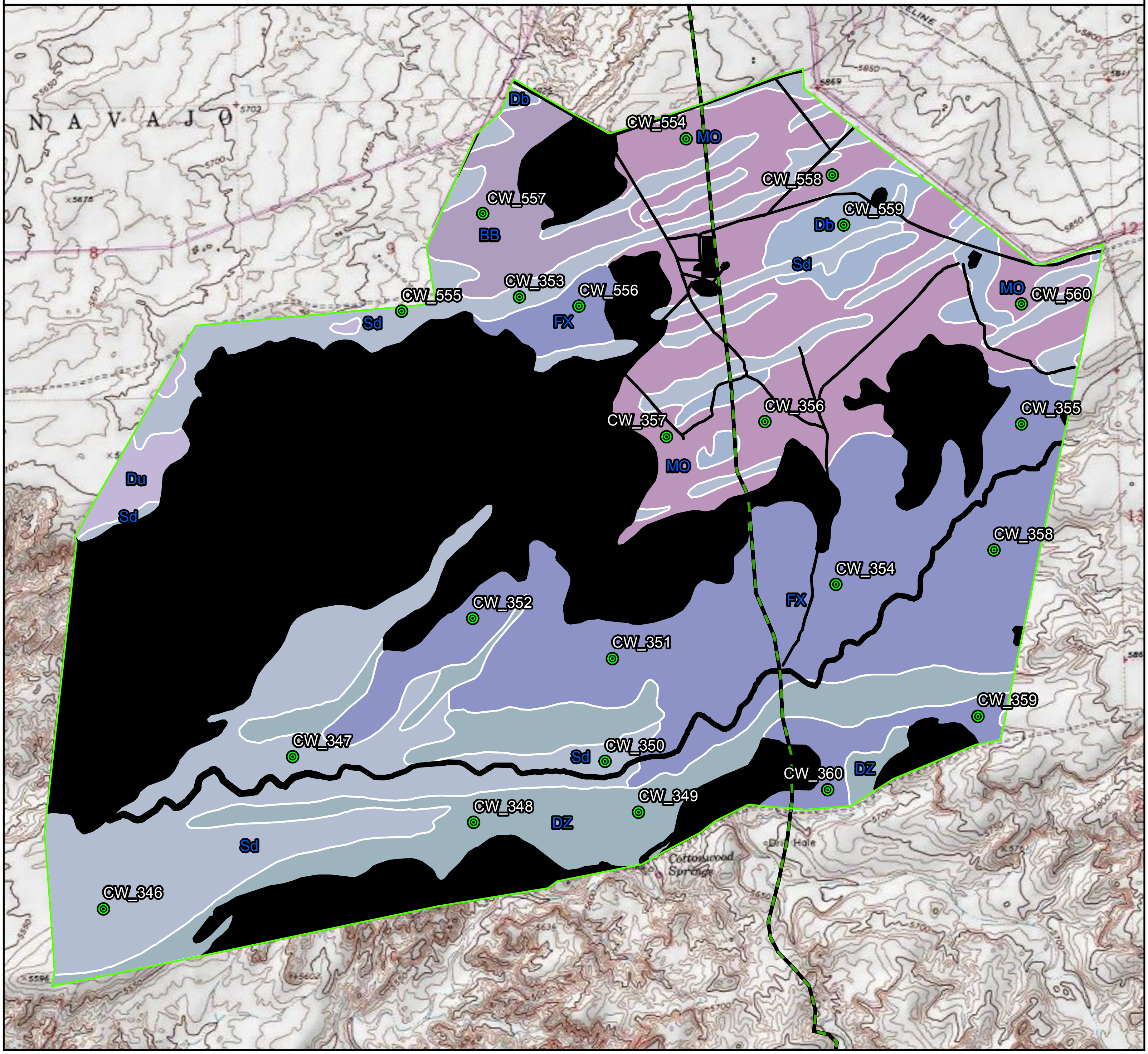
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	12	16.78	575.82	141.24	4.08	4.00	2.28
R035XB006NM Shallow	5	16.78	570.71	141.24	4.04	4.02	3.70
Dune land	2	12.22	431.51	193.94	2.22	2.14	0.42
R035XB007NM Deep Sand	1	8.32	927.19	284.86	3.25	3.19	1.24
R035XB004NM Clayey	1	13.03	58.83	181.89	0.32	0.30	0.28
R035XB001NM Loamy	1	6.28	148.04	377.39	0.39	0.37	0.30
R035XB005NM Salt Flats	0		21.13				
R035XA130NM Shale Hills	0		291.86				
Badland	0		55.04				
Rock outcrop	0		27.52				

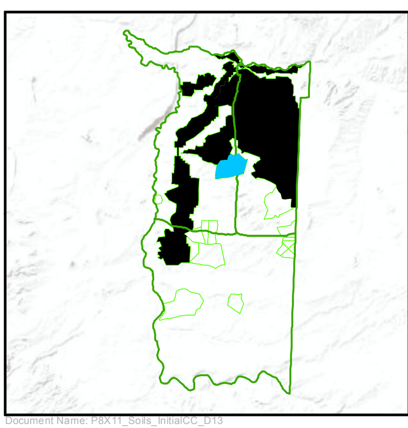
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 4,873
Grazeable Acres*: 3,107
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
14 Sheep

Nenahnezad/ San Juan Chapter, Cottonwood Wash





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

Ecosphere Environmental Services

1:30,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

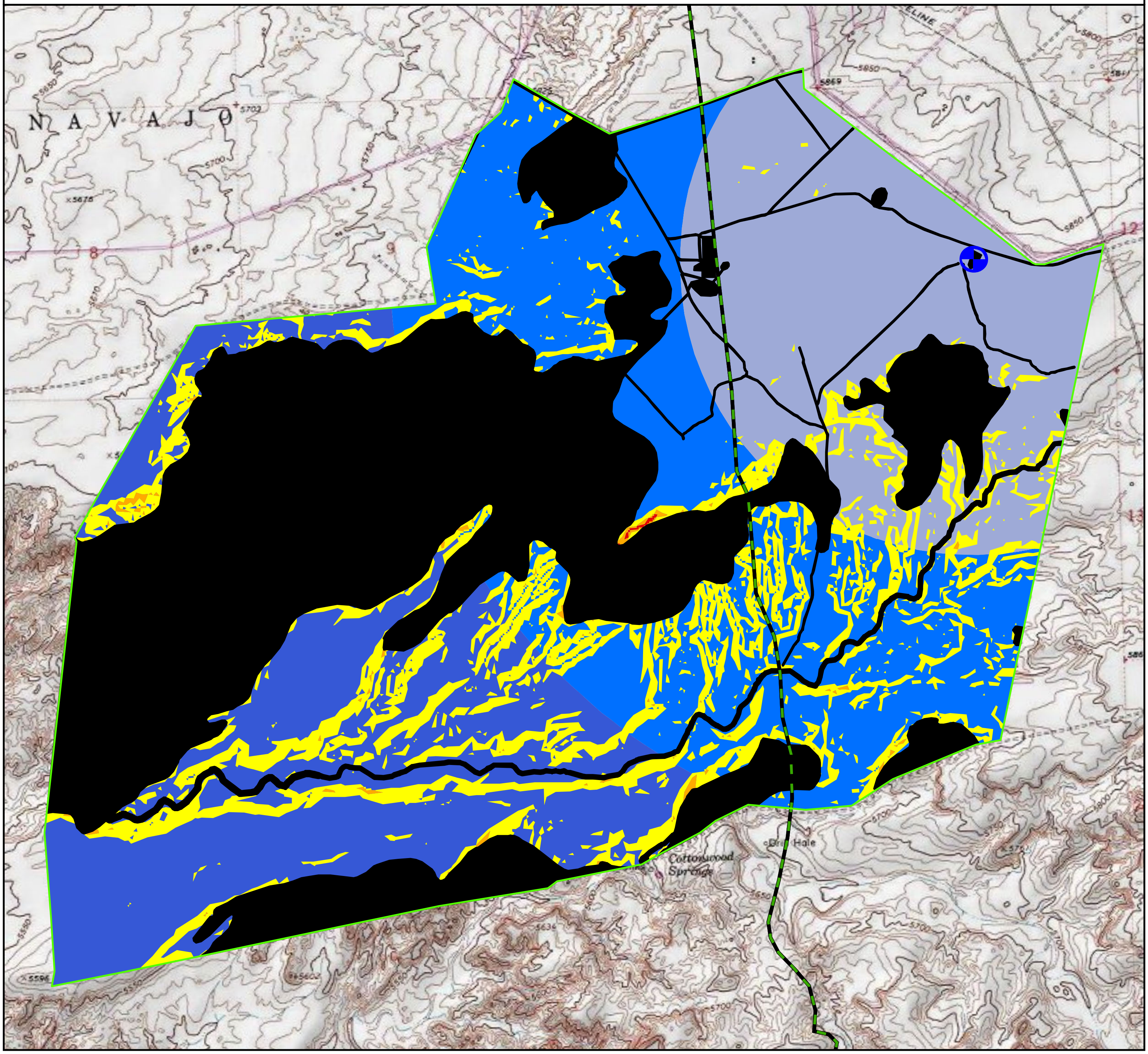
Document Name: P8X11_Soils_InitialCC_D13

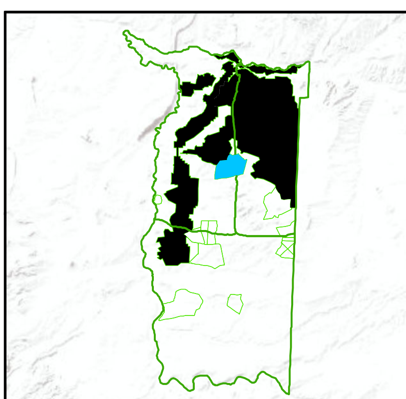
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 4,873
Grazeable Acres*: 3,107
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 6 Sheep

Nenahnezad/ San Juan Chapter, Cottonwood Wash





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

N

0 0.25 0.5
Miles

Ecosphere Environmental Services

1:30,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

5.3.4 Diswood

Ecological Site Summary

The Diswood RMU is located in the northeast corner of Burnham community directly below the Collins RMU. Diswood RMU has 18 transects in four pastures. The east pasture has 374 grazeable acres and four transects within two ecological sites. The north pasture has 542 grazeable acres and six transects in three ecological sites. The south pasture has 568 grazeable acres and four transects in two ecological sites. The west pasture has four transects in two ecological sites and 556 grazeable acres. Each pasture contains an ecological site with a single transect. The R035XB005NM site is found within the east and north pastures and has some of the highest available forage values. The site occurs within salt flats and has sodium-affected soils that are usually deep, but can be shallow in areas associated with the Huerfano soil component. Shrubland with perennial grasses in the shrub interspaces typifies the reference plant community. Unmanaged grazing often leads to a shrub-dominated site with mainly annual forbs and grasses making up the herbaceous understory. Common species in both pastures include James' galleta (*Pleuraphis jamesii*), cryptantha (*Cryptantha* spp.), and Greene's rabbitbrush (*Chrysothamnus greenei*). Blue grama (*Bouteloua gracilis*) is also abundant in the north pasture. Cheatgrass (*Bromus tectorum*) makes up a minor component of the plant community in both pastures.

The R035XB007NM site is found in all pastures with the exception of the North pasture. Available forage is highest in the East pasture and lowest in the West pasture. This is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush (*Atriplex canescens*), and sand sagebrush (*Artemisia filifolia*). The east pasture is dominated by James' galleta (*Pleuraphis jamesii*), Bigelow's sagebrush (*Artemisia bigelovii*), Indian ricegrass, and Torrey's jointfir (*Ephedra torreyana*). The West pasture also has a large proportion of James' galleta and Indian ricegrass as well as sand dropseed (*Sporobolus cryptandrus*) and blue grama. Dominant species in the South pasture are Torrey's jointfir and common dunebroom (*Parryella filifolia*).

The R035XB002NM site is located in the north, south, and west pastures. Available forage is highest in the south pasture and lowest in the west pasture. This is a sandy site with deep, well-drained soils. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass, dropseed, needle and thread (*Hesperostipa comata*), and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush, winterfat (*Krascheninnikovia lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase, and the site eventually shifts towards a shrub/subshrub dominated plant community. James' galleta and blue grama are the primary producers of available forage in all pastures. The south pasture also has a significant contribution from Indian ricegrass. The most common shrubs are Greene's rabbitbrush and broom snakeweed.

The R035XB003NM site only occurs in the north pasture. Soils are distinguished by being calcareous and loamy. Perennial grasses make up the majority of the reference plant community, but shrubs and annual forbs are generally present in small amounts. Juniper (*Juniperus* spp.) may invade the site following prolonged disturbance. The plant community found during the field survey was not very diverse and was dominated by Greene's rabbitbrush.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Diswood pastures are listed below:

Frequently Encountered Species

1. James' galleta (*Pleuraphis jamesii*) (occurred on 100% of all transects)
2. Greene's rabbitbrush (*Chrysothamnus greenei*) (occurred on 78% of all transects)
3. blue grama (*Bouteloua gracilis*) (occurred on 72% of all transects)
4. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 67% of all transects)
5. cryptantha (*Cryptantha sp.*) (occurred on 61% of all transects)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (1,937 lbs/acre)
2. tansymustard (*Descurainia* sp.) (380 lbs/acre)
3. Greene's rabbitbrush (*Chrysothamnus greenei*) (328 lbs/acre)
4. thicksepal cryptantha (*Cryptantha crassisepala*) (317 lbs/acre)
5. Indian ricegrass (*Achnatherum hymenoides*) (292 lbs/acre)

Ground Cover

The percentage of bare ground is below the project area average in all Diswood pastures, and foliar cover is above average in all but the south pasture. This RMU also has some of the highest percentages of basal cover with the east pasture having the highest at six percent. Erosion was minimal at all transect locations.

Analysis Unit Diswood_West

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		612.24
Non-Grazeable Acres	Developed	0.00
	Hydro	1.00
	Roads	5.49
	Slope >60%	0.03
	Soils	50.17
Grazeable Acres		555.54

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	6.0
Maximum	18.0
Median	14.0

Summary of Cover by Analysis Unit

Foliar Cover	23.50%
Bareground	61.00%
Basal	1.50%

Results by Ecological Site in Sheep Units Year Long

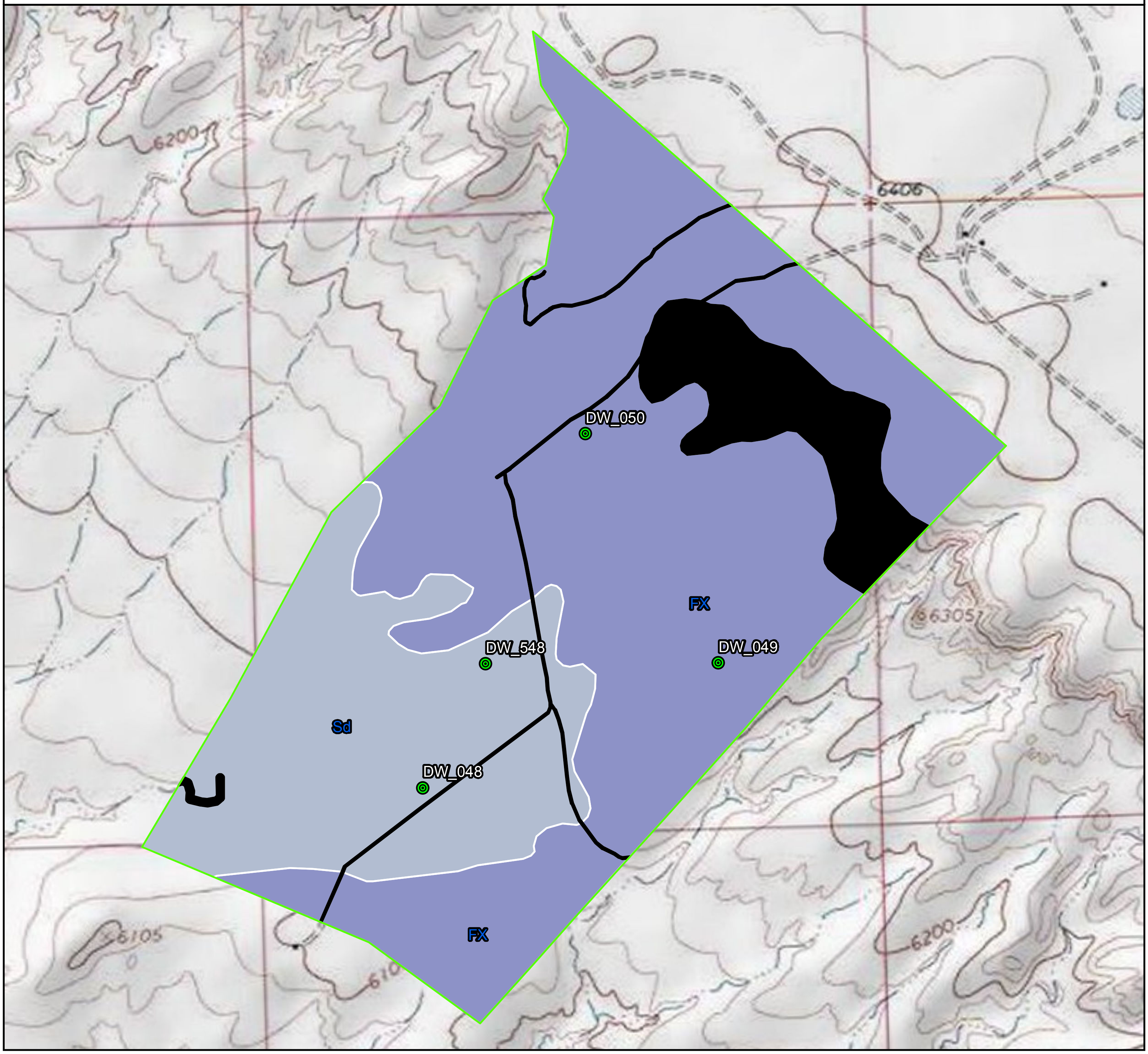
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	3	14.49	199.35	163.56	1.22	1.15	0.00
R035XB007NM Deep Sand	1	15.71	232.65	150.86	1.54	1.50	0.00
R035XA130NM Shale Hills	0		123.58				

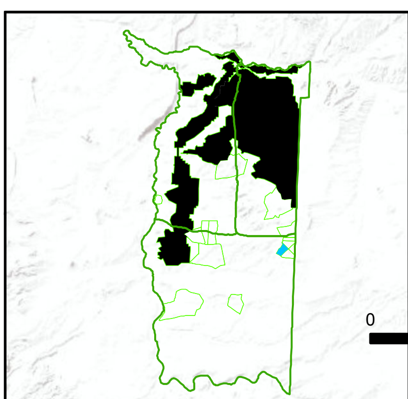
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 612
Grazeable Acres*: 556
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
3 Sheep

Burnham Chapter, Diswood West





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

1:14,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

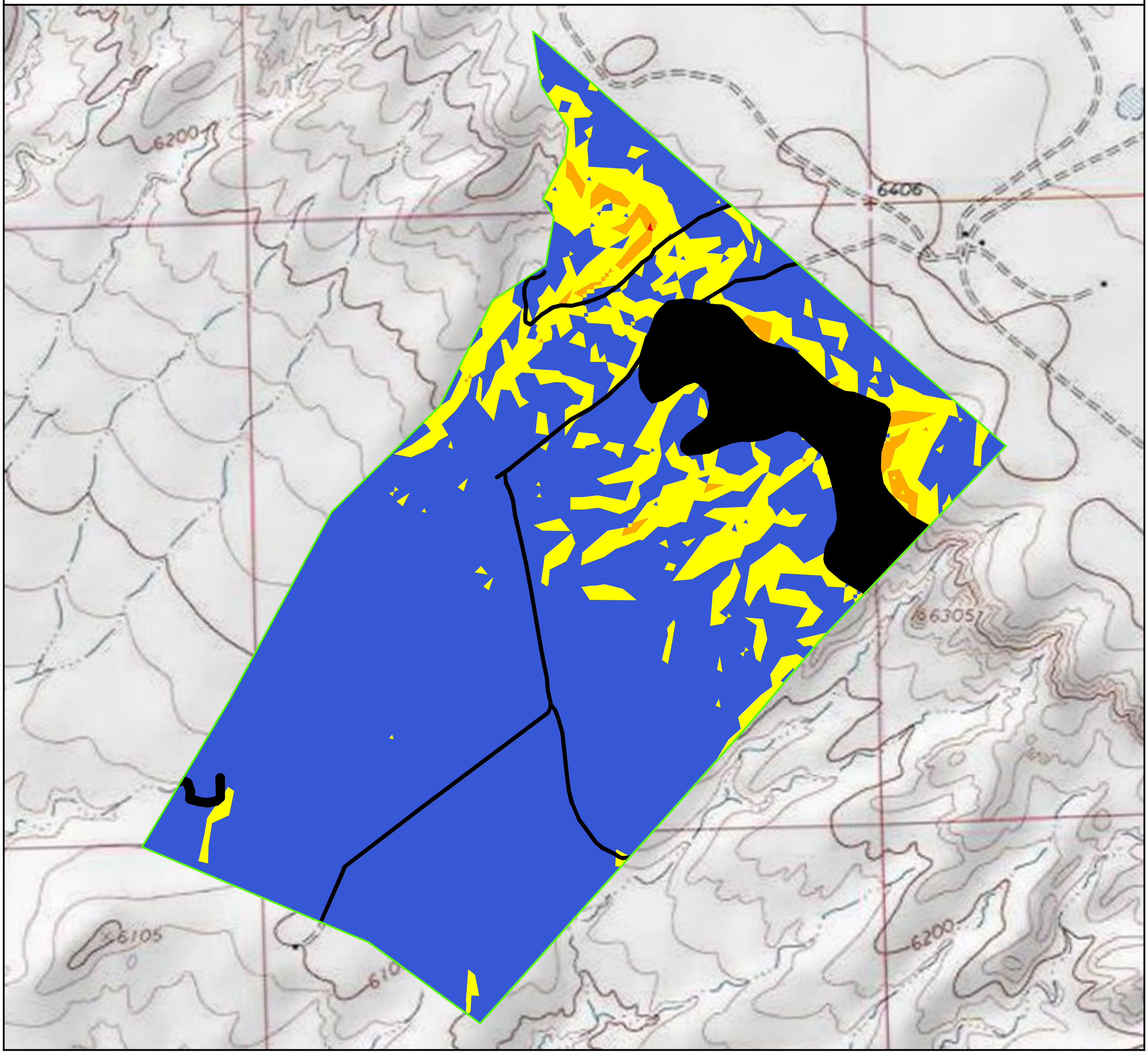
Document Name: P8X11_Soils_InitialCC_D13

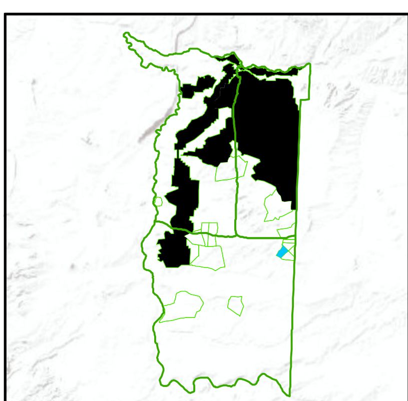
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 612
Grazeable Acres*: 556
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Burnham Chapter, Diswood West





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

1:14,000

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit Diswood_North

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		556.73
Non-Grazeable Acres	Developed	2.48
	Hydro	1.26
	Roads	10.86
	Slope >60%	0.00
	Soils	0.00
Grazeable Acres		542.13

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	6.0
Maximum	36.0
Median	15.5

Summary of Cover by Analysis Unit

Foliar Cover	21.33%
Bareground	68.00%
Basal	1.00%

Results by Ecological Site in Sheep Units Year Long

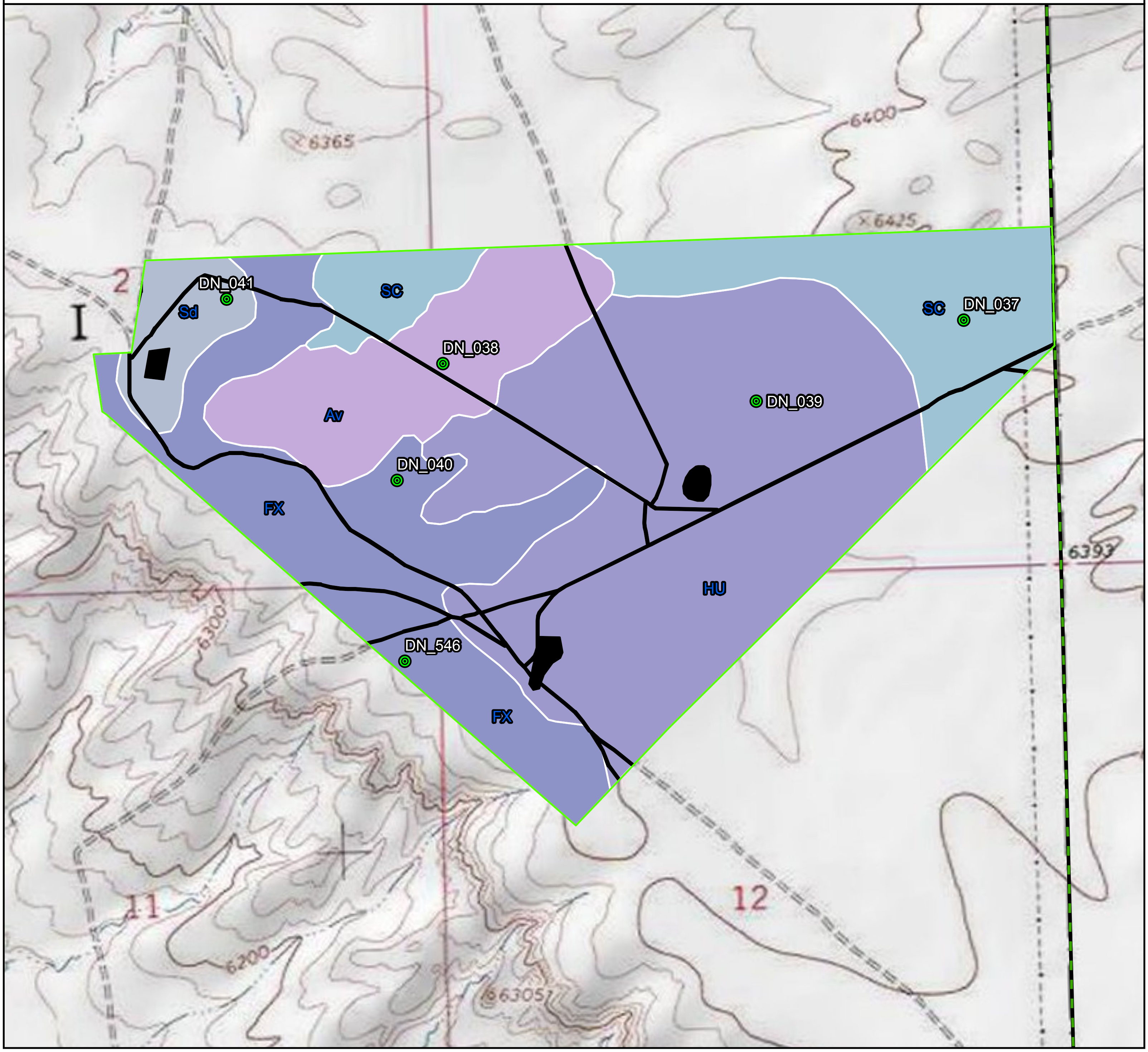
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	3	18.40	55.13	128.80	0.43	0.43	0.00
R035XB005NM Salt Flats	2	40.08	288.88	59.13	4.89	4.89	0.00
R035XB003NM Limy	1	16.76	70.98	141.41	0.50	0.50	0.00
R035XB007NM Deep Sand	0		89.20				
R035XA130NM Shale Hills	0		37.93				

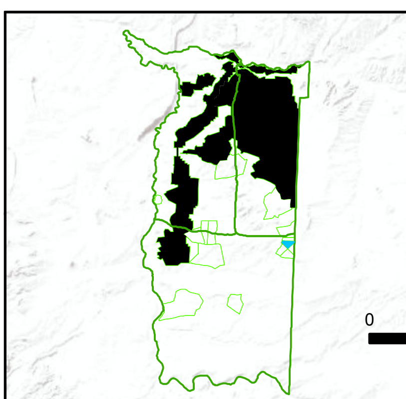
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 557
Grazeable Acres*: 542
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 6 Sheep

Burnham Chapter, Diswood North





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

1:14,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

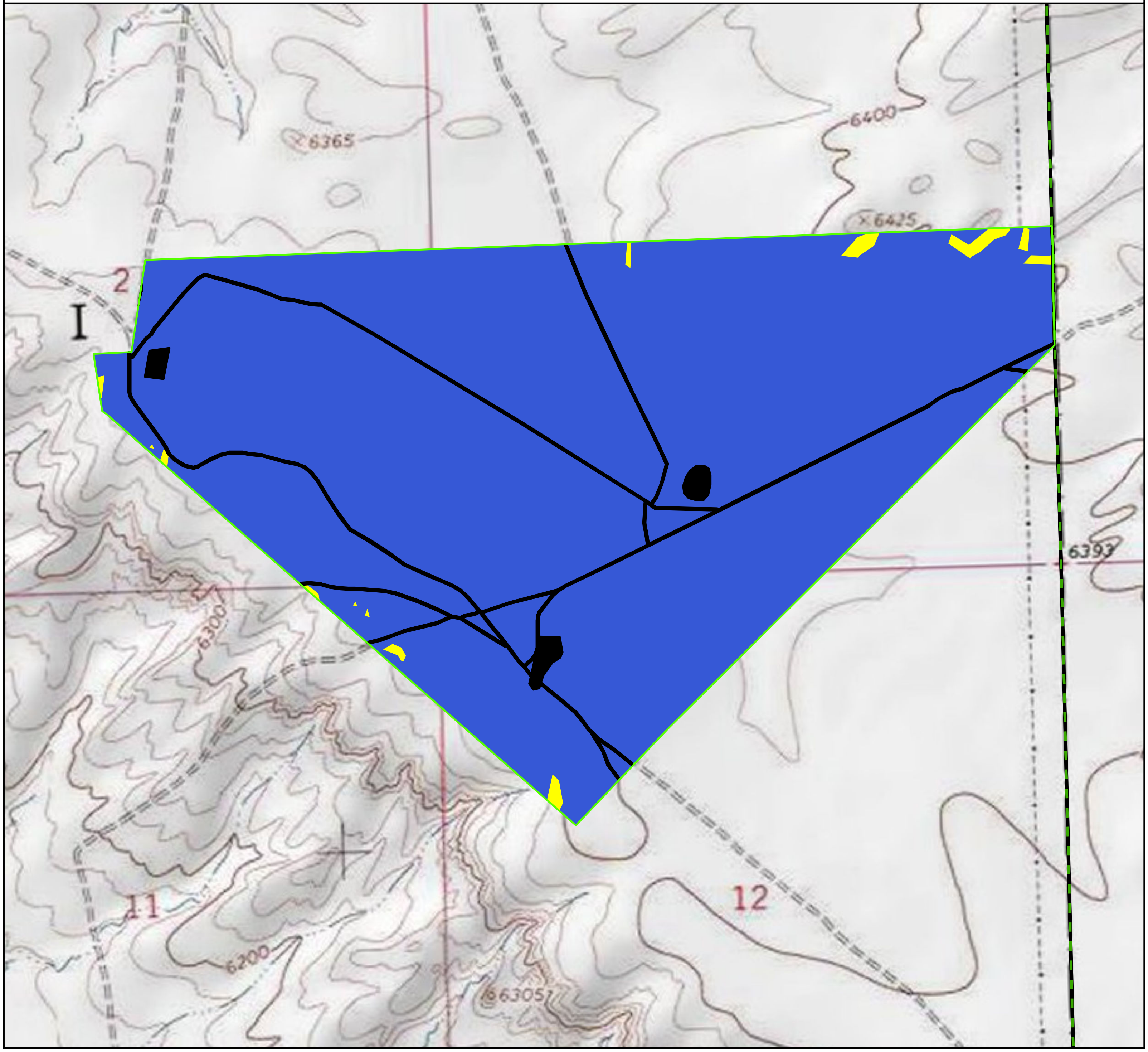
Document Name: P8X11_Soils_InitialCC_D13

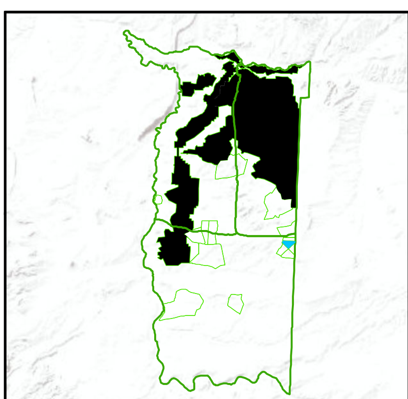
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 557
Grazeable Acres*: 542
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Burnham Chapter, Diswood North





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

1:14,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit: Diswood_East

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		382.42
Non-Grazeable Acres	Developed	1.01
	Hydro	0.00
	Roads	7.11
	Slope >60%	0.00
	Soils	0.00
Grazeable Acres		374.30

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	17.0
Maximum	27.0
Median	24.5

Summary of Cover by Analysis Unit

Foliar Cover	23.00%
Bareground	59.00%
Basal	6.50%

Results by Ecological Site in Sheep Units Year Long

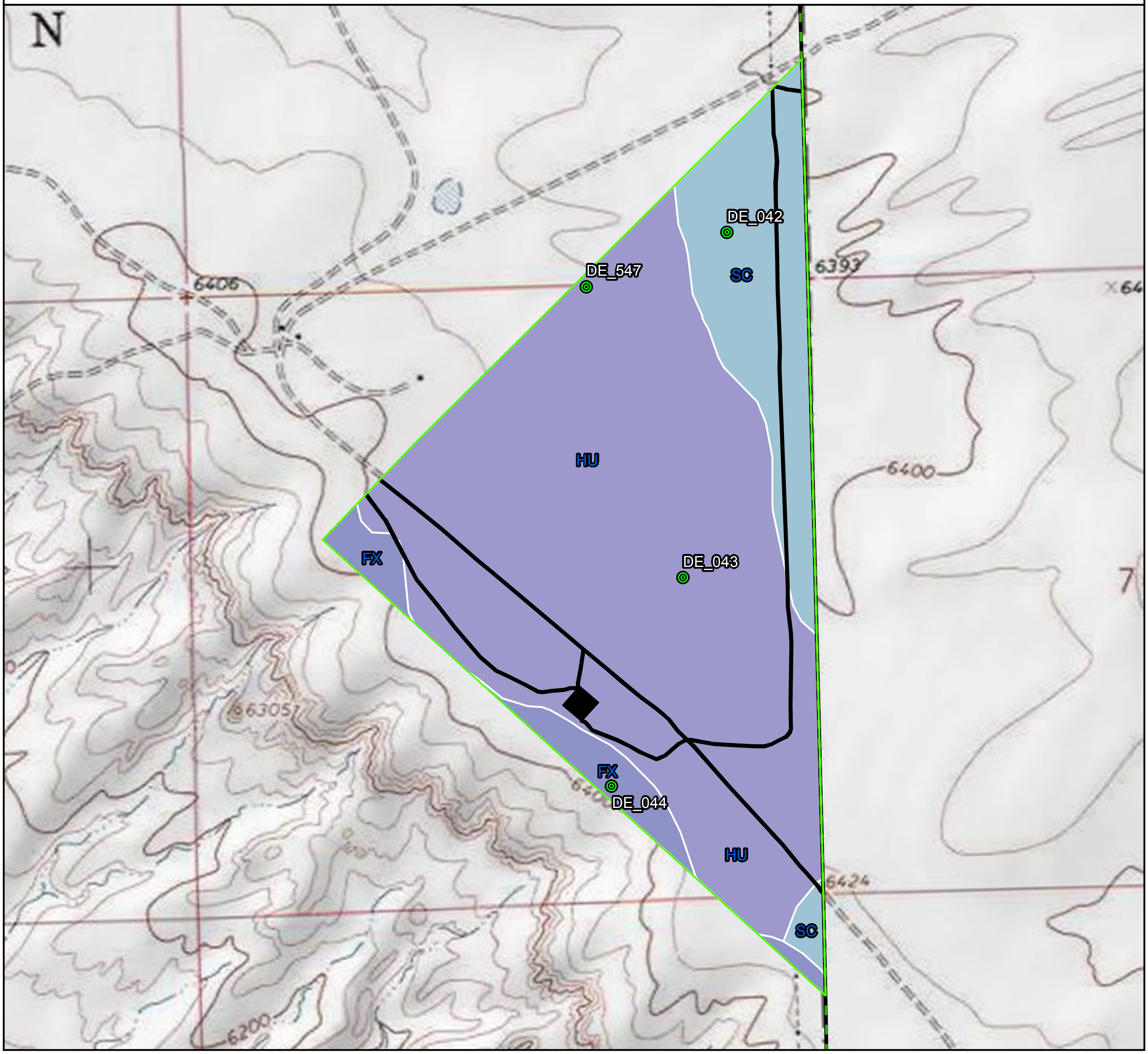
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB005NM Salt Flats	3	46.65	323.39	50.80	6.37	6.37	0.00
R035XB007NM Deep Sand	1	43.34	35.31	54.68	0.65	0.65	0.00
R035XB002NM Sandy	0		8.92				
R035XA130NM Shale Hills	0		6.69				

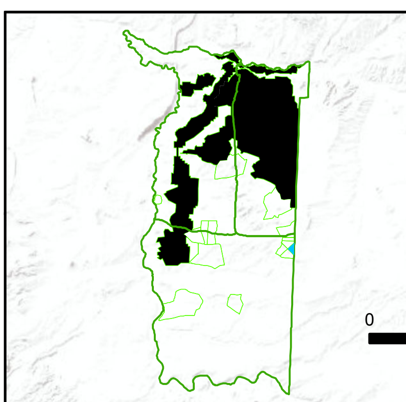
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 382
Grazeable Acres*: 374
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
7 Sheep

Burnham Chapter, Diswood East





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

1:14,000

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

Date: 1/5/2015

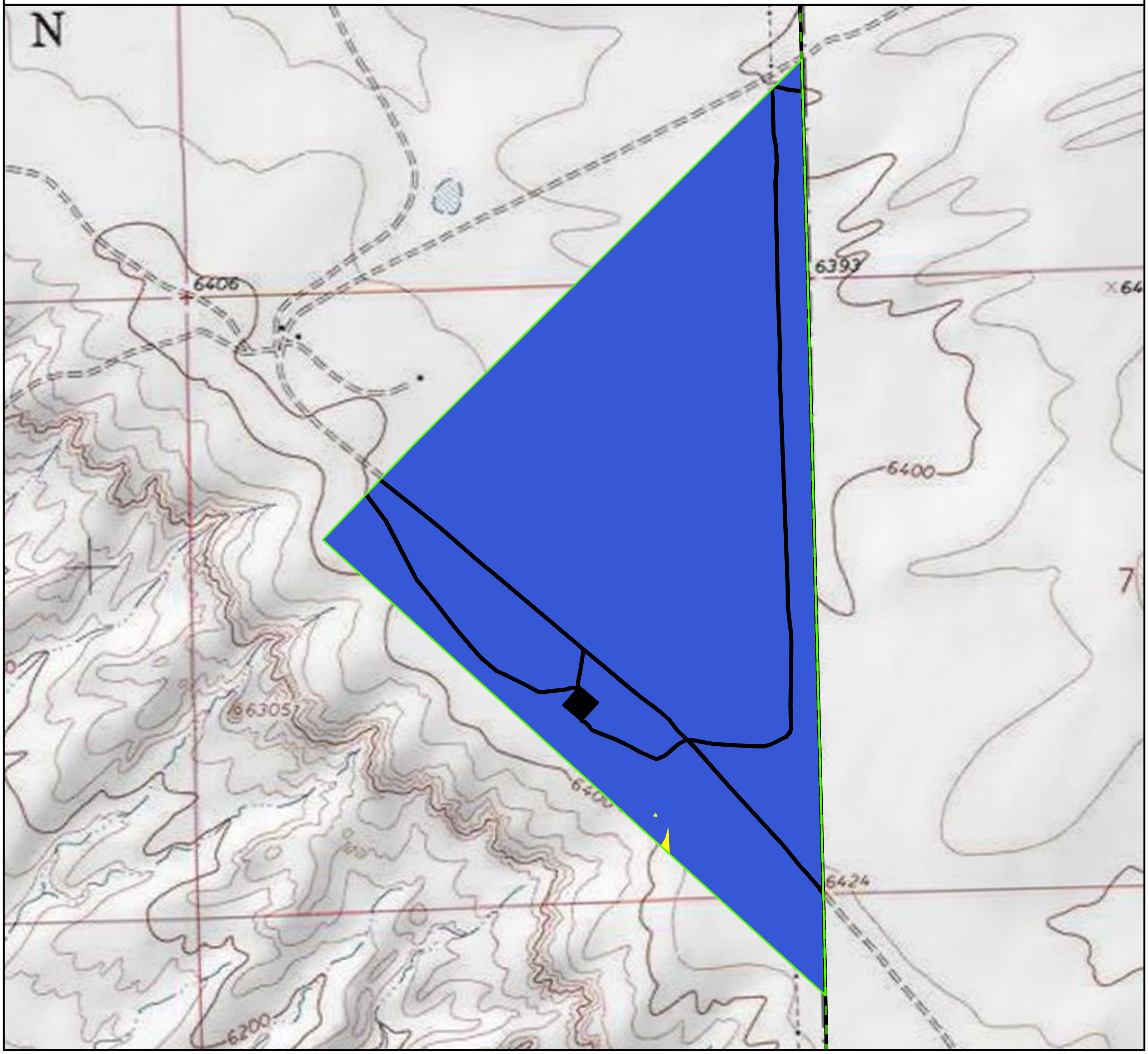
Document Name: P8X11_Soils_InitialCC_D13

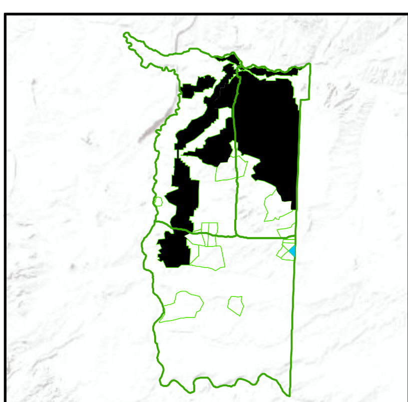
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 382
Grazeable Acres*: 374
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Burnham Chapter, Diswood East





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Ecosphere Environmental Services

1:14,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit Diswood_South

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		688.62
Non-Grazeable Acres	Developed	0.00
	Hydro	0.00
	Roads	0.09
	Slope >60%	0.04
	Soils	120.64
Grazeable Acres		567.84

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	5.0
Maximum	33.0
Median	18.5

Summary of Cover by Analysis Unit

Foliar Cover	13.50%
Bareground	65.50%
Basal	3.00%

Results by Ecological Site in Sheep Units Year Long

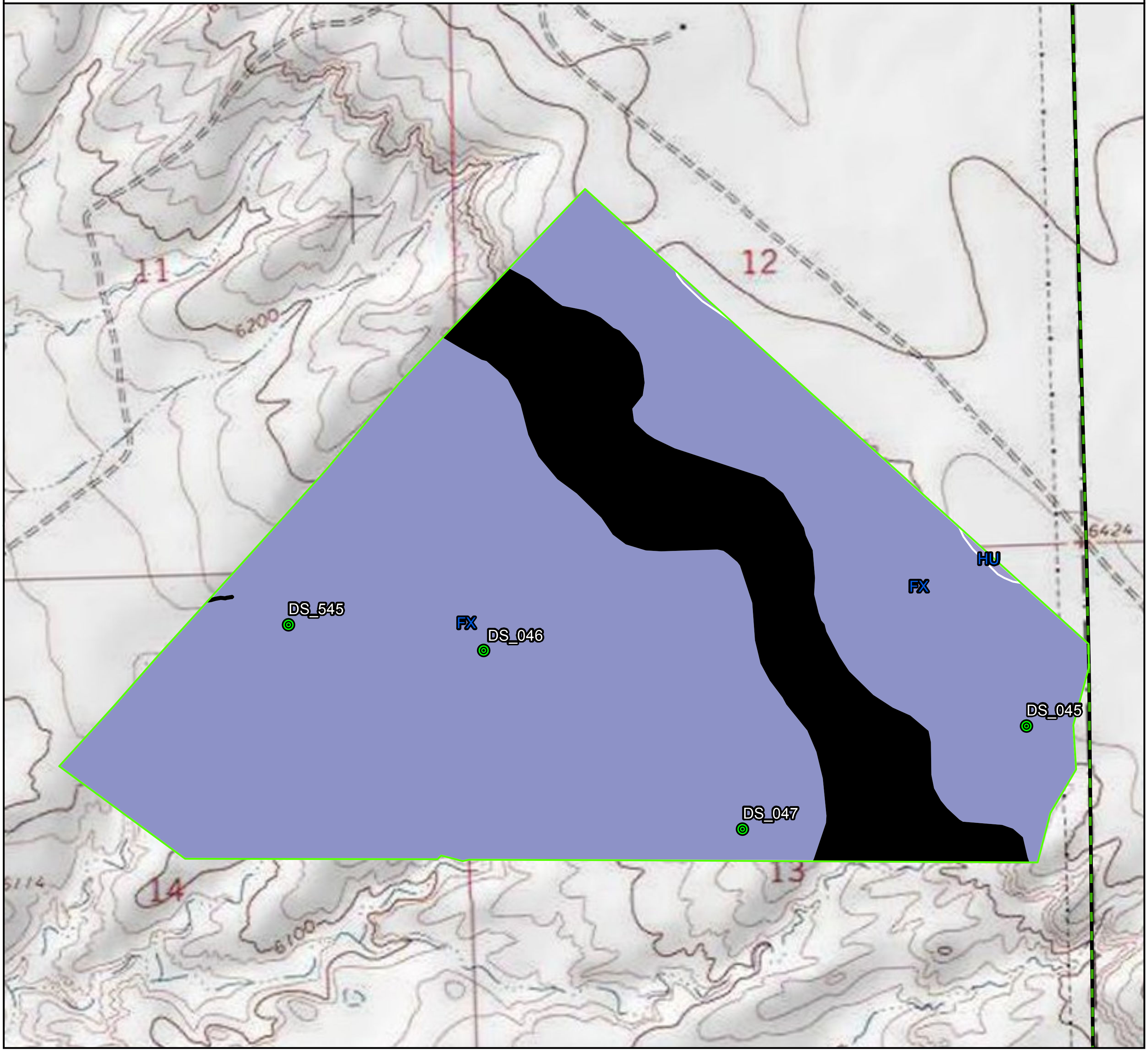
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	3	33.73	238.59	70.26	3.40	3.30	0.00
R035XB007NM Deep Sand	1	19.97	149.12	118.68	1.26	1.16	0.00
R035XB005NM Salt Flats	0		1.23				
R035XA130NM Shale Hills	0		178.94				

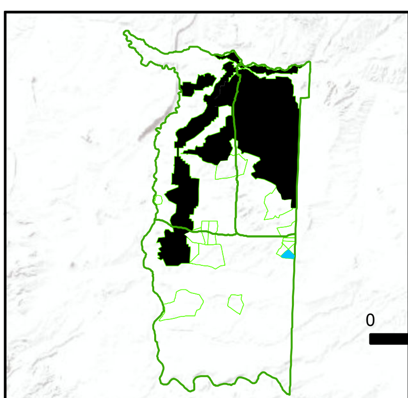
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 689
Grazeable Acres*: 568
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 5 Sheep

Burnham Chapter, Diswood South





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

1:14,000

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

Date: 1/5/2015

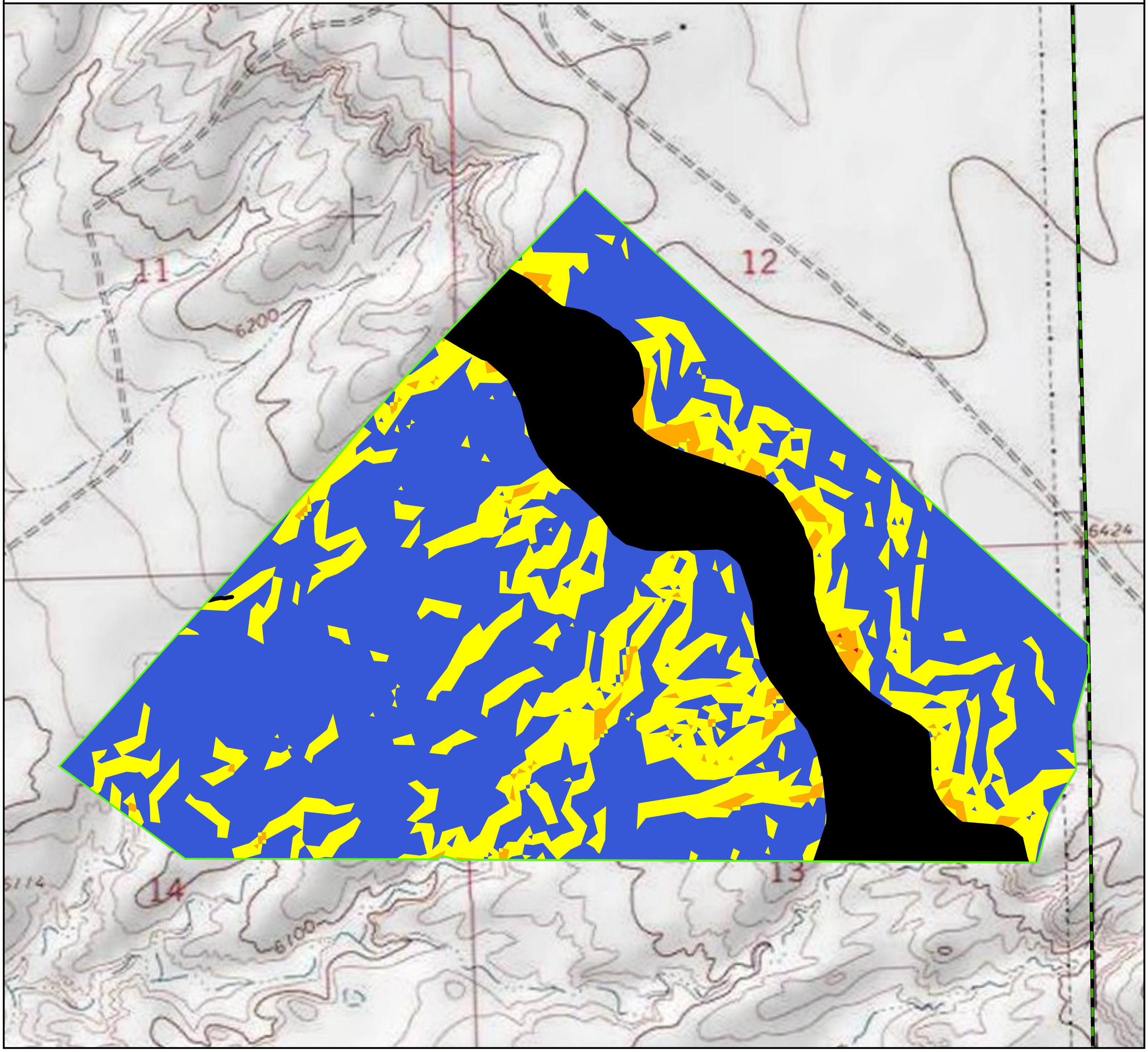
Document Name: P8X11_Soils_InitialCC_D13

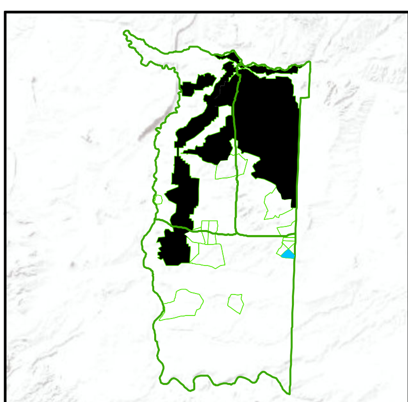
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 689
Grazeable Acres*: 568
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Burnham Chapter, Diswood South





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Ecosphere Environmental Services

1:14,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

5.3.5 Gilmore

Ecological Site Summary

The Gilmore RMU is located in north central portion of Burnham community. Gilmore RMU contains eight transects, two ecological sites, and 1,645 grazeable acres. Available forage is low throughout the RMU, but is higher in the R035XB007NM site versus the R035XB005NM site. The R035XB007NM is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush (*Atriplex canescens*), and sand sagebrush (*Artemisia filifolia*). Prolonged, unmanaged grazing can lead to a shrub dominated site with large areas of bare ground and few perennial grasses. Currently, shrubs do make up a large portion of the plant community, but shrub interspaces on most transects are populated with perennial grasses. The common grasses that were encountered include Indian ricegrass, alkali sacaton (*Sporobolus airoides*) and James' galleta (*Pleuraphis jamesii*), and mesa dropseed (*Sporobolus flexuosus*). Common shrubs are shadscale (*Atriplex confertifolia*), Torrey's jointfir (*Ephedra torreyana*), rubber rabbitbrush (*Ericameria nauseosa*), and narrowleaf yucca (*Yucca angustissima*). Prickly Russian thistle (*Salsola tragus*) seedlings were also widely occurring in many transects.

The R035XB005NM site occurs within salt flats and has sodium-affected soils that are usually deep, but can be shallow in areas associated with the Huerfano soil component. Shrubland with perennial grasses in the shrub interspaces typifies the reference plant community. Unmanaged grazing often leads to a shrub-dominated site with mainly annual forbs and grasses making up the herbaceous understory. The sampled community contained some areas with a moderate cover of James' galleta and Indian ricegrass, but other areas were largely depauperate of vegetation. Prickly Russian thistle and saltlover (*Halogeton glomeratus*) were also encountered on several transects.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Gilmore RMU are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 100% of all transects)
2. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 75% of all transects)
3. James' galleta (*Pleuraphis jamesii*) (occurred on 75% of all transects)
4. Torrey's jointfir (*Ephedra torreyana*) (occurred on 75% of all transects)
5. rose heath (*Chaetopappa ericoides*) (occurred on 62% of all transects)

Species by Weight

1. prickly Russian thistle (*Salsola tragus*) (203 lbs/acre)
2. Indian ricegrass (*Achnatherum hymenoides*) (142 lbs/acre)

3. James' galleta (*Pleuraphis jamesii*) (115 lbs/acre)
4. rubber rabbitbrush (*Ericameria nauseosa*) (42 lbs/acre)
5. mesa dropseed (*Sporobolus flexuosus*) (30 lbs/acre)

Ground Cover

The percentage of bare ground is well above the project area average, and the percentage of foliar cover is well below average. At this time, there is little erosion occurring in the RMU, but the amount of bare ground suggests that the risk of future erosion is high.

Analysis Unit: Gilmore

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		5,130.68
Non-Grazeable Acres	Developed	1.71
	Hydro	12.82
	Roads	2.41
	Slope >60%	0.00
	Soils	3,469.18
Grazeable Acres		1,644.56

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	0.0
Maximum	31.0
Median	9.5

Summary of Cover by Analysis Unit

Foliar Cover	7.25%
Bareground	76.75%
Basal	0.00%

Results by Ecological Site in Sheep Units Year Long

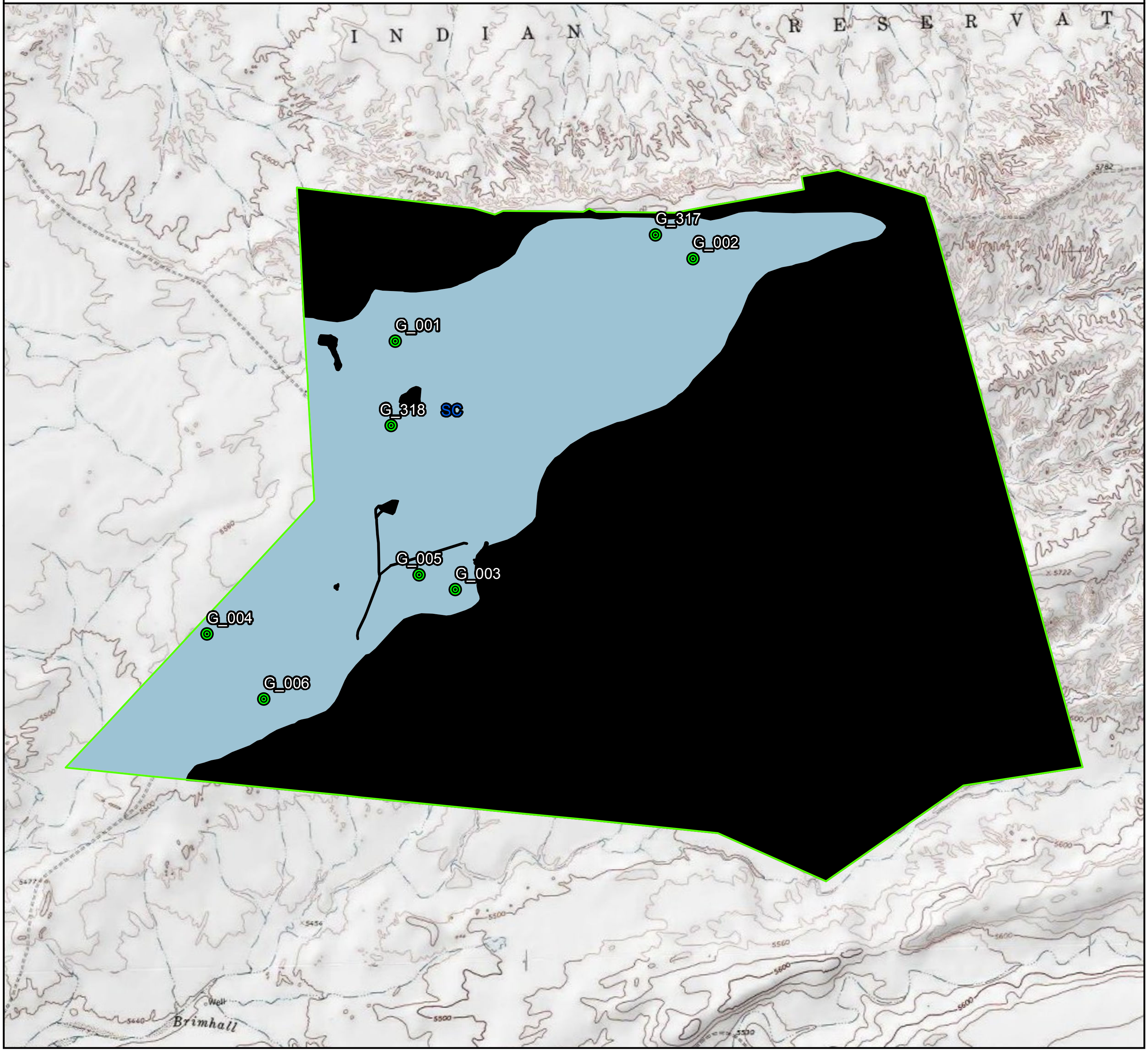
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	5	11.45	730.91	206.99	3.53	3.52	2.99
R035XB005NM Salt Flats	3	3.87	913.64	612.40	1.49	1.48	1.26

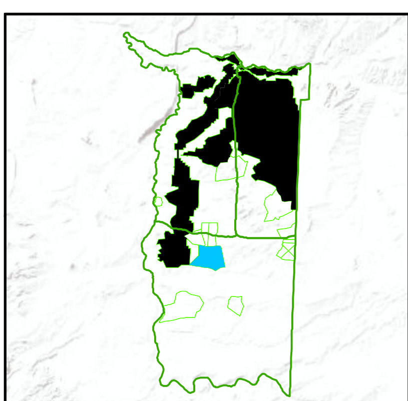
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 5,131
Grazeable Acres*: 1,645
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
5 Sheep

Burnham Chapter, Gilmore





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:36,000

Ecosphere Environmental Services

Date: 1/5/2015

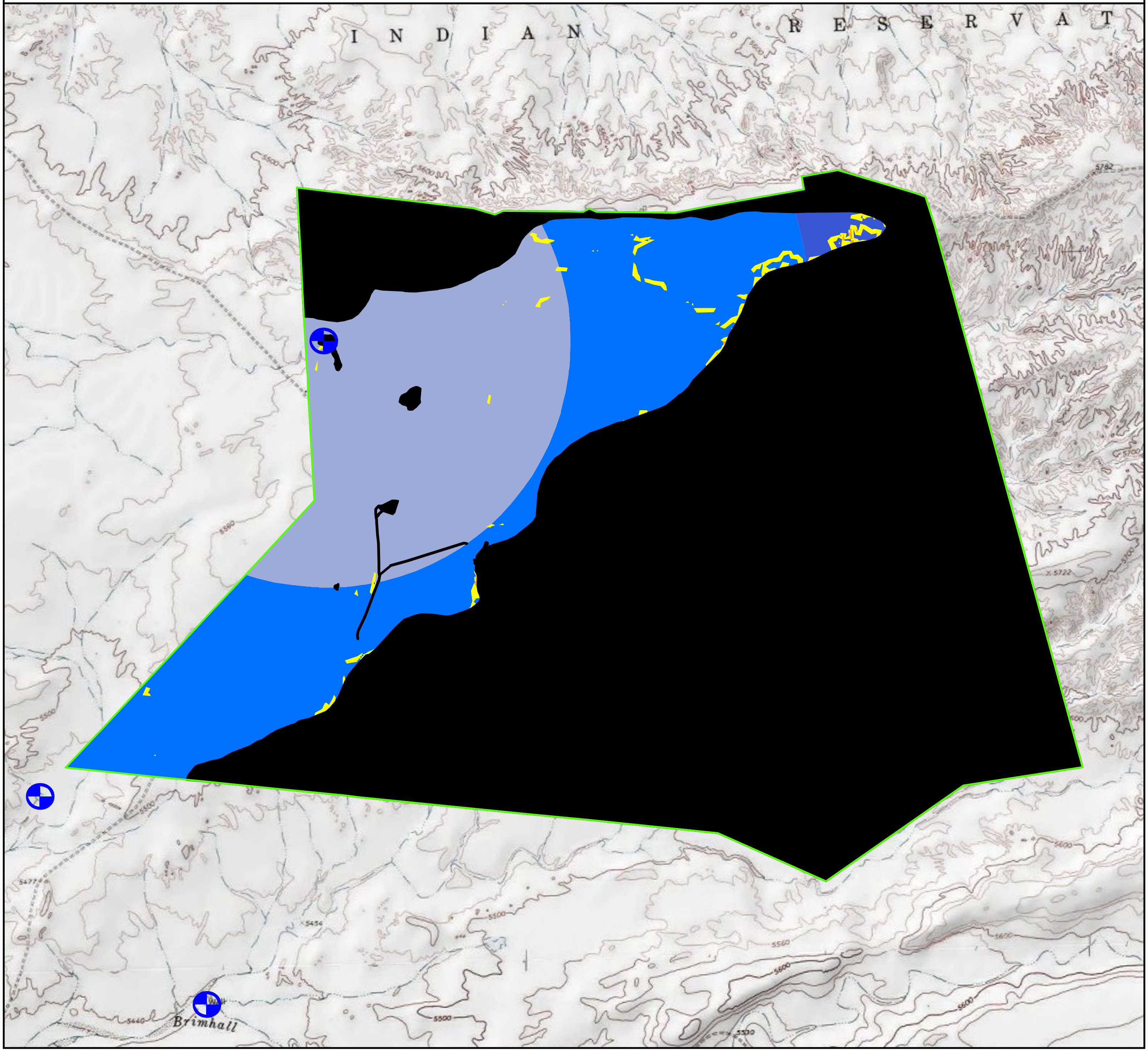
Document Name: P8X11_Soils_InitialCC_D13

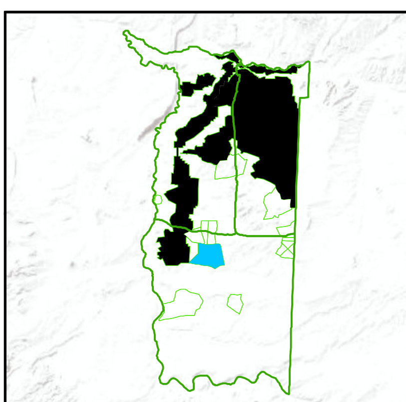
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 5,131
Grazeable Acres*: 1,645
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
4 Sheep

Burnham Chapter, Gilmore





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:36,000

Ecosphere Environmental Services

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

5.3.6 Monsisco Mesa

Ecological Site Summary

The Monsisco Mesa RMU is located in the southern half of the Upper Fruitland community and borders NAPI land on its northeast and east sides. This RMU covers 4,302 grazeable acres and contains 28 transects within five ecological sites. Nearly half of all available forage is being produced in the R035XA130NM site. However, this site also has only one transect, so the gathering of additional data is recommended in order to gain a more complete picture of current conditions. This site occurs on the sides of mesas and is usually dissected by numerous small arroyos. Slopes can range as high as 35 percent, and soils tend to be clayey and deep. The reference plant community is a mix of shrubs and grasses with dominant species being alkali sacaton (*Sporobolus airoides*), fourwing saltbush (*Atriplex canescens*), and broom snakeweed (*Gutierrezia sarothrae*). Subdominants include James' galleta (*Pleuraphis jamesii*), blue grama (*Bouteloua gracilis*), and sideoats grama (*Bouteloua curtipendula*). In the sampled community, available forage is mainly being produced by James' galleta and to a lesser extent, Indian ricegrass (*Achnatherum hymenoides*).

The R035XB001NM site contains six transects and has the second highest amount of available forage. Perennial grasses dominate the reference plant community while shrubs and forbs make up only a minor component of the site. Common species in the reference community include James' galleta, Indian ricegrass, needle and thread (*Hesperostipa comata*), and bottlebrush squirreltail (*Elymus elymoides*). Prolonged grazing pressure will eventually convert the site to shrubland with numerous forbs in the understory. James' galleta and Indian ricegrass are primary contributors of available forage. Cheatgrass (*Bromus tectorum*) and prickly Russian thistle (*Salsola tragus*) were found on a few transects, but at this time, only make up a minor component of the plant community.

The R035XB003NM site is only slightly smaller than the sites described above, but carrying capacity is much lower due to a much lower amount of available forage. Soils are distinguished by being calcareous and loamy. Perennial grasses make up the majority of the reference plant community, but shrubs and annual forbs are generally present in small amounts. Juniper (*Juniperus* spp.) may invade the site following prolonged disturbance. The current plant community still consists primarily of perennial grasses, but they are occurring less frequently than in the reference state. The most abundant grasses at this time are blue grama and James' galleta.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Monsisco Mesa RMU are listed below:

Frequently Encountered Species

1. James' galleta (*Pleuraphis jamesii*) (occurred on 100% of all transects)
2. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 89% of all transects)
3. cryptantha (*Cryptantha sp.*) (occurred on 75% of all transects)

4. blue grama (*Bouteloua gracilis*) (occurred on 71% of all transects)
5. false buffalograss (*Monroa squarrosa*) (occurred on 68% of all transects)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (3,784 lbs/acre)
2. Indian ricegrass (*Achnatherum hymenoides*) (1,112 lbs/acre)
3. blue grama (*Bouteloua gracilis*) (358 lbs/acre)
4. rubber rabbitbrush (*Ericameria nauseosa*) (249 lbs/acre)
5. tansymustard (*Descurainia sp.*) (216 lbs/acre)

Ground Cover

The amount of bare ground in the Monsisco Mesa RMU is below the project area average, while foliar and basal cover are above average. Very little erosion was noted in the vicinity of the transects.

Analysis Unit Monsisco Mesa

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		4,644.98
Non-Grazeable Acres	Developed	3.35
	Hydro	32.41
	Roads	29.98
	Slope >60%	0.61
	Soils	276.94
Grazeable Acres		4,301.70

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	9.0
Maximum	42.0
Median	20.5

Summary of Cover by Analysis Unit

Foliar Cover	20.64%
Bareground	67.21%
Basal	2.93%

Results by Ecological Site in Sheep Units Year Long

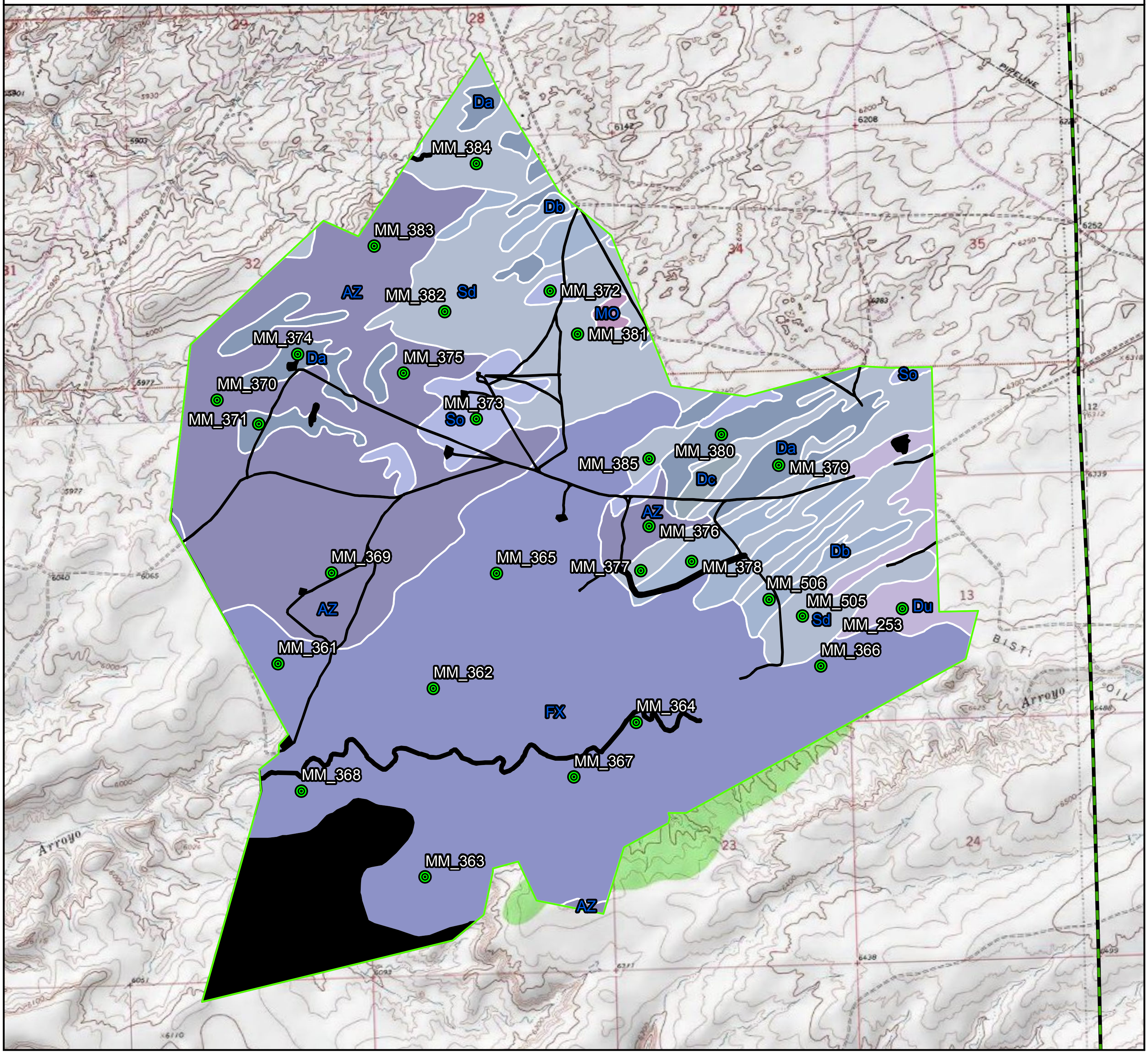
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	12	30.51	1,347.60	77.68	17.35	17.30	0.00
R035XB001NM Loamy	7	44.86	521.71	52.83	9.88	9.88	0.00
R035XB007NM Deep Sand	6	26.23	1,397.59	90.35	15.47	15.44	0.00
R035XB003NM Limy	2	18.59	407.47	127.49	3.20	3.20	0.00
R035XA130NM Shale Hills	1	94.80	570.25	25.00	22.81	22.72	0.00
R035XB006NM Shallow	0		8.67				
R035XB005NM Salt Flats	0		48.05				
R035XB004NM Clayey	0		0.96				

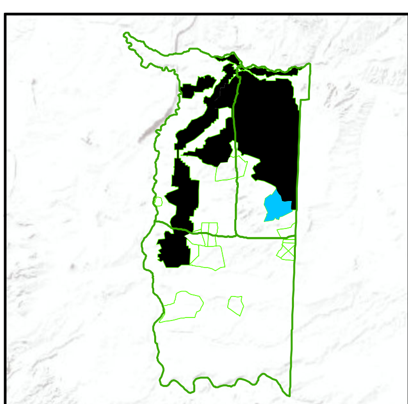
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 4,645
Grazeable Acres*: 4,302
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 69 Sheep

Upper Fruitland Chapter, Monsisco Mesa





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:36,000

Ecosphere Environmental Services

Date: 1/5/2015

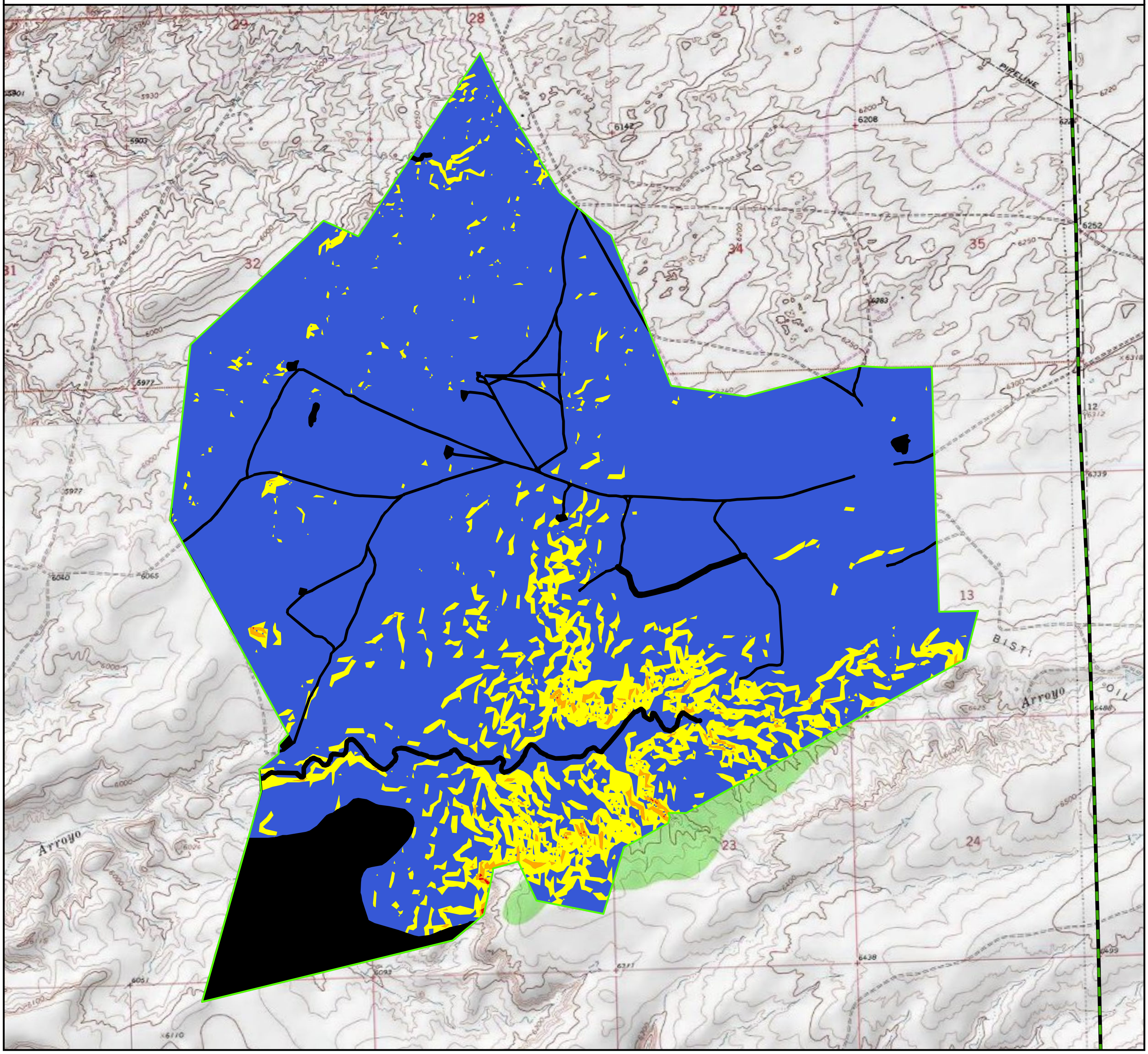
Document Name: P8X11_Soils_InitialCC_D13

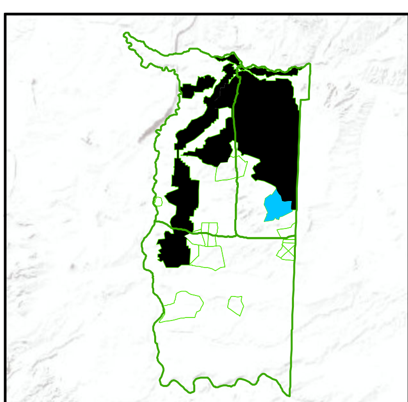
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 4,645
Grazeable Acres*: 4,302
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Upper Fruitland Chapter, Monsisco Mesa





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
- < 1 Mile
- 1 - 2 Miles
- > 2 Miles

Slope
- 10 - 30% Slope
- 30 - 60% Slope
- > 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:36,000

Ecosphere Environmental Services

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

5.3.7 Puggie

Ecological Site Summary

Puggie RMU has four pastures with 3 transects each. Pastures 1, 2 and 3 of the Puggie RMU are located at the north border of the Burnham community and the southern border of the Nenahnezad/San Juan community, close to the mine lease area. The west pasture is not contiguous with the rest of the RMU and is located to the northwest on the other side of the mine lease area by the confluence of Chaco Wash and Pinabete Arroyo. Pinabete Arroyo runs through the rest of RMU. The area south of Pinabete Arroyo in all three pastures is primarily badlands and was not analyzed. Pastures 1 and 2 contain only a single ecological site that is present in all four pastures. Pasture 3 has two ecological sites, and the west pasture has two ecological sites. Pasture 1 has 368 grazeable acres, Pasture 2 has 680, Pasture 3 has 885, and the west pasture has 494. In general, the RMU is in poor condition. Only six species contributed to 92 percent of the biomass. More than half of the similarity indices for transects throughout this RMU were in single digits.

The R035XB007NM deep sand ecological site occurs in all four pastures. All three transects in Pasture 1, all three transects in Pasture 2, one transect in Pasture 3 and two transects in the west pasture are in this ecological site. The stocking rates varied from 865 acres per sheep unit year long for this ecological site in the west pasture, to a relative low of 140 acres per sheep unit year long for this ecological site in Pasture 2. The stocking rate in Pastures 1 and 3 was 319 and 203 acres per sheep unit year long, respectively. This ecological site, which contributes to most of the analyzed grazeable acres in this RMU, is a sandy site with deep, well-drained soils and a reference plant community dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush (*Atriplex canescens*), and sand sagebrush (*Artemisia filifolia*). In the current condition of the RMU, six species made up 92 percent of the biomass.

The R035XB002NM ecological site is a sandy site with well-drained and deep soils. This site only occurs on about 73 acres of Pasture 3. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass, dropseed, needle and thread (*Hesperostipa comata*), and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush, winterfat (*Krascheninnikovia lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase and the site eventually shifts towards a shrub/subshrub dominated plant community. Currently, Pasture 3 is dominated by prickly Russian thistle (*Salsola tragus*), with Indian ricegrass and James' galleta grass (Pleuraphis jamesii) following behind. The similarity index on both transects in this ecological site was 7 percent.

One transect was located in the R035XB006NM Shallow ecological site. This was in the west pasture. Soils range from sandy loams to clay loams and the reference plant community is a mix of shrubs and grasses with the most prominent species being Indian ricegrass, James' galleta, needle and thread (*Hesperostipa comata*), buckwheat (*Eriogonum* spp.), winterfat, Cutler's jointfir (*Ephedra cutleri*), and fourwing saltbush. Site deterioration leads to an initial increase in shrubs followed by a shrub dominated community with large areas of bare ground. Currently, this site is dominated by Russian thistle and alkali sacaton (*Sporobolus airoides*) with few other species contributing significant biomass.

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Puggie RMU community are listed below:

Frequently Encountered Species

1. prickly Russian thistle (*Salsola tragus*) (occurred on 100% of all transects)
2. James' galleta (*Pleuraphis jamesii*) (occurred on 100% of all transects)
3. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 83% of all transects)
4. false buffalograss (*Monroa squarrosa*) (occurred on 83% of all transects)
5. Alkali sacaton (*Sporobolus airoides*) and Torrey's jointfir (*Ephedra torreyana*) (each occurred on 58% of all transects).

Species by Weight

1. Russian thistle (*Salsola tragus*) (561 lbs/acre) (43% of total)
2. Alkali sacaton (*Sporobolus airoides*) (279 lbs/acre)
3. James' galleta (*Pleuraphis jamesii*) (164 lbs/acre)
4. Indian ricegrass (*Achnatherum hymenoides*) (145 lbs/acre)
5. Rubber rabbitbrush (*Ericameria nauseosa*) (25 lbs/acre)

Ground Cover

No basal vegetation hits were recorded in the Puggie RMU. Bare ground was high for all pastures, with a low of 79 percent in Pasture 2 to a high of 87 in Pasture 3. Pastures 1 and 4 had 81 and 82 percent, respectively. Foliar cover was correspondingly low, with the lowest in Pasture 2 at only 7 percent, and the highest in the west pasture at 13 percent due to the higher amount of prickly Russian thistle in this pasture. Pastures 1 and 3 had 9 and 8 percent foliar cover, respectively. Active water erosion is not a significant issue, but there is evidence of blowouts and other signs of wind erosion, which is exacerbated by the very high percentage of bare ground in this RMU.

Analysis Unit **Puggie_1**

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		1,779.93
Non-Grazeable Acres	Developed	0.00
	Hydro	25.64
	Roads	3.29
	Slope >60%	0.00
	Soils	1,383.31
Grazeable Acres		367.69

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	3.0
Maximum	15.0
Median	6.0

Summary of Cover by Analysis Unit

Foliar Cover	9.33%
Bareground	81.33%
Basal	0.00%

Results by Ecological Site in Sheep Units Year Long

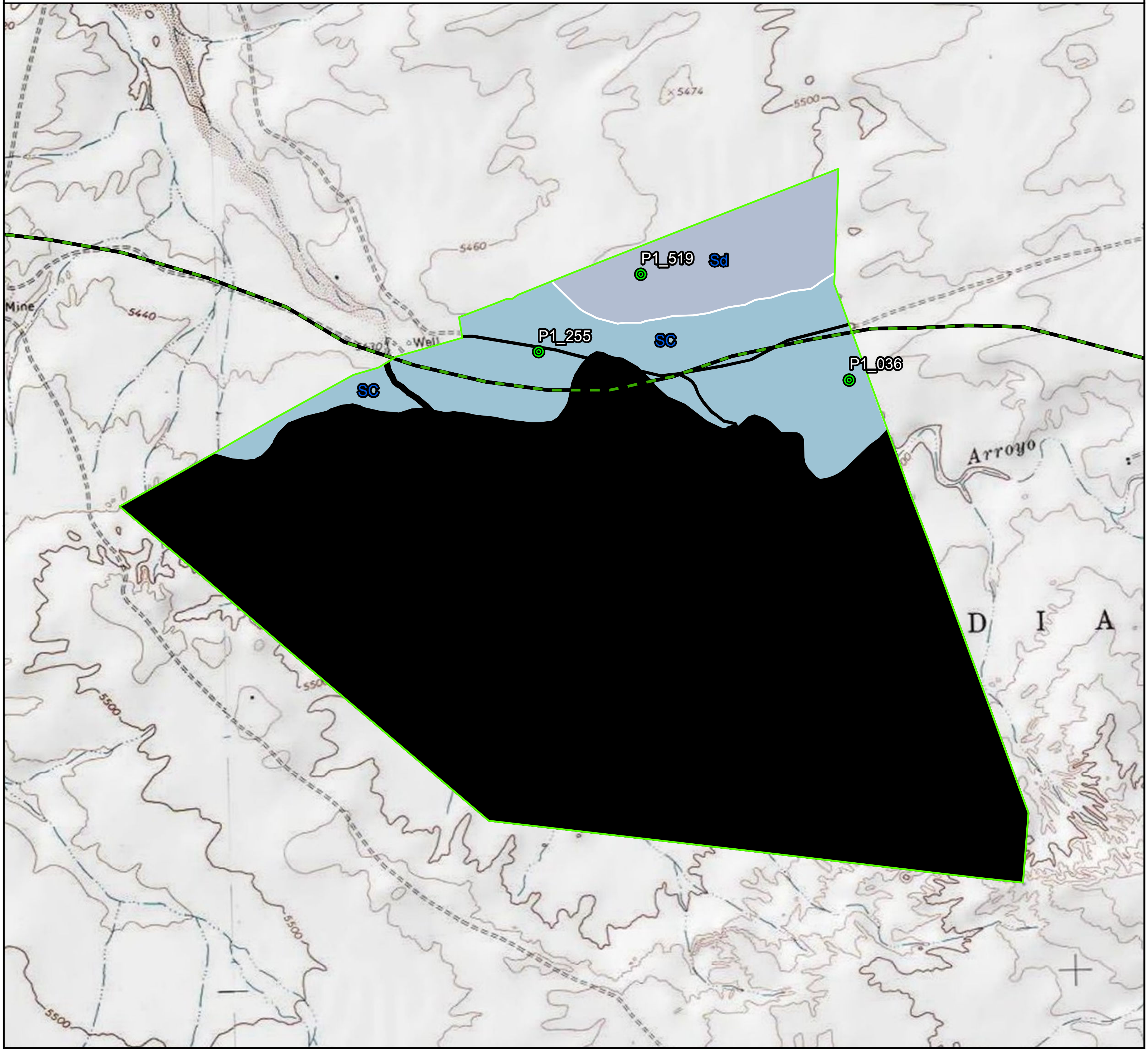
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	3	7.42	201.97	319.41	0.63	0.63	0.00
R035XB005NM Salt Flats	0		142.19				
R035XB002NM Sandy	0		23.53				

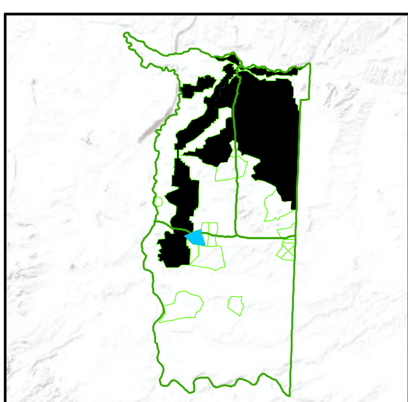
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,780
Grazeable Acres*: 368
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 1 Sheep

Burnham Chapter, Puggie 1





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

1:24,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

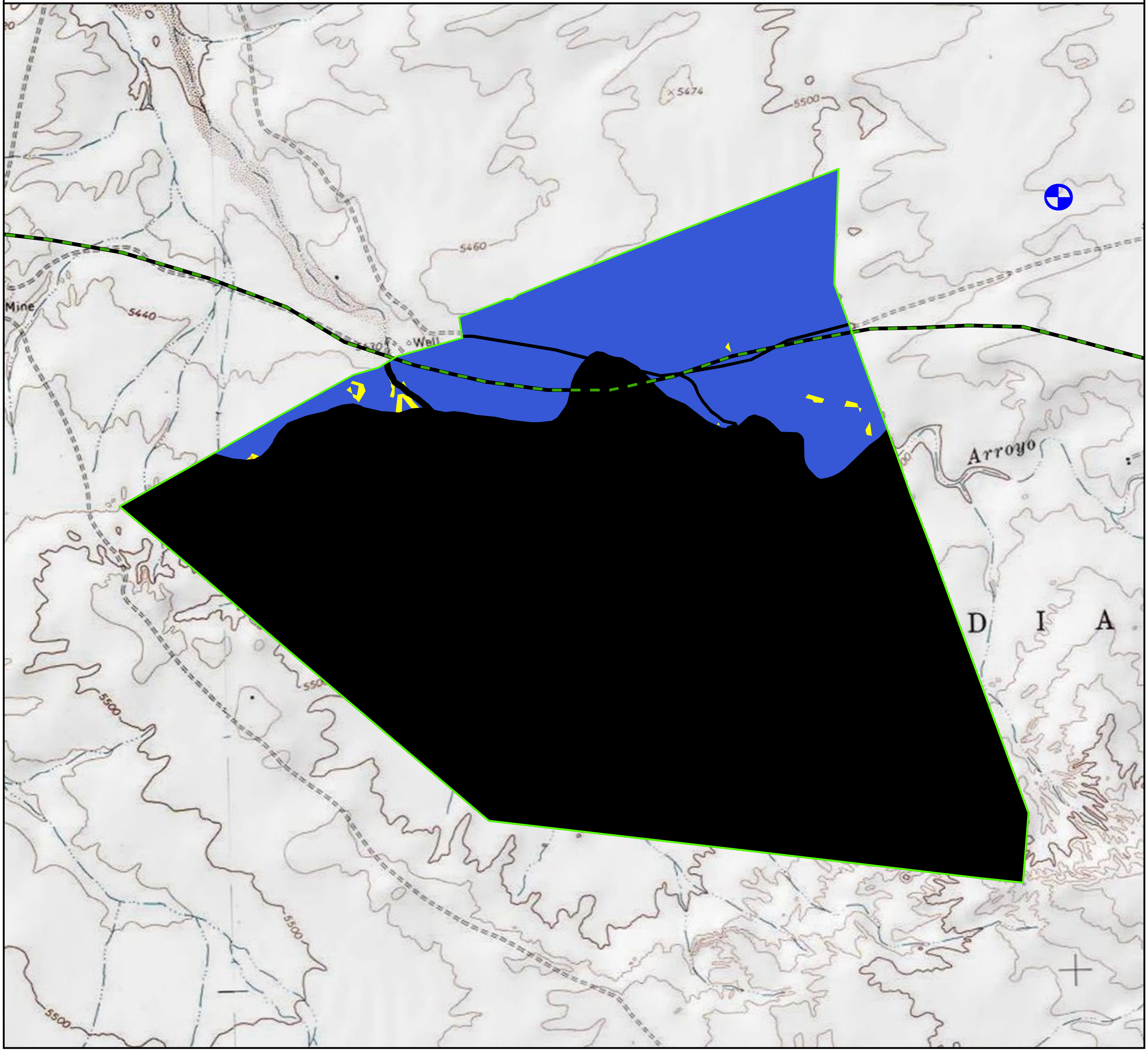
Document Name: P8X11_Soils_InitialCC_D13

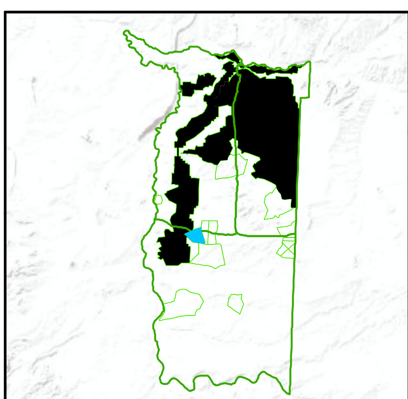
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,780
Grazeable Acres*: 368
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 0 Sheep

Burnham Chapter, Puggie 1





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

1:24,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit Puggie_2

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		1,161.94
Non-Grazeable Acres	Developed	0.00
	Hydro	12.05
	Roads	4.05
	Slope >60%	0.00
	Soils	465.56
Grazeable Acres		680.28

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	8.0
Maximum	22.0
Median	16.0

Summary of Cover by Analysis Unit

Foliar Cover	7.33%
Bareground	79.33%
Basal	0.00%

Results by Ecological Site in Sheep Units Year Long

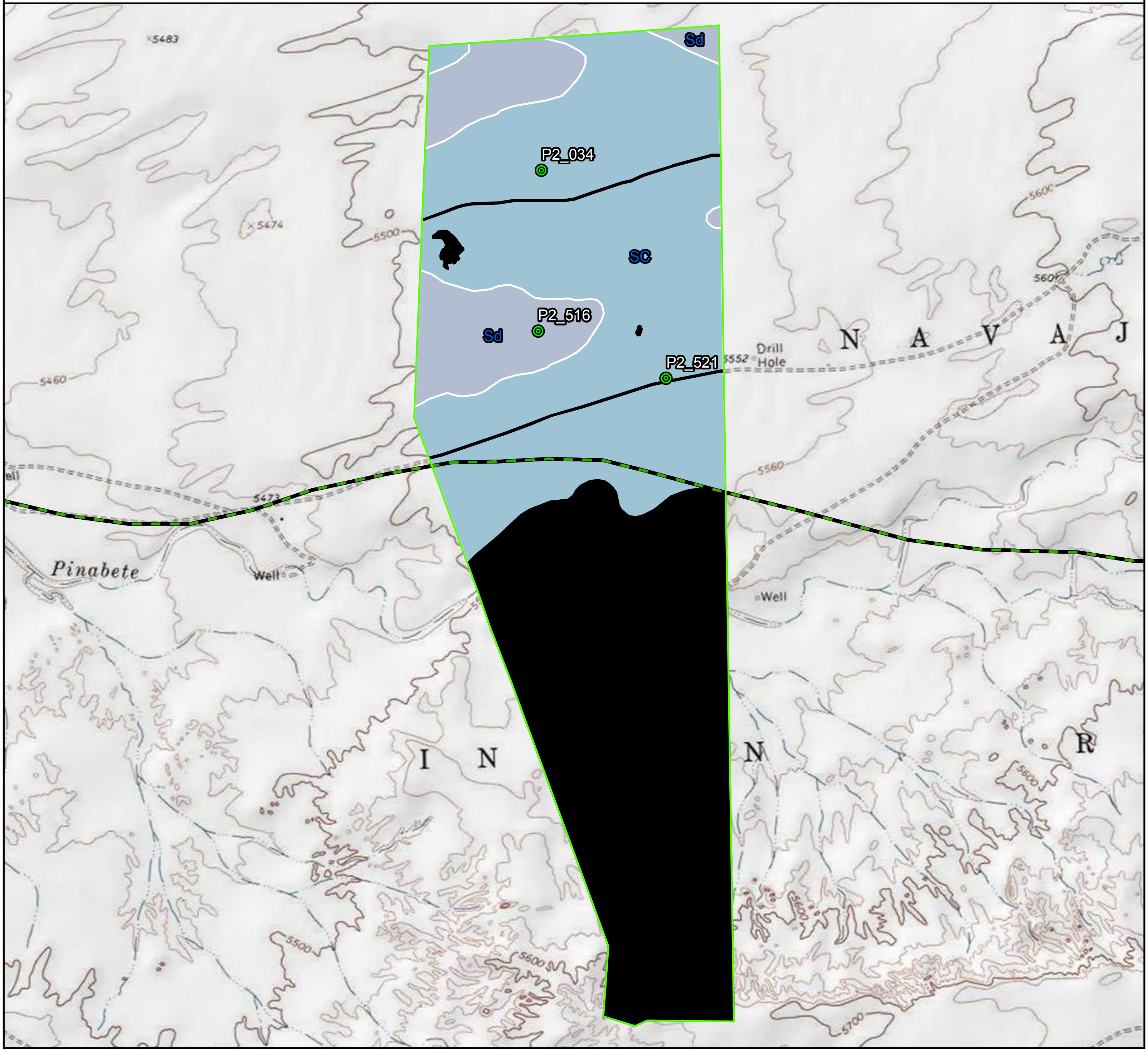
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	3	16.88	348.85	140.40	2.48	2.48	2.48
R035XB005NM Salt Flats	0		303.06				
R035XB002NM Sandy	0		28.38				

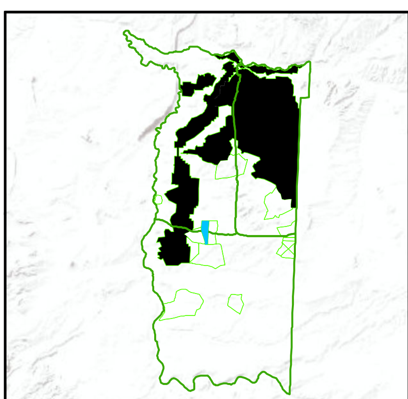
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,162
Grazeable Acres*: 680
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 2 Sheep

Nenahnezad/ San Juan Chapter, Puggie 2





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

Coordinate System: NAD 1983 UTM Zone 12N

1:24,000

Ecosphere Environmental Services

Date: 1/5/2015

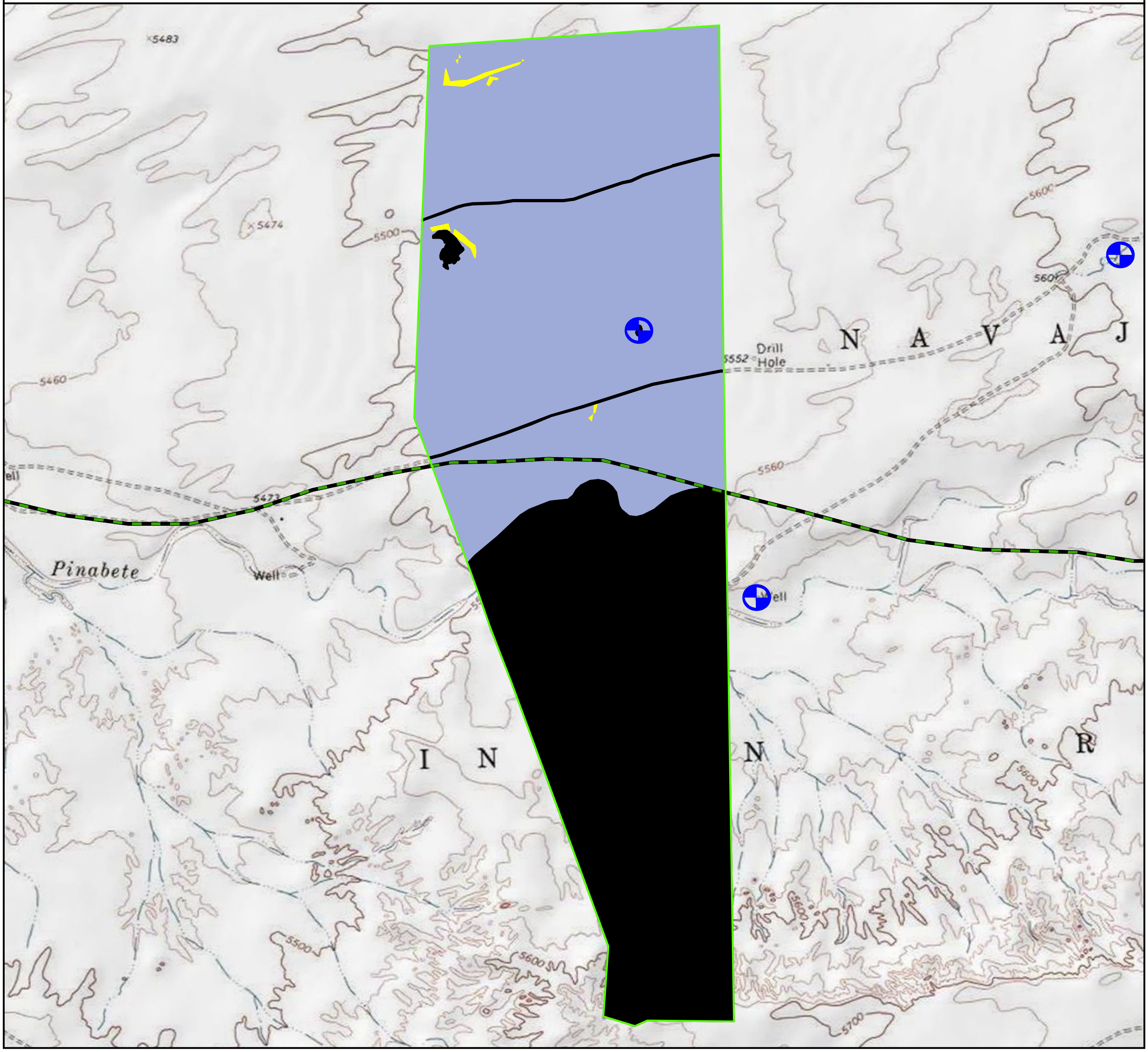
Document Name: P8X11_Soils_InitialCC_D13

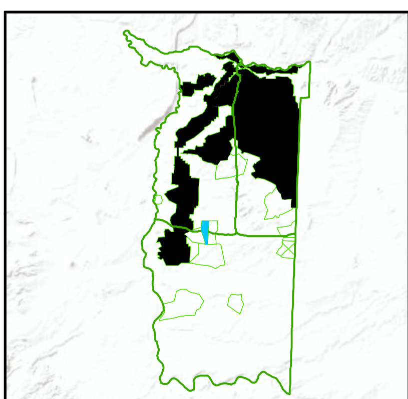
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,162
Grazeable Acres*: 680
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 2 Sheep

Nenahnezad/ San Juan Chapter, Puggie 2





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Ecosphere Environmental Services

1:24,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit Puggie_3

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		1,692.34
Non-Grazeable Acres	Developed	0.00
	Hydro	14.15
	Roads	5.35
	Slope >60%	0.00
	Soils	788.17
Grazeable Acres		884.67

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	7.0
Maximum	13.0
Median	7.0

Summary of Cover by Analysis Unit

Foliar Cover	8.00%
Bareground	86.67%
Basal	0.00%

Results by Ecological Site in Sheep Units Year Long

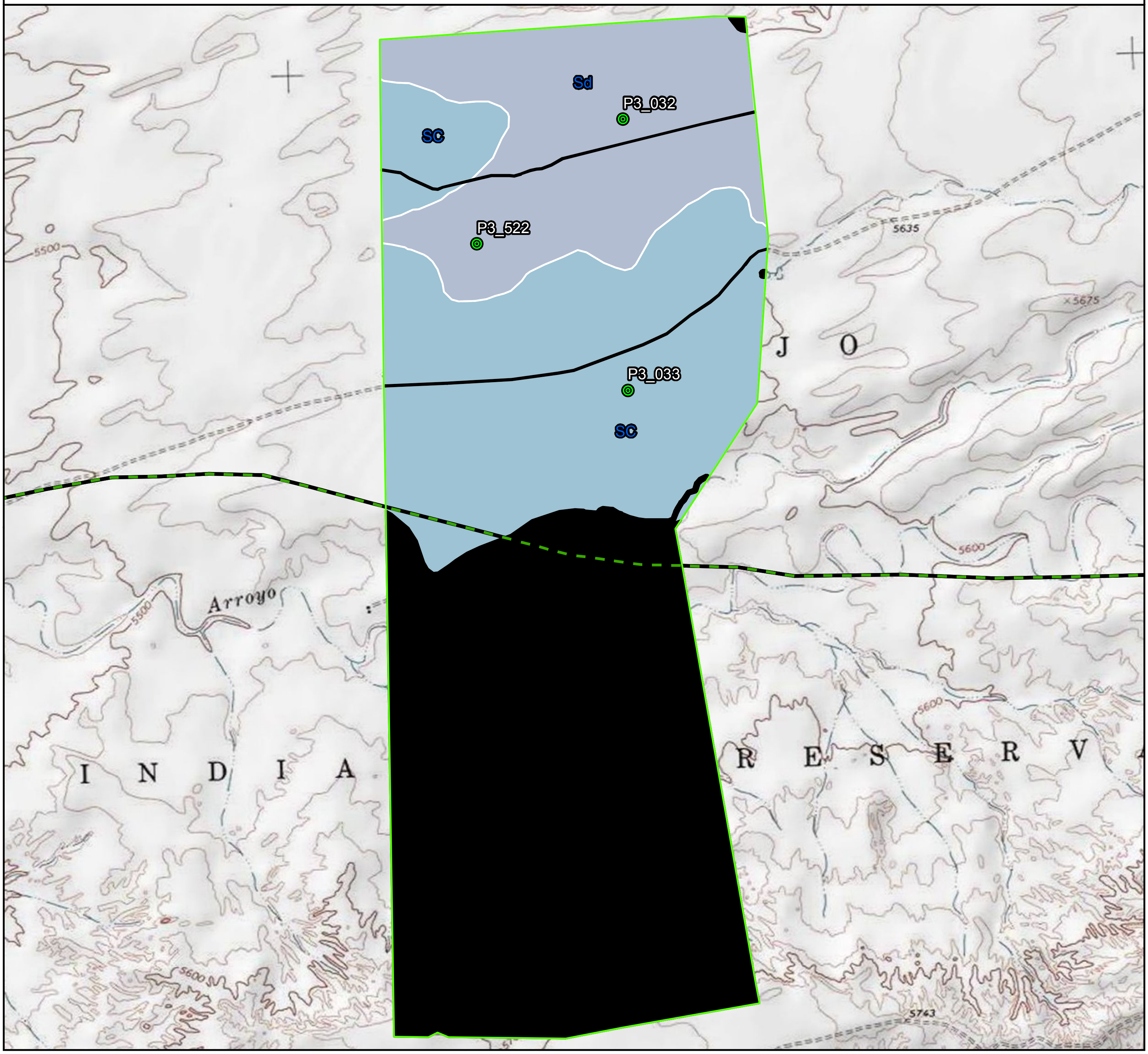
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB002NM Sandy	2	7.22	73.06	328.25	0.22	0.00	0.00
R035XB007NM Deep Sand	1	11.67	512.92	203.08	2.53	2.23	1.86
R035XB005NM Salt Flats	0		298.70				

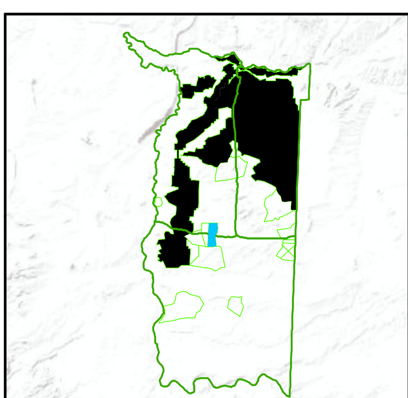
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,692
Grazeable Acres*: 885
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
3 Sheep

Nenahnezad/ San Juan Chapter, Puggie 3





Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

1:24,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

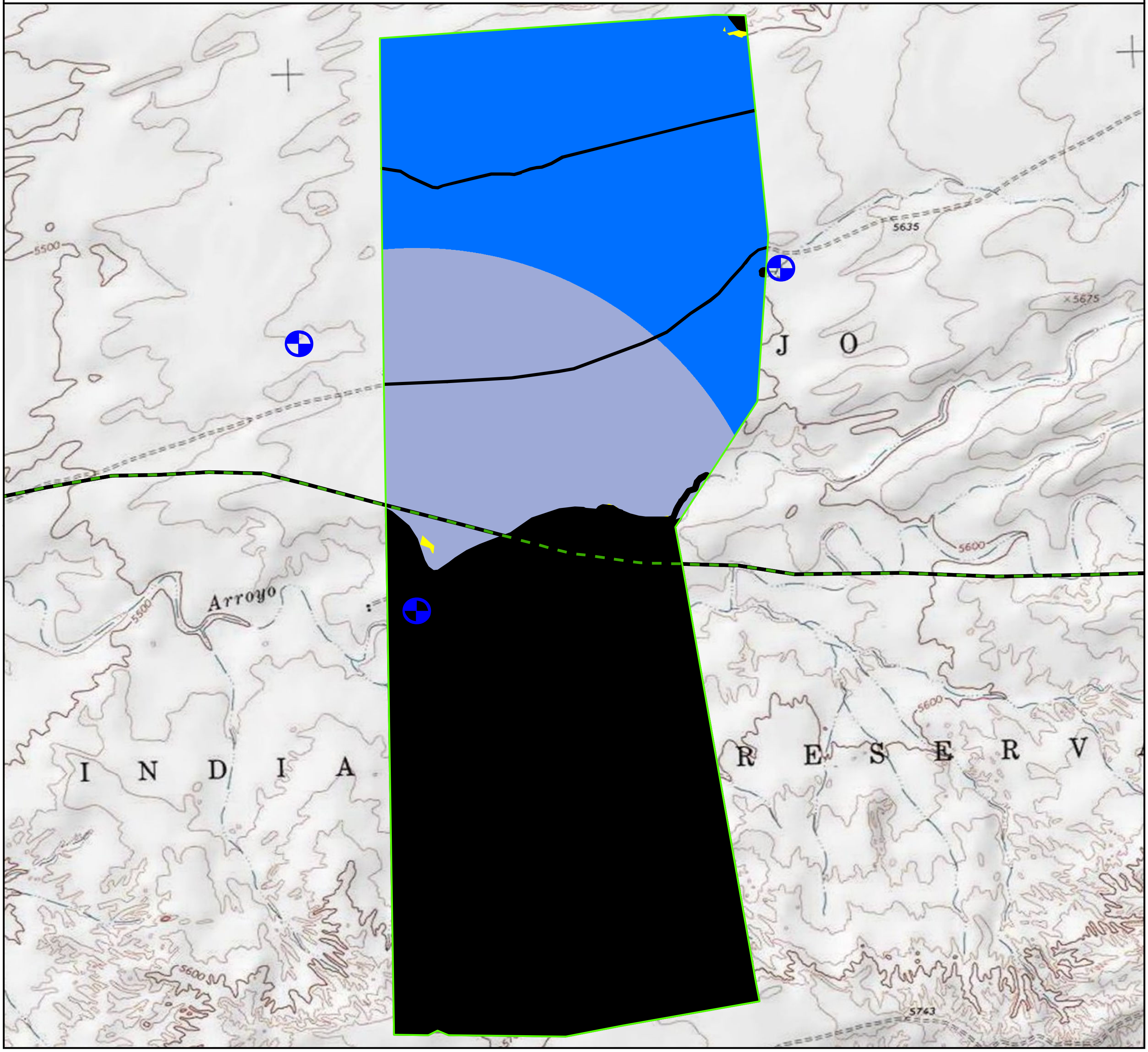
Document Name: P8X11_Soils_InitialCC_D13

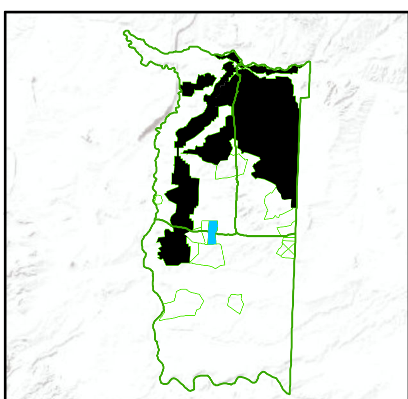
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,692
Grazeable Acres*: 885
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity: 2 Sheep

Nenahnezad/ San Juan Chapter, Puggie 3





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

1:24,000

Date: 1/5/2015

Document Name: P8X11_Slope_AdjCC_D13

Analysis Unit: Puggie_West

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		504.06
Non-Grazeable Acres	Developed	0.56
	Hydro	4.49
	Roads	4.90
	Slope >60%	0.46
	Soils	0.00
Grazeable Acres		493.64

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	4.0
Maximum	14.0
Median	6.0

Summary of Cover by Analysis Unit

Foliar Cover	13.33%
Bareground	82.00%
Basal	0.00%

Results by Ecological Site in Sheep Units Year Long

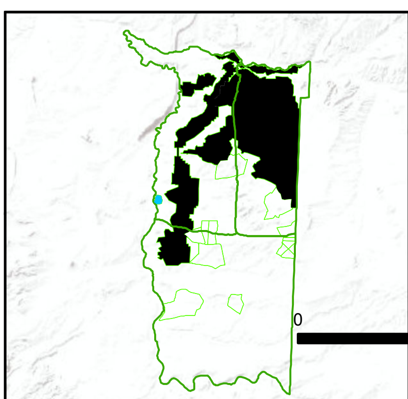
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	2	2.74	179.13	864.96	0.21	0.20	0.00
R035XB006NM Shallow	1	10.76	27.97	220.26	0.13	0.02	0.00
Badland	0		37.29				
Riverwash	0		7.16				
R035XB005NM Salt Flats	0		223.91				
Rock outcrop	0		18.64				

2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 504
Grazeable Acres*: 494
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity: 0 Sheep

Nenahnezad/ San Juan Chapter, Puggie West



Transect Location
Non Grazeable Range
Unit Boundary
Soil Map Units
Community Boundary

0 0.5 1
Miles

1:12,000

Coordinate System: NAD 1983 UTM Zone 12N

Ecosphere Environmental Services

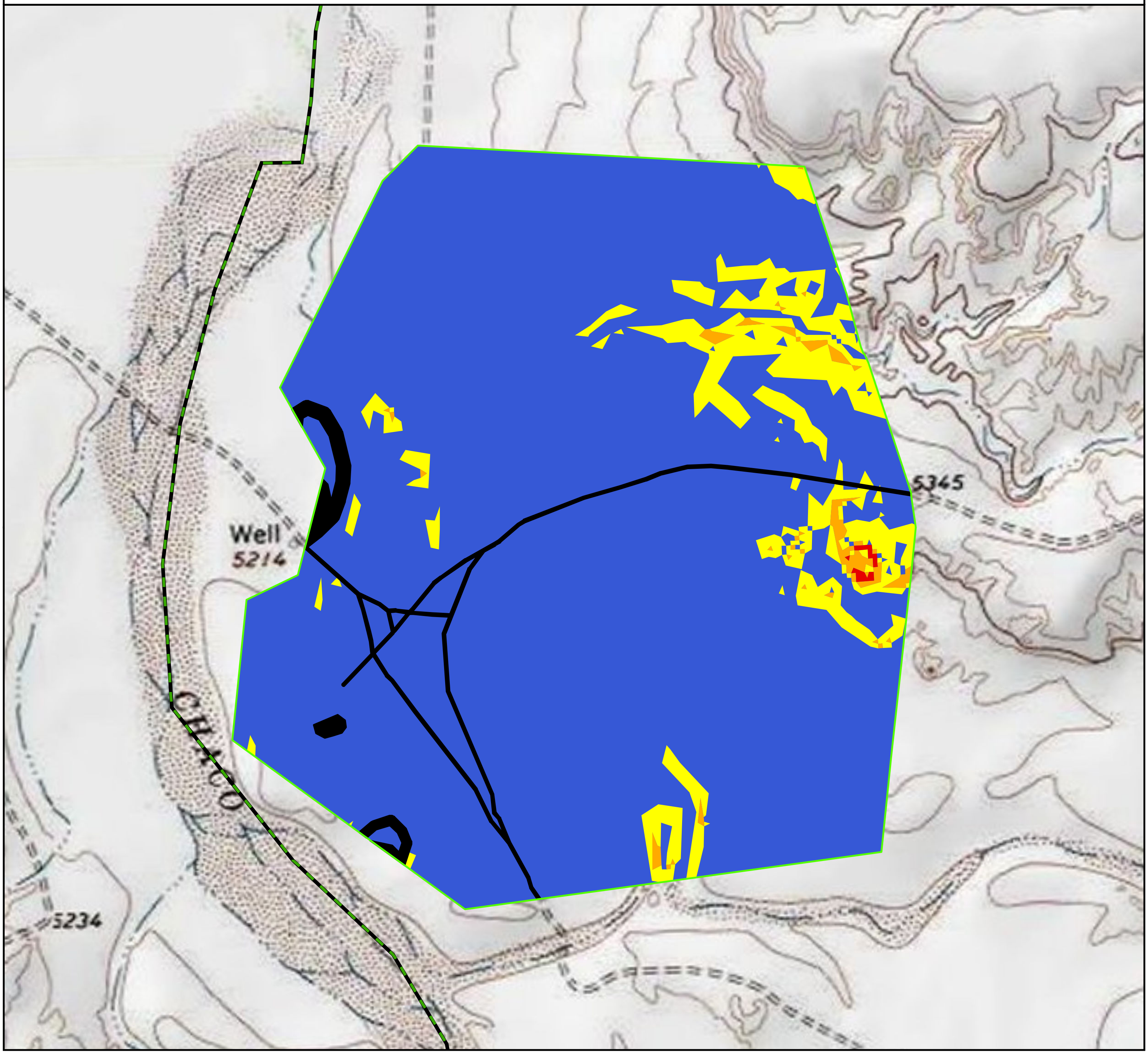
Date: 1/5/2015

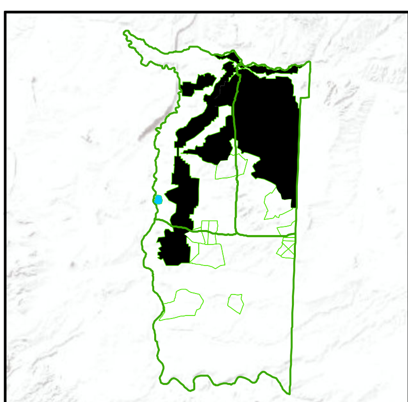
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 504
Grazeable Acres*: 494
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
0 Sheep

Nenahnezad/ San Juan Chapter, Puggie West





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

N

0 0.25 0.5
Miles

Ecosphere
Environmental Services

1:12,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

5.3.8 Yazzie

Ecological Site Summary

The Yazzie RMU is located in the middle of the Burnham community. About a third of the acres are badlands and were not analyzed. The rest of the area is mostly flat grasslands and rolling sandy grasslands. The Yazzie RMU includes 1,197.7 grazeable acres, contains seven transects and two ecological sites.

The R035XB002NM ecological site had 54.49 pounds per acre of available forage. Even though this site has fewer acres than the other ecological site, the carrying capacity is higher because there is more available forage for the stocking rate. Three transects were located in this sandy site which has deep, well-drained soils. The reference plant community is composed mostly of perennial grasses such as Indian ricegrass (*Achnatherum hymenoides*), dropseed (*Sporobolus* spp.), needle and thread (*Hesperostipa comata*), and New Mexico feathergrass (*Hesperostipa neomexicana*). Shrubs are not common, but can include fourwing saltbush (*Atriplex canescens*), winterfat (*Krascheninnikovia lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Under continuous grazing, shrubs and forbs increase, and the site eventually shifts towards a shrub/subshrub dominated plant community. Prickly pear (*Opuntia polyacantha*) has encroached on the site, but there are few invasive species. Diversity is low with only 14 species encountered on three transects. The current plant community is dominated by perennial grasses, but the species composition does not match the reference community so the similarity index ranged from 13 to 41 percent.

The R035XB007NM ecological site had 20.5 average pounds per acre of available forage. Four transects were located in this deep sand site. The soils are deep and well-drained and the reference plant community is dominated by a mix of grasses, forbs, and shrubs. Common species include Indian ricegrass, dropseed, alkali sacaton (*Sporobolus airoides*), globemallow (*Sphaeralcea* spp.), beardtongue (*Penstemon* spp.), Mormon tea (*Ephedra viridis*), fourwing saltbush, and sand sagebrush (*Artemisia filifolia*). Shrubs, cacti, and forbs all increase following continuous grazing pressure. At the time of the survey, the highest producing species were perennial grasses and Torrey's jointfir (*Ephedra torreyana*).

Species Frequency and Composition

The most commonly encountered species and the ones contributing the most biomass in the Yazzie RMU community, are listed below:

Frequently Encountered Species

1. Indian ricegrass (*Achnatherum hymenoides*) (occurred on 100% of all transects)
2. Sand dropseed (*Sporobolus cryptandrus*) (occurred on 100% of all transects)
3. Torrey's jointfir (*Ephedra torreyana*) (occurred on 86% of all transects)
4. James' galleta (*Pleuraphis jamesii*), plains pricklypear (*Opuntia polyacantha*), false buffalograss (*Monroa squarrosa*) and sandmat (*Chamaesyce* sp) (Each occurred on 71% of all transects.)

Species by Weight

1. James' galleta (*Pleuraphis jamesii*) (432 lbs/acre) (26% of total)
2. Indian ricegrass (*Achnatherum hymenoides*) (358 lbs/acre)
3. Sand dropseed (*Sporobolus cryptandrus*) (249 lbs/acre)
4. Black grama (*Bouteloua eriopoda*) (156 lbs/acre)
5. Blue grama (*Bouteloua gracilis*) (103 lbs/acre)

Ground Cover

Bare ground in the Yazzie RMU is 69 percent and the percent of foliar cover is 23 percent which is above average for the analysis units. Active water erosion is not a significant issue but the high percentage of bare ground may contribute to wind erosion especially because the exposed soils in this RMU are sandy.

Analysis Unit | Yazzie

Summary of Grazeable and Non-Grazeable Acres in Analysis Unit

Total Acres		1,870.20
Non-Grazeable Acres	Developed	1.99
	Hydro	2.23
	Roads	9.73
	Slope >60%	0.00
	Soils	658.56
Grazeable Acres		1,197.69

Summary of Similarity Indices within Analysis Unit

Similarity Indices (%)	
Minimum	13.0
Maximum	41.0
Median	33.0

Summary of Cover by Analysis Unit

Foliar Cover	23.14%
Bareground	68.86%
Basal	1.43%

Results by Ecological Site in Sheep Units Year Long

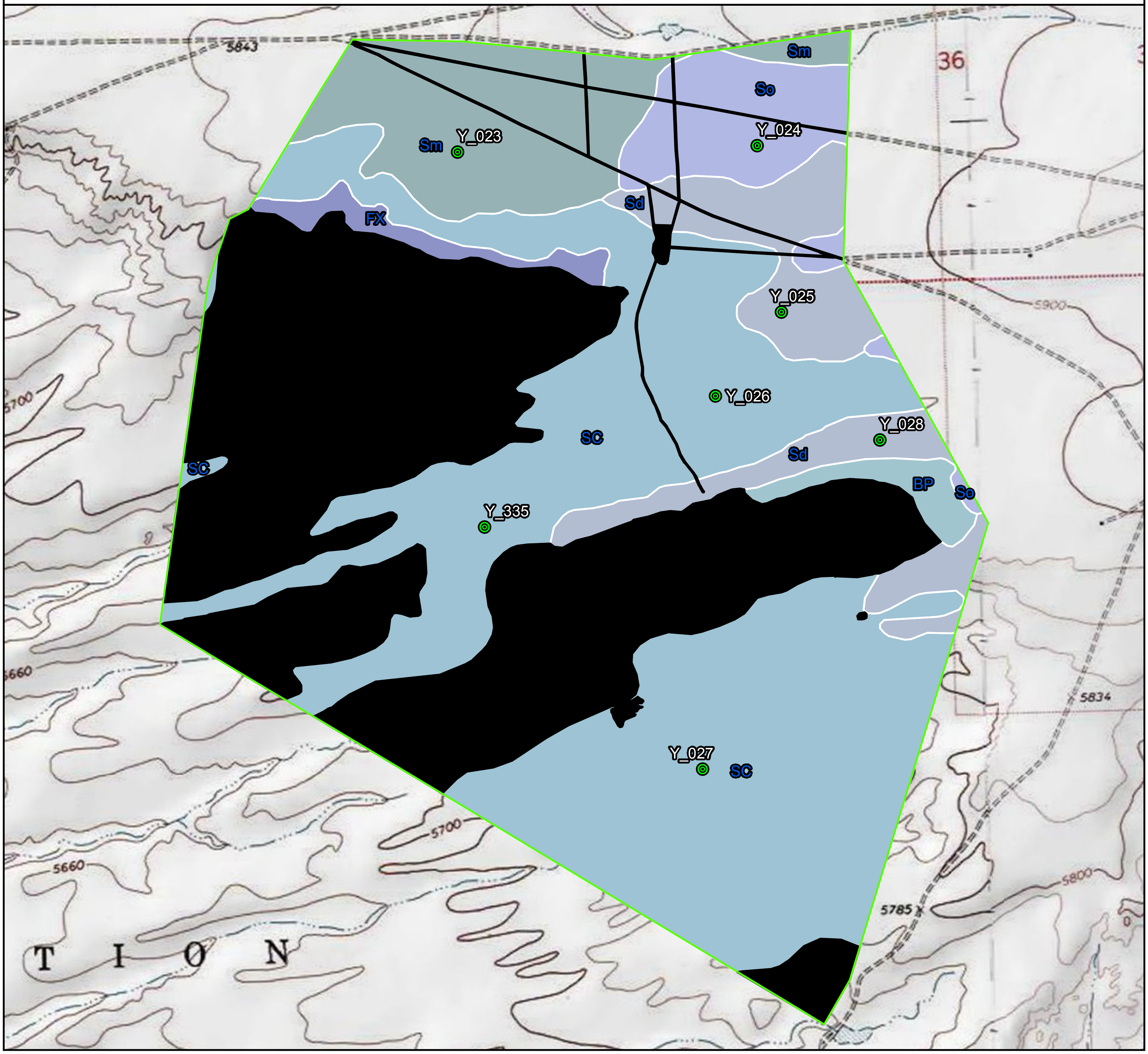
Ecological Site	Number of Transects	Available Forage (lbs/Acre)	Initial Grazeable Acres	Sheep Stocking Rate (Acres)	Initial Sheep Carrying Capacity	Slope Adjusted Carrying Capacity	Distance-to-Water Adjusted Carrying Capacity
R035XB007NM Deep Sand	4	20.50	455.74	115.61	3.94	3.92	3.74
R035XB002NM Sandy	3	54.49	290.25	43.49	6.67	6.66	5.13
R035XB006NM Shallow	0		8.80				
R035XB005NM Salt Flats	0		420.47				
R035XB003NM Limy	0		14.66				
R035XA130NM Shale Hills	0		7.76				

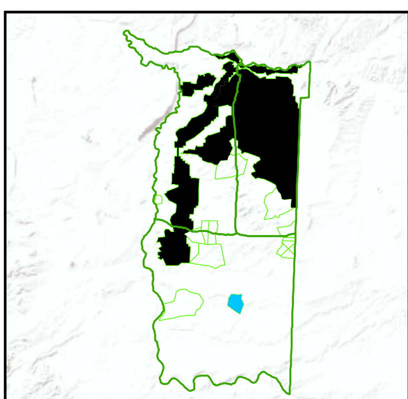
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,870
Grazeable Acres*: 1,198
*Total acres minus non grazeable areas and areas with > 60% slope.

Initial Annual Carrying Capacity:
11 Sheep

Burnham Chapter, Yazzie





Transect Location
Unit Boundary
Community Boundary
Non Grazeable Range
Soil Map Units

0 0.5 1
Miles

1:20,000

Ecosphere Environmental Services

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

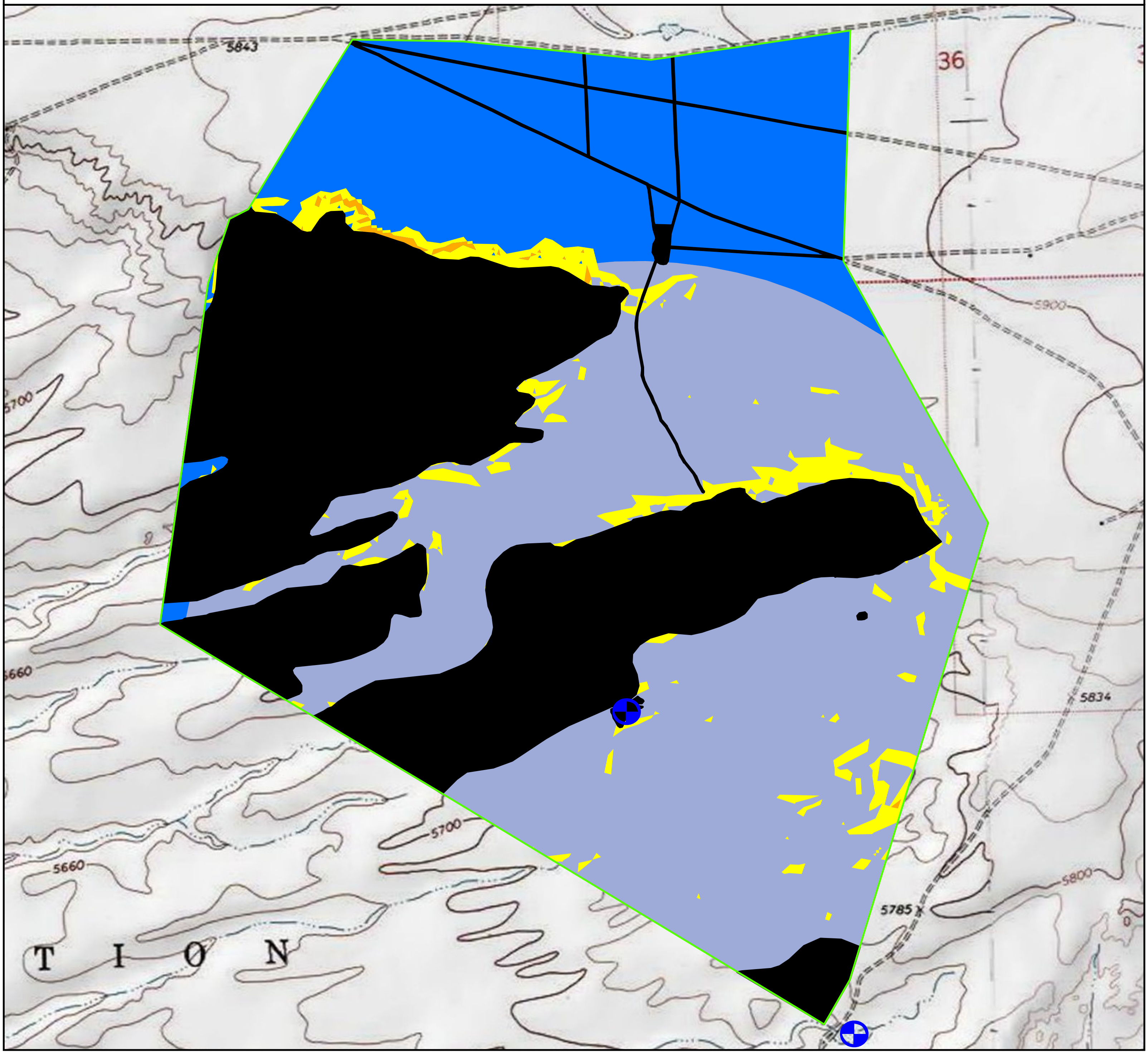
Document Name: P8X11_Soils_InitialCC_D13

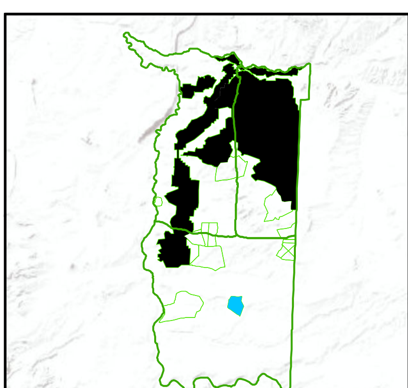
2014 Range Inventory
BIA Northern Navajo Agency
Land Management District 13

Total Acres: 1,870
Grazeable Acres*: 1,198
*Total acres minus non grazeable areas and areas with > 60% slope.

Adjusted Annual Carrying Capacity:
8 Sheep

Burnham Chapter, Yazzie





Water Source
Unit Boundary
Community Boundary
Non Grazeable Range

Distance to Water
< 1 Mile
1 - 2 Miles
> 2 Miles

Slope
10 - 30% Slope
30 - 60% Slope
> 60% Slope

0 0.25 0.5
Miles

Ecosphere Environmental Services

1:20,000

Date: 1/5/2015

Coordinate System: NAD 1983 UTM Zone 12N

Document Name: P8X11_Slope_AdjCC_D13

6. Conclusions and Recommendations

The study area is composed of sandy grasslands alternating with badland areas. Several large washes cut through the project site and occasional pockets of pinyon-juniper woodland can be found on top of low mesas and in the breaks above the San Juan River. Production in the Nenahnezad/San Juan, Burnham, and Upper Fruitland communities tends to range from low in the badland sites to moderate in the grassland areas. Some RMUs, like Diswood, Monsisco Mesa, and Collins, contain ecological sites with good production and fairly intact plant communities. However, much of area in the Puggie, Cottonwood Wash, Billey, and Gilmore RMUs are in fairly poor condition.

Increases in shrubs are most marked by black greasewood (*Sarcobatus vermiculatus*) in the large washes, especially in the Burnham and Nenahnezad/San Juan communities and by rubber rabbitbrush (*Ericameria nauseosa*) in the some of the sandier sites. The most commonly encountered invasive species were prickly Russian thistle (*Salsola tragus*), saltlover (*Halogeton glomeratus*), and cheatgrass (*Bromus tectorum*). Prickly Russian thistle is widespread throughout the project area with some areas containing only small amounts while others have this species as a dominant species in the plant community. Cheatgrass was found in a number of locations, but only as a minor component of the current plant community. Saltlover is most prominent in the R035XB005NM ecological site, especially in the Nenahnezad/San Juan and Burnham communities and in the Billey RMU. The decline in plant communities is largely a result of continuous grazing pressure and past drought conditions. The following sections provide some recommendations regarding drought and grazing management, shrub reduction, weed control, and data analysis and monitoring.

6.1 Drought

Precipitation is one of the greatest obstacles to overcome when managing and restoring rangeland. Local precipitation monitoring stations recorded lower than average precipitation, except for May and July, throughout the growing season in 2014. Despite this, precipitation levels throughout the southwest indicate ongoing long-term drought conditions (National Drought Mitigation Center [NDMC] 2014). Therefore, it is extremely important to maintain healthy plant communities, not only for forage purposes, but to reduce soil exposure and loss. To complicate matters, moisture arriving during the monsoon season often is in the form of severe thunderstorms that can produce several inches of rain in a short time. As the percentage of bare ground is fairly high in much of the study area, many areas are at risk of accelerated water erosion during this type of storm event. This increases soil loss while decreasing water retention. The potential for soil loss due to wind erosion is also very high, as much of the study area contains unstable sandy soils. Sandy soils require a lot of plant cover to become stable. It may be necessary to encourage growth of less palatable, stabilizing species initially. Grasses such as sandhill muhly (*Muhlenbergia pungens*) and James' galleta (*Pleuraphis jamesii*) are excellent cover plants that do well in loose soils.

It also is very important to collect accurate precipitation data. Calculations for annual production (and resulting stocking rates) incorporate average precipitation for a given water year. Location-specific precipitation gauges allow managers to more closely monitor precipitation, giving them the opportunity to proactively implement drought management plans. Plants demonstrate rapid growth during a certain portion of the growing season; cool-season plants tend to experience this between March and the beginning of June, with a smaller growth surge in the fall, while warm-season plants grow more quickly during mid-summer. These are critical time periods for forage species and a lack of adequate moisture will compromise growth for the duration of the growing season. Moisture that arrives outside of these windows of rapid growth will help plants, but will be much less effective. Semiarid regions generally are considered to be experiencing drought conditions when the cumulative growing season precipitation is 20 to 25 percent below average during these periods of rapid growth (NDMC 2014). Closely monitoring precipitation would alert managers to impending drought toward the beginning of the growing season and allow for drought mitigation plans to be put into place in a more timely fashion. This is particularly important for the lower-elevation sites in the study area as the majority of forage plants are warm-season grasses like James's galleta and blue grama (*Bouteloua gracilis*). Monsoonal moisture arriving in mid to late July corresponds well with the period of rapid growth for these grasses. However, in years where the monsoons are delayed or largely absent, it will be necessary to adjust grazing plans. Ultimately, it is up to the individual livestock owner to gain the most thorough knowledge possible of the area being grazed. The best way to mitigate the effects of drought is to keep or restore rangeland to a good condition with a healthy diversity of plants species.

6.2 Soil and Grazing Management

Soils are an extremely important component of rangeland ecosystems. Well-developed soils retain water and provide the substrate and nutrients necessary to produce vibrant plant communities. In areas with large patches of bare ground and/or active erosion, the best way to recover forage production is to build up the soils so they are capable of supporting viable plant populations. Rebuilding soils requires a combination of erosion control, revegetation, and periodic disturbance of the soil surface. Deeply eroded gullies and arroyos are the most difficult and cost-prohibitive features to restore. In their immature form, the sides of channels usually are very steep or even vertical, which makes it difficult for stabilizing vegetation to establish. An effective technique for decreasing slope gradient is to use earthmoving equipment to reshape or terrace the banks, thus creating substrates suitable for plant colonization. This method is particularly effective in arid regions, where work can be completed prior to seasonal flows (Valentin et al. 2005). Unfortunately, the cost and logistics involved with getting equipment into more remote locations can make this option prohibitive. Another alternative is to focus efforts upstream from deeply eroded channels. In areas where channels are just beginning to develop and the rate and volume of surface runoff is lower, effective countermeasures to erosion include simple hand-constructed rock check dams. In addition to capturing soil and preventing further loss, check dams redistribute water, especially during the monsoon season. Spreading runoff across the landscape and retaining water for longer periods leads to more plant growth and cover, which increases infiltration and soil moisture (Nichols et al. 2012). Seeding programs that utilize fast-growing, native pioneer species tend to produce better and quicker results when working to stabilize channel walls (Valentin et al. 2005). Water erosion is a potential problem for most of the study area, especially in regions containing moderate to steep slopes and high clay content in the soils.

Revegetation may require reseeding programs, particularly in areas experiencing channelization and in sandy regions with active dunes; however, elements of the native plant community are still present within much of the study area. The higher pine forests often have large populations of black sagebrush (*Artemisia nova*), blue grama (*Bouteloua gracilis*) and mountain muhly (*Muhlenbergia montana*). Other areas often have additional perennial grasses like muttongrass (*Poa fendleriana*), James' galleta, and dropseed (*Sporobolus* spp.). Important forb and shrub species such as globemallow (*Sphaeralcea* spp.), fourwing saltbush (*Atriplex canescens*), jointfir (*Ephedra* spp.), and Stansbury cliffrose (*Purshia stansburiana*) are also abundant. This indicates that with careful and proactive management, native species production and frequency should increase naturally without much intervention. In areas that are more deteriorated, seeding with local, drought-tolerant species that can germinate early, such as scarlet globemallow (*Sphaeralcea coccinea*) and sand dropseed (*Sporobolus cryptandrus*), may speed up revegetation, and increase the likelihood of success.

The lack of native herbaceous diversity is due, in large part, to unmanaged continuous grazing systems. Determining forage production based upon a normal precipitation year allows managers to establish a "ceiling" or carrying capacity for their land. Stocking rates developed for a normal precipitation year should not be used when precipitation is below normal, especially during drought conditions. In a continuous grazing system, it is difficult to prepare for times of scarce moisture; however, this situation can be partially mitigated by allowing managers to reduce and increase 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 through the winter. If precipitation is low during the winter, then spring and early summer forage production also are expected to be low and livestock numbers should be adjusted accordingly.

The final part of rebuilding soil is to make sure it undergoes periodic disturbance. This is where livestock play a very important role. The trampling effect of livestock works to incorporate manure and litter into the soil, which increases aeration and organic matter content. Hoof indentations also create microsites that encourage seedling growth and moisture retention; however, controlling the timing and duration of grazing is the key to reaping these benefits. Many of the ESDs available for the study area recommend deferring grazing from late winter through early spring. This practice alone would help increase available forage. Other areas are better suited for winter/spring grazing and can be utilized to provide forage while less suitable areas are rested. Data collected from this survey can help identify these areas. A critical part of grazing management is allowing the forage to grow before being grazed and allowing it to recoup following grazing. Fences greatly facilitate the process of pasture deferment, rest, and rotation. They also are valuable tools for excluding stray livestock, especially horses. NRCS programs such as the Environmental Quality Incentives Program can aid in providing the technical and financial support needed for this to occur.

6.3 Shrub Composition

Shrubs play a valuable role in maintaining healthy, functioning rangelands, but the ratio of shrubs to forb and grass species is a little higher than it should be in many parts of the study area. For example, dense stands of black greasewood exist along many of floodplain areas associated with the larger washes. Rubber rabbitbrush (*Ericameria nauseosa*) also occurs in dense stands in various locations, but usually only in small pockets. Many of grassland areas contain a fair amount of small shrubs like Broom snakeweed (*Gutierrezia sarothrae*) and Greene's rabbitbrush (*Chrysothamnus greenei*), as well.

In most cases, employing proper grazing management should be sufficient to encourage the re-establishment of native forbs and grasses. As the herbaceous component begins to flourish, woody species will cease to dominate, and a more balanced plant community will develop. A number of mechanical and chemical methods have been used to control shrubs on rangelands, but as shrub density is not a large problem in the majority of Land Management District 13, these methods would likely not produce enough gain to offset the expense of employing them.

6.4 Invasive Species

Prickly Russian thistle (*Salsola tragus*)

Prickly Russian thistle is a drought tolerant, disturbance-loving species that does well in sandy soils. Although this plant is an invasive species, it does provide forage for sheep and cattle in its immature form and when softened by snow or rain (USDA USFS 1937). However, consumption of large quantities of this plant has been known to cause diarrhea, especially in lambs, which can compromise the heath of animals already in a weakened condition (Cook et al. 1954). This can be an issue in areas where little else is growing and consumption is likely to be high.

Prickly Russian thistle also can accelerate revegetation of disturbed areas by supporting the growth of soil mycorrhizae. Soil mycorrhizae are fungi that form associations with many native plant species. The fungi help the plants absorb more water and nutrients and, in return, receive carbohydrates from the plant roots. Certain mycorrhizae invade the roots of Russian thistle and do not form an association with this plant, but rather kill the infected roots and move on to the roots of neighboring plants. In this manner, the fungi population increases while prickly Russian thistle populations begin to die (Allen and Allen 1988; Allen et al. 1989). The dead plants provide cover for seedlings of other species that are capable of forming associations with the newly established mycorrhiza colonies (Allen and Allen 1988; Grilz et al. 1988). Typically, prickly Russian thistle will persist on a site for about 2 years and then will be replaced by annual and biennial mustards like tall tumblemustard (*Sisymbrium altissimum*) and various tansymustard (*Descurainia* spp.) (Chapman et al. 1969). The mustard species continue to build up the soil substrate by maintaining soil mycorrhiza populations and adding organic matter to the soil as the plants die. However, it is important to note that this process can only occur in sites where disturbance factors, such as grazing, are removed or at least minimized. In most parts of the project area, continuous, year-round grazing effectively causes this plant to persist in the plant community as native species are consumed before they have the chance to become established and seeds from thistle plants are free to sprout and establish additional populations.

Prickly Russian thistle also helps prepare a site by releasing oxalates into the soil. These chemicals work to change inorganic phosphorous into a soluble form that can be taken up by plants (Cannon et al. 1995).

Phosphorus often is a limiting nutrient in the soil and by increasing its availability, favorable forage plants can become established more quickly. Prickly Russian thistle can be controlled or even eradicated through various mechanical and chemical treatments (Burrill et al. 1989; Young and Whitesides 1987); however, this process is time consuming and expensive. Given the potential benefits of the plant, it is generally better to leave it and focus on encouraging the establishment of desirable, perennial species through proper grazing management and seeding treatments.

Cheatgrass (*Bromus tectorum*)

Cheatgrass is not widespread in the study area, but it was encountered fairly frequently in all three of the communities and in the Monsisco Mesa RMU. In these areas, this grass was most often found within the R035XB002NM ecological site. Cheatgrass is difficult to control due to its ability to produce large quantities of seed, which either germinate in the fall or carry over in the seed bank to germinate in the following spring (Smith et al. 2008). Germination typically occurs well in advance of most native species, which works to deplete soil moisture (Floyd et al. 2006; Melgoza et al. 1990; Smith et al. 2008). Additionally, seedling emergence can occur under a variety of soil temperatures and plants germinating in the fall continue to experience root growth during the winter. This gives individuals a significant advantage the following spring (Beckstead et al. 2007; Mack and Pike 1983; Meyer et al 2007; Thill et al. 1979). The best way to prevent the spread of cheatgrass is to reestablish viable native plant communities. In invaded areas, use of the herbicide imazapic (Plateau®) has proven to be very effective control measure. A moderate application rate (0.6 L ha-1) was found to kill virtually all cheatgrass and seeds when applied in the fall to infestations in Zion Nation Park (Brisbin et al. 2013; Dela Cruz 2008). However, the control affected by this herbicide only provides a window of about 1-2 years. If alternate vegetation has not reestablished in sprayed areas at this time, it is very probable that cheatgrass will reoccupy the area. A good practice is to spray in the fall and apply seeding treatments in the following late winter/early spring season. The NRCS is a valuable resource for obtaining site specific seed mixes as well as technical and financial support.

Saltlover (*Halogeton glomeratus*)

Saltlover is a summer annual that readily invades saline soils when disturbances remove the pre-existing vegetation. Once established, it can quickly spread and out-compete other species due to its ability to germinate early in the spring, produce large quantities of long-lived seed, resist predation, and withstand harsh conditions (Duda et al. 2003). There also is evidence that this species alters the soil chemistry around individual plants by increasing soil pH, electrical conductivity, and soluble sodium content. This alteration makes it difficult for native species to become re-established even if saltlover plants are removed (Duda et al. 2003; Eckert and Kinsinger 1960; Lancaster et al. 1987). In the project area, saltlover is most affiliated with the R035XB005NM ecological site, which contains soils high in sodium. Some of the highest concentrations of this species occur along the western edge of the Nenahnezad/San Juan community.

A second concern is that saltlover is highly toxic to livestock, especially sheep. Sodium oxalate, the lethal component of this species, is sequestered in the leaves and stems, and the highest levels are achieved during the fall, winter, and spring when the plant reaches maturity. This also is the time frame when this plant is more likely to be consumed, since desirable forage plants are typically scarce or too dry to be palatable (USDA Agricultural Research Service 2006; Whitson et al. 2002).

Saltlover control is difficult. Seeds, which are abundant, can remain viable in the soil for up to 10 years, requiring annual applications of herbicide for many years to effectively deplete seed reserves (West 1983). In addition to being expensive, this approach is not particularly agreeable as the main herbicide that has proven to be effective is 2,4-D. This chemical, when applied at the rates necessary to control saltlover, also will have a negative impact on native species (Cook et al. 1953). The best approach is to establish alternate species that can grow in saline conditions and compete with saltlover. Two species in particular have successfully become established in saltlover invaded sites: forage kochia (*Bassia prostrata*) and desert wheatgrass (*Agropyron desertorum*) (Asay and Johnson 1987; McArthur et al. 1990; Stevens and McArthur 1990). Reducing or excluding grazing pressure during the late winter/early spring is important, as well, to allow desirable species the opportunity to grow and develop prior to consumption. Establishing a diverse, perennial plant community that undergoes light to moderate grazing towards the end of the growing season appears to be the best strategy to prevent saltlover invasions (Blaisdell and Holmgren 1984; Keller 1979; West 1983; Whisenant and Wagstaff 1991).

6.5 Data Analysis and Monitoring

Data analysis revealed several patterns, including areas with large populations of invasive species, areas lacking in ground cover, and other sites that are maintaining good populations of key forage species such as Indian ricegrass (*Achnatherum hymenoides*), James' galleta, alkali sacaton (*Sporobolus airoides*), tall dropseed (*Sporobolus contractus*), blue grama, needle and thread (*Hesperostipa comata*), and fourwing saltbush. The next step is to use this data to identify specific locations that would benefit most from improvement measures and then organize field visits to gain an "on-the-ground" perspective. Groups of transects that yielded low production and high counts of bare ground may be in severely eroded areas and great effort would be necessary to improve these sites. On the other hand, these groups of transects may just have a high potential for erosion and simple improvements could greatly enhance the soil and plant community. Using the data to pinpoint areas with the highest densities of shrubs would serve as a starting point for assessing whether chemical control measures are necessary. In some cases, it may be better to focus on grazing strategies and let natural succession run its course. Identifying places with high forage production can be helpful for implementing rotational grazing schemes. These areas would be able to withstand higher grazing pressures, while more fragile locations are rested. Visits to these areas would allow managers to determine the feasibility of adding water sources if none are present. If data from certain transects show that native forage species are not present, it may be necessary to implement reseeding programs. Agriculture extension offices and the NRCS are good resources to help determine appropriate seed mixes and find seed sources.

Grazing programs should make use of available tools. When it is possible to erect fences, they should be designed to ease movement and exclusion of livestock, as dictated by the condition of the vegetation. Designating pastures where fences already exist, such as the highway fences that bisect grazing units, also would be useful for monitoring forage in those pastures. Currently, the forage on one of side the highway is applied to the carrying capacity on both sides of the highway. Separating the grazing units into pastures would allow for more site-specific data collection and monitoring, as well as livestock management. Water sources and salt blocks can also be situated to move animals out of areas or to encourage them to use underutilized locations. In addition, the initial stocking rates and carrying capacities provided in this report should be used as a guide to be adjusted appropriately with consideration of forage value, seasonal palatability of forage, and variability of precipitation. For example, a conservative initial stocking rate is appropriate under drought conditions. If there is very little precipitation during the winter and early spring, stock numbers should not be permitted at the rate of a normal year production. The same is true when an area endures several years of precipitation below normal levels. However, placement of check dams and other water catchment systems such as ponding dikes can greatly offset the negative impacts associated with drought and lessen the need to cut livestock numbers.

After restoration efforts have begun, it is important to establish monitoring programs. Now that the initial baseline data have been collected, it is not necessary to sample vegetation at each transect again. Instead, a smaller number of permanent transects and photo-monitoring points can be set up at locations targeted for restoration and in representative areas for each ecological site. In addition to monitoring species composition and production, it also would be valuable to assess soil stability and hydrologic function. Numerous references can be utilized to develop monitoring programs and help interpret the results, such as the Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems published by the Arid Lands Research Program (Herrick et al. 2005) and the Bureau of Land Management’s Technical Reference 1734-6: Interpreting Indicators of Rangeland Health (Pellant et al. 2005).

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Appendix A – Precipitation Data

Appendix B – Plant List