Ecosphere
Environmental Services

District 9
2012 Vegetation Inventory

Mexican Water, Sweetwater and Rock Point Communities

Arizona and Utah

Prepared for:

Bureau of Indian Affairs
Shiprock Agency – Natural Resources

December 2012

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

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ACRONYMS

ADW	air-dry weight
AUM	animal unit months
BIA	Bureau of Indian Affairs
Ecosphere	Ecosphere Environmental Services
ESD	Each ecological site description
ft²	square foot
G	grams
GPS	Global Positioning System
HCPC	historic climax plant community
MLRA	Major Land Resource Area
NNDOA	Navajo Nation Department of Agriculture
NNDWR	Navajo Nation Division of Water Resources
NRCS	Natural Resource Conservation Service
p.z.	Precipitation zone
PNC	potential natural community
RMU	Range Management Unit
Shiprock	Northern Navajo Agency
SOW	Statement of Work
SUYL	sheep unit year long
USDA	United States Department of Agriculture

ABSTRACT

Ecosphere Environmental Services was contracted by the Bureau of Indian Affairs to collect and compile vegetation data on portions of Land Management District 9, of the Northern Navajo Agency. Data were collected for 714 transects located in three communities; Mexican Water, Sweetwater and Rock Point. Data collection occurred during June of 2012. 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 each community. Carrying capacities and recommended stocking rates were calculated by community using available forage. The data were aggregated by ecological site within communities and then applied according to the acreage of ecological sites within each pasture.

Overall, the similarity of the ecological sites in the project area to their historical potential is low, available forage production is below potential and the carrying capacity of the range resource is considerably 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 a portion of District 9 of the Northern Navajo Agency (Shiprock). Species-specific vegetation data measurements included biomass production and cover. These data were also used to calculate frequency, annual production, and 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 this inventory was to provide baseline information about the existing range resource to enable resource managers and permittees to improve and/or maintain the condition of the range resource. The results of this inventory will enable recommendations for adjusted stocking rates in District 9, 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). All three parties (BIA, NNDOA, and the Grazing Committees) coordinate their activities in an effort to utilize and manage the range resources.

1.2.1 BIA Agency Natural Resources Program

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

BIA Range Policy

- Comply with the American Indian Agricultural Resources Management Act of December 3, 1993, as amended.

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

1.2.2 District Grazing Committees

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

The Navajo Nation is organized into 110 Chapters. Chapters, also called communities, are locally organized entities similar to counties, and are the smallest political unit. District grazing committees review and recommend the carrying capacities of their districts. District grazing committees approve the carrying capacities of their districts.

According to the District Grazing Committee Policy and Procedure Manual, the district grazing committee members are responsible for attending district grazing committee meetings and Chapter meetings, and for ensuring that permittees respect applicable laws, regulations, and policies. Individual grazing district committee members are directly accountable to their local chapters and administratively accountable to the Director of the NNDOA. The NNDOA is responsible for annual livestock tallies to determine if permittees are in compliance with their permit. In addition, the NNDOA and the district grazing committees are responsible for enforcement of range management and resolving grazing disputes.

1.2.3 Grazing Overview

Timing of grazing, movement and dispersal of livestock, and animal numbers are all factors that must be considered when optimizing livestock production. Prior to considering these factors, managers should first recognize animals' ability to efficiently harvest the nutrients present in their surroundings. This requires an understanding of foraging behavior, as influenced by an animal's environment. 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 that restrict forage availability such as inaccessibility, long distances to water, or steep slopes. Once identified, production from these areas can be subtracted from the total forage production or adjustments can be made for inclusion of these areas. An example of this would be to develop additional water sources in areas rarely visited by livestock due to a scarcity of water.

After likely foraging patterns have been determined, production and forage value data can be used to help determine how many animals should be allowed to graze in a given area. Low stocking rates benefit individual animals, as more resources are available due to lowered competition with other animals. Conversely, high stocking rates can inhibit the individual animal, but the increase in total livestock production allows for greater, short-term gains for the producer. The final stocking-rate decision must take into consideration the ecosystem as a whole. Maintaining long-term viable rangelands provides for the continued health of livestock and long-term financial gains for producers or permittees. Viable rangelands also provide for the continued health of the local air, water, and other ecological resources.

Plant vigor and root development can be adversely affected when grazing occurs during periods of initial plant growth or during the time of 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.

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

In general, managers should be aware that the final products of this inventory are subject to a variety of factors. The application of stocking rates to determine carrying capacity should be used with care and in context to seasonal, topographic, and behavioral factors.

2. RESOURCE DESCRIPTIONS

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 District 9 Sweetwater, Mexican Water, and Rock Point communities. This information can be used to document future changes on the rangelands and assist with management decisions.

2.1 Geographic Setting

The project area is located within the Colorado Plateau Major Land Resource Area (MLRA). The surveyed study area is geographically diverse and ranges from the piñon-juniper woodlands in the foothills of the Carrizo Mountains at 6,900 feet in elevation to the San Juan River at 4,400 feet. The Sweetwater community contains piñon-juniper woodlands on its eastern edge, where the community lies against the mountains; the western edge of Sweetwater includes stabilized dunes that continue into Rock Point community. Rock Point, as the name suggests, consists of sandstone rockland and slickrock canyons. The Mexican Water community is largely comprised of extended blackbrush plains with some greasewood flats. The topography of Mexican Water is rolling and far less drastic than the mesas, cliffs, and steep slopes of Rock Point and Sweetwater.

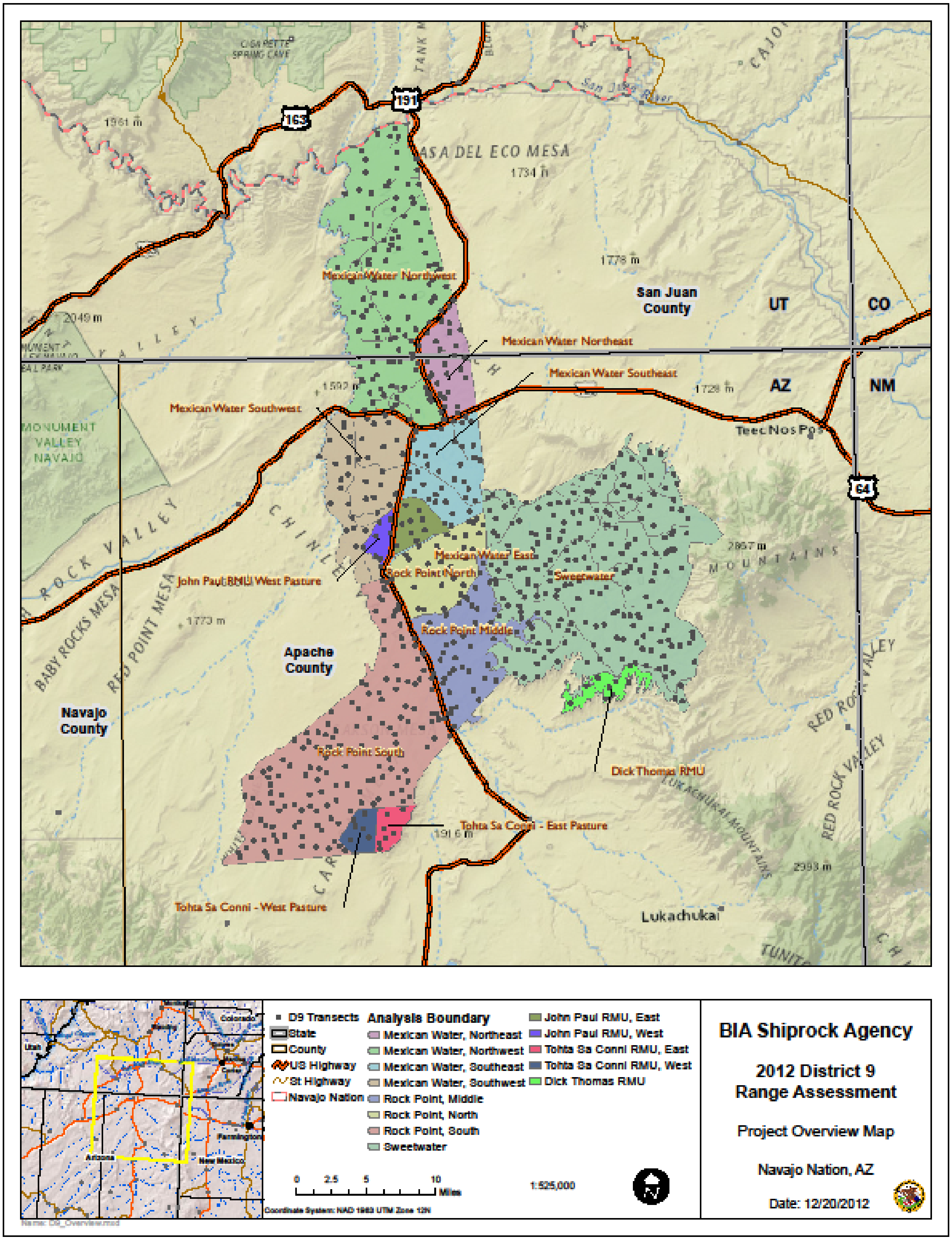
The communities of Sweetwater, Mexican Water and Rock Point are all located in Apache County, Arizona and Mexican Water extends into San Juan County, Utah. Mexican Water is bordered on the east by Chinle Wash, while the western side has a man-made border that more or less parallels Highway 191. Highway 191 continues south to Rock Point. The Rock Point community extends southwest to and includes Whitetop Mesa. The eastern boundary with Sweetwater is primarily drawn along canyons. Sweetwater community is bordered on the south by canyons and on the east by the higher elevations of the Carrizo Mountains. Sweetwater wash is close to the community’s northern boundary.

Acreages for each compartment were extracted from shapefiles provided by the Shiprock Agency. Using these shapefiles and the soil survey boundaries, the three communities in District 9 covered 456,359 acres. Acreage per pasture is listed in Table 2-1.

Table 2-1 Acres in Project Area by Community and Pasture

Pasture	Acres	
Mexican Water John Paul RMU East	6,319	**163,978**
Mexican Water John Paul RMU West	3,603	
Mexican Water Northeast Pasture	14,175	
Mexican Water Northwest Pasture	83,536	
Mexican Water Southeast Pasture	23,211	
Mexican Water Southwest Pasture	33,133	
Rock Point Middle Pasture	29,760	**152,353**
Rock Point North Pasture	20,813	
Rock Point South Pasture	93,511	
Rock Point Tohta Sa Conni East Pasture	4,043	
Rock Point Tohta Sa Conni West Pasture	4,227	
Sweetwater	134,983	**140,028**
Sweetwater Dick Thomas RMU	5,045	
Project Area Total	**456,359**	

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


Mexican Water Northwest
Mexican Water Northeast
Mexican Water Southeast
Mexican Water Southwest
Mexican Water East
John Paul RMU West Pasture
Rock Point North
Sweetwater
Rock Point Middle
Rock Point South
Dick Thomas RMU
Tohta Sa Conni - East Pasture
Tohta Sa Conni - West Pasture
San Juan County
Apache County
Navajo County
UT
CO
AZ
NM
Teec Nos Pos
Lukachukai
163
191
64
1961 m
1734 m
1778 m
2049 m
1592 m
1728 m
2867 m
1773 m
1916 m
2993 m
MONUMENT VALLEY NAVAJO
ROCK VALLEY
BABY ROCKS MESA
RED POINT MESA
CHINLE
RED ROCK VALLEY
LUKACHUKAI MOUNTAINS
San Juan River
D9 Transects
State
County
US Highway
St Highway
Navajo Nation
Analysis Boundary
Mexican Water, Northeast
Mexican Water, Northwest
Mexican Water, Southeast
Mexican Water, Southwest
Rock Point, Middle
Rock Point, North
Rock Point, South
Sweetwater
John Paul RMU, East
John Paul RMU, West
Tohta Sa Conni RMU, East
Tohta Sa Conni RMU, West
Dick Thomas RMU
0 2.5 5 10 Miles
1:525,000
Coordinate System: NAD 1983 UTM Zone 12N
N
BIA Shiprock Agency
2012 District 9
Range Assessment
Project Overview Map
Navajo Nation, AZ
Date: 12/20/2012
Utah
Colorado
Arizona
New Mexico
Farmington
Name: D9_Overview.mxd

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 overestimated in the reconstruction factor, the total annual production estimate decreases. If precipitation is underestimated in the reconstruction factor, the total annual production estimate increases. Precipitation gauges are located throughout the Navajo Nation and the corresponding data is managed by the Navajo Nation Division of Water Resources (NNDWR). The NNDWR provided 18 years of precipitation data from two gauging stations outside of, but adjacent to, District 9. These precipitation stations are the Bluff WX and Teec Nos Pos O & M. The precipitation data are provided as Appendix A.

2.3 Soils

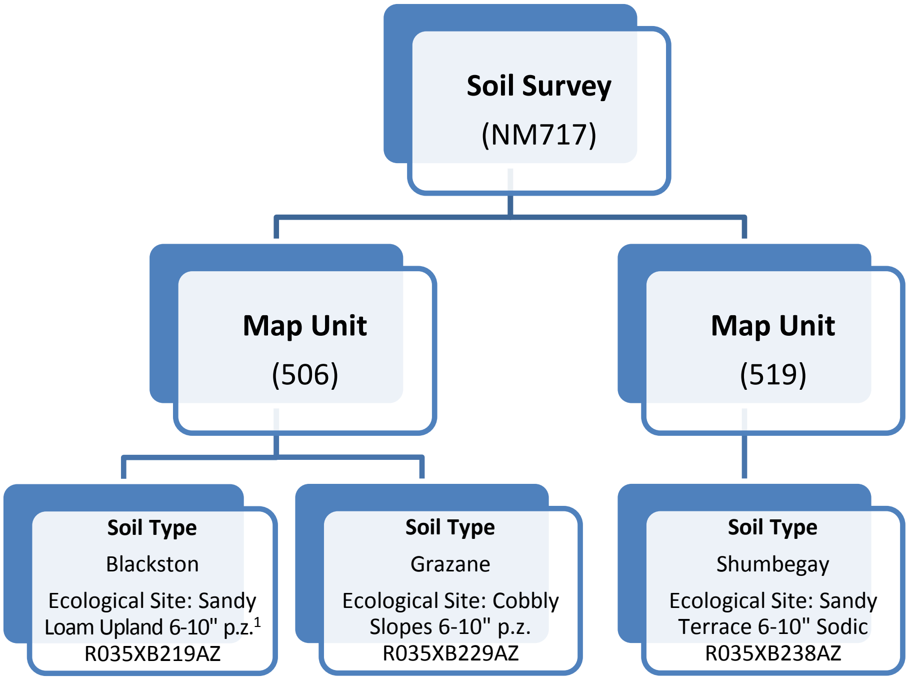
Knowledge of the soil properties in a particular area can help in predicting forage production. Soil properties such as texture, depth, moisture content, and capacity can dictate the type and amount of vegetation that will grow in that soil. The application of soil survey information is what enables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

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

The inventory project area is located within the boundaries of three soil surveys produced by the United States Department of Agriculture, Soil Conservation Service. The three surveys are: Shiprock Area, Parts of Apache County, Arizona and San Juan County, New Mexico (NM717), San Juan County, Utah, Navajo Indian Reservation (UT643), and Navajo Mountain Area, AZ, Parts of Apache, Coconino and Navajo Counties (AZ711).

These soil surveys are Order III mapped, which means they include soil and plant components at association or complex levels (called map units). Within each soil map unit, finer levels (called soil types) are described, but not mapped. Each soil map unit contains one, two, or three soil types within it. Each soil type is correlated with a specific ecological site. But ecological sites cannot be mapped directly from Order III soil map information because they are not correlated with the soil map units; these are correlated with the finer levels of unmapped soil types.

Some of the associated ecological site descriptions that correspond to soils in these soil surveys are in draft form and have not yet been finalized, or have changed. Soil surveys and ecological site descriptions are valuable for rangeland managers, as long as their limitations are understood. The following graph illustrates the hierarchy of *unmapped* soil types and their corresponding ecological sites within a *mapped* soil unit within a given soil survey. The examples in the chart are extracted from the soil survey used for this project.



[1] p.z.—precipitation zone.

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 water infiltration into the soil (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 differences 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 variations in topography, climate, and environmental factors or the response of vegetation to management. Each ecological site description (ESD) describes the historic climax plant community (HCPC) that was present during European settlement of North America. Many rangelands have undergone significant transitions to a state in which they are never again expected to display the characteristics of the HCPC. In their best condition, these rangelands would instead reach their potential natural community (PNC). PNCs may include non-native plant species and other factors, which differentiate them from an HCPC on the same site.

Ecological sites are directly associated with soil types. The determination of ecological site for each transect was complicated due to inconsistencies of scale in the soil surveys. As described in Section 2.3 Soils, the Soil Survey was mapped at the soil complex scale (Order III), meaning that there are up to three soil types inside of a mapped soil complex. The smaller soil types are not mapped. Since each soil type has a single ecological site assigned to it, the map unit has up to three unmapped ecological site possibilities.

Rangeland managers should be aware that maps of ecological sites are available on the Natural Resource Conservation Service (NRCS) Web Soil Survey website. 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 type/ecological site is 60 percent of the soil map unit, then the other 40 percent of the soil unit would be mapped incorrectly. An analogy might use a basket of fruit in which there are six apples and four oranges. Using the dominant system, the entire basket of fruit would be labeled as apples. While the dominant ecological site map may be appropriate at a landscape level, it is inaccurate for use with rangeland management of pastures.

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

The ecological sites from the District 9 study area transect sites are listed in Table 3-1; followed by representative examples of ecological sites which contained transects, in one or two photographs, with transect locations identified. Some sites had only one transect located within the ecological site. Many ecological sites contained no transects, especially those with few acres.

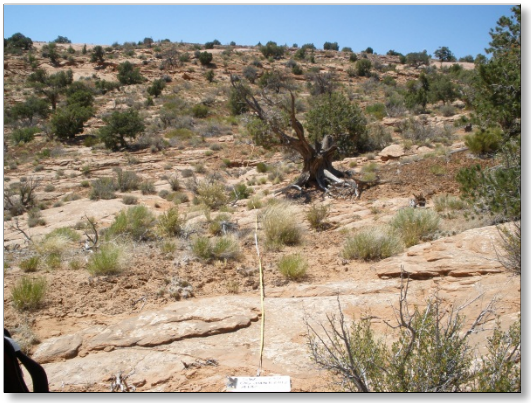
Table 3-1 Ecological Sites

Ecological Site*	Acres	% of Project Area
Badland	1256.4	0.28%
F035XG134NM Gravelly-Woodland	19464.4	4.26%
F035XH005NM Playa	15.4	0.00%
F036XA001NM South of Gallup 13-16	30.9	0.01%
No ESID	12168.5	2.67%
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	3106.2	0.68%
R035XB210AZ Loamy Upland 6-10" p.z.	12600.2	2.76%
R035XB215AZ Sandstone/Shale Upland 6-10" p.z.	3450.5	0.76%
R035XB216AZ Sandy Wash 6-10" p.z.	3641.5	0.80%
R035XB217AZ Sandy Upland 6-10" p.z.	74645.3	16.35%
R035XB219AZ Sandy Loam Upland 6-10" p.z.	68774.9	15.06%
R035XB222AZ Sandy Terrace 6-10" p.z.	3579.8	0.78%
R035XB224AZ Clayey Slopes 6-10" p.z. Bouldery	458.5	0.10%
R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic	7090.6	1.55%
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	820.2	0.18%
R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane	662.7	0.15%
R035XB230AZ Sandstone Upland 6-10" p.z. Calcareous	15118.0	3.31%
R035XB234AZ Shallow Sandy Loam 6-10" p.z. Calcareous	3178.5	0.70%
R035XB235AZ Sandy Loam Upland 6-10" p.z. Calcareous	10823.1	2.37%
R035XB236AZ Stony Slopes 6-10" p.z. Calcareous	851.5	0.19%
R035XB237AZ Clay Loam Terrace 6-10" p.z. Sodic	8491.8	1.86%
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	13427.1	2.94%
R035XB239AZ Clayey Fan 6-10" p.z.	3755.6	0.82%
R035XB255AZ Sandstone Rockland 6-10" p.z.	430.9	0.09%
R035XB260AZ Sand Dunes 6-10" p.z.	2010.7	0.44%
R035XC302AZ Sedimentary Cliffs 10-14" p.z.	5435.8	1.19%
R035XC313AZ Loamy Upland 10-14" p.z.	4921.7	1.08%
R035XC315AZ Sandy Upland 10-14" p.z.	8977.2	1.97%
R035XC316AZ Clay Loam Swale 10-14" p.z. Limy, Shallow	15739.9	3.45%
R035XC317AZ Sandy Loam Upland 10-14" p.z.	13222.9	2.90%
R035XC324AZ Clayey Slopes 10-14" p.z. Bouldery	2090.7	0.46%
R035XC328AZ Cobbly Slopes 10-14" p.z.	379.1	0.08%
R035XC329AZ Loamy Upland 10-14" p.z. Gravelly	1642.8	0.36%

Ecological Site*	Acres	% of Project Area
R035XC330AZ Sandy Terrace 10-14" p.z. Stony	320.5	0.07%
R035XY009UT Alkali Flat (Greasewood)	843.9	0.18%
R035XY012UT Semiwet Saline Streambank	570.2	0.12%
R035XY109UT Desert Loam (Shadscale)	898.3	0.20%
R035XY115UT Desert Sand (Sand Sagebrush)	7306.5	1.60%
R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	10.4	0.00%
R035XY121UT Desert Sandy Loam (Blackbrush)	17925.9	3.93%
R035XY130UT Desert Shallow Sandy Loam (Shadscale)	17038.3	3.73%
R035XY133UT Desert Shallow Sandy Loam (Blackbrush)	1048.1	0.23%
R036XB006NM Loamy	693.2	0.15%
Rock outcrop	87322.0	19.13%
Water	118.8	0.03%
Total	**456359.3***	**99.96%****

*The New Mexico NRCS has updated the Ecological Sites associated with the Soil Units in the soil survey. These changes are listed in a separate document from the soil survey and are included as Appendix B. **0.04% or 193.7 acres is a result of the overlaps and gaps in the soil layers combined with calculations for ecological sites which are not spatially represented.

F035XG134NM Gravelly—Woodland (Transects SW-11 and SW-39)



R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z. (Transects RP-219 and SW-195)

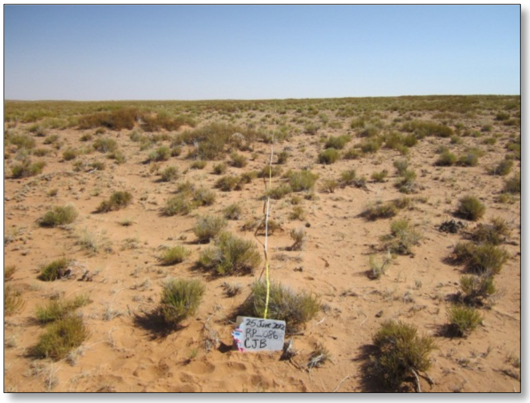
R035XB210AZ Loamy Upland 6-10" p.z. (Transects RP-193 and RP-057)

R035XB215AZ Sandstone/Shale Upland 6-10" p.z. (Transects SW-198 and New-23)

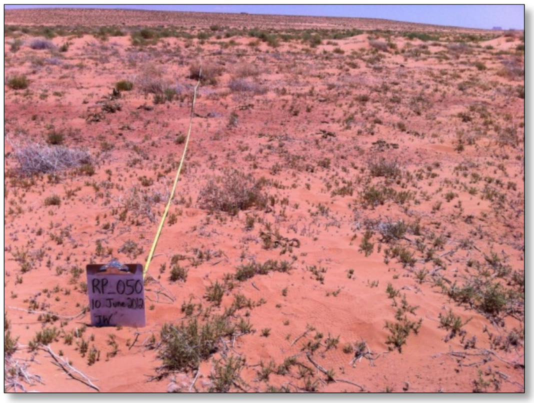
R035XB216AZ Sandy Wash 6-10" p.z. (Transects RP-03 and SW-189)

R035XB217AZ Sandy Upland 6-10" p.z. (Transects MW-21 and RP-98)

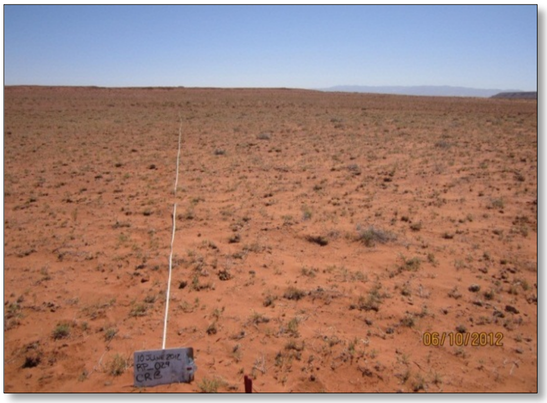
R035XB219AZ Sandy Loam Upland 6-10" p.z. (Transects RP-86 and SW-168)



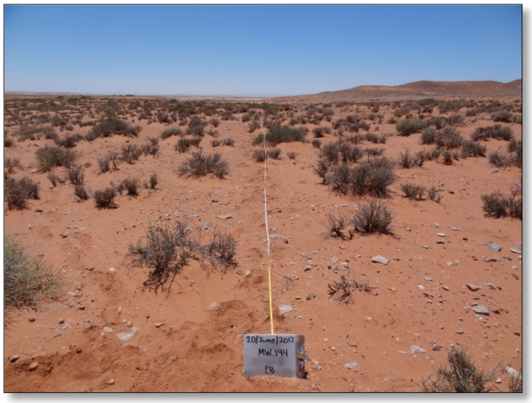
R035XB222AZ Sandy Terrace 6-10" p.z. (Transects RP-50 and RP-51)



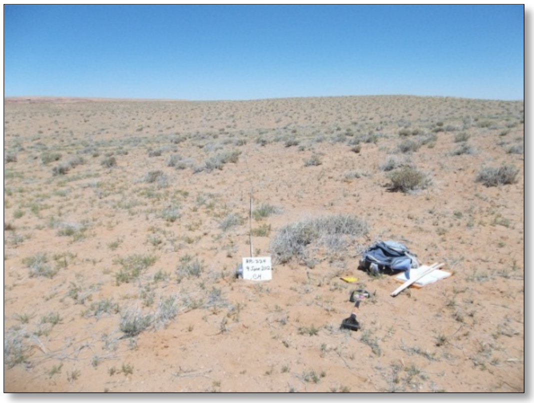
R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic (Transects MW-05 and RP-29)



R035XB228AZ Sandstone Upland 6-10" p.z. Sodic (Transects MW-194 and MW-195))



R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane (Transect RP-224)

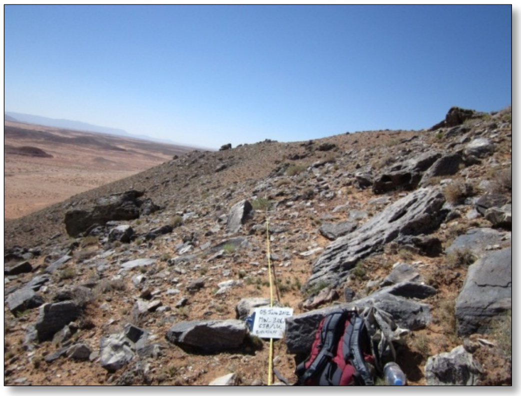


R035XB230AZ Sandstone Upland 6-10" p.z. Calcareous (Transects MW-66 and MW-67)

R035XB234AZ Shallow Sandy Loam 6-10" p.z. Calcareous (Transects MW-35 and MW-79)

R035XB235AZ Sandy Loam Upland 6-10" p.z. Calcareous (Transects MW-54 and MW-59)

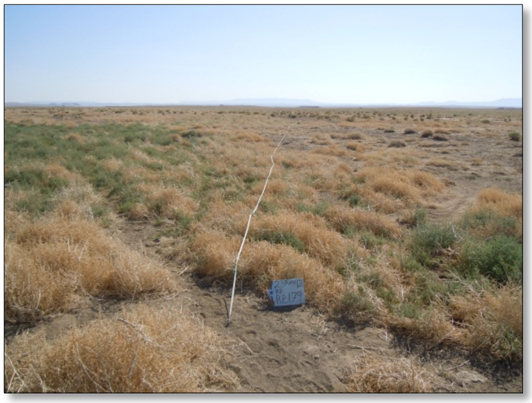
R035XB236AZ Stony Slopes 6-10" p.z. Calcareous (Transect MW-206)



R035XB237AZ Clay Loam Terrace 6-10" p.z. Sodic (Transects MW-84 and RP-157)

R035XB238AZ Sandy Terrace 6-10" p.z. Sodic (Transect MW-214 and RP-62)

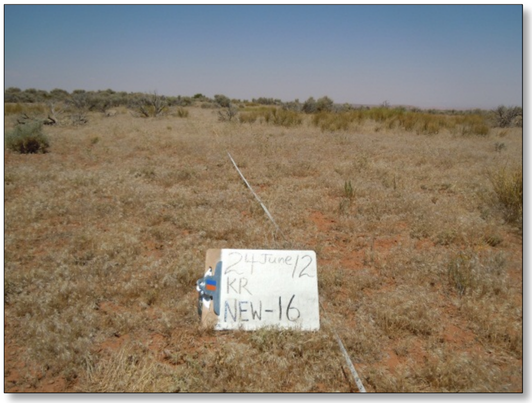
R035XB239AZ Clayey Fan 6-10" p.z. (Transects RP-177 and RP-179)



R035XB260AZ Sand Dunes 6-10" p.z. (Transects RP-203 and RP-205)

R035XC302AZ Sedimentary Cliffs 10-14" p.z. (Transects SW-91 and SW_162)

R035XC313AZ Loamy Upland 10-14" p.z. (Transects SW-197 and New-16)



R035XC315AZ Sandy Upland 10-14" p.z. (Transects SW-26 and SW-44)

R035XC316AZ Clay Loam Swale 10-14" p.z. Limy, Shallow (Transects SW-107 and SW-59)

R035XC317AZ Sandy Loam Upland 10-14" p.z. (SW-03 and SW-161)

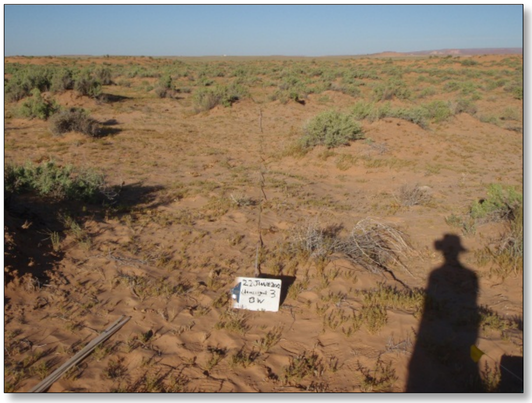
R035XC324AZ Clayey Slopes 10-14" p.z. Bouldery (Transects SW-134 and SW-214)

R035XC328AZ Cobbly Slopes 10-14" p.z. (Transect SW-122)

R035XC329AZ Loamy Upland 10-14" p.z. Gravelly (Transects SW-08 and SW-176)

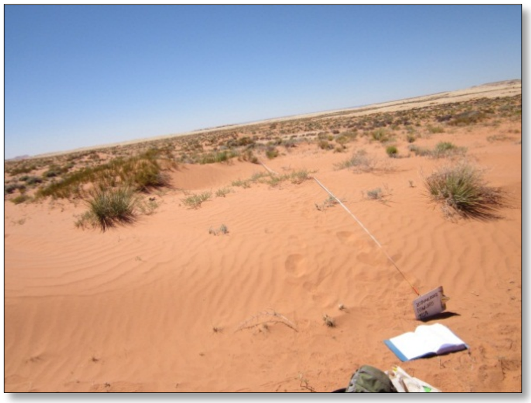
R035XC330AZ Sandy Terrace 10-14" p.z. Stony (Transect SW-211)

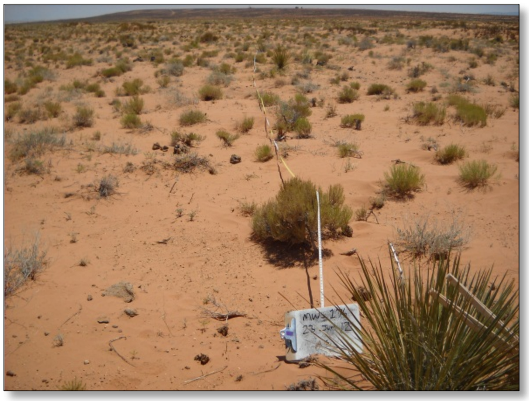
R035XY009UT Alkali Flat (Greasewood) (Transects New-3 and New-5)



R035XY012UT Semiwet Saline Streambank (Transect MW-108)

R035XY115UT Desert Sand (Sand Sagebrush) (Transects MW-175 and MW-176)





R035XY121UT Desert Sandy Loam (Blackbrush) (Transects MW-148 and MW-153)

R035XY130UT Desert Shallow Sandy Loam (Shadscale) (Transect MW-097)

R035XY133UT Desert Shallow Sandy Loam (Blackbrush) (Transects MW-105 and MW-113)

Rock Outcrop (Transects MW-101 and SW-87)

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, described the study design and cited specific methodologies for data collection (Coulloudon 1999, Habich 2001, and 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 June 3 and June 26, 2012. The BIA provided Ecosphere with predetermined transect locations. The Universal Transverse Mercator UTM coordinates of these transect locations were downloaded into hand held Global Positioning System (GPS) units. The GPS unit was used in combination with topographic maps to navigate by vehicle and foot to the transect locations. Transects were established within ten meters of the GPS coordinates and usually within one meter.

Transects consisted of a 200-foot straight 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. The transect azimuth was read with a compass and recorded. The 200-foot tape was then extended along the transect azimuth. Vegetation attributes were read 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 (USDA NRCS 2003). Care was taken to avoid bias by establishing each plot using a consistent method, in this case always laying the frame to the right side of the tape. The point intercept for ground cover was measured first, on the left side of the tape. Aspect, slope, surface soil texture, and notes were recorded in addition to the vegetative attributes.

4.1.2 Production Data Collection

Weight is the most meaningful expression of the productivity of a plant community or an individual species. It has a direct relationship to feed units for grazing animals that other measurements do not have. Production is determined by measuring the annual aboveground growth of vegetation.

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, while peak standing crop is the greatest amount of plant biomass aboveground present during a given year (Coulloudon et al. 1999). Production includes the aboveground parts of all plants produced during a single growth year. Excluded are underground growth, production from previous years, and any increase in the stem diameter of shrubs.

Production and composition of the plant communities were determined by a combination of estimating and harvesting (double sampling). Ecosphere followed the double sampling methodology of the United States Department of Agriculture (USDA), NRCS modified to standards outlined in the SOW, and with modifications generated from the pre-work conference. This method is detailed in the following sections.

4.1.2.1 Establishing a Weight Unit

The weight unit method is an efficient means of estimating production. A weight unit is a part of a plant, an entire plant, or a group of plants of the same species used for assessing production. After weight units are established, field teams can be very accurate in production estimation. 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 *Achnatherum hymenoides* (Indian ricegrass) may be visually estimated to equal ten grams. This clump of grass is then harvested and weighed with a hand scale to determine actual weight. This process is repeated until ten grams of *Achnatherum hymenoides* (Indian ricegrass) can be visually estimated with accuracy. The field team maintained proficiency by periodically harvesting and weighing to check estimates of production.

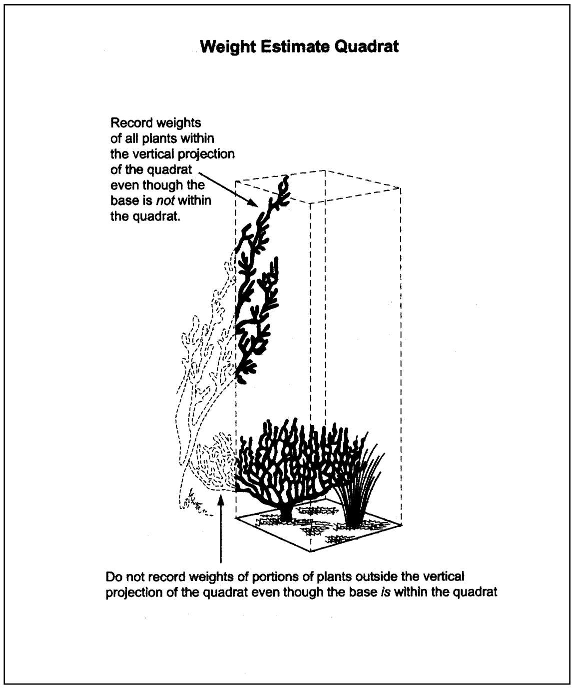
4.1.2.2 Double Sampling Methodology (Estimating and Harvesting)

Production (in grams) was estimated by counting the weight units of each species in each plot. All plants and parts of plants inside an imaginary box outlined by the actual 9.6 ft^2 frame up to a height of four feet were estimated. Excluded were any plants and parts of plants outside of the box (Figure 4.1). 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 (1/4 in. stubble height). In many cases, vegetation was diverse and widespread so no two plots could effectively represent all species.

Ecosphere has determined, through several years of data collection and analysis, that intermittently occurring species are underrepresented in the harvested material to be used for both correction factors and air dry weights. The problem is that small samples have a greater chance of inaccuracy when expanded to apply to pounds per acre. In other words, a sample that was measured as 1 gram actually weighs 1.1 grams, has a greater effect on the results than a sample measured as 10 grams that actually weighs 10.1 grams. In an effort to include more data in the harvested material to reduce this potential for error, a weight unit of any species that contributed 10 grams or more of estimated production on the transect, but did not occur in the two selected harvested plots, was estimated and clipped individually outside of the transect and recorded as “plot 11”. These data were not used for production, only to improve the accuracy and limit the proportional bias inherent in small samples for correction factors and air dry weights.

Clipped biomass was weighed with a hand scale, and both estimated and harvested (green) weights were recorded. All harvested materials were collected and stored in paper bags labeled with tracking information including transect, date, species, and plot number. All of the harvested material was allowed to air dry for ten days or more before re-weighing to convert from 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 methodology.

Figure 4-1: Weight Estimate Box



Source: Coullodon et al. (1999)

4.1.2.3 Large Shrub Plots

Extended plots were established when the vegetation consisted of “large” shrubs. Neither the SOW or the National Range and Pasture Handbook adequately define the large shrub plot methodology. However, the purpose of the large shrub plots is to capture the production of larger shrubs that are too big to be adequately measured within the 9.6 ft^2 frame. Two extended plots (0.01 acre) were measured at fixed points along the transect and only the large shrub species inside those plots were estimated. These shrubs were not measured in the ten 9.6 ft^2 plots because that would be doubling the measurement. Large shrub plots were usually established in areas of tall, thick *Artemisia tridentata* (big sagebrush) or on *Sarcobatus vermiculatus* (greasewood) flats, or on rolling hills with *Purshia tridentata* (antelope bitterbrush) and *Cercocarpus montanus* (mountain mahogany).

4.1.2.4 Ocular Estimates of Utilization

Utilization, or use, is the proportion of annual growth that has been consumed by grazing animals. The purpose of estimating utilization is to include in the vegetation measurements the forage which has been consumed prior to the vegetation inventory. With the Ocular Estimation Method (Coulloudon et al. 1999a), utilization is determined by visual inspection of forage species. This method is reasonably accurate, commonly applied, and suited for use with both grasses and forbs. Field team personnel were thoroughly trained and practiced in making ocular estimates of utilization of plants. An attempt was made to locate un-grazed plants near the transect. These un-grazed plants were assumed to approximately represent the species before grazing occurred. 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.

4.1.2.5 Sensitive Plants Protocol

Threatened, endangered, culturally important, or otherwise sensitive plants were never intentionally harvested for the purposes of this inventory. The weight of such plants was estimated but the plants were not clipped. Cacti and yucca species were not clipped, their annual production was estimated using standard protocols as described in the National Range and Pasture Handbook (2003). Production for yuccas was considered 15 percent of total green weight. Cholla cacti production was considered 15 percent of active tissue, prickly pear 10 percent, and barrel cacti 5 percent. A list of all plant species recorded during the inventory is included as Appendix C. Also in Appendix C is a list of scientific collections made during the data collection, under Ecosphere’s valid Navajo Nation permit.

4.1.3 Frequency Data Collection

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

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

4.1.4 Cover Data Collection

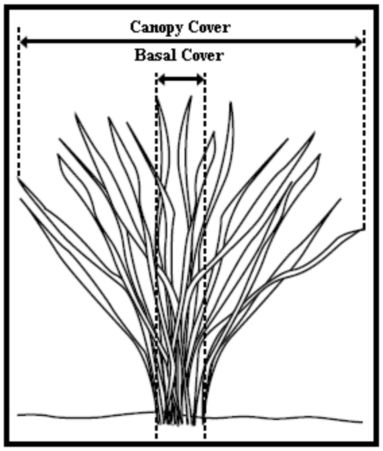
Ground cover measurements are used to quantify the amount of vegetation, organic litter, biological crusts, and exposed soil surface throughout an area. Cover is also important from a hydrologic perspective when examining basal and canopy (foliar) cover of perennial and annual species and litter cover.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

Ground cover data can assist in determining the soil stability and proper hydrologic function of a site, as well as the biotic integrity of a site. Point-Intercept cover measurements are highly repeatable and lead to more precise measurements than cover estimates using quadrants. For trend comparisons in herbaceous plant communities, basal cover is generally considered to be the most stable 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. The change in canopy cover over the course of the growing season can make it hard to compare results from different portions of large areas where sampling takes several weeks or a few months. In the future, ground cover monitoring for each ecological site within each grazing unit should replicate the sampling time 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 4.1-2) 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)

4.1.5 Soil Surface Texture Test

At each transect in which there was a choice of soil types and ecological sites, the A Horizon (top 0-6 inches) of the soil surface was sampled. The surface was cleared of debris to bare mineral soil. A small sample was analyzed using the USDA Soil Texturing Field Flow Chart (Appendix D). The Flow Chart uses a step-by-step procedure for estimating sand, silt, and clay content. The test also uses the ribbon method to determine the fraction of fine-grained particles within the sample. Field teams assigned a texture class to the sample based on its tested content and ribbon characteristics.

4.2 Post-Field Methodology

After field data collection is complete, the data was prepared and analyzed. All field data was downloaded into a database. Harvested biomass was air dried for ten days and then each sample was weighed. Dry weights were then entered individually into the database, by each species on each transect. When the initial field dataset was complete, calculations were applied to reconstruct the collected production data to the amount of vegetation that would occur in a “normal” year. These adjustments included utilization, climate, growth curve, and air dry weight corrections.

When the reconstruction factor calculation was complete for every species on every transect, the results were grouped by ecological sites within each community and the data were analyzed. Analysis included similarity indices, available forage based on forage value and harvest efficiency factors, stocking rates, and carrying capacity.

4.2.1 Reconstructed Annual Production

The translation of a plot full of plants to a measure of pounds per acre was achieved through a series of calculations. The formula, derived from technical reference 1734-7 Ecological Site Inventory (Habich 2001) and the National Range and Pasture Handbook (USDA NRCS 2003), reconstructed the measured weight of biomass to a “normal” annual air-dry production weight that accounts for physical, physiological, and climatological factors. First, the green weight of a species that was estimated in the field was multiplied by an estimation correction factor and then by a reconstruction factor. The reconstruction factor is the percent air-dry weight (%ADW) of the species, divided by the result of the utilization, multiplied by growth curve for that time of year, and multiplied by the percent of normal precipitation for the current water year. This may be more easily understood with the formula below:

$$\mathit{CorrectedGreenWeight}\left\{\frac{\%\mathit{ADW}}{(\%\mathit{Utilization})(\%\mathit{NormalPrecipitation})(\%\mathit{GrowthCurve})}\right\}$$

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

4.2.1.1 Corrected Green Weight (Estimation Correction Factor)

The harvested or clipped plots provide the data for correction factors of estimated species weights from the field. Measured (clipped) weights of species were divided by the estimated weights of the same species in the same plots to establish a correction factor. This correction factor was then applied to all estimations of that species for the entire transect. For example, if *Sporobolus airoides* (alkali sacaton) was estimated to weigh 10 grams (g), but the clipped weight was actually 9g, then all estimates of *Sporobolus airoides* (alkali sacaton) for that transect would be multiplied by 0.90. If the total estimated weight for estimates of *Sporobolus airoides* (alkali sacaton) on all plots in this transect was 80g, the resulting corrected weight would be 72g, as illustrated below:

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

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

4.2.1.2 Biomass ADW Conversion

The air dry weight percentage is part of the Reconstruction Factor and accounts for the amount of water contained in the plants. The purpose is to remove the weight of water from the weight of the actual forage of the plant. All biomass from clipped plots was collected in paper bags with tracking information recorded on the bags (date, transect identification, plot number, and species). Clipped, or green, weights were immediately weighed with a hand scale, which was adjusted for the weight of the bag, and recorded. The paper bags filled with biomass were air dried for a minimum of ten days. All bags were then weighed again and dry weights were recorded into the dataset. After drying, the weights were divided by the green weights to give a %ADW in grams to be used in the reconstruction factor. In the example above, the green weight of the clipped biomass was 9g. If the dry weight in the lab was measured at 8g, then the %ADW would be 0.888.

For species in a transect that were not clipped, an average %ADW was used that was generated from the same species in the same community. In the case of remaining species the %ADW defaulted to one.

$$\%ADW = \frac{\text{Dry Weight (lab)}}{\text{Green Weight(field)}} = \frac{8g}{9g} = 0.8888$$

This value (0.8888) represents the numerator of the reconstruction factor. The three values in the denominator are explained below.

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 in the vicinity of the transect. For example, if *Sporobolus airoides* (alkali sacaton) was recorded at a utilization factor of 90 percent un-grazed, then the amount of *Sporobolus airoides* (alkali sacaton) estimated would represent only 90 percent of the total amount of *Sporobolus airoides* (alkali sacaton):

Utilization = 0.9000

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

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 measurement taken in June will be much less than a measurement of the same plant taken in September, when the plant is nearing full growth. A growth curve calculates the average growth, by month, of plant species throughout the year within a specific region. For example, if *Sporobolus airoides* (alkali sacaton) was measured in a transect during August, that measurement may represent only 88 percent of the full growth of that species.

Each growth curve entry was a pro-rated value according to the day of the month. For example, using the growth curve AZ3521, and a transect that was sampled August 21st, the first step would be to total the percentage of growth completed up to that date by adding up the monthly categories:

Feb (1%) +Mar(9%)+Apr(20%)+May(27%)+June(14%)+July(10%) for a subtotal of 81 percent of the growth curve completed.

Then, for the month of August, 21 days would need to be 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 percent) is multiplied by the daily rate (.35 percent) for 7.45 percent. This is added to the 81 percent that had occurred up to the end of July for 88.45 percent of the growth curve completed.

Growth curves are typically presented in an ecological site description. However, many of the ESDs in Ecosphere's study area were incomplete or had incorrect growth curves. If the ESD was not available, no growth curve was written in the ESD, or the growth curve in the ESD was incorrect, then the ESD was replaced with the most suitable growth curve in the same common resource area if possible. The growth curve used for many sites listed in MLRA 35 (6-10" sites) was:

AZ3521, 35.2, 6-10" p.z. all sites.

Growth Curve Description: Growth begins in the spring and continues through the summer, most growth occurs in the spring using stored winter moisture.

Percent production by month:

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

Growth Curve = 0.8845

The growth curve for the example equation is 0.8845 percent. The total weight of the species in the transect is divided by 0.8845 to bring the measured weight up to 100 percent of growth for the year.

4.2.1.5 Percent Normal Production

The Percent Normal Production is directly affected by growing conditions. Precipitation amount and timing, as well as temperature and their relationship, have an impact on species production. Production varies each year depending on the favorability of growing conditions. Biomass production measurements from year to year are not accurate without accounting for percent of normal production influences. For this inventory, the variation in precipitation was used as the value for percent of normal production. The factors of precipitation timing and temperature are extremely difficult factors to quantify and apply to biomass production because the impacts vary by individual species. The Bluff, Utah and Teec Nos Pos, Arizona weather stations precipitation percentage was used in the calculations to determine the percent of normal production. After May of 2012, the water year average was 76 percent compared to the previous 17 years of data.

4.2.1.6 Reconstruction Equation

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

$$\text{Reconstruction Equation} = \frac{0.888}{(0.900 \times 1.02 \times 0.8845)} = \underline{1.094}$$

For this example calculation, the water year was 102 percent of the average. The formula for the reconstruction equation, shown above, is repeated here:

$$CorrectedGreenWeight\left\{\frac{\%ADW}{(\%Utilization)(\%NormalPrecipitation)(\%GrowthCurve)}\right\}$$

When actual values from the *Sporobolus airoides* (alkali sacaton) example are inserted into the formula the equation becomes:

$$72g\left\{\frac{0.8888}{0.900 \times 1.02 \times 0.8845}\right\} = 72g \times 1.094 = 78.74g$$

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

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 factored into the formula. The plot size, 9.6 ft^2, was repeated ten times in each transect, thereby creating 96 ft^2 of sampling area, which calculates into a 1:1 conversion (Coulloudon et al. 1999); therefore, in this case the conversion factor equals one and so is not explicitly written into the equation. Hence, in the example, there were 78.74 pounds per acre of *Sporobolus airoides* (alkali sacaton). The value 78.74 represents the total reconstructed annual production of the species in pounds per acre.

4.2.2 Calculating Ground Cover

Fifty ground cover point intercepts were measured, so ground cover categories were divided by 50 and the result was multiplied by 100 to reach a percentage. Ground cover calculation categories were top canopy, basal cover, and bare ground. For example, if 30 hits were recorded for bare ground, the percent bare ground on that transect would be 60 percent. 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 to be "bare ground." This is because true bare soil has less soil stability than duff, litter, rock, or bedrock. Cover data was averaged by compartment, Range Management Unit (RMU) or pasture:

*((30 "bare ground" hits per transect)/50 sample points per transect)*100= 60% bare ground*

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 *Sporobolus airoides* (alkali sacaton) occurred in six of the ten plots on a given transect, the frequency would be 60 percent. Frequency of species on each transect is included in the spreadsheet production data with this report. Frequency of the five most common species to appear on transects within each community is presented in Section 5: Results.

4.2.4 Calculating Similarity Index

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

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

Each ESD lists a range of expected production for above-average years and below-average years for each species (or group of species), as well as the total annual production for the site. If a normal year expected production is not provided then a median of the above and below average years is calculated. The normal year, or median of the above average and below average, is always used as the comparison production amount because all of the variable factors (such as above average precipitation) have already been factored into the reconstruction process. This is the recommended and accepted method of calculating a similarity index. The sum total of these median values is used to compare the measured vegetation against the HCPC.

As ecological site descriptions are updated, the expected production values may change. This affects the similarity index value, sometimes significantly. All similarity index values were calculated based on ecological site descriptions that were available during the period of the field survey. Several ESDs have since been updated.

To calculate a similarity index, each plant species was compared to the ESD. The ESD has an assigned production value for each species (or group of species) expected to occur in the HCPC. Production that is expected to occur in the ecological site (up to the maximum percent listed) is termed allowable production. If an individual species (or group of species) is not listed in the ESD, no production is assigned or “allowed” from that species. For example:

1. A transect had 78.74 pounds/acre of *Sporobolus airoides (*alkali sacaton*)*.
2. Based on the information in the ESD, the “allowable” production for *Sporobolus airoides* (alkali sacaton) is 50 pounds/acre.
3. No more than 50 pounds may be “allowed” to be counted toward the similarity index for the transect.
4. If the ESD had listed the allowable percentage of *Sporobolus airoides* (alkali sacaton) at 200 pounds/acre, then all 78.74 pounds (and no more) would have been “allowed” to be counted toward the similarity index for the transect.

Thus, 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 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. Ecological site descriptions list only the values for common plant species. However, a comprehensive list of species from the Colorado Plateau area was developed by the Utah NRCS. This list was used to assign forage values to all species recorded in the data collection. The list is included with the data in Appendix E. Species are grouped into five categories and each category is weighted accordingly. The five groups recognized by the National Range and Pasture Handbook (USDA NRCS 2003) are as follows:

- **Preferred plants**—These plants are abundant and furnish useful forage for a reasonably long grazing period. They are preferred by grazing animals. Preferred plants are generally more sensitive to grazing misuse than other plants and they decline under continued heavy grazing.
- **Desirable plants**—These plants are useful forage plants, although not highly preferred by grazing animals. They either provide forage for a relatively short period, or they are not generally abundant in the stand. Some of these plants increase, at least in percentage, if the more highly preferred plants decline.
- **Emergency (or Undesirable) plants**—These plants are relatively unpalatable to grazing animals, or they are available for only a very short period. They generally occur in insignificant amounts, but may become abundant if more highly preferred species are removed.
- **Nonconsumed plants**—These plants are unpalatable to grazing animals or they are unavailable for use because of structural or chemical adaptations. They may become abundant if more highly preferred species are removed.
- **Toxic plants**—These plants are poisonous to grazing animals. They have various palatability ratings and may or may not be consumed. Toxic plants may become abundant if unpalatable and if the more highly preferred species are removed.

Species that can be injurious to livestock, regardless of their palatability, were also noted with the forage value.

In many cases, a species has more than one forage value according to the season of use. For example, *Poa fendleriana* (muttongrass) is considered preferred in the spring, but desirable during the remainder of the year. The District 9 range management currently allows for year round grazing so a single forage value is needed. The lowest value was chosen for each species to achieve a conservative estimate of the forage available and to avoid overgrazing during times of the year when forage palatability is lowest. For this inventory, we used sheep forage preference during the least palatable season, usually fall or winter.

Each category of plants is assigned a harvest efficiency factor. The harvest efficiency factor accounts for production that is actually consumed by grazers and generally averages 25 percent on rangelands with continuous grazing (NRCS 2003). Not all annual production is available for livestock consumption due to trampling, loafing, and other non-livestock factors such as loss to disease, insects, or utilization by wildlife. Using NRCS guidelines, the harvest efficiency factors applied for this project were 35 percent for preferred plants, 25 percent for desirable, and 15 percent for undesirable/emergency plants. Non-consumed and toxic species were excluded from the calculations. The harvest efficiency factor is applied to the amount of production within a management area and its purpose is to ensure watershed protection and sustainability of the range resource by limiting allocation of the available forage.

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

4.2.6 Acreage Reductions

The amount of actual land available for grazing was quantified using GIS files from the BIA. Homesites, farmlands, and roads (as designated on shapefiles) were buffered and removed from the total acreage available for livestock grazing. Areas that were more than two miles from water sources and on steep slopes greater than 60 percent were not removed from calculations. These should be considered when adjusting stocking rates. See Section 6.4.

4.2.7 Initial Stocking Rates and Carrying Capacity

A maximum stocking rate is the number of animals grazing a specific area of land for a specific period of time. Carrying capacity for rangeland management purposes defines the number of grazing animals (maximum stocking rate) that a specified area is able to support without depleting the forage resources of that area. Carrying capacity incorporates both domestic and wild grazing animals, and the capacity may vary annually in response to forage production.

Maximum stocking rates were derived from the preferred and desirable and the undesirable or emergency production with an application of harvest efficiency factors. The pounds of preferred, desirable, and emergency forage were incorporated into animal unit months (AUMs) or 790 pounds of forage per month. This standard figure was approved by BIA rangeland managers instead of a more conservative figure.

Carrying capacities were calculated using the available forage. Carrying capacities were calculated by the acreage of each ecological site within a community. This was accomplished using the soil types to which each ecological site is correlated. The soil types with which ecological sites are correlated are not mapped; therefore, acreage estimates for ecological sites were based on soil map unit descriptions. Soil map unit descriptions allocate percentages of the entire soil map unit to each individual soil type; therefore, for each ecological site within that soil map unit complex. For example, if there are 200 acres of the Shumbegay soil map unit and 20 percent of this soil map unit consists of soil type “yy” while 80 percent consists of soil type “zz”, then soil type “yy” is calculated as 40 acres, while soil type “zz” is calculated as 160 acres.

Often, minor soils are included in the soil complex and the percentage of minor soils is added to the major soil units to account for 100 percent of the acreage of the soil map unit complex. Sometimes, the soil map units do not usually add up to 100 percent of the acreage in an area and no minor soils are described. On the advice of the NRCS (Scott Zschetzsche, personal communication), Ecosphere filled in the percentage gap with the major components in their same proportions.

5. RESULTS

The District 9 study area included the communities of Sweetwater, Mexican Water, and Rock Point. These communities contain smaller management areas called pastures or RMUs and results were applied to these analysis units. The attributes collected at each transect were biomass production, ground cover, and species composition. The biomass data was used to calculate total annual production, species frequency, and initial stocking rates by ecological sites within each analysis area. Carrying capacity was calculated by GIS analysis of the acres of each ecological site within each analysis area. A total of 714 transects data sets were included in the analysis. In the final analysis, thirteen transects were excluded due to a lack of ecological site correlations in the soil survey map unit (SW_030, New-29, RP_201, RP_202A, RP_211A, RP_220, RP_194, RP_195, RP_196, RP_197, RP_198, RP_199, MW_003). Another 27 transects were not assigned an ecological site either because there wasn't enough information in the ESD to compare two ecological sites, or because the location was distinctly different from the soil or ecological site description (i.e. clay was found at the transect site but the only ecological site choices were for sandy soils). These inconsistencies are often the result of coarse-scale soil mapping, or from inclusions within a soil unit that contrast with the major components; these inconsistencies are not unexpected. Data from transects in these areas were calculated but they were not included in the analysis by ecological site.

The results of the data analysis indicate the carrying capacity of the range resource is currently exceeded. The total size of the study area is 456,553 acres. Currently, there are 10,043 sheep units year long permitted in the project area. The study results show an unadjusted carrying capacity of 1,523.89 sheep units. The analysis covered about 89 percent of the acreage in the study area. A majority of the remaining 11 percent of the study area was removed from the analysis because it is considered rock outcrop with little to no production potential. A fraction of the study area was not analyzed because there were no transects located in the soil units or no transects were located in ecological sites within specific soil units. No carrying capacity was assigned to non-sampled areas due to a lack of transects within ecological sites.

The sample design was stratified by soil unit to ensure that several transects were located in most of the soil units within the entire study area. Initially, results were analyzed by ecological sites within each pasture, not by ecological sites within the entire study area, but several gaps were created when the data set was analyzed by pastures. In other words, the results were stratified by pasture, but the sample design was not. This led to deficiencies in sample transects for each pasture. To minimize this, data was analyzed by community and then applied to each pasture according to the acres of each soil map unit and percentage of ecological sites within each pasture. Soil map units that consisted primarily of rock outcrop were not included in the sample design.

Table 5-1 displays the total acres present in each pasture, the number of acres analyzed, and the number of acres excluded from the analysis.

Table 5-1 Acres by Pasture

Pasture	Total Acres	Analyzed Acres	Excluded Acres
Mexican Water NE	14,175.35	11,565.07	2,610.28
Mexican Water NW	85,535.71	65,602.24	17,933.47
Mexican Water SE	23,211.11	23,064.24	146.87
Mexican Water SW	33,133.25	30,492.38	2,640.87
John Paul RMU East	6,319.34	6,319.34	0
John Paul RMU West	3,603.38	3,593.31	10.07
Rock Point North	20,812.68	20,665.88	146.80
Rock Point Middle	29,759.76	29,602.86	156.90
Rock Point South	93,510.77	82,942.73	10,568.04
Tohta sa Conni RMU East	4,043.11	4,042.69	0.42
Tohta sa Conni RMU West	4,227.00	4,122.59	104.41
Sweetwater	134,982.91	118,338.47	16,644.44
Dick Thomas RMU	5,045.04	3,728.60	1,316.44
Total	**456,359.41**	**404,080.40**	**52,279.01**

Despite the fact that large areas of rock outcrop were excluded from the study area the results are still indicative of declining forage availability in the District 9 rangelands. Initial carrying capacities, even before adjusting for steep slopes or distance to water, are well below current permits.

Table 5-2 Carrying Capacity by Community

	Mexican Water	Rock Point	Sweetwater
Unadjusted Carrying Capacity (including RMUs)	76.88	568.26	878.75
Currently permitted Sheep Units Year Long	2,722	3,467	3,854

5.1 Description of Results by Community

The results of this study have been broken down into the following categories: carrying capacity, stocking rates, similarity indices, available forage, ground cover, and species frequency. We first present a short discussion of the categories as they apply to each of the communities in order to present an overall picture of prevailing conditions. Following this is a more detailed analysis of the results as they apply to individual pastures.

5.1.1 Initial Stocking Rates and Carrying Capacity

The initial stocking rate and carrying capacities were calculated by percentage of ecological site within each soil map unit within each community. The calculations for carrying capacity are run in a GIS model of percentage each soil component of each soil map unit within each analysis area. Soil map units that did not have any transects were not included in the GIS analysis. 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 community. In these situations, it may be necessary to gather additional data prior to adjusting animal numbers. As a reminder, stocking rates and carrying capacity were not calculated by pasture. In order to include as many ecological sites as possible, stocking rates were calculated by ecological sites in each community and were then applied to the ecological sites in each pasture within a community.

Forage production is low across all three communities, but the Sweetwater community is in the best shape. In the Mexican Water and Rock Point communities, an average of 4,300 acres is needed to produce 790 pounds of forage per month, compared to about 1,600 in Rock Point and about 770 acres in the Sweetwater community.

5.2 Similarity Index

Similarity indices are only possible for those ecological sites with developed ecological site descriptions. Similarity index values are low throughout the project area, although some analysis areas (such as the Mexican Water NW pasture) do have a maximum value close to 50 percent. These values are meant to be used as a management tool and do not factor into stocking rate and carrying capacity. For example, a given ecological site may be producing over 2,000 pounds of *Pleuraphis jamesii* (galleta grass) and *Sporobolus Airoides* (alkali sacaton). These two grasses are considered to be “available forage” and all of this weight would be factored into the stocking rate and carrying capacity calculations. As a result, both the stocking rate and the carrying capacity would be relatively high. However, the reference plant community in the ecological site description may only be comprised of a small percentage of the two aforementioned grass species. This would likely result in a low similarity index. In this case, it becomes a management decision as to whether or not it is more beneficial to manage for the current, high producing plant community or to try and establish a plant assemblage more similar to the reference community. The benefit of the reference community is that it is typically comprised of the suite of species best adapted to the area and reflects healthy, functioning rangeland. In most cases, production and similarity indices are both low, so although it may not be desirable to try and achieve a similarity index of 100 percent, managing for increased similarity indices would likely improve range conditions and result in more forage availability for livestock at the same time.

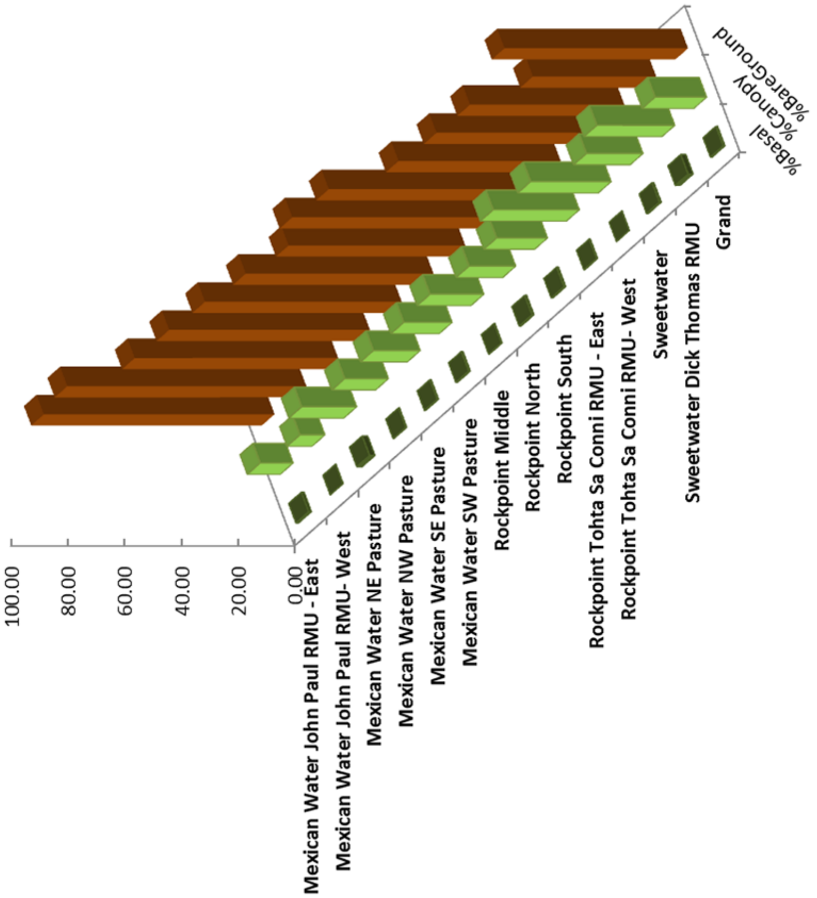
5.3 Available Forage Production

Available forage is the portion of the total reconstructed production classified as preferred, desirable, and emergency forage. It is this quantity that is used to calculate stocking rates. Consistent with the initial stocking rates generated in each community, Mexican Water had the lowest overall available forage production (averaging 2 lbs/acre) while the Sweetwater community had the highest (averaging 14.5 lbs/acre). In the available forage tables associated with individual pastures, these figures are compared with the production expected for the reference plant community for each ecological site and the average reconstructed production calculated from the collected biomass data. In addition, each table presents the acres associated with each ecological site, and the number of acres needed to support one sheep unit for one year (Acres/SUYL). The sheep unit year long numbers are based off of an AUM of 790 pounds rather than the more conservative AUM of 912.5 pounds.

5.4 Ground Cover

Ground cover values provide a baseline for determining trend in future studies. An average of all ground cover data for the project area in District 9 is included for comparison (Figure 5-1). The most represented ground cover category across the project area is bare ground. The next category is canopy cover, but on average bare ground more than doubles the percent of canopy cover. The Mexican Water community has the highest percent of bare ground followed closely by Rock Point. The lowest percentage of bare ground was found in the Sweetwater community, especially in the Dick Thomas RMU. The east and west pastures in the John Paul RMU in the Mexican Water community have the highest percentage of bare ground and the lowest percentage of canopy cover.

Figure 5-1 Point Intercept Results by Pasture



Note: The Figure includes the following acronyms—Range Management Unit (RMU) and percent (%).

5.5 Frequency and Composition

The five, most common species recorded on transects in each analysis area are presented here with forage value information (an explanation of forage values is found in Section 4.2.5: Calculating Available Forage.) The Individual species frequency data (by the ten plots within each transect) are included in the electronic data with this report. Composition is reported by the total amount of reconstructed production of each species in the analysis area. Several species are repeatedly found in the top five across most pastures, these include *Salsola tragus* (prickly Russian thistle), *Ephedra cutleri* (Cutler's jointfir), *Achnatherum hymenoides* (Indian ricegrass), *Gutierrezia sarothrae* (broom snakeweed), and *Pleuraphis jamesii* (galleta grass).

5.6 Mexican Water

Highways 160 and 191 intersect the Mexican Water community, creating four pastures. In the northeast pasture there were 27 transects, 126 transects in the northwest pasture, and 36 and 37 transects in the southeast and southwest pastures, respectively. In the southern region of the Mexican Water Chapter boundary, there are also two pastures located within the John Paul RMU; John Paul West (8 transects) and John Paul East (9 transects). Stocking rates were calculated by the entire Mexican Water community and applied to each pasture, in order to include more data from each ecological site. Maximum and minimum stocking rates are shown in Table 5-3. Table 5-4 shows the ecological sites that contained transects in Mexican Water, the production associated with the reference state for those ecological sites, average reconstructed production derived from transect data, average available forage, and stocking rates associated with each sampled ecological site. For each pasture and RMU there is a table showing carrying capacity and acres of each ecological site, including those without transects.

Table 5-3 Initial Maximum and Minimum Stocking Rates in Mexican Water Community

Analysis Area	Stocking Rate Minimum (Acres/SUYL)	Ecological Site with Minimum Stocking Rate	Stocking Rate Maximum (Acres/SUYL)	Ecological Site with Maximum Stocking Rate
Mexican Water	54,098.64	R035XY130UT Desert Shallow Sandy Loam (Shadscale) (1 Transect)	296.24	R035XB219AZ Sandy Loam Upland 6-10" p.z. (1 Transect)

The reconstructed production includes all plants in the sample; the available forage includes only the preferred, desirable, and emergency forage that is available during the most limiting season of use (usually winter). The average available forage in Mexican Water ranges between zero and eight pounds per acre. The upland ecological sites are generally more productive than the desert sites.

Table 5-4 Mexican Water Available Forage by Sampled Ecological Site

Ecological Site	Number of Transects	Total Production in Reference State pounds/Acre	Average Reconstructed Production pounds/Acre	Average Available Forage Per Acre pounds/Acre	Acres/SUYL
10% of UT643 RO	7	N/A	71.65	1.14	2,079.40
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	1	342.00	25.62	0.98	2,419.79
R035XB215AZ Sandstone Upland 6-10" p.z.	1	345.00	30.45	3.02	785.65
R035XB216AZ Sandy Bottom 6-10" p.z.	3	900.00	90.55	6.25	379.39
R035XB217AZ Sandy Upland 6-10" p.z.	42	439.81	90.02	3.20	741.31
R035XB219AZ Sandy Loam Upland 6-10" p.z.	1	663.00	66.55	8.00	296.24
R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic	4	362.00	85.64	4.31	549.83
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	3	N/A	61.81	3.78	627.26
R035XB230AZ Sandstone Upland 6-10" p.z. Calcareous	16	216.00	58.04	0.71	3,315.44
R035XB234AZ Shallow Sandy Loam 6-10" p.z.	8	319.38	59.74	1.43	1,655.03
R035XB235AZ Sandy Loam Upland 6-10" p.z.	33	384.15	83.13	1.61	1,474.73
R035XB236AZ Stony Slopes 6-10" p.z.	3	273.00	73.93	1.06	2,241.27
R035XB237AZ Clay Loam Terrace 6-10" p.z.	6	490.00	118.53	1.11	2,128.80
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	9	500.00	217.10	2.01	1,179.21
R035XY009UT Alkali Flat (Greasewood)	3	526.67	118.20	0.74	3,204.40
R035XY012UT Semiwet Saline Streambank	1	1,314.00	108.00	0.06	42,173.46
R035XY115UT Desert Sand (Sand Sagebrush)	10	304.10	106.41	0.85	2,799.86
R035XY121UT Desert Sandy Loam (Blackbrush)	58	264.00	52.00	1.01	2,351.53
R035XY130UT Desert Shallow Sandy Loam (Shadscale)	3	220.00	200.59	0.04	54,098.64
R035XY133UT Desert Shallow Sandy Loam (Blackbrush)	3	220.00	275.65	2.83	838.34
Rock Outcrop	8	N/A	10.14	0.16	14,909.61
ESD Unavailable/Unassigned	21	352.20	37.93	0.68	3,504.92
No ESID (No soil map unit correlation to ESD)	1	N/A	165.94	0.00	0.00

5.6.1 Mexican Water Northeast

The initial carrying capacity for Mexican Water northeast pasture is 8.39 SUYL. The majority of transects are located within the Sandy Loam Upland (R035XB235AZ) and Desert Sandy Loam (R035XY121UT) ecological sites. Available forage is quite low for both sites and the acreage needed to support a sheep unit per year is high. However, as each site occupies about 4,000 acres within the analysis unit, carrying capacities are higher than most other ecological sites within this pasture. A few ecological sites are currently not capable of supporting livestock based upon the stocking rate and total acreage for each site. Nevertheless, as these sites make up such a small percentage of the pasture, it would not be advisable to manage for them on an individual basis at the pasture level. Overall, available forage needs to be increased in order to be able to increase stocking rates and subsequently improve carrying capacity.

Table 5-5 Stocking Rates and Carrying Capacity Applied to Mexican Water Northeast

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
10% of UT643 RO	0	14.2	0.001	2,079.40	0.01
Rock Outcrop	0	421.09	0.02	14,909.61	0.03
Badland	0	892.18	6.29	N/A	N/A
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	1	244.18	1.72	2,419.79	0.10
R035XB217AZ Sandy Upland 6-10" p.z.	3	1,782.85	12.58	741.31	2.40
R035XB224AZ Clayey Slopes 6-10" p.z. Bouldery	0	332.91	2.35	N/A	N/A
R035XB227AZ Sandy Loam Upland 6-10" p.z.	0	391.48	2.76	549.83	0.71
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	0	213.54	1.51	627.26	0.34
R035XB230AZ Sandstone Upland 6-10" p.z.	1	346.03	2.44	3,315.44	0.10
R035XB234AZ Shallow Sandy Loam 6-10” p.z.	0	3.57	0.03	1,655.03	0.00
R035XB235AZ Sandy Loam Upland 6-10" p.z.	9	4,084.78	28.82	1,474.73	2.77
R035XB236AZ Stony Slopes 6-10" p.z.	1	618.27	4.36	2,241.27	0.28
R035XY109UT Desert Loam (Shadscale)	0	669.13	4.72	N/A	N/A
R035XY115UT Desert Sand (Sand Sagebrush)	0	46.73	0.33	2,799.86	0.02
R035XY118UT Desert Sandy Loam (Fourwing Saltbush)	0	10.38	0.07	N/A	N/A
R035XY121UT Desert Sandy Loam	9	3,819.44	26.94	2351.53	1.62
R035XY130UT Desert Shallow Sandy Loam (Shadscale)	0	284.59	2.01	54,098.64	0.01
Ecological Site Unassigned/Unavailable	3	N/A	3.07	3,504.92	N/A

Similarity indices are very low for all ecological sites found within the northeast pasture. Reconstructed weights were close to the production expected from the representative states for the Sandy Loam Upland (R035XB235AZ) and Desert Sandy Loam (R035XY121UT) sites, but only a small fraction of these weights were "allowable." A more detailed look at the vegetation communities present in this pasture can be found in the species frequency/composition tables and corresponding discussion.

Table 5-6 Similarity Index for Mexican Water Northeast

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Mexican Water NE Pasture	12.18%	0.98%	4.85%

It is not surprising to see that the percent of bare ground is high in this pasture given its low production values. What is somewhat striking, is that even though percent bare ground is higher than any other pasture, with the exception of the two John Paul RMUs, the percent of canopy cover is also the highest. This is probably due to the prevalence of *Coleogyne ramosissima* (blackbrush) and *Salsola tragus* (prickly Russian thistle) which do not produce much litter, except for in localized accumulations such as along fence lines, in the case of *Salsola tragus* (prickly Russian thistle). The percent of basal hits, while low, is also higher than any other pasture or RMU in this community. Virtually all basal hits were for *Coleogyne ramosissima* (blackbrush).

Table 5-7 Point Intercept Cover Results for Mexican Water Northeast

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Mexican Water NE Pasture	19.33	71.70	1.85

The percent frequency of occurrence is an important number as it provides an idea of the distribution of a species across a given area. Table 5-8 displays the top five most frequently occurring species in the northeast pasture. Two forage grasses, *Achnatherum hymenoides* (Indian ricegrass) and *Pleuraphis jamesii* (galleta grass), were found in over 50 percent of the transects. *Ephedra cutleri* (Cutler's jointfir) was found in over 80 percent of the transects. This plant typically only makes up a small portion of the representative plant communities associated with the ecological sites in this pasture, but it is considered to be a desirable forage for sheep. Along with frequency, it is useful to know how much biomass or weight is being produced by a given plant species. Based upon reconstructed weights, (Table 5-9) displays the top five contributors of biomass to the total production in Mexican Water northeast pasture. All species with the exception of *Ericameria nauseosa* (rubber rabbitbrush) are also among the five most frequently occurring species. The large size of this shrub accounts for its high production even though it was infrequently encountered during the survey. Conversely, *Achnatherum hymenoides*

(Indian ricegrass) is an abundant species throughout the pasture, but did not contribute a substantial portion to the overall production of the pasture. The majority of the production comes from *Coleogyne ramosissima* (blackbrush) and *Salsola tragus* (prickly Russian thistle).

Table 5-8 Mexican Water Northeast Pasture Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Coleogyne ramosissima	23	85.19%	Shrub	Perennial	N	Non Consumed
Ephedra cutleri	22	81.48%	Shrub	Perennial	N	Desirable
Salsola tragus	21	77.78%	Forb	Annual	I	Injurious
Achnatherum hymenoides	17	62.96%	Graminoid	Perennial	N	Desirable
Pleuraphis jamesii	15	55.56%	Graminoid	Perennial	N	Emergency

Table 5-9 Mexican Water Northeast Pasture Species Composition by Weight

Species	Total Reconstructed Weight (lbs/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Coleogyne ramosissima	325.79	33.05%	Shrub	Perennial	N	Non Consumed
Salsola tragus	297.44	30.17%	Forb	Annual	I	Injurious
Ericameria nauseosa	149.51	15.17%	Shrub	Perennial	N	Non Consumed
Ephedra cutleri	66.36	6.73%	Shrub	Perennial	N	Desirable
Pleuraphis jamesii	36.81	3.73%	Graminoid	Perennial	N	Emergency

5.6.2 Mexican Water Northwest

The initial carrying capacity for Mexican Water northwest pasture is 22.97 SUYL. Nearly 40 percent of all the transects in this pasture are in the Desert Sandy Loam (R035XY121UT) ecological site which makes up almost 17 percent of the total area. Available forage in this ecological site is one pound/acre and almost 2,300 acres are needed to support one sheep one for one year. The lowest number of acres needed to support one sheep unit (296.24) is associated with the Sandy Loam Upland (R035XB219AZ) ecological site which also has the highest available forage in Mexican Water, but this ecological site comprises less than two percent of the total area. The amount of available forage in every ecological site is very low.

Table 5-10 Stocking Rates and Carrying Capacity Applied to Mexican Water Northwest

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
10% of UT643 RO	7	2,636.97	31.5	2,078.95	1.27
Rock Outcrop	7	29,105	6.4	14,909.61	1.95
Badland	0	305.58	0.37	N/A	N/A
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	0	9.41	0.01	2,419.79	0.00
R035XB216AZ Sandy Bottom 6-10" p.z.	2	452.99	0.54	379.39	1.19
R035XB217AZ Sandy Upland 6-10" p.z.	4	1,513.69	1.81	741.31	2.04
R035XB219AZ Sandy Loam Upland 6-10" p.z.	0	44.24	0.05	296.24	0.15
R035XB222AZ Sandy Terrace 6-10" p.z.	0	87.79	0.11	N/A	N/A
R035XB224AZ Clayey Slopes 6-10" p.z. Bouldery	0	125.61	0.15	N/A	N/A
R035XB227AZ Sandy Loam Upland 6-10" p.z.	0	778.36	0.93	549.83	1.42
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	3	424.56	0.51	627.26	0.68
R035XB230AZ Sandstone Upland 6-10" p.z.	3	2,384.80	2.85	3,315.44	0.72
R035XB234AZ Shallow Sandy Loam 6-10” p.z.	2	627.77	0.75	1,655.03	0.38
R035XB235AZ Sandy Loam Upland 6-10" p.z.	8	2,014.96	2.41	1,474.73	1.37
R035XB236AZ Stony Slopes 6-10" p.z.	2	233.27	0.28	2,241.27	0.10
R035XB237AZ Clay Loam Terrace 6-10" p.z.	1	111.36	0.13	2,128.80	0.05
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	4	1,436.42	1.72	1,179.21	1.22
R035XY009UT Alkali Flat (Greasewood)	3	843.93	1.01	3,204.40	0.26
R035XY012UT Semiwet Saline Streambank	1	570.18	0.68	42,173.46	0.01
R035XY109UT Desert Loam (Shadscale)	0	229.19	0.27	N/A	N/A
R035XY115UT Desert Sand (Sand Sagebrush)	10	7,259.77	8.67	2,799.86	2.59
R035XY121UT Desert Sandy Loam	49	14,106.48	16.85	2,351.53	6.00
R035XY130UT Desert Shallow Sandy Loam (Shadscale)	1	16,753.70	20.01	54,098.64	0.31
R035XY133UT Desert Shallow Sandy Loam	3	1,048.08	1.25	838.34	1.25
Water	0	9.41	0.01	2,419.79	0.00
Ecological Site Unassigned/Unavailable	16	N/A	N/A	3,504.92	N/A
No ESID	0	312.84	0.37	N/A	N/A

Plant communities that ranged from 30-57 percent similar to the reference community were almost all associated with transects found within the Desert Sandy Loam (R035XY121UT) ecological site, which is also the most common site in the pasture. The representative plant community produces 260 pounds of biomass annually and is characterized by a *Coleogyne ramosissima* (blackbrush) canopy with numerous forb and grass species in the shrub interspace. This community is also highly variable and a large variety of grass, forb, and shrub species are considered to be “allowable” when calculating the similarity index. In this pasture, the higher similarity index values were primarily driven by the presence of *Coleogyne ramosissima* (blackbrush). Transects with a similarity index of less than five ranged across many ecological sites, but the majority also fell within the Desert Sandy Loam (R035XY121UT) ecological site. These transects contained a lot of species found within the reference community, but total production was extremely low.

Table 5-11 Similarity Index for Mexican Water Northwest

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Mexican Water NW Pasture	56.72%	0.00%	6.51%

The percentage of bare ground and canopy cover are very similar to that found in the Mexican Water northeast pasture. Forbs and shrubs are more dominant than grasses in this pasture and a few transects did not contain any plant species. This fact combined with a prevalence of low producing sites like rock outcrops, sandstone uplands, and stony slopes is one of the main factors behind the high percentage of bare ground. Efforts to increase forage production and reduce bare ground would do well to focus on ecological sites that have the potential to produce moderate to high yielding stands of forage species, but that are currently dominated by species less palatable and less capable of producing adequate ground cover. One example is the Sandy Upland (R035XB217AZ) site which has the potential to produce over 400 pounds of biomass, mostly coming from perennial grasses. Currently, production is comes mostly from *Ephedra cutleri* (Cutler’s jointfir), *Ericameria nauseosa* (rubber rabbitbrush), *Salsola tragus* (prickly Russian thistle), and *Gutierrezia sarothrae* (broom snakeweed).

Table 5-12 Point Intercept Cover Results for Mexican Water Northwest

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Mexican Water NW Pasture	15.36	70.75	0.25

The majority of transects in this pasture fall within an ecological site that is typically dominated by shrub species, especially *Coleogyne ramosissima* (blackbrush). This is reflected in the results which found *Coleogyne ramosissima* (blackbrush) to be the most frequently occurring species and one of the highest producers of biomass (Tables 5-13 and 5-14). *Gutierrezia sarothrae* (broom snakeweed) is another shrub that is both widely distributed and a major contributor to biomass. This ecological site (Desert Sandy Loam R035XY121UT) is known to move away from the reference state when disturbed by way of climate fluctuations and livestock grazing. The most common result observed is the presence of invasive forb and grass species. Only one transect recorded the invasive grass *Bromus tectorum* (cheatgrass), but the invasive forb *Salsola tragus* (prickly Russian thistle) is prevalent throughout the pasture. The forage grasses *Achnatherum hymenoides* (Indian ricegrass) and *Pleuraphis jamesii* (galleta grass) are both well distributed in the pasture, but the species still do not occur often enough to produce adequate forage for livestock.

Table 5-13 Mexican Water Northwest Pasture Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Coleogyne ramosissima	83	65.87%	Shrub	Perennial	N	Non Consumed
Achnatherum hymenoides	74	58.73%	Graminoid	Perennial	N	Desirable
Salsola tragus	72	57.14%	Forb	Annual	I	Injurious
Gutierrezia sarothrae	64	50.79%	Shrub	Perennial	N	Toxic
Pleuraphis jamesii	50	39.68%	Graminoid	Perennial	N	Emergency

Table 5-14 Mexican Water Northwest Pasture Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	1919.87	20.49%	Forb	Annual	I	Injurious
Coleogyne ramosissima	1536.43	16.40%	Shrub	Perennial	N	Non Consumed
Gutierrezia sarothrae	1022.03	10.91%	Shrub	Perennial	N	Toxic
Ericameria nauseosa	756.33	8.07%	Shrub	Perennial	N	Non Consumed
Sarcobatus vermiculatus	733.70	7.83%	Shrub	Perennial	N	Non Consumed

5.6.3 Mexican Water Southeast

The initial carrying capacity for Mexican Water southeast pasture is 19.59 SUYL. The majority of transects in this pasture are in the Sandy Upland (R035XB217AZ) ecological site. This site has the highest carrying capacity and fewer acres are needed to support a sheep unit when compared to most other sites within the pasture. Although no transects landed in the Sandy Bottom (R035XB216AZ) site in this pasture, the overall community results suggest that pounds of available forage are much higher than in all other sites. However, as this site only occupies 180 acres, the carrying capacity is quite low. As with all pastures in the Mexican Water community, livestock production cannot continue in a reasonable fashion without efforts to increase available forage.

Table 5-15 Stocking Rates and Carrying Capacity Applied to Mexican Water Southeast

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
R035XB201AZ Mudstone/Sandstone Hills 6-10"	0	86.55	0.37	2,419.79	0.04
R035XB215AZ Sandstone Upland 6-10" p.z	1	174.99	0.75	785.65	0.22
R035XB216AZ Sandy Bottom 6-10" p.z.	0	181.45	0.78	379.39	0.48
R035XB217AZ Sandy Upland 6-10" p.z.	17	9,414.87	40.56	741.31	12.70
R035XB219AZ Sandy Loam Upland 6-10" p.z.	1	355.67	1.53	296.24	1.20
R035XB222AZ Sandy Terrace 6-10" p.z.	0	25.90	0.11	N/A	N/A
R035XB227AZ Sandy Loam Upland 6-10" p.z.	1	293.09	1.26	549.83	0.53
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	0	32.29	0.14	627.26	0.05
R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane	0	0.67	0.00	627.26	0.00
R035XB230AZ Sandstone Upland 6-10" p.z.	2	3,323.79	14.32	3,315.44	1.00
R035XB234AZ Shallow Sandy Loam 6-10" p.z.	4	1,493.94	6.44	1,655.03	0.90
R035XB235AZ Sandy Loam Upland 6-10" p.z.	6	1,670.96	7.20	1,474.73	1.13
R035XB237AZ Clay Loam Terrace 6-10" p.z.	0	50.02	0.22	2,128.80	0.02
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	2	1,159.78	5.00	1,179.21	0.98
Rock Outcrop	0	4,826.17	20.79	14,909.61	0.32
Ecological Site Unassigned/Unavailable	1	N/A	N/A	3,504.92	N/A
No ESID	1	120.97	0.52	N/A	N/A

The maximum similarity index came from a transect within the Sandy Terrace (R035XB238AZ) ecological site. This site is characterized by perennial grasses and *Sarcobatus vermiculatus* (black greasewood). The fairly high similarity index was the result of high *Sarcobatus vermiculatus* (black greasewood) production. No perennial grasses were present on the transect. The next highest index was 29.8 percent and most other transects had an index of around 10 percent or less. All transects in the dominant R035XB217AZ site have an index below 10 percent. In its reference state, the plant community will be comprised mostly of perennial warm and cool season grasses with a moderate amount of sub-shrubs and forbs. Continuous grazing leads to reduced bunchgrasses, increases in less palatable sodgrasses, like *Pleuraphis jamesii* (galleta grass), and increases in shrub species such as *Gutierrezia sarothrae* (broom snakeweed), *Ericameria nauseosa* (rubber rabbitbrush), and *Ephedra* species (jointfir).

Table 5-16 Similarity Index for Mexican Water Southeast

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Mexican Water SE Pasture	45.14%	2.00%	6.95%

The percentage of bare ground in the southeast pasture is less than in the northwest and northeast pastures, but is still high. The lower number is probably due to the higher incidence of sod forming species such as *Pleuraphis jamesii* (galleta grass) and *Bouteloua gracilis* (blue grama).

Table 5-17 Point Intercept Cover Results for Mexican Water Southeast

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Mexican Water SE Pasture	16.46	69.31	0.40

The invasive forb, *Salsola tragus* (prickly Russian thistle) is a common plant in the pasture and is the top producer of biomass. The only grass species on in either Table 5-18 or 5-19, is *Achnatherum hymenoides* (Indian ricegrass). This grass is widely distributed throughout the pasture, but does not contribute much too overall biomass production. *Sarcobatus vermiculatus* (black greasewood) is locally abundant in portions of the pasture, mostly within the Sandy Terrace (R035XB238AZ) ecological site. *Gutierrezia sarothrae* (broom snakeweed) and *Ephedra cutleri* (Cutler's jointfir) are widespread and contribute much of the biomass in the pasture.

Table 5-18 Mexican Water Southeast Pasture Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	33	91.67%	Forb	Annual	I	Injurious
Achnatherum hymenoides	31	86.11%	Graminoid	Perennial	N	Desirable
Ephedra cutleri	23	63.89%	Shrub	Perennial	N	Desirable
Gutierrezia sarothrae	19	52.78%	Shrub	Perennial	N	Toxic
Ericameria nauseosa	14	38.89%	Shrub	Perennial	N	Non Consumed

Table 5-19 Mexican Water Southeast Pasture Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	1009.11	25.43%	Forb	Annual	I	Injurious
Sarcobatus vermiculatus	949.90	23.94%	Shrub	Perennial	N	Non Consumed
Gutierrezia sarothrae	319.59	8.06%	Shrub	Perennial	N	Toxic
Coleogyne ramosissima	248.46	6.26%	Shrub	Perennial	N	Non Consumed
Ephedra cutleri	215.06	5.42%	Shrub	Perennial	N	Desirable

5.6.4 Mexican Water Southwest

The initial carrying capacity for Mexican Water southwest pasture is 15.39 SUYL. The dominant ecological sites in the southwest pasture are Rock Outcrop, Sandy Upland (R035XB217AZ), Sandstone Upland (R035XB230AZ), and Sandy Loam Upland (R035XB235AZ). Ecological sites without transects only make up about one percent of the pasture. Carrying capacity is low throughout and the better stocking rates, relatively speaking, are associated with poorly represented ecological sites.

Table 5-20 Stocking Rates and Carrying Capacity Applied to Mexican Water Southwest

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
R035XB201AZ Mudstone/Sandstone Hills 6-	0	23.22	0.07	2,419.79	0.01
R035XB216AZ Sandy Bottom 6-10” p.z.	1	584.36	1.76	379.39	1.54
R035XB217AZ Sandy Upland 6-10” p.z.	9	4,882.55	14.74	741.31	6.59
R035XB219AZ Sandy Loam Upland 6-10” p.z.	0	2.30	0.00	296.24	0.01
R035XB222AZ Sandy Terrace 6-10” p.z.	0	42.05	0.13	N/A	N/A
R035XB227AZ Sandy Loam Upland 6-10” p.z.	0	297.04	0.90	549.83	0.54
R035XB230AZ Sandstone Upland 6-10” p.z.	10	8,017.40	24.20	3,315.44	2.42
R035XB234AZ Shallow Sandy Loam 6-10” p.z.	2	973.03	2.94	1,655.03	0.59
R035XB235AZ Sandy Loam Upland 6-10” p.z.	9	2,864.21	8.65	1,474.73	1.94
R035XB237AZ Clay Loam Terrace 6-10” p.z.	4	1,395.16	4.21	2,128.80	0.66
R035XB238AZ Sandy Terrace 6-10” p.z. Sodic	1	428.67	1.29	1,179.21	0.36
R035XB255AZ Sandstone Rockland 6-10” p.z.	0	12.39	0.04	N/A	N/A
R035XB260AZ Sand Dunes 6-10” p.z.	0	57.84	0.18	N/A	N/A
Rock Outcrop	1	11,024.44	33.27	14,909.61	0.74
No ESID	0	2528.59	7.63	N/A	N/A

The highest similarity numbers came primarily from transects in the Sandstone Upland (R035XB230AZ) and Sandy Loam Upland (R035XB235AZ) ecological sites. The Sandstone Upland (R035XB230AZ) reference community is made up primarily of warm and cool season grasses, shrubs and a light pinyon-juniper overstory. Continues grazing will lead to an increase in sod forming grasses like *Pleuraphis jamesii* (galleta grass) and *Bouteloua gracilis* (blue grama), and composite shrubs such as *Gutierrezia sarothrae* (broom snakeweed) and *Artemisia bigelovii* (Bigelow sagebrush). The similarity scores were driven primarily by *Achnatherum hymenoides* (Indian ricegrass) and *Coleogyne ramosissima* (blackbrush). The reference community for the Sandy Loam Upland (R035XB235AZ) ecological site is characterized by *Coleogyne ramosissima* (blackbrush) and mixed, perennial grasses. *Achnatherum hymenoides* (Indian ricegrass), *Pleuraphis jamesii* (galleta grass), and *Coleogyne ramosissima* (blackbrush) are the main species contributing to the similarity scores.

Table 5-21 Similarity Index for Mexican Water Southwest

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Mexican Water SW Pasture	31.31%	0.00%	6.46%

One desirable grass, *Achnatherum hymenoides* (Indian ricegrass), occurs often in this pasture, but does not contribute very much biomass. The most abundant species in this pasture are a mix of shrubs and *Salsola tragus* (prickly Russian thistle). *Quercus turbinella* (Sonoran scrub oak) is among the top five species for production, but only occurs on four transects in the entire pasture.

Table 5-22 Mexican Water Southwest Pasture Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	27	72.97%	Forb	Annual	I	Injurious
Coleogyne ramosissima	24	64.86%	Shrub	Perennial	N	Non Consumed
Achnatherum hymenoides	22	59.46%	Graminoid	Perennial	N	Desirable
Gutierrezia sarothrae	21	56.76%	Shrub	Perennial	N	Toxic
Ephedra cutleri	16	43.24%	Shrub	Perennial	N	Desirable
Ericameria nauseosa	16	43.24%	Shrub	Perennial	N	Non Consumed

Table 5-23 Mexican Water Southwest Pasture Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Ericameria nauseosa	871.53	23.83%	Shrub	Perennial	N	Non Consumed
Coleogyne ramosissima	843.66	23.06%	Shrub	Perennial	N	Non Consumed
Salsola tragus	368.31	10.07%	Forb	Annual	I	Injurious
Gutierrezia sarothrae	288.43	7.89%	Shrub	Perennial	N	Toxic
Quercus turbinella	257.54	7.04%	Shrub	Perennial	N	Non Consumed

5.6.5 John Paul RMU

The initial carrying capacity for the John Paul RMU includes 7.70 SUYL in the east pasture and 2.84 SUYL in the west pasture. The John Paul RMU only contains nine transects in the eastern portion and eight transects in the western portion. All but one transects in the east pasture are in the Sandy Upland (R035XB217AZ) ecological site. This site makes up a little over 50 percent of the area and has the highest carrying capacity. The eight transects in the west pasture are scattered over numerous ecological sites and carrying capacities are very low. This is the smallest pasture in the Mexican Water community and contains only 3,600 acres.

Table 5-24 Stocking Rates and Carrying Capacity Applied to John Paul RMU East

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
R035XB215AZ Sandstone Upland 6-10" p.z.	0	248.00	3.93	785.65	0.32
R035XB217AZ Sandy Upland 6-10" p.z.	8	3514.72	55.62	741.31	4.74
R035XB219AZ Sandy Loam Upland 6-10" p.z.	0	48.31	0.76	296.24	0.16
R035XB227AZ Sandy Loam Upland 6-10" p.z.	1	1106.24	17.51	549.83	2.01
R035XB230AZ Sandstone Upland 6-10" p.z.	0	253.43	4.01	3,315.44	0.08
R035XB234AZ Shallow Sandy Loam 6-10” p.z.	0	80.17	1.27	1,655.03	0.05
R035XB235AZ Sandy Loam Upland 6-10" p.z.	0	89.41	1.42	1,474.73	0.06
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	0	276.56	4.38	1,179.21	0.23
Rock Outcrop	0	702.46	11.12	14,909.61	0.05

Table 5-25 Stocking Rates and Carrying Capacity Applied to John Paul RMU West

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Mexican Water Community Average)	Carrying Capacity (SUYL)
R035XB201AZ Mudstone/Sandstone Hills 6-	0	26.96	0.75	2,419.79	0.01
R035XB216AZ Sandy Bottom 6-10" p.z.	0	15.11	0.42	379.39	0.04
R035XB217AZ Sandy Upland 6-10" p.z.	1	401.86	11.15	741.31	0.54
R035XB219AZ Sandy Loam Upland 6-10" p.z.	0	102.63	2.85	296.24	0.35
R035XB227AZ Sandy Loam Upland 6-10" p.z.	2	653.36	18.13	549.83	1.19
R035XB230AZ Sandstone Upland 6-10" p.z.	0	364.80	10.12	3,315.44	0.11
R035XB235AZ Sandy Loam Upland 6-10" p.z.	1	98.80	2.74	1,474.73	0.07
R035XB237AZ Clay Loam Terrace 6-10" p.z.	1	277.63	7.71	2,128.80	0.13
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	2	371.21	10.30	1,179.21	0.31
Rock Outcrop	0	1,280.95	35.55	14,909.61	0.09
Ecological Site Unassigned/Unavailable	1	N/A	N/A	3,504.92	N/A
No ESID	0	10.07	0.28	N/A	N/A

Similarity indices in both the east and west portions of this RMU average below 10 percent. Many of the perennial grass species associated with the ecological site reference states are absent or diminished and shrubs that increase with disturbance, such as *Gutierrezia sarothrae* (broom snakeweed) and *Ericameria nauseosa* (rubber rabbitbrush) are dominant.

Table 5-26 Similarity Index for John Paul RMU

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Mexican Water John Paul RMU- East	11.81%	2.75%	5.81%
Mexican Water John Paul RMU- West	11.94%	0.71%	5.11%

The John Paul RMU has the highest percentage of bare ground and lowest percentage of canopy cover in all of the Mexican Water community. This is due in large part to the general lack of perennial grasses within the shrub interspaces. The dominant ecological site, especially in the eastern portion of the RMU, is Sandy Upland (R035XB217AZ). Grazing pressure within this site will typically be expressed by an increase in sod forming grasses and shrub species. The sod forming grass species are very good at covering exposed soil and reducing erosion, but continued year-long grazing, especially in late winter and early spring, will cause these species to decline and open up the area to invasion from less far less desirable species such as *Salsola tragus* (prickly Russian thistle). Additional aggravating factors, like drought, will result in many perennial species dropping out of the vegetation community and creating large areas of bare ground.

Table 5-27 Point Intercept Cover Results for John Paul RMU

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Mexican Water John Paul RMU—East	11.56	81.33	0.89
Mexican Water John Paul RMU—West	8.75	84.25	0.00

Several perennial grass species occurred frequently in the John Paul RMU and *Achnatherum hymenoides* (Indian ricegrass) even showed up as a top contributor of biomass in the east pasture and *Sporobolus airoides* (alkali sacaton) is a top producer in the west pasture. This is encouraging, but the overall production across the RMU is still very low and incapable of supporting many animals on an annual basis. Increasing production in the RMU will be difficult due to low average precipitation, but taking steps such as eliminating grazing during critical plant growth periods (late winter, early spring) will help reestablish key forage species.

Table 5-28 John Paul RMU Species Frequency

Pasture	Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
East	*Achnatherum hymenoides*	9	100.00%	Graminoid	Perennial	N	Desirable
East	*Ephedra cutleri*	9	100.00%	Shrub	Perennial	N	Desirable
East	*Eriogonum leptocladon*	8	88.89%	Subshrub	Perennial	N	Non Consumed
East	*Salsola tragus*	7	77.78%	Forb	Annual	I	Injurious
East	*Ericameria nauseosa*	6	66.67%	Shrub	Perennial	N	Non Consumed
East	*Gutierrezia sarothrae*	6	66.67%	Shrub	Perennial	N	Toxic
West	*Salsola tragus*	7	87.50%	Forb	Annual	I	Injurious
West	*Achnatherum hymenoides*	5	62.50%	Graminoid	Perennial	N	Desirable
West	*Hesperostipa neomexicana*	4	50.00%	Graminoid	Perennial	N	Desirable
West	*Sporobolus cryptandrus*	4	50.00%	Graminoid	Perennial	N	Non Consumed
West	*Atriplex obovata*	3	37.50%	Subshrub/Shrub	Perennial	N	Emergency
West	*Ericameria nauseosa*	3	37.50%	Shrub	Perennial	N	Non Consumed
West	*Gutierrezia sarothrae*	3	37.50%	Shrub	Perennial	N	Toxic
West	*Sarcobatus vermiculatus*	3	37.50%	Shrub	Perennial	N	Non Consumed
West	*Sporobolus airoides*	3	37.50%	Graminoid	Perennial	N	Emergency

Table 5-29 John Paul RMU Species Composition

Pasture	Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
East	*Eriogonum leptocladon*	61.43	14.18%	Subshrub	Perennial	N	Non Consumed
East	*Achnatherum hymenoides*	49.79	11.50%	Graminoid	Perennial	N	Desirable
East	*Yucca angustissima*	44.85	10.36%	Subshrub/Shrub	Perennial	N	Injurious
East	*Ephedra cutleri*	42.55	9.82%	Shrub	Perennial	N	Desirable
East	*Ericameria nauseosa*	41.70	9.63%	Shrub	Perennial	N	Non Consumed
West	*Salsola tragus*	139.46	31.72%	Forb	Annual	I	Injurious
West	*Ericameria nauseosa*	90.12	20.50%	Shrub	Perennial	N	Non Consumed
West	*Sporobolus airoides*	34.67	7.89%	Graminoid	Perennial	N	Emergency
West	*Sarcobatus vermiculatus*	33.77	7.68%	Shrub	Perennial	N	Non Consumed
West	*Atriplex obovata*	32.30	7.35%	Subshrub/Shrub	Perennial	N	Emergency

5.7 Rock Point

Rock Point is divided into three pastures by paved roads with right-of-way fencing that inhibits livestock crossing. Thirty-one transects were located in the north pasture, 44 in the middle pasture, and 153 in the south pasture. This community also has two pastures located within the Tohta Sa Conni RMU. The west pasture has six transects and the east pasture has seven transects.). Stocking rates were calculated by the entire Rock Point community and applied to each pasture, in order to include more data from each ecological site. Maximum and minimum stocking rates are shown in Table 5-30. Table 5-31 shows the ecological sites that contained transects in Rock Point, the production associated with the reference state for those ecological sites, average reconstructed production derived from transect data, average available forage, and stocking rates associated with each sampled ecological site. For each pasture and RMU there is a table showing carrying capacity and acres of each ecological site, including those without transects.

Table 5-30 Initial Maximum and Minimum Stocking Rates in Rock Point Community

Analysis Area	Stocking Rate Minimum (Acres/SUYL)	Ecological Site with Minimum Stocking Rate	Stocking Rate Maximum (Acres/SUYL)	Ecological Site with Maximum Stocking Rate
Rock Point	4836.73	R035XB239AZ Clayey Fan 6-10” p.z. (7 Transects)	81.17	R035XC315AZ Sandy Upland 10-14" p.z. (2 Transects)

The reconstructed production includes all plants in the sample; the available forage includes only the preferred, desirable, and emergency forage that is available during the most limiting season of use (usually winter). The average available forage in Rock Point ranges between zero and 29.20 pounds per acre. The Sandy Upland (R035XB217AZ) ecological site is one of the highest producing sites, contains the most transects, and covers more than 26,000 acres.

Table 5-31 Rock Point Available Forage by Sampled Ecological Site

Ecological Site	Number of Transects	Total Production in Reference State pounds/Acre	Average Reconstructed Production pounds/Acre	Average Available Forage Per Acre pounds/Acre	Acres/SUYL
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	5	342.00	56.99	2.71	874.49
R035XB210AZ Loamy Upland 6-10" p.z.	17	532.41	138.34	8.65	273.94
R035XB215AZ Sandstone Upland 6-10" p.z.	3	345.00	66.61	5.94	399.21
R035XB216AZ Sandy Bottom 6-10" p.z.	5	900.00	483.65	0.00	0.00
R035XB217AZ Sandy Upland 6-10" p.z.	79	445.82	118.96	9.21	257.26
R035XB219AZ Sandy Loam Upland 6-10" p.z.	63	663.00	133.65	11.17	212.17
R035XB222AZ Sandy Terrace 6-10" p.z.	5	459.80	171.59	1.25	1,898.52
R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic	3	362.00	69.55	8.36	283.48
R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane	4	274.00	175.65	10.47	226.45
R035XB237AZ Clay Loam Terrace 6-10" p.z.	10	490.00	135.43	3.96	598.81
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	18	500.00	321.40	1.67	1,420.12
R035XB239AZ Clayey Fan 6-10" p.z.	7	465.00	114.68	0.52	4,554.61
R035XB260AZ Sand Dunes 6-10" p.z.	6	443.00	186.91	1.54	1,541.96
R035XC315AZ Sandy Upland 10-14" p.z.	2	731.00	318.20	29.20	81.17
Rock Outcrop	1	N/A	126.48	15.40	153.95
ESD Unassigned/Unavailable	2	N/A	102.32	0.18	12,877.02
No ESID (No soil map unit correlation to ESD)	11	457.20	90.28	5.38	440.78

5.7.1 Rock Point North

The initial carrying capacity for the Rock Point north pasture is 87.86 SUYL. The Sandy Upland 6-10" p.z. (R035XB217AZ) ecological site occupies the largest area in this pasture and has the highest carrying capacity. The majority of the transects fall within this site. The Sandy Loam Upland (R035XB219AZ) ecological site also occupies a large part of the pasture and the carrying capacity is second only to Sandy Upland (R035XB217AZ) site. Areas of vegetation among rock outcrop sites also contribute heavily to the carrying capacity in this pasture, however the available forage is based on the community average of only one transect.

Table 5-32 Stocking Rates and Carrying Capacity Applied to Rock Point North

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Rock Point Community Average)	Carrying Capacity (SUYL)
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	1	216.08	1.04	874.49	0.25
R035XB215AZ Sandstone Upland 6-10" p.z.	0	583.88	2.81	399.21	1.46
R035XB216AZ Sandy Bottom 6-10" p.z.	0	13.95	0.07	0.00	N/A
R035XB217AZ Sandy Upland 6-10" p.z.	19	7,654.66	36.78	257.26	29.75
R035XB219AZ Sandy Loam Upland 6-10" p.z.	4	3,585.67	17.23	212.17	16.90
R035XB222AZ Sandy Terrace 6-10" p.z.	1	396.63	1.91	1,898.52	0.21
R035XB227AZ Sandy Loam Upland 6-10" p.z.	2	1,361.23	6.54	283.48	4.80
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	0	137.50	0.66	N/A	N/A
R035XB237AZ Clay Loam Terrace 6-10" p.z.	2	1,505.75	7.24	598.81	2.51
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	1	350.09	1.68	1,420.12	0.25
R035XB239AZ Clayey Fan 6-10" p.z.	0	117.39	0.56	4,554.61	0.03
Rock Outcrop	0	4,880.55	23.45	153.95	31.70
Ecological Site Unassigned/Unavailable	1	N/A	N/A	12,877.02	N/A
No ESID	0	9.30	0.05	N/A	N/A

Similarity index values are low across the pasture. Similar to what was observed in the Mexican Water community, the dominant ecological sites have departed from the reference state and we see an increase in less desirable shrub species like *Gutierrezia sarothrae* (broom snakeweed) and *Ericameria nauseosa* (rubber rabbitbrush), decreases in perennial bunchgrasses, and high numbers of the invasive forb, *Salsola tragus* (prickly Russian thistle). Certain members of the reference communities, such as *Achnatherum hymenoides* (Indian ricegrass) and *Ephedra cutleri* (Cutler’s jointfir) are present as well, but they either do not contribute much to production or the lack of additional reference species work to keep index values low throughout.

Table 5-33 Similarity Index for Rock Point North

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Rock Point North	16.45%	0.00%	7.34%

The Rock Point North pasture has both the highest amount of bare ground and the lowest percentage of canopy cover in the community. Given the prevalence of shrub species and exotic forbs, it is somewhat surprising to see the low canopy score. However, the correlating high percentage of bare ground indicates that the interspace between shrubs is largely barren and that the herbaceous plants are widely scattered.

Table 5-34 Point Intercept Cover Results for Rock Point North

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Rock Point North	16.39	72.19	0.65

The shrub species *Gutierrezia sarothrae* (broom snakeweed) is a native species that is expected to occur in the Rock Point region. However, it has now come to be a dominant species at the expense of other, more desirable species. The same is true for *Ephedra cutleri* (Cutler's jointfir). Two perennial grass species frequently occur in the pasture, but neither contributes greatly to production and *Sporobolus cryptandrus* (sand dropseed) has little forage value except when it is actively growing. However, the value of this grass should not be overlooked as ground cover. This species produces abundant, highly germinable seed and can therefore effectively compete against non-native exotics and quickly become established in areas lacking vegetation (Brisbin et al. 2013).

Table 5-35 Rock Point North Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	28	90.32%	Forb	Annual	I	Injurious
Achnatherum hymenoides	25	80.65%	Graminoid	Perennial	N	Desirable
Gutierrezia sarothrae	22	70.97%	Shrub	Perennial	N	Toxic
Sporobolus cryptandrus	22	70.97%	Graminoid	Perennial	N	Non Consumed
Ephedra cutleri	20	64.52%	Shrub	Perennial	N	Desirable

Table 5-36 Rock Point North Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Gutierrezia sarothrae	653.79	20.10%	Shrub	Perennial	N	Toxic
Salsola tragus	446.03	13.72%	Forb	Annual	I	Injurious
Ericameria nauseosa	265.47	8.16%	Shrub	Perennial	N	Non Consumed
Ephedra cutleri	251.19	7.72%	Shrub	Perennial	N	Desirable
Eriogonum leptocladon	248.56	7.64%	Subshrub	Perennial	N	Non Consumed

5.7.2 Rock Point Middle

The initial carrying capacity for the Rock Point middle pasture is 118.46 SUYL. The dominant ecological site in this pasture is Sandy Upland (R035XB217AZ). Much like the Rock Point North pasture, this site has the most transects and a high carrying capacity. The highest carrying capacity was reported for the Rock Outcrop site. However, this number was derived using the stocking rate applied to all Rock Outcrop areas in the entire Rock Point community. As there were no transects in this site within the Rock Point Middle pasture, this figure may not be accurate. Although not well represented, the Sandy Upland 10-14” (R035XC315AZ) ecological site has the highest stocking rate. The least performing sites all make up only a small component of the pasture with the exception of the Sandy Terrace (R035XB222AZ) site.

Table 5-37 Stocking Rates and Carrying Capacity Applied to Rock Point Middle

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Rock Point Community Average)	Carrying Capacity (SUYL)
F035XG134NM Gravelly-Woodland	0	3.87	0.01	N/A	N/A
R035XB201AZ Mudstone/Sandstone Hills 6-10"	1	129.95	0.44	874.49	0.15
R035XB210AZ Loamy Upland 6-10” p.z.	0	65.82	0.22	273.94	0.24
R035XB215AZ Sandstone Upland 6-10" p.z.	1	474.67	1.60	399.21	1.19
R035XB216AZ Sandy Bottom 6-10" p.z.	1	207.39	0.70	0.00	N/A
R035XB217AZ Sandy Upland 6-10" p.z.	19	10,452.12	35.12	257.26	40.63
R035XB219AZ Sandy Loam Upland 6-10" p.z.	6	2,891.13	9.72	212.17	13.63
R035XB222AZ Sandy Terrace 6-10” p.z.	3	1,475.09	4.96	1,898.52	0.78
R035XB227AZ Sandy Loam Upland 6-10" p.z.	0	72.99	0.25	283.48	0.26
R035XB229AZ Cobbly Slopes 6-10” p.z. Grazane	1	99.96	0.34	226.45	0.44
R035XB237AZ Clay Loam Terrace 6-10" p.z.	2	2,339.00	7.86	598.81	3.91
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	8	3,401.18	11.43	1,420.12	2.39
R035XB239AZ Clayey Fan 6-10” p.z.	0	7.41	0.03	4,554.61	0.00
R035XC315AZ Sandy Upland 10-14" p.z.	2	510.19	1.71	81.17	6.29
Rock Outcrop	0	7,475.96	25.12	153.95	48.56
No ESID	0	153.03	0.51	N/A	N/A

The highest similarity index values (> 25%) all come from the Sandy Terrace Sodic (R035XB238AZ) site. This reference community for this site is comprised of mid to short grasses with a dominant overstory of shrubs, especially *Sarcobatus vermiculatus* (black greasewood). Transect data shows that grass species were rarely encountered and that the similarity scores were driven almost exclusively by the high production of *Sarcobatus vermiculatus* (black greasewood). Initial deterioration of this site is marked by an increase in the aforementioned shrub as well as *Suaeda moquinii* (Torrey seepweed) and various annuals. This appears to be the current state of this ecological site. The dominant ecological site, Sandy Upland (R035XB217AZ), has scores ranging from over 20 percent to below 5 percent.

Table 5-38 Similarity Index for Rock Point Middle

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Rock Point Middle	48.14%	0.00%	10.50%

The percentage of bare ground in this pasture is high, but there is less bare ground than in the north pasture and there is more canopy cover. Shrubs and *Salsola tragus* (prickly Russian thistle) are the most prevalent plants, but ground cover also consist of bunchgrasses and sod forming grasses such as *Pleuraphis jamesii* (galleta grass).

Table 5-39 Point Intercept Cover Results for Rock Point Middle

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Rock Point Middle	18.93	62.28	0.19

A key indicator of degraded rangeland in this pasture is the abundance of *Salsola tragus* (prickly Russian thistle). *Sarcobatus vermiculatus* (black greasewood) has also increased beyond the reference state. *Achnatherum hymenoides* (Indian ricegrass) is widely distributed, but is rarely occurs enough to contribute substantially to forage production. *Pleuraphis jamesii* (galleta grass) on the other hand, occurs frequently and does produce a fair amount of biomass. This species is not as palatable as the cool season bunchgrasses, but it does provide forage and can form dense patches which helps reduce erosion.

Table 5-40 Rock Point Middle Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	44	100.00%	Forb	Annual	I	Injurious
Achnatherum hymenoides	31	70.45%	Graminoid	Perennial	N	Desirable
Ephedra cutleri	23	52.27%	Shrub	Perennial	N	Desirable
Pleuraphis jamesii	18	40.91%	Graminoid	Perennial	N	Emergency
Sporobolus cryptandrus	17	38.64%	Graminoid	Perennial	N	Non Consumed

Table 5-41 Rock Point Middle Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	2140.70	26.10%	Forb	Annual	I	Injurious
Sarcobatus vermiculatus	1858.28	22.65%	Shrub	Perennial	N	Non Consumed
Ephedra cutleri	865.78	10.55%	Shrub	Perennial	N	Desirable
Chrysothamnus greenei	471.36	5.75%	Shrub	Perennial	N	Emergency
Pleuraphis jamesii	310.30	3.78%	Graminoid	Perennial	N	Emergency

5.7.3 Rock Point South

The initial carrying capacity for the Rock Point south pasture is 324.54 SUYL. The Rock Point South pasture has the highest carrying capacities in the community, particularly in the Loamy Upland (R035XB210AZ), Sandy Upland (R035XB217AZ), and Sandy Loam Upland (R035XB219AZ) ecological sites. Together, they make up almost 80 percent of the pasture. The Sandy Bottom (R035XB216AZ) site has no production of available forage species which is typical of this site throughout the entire community. This site only makes up a small portion of this pasture and the community at large and is characterized by drainage bottoms with various grasses, shrubs, and *Populus fremontii* (Fremont cottonwood). These areas tend to see a lot of livestock use, especially when water is present. In their current state, they are dominated by *Tamarisk* species (salt cedar), *Ericameria nauseosa* (rubber rabbitbrush), and *Salsola tragus* (prickly Russian thistle).

Table 5-42 Stocking Rates and Carrying Capacity Applied to Rock Point South

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Rock Point Community Average)	Carrying Capacity (SUYL)
R035XB201AZ Mudstone/Sandstone Hills 6-10"	3	793.33	0.85	874.49	0.91
R035XB210AZ Loamy Upland 6-10" p.z.	17	11,486.27	12.28	273.94	41.93
R035XB215AZ Sandstone Upland 6-10" p.z.	1	767.04	0.82	399.21	1.92
R035XB216AZ Sandy Bottom 6-10" p.z.	4	1,209.76	1.29	0.00	N/A
R035XB217AZ Sandy Upland 6-10" p.z.	36	13,217.70	14.14	257.26	51.38
R035XB219AZ Sandy Loam Upland 6-10" p.z.	46	36,643.31	39.19	212.17	172.71
R035XB222AZ Sandy Terrace 6-10" p.z.	1	1,178.03	1.26	1,898.52	0.62
R035XB227AZ Sandy Loam Upland 6-10" p.z.	1	1,619.70	1.73	283.48	5.71
R035XB228AZ Sandstone Upland 6-10" p.z. Sodic	0	12.33	0.01	N/A	N/A
R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane	3	415.86	0.45	226.45	1.84
R035XB230AZ Sandstone Upland 6-10" p.z. Calcareous	0	418.47	0.45	N/A	N/A
R035XB237AZ Clay Loam Terrace 6-10" p.z.	6	2,812.92	3.01	598.81	4.70
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	9	3,243.80	3.47	1,420.12	2.28
R035XB239AZ Clayey Fan 6-10" p.z.	7	3,630.76	3.88	4,554.61	0.80
R035XB255AZ Sandstone Rockland 6-10" p.z.	0	418.47	0.45	N/A	N/A
R035XB260AZ Sand Dunes 6-10" p.z.	6	1,952.85	2.09	1541.96	1.27
Rock Outcrop	1	5,924.25	6.34	153.95	38.48
Ecological Site Unassigned/Unavailable	1	N/A	N/A	12,877.02	N/A
No ESID	11	7,765.92	8.31	N/A	N/A

As with the middle pasture, the highest similarity index values come from the Sandy Terrace Sodic (R035XB238AZ) site. Similarity scores were driven largely by the high production of *Sarcobatus vermiculatus* (black greasewood) and to a lesser extent, *Suaeda moquinii* (Torrey seepweed). Index values for the remaining ecological sites were variable and no clear patterns were discernible.

Table 5-43 Similarity Index for Rock Point South

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Rock Point South	48.21%	0.00%	6.10%

Ground cover results are typical for the Rock Point community with a lot of bare ground, diminished canopy cover, and infrequent basal counts. This pasture and much of the Rock Point community in general, is at a high risk for wind erosion due to the combination of bare ground, sandy soils, and a hot, dry, windy climate.

Table 5-44 Point Intercept Cover Results for Rock Point South

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Rock Point South	17.86	70.53	0.58

Three perennial grass species, *Pleuraphis jamesii* (galleta grass), *Achnatherum hymenoides* (Indian ricegrass), and *Sporobolus cryptandrus* (sand dropseed) occur frequently in this pasture. Two of these grasses, *Pleuraphis jamesii* (galleta grass) and *Achnatherum hymenoides* (Indian ricegrass), also contribute a lot of forage to overall production. This helps explain why stocking rates and carrying capacity were comparatively high in several ecological sites. *Sarcobatus vermiculatus* (black greasewood) does not occur that frequently, but does contribute a large portion of biomass. *Salsola tragus* (prickly Russian thistle) occurred in almost every transect and is the highest producer of biomass across the pasture.

Table 5-45 Rock Point South Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	147	96.08%	Forb	Annual	I	Injurious
Pleuraphis jamesii	111	72.55%	Graminoid	Perennial	N	Emergency
Achnatherum hymenoides	105	68.63%	Graminoid	Perennial	N	Desirable
Ephedra cutleri	81	52.94%	Shrub	Perennial	N	Desirable
Sporobolus cryptandrus	72	47.06%	Graminoid	Perennial	N	Non Consumed

Table 5-46 Rock Point South Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Salsola tragus	9367.24	41.44%	Forb	Annual	I	Injurious
Sarcobatus vermiculatus	4397.63	19.46%	Shrub	Perennial	N	Non Consumed
Pleuraphis jamesii	2603.29	11.52%	Graminoid	Perennial	N	Emergency
Ephedra cutleri	952.68	4.21%	Shrub	Perennial	N	Desirable
Achnatherum hymenoides	811.62	3.59%	Graminoid	Perennial	N	Desirable

5.7.4 Tohta Sa Conni RMU

The initial carrying capacity for the Tohta Sa Conni RMU is 18.35 SUYL in the east pasture and 19.04 SUYL in the west pasture. The Tohta Sa Conni RMU is relatively small compared to the other pastures in the Rock Point community. The seven transects in the east pasture fell within three ecological sites with the Sandy Loam Upland (R035XB219AZ) site have the most acreage and highest carrying capacity. This ecological site also has the highest carrying capacity in the west pasture and contains four of six transects.

Table 5-47 Stocking Rates and Carrying Capacity Applied to Tohta Sa Conni RMU East

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Rock Point Community Average)	Carrying Capacity (SUYL)
R035XB215AZ Sandstone Upland 6-10" p.z.	1	111.73	5.94	399.21	0.28
R035XB217AZ Sandy Upland 6-10" p.z.	3	1,246.14	8.38	257.26	4.84
R035XB219AZ Sandy Loam Upland 6-10" p.z.	3	2,186.82	10.81	212.17	10.31
R035XB227AZ Sandy Loam Upland 6-10" p.z.	0	70.66	6.35	283.48	0.25
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	0	17.66	1.67	1,420.12	0.01
Rock Outcrop	0	409.68	15.40	153.95	2.66
Ecological Site Unassigned/Unavailable	0	N/A	N/A	12,877.02	N/A
No ESID	0	0.42	0.01	N/A	N/A

Table 5-48 Stocking Rates and Carrying Capacity Applied to Tohta Sa Conni RMU West

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Rock Point Community Average)	Carrying Capacity (SUYL)
R035XB215AZ Sandstone Upland 6-10" p.z.	0	83.53	1.98	399.21	0.21
R035XB217AZ Sandy Upland 6-10" p.z.	2	994.06	23.52	257.26	3.86
R035XB219AZ Sandy Loam Upland 6-10" p.z.	4	3,007.82	71.16	212.17	14.18
R035XB227AZ Sandy Loam Upland 6-10" p.z.	0	29.74	0.70	283.48	0.10
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	0	7.44	0.18	1,420.12	0.01
Rock Outcrop	0	104.41	2.47	153.95	0.68
Ecological Site Unassigned/Unavailable	0	N/A	N/A	12,877.02	N/A

The higher similarity index values were found in Sandy Loam Upland (R035XB219AZ) ecological site in the east pasture and both Sandy Loam Upland (R035XB219AZ) and Sandy Upland (R035XB217AZ) sites in the west pasture. Productions numbers were fairly low in all transects located within this site, but several perennial grass species ranked among the higher producing species. These included *Achnatherum hymenoides* (Indian ricegrass), *Pleuraphis jamesii* (galleta grass), and *Bouteloua gracilis* (Blue grama).

Table 5-49 Similarity Index for Tohta Sa Conni RMU

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Rock Point Tohta Sa Conni RMU - East	27.66%	6.40%	11.35%
Rock Point Tohta Sa Conni RMU - West	36.70%	13.50%	18.80%

The relative abundance of perennial grass species, especially sod formers like *Pleuraphis jamesii* (galleta grass) and *Bouteloua gracilis* (blue grama), is reflected in the percent canopy and bare ground. Although the percentage of bare ground is still somewhat unsatisfactory, it is far lower in this RMU than in any other pasture located within the Rock Point community.

Table 5-50 Point Intercept Cover Results for Tohta Sa Conni RMU

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Rock Point Tohta Sa Conni RMU—East	30.29	57.14	0.29
Rock Point Tohta Sa Conni RMU—West	28.33	55.00	0.00

Achnatherum hymenoides (Indian ricegrass) was one of the most frequently encountered species in this RMU and also contributed the greatest amount of production. From a production standpoint, perennial grass species were the dominant contributors in both the east and west pastures. It is also notable that even though *Salsola tragus* (prickly Russian thistle) was widespread in the east pasture, this plant was not among the top producers of biomass in either pasture. The dominance of forage grasses in this RMU, coupled with its relative small size, mark as a very good candidate for the implementation of restoration practices including reseeding and rotational grazing.

Table 5-51 Tohta Sa Conni RMU Species Frequency

Pasture	Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
East	*Achnatherum hymenoides*	7	100.00%	Graminoid	Perennial	N	Desirable
East	*Ephedra cutleri*	7	100.00%	Shrub	Perennial	N	Desirable
East	*Sporobolus cryptandrus*	7	100.00%	Graminoid	Perennial	N	Non Consumed
East	*Astragalus* sp.	6	85.71%	Forb	Unknown	N	Toxic
East	*Cryptantha* sp.	5	71.43%	Forb	Annual	N	Non Consumed
East	*Pleuraphis jamesii*	5	71.43%	Graminoid	Perennial	N	Emergency
East	*Salsola tragus*	5	71.43%	Forb	Annual	I	Injurious
East	*Sphaeralcea coccinea*	5	71.43%	Forb	Perennial	N	Non Consumed
West	*Pleuraphis jamesii*	7	100.00%	Graminoid	Perennial	N	Emergency
West	*Achnatherum hymenoides*	6	85.71%	Graminoid	Perennial	N	Desirable
West	*Bouteloua gracilis*	6	85.71%	Graminoid	Perennial	N	Desirable
West	*Chaetopappa ericoides*	6	85.71%	Forb	Perennial	N	Non Consumed
West	*Ephedra cutleri*	6	85.71%	Shrub	Perennial	N	Desirable
West	*Sporobolus cryptandrus*	6	85.71%	Graminoid	Perennial	N	Non Consumed

Table 5-52 Tohta Sa Conni RMU Species Composition

Pasture	Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
East	*Achnatherum hymenoides*	135.35	18.01%	Graminoid	Perennial	N	Desirable
East	*Pleuraphis jamesii*	125.42	16.69%	Graminoid	Perennial	N	Emergency
East	*Sporobolus cryptandrus*	84.86	11.29%	Graminoid	Perennial	N	Non Consumed
East	*Mentzelia multiflora*	79.53	10.58%	Forb	Perennial	N	Non Consumed
East	*Ephedra cutleri*	63.09	8.40%	Shrub	Perennial	N	Desirable
West	*Achnatherum hymenoides*	290.81	27.49%	Graminoid	Perennial	N	Desirable
West	*Pleuraphis jamesii*	195.16	18.45%	Graminoid	Perennial	N	Emergency
West	*Ephedra cutleri*	160.36	15.16%	Shrub	Perennial	N	Desirable
West	*Bouteloua gracilis*	102.79	9.72%	Graminoid	Perennial	N	Desirable
West	*Sporobolus cryptandrus*	59.83	5.66%	Graminoid	Perennial	N	Non Consumed

5.8 Sweetwater

The Sweetwater community consists of one large pasture and one RMU. The initial carrying capacity for the Sweetwater pasture is 829.14 SUYL. The Sweetwater pasture contains 222 transects and the Dick Thomas RMU has eight. Stocking rates were calculated by the entire Sweetwater community and applied to each pasture, in order to include more data from each ecological site. Maximum and minimum stocking rates are shown in Table 5-53. Table 5-54 shows the ecological sites that contained transects in Sweetwater, the production associated with the reference state for those ecological sites, average reconstructed production derived from transect data, average available forage, and stocking rates associated with each sampled ecological site. For each pasture and RMU there is a table showing carrying capacity and acres of each ecological site, including those without transects..

Table 5-53 Initial Maximum and Minimum Stocking Rates in Sweetwater Community

Analysis Area	Stocking Rate Minimum (Acres/SUYL)	Ecological Site with Minimum Stocking Rate	Stocking Rate Maximum (Acres/SUYL)	Ecological Site with Maximum Stocking Rate
Sweetwater	7,088.15	R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic (1 Transect)	44.42	R035XC313AZ Loamy Upland 10-14" p.z. (6 Transects)

The reconstructed production includes all plants in the sample; the available forage includes only the preferred, desirable, and emergency forage that is available during the most limiting season of use (usually winter). The forested Gravelly Woodland (F035XG134NM) ecological site is one of the dominant sites and also has one of the highest carrying capacities of all the sites within the Sweetwater pasture. The average available forage in Sweetwater ranges between 0.33 and 53.36 pounds per acre. Other common ecological sites are Sandy Loam Upland (R035XB219AZ) and Sandy Upland 6-10” p.z. (R035XB217). They are relatively productive sites with high carrying capacities. Overall, stocking rates and carrying capacity are much higher in this community as compared to the Mexican Water and Rock Point communities.

Table 5-54 Sweetwater Available Forage by Sampled Ecological Site

Ecological Site	Number of Transects	Total Production in Reference State pounds/Acre	Average Reconstructed Production pounds/Acre	Average Available Forage Per Acre pounds/Acre	Acres/SUYL
F035XG134NM Gravelly- Woodland	36	177.58	N/A	15.17	156.22
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	4	80.36	342.00	8.62	274.81
R035XB210AZ Loamy Upland 6-10" p.z.	3	111.88	538.00	5.42	437.32
R035XB215AZ Sandstone Upland 6-10" p.z.	4	227.36	296.25	4.97	476.87
R035XB216AZ Sandy Bottom 6-10" p.z.	4	144.38	900.00	0.47	4,994.05
R035XB217AZ Sandy Upland 6-10" p.z.	44	129.08	449.56	10.03	236.21
R035XB219AZ Sandy Loam Upland 6-10" p.z.	27	151.47	663.00	13.25	178.81
R035XB222AZ Sandy Terrace 6-10" p.z.	2	75.12	426.00	2.83	836.63
R035XB227AZ Sandy Loam Upland 6-10" p.z. Sodic	1	90.28	362.00	0.33	7,088.15
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	6	218.47	500.00	1.14	2,070.57
R035XC302AZ Sedimentary Cliffs 10-14" p.z.	5	255.00	417.50	25.70	92.21
R035XC313AZ Loamy Upland 10-14" p.z.	6	419.48	871.00	53.36	44.42
R035XC315AZ Sandy Upland 10-14" p.z.	23	178.94	720.30	18.44	128.53
R035XC316AZ Clay Loam Upland 10-14" p.z. Limy	4	269.67	N/A	21.45	110.49
R035XC317AZ Sandy Loam Upland 10-14" p.z.	36	245.12	630.00	23.08	102.68
R035XC324AZ Clayey Slopes 10-14" p.z. Bouldery	8	144.02	396.75	13.21	179.45
R035XC328AZ Cobbly Slopes 10-14" p.z.	1	38.42	485.00	3.19	742.44
R035XC329AZ Loamy Upland 10-14" p.z. Gravelly	3	107.99	516.00	7.48	316.83
R035XC330AZ Sandy Terrace 10-14" p.z. Stony	1	203.21	515.00	26.09	90.85
Rock Outcrop	7	53.70	N/A	2.56	925.64
Ecological Site Unassigned/Unavailable	4	84.06	500.00	2.47	958.98
No ESID (No soil map unit correlation to ESD)	1	211.43	N/A	23.91	99.13

The highest carrying capacity in Sweetwater was the Clay Loam Swale site (R035XC316AZ) which covers more than 14,000 acres. Other dominant sites include Gravelly Woodland (F035XG134NM), Sandy Upland 6-10”p.z. (R035XB217AZ), Sandy Loam Upland 6-10”p.z. (R035XB219AZ), and Sandy Loam Upland 10-14” p.z. (R035XC317AZ). All of these sites have comparatively high carrying capacities as well.

Table 5-55 Stocking Rates and Carrying Capacity Applied to Sweetwater

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Sweetwater Community Average)	Carrying Capacity (SUYL)
Badland	0	58.66	0.04	N/A	N/A
F035XG134NM Gravelly- Woodland	34	19,236.47	14.25	156.22	123.14
F035XH005NM Playa	0	15.40	0.01	N/A	N/A
F036XA001NM South of Gallup 13-16	0	30.92	0.02	N/A	N/A
R035XB201AZ Mudstone/Sandstone Hills 6-10" p.z.	4	1,576.53	0.85	274.81	5.74
R035XB210AZ Loamy Upland 6-10" p.z.	3	1,048.08	0.78	437.32	2.40
R035XB215AZ Sandstone Upland 6-10" p.z.	4	1,006.58	0.75	476.87	2.11
R035XB216AZ Sandy Bottom 6-10" p.z.	4	976.47	0.72	4,994.05	0.20
R035XB217AZ Sandy Upland 6-10" p.z.	44	19,570.11	14.50	236.21	82.85
R035XB219AZ Sandy Loam Upland 6-10" p.z.	27	19,906.95	14.75	178.81	111.33
R035XB222AZ Sandy Terrace 6-10" p.z.	2	374.34	0.28	836.63	0.45
R035XB227AZ Sandy Loam Upland 6-10" p.z.	1	416.73	0.31	7,088.15	0.06
R035XB229AZ Cobbly Slopes 6-10" p.z. Grazane	0	146.19	0.11	N/A	N/A
R035XB230AZ Sandstone Upland 6-10" p.z. Calcareous	0	9.28	0.007	N/A	N/A
R035XB238AZ Sandy Terrace 6-10" p.z. Sodic	6	2,734.33	0.08	2,070.57	1.32
R035XC302AZ Sedimentary Cliffs 10-14" p.z.	5	5,335.77	2.03	92.21	57.87
R035XC313AZ Loamy Upland 10-14" p.z.	4	4,190.80	3.95	44.42	94.34
R035XC315AZ Sandy Upland 10-14" p.z.	23	7,919.29	3.11	128.53	61.61
R035XC316AZ Clay Loam Swale 10-14" p.z. Limy, Shallow	4	14,542.35	5.87	110.49	131.62
R035XC317AZ Sandy Loam Upland 10-14" p.z.	32	11,713.27	10.77	102.68	114.08
R035XC324AZ Clayey Slopes 10-14" p.z. Bouldery	8	2,052.22	8.68	179.45	11.44
R035XC328AZ Cobbly Slopes 10-14" p.z.	1	379.12	1.52	742.44	0.51
R035XC329AZ Loamy Upland 10-14" p.z. Gravelly	3	1,642.85	0.28	316.83	5.19
R035XC330AZ Sandy Terrace 10-14" p.z. Stony	1	320.47	1.28	90.85	3.53
R036XB006NM Loamy	0	693.17	0.24	N/A	N/A
Rock Outcrop	7	17,938.09	0.51	925.64	19.38
Ecological Site Unassigned/Unavailable	4	N/A	13.29	958.98	N/A
No ESID	1	1,148.47	0.85	N/A	N/A

The median similarity index is comparatively high in the Sweetwater community. Transects with the highest similarity values came from the Sandy Terrace (R035XB238AZ), Sandy Upland (R035XC315AZ), and Sandy Loam Upland (R035XC317AZ) ecological sites. Current species composition in the Sandy Upland (R035XC315AZ) match the reference community fairly well, but the dominance of *Gutierrezia sarothrae* (broom snakeweed), *Chrysothamnus greenei* (Greene's rabbitbrush), and *Ephedra Cutleri* (Cutler's jointfir) help explain why index values are all below 50 percent. This situation is similar to what was found for the Sandy Loam Upland (R035XC317AZ) site, except that main species seeing an increase is *Artemisia tridentata* (big sagebrush).

Table 5-56 Similarity Index for Sweetwater

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Sweetwater	47.07%	0.10%	9.10%

A good cover of perennial grass species, especially *Pleuraphis jamesii* (galleta grass), has helped reduce the amount of bare ground found in this pasture. The presence of a large shrub like *Artemisia tridentata* (big sagebrush) has also reduced bare ground and increased the percent canopy.

Table 5-57 Point Intercept Cover Results for Sweetwater

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Sweetwater	19.86	54.41	0.62

The most frequently occurring species in the Sweetwater pasture is *Gutierrezia sarothrae* (broom snakeweed). This species is followed closely by *Achnatherum hymenoides* (Indian ricegrass) and *Pleuraphis jamesii* (galleta grass). *Gutierrezia sarothrae* (broom snakeweed) also produces the most biomass, but *Pleuraphis jamesii* (galleta grass) is also a top contributor. Unlike pastures in other communities, Sweetwater also has a fair amount of *Bromus tectorum* (cheatgrass), especially in the *Artemisia tridentata* (big sagebrush) dominated areas. This invasive, exotic grass is not widely distributed, but its ability to spread rapidly is a cause for concern.

Table 5-58 Sweetwater Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Gutierrezia sarothrae	192	86.10%	Shrub	Perennial	N	Toxic
Achnatherum hymenoides	181	81.17%	Graminoid	Perennial	N	Desirable
Pleuraphis jamesii	157	70.40%	Graminoid	Perennial	N	Emergency
Ephedra cutleri	121	54.26%	Shrub	Perennial	N	Desirable
Chrysothamnus greenei	117	52.47%	Shrub	Perennial	N	Emergency
Salsola tragus	117	52.47%	Forb	Annual	I	Injurious

Table 5-59 Sweetwater Species Composition

Species	Total Reconstructed Weight (lbs/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Gutierrezia sarothrae	7007.52	18.41%	Shrub	Perennial	N	Toxic
Artemisia tridentata	3775.94	9.92%	Shrub	Perennial	N	Emergency
Chrysothamnus greenei	3570.40	9.38%	Shrub	Perennial	N	Emergency
Ephedra cutleri	2847.82	7.48%	Shrub	Perennial	N	Desirable
Pleuraphis jamesii	2711.50	7.12%	Graminoid	Perennial	N	Emergency

5.8.1 Dick Thomas RMU

The initial carrying capacity for the Dick Thomas RMU is 49.61 SUYL. The largest area in the Dick Thomas RMU is classified as a Sandy Loam Upland (R035XC317AZ) ecological site and contains half of the transects within the RMU. The highest carry capacity was recorded for the Loamy Upland (R035XC313AZ) site. This site contains two transects and makes up the second largest area in the RMU.

Table 5-60 Stocking Rates and Carrying Capacity Applied to Dick Thomas RMU

Ecological Site	# of Transects	Total Acres	% of ESD in Analysis Unit	Acres/SUYL (Sweetwater Community Average)	Carrying Capacity (SUYL)
F035XG134NM Gravelly- Woodland	2	224.03	4.44	156.22	1.43
R035XC302AZ Sedimentary Cliffs 10-14" p.z.	0	100.01	1.98	92.21	1.08
R035XC313AZ Loamy Upland 10-14" p.z.	2	730.93	14.49	44.42	16.45
R035XC315AZ Sandy Upland 10-14" p.z.	0	547.69	10.86	128.53	4.26
R035XC316AZ Clay Loam Swale 10-14" p.z. Limy, Shallow	0	1,197.57	23.74	110.49	10.84
R035XC317AZ Sandy Loam Upland 10-14" p.z.	4	1,509.68	29.92	102.68	14.70
R035XC324AZ Clayey Slopes 10-14" p.z. Bouldery	0	38.46	0.76	179.45	0.21
Rock outcrop	0	577.80	11.45	925.64	0.62
Ecological Site Unassigned/Unavailable	0	N/A	N/A	958.98	N/A
No ESID	0	118.87	2.36	N/A	N/A

Two transects had similarity index scores of over 30 percent, the rest were below ten percent. The two high scores were both from transects in the Loamy Upland (R035XC313AZ) ecological site. The representative plant community is characterized by a mix of perennial warm and cool season grasses with a moderate overstory of *Artemisia tridentata* (big sagebrush) and *Atriplex canescens* (fourwing saltbush). Production on both transects was high for desirable grass species like *Pascopyrum smithii* (western wheatgrass), *Achnatherum hymenoides* (Indian ricegrass), and *Hesperostipa comata* (needle and thread). *Artemisia tridentata* (big sagebrush) contributed a lot of biomass on one of the transects. Unfortunately, both transects also had a lot of the exotic *Bromus tectorum* (cheatgrass).

Table 5-61 Similarity Index for Dick Thomas RMU

Analysis Area	Maximum Similarity Index	Minimum Similarity Index	Median Similarity Index
Sweetwater Dick Thomas RMU	35.09%	4.62%	8.44%

The proportions of ground cover in the Dick Thomas RMU are very encouraging. Bare ground is below 50 percent and percent canopy cover was nearly 30 percent. There will always be bare ground on rangeland exposed to harsh conditions on a year-long basis, but it is reasonable to expect the percentage to be below 50 percent when disturbance factors are managed for or mitigated.

Table 5-62 Point Intercept Cover Results for Dick Thomas RMU

Analysis Unit	Canopy (%)	Bare Ground (%)	Basal (%)
Sweetwater Dick Thomas RMU	27.43	43.43	1.71

Bromus tectorum (cheatgrass) and *Gutierrezia sarothrae* (broom snakeweed) are both common species and contribute a lot to the total production within in this RMU. However, *Pascopyrum smithii* (western wheatgrass) and *Hesperostipa comata* (needle and thread) were also frequently encountered and *Hesperostipa comata* (needle and thread) contributes more biomass than any of the shrub species. Both of these grasses are very desirable and are often some of the first species to disappear under continuous grazing pressure. Their abundance within this RMU coupled with the reduced percentage of bare ground is indicative of healthy rangeland. The presence of *Bromus tectorum* (cheatgrass) requires a high degree of diligence to insure that it does not spread. However, maintenance of the current native forage will go a long ways towards preventing this situation from occurring.

Table 5-63 Dick Thomas RMU Species Frequency

Species	Frequency by Transect	Percentage of Total Transects	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Gutierrezia sarothrae	8	100.00%	Shrub	Perennial	N	Toxic
Bromus tectorum	7	87.50%	Graminoid	Annual	I	Injurious
Achnatherum hymenoides	6	75.00%	Graminoid	Perennial	N	Desirable
Artemisia tridentata	6	75.00%	Shrub	Perennial	N	Emergency
Ephedra cutleri	6	75.00%	Shrub	Perennial	N	Desirable
Hesperostipa comata	6	75.00%	Graminoid	Perennial	N	Injurious

Table 5-64 Dick Thomas RMU Species Composition

Species	Total Reconstructed Weight (pounds/acre)	Percentage of Total Weight in Community	Growth Habit	Duration	Nativity I=Introduced, N=Native	Sheep Forage Value (Most Limiting Season of Use)
Hesperostipa comata	368.07	16.45%	Graminoid	Perennial	N	Injurious
Artemisia tridentata	340.52	15.22%	Shrub	Perennial	N	Emergency
Gutierrezia sarothrae	309.82	13.85%	Shrub	Perennial	N	Toxic
Pascopyrum smithii	305.06	13.63%	Graminoid	Perennial	N	Desirable
Bromus tectorum	162.93	7.28%	Graminoid	Annual	I	Injurious

6. CONCLUSIONS AND RECOMMENDATIONS

Analysis of the three communities show that overall, pastures in the Sweetwater community are in the best condition, followed by Rock Point and then Mexican Water. The potential production for all ecological sites is below average and grazing strategies will need to be adjusted to allow forage species to recover. The stocking rates and carrying capacities provided by this study represent a starting place for local managers. In most cases, especially in the Mexican Water community, current carrying capacities are well below what is needed to support viable livestock enterprises. As a result, initial livestock reductions will likely be necessary. However, the implementation of alternate grazing strategies coupled with range improvements should increase available forage to the point that livestock numbers can be increased within a few years. The following sections provide some recommendations pertaining to fencing, seasonal grazing, forage availability, slope and accessibility, the distribution of water sources, and increasing water retention.

6.1 Drought

One of the greatest obstacles to overcome when restoring rangeland in the project area is precipitation. Local precipitation monitoring stations recorded lower than normal precipitation in 2012 and precipitation levels throughout the Southwest indicate the prevalence of drought conditions. Even when drought conditions are not present, most of this region only receives between six and ten inches a year. It is therefore extremely important to maintain healthy plant communities, not only for forage purposes, but to reduce soil exposure and loss as well. To complicate matters, moisture arriving during the monsoon season is often in the form of severe thunderstorms which can produce several inches of rain at one time. The high percentage of bare ground found in much of the project area accelerates water erosion. This increases soil loss while decreasing water retention. All rehabilitation efforts hinge upon having soils that are capable of supporting healthy plant communities. Thus, it is clear that the first steps that need to be taken are to prevent further erosion and rebuild soils where they have been lost.

6.2 Soil and Grazing Management

Deeply eroded gullies and arroyos are the most difficult and cost prohibitive features to restore. In their immature form, the sides of the channels are usually 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. Unfortunately, the cost and logistics involved with getting equipment into more remote locations can make this option prohibitive (Valentin et al. 2005).

Another option 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 fairly low, effective countermeasures to erosion are simple, hand constructed rock check dams. In addition to capturing soil and preventing further loss, they also serve to redistribute water, especially during the monsoon season.

Spreading runoff across the landscape and retaining water for longer periods leads to more plant growth and plant 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).

Rebuilding soils requires a combination of erosion control, revegetation, and periodic disturbance of the soil surface. Revegetation may require reseeding programs in some parts. However, this study found that much of the native plant community is still present within the vast majority of the project area. Production from native species may be low in many areas, but the components are still in place. Especially visible are perennial grass species like *Achnatherum hymenoides* (Indian ricegrass)*, Pleuraphis jamesii* (galleta grass), *Bouteloua gracilis* (blue grama), and *Sporobolus* (dropseed grass) species. Important forb and shrub species such as *Sphaeralcea* (globemallow) spp*., Atriplex canescens* (fourwing saltbush)*,* and *Ephedra cutleri* (Cutler's jointfir) are fairly abundant as well. This indicates that with careful and proactive management, native species production and frequency should increase naturally without a lot of intervention. Areas with dense shrubs or trees may need to be thinned to release the native herbaceous component. Although shrub production is high throughout the study area, shrub populations are not always dense. In many cases, shrub growth stands out simply because there are few other species present in the community. The lack of native herbaceous production is due; in large part, to unmanaged, continuous grazing systems.

Determining forage production based upon a normal precipitation allows managers to establish a "ceiling" or carrying capacity for their land. These determinations should not be used to generate stocking rates when precipitation is below normal, especially during drought conditions. In a continuous grazing system, it is difficult to prepare for times of scarce moisture. 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 it can be expected that spring and early summer production will also be low and livestock numbers should be adjusted accordingly. To aid in this process, managers should prioritize monthly data collection and record keeping so that valid information can be provided to the district grazing committees. Because all production measurements are affected by annual precipitation, it is crucial that accurate precipitation data is applied to the production measurements. Calculations for annual production (and resulting stocking rates) would be more accurate if a comprehensive precipitation record was available for multiple locations throughout the District.

The final part of rebuilding soil is to make sure that 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 ecological site descriptions for the project area recommend deferring grazing from late winter through early spring. This practice alone would do much to increase available forage. Other areas are better suited for winter/spring grazing and can be utilized to provide forage while less suitable areas are being rested. The 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 are also valuable tools for excluding stray livestock, especially horses. Two major hurdles to fence construction are the common property aspect of the Navajo Reservation and financial constraint. A common sentiment encountered while performing the vegetation surveys was that people want to improve the land, but they aren't receiving help or don't know where to ask for help. Getting people involved at the chapter level may be one way of arriving at unanimous decisions to implement range improvement projects. Approaching permittees with specific, proactive improvement plans and the support for carrying out the plans would greatly help build the momentum necessary for enacting large-scale, long-term changes. NRCS programs like the Environmental Quality Incentives Program can aid in providing the technical and financial support needed for this to happen.

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 higher than it should be in many parts of the study area. Many pastures in the Sweetwater community have areas that are dominated by *Artemisia tridentata* (big sagebrush) and *Atriplex canescens* (fourwing saltbush). The Mexican Water and Rock Point communities have large areas dominated by *Coleogyne ramosissima* (black brush) and virtually all pastures in the project area have substantial populations of *Gutierrezia sarothrae* (broom snakeweed). In most cases, proper grazing management may be sufficient to encourage the reestablishment 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. In other cases, it may be necessary to reduce shrub populations either by mechanical or chemical means. A number of mechanical methods have been used to control shrubs on rangelands including roller chopping, root-plowing, shredding, chaining, and bulldozing. These practices require relatively gentle terrain to implement and the cost of operating the equipment can be expensive, which limits their practicality in this area. There is also the danger of encouraging the spread of invasive species by removing large swaths of vegetation at one time (DiTomaso 2000).

Chemical control is cheaper than mechanical methods and can be more effective at thinning brush stands rather than eradicating them entirely. This is generally the more desirable route to take, as it leaves cover and browse for livestock and wildlife. Soil exposure is also much reduced, which decreases opportunities for exotic plants to invade the site (Olsen et al. 1994; DiTomaso 2000).The use of the herbicide tebuthiuron (Spike®, Scrubmaster® , Perflan®) which works to inhibit photosynthetic activity, has been quite successful in thinning dense stands of *Artemisia tridentata* (big sagebrush). Low rates of this chemical effectively thin the stand, while still leaving adequate cover and browse for wildlife species. Application rates ranging from 0.3 to 0.5 lbs of active ingredient per acre have proven to be both cost effective and suitable for creating a mix of shrubs, grasses, and forbs (Hooley 1991; Olsen et al. 1994). Tebuthiuron and Picloram (Tordon®, Grazon®) have proven to be effective in controlling *G. sarothrae* as well. However, most studies have found that at least 90 percent of the plants need to be killed to see significant increases in perennial forage species (Schmutz and Little 1970; Gesink et al. 1973; Sosebee et al. 1979; McDaniel and Duncan 1987). Consultation with experts is recommended prior to implementing shrub control measures to determine the best rates and timing for herbicide applications and to explore alternate control methods.

6.4 Exotic Species

The invasive forb, *Salsola tragus* (prickly Russian thistle), was found in abundance in nearly every pasture surveyed. This is a drought tolerant, disturbance-loving species that does well in sandy soils (Whitson et al. 2002). The largest populations were found in disturbed areas close to highway corridors and population centers, but the sandy soils found throughout the project area provide ample habitat for this species in the absence of healthy native populations. 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 (United States Department of Agriculture 1937). 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. On the positive side, *Salsola tragus* (prickly Russian thistle) can also accelerate revegetation of disturbed areas by supporting the growth of soil mycorrhiza. Soil mycorrhiza are fungi that form associations with many native plant species. The fungi help the plants absorb more soil water and nutrients and, in return, receive carbohydrates from the roots of the plants. Certain mycorrhiza will invade the roots of *Salsola tragus* (prickly Russian thistle), but instead of forming an association with this plant, they will kill the infected roots and then move on to the roots of neighboring plants. In this manner, the fungi population increases while *Salsola tragus* (prickly Russian thistle) populations begin to decline (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, *Salsola tragus* (prickly Russian thistle) will persist on a site for about two years and then will be replaced by various annual and biennial species. These plants continue to build up the soil substrate by maintaining soil mycorrhiza populations and adding organic matter to the soil as the plants die. *Salsola tragus* (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 is often a limiting nutrient in the soil and by increasing its availability, favorable forage plants can become established at faster rates. *Salsola tragus* (prickly Russian thistle) can be controlled or even eradicated through various mechanical and chemical treatments (Young and Whitesides 1987; Burrill et al. 1989). 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.

The exotic annual grass, *Bromus tectorum* (cheatgrass) is a commonly occurring species in the Sweetwater Community. *Bromus tectorum* (cheatgrass) is a difficult grass 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 *Bromus tectorum* (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 *Bromus tectorum* (cheatgrass) plants and seeds when applied in the fall to infestations in Zion Nation Park (Dela Cruz 2008, Brisbin et al. 2013). 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 *Bromus tectorum* (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.

6.5 Forage values

Range managers that issue permits in the District 9 area need to recognize species within the individual permit areas, and know their forage values, to more finely tune the stocking rates. For example, if a permitted area only has palatable species available to livestock in the spring and summer and there is no forage available during the fall and winter seasons, the area will likely be overgrazed at the end of the year and resources could suffer permanent damage. This is why it’s safer to start with stocking rates based upon forage available throughout the year, as this study used. Seasonal grazing would allow for additional livestock during spring and summer when forage is palatable.

The forage values for a limited number of species may be listed in the ESDs. The comprehensive list used to assign forage values for this inventory is included in Appendix E and should be referenced by rangeland managers to assess seasonal availability of forage.

6.6 Sample Design

The sample design was stratified by soil map units which helped to distribute the transects throughout the study area. Unfortunately, due to both the unmapped soil components within the soil map units, and the creation of smaller pastures after designing the sample scheme, the sample distribution was unable to capture all of the soil components or their associated ecological sites. Analyzing by ecological sites is, at best, difficult when using soil surveys mapped at the Order III level; the difficulty is compounded when the sample design does not include the analysis units and when the analysis units are small. Therefore, future sample designs should incorporate RMUs and pastures as analysis units in the distribution of transects within soil map units.

6.7 Data Analysis and Monitoring

Analysis of the data revealed several patterns including high shrub density, numerous areas devoid of vegetative cover, and other areas that are maintaining good populations of key grass species like *Achnatherum hymenoides* (Indian ricegrass) and *Hesperostipa comata* (needle and thread). The next step is to use this data to identify specific locations that would benefit most from improvement measures and 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 areas were being rested. Visits to these areas would allow managers to determine the feasibility of adding water sources if none are currently present. If the data from certain transects showed that native forage species were not present, it may be necessary to implement reseeding programs. Agriculture extension offices and the NRCS are good resources to use for help in determining appropriate seed mixes and finding seed sources. Using local, drought tolerant species that can germinate early, like *Sphaeralcea coccinea* (scarlet globemallow) and *Sporobolus cryptandrus* (sand dropseed), will speed up revegetation and increase the likelihood of success.

Grazing programs should make use of available tools. When it is possible to erect fences, they should be designed to ease the movement and exclusion of livestock, as dictated by the condition of the vegetation. In keeping with this, water sources and salt blocks can be situated to move animals out of some areas or to encourage them to use underutilized locations. In addition, the provided initial stocking rates and carrying capacities in this report should be used as a guide to be adjusted appropriately with consideration of forage value, the seasonal palatability of forage, and the 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, the placement of the previously discussed check dams and other water catchment systems like 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 has been collected, it is not necessary to sample vegetation at each transect. 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 range site. In addition to monitoring species composition and production, it would also be valuable to assess soil stability and hydrologic function. There are numerous references that can be utilized to develop monitoring programs and help interpret the results, such as the Monitoring Manuel for Grassland, Shrubland, and Savanna Ecosystems put out by the Arid Lands Research Program (Herrick et al. 2005) and the BLM's Technical Reference 1734-6: Interpreting Indicators of Rangeland Health (Pellant et al. 2005).

Because current livestock numbers exceed the overall carrying capacity of the project area, this report provides recommendations for improving rangeland conditions not simply by adjusting stocking rates but, more importantly, by restoring biotic, hydrologic, and soil stability components of the landscape.

7. REFERENCES AND LITERATURE CITED

Allen, E.B. and M.F. Allen. 1988. Facilitation of succession by the nonmycotrophic colonizer Salsola kali (Chenopdiaceae) on a harsh site: effects of mycorrhizal fungi. Amer. Jour. of Botany. 75(2): 257-266.

Allen, M.F., E.B. Allen, and C.F. Friese. 1989. Responses of the non-mycotrophic plant Salsola kali to invasion by vesicular-arbuscular mycorrhizal fungi. New Phytologist. 111(1): 45-49.

Beckstead, J., S. E. Meyer, C. J. Molder, and C. Smith. 2007. A race for survival: can Bromus tectorum seeds escape Pyrenophora semeniperda caused mortality by germinating quickly? Ann. Bot. 99:907–914.

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

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

Brisbin, H., A. Thode, M. Brooks, and K. Weber. 2013. *In Press*. Soil seedbank responses to postfire herbicide and native seeding treatments designed to control cheatgrass in a pinyon-juniper woodland at Zion National Park, USA. Invasive Plant Science and Management.

Burrill, L.C., W.S. Braunworth, jr., and William R.D. (compilers). 1989. Pacific Northwest weed control handbook. Oregon State University, Extension Service, Agricultural Communications. Corvallis, OR. 276 p.

Cannon, J.P., E.B. Allen, M.F. Allen, L.M. Dudley, and I.J. Jirimack. 1995. The effects of oxalates produced by Salsola tragus on the phosphorus nutrition of Stipa pulchra. Oecologia. 102: 265-272.

Cook, C.W., L.A. Stoddart, and L.E. Lorin. 1954. The nutritive value of winter range plants in the Great Basin as determined with digestion trials with sheep. Bulletin 372. Utah State University,

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

Coulloudon, Bill, et al. 1999a. Utilization Studies and Residual Measurements, Interagency Technical Reference 1734-3. Bureau of Land Management, Denver, Colorado.

Dela Cruz, M. P. 2008. Exotic brome control and revegetation trials in the xeric riparian corridor at Zion National Park. M.S. Thesis. Flagstaff, AZ: Northern Arizona University. 83 p.

DiTomaso, J.M. 2000. Invasive weeds in rangelands: species, impacts, and management. Weed Science. 48:255-265.

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

Floyd, L. M., D. Hanna, W. H. Romme, and T. E. Crews. 2006. Predicting and mitigating weed invasions to restore natural post-fire succession in Mesa Verde National Park, Colorado, USA. Int. J. Wildland Fire 15:247–259.Colorado.

Gesink, H.P., H.P. Alley, and G.A. Lee. 1973. Vegetative response to chemical control of broom snakeweed on a blue grama range. Journal of Range Mgmt. 26(2): 139-143.

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

Grilz, P., L. Delanoy, and G. Grismer. 1988. Site preparation, seeding, nurse crop methods tested in dune restoration (Saskatchewan). Restoration and Mgmt. Notes. 6(1): 47-48.

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

Heady, H.F. and R. D. Child. 1994. Rangeland Synecology. pp. 123-149. In: Rangeland Ecology & Management. Westview Press. Boulder. San Francisco. Oxford.

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

Herrick, Jeffrey E., Justin W. Van Zee, Kris M. Havstad, Laura M. Burkett and Walter G. Whitford. 2005. Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems, Volume I: Quick Start. USDA-ARS Jornada Experimental Range, Las Cruces, New Mexico. Holecheck, Jerry L. et al. 1988. An Approach for Setting the Stocking Rate. Rangelands 10(1).

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

Hooley, C. 1991. Pronghorn antelope use of tebuthiuron treated areas in northwestern New Mexico. Paper presentation, 15th Biennial Pronghorn Antelope Workshop, Rock Springs, WY.

Mack, R. N. and D. A. Pyke. 1983. The demography of Bromus tectorum: variation in time and space. J. Ecol. 71:69–93.

McDaniel, K.C and K.W. Duncan. 1987. Broom snakeweed (Gutierrezia sarothrae) control with picloram and metsulfuron. Weed Science. 35(6): 837-841.

Melgoza, G., R. S. Nowak, and R. J. Tausch. 1990. Soil water exploitation after fire: competition between Bromus tectorum (cheatgrass) and two native species. Oecologia 83:7–13.

Meyer, S. E., D. Quinney, D. L. Nelson, and J. Weaver. 2007. Impact of the pathogen Pyrenophora semeniperda on Bromus tectorumseedbank dynamics in North American cold deserts. Weed Res. 47:54–62.

Navajo Nation, Department of Water Resources. 2003. Navajo Nation Drought Contingency Plan. In cooperation with U.S. Bureau of Reclamation, U.S. Bureau of Indian Affairs, Navajo Nation Department of Emergency Management. Accessed at: http://www.frontiernet.net/~nndwr_wmb/PDF/drought/drghtcon_plan2003_final.pdf

Ogle, Dan and Brendan Brazee. 2009. Estimating Initial Stocking Rates. USDA- Natural Resources Conservation Service Technical Note.

Olsen, R., J. Hansen, T. Whitson, and K. Johnson. 1994.Tebuthiuron to enhance rangeland diversity. Rangelands. 16(5): 197-201.

Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting indicators of rangeland health, version 4. Technical Reference 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05. 122 p.

Schmutz, E.M. and D.E. Little. 1970. Effects of 2,4,5-T and picloram on broom snakeweed in Arizona. Journal of Range Mgmt. 23(5): 354-357.

Sosebee, R.E., W.E. Boyd, and C.S. Brumley. 1979. Broom snakeweed control with tebuthiuron. Journal of Range Mgmt. 32(3): 179-182.

Thill, D. C., R. D. Schirman, and A. P. Appleby. 1979. Influence of soil moisture, temperature and compaction on the germination and emergence of downy brome (Bromus tectorum). Weed Sci. 27:625–630.

United States Department of Agriculture, Bureau of Indian Affairs (BIA). 2003. Draft Management of Agriculture & Range Resources on Indian Lands. Washington, DC.

United States Department of Agriculture. 1937. Range Plant Handbook. United States Government Printing Office, Washington DC. 1,248 p.

United States Department of Agriculture, Natural Resources Conservation Service. Soil Survey of Navajo Mountain Area, AZ, Parts of Apache, Coconino and Navajo Counties (AZ711), 2008.

United States Department of Agriculture, Natural Resources Conservation Service. Soil Survey of Shiprock Area, Parts of San Juan County, New Mexico and Apache County, Arizona (NM717), 2001.

United States Department of Agriculture, Natural Resources Conservation Service. Soil Survey of San Juan County, Utah, Navajo Indian Reservation (UT643), 1980.

USDA Plants databases (2010). Available at http://plants.usda.gov/

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

Valentin, C., J. Poesen, and Y. Li. 2005. Gully erosion: impacts, factors and control. Catena. 63(2-3): 132-153.

Whitson, T.D., L.C. Burrill, S.A. Dewey, D.W. Cudney, B.E. Nelson, R.D. Lee, and R. Parker. (ed). 2002. Weeds of West.9th Ed. University of Wyoming. Laramie, WY. 628 p.

Young, F.L. and R.E. Whitesides. 1987. Efficacy of postharvest herbicides on Russian thistle (Salsola iberica) control and seed germination. Weed Science. 35: 554-559.

Appendices

Appendix A

Station Name	**Water Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
BLUFF WX	1994	0.05	0.55	0.10	1.00	0.60	0.30	0.00	0.20	0.80	1.10	0.40	0.00
BLUFF WX	1995	0.70	0.30	1.85	0.75	0.50	0.60	1.10	0.10	0.40	1.05	0.45	0.60
BLUFF WX	1996	0.30	0.10	0.10	0.00	0.20	0.85	0.05	0.28	1.00	0.10	0.00	0.10
BLUFF WX	1997	0.28	0.28	0.28	0.28	0.28	0.28	0.65	2.15	1.35	0.95	0.28	2.00
BLUFF WX	1998	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
BLUFF WX	1999	2.00	0.28	0.10	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
BLUFF WX	2000	0.28	0.28	2.06	0.28	0.28	1.10	0.28	0.48	0.24	0.28	0.28	0.14
BLUFF WX	2001	0.77	0.80	0.28	0.28	0.28	0.28	0.20	0.70	0.40	0.28	2.00	0.49
BLUFF WX	2002	0.18	0.00	0.74	0.13	0.00	0.00	0.08	0.07	2.55	0.00	0.10	0.61
BLUFF WX	2003	0.15	1.21	0.67	0.07	0.05	0.00	0.18	0.28	1.82	0.91	0.20	0.22
BLUFF WX	2004	0.40	0.75	0.07	0.75	0.03	0.12	0.39	0.14	1.42	0.45	0.55	0.10
BLUFF WX	2005	1.53	0.73	0.83	0.75	0.07	0.11	0.42	0.76	0.69	0.96	1.32	0.24
BLUFF WX	2006	0.39	0.02	0.90	0.09	0.19	0.21	0.30	0.90	0.30	0.74	0.07	0.03
BLUFF WX	2007	0.40	0.28	0.28	0.40	0.60	0.30	0.60	0.40	1.50	1.95	0.05	0.46
BLUFF WX	2008	0.28	1.10	0.10	0.32	0.21	0.17	0.45	0.55	0.15	0.08	0.00	0.28
BLUFF WX	2009	0.28	0.24	0.02	0.23	1.46	0.13	0.30	0.02	0.00	0.35	0.55	0.28
BLUFF WX	2010	1.45	0.92	1.13	0.05	0.30	0.28	0.45	2.75	0.70	0.38	0.10	1.25
BLUFF WX	2011	0.28	0.22	0.20	0.35	0.53	0.00	0.28	0.27	0.68	0.30	0.07	0.28
TEEC NOS POS O & M	1994	0.80	1.00	0.60	0.58	1.12	1.90	0.15	0.30	0.85	1.00	0.56	0.60
TEEC NOS POS O & M	1995	2.20	0.40	1.50	0.66	2.20	0.20	0.10	0.80	0.60	0.10	1.85	0.77
TEEC NOS POS O & M	1996	0.30	0.10	0.10	0.20	0.10	0.35	0.50	0.75	1.40	0.43	0.43	0.20
TEEC NOS POS O & M	1997	0.56	0.52	1.10	1.10	1.20	1.70	0.85	0.92	2.25	1.03	0.79	0.52
TEEC NOS POS O & M	1998	0.24	0.42	0.90	0.23	0.35	0.00	1.30	2.30	0.03	0.35	0.16	0.10
TEEC NOS POS O & M	1999	0.25	0.13	0.40	0.70	0.75	0.15	1.55	0.45	0.40	3.45	0.35	0.00
TEEC NOS POS O & M	2000	0.30	0.58	1.00	0.25	0.00	0.75	0.25	0.30	0.00	0.03	0.00	0.08
TEEC NOS POS O & M	2001	0.20	1.70	0.20	0.00	0.58	0.40	1.90	2.10	0.15	0.82	1.68	0.40
TEEC NOS POS O & M	2002	0.02	0.37	0.45	0.16	0.12	0.00	0.03	0.75	2.43	0.20	0.26	0.53
TEEC NOS POS O & M	2003	0.40	1.25	0.58	0.05	0.28	0.22	0.15	0.15	1.97	1.11	0.39	0.40
TEEC NOS POS O & M	2004	0.42	0.58	0.13	1.59	0.08	0.23	0.77	0.07	0.68	0.90	1.21	0.34
TEEC NOS POS O & M	2005	1.53	0.75	0.48	0.92	0.53	0.14	0.70	1.07	0.60	1.11	0.77	0.32
TEEC NOS POS O & M	2006	0.32	0.08	1.20	0.28	0.24	0.25	2.10	1.02	0.88	0.93	0.15	0.03
TEEC NOS POS O & M	2007	0.38	0.20	1.12	1.05	0.85	0.11	0.97	0.77	0.95	2.11	0.19	0.92
TEEC NOS POS O & M	2008	0.93	1.70	0.25	0.13	0.32	0.40	0.45	0.35	0.25	0.07	0.00	0.81
TEEC NOS POS O & M	2009	0.54	0.50	0.40	0.50	1.68	0.35	0.42	0.02	0.78	0.35	0.60	0.65
TEEC NOS POS O & M	2010	2.00	1.25	0.70	0.20	0.20	0.15	0.60	4.30	0.75	0.58	0.20	1.20
TEEC NOS POS O & M	2011	0.35	0.65	0.50	1.05	0.87	0.00	1.45	0.43	1.18	0.46	0.66	0.87
Average		**0.60**	**0.57**	**0.60**	**0.44**	**0.49**	**0.35**	**0.57**	**0.76**	**0.85**	**0.71**	**0.48**	**0.45**

Station Name	**Water Year**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9 (end)**	**10 (Start)**	**11**	**12**
BLUFF WX	2012	0.70	0.33	0.25	0.02	0.04	0.05	0.26	1.45		0.92	0.31	0.69
TEEC NOS POS O & M	2012	0.35	0.24	0.40	0.10	0.00	0.01	1.24	1.13		0.97	0.97	0.31
Total Combined	2012	0.53	0.29	0.33	0.06	0.02	0.03	0.75	1.29	0.00	0.95	0.64	0.50
Historic Avg.	HISTORIC	0.60	0.57	0.60	0.44	0.49	0.35	0.57	0.76	0.85	0.71	0.48	0.45
% of Normal		116	93	94	85	76	71	77			133.6082	134	127

Appendix B

Ecological Site Description

Major Land Resource Area - 37

San Juan River Valley, Mesas and Plateaus (Northern Desert) (ND-1)

New Mexico Site Description	New Mexico - Site Number The following documents require Adobe Acrobat.	Current Site Description	Current Site Number
Loamy	R037XA001NM (PDF; 656 KB)	Loamy	R035XB001NM
Sandy	R037XA002NM (PDF; 697 KB)	Sandy	R035XB002NM
Limy	R037XA003NM (PDF; 675 KB)	Limy	R035XB003NM
Clayey	R037XA004NM (PDF; 664 KB)	Clayey	R035XB004NM
Salt Flats	R037XA005NM (PDF; 655 KB)	Salt Flats	R035XB005NM
Shallow	R037XA006NM (PDF; 630 KB)	Shallow	R035XB006NM
Deep Sand	R037XA007NM (PDF; 627 KB)	Deep Sand	R035XB007NM
Sodic Slopes	R037XA008NM (PDF; 610 KB)	Sodic Slopes	R035XB008NM
Shale Hills	R037XA009NM (PDF; 569 KB)	Shale Hills	R035XB009NM
Cobbly Hills	R037XA010NM (PDF; 545 KB)	Cobbly Hills	R035XB010NM
Breaks	R037XA015NM (PDF; 274 KB)	Shale Hills 6-10"p.z. Sodic	R035XB268AZ
Clay Loam Terrace (sodic) 7-10"	R037XA016NM (PDF; 47 KB)	Clay Loam Terrace (sodic) 7-10"	R035XB016NM
Cobbly Slopes 6-10"	R037XA017NM (PDF; 239 KB)	Cobbly Slopes 6-10"	R035XB017NM
Loamy Bottom 6-10"	R037XA018NM (PDF; 240 KB)	Loamy Bottom 6-10"	R035XB018NM
Loamy Bottom Subirrigated	R037XA019NM (PDF; 240 KB)	Loamy Bottom 6-10" p.z. Perennial	R035XB269AZ
Loamy 6-10" terrace	R037XA020NM (PDF; 240 KB)	Loamy 6-10" terrace	R035XB020NM
Loamy Upland 7-10"	R037XA021NM (PDF; 44 KB)	Loamy Upland 7-10"	R035XB021NM

Loamy Upland Sodic	R037XA022NM (PDF; 47 KB)	Loamy Upland Sodic	R035XB022NM
Porcelanite Hills	R037XA023NM (PDF; 253 KB)	Porcelanite Hills 6-10" p.z.	R035XB270AZ
Saline Bottom 6-10"	R037XA024NM (PDF; 254 KB)	Saline Bottom 6-10"	R035XB024NM
Saline Sodic Upland	R037XA025NM (PDF; 248 KB)	Loamy Upland 6-10" p.z. Saline Sodic	R035XB271AZ
Salt Meadow	R037XA026NM (PDF; 242 KB)	Loamy Bottom 6-10" p.z. Perennial. Saline	R035XB272AZ
Sandstone Upland	R037XA027NM (PDF; 48 KB)	Sandstone Upland 6-10" p.z. Very Shallow	R035XB204AZ
Sandy Bottom 6-10"	R037XA028NM (PDF; 55 KB)	Sandy Bottom 6-10"	R035XB028NM
Sandy Bottom, Subirrigation	R037XA029NM (PDF; 48 KB)	Sand Bottom 6-10" p.z. Perennial	R035XB273AZ
Sandy Loam Upland 6-10"	R037XA030NM (PDF; 48 KB)	Sandy Loam Upland 6-10"	R035XB030NM
Sandy Loam Upland Gravelly	R037XA031NM (PDF; 254 KB)	Sandy Loam Upland 6-10" p.z. Limy, Gravelly	R035XB267AZ
Sandy Loam Upland Saline	R037XA032NM (PDF; 286 KB)	Sandy Loam Upland 6-10" p.z. Saline	R035XB274AZ
Sandy Loam Upland 6-10" Sodic	R037XA033NM (PDF; 236 KB)	Sandy Loam Upland 6-10" Sodic	R035XB033NM
Sandy Terrace 6-10" Sodic	R037XA034NM (PDF; 241 KB)	Sandy Terrace 6-10" Sodic	R035XB034NM
Sandy Upland 6-10"	R037XA035NM (PDF; 51 KB)	Sandy Upland 6-10"	R035XB035NM
Silty Fan	R037XA036NM (PDF; 249 KB)	Loamy Fan 6-10" p.z.	R035XB275AZ
Silty Shallow	R037XA037NM (PDF; 264 KB)	Siltstone Upland 6-10" p.z. Saline	R035XB276AZ
Silty Shallow Calcareous	R037XA038NM (PDF; 262 KB)	Siltstone Upland 6-10" p.z. Limy	R035XB277AZ
Silty Upland	R037XA039NM (PDF; 247 KB)	Loamy Upland 6-10" p.z. Saline, Gypsic	R035XB278AZ
Silty Upland Sodic	R037XA040NM (PDF; 258 KB)	Clay Loam Upland 6-10" p.z. Sodic, Gypsic	R035XB279AZ

Appendix C

Symbol	Species Name	Growth Habit	Duration	Nativity	Sheep Forage Value (Most Limiting Season of Use)
ABEL	*Abronia elliptica*	Forb	Perennial	N	Non Consumed
ABFR2	*Abronia fragrans*	Forb	Perennial	N	Non Consumed
ABRON	*Abronia sp.*	Forb	Unknown	N	Non Consumed
ACHY	*Achnatherum hymenoides*	Graminoid	Perennial	N	Desirable
ACRE3	*Acroptilon repens*	Forb	Perennial	I	Non Consumed
AGDE2	*Agropyron desertorum*	Graminoid	Perennial	I	Desirable
AGROP2	*Agropyron sp.*	Graminoid	Unknown	Unknown	Emergency
AGROS2	*Agrostis sp.*	Graminoid	Unknown	Unknown	Non Consumed
ALHU6	*Aliciella hutchinsifolia*	Forb	Unknown	N	Desirable
ALHU6	*Aliciella hutchinsifolia*	Forb	Unknown	N	Non Consumed
ALLIU	*Allium sp.*	Forb	Perennial	N	Non Consumed
ALMA12	*Alhagi maurorum*	Subshrub/ Shrub	Perennial	I	Unknown
AMAC2	*Ambrosia acanthicarpa*	Forb	Annual	N	Non Consumed
AMARA	*Amaranthus sp.*	Forb	Unknown	Unknown	Non Consumed
AMBRO	*Ambrosia sp.*	Forb	Unknown	Unknown	Non Consumed
AMBRO	*Ambrosia sp.*	Unknown	Unknown	Unknown	Non Consumed
ARABI2	*Arabis sp.*	Forb	Unknown	N	Non Consumed
ARBI3	*Artemisia bigelovii*	Subshrub/ Shrub	Perennial	N	Emergency
ARDR4	*Artemisia dracunculus*	Subshrub	Perennial	N	Desirable
AREA	*Arenaria eastwoodiae*	Subshrub	Perennial	N	Emergency
ARFI2	*Artemisia filifolia*	Shrub	Perennial	N	Emergency
ARIST	*Aristida sp.*	Graminoid	Perennial	N	Non Consumed
ARLU	*Artemisia ludoviciana*	Subshrub	Perennial	N	Emergency
ARPU9	*Aristida purpurea*	Graminoid	Annual, Perennial	N	Non Consumed
ARTEM	*Artemisia sp.*	Unknown	Unknown	N	Emergency
ARTEM	*Artemisia sp.*	Unknown	Unknown	Unknown	Unknown
ARTR2	*Artemisia tridentata*	Shrub	Perennial	N	Emergency
ASCE	*Astragalus ceramicus*	Forb	Perennial	N	Toxic
ASCLE	*Asclepias sp.*	Unknown	Unknown	Unknown	Toxic
ASCU9	*Asclepias cutleri*	Forb	Perennial	N	Toxic
ASEN	*Asclepias engelmanniana*	Forb	Perennial	N	Toxic
ASFU2	*Astragalus fucatus*	Forb	Perennial	N	Toxic
ASIN14	*Asclepias involucrata*	Forb	Perennial	N	Toxic
ASSU2	*Asclepias subverticillata*	Forb	Perennial	N	Toxic
ASTRA	*Astragalus sp.*	Forb	Unknown	N	Toxic
ASTRA	*Astragalus sp.*	Forb	Annual	N	Toxic
ATCA2	*Atriplex canescens*	Shrub	Perennial	N	Desirable
ATCO	*Atriplex confertifolia*	Shrub	Perennial	N	Injurious
ATOB	*Atriplex obovata*	Subshrub/ Shrub	Perennial	N	Emergency
ATPO2	*Atriplex powellii*	Forb	Annual	N	Emergency

ATRIP	*Atriplex sp.*	Unknown	Unknown	N	Emergency
BASC5	*Bassia scoparia*	Forb	Annual	I	Injurious
BOER4	*Bouteloua eriopoda*	Graminoid	Perennial	N	Preferred
BOGR2	*Bouteloua gracilis*	Graminoid	Perennial	N	Desirable
BRMI	*Brickellia microphylla*	Subshrub	Perennial	N	Unknown
BRTE	*Bromus tectorum*	Graminoid	Annual	I	Injurious
CEIN7	*Cercocarpus intricatus*	Shrub	Perennial	N	Preferred
CHAET2	*Chaetopappa sp.*	Forb	Perennial	N	Non Consumed
CHAL7	*Chenopodium album*	Forb	Annual	I	Non Consumed
CHAMA15	*Chamaesyce sp.*	Forb	Unknown	N	Non Consumed
CHCH5	*Chamaesyce chaetocalyx*	Subshrub	Perennial	N	Non Consumed
CHENO	*Chenopodium sp.*	Unknown	Unknown	Unknown	Unknown
CHENO	*Chenopodium sp.*	Forb	Unknown	Unknown	Unknown
CHER2	*Chaetopappa ericoides*	Forb	Perennial	N	Non Consumed
CHFE3	*Chamaesyce fendleri*	Forb	Perennial	N	Non Consumed
CHGR6	*Chrysothamnus greenei*	Shrub	Perennial	N	Emergency
CHPA28	*Chamaesyce parryi*	Forb	Annual	N	Non Consumed
CHRYS9	*Chrysothamnus sp.*	Shrub	Perennial	N	Emergency
CHST	*Chaenactis stevioides*	Forb	Annual	N	Unknown
CHVI8	*Chrysothamnus viscidiflorus*	Shrub	Perennial	N	Emergency
CLLU2	*Cleome lutea*	Forb	Annual	N	Unknown
CLSE	*Cleome serrulata*	Forb	Annual	N	Non Consumed
COAR4	*Convolvulus arvensis*	Forb	Perennial	I	Non Consumed
COPA9	*Cordylanthus parviflorus*	Forb	Annual	N	Non Consumed
CORA	*Coleogyne ramosissima*	Shrub	Perennial	N	Non Consumed
CORDY	*Cordylanthus sp.*	Forb	Annual	N	Non Consumed
COUM	*Comandra umbellata*	Subshrub	Perennial	N	Non Consumed
COUMP	*Comandra umbellata ssp. pallida*	Subshrub/ Forb	Perennial	N	Non Consumed
COWR2	*Cordylanthus wrightii*	Forb	Annual	N	Non Consumed
CRCI3	*Cryptantha cinerea*	Forb	Perennial	N	Non Consumed
CRCR3	*Cryptantha crassisepala*	Forb	Annual	N	Non Consumed
CRFE3	*Cryptantha fendleri*	Forb	Annual	N	Non Consumed
CROTO	*Croton sp.*	Forb	Annual	N	Non Consumed
CRTE4	*Croton texensis*	Forb	Annual	N	Non Consumed
CRYPT	*Cryptantha sp.*	Forb	Annual	N	Non Consumed
CRYPT	*Cryptantha sp.*	Forb	Perennial	N	Non Consumed
CYMOP2	*Cymopterus sp.*	Forb	Annual	N	Toxic
CYNE	*Cymopterus newberryi*	Forb	Perennial	N	Toxic
DELPH	*Delphinium sp.*	Forb	Annual	N	Injurious
DEPI	*Descurainia pinnata*	Forb	Annual, Biennial, Perennial	N	Non Consumed
DESC	*Delphinium scaposum*	Forb	Perennial	N	Injurious
DESCU	*Descurainia sp.*	Forb	Annual	N	Non Consumed
DESO2	*Descurainia sophia*	Forb	Annual	I	Non Consumed
DICA4	*Dicoria canescens*	Forb	Annual	N	Unknown

DICAB2	*Dicora canescens var. brandegeei*	Forb	Annual	N	Unknown
DIWI2	*Dimorphocarpa wislizeni*	Forb	Annual	N	Emergency
DRCU	*Draba cuneifolia*	Forb	Annual	N	Unknown
ECTR	*Echinocereus triglochidiatus*	Shrub	Perennial	N	Injurious
ELEL5	*Elymus elymoides*	Graminoid	Perennial	N	Emergency
ELIN6	*Elymus interruptus*	Graminoid	Perennial	N	Desirable
ENDE	*Enneapogon desvauxii*	Graminoid	Perennial	N	Unknown
EPCU	*Ephedra cutleri*	Shrub	Perennial	N	Desirable
EPHED	*Ephedra sp.*	Shrub	Perennial	N	Desirable
EPTO	*Ephedra torreyana*	Shrub	Perennial	N	Desirable
EPVI	*Ephedra viridis*	Shrub	Perennial	N	Desirable
ERAL4	*Eriogonum alatum*	Subshrub/ Forb	Perennial	N	Non Consumed
ERAP	*Erigeron aphanactis*	Forb	Perennial	N	Non Consumed
ERBE2	*Erigeron bellidiastrum*	Forb	Annual	N	Non Consumed
ERCE2	*Eriogonum cernuum*	Forb	Annual	N	Emergency
ERCI6	*Erodium cicutarium*	Forb	Annual	I	Non Consumed
ERCO14	*Eriogonum corymbosum*	Shrub	Perennial	N	Non Consumed
ERCO27	*Erigeron concinnus*	Forb	Perennial	N	Non Consumed
ERDE6	*Eriogonum deflexum*	Forb	Annual	N	Non Consumed
ERDI2	*Eriastrum diffusum*	Forb	Annual	N	Unknown
ERIGE2	*Erigeron sp.*	Forb	Unknown	N	Non Consumed
ERIOG	*Eriogonum sp.*	Unknown	Annual	N	Non Consumed
ERIOG	*Eriogonum sp.*	Unknown	Perennial	N	Non Consumed
ERIOG	*Eriogonum sp.*	Shrub	Unknown	N	Non Consumed
ERLE10	*Eriogonum leptophyllum*	Subshrub	Perennial	N	Non Consumed
ERLE9	*Eriogonum leptocladon*	Subshrub	Perennial	N	Non Consumed
ERMI4	*Eriogonum microthecum*	Shrub	Perennial	N	Non Consumed
ERNA10	*Ericameria nauseosa*	Shrub	Perennial	N	Non Consumed
ERSU5	*Eriogonum subreniforme*	Forb	Annual	N	Non Consumed
ERTR13	*Eremopyrum triticeum*	Graminoid	Annual	I	Non Consumed
ERYSI	*Erysimum sp.*	Unknown	Unknown	N	Unknown
EUPHO	*Euphorbia sp.*	Forb	Unknown	N	Unknown
FRAL5	*Frasera albomarginata*	Forb	Perennial	N	Non Consumed
FRAN2	*Fraxinus anomala*	Shrub	Perennial	N	Unknown
GILIA	*Gilia sp.*	Forb	Unknown	N	Non Consumed
GILIA	*Gilia sp.*	Forb	Unknown	N	Desirable
GIOP	*Gilia ophthalmoides*	Forb	Annual	N	Non Consumed
GISI	*Gilia sinuata*	Forb	Annual	N	Non Consumed
GRFA	*Grindelia fastigiata*	Forb	Perennial	N	Non Consumed
GRSQ	*Grindelia squarrosa*	Forb	Annual, Biennial, Perennial	N	Non Consumed
GUSA2	*Gutierrezia sarothrae*	Shrub	Perennial	N	Toxic
HAGL	*Halogeton glomeratus*	Forb	Annual	I	Toxic
HEAN3	*Helianthus annuus*	Forb	Annual	N	Non Consumed
HECO26	*Hesperostipa comata*	Graminoid	Perennial	N	Injurious

HELIA3	*Helianthus sp.*	Forb	Unknown	N	Non Consumed
HEMU3	*Heliomeris multiflora*	Subshrub/ Forb	Perennial	N	Unknown
HENE5	*Hesperostipa neomexicana*	Graminoid	Perennial	N	Desirable
HEVI4	*Heterotheca villosa*	Subshrub/ Shrub	Perennial	N	Non Consumed
HORDE	*Hordeum sp.*	Graminoid	Unknown	Unknown	Non Consumed
HYFI	*Hymenopappus filifolius*	Forb	Perennial	N	Non Consumed
IPAG	*Ipomopsis aggregata*	Forb	Perennial	N	Non Consumed
IPGU	*Ipomopsis gunnisonii*	Forb	Annual	N	Non Consumed
IPLO2	*Ipomopsis longiflora*	Forb	Annual	N	Non Consumed
IPOMO	*Ipomopsis sp.*	Forb	Unknown	N	Non Consumed
IPPO2	*Ipomopsis polycladon*	Forb	Annual	N	Non Consumed
IPPU4	*Ipomopsis pumila*	Forb	Annual	N	Non Consumed
JUNCU	*Juncus sp.*	Unknown	Unknown	Unknown	Non Consumed
KRLA2	*Krascheninnikovia lanata*	Subshrub	Perennial	N	Preferred
LAOC3	*Lappula occidentalis*	Forb	Annual	N	Non Consumed
LAPPU	*Lappula sp.*	Forb	Unknown	N	Non Consumed
LASE	*Lactuca serriola*	Forb	Annual	I	Non Consumed
LEAU3	*Lepidium austrinum*	Forb	Annual	N	Non Consumed
LEFR2	*Lepidium fremontii*	Shrub	Perennial	N	Non Consumed
LEPID	*Lepidium sp.*	Forb	Annual	Unknown	Non Consumed
LESQU	*Lesquerella sp.*	Forb	Unknown	N	Non Consumed
LIAR3	*Linum aristatum*	Forb	Annual	N	Non Consumed
LINUM	*Linum sp.*	Forb	Annual	N	Non Consumed
LIPU4	*Linum puberulum*	Forb	Annual	N	Non Consumed
LUPIN	*Lupinus sp.*	Unknown	Annual	N	Non Consumed
LUPU	*Lupinus pusillus*	Forb	Annual	N	Non Consumed
LYAR2	*Lygodesmia arizonica*	Forb	Perennial	N	Injurious
LYGOD	*Lygodesmia sp.*	Forb	Perennial	N	Injurious
LYPA	*Lycium pallidum*	Shrub	Perennial	N	Unknown
MACA2	*Machaeranthera canescens*	Forb	Annual, Biennial, Perennial	N	Non Consumed
MACHA	*Machaeranthera sp.*	Forb	Perennial	N	Non Consumed
MAGL3	*Malacothrix glabrata*	Forb	Annual	N	Unknown
MATA2	*Machaeranthera tanacetifolia*	Forb	Annual	N	Non Consumed
MEAL6	*Mentzelia albicaulis*	Forb	Annual	N	Non Consumed
MELU	*Medicago lupulina*	Forb	Annual, Perennial	I	Preferred
MEMU3	*Mentzelia multiflora*	Forb	Perennial	N	Non Consumed
MEMUI	*Mentzelia multiflora var. integra*	Forb	Perennial	N	Non Consumed
MENTZ	*Mentzelia sp.*	Forb	Unknown	N	Non Consumed
MEPU3	*Mentzelia pumila*	Forb	Biennial	N	Non Consumed
MIMU	*Mirabilis multiflora*	Forb	Perennial	N	Non Consumed
MUHLE	*Muhlenbergia sp.*	Graminoid	Perennial	N	Emergency
MUPU2	*Muhlenbergia pungens*	Graminoid	Perennial	N	Non Consumed
NAMA4	*Nama sp.*	Forb	Unknown	N	Unknown

OECA10	*Oenothera caespitosa*	Forb	Perennial	N	Non Consumed
OENOT	*Oenothera sp.*	Forb	Unknown	N	Non Consumed
OEPA	*Oenothera pallida*	Forb	Perennial	N	Non Consumed
OPPH	*Opuntia phaeacantha*	Shrub	Perennial	N	Injurious
OPPO	*Opuntia polyacantha*	Shrub	Perennial	N	Injurious
OPUNT	*Opuntia sp.*	Shrub	Perennial	N	Injurious
PAMU11	*Packera multilobata*	Forb	Annual, Perennial	N	Toxic
PASM	*Pascopyrum smithii*	Graminoid	Perennial	N	Desirable
PEAM	*Penstemon ambiguus*	Subshrub	Perennial	N	Non Consumed
PENST	*Penstemon sp.*	Forb	Perennial	N	Non Consumed
PEPA2	*Pectis papposa*	Forb	Annual	N	Unknown
PEPU7	*Petradoria pumila*	Forb	Perennial	N	Non Consumed
PHACE	*Phacelia sp.*	Forb	Unknown	N	Non Consumed
PHCR	*Phacelia crenulata*	Forb	Annual	N	Non Consumed
PHHO	*Phlox hoodii*	Forb	Perennial	N	Emergency
PHIV	*Phacelia ivesiana*	Forb	Annual	N	Non Consumed
PHLO2	*Phlox longifolia*	Forb	Perennial	N	Non Consumed
PHLOX	*Phlox sp.*	Forb	Annual	N	Non Consumed
PHYSA	*Physalis sp.*	Forb	Unknown	Unknown	
PHYSA2	*Physaria sp.*	Forb	Unknown	Unknown	
PLANT	*Plantago sp.*	Forb	Unknown	Unknown	Non Consumed
PLJA	*Pleuraphis jamesii*	Graminoid	Perennial	N	Emergency
PLOV	*Plantago ovata*	Forb	Annual	N	Non Consumed
PLPA2	*Plantago patagonica*	Forb	Annual	N	Non Consumed
POA	*Poa sp.*	Graminoid	Unknown	Unknown	Desirable
POFE	*Poa fendleriana*	Graminoid	Perennial	N	Desirable
POIN3	*Poliomintha incana*	Shrub	Perennial	N	Unknown
POSE	*Poa secunda*	Graminoid	Perennial	N	Emergency
PUST	*Purshia stansburiana*	Shrub	Perennial	N	Desirable
PUTR2	*Purshia tridentata*	Shrub	Perennial	N	Desirable
QUGA	*Quercus gambelii*	Shrub	Perennial	N	Non Consumed
QUPA4	*Quercus pauciloba*	Shrub	Perennial	N	Non Consumed
QUTU2	*Quercus turbinella*	Shrub	Perennial	N	Non Consumed
RANUN	*Ranunculus sp.*	Unknown	Unknown	Unknown	Unknown
RHTR	*Rhus trilobata*	Shrub	Perennial	N	Non Consumed
RUAC3	*Rumex acetosella*	Forb	Perennial	I	Non Consumed
RUHY	*Rumex hymenosepalus*	Forb	Perennial	N	Non Consumed
RUMEX	*Rumex sp.*	Unknown	Unknown	Unknown	Unknown
SAEX	*Salix exigua*	Shrub	Perennial	N	Unknown
SALIX	*Salix sp.*	Shrub	Perennial	N	Unknown
SATR12	*Salsola tragus*	Forb	Annual	I	Injurious
SAVE4	*Sarcobatus vermiculatus*	Shrub	Perennial	N	Non Consumed
SCLER10	*Sclerocactus sp.*	Shrub	Perennial	N	Injurious
SENEC	*Senecio sp.*	Forb	Unknown	N	Toxic
SESP3	*Senecio spartioides*	Forb	Perennial	N	Toxic
SHRO	*Shepherdia rotundifolia*	Shrub	Perennial	N	Emergency
SIAL2	*Sisymbrium altissimum*	Forb	Annual	I	Non Consumed

SOEL	*Solanum elaeagnifolium*	Forb	Perennial	N	Non Consumed
SOLAN	*Solanum sp.*	Forb	Unknown	N	Non Consumed
SONCH	*Sonchus sp.*	Unknown	Unknown	Unknown	Unknown
SPAI	*Sporobolus airoides*	Graminoid	Perennial	N	Emergency
SPAM2	*Sphaeralcea ambigua*	Forb	Perennial	N	Non Consumed
SPCO	*Sphaeralcea coccinea*	Forb	Perennial	N	Non Consumed
SPCOC	*Sphaeralcea coccinea ssp. coccinea*	Forb	Perennial	N	Non Consumed
SPCR	*Sporobolus cryptandrus*	Graminoid	Perennial	N	Non Consumed
SPFE	*Sphaeralcea fendleri*	Forb	Perennial	N	Non Consumed
SPGR2	*Sphaeralcea grossulariifolia*	Forb	Perennial	N	Non Consumed
SPHAE	*Sphaeralcea sp.*	Forb	Perennial	N	Non Consumed
SPHAE	*Sphaeralcea sp.*	Forb	Annual	N	Non Consumed
SPLE	*Sphaeralcea leptophylla*	Forb	Perennial	N	Non Consumed
SPORO	*Sporobolus sp.*	Graminoid	Perennial	N	Non Consumed
SPPA2	*Sphaeralcea parvifolia*	Forb	Perennial	N	Non Consumed
STCO6	*Streptanthus cordatus*	Forb	Perennial	N	Unknown
STEPH	*Stephanomeria sp.*	Unknown	Unknown	N	Emergency
STEX	*Stephanomeria exigua*	Forb	Annual, Biennial, Perennial	N	Emergency
STLO4	*Streptanthella longirostris*	Forb	Annual	N	Unknown
STPI	*Stanleya pinnata*	Forb	Perennial	N	Unknown
SUAED	*Suaeda sp.*	Subshrub/ Shrub	Perennial	N	Non Consumed
SUMO	*Suaeda moquinii*	Subshrub/ Shrub	Perennial	N	Non Consumed
SYOR2	*Symphoricarpos oreophilus*	Shrub	Perennial	N	Non Consumed
TAOF	*Taraxacum officinale*	Forb	Perennial	I	Non Consumed
TEAC	*Tetraneuris acaulis*	Forb	Perennial	N	Non Consumed
TEAR4	*Tetraneuris argentea*	Forb	Perennial	N	Non Consumed
TECA2	*Tetradymia canescens*	Shrub	Perennial	N	Toxic
TETRA17	*Tetraneuris* sp.	Unknown	Unknown	Unknown	Non Consumed
THELE	*Thelesperma sp.*	Forb	Perennial	N	Unknown
THME	*Thelesperma megapotamicum*	Forb	Perennial	N	Unknown
THSU	*Thelesperma subnudum*	Forb	Perennial	N	Unknown
TILA6	*Tiquilia latior*	Subshrub/ Forb	Perennial	N	Unknown
TOAN	*Townsendia annua*	Forb	Annual	N	Non Consumed
TOIN	*Townsendia incana*	Forb	Annual, Biennial, Perennial	N	Non Consumed
TRCA34	*Tripterocalyx carneus*	Forb	Annual	N	Unknown
UNK	*Unknown sp.*	Unknown	Unknown	Unknown	Unknown
VAST3	*Vanclevea stylosa*	Forb	Perennial	N	Unknown
VUOC	*Vulpia octoflora*	Graminoid	Annual	N	Non Consumed
YUAN2	*Yucca angustissima*	Subshrub/ Shrub	Perennial	N	Injurious

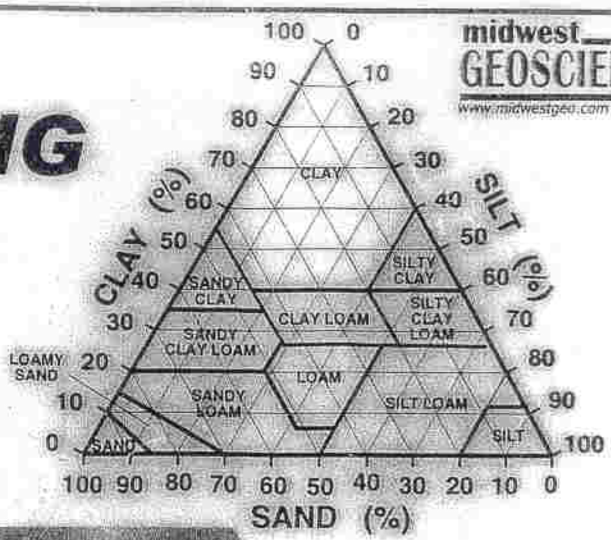
YUBA	*Yucca baccata*	Subshrub/ Shrub	Perennial	N	Injurious
YUCCA	*Yucca sp.*	Shrub	Perennial	N	Injurious

* Collections are included as Excel spreadsheet with digital Appendices

Appendix D

USDA SOIL TEXTURING FIELD FLOW CHART

midwest GEOSCIENCES group
www.midwestgeo.com



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

Does soil hold together when squeezed? — NO → Is soil too dry? (YES → back to start) — NO → Is sediment too wet? (YES → Add dry sediment → back to start) — NO → SAND

Does soil hold together when squeezed? — YES →

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

YES → Does the soil form a ribbon? — NO → LOAMY SAND

YES →

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

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

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

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

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

TEXTURE MODIFIERS
Fragment Content % by Volume

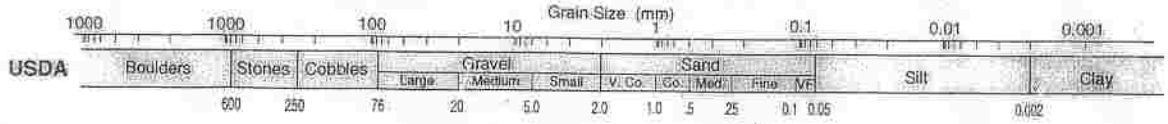
< 15%	No modifier
15% to <35%	Add modifer
36% to <60%	Add "very" with modifier
60% to 90%	Add "extremely" with modifier
>90%	No modifer: use Size Class only

ROCK FRAGMENT MODIFIERS
Size Class & Quantity

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

COMPOSITIONAL TEXTURE MODIFIERS
Organic Class

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



Appendix E

Appendix E, NRCS Forage Values, is too large to print and is included as a worksheet with the digital data in Excel format.