Navajo Nation Grazing District 11 Range Inventory Report

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1.0 INTRODUCTION AND PROJECT DESCRIPTION

Ecosystem Management, Inc., (EMI) was contracted by the U.S. Department of Interior Bureau of Indian Affairs, Chinle Agency, Natural Resources Department (BIA) to conduct range surveys on 541 vegetation sampling transects across approximately 335,837 acres on Grazing Land Management District 11 (District 11). Surveys were conducted in 2016 and excluded commercial forests. This report presents the results of those surveys.

As required by and pursuit to 25 CFR Part 167, the Navajo Grazing Regulation of December 24, 1957, the BIA is to adjust the livestock number to the range's grazing carrying capacity so that the Navajo livestock economy will not diminish. District 11 currently has 452 grazing permits, containing over 12,000 sheep units.

1.1 Purpose and Need

The BIA is working to document and establish range trend, vegetation utilization, rangeland health, and vegetation production on District 11. Field data will be used to adjust livestock stocking rate, assess range improvement needs, and in making natural resource management decisions. The current production and carrying capacity of the range is unknown and has not been sampled in decades. It is suspected that current stocking rates may not be appropriated for what the range can actually support. The results will be incorporated into the conservation plans that will be developed by the BIA.

1.2 Inventory History

Parts of District 11were inventoried in 2005 (Ecosphere 2005). Sampling in 2005 focused on commercial forests; this study focused only on lands outside of commercial forests. Thus, comparison of results between the two studies is not warranted.

2.0 RESOURCE DESCRIPTIONS

2.1 General Setting

The sampling area is located east and northeast of Chinle in Apache County, AZ, on the Navajo Nation (**Figure 18** Appendix A). Survey transects span portions of Round Rock, Lukachukai, and Tsaile/Wheatfields Chapters. A few transects occur in Chinle and Many Farms Chapters near the borders of one of the aforementioned chapters. The sampling area is roughly bordered by the Chinle Valley to the northwest, Canyon del Muerto, Canyon de Chelly, and Black Rock Canyon (all part of Canyon de Chelly National Monument) to the southwest, and the Chuska Mountains to the east. The southern portion of the sampling area is located on the northern end of the Defiance Plateau.

2.2 Topography

The study area occurs within the Colorado Plateau Physiographic Province, which is characterized by a sequence of flat to gently dipping sedimentary rocks eroded into plateaus, valleys, and deep canyons. Elevation in the sampling area ranges between approximately 4,790 and 8,530 feet. The sampling area boundary roughly follows the contours of the Chuska Mountains and Carson Mesa, with the majority lying within the Chinle Valley. Canyon de Chelly and Canyon del Muerto traverse the sampling area in the southern portion. Landform types within the sampling area include plateaus, fans, mesas, cuestas, valley sides, structural benches, and fan remnants.

2.3 Geology

The geology underlying the sampling area is mapped as Glen Canyon Group (Early Jurassic), including Navajo Sandstone; sedimentary rocks (Oligocene to Eocene or locally Paleocene); Chinle Formation (Late Triassic), including the Shinarump Conglomerate Member; older surficial deposits (middle Pleistocene to latest Pliocene); and sedimentary rocks (Permian and Pennsylvanian), including De Chelly Sandstone (Richard et al. 2000).

The sampling area encompasses portions of the Chinle Formation at the western end, in which colorful beds of fine mudstone, volcanic ash, and conglomerate occur in the landscape. The Chinle Valley expands a wide open area where barren strata display a westward dip. To the northeast, the Chuska Mountains shape the skyline, and thick layers of sandstone from the Bidahochi Lake deposits make up the mountain wall and are covered with remnants of once extensive lava flows. To the east rises the incline of the Defiance Upward, and horizontal rock layers that edge Carson Mesa and Black Mesa border the valley on the west. Most of the pebbles that make up desert pavement in the Chinle Valley come from conglomerate layers in the Chinle Formation. Among these layers is the lowest member of the Chinle Formation, the Shinarump Conglomerate, which covers the sloping Defiance Plateau to the east. Canyon de Chelly and Canyon del Muerto cut through this layer and into the De Chelly Sandstone below (Chronic 1983).

The most prominent formation of the Glen Canyon Group is Navajo Sandstone, easily recognizable with its pale pink, salmon, or light gray color and large-scale cross bedding. The Chuska Mountains east of Round Rock are close to New Mexico and exhibit the Chuska Formation, which caps the light-colored Tertiary sedimentary rocks. The north end of the sampling area drops rapidly off the Defiance Upward, and Agathla Peak is in view to the west, along with Comb Ridge (Navajo Sandstone) below it (Chronic 1983).

Canyon walls of Canyon de Chelly National Monument and Canyon del Muerto expose the De Chelly Sandstone, eolian sandstone and pale peach-colored rock deposited in a vast desert in the supercontinent Pangaea. Giant slabs of the canyon wall crash to the floor of the canyon due to stream erosion and repeated frost action, which was more forceful in the past when Ice Age climates brought increases in precipitation and long, frigid winters. The thousand-foot walls of these canyons and their tributaries are marked with dark, shiny stains of iron oxides and manganese in which early residents created petroglyphs (Chronic 1983).

2.4 Soils

According to ecological site description (ESDs) covering the sampling area, the soil temperature regime is mesic, and the soil moisture regime consists of aridic ustic, typic aridic and ustic aridic. Soil features in higher elevations of the sampling area are generally very shallow to shallow, with surface textures consisting of gravelly fine sandy loam, channery fine sandy loam, very fine sandy loam, and loam. Parent materials include fine-loamy eolian deposits and/or residuum weathered from sandstone. Lower elevations tend to have soils that are moderately deep to very deep, well drained and saline-sodic that formed in reworked eolian material and alluvium derived from sandstone, shale, and siltstone. Surface textures range from very fine sandy loam to sandy loam, and subsurface textures range from sandy loam to sandy clay loams. **Table 68** in Appendix B presents the soil map units on which sampling transects occur.

2.5 Hydrology

Influencing water features could vary within the sampling area. The site could receive runoff from sites with deeper soils above it and high runoff potential to generate runoff to sites that lie below it. Some sites neither benefit significantly from run-in of moisture nor suffer from excessive loss of moisture from runoff. Sites with sandy surface textures allow the site to capture the majority of both gentle winter storms and intense summer thunderstorms with little runoff. The sampling area contains numerous ephemeral washes; some, such as Chine Wash and washes in Canyon de Chelly, are of substantial size. The watershed is the Chinle Subbasin, Lower San Juan Basin, San Juan Subregion, and Upper Colorado Region.

2.6 Climate

According to ecological site descriptions covering the study area, the sampling area falls under a bi-seasonal weather regime identified by summer and winter precipitation and fall and spring droughts. Summer months receive the greatest amount of precipitation in the form of heavy rain storms with limited infiltration that originates from the Gulf of Mexico, while winter precipitation originates from the Pacific Ocean and contributes to less intense storms but brings significant precipitation and contributes to groundwater recharge. Winds are southwesterly, and the area is generally arid, with the higher elevations of the Navajo Nation receiving far more precipitation than other areas. In the sampling area, average annual high temperature is 67.6ºF, and maximum temperatures can exceed 105ºF; annual low temperatures average 38.7ºF, with minimums reaching −20ºF. Average annual precipitation ranges 6–17 inches, and average annual snowfall is six inches.

2.7 Vegetation Communities

The project is located within the Colorado Plateau and Arizona–New Mexico Mountains terrestrial ecoregions (The Nature Conservancy 2009) and Colorado Plateau Major Land Resource Area (USDA Natural Resources Conservation Service 2006). The vegetation communities are mapped as Great Basin desert scrub, plains and Great Basin grassland, Great Basin conifer woodland, and Petran montane conifer forest (Brown 1994). According to ecological site descriptions covering the sampling area, the historic climax plant communities were dominated by warm- and cool-season grasses with scattered shrubs and trees.

The majority of the sampling area is dominated by *Pinus edulis*, *Juniperus osteosperma*, and *Artemisia tridentata*. *Bouteloua gracilis* and *Pleuraphis jamesii* are the dominant grasses. *Gutierrezia sarothrae* is an abundant subshrub in many areas. The northwestern portion of the sampling area is sandier and lacks large shrubs. This area is manly desert scrub and consists of *Atriplex*, other low shrubs, and a variety of grasses and forbs.

3.0 METHODOLOGY

3.1 Survey Area and Analysis Units

The sampling area consisted of roughly three-fourths of grazing district 11 (Appendix A **Figure 18**), totaling approximately 352,624 acres. The BIA selected 541 vegetation sampling transects and their locations.

There were 16 analysis units established by the BIA for this study (Appendix B **Table 66**). Analysis units consist of separate grazing range units. Most of these are Range Management Units (RMU); chapter boundaries were used as analysis units for areas not falling within an RMU. Commercial forests outside of RMUs were not included. There are nine RMUs, but one is split into five smaller analysis units. Of the nine RMUs, seven are located within the Tsaile/Wheatfields Chapter. The remaining portions of the Chapter located outside the RMUs, minus commercial forests, is an analysis unit. Two RMUs are located within the Lukachukai Chapter; the part of the Chapter located outside the RMUs is an analysis unit, minus commercial forests. Lastly, the entire Round Rock Chapter, minus commercial forests, is an analysis unit. The term analysis unit, or just unit, is used in this report to refer to RMUs or Chapters areas outside RMUs. Data collected in this study were analyzed and summarized by the 16 analysis units. Nine transects were not located in any analysis unit or were located in commercial forests and were thus not included in analyses.

3.2 Vegetation Sampling

Methods for vegetation sampling were described in the scope of work for this project and further detailed in three government-agency manuals: Sampling Vegetation Attributes Interagency Technical Reference (U.S. Department of the Interior Bureau of Land Management National Applied Resource Sciences Center 1999), Inventory and Monitoring Technical Reference 1734-7 (Habich 2001), and National Range and Pasture Handbook (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003). Transects were sampled early June through early August 2016.

Transect Establishment—541 transect locations were provided as GIS shapefile points by the BIA (Appendix A **Figure 19**). Points were loaded on GPS units, which were used to located transect locations in the field. GPS units typically allowed samplers to located points within three meters. If a transect point was located in an unattainable location, such as a residence or steep canyon, it was relocated as close as possible to the original location, and the new location was documented. The letter A was attached to the transect name to designate it as moved. Two sites were unattainable due to location and were not reestablished (11-149 and 11-534).

Once transect points were located, transect direction was established by randomly selecting a compass bearing (0–360°), and various landscape data were collected. All compasses had declination set to + 11 West. If a transect direction crossed a main road, different ecological site, or topographic feature such as a steep cliff, another random bearing was selected. Transect bearing was recorded along with the landform type, aspect, and slope. The dominant plant community and forage plants were also recorded. Soil texture was determined using a Wetland Training Institute soil texture key.

Sampling Biomass Production—Biomass sampling was based on the double sampling method. Vegetation sampling transects were 200 feet long. At the zero foot location, or transect beginning, a landscape photo was taken in the direction of the transect. Transects were paced out, and every 20 feet a 9.6-ft.^{2} sampling quadrat was placed on the ground at the surveyor's toe, with the quadrat placed on the right side of the transect at each 20-ft location. Thus, ten quadrats were sampled on each transect. A photo was taken of the first quadrat on each transect.

The weight of the current year's production (annual production; wet weight) for each species in the quadrat was estimated in grams. The area of estimation was three dimensional. It consisted of the quadrat and an imaginary wall, or rectangular prism, 4.5 feet high extending up from each side of the quadrat. All parts of all plants located within the quadrat were estimated, regardless of if they were rooted inside the quadrat; all parts of plants outside the vertical projection of the quadrat were excluded, even if the bases were rooted within the quadrat. Sampling only included ground and understory plants; large shrubs or trees like *Pinus*, *Juniperus*, and *Quercus* were not sampled. Woody plants with an estimated diameter at breast height (DBH) of three inches or larger were classified as large shrubs or trees. Species occurring in quadrats obviously weighing less than a gram were recorded and assigned a wet weight of 0.25 gram.

Larger 0.01-acre plots were used to estimate shrub and subshrub biomass. A 21 x 21-foot plot was placed around each 9.6-ft^2 quadrat. All shrubs (e.g., *Artemisia*, *Ericameria*, *Chrysothamnus*, *Ephedra*, *Purshia*, *Eriogonum*, *Atriplex*) and subshrubs such as *Gutierrezia sarothrae* were estimated within these larger plots. Species estimated in larger plots were marked thus on datasheets for later conversion to grams per acre.

Weight units were established for plants. Surveyors calibrated their biomass estimates by periodically clipping and weighing a representative part of a plant species, such as a tuft of grass, clump of *Gutierrezia*, or branch of *Artemisia*. This method is detailed in USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003). Biomass within quadrats could then be easily estimated by counting the number of weight units for a species and multiplying this times the weight unit's wet weight.

Current year's biomass for each species in the third and seventh quadrats (60 and 140 feet on the transect; "clipping plots") was clipped and weighed after estimation. In clipping plots, current year's biomass was estimated as in other quadrats, and then the biomass of each species was clipped to approximately 0.5 inches above the ground. Clipped biomass of each species was weighed to the nearest gram, recorded, and bagged in paper bags. Bags were labeled for later processing in Albuquerque, NM. Vegetation was allowed to air dry indoors as long as needed until each sample was completely dry. The no-clip list approved by BIA for the 2005 range inventory (Ecosphere Environmental Services 2007) was used (Appendix B **Table 67**), with the addition of an invader annual composite forb. These plants, which are considered undesirable for livestock, were estimated only and were not clipped.

Species abundant on a transect but not occurring in a clipping plot were sampled off transect. A clipping of the species was sampled off transect to capture the desired species information missed in the principal clipping plots. The target species was estimated, clipped, weighed, and bagged as described above. The purpose of this sample was to allow the calculation of an estimation correction factor and air-dry weight conversions (see below) for species contributing substantial biomass to a transect but not captured in the main two clipping plots. The actual weight of the species sampled off transect was not included in reconstructed weights for the transect.

A utilization correction factor (UCF) was recorded for grazed species on each transect based on observed utilization on the local surrounding landscape. For this, the percent of grazed, or missing, current year's biomass was estimated for species with obviously grazed biomass in the area surrounding the transect, most often common grasses such as *Bouteloua gracilis* but also shrubs such as *Artemisia tridentata*. This is based on methods described in USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003). Surveyors estimated the percent grazed on the local landscape, and this was converted to percent ungrazed, which is what a UCF represents. This factor is used to calculate the amount of biomass that would be present in the absence of grazing (see below).

Ground Cover and Canopy Closure—Two other variables were also measured on transects. Ground cover was estimated by placing a pencil at each of the four corners of the 9.6-ft.^{2} quadrats and recording the ground cover intersected by the pencil tip. Ground cover types consisted of bare ground, gravel/rock, plant litter, bio crust (including moss), basal vegetation (plant parts attached to the ground), and canopy vegetation (plant parts over the ground but not attached such as bent grass blades). Across the entire transect, 40 cover measurements were taken total. Canopy closure was measured using a densiometer. Four readings were taken at the 100-ft. location on the transect. One reading was taken in the direction of the transect, one in the opposite direction, and two readings perpendicular to the transect. Note that canopy closure measures available light from above and around the observer and is not the same as canopy cover, which measures only light from above.

3.3 Data Processing and Analyses

3.3.1 Precipitation Data and Water Sources

Data from eight rain gauges in or near District 11 were used to calculate biomass production and convert annual production to (Appendix B **Figure 19**). Annual precipitation data and gauge locations across the sampling area were provided by Navajo Nation Water Resources. Data ranged from 2005 to 2016. For each station, the 12-year normal precipitation was calculated along with the 2016 departure from normal (Appendix B **Table 69**). Thus, each species's reconstructed weight was adjusted, so the final value is not representative of the sampling year's weight but the annual weight during a normal precipitation year. Data from some months of some years were missing or estimated due to gauges being damaged (e.g., screens off or antifreeze lose).

Sources of water were provided by the BIA. These include windmills, springs, wells, and other sources available to livestock. These can be used to adjust stocking rates based on distance to water. Distance to water for analysis units was summarized by taking the average distance of vegetation sampling transects to the nearest water source within each analysis unit. Many livestock ranchers haul water in the study area. These water sources could not be quantified.

3.3.2 Annual Biomass Production

The calculation of annual biomass production, or reconstructed weight, involves the use of multiple correction or conversion factors to calculate pounds per acre dry weight for a species detected on a transect. These include correcting for observer weight estimation, converting wet weights to dry weights, correcting for missing grazed vegetation at the time of sampling, correcting for production that has yet to occur when sampling occurs early in the season before production peaks, and finally, a correction factor for the amount of growth relative to normal growing conditions for the year, which in this case is the percent of normal precipitation for the sampling year. The resulting annual biomass production for a species on a transect represents the normal production expected to occur during years with normal precipitation.

Estimation Correction Factor—This factor (ECF) is calculated for species on a transect that were clipped and weighed. The actual wet weight (wt.) of a species is divided by the estimated wet weight of that species within a clipping plot (or summed weights if it occurs in two clipping plots). This factor is then applied to the combined estimated weights for that species across a transect and can either increase or decrease the estimated weight, depending if observer error is above or below the actual wet weight. The correction factor is set to one if a species on a transect did not occur in a clipping plot or was not clipped off transect and thus has no effect on the biomass estimate. The estimation correction factor formula is:

$$\text{Estimation Correction Factor (ECF)} = \frac{\text{Actual wet wt. clipped}}{\text{Estimated wet wt. clipped}}$$

Air-dry Weight Conversion—The air-dry weight (ADW) conversion accounts for the percentage of the dry biomass weight remaining from wet weight biomass. Annual biomass production is reported in dry weights, so this conversion accounts for that. The resulting percentage is applied to the combined estimated wet weights for a species across a transect. The conversion formula is:

$$\text{Air-dry Weight Conversion (ADW)} = \frac{\text{Air dry wt.}}{\text{Wet wt.}}$$

Species not clipped on a transect were assigned ADW conversions based on those presented for various plant types in Exhibit 4-2 in USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003).

Utilization Correction Factor—The utilization correction factor (% ungrazed) is estimated for species to account for grazed, or missing, current year's biomass. This is used in the calculation of the annual biomass for a species on a transect. For example, if a site had 100 lbs./ac. of *Bouteloua gracilis*, but a 90% UCF, then the actual biomass in the absence of grazing would be 100/0.90 = 111 lbs./ac. Thus, in this example, the UFC value is 0.90.

Annual Production Seasonal Growth Curve Factor—Percent of annual production seasonal growth factors (SGF) are assigned to transects based on the month in which they were sampled. This is a percentage of completed annual growth that accounts for the amount of plant production that has yet to occur during the time of sampling. For example, if a site had 100 lbs./ac. of a species when sampled in July when percent annual production was only 70%, then the actual biomass at the end of the growing season would be 100/0.70 = 143 lbs./ac. Thus, in this example, the SGF value is 0.70.

Seasonal growth curves are found in some ESDs and portray the annual percentages of a species's production throughout the year. ESDs typically present growth curves for select species and for all sites combined. The all-sites growth curves were used for calculating annual biomass production on transects. Some ESDs assigned to transects lacked growth curves or all-sites growth curves, so these were assigned the all-site growth curve used in other ESDs in the same Major Land Resource Area and Land Resource Unit, with ranges and forest ESDs matched accordingly. Transects were then assigned the value on the curve that matched the month in which they were sampled.

Percent of Normal Precipitation Correction Factor—The percent of normal precipitation (PNP) correction factor is used to adjust what would otherwise be only current year's annual biomass production to annual biomass production, or the typical annual production for a site given normal precipitation. This facilitates among-year comparisons and in determining similarity indices by removing year-to-year precipitation variation, which greatly affects biomass production.

Transects were assigned PNP values determined from the nearest precipitation gauge station. The PND is applied to biomass and can either reduce or increase the final constructed weight, depending on if precipitation was above or below normal. For example, if a species on a transect has a biomass of 100 lbs./ac., then this is the biomass for the current year. If precipitation for the year was 10% above normal, then the actual annual production, or reconstructed weight, is 100/1.1 = 90.1 lbs./ac. Thus, in this example, the PNP value is 1.1.

Annual Biomass Production, or Reconstructed Weight—This is the principal calculated value for a species on a transect produced by double estimate biomass sampling and all the above conversion/correction factors. The formula for calculating biomass production from transect data, using the correction and conversion factors discussed above, is taken from Habich (2001) and USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003). Habich (2001) uses a formula that does not include correcting for annual percent of normal precipitation, which is used here. The formula is:

$$\text{Reconstructed weight} = \frac{(\text{Actual wet wt.})\ (\text{ECF})\ (\text{ADW})}{(\text{UCF})\ (\text{SGF})\ (\text{PNP})}$$

For example, a species has 100 g of summed wet weights across a transect. In a clipping plot, the wet weight was estimated to be 20 g and the actual weight was 23 g. After drying, the dry weight from the clipping plot sample was 5 g. The ECF would be 23/20 = 1.15. The ADW would be 5/20 = 0.25. The UCF for this species on this transect was estimated at 90%, or 0.9, ungrazed. The SGF for this species, which was sampled in July, is 70%, or 0.7. Finally, the PNP for the year is 90%, or 0.9 of normal precipitation. The reconstructed dry weight in this example would be:

$$\frac{(100)\,(1.15)\,(0.25)}{(0.9)\,(0.7)\,(0.9)} = 50.7 \text{ g dry weight}$$

Biomass estimates and clipped weights collected off transect were used to calculate the estimation correction factor and air dry weight conversion for species sampled off transect. Biomass estimates from off-transect species were not used in the final calculation of annual biomass production because this would alter the conversions to pounds per acre from grams per ten quadrats on a transect.

Conversion to Pounds per Acre—On each transect, ten 9.6-ft.^{2} quadrats were sampled, which equal an area of 96 ft.^{2}. Biomass weights were estimated and weighed in grams. The conversion of g/96 ft.^{2} to lbs./ac. is 1:1 (U.S. Department of the Interior Bureau of Land Management National Applied Resource Sciences Center 1999). For larger 0.01 shrub plots, the total area sampled is 0.1 acre per transect, and the resulting data are in g/0.1 ac. The reconstructed weight of species sampled in larger plots was converted to lbs./ac by multiplying the weight by 0.0022046, which converts grams to pounds, then multiplying this by ten, which converts 0.1 acre to 1.0 acre.

Note that annual biomass production was calculated two ways: 1. Using all sampled species on a transect for calculating similarity indices, range conditions, and apparent trend; and 2. Using only desirable species and excluding undesirable species (from a sheep's perspective) to calculate stocking rates (see Section 3.3.5). Biomass production for each transect were averaged across analysis unit and ESD for results.

3.3.3 Ecological Sites

Ecological sites were assigned to transects to facilitate the calculation of similarity indices, seasonal productions, and range condition. Ecological sites are described in ESDs, which contain information on plant communities, soil types, climate, plant production, plant cover and structure, and ecological dynamics. Different states and transitional states are often described for an ecological site, but often the in-depth details described above are provided only for the reference site. The reference site represents the historical climax plant community, which is what is believed to have been present before the European invasion of North America.

A subset of ESDs were first assigned to transects based on the soil map unit on which a transect occurs (Appendix B **Table 68**). Soil map units for transects were determined from three USDA Natural Resource Conservation Service soil reports (2014, 2015, 2016). Soil map unit descriptions contain one or more ESDs, depending on the number of soil types comprising a map unit. Each soil type is assigned one ESD. Once a subset of ESDs were assigned to transects, the dominant vegetation community, species composition, and soil texture data collected on the transect were used to determine which ESD best fit. In many cases, the existing community was in a state far from the reference state, and in other cases, none of the ESDs was a good option. In these cases, the final selection was based on either the presence of a dominant tree or shrub or soils alone. Almost all of the ESDs used were in provisional stage of development. The ecological sites selected for transects are presented in Appendix B **Table 70**.

3.3.4 Calculating Similarity Indices

Similarity indices were used to compare transect vegetation conditions to the reference plant community described in the ESD to which the transect was assigned. A similarity index is a percentage, where a site at 100% would be as close as possible to the reference site plant community, or historical climax plant community. Calculating a site's similarity index involves multiple steps and is described in USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003). First, the reconstructed annual biomass for all species on a transect is calculated, as described above, using the vegetation biomass data collected in the field. This is what is compared to the production of species in the ESD reference site to determine similarity index.

Next, the "allowable production," as determined from the transect's ESD, for each species must be determined. ESDs describe the potential low and high production (lbs./ac.) values for select species and lifeform groups (e.g., perennial forbs). For each species on a transect, the low and high production values described in the ESD are averaged. The reconstructed biomass production for a species is compared to percentage of total allowable production for the site that species is allowed. If the reconstructed weight is less than this value, then this value is used to calculate the similarity index; if the weight is greater than this value, then the allowable percentage previously calculated is used. ESDs also describe the representative annual production values for the plant types grass/grasslike, forb, shrub/vine, and tree in the ESD (lbs./ac.). The representative values for grass/grasslike, forb, and shrub/vine are summed to get a the total allowable production for the ecological site, minus trees. Tree production is not included in our analyses because this category includes mostly species that were not sampled on transects such as *Pinus*, *Juniperus*, and *Quercus*. Each low–high species production average is then divided by the summed representative annual production values (grass, forb, shrubs). This is the percent of biomass production each species can contribute to the site's allowable production. If a species was sampled on a transect but is not included in the ESD, it is assigned a production percent of zero toward the site's allowable production.

For example, say a transect has 100 lbs./ac. of reconstructed annual *Bouteloua gracilis* production as determined from field data. The transect's assigned ESD says that the summed representative, or potential, annual production for grasses, forbs, and shrubs is 500 lbs./ac. The ESD says the low and high production values for *Bouteloua* are 40 and 105 lbs./ac., respectively. The low–high average is 72.5. Now, 72.5 divided by the 500 total site production = 0.15. Thus, *Bouteloua* is allowed to contribute 15% of biomass towards the total allowable production of 500 lbs./ac., which is 75 lbs./ac. So, how much of the actual 100 lbs./ac. of *Bouteloua* from the sampled transect can contribute towards the similarity index? The allowable contribution of *Bouteloua*, based on the calculations from the ESD values, is only 75 lbs./ac., but the reconstructed weight is 100 lbs./ac. Hence, only the value of 75 can be used toward calculating the similarity index. If the reconstructed weight of *Bouteloua* was less than 75, say 60, then all 60 lbs./ac. would be used in the similarity index calculation.

Finally, the allowable biomass for each species (allowed to contribute to the similarity index) is summed. The sum is divided by the total allowable production (sum of representative annual production values) to get the similarity index. For example, adding to the example above, say the same transect also had *Atriplex*, *Ipomopsis*, and *Pleuraphis*. Now say the allowable biomass that can be contributed toward the similarity index was calculated for the first two species (as in the *Bouteloua* example) to be 50 and 5 lbs.ac., respectively. If we say that *Pleuraphis* is not in the ESD, it can contribute nothing. Thus, the matrix of biomass contribution for all the species used to calculate the similarity index would be:

Bouteloua = 75
Atriplex = 50
Ipomopsis = 5

Pleuraphis = 0

These values are summed to get 130 lbs./ac. This is the amount of the transect's historic climax plant community allowable biomass. This value of 130 divided by the total allowable production of 500 lbs./ac. from the example = 0.26; thus, the similarity index for this site is 26%. One can infer that this site is far from historic conditions. Allowable lbs./ac. were averaged across analysis units and ESDs first, then the average was divided by the total allowable, or potential, production to get a similarity index for the analysis unit/ESD.

3.3.5 Range Condition

Range condition is determined by grouping analysis units/ESDs' similarity indices into four range categories. The categories are Poor (0–25%), Fair (26–50%), Good (51–75%), and Excellent (76–100%). Thus, the closer a site is to its historic climax plant community the better the range condition. Range condition was assigned based on the average similarity index for analysis unit and ESD.

3.3.6 Carrying Capacity and Stocking Rates

Long-term carrying capacity and stocking rates were determined from the annual biomass production for each analysis unit/ESD. To calculate these, the amount of forage available is multiplied by the expected harvest efficiency for the area of interest. The harvest efficiency is the amount of forage allocated for the animal's consumption. A harvest efficiency of 25% was used, which is typically for range land (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003). The harvest efficiency is then divided by the amount of forage allocated to an AUM. The amount of forage allocated to one animal for one month is derived from the literature. For this study, sheep is the main livestock, and the values for a mature sheep are: 0.20 = animal unit equivalent; 158 lbs. dry forage per month. The BIA determined that stocking rates should be calculated for nine-month periods for three analysis units (Appendix B **Table 66**) because sheep tend to be grazed on commercial forests three months out of the year. During this time, non-commercial forest grazing lands are presumably rested. Thus, a mature sheep would consume approximately 1,422 lbs. of forage over nine months. The remaining analysis units have carrying capacities calculated for a year, so one mature sheet would consume 1,898 lbs. dry forage per year.

Several adjustments were made before calculating stocking rates. First, undesirable plant species were excluded from the data (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003). Species on the undesirable plant list in Appendix B **Table 67** were excluded from the data before stocking rates were calculated. If they were not, stocking rates could be estimated too high because nonedible species would contribute to available forage.

Following is an example. Say the average annual biomass for an analysis unit/ESD is 1,000 lbs./ac after removing undesirable species. This amount multiplied by the harvest efficiency rate of 0.25 = 250 lbs./ac. This, divided by the 1,422 lbs. for one sheep for nine months = 0.18 sheep/ac./9 months stocking rate, or, 5.56 acres needed for one sheep for nine months. This could be modified based on the distance to water and feral horses (see Discussion).

Long-term carrying capacities were calculated for each ESD by analysis unit. This was done by calculating the acreage of each ESD in each analysis unit. For this, the acreages of the soil map units in which the ESDs occurred were calculated for each analysis unit. ESDs were assigned the percentage of the total map unit acreage based on the percentage of soil type in which the ESD occurred. Remaining percentages of minor soil types were split up by the same percentages and assigned to the total ESD acreage percent. Rock outcrop percentages were not included in these calculations as this terrain does not support livestock grazing.

For example, say soil map unit XX consisted of soil type A, which comprised 50% of the soil unit, and soil type B, which comprised 45% of the map unit. This would mean the remaining 5% was comprised of minor soil types. Now say soil A was assigned ESD Y, and soil B ESD Z. Using GIS, we determined that in grazing district 123, soil unit XX covered 1,000 acres. So what is the acreage of ESD Y? ESD Y occurs in soil type A, which occurs in 50% of the soil unit, so 50% of 1,000 acres is 500 acres. Then, the remaining 5% is split by the 50% and assigned to the acreage of soil type A, so 50% of 5% = 2.5%, added to 500 = 502.5 acres of soil type in district 123, which means that there are 502.5 acres of ESD Y in district 123. Now using the sheep example above for a nine-month analysis unit, the carrying capacity for this area, based on the sheep example stocking rate of 0.18 sheep/ac/9 months, would equal a 90 sheep/9 month carrying capacity in ESD Y in grazing district 123. The carrying capacities for all ESDs can be summed to get the total carrying capacity for the entire analysis unit. Note, however, that the carrying capacity does not account for additional grazing pressure from cattle, feral horses, or native ungulates.

3.3.7 Ground Cover, Frequency, and Canopy Closure

Ground cover percentages for each cover types were calculated for each transect using the 40 cover measurements. The total of all percentages for each type total 100% for each transect. Canopy closure was calculated for each transect by averaging the four readings. Select species frequencies of common species were calculated based on the number of transects on which a species occurred.

3.3.8 Apparent Trend

Trend is the direction of change in a plant community relative to the historic climax plant community, or reference site (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003). In this study, we discuss apparent trend, which is a point-in-time determination of the direction of change (vs. measured trend). There are different ways to determine apparent trend; for this study we are limited to looking at compositional changes in species frequency between what would be expected in the historical community and the current community. For this, select species classified as either decreasers, increasers, or invaders were used.

The designation of decreaser, increaser, and invader species refers to the way in which a species responds under continuous grazing and can be used to assess apparent trend via compositional change (see below). The National Range and Pasture Handbook (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003) defines these terms as follows:

Decreaser—Plant species of the climax vegetation that will decrease in relative amount with continued heavy defoliation (grazing).

Increaser—The climax native plants in a community of different plants that, under excessive continuous grazing by livestock, are not selected initially, and increase in abundance. If the heavy grazing continues, livestock will reduce the more palatable plants and shift to the increaser species causing them to decrease in abundance.

Invader—Plants that are not a part of the original plant community that invade an area as a result of disturbance, or plant community deterioration, or both.

A trend can be assigned to ESDs in analysis units by assessing the mean frequency of species occurring in each of the three classes. For example, if frequencies are highest in the increaser category, the trend would be moving "away" from the historical climax community.

4.0 RESULTS

Non-edible plant species biomass was removed for the calculation of stocking rates and carrying capacities. One transect (11-209; ESD R035XB220AZ) in Round Rock unit was completely removed because *Gutierrezia sarothrae* was the only species occurring. Stocking rates are shown for ecological sites in which sampling transects were located and for the entire analysis unit. Note that carrying capacities by ecological site are based on the estimated maximum potential acreage of ecological site for an analysis unit, as determined from soil map unit acreage. However, most soil map units can consist of more than one ecological site, which would affect ecological site acreages and thus carrying capacities. The unit-wide carrying-capacity estimates are based on the total acreage of the unit and do not account for slope, distance to water, inaccessible areas, unvegetated areas (e.g., cliffs, rock, developed areas), or unsampled ecological sites, which could affect production averages. Stocking rates and available acreage are best used. Adjustments should be made to account for feral horses (see Discussion and Recommendations).

4.1 District Wide

Cover and Canopy Closure

The mean canopy closures for District 11 and each analysis unit in the sample are shown in **Table 1**. Mean ground covers for District 11 are shown in **Figure 1**. Across all transects, basil ground cover ranged 0–68%, canopy ground cover 0–75%, litter, bare, gravel/rock all ranged 0–100%, and biocrust ranged 0–58%. Canopy closure ranged 0–100%. Across District 11, gravel/rock and bare ground comprised most of the ground cover.

Table 1. Mean canopy closures for District 11 and analysis units.

Analysis Unit	Mean % canopy closure
Albert Lee	33
Ason Ben Yazz	1
David Kedelty	5
John Smith	20
Keyoni	2
Litson	52
Lukachukai	5
Ram Pasture	0
Round Rock	1
Sam Johnny 1	42
Sam Johnny 2	49
Sam Johnny 3	55
Sam Johnny 4	29
Sam Johnny 5	36
Wheatfields	14

Analysis Unit	Mean % canopy closure
Willie Shirley	27
District 11	**11**

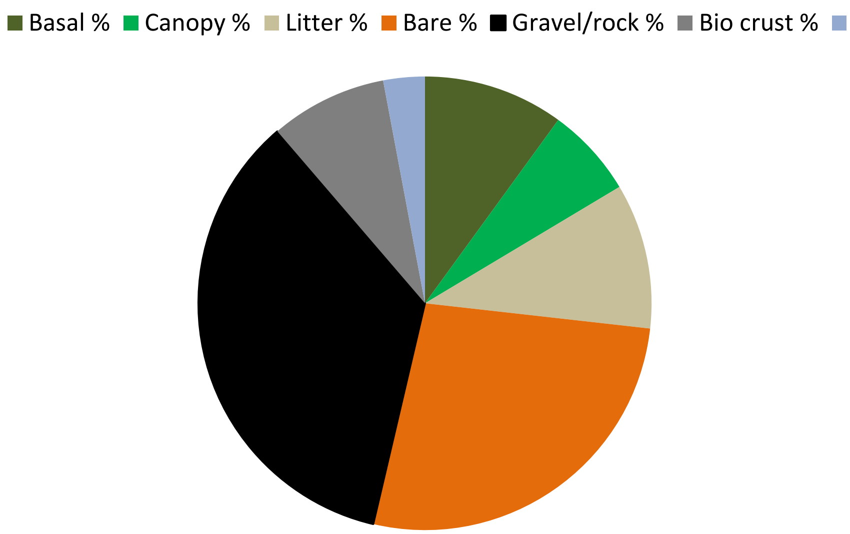

Figure 1. Mean ground cover in District 11.

Species Frequency

Frequencies of common plants in District 11 are shown in **Table 2**. By far the most frequently occurring plant on transects was *Gutierrezia sarothrae*. The next most frequent plants were *Artemisia tridentata*, *Bouteloua gracilis*, and *Pleuraphis jamesii*. Both of these grasses are warm-season grasses that increase with grazing pressure (Waller and Lewis 1979, Monsen et al. 2004). Note that canopy species like piñon pine, junipers, and oaks were not sampled.

Table 2. Species frequency of common plants in District 11.

Species	Frequency
Decreasers	
Achnatherum hymenoides	25%
Amelanchier utahensis	1%
Carex spp.	5%
Elymus longifolius	27%
Hesperostipa comata	15%
Kraschenínnikovia lanata	2%
Muhlenbergia montana	6%
Pascopyrum smithii	11%
Poa fendleriana	14%
Sporobolus contractus	1%

Species	Frequency
Sporobolus cryptandrus	15%
Sporobolus spp.	2%
Increasers	
Aristida spp.	8%
Artemisia spp. (forb)	5%
Artemisia bigelovii	5%
Artemisia cana	0%
Artemisia filifolia	5%
Artemisia nova	2%
Artemisia tridentata	49%
Atriplex canescens	3%
Atriplex confertifolia	19%
Bouteloua gracilis	41%
Ephedra spp.	16%
Eriogonum corymbosum	0%
Eriogonum spp.	3%
Pleuraphis jamesii	40%
Purshia stansburiana	8%
Purshia tridentata	3%
Rhus trilobata	1%
Sphaeralcea spp.	23%
Invaders	
Antennaria spp.	3%
Asteraceae annual forb (unknown)	30%
Astragalus spp.	6%
Bromus tectorum	17%
Chrysothamnus depressus	7%
Chrysothamnus greenei	19%
Chrysothamnus spp.	2%
Chrysothamnus viscidiflorus	2%
Cordylanthus wrightii	3%
Ericameria nauseosa	10%
Gutierrezia sarothrae	82%
Opuntia spp.	8%
Senecio spp. sensu lato	15%
Salsola tragus	5%
Sarcobatus vermiculatus	3%
Yucca spp.	2%
Total decreasers	**124%**
Total increasers	**230%**
Total invaders	**212%**

Production and Trends

The average reconstructed biomass production, including all species, across District 11, was 224 lbs./ac., with a standard deviation of 642 lbs./ac. Of the common plants in District 11, increasers were the most frequent, followed closely by invaders (**Table 2**); thus, the apparent trend is determined to be *away* from reference conditions. Across all ecological sites/analysis units in District 11, range conditions ranged from mainly poor to one site in in good condition; no sites were in excellent condition (Appendix A **Figure 21**).

4.2 Albert Lee

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 2**.

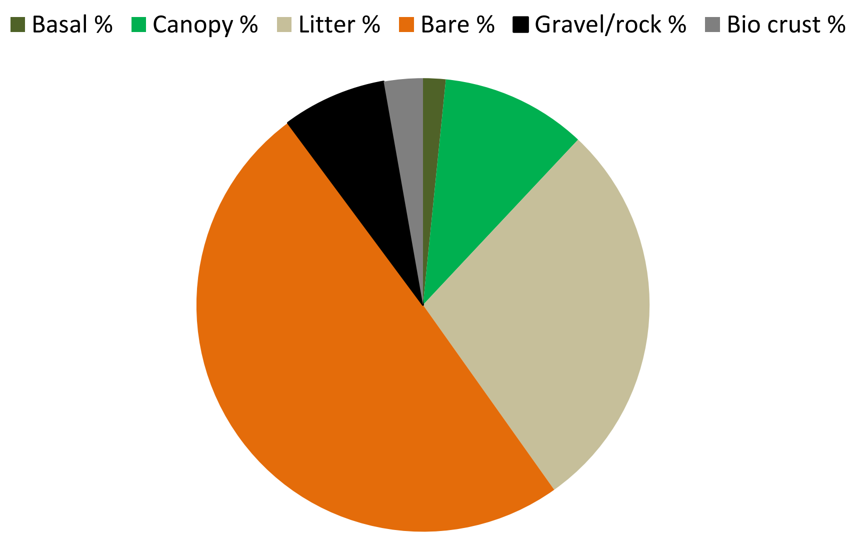

Figure 2. Mean ground cover in Albert Lee unit.

Species Frequency

Frequencies of common plant species are shown in **Table 3**. Most common species in this unit had low frequencies. The exception was *Sporobolus* spp., a common genus of warm-season grasses in the Southwest.

Table 3. Species frequency of common plants in Albert Lee unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%

Species	Frequency
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	2%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	0%
Poa fendleriana	7%
Sporobolus contractus	0%
Sporobolus cryptandrus	7%
Sporobolus spp.	30%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	3%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	2%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	0%
Purshia stansburiana	2%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	0%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	2%
Chrysothamnus depressus	0%
Chrysothamnus greenei	2%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%

Species	Frequency
Gutierrezia sarothrae	5%
Opuntia spp.	0%
Senecio spp. sensu lato	0%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**46%**
Total increasers	**7%**
Total invaders	**9%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

The range condition for the single ecological site in Albert Lee is poor; however, the apparent trend was determined to be *toward* reference conditions. The frequency of decreaser species is much higher than increasers or invaders. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 4**. Unsampled ecological sites are shown in **Table 5**.

Table 4. Reconstructed production, potential production, similarity indices, and range conditions for Albert Lee unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	232	141	22.8	285	8	Poor	5

Table 5. Unsampled ecological sites and total acreage of barren land in Albert Lee unit.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	91
F035XF625AZ	181
F035XF627AZ	75
F035XF633AZ	139
F035XH818AZ	102
R035XC309AZ	2
R035XC313AZ	3
R035XC317AZ	1
Total	**596**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 6**. Not all the potential ecological sites within this unit were sampled. The current sheep units in this unit are 41, which is well above the unit-wide carrying capacity.

Table 6. Stocking rates and carrying capacities for Albert Lee unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	232	128	59	4	5
Unit wide		**849**	**128**	**59**	**14**	**5**

4.3 Ason Ben Yazz

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. This analysis unit had some of the lowest canopy closure with a mean of only 1%. Mean ground covers are shown in **Figure 3**. This unit had very little gravel/rock ground cover.

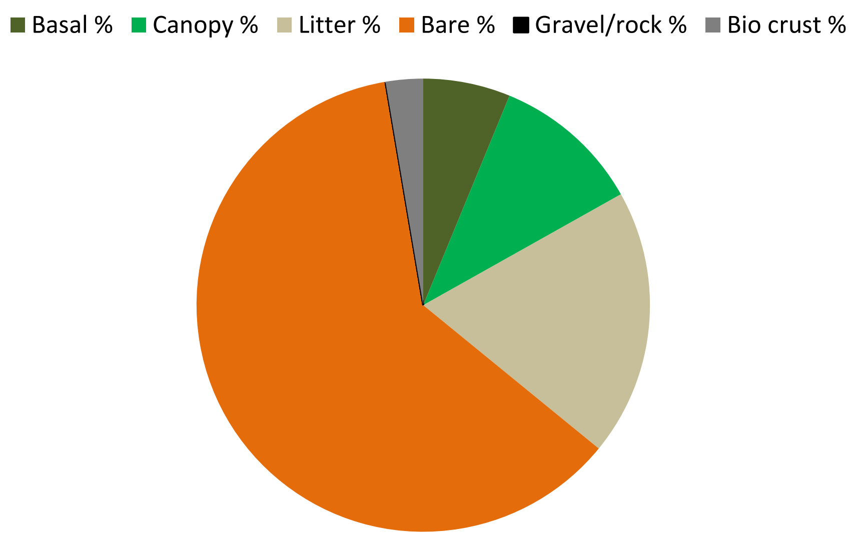

Figure 3. Mean ground cover in Ason Ben Yazz unit.

Species Frequency

Species frequency was dominated in this unit by *Elymus longifolius*, a cool-season grass, *Bouteloua gracilis*, *Pleuraphis jamesii*, *Artemisia tridentata*, *Gutierrezia sarothrae*, and *Sphaeralcea* spp. Frequencies are shown in **Table 7**.

Table 7. Species frequency of common plants in Ason Ben Yazz unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	60%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	0%
Poa fendleriana	0%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	100%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	60%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	40%
Purshia stansburiana	20%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	40%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	0%

Species	Frequency
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	100%
Opuntia spp.	0%
Senecio spp. sensu lato	20%
Salsola tragus	20%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**60%**
Total increasers	**260%**
Total invaders	**140%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to the high frequency of increasers, followed by decreasers. The range condition for the single ecological site in Ason Ben Yazz is poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 8**. Unsampled ecological sites not are shown in **Table 9**.

Table 8. Reconstructed production, potential production, similarity indices, and range conditions for Ason Ben Yazz unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	268	181	121.3	495	24	Poor	5

Table 9. Unsampled ecological sites and total acreage of barren land in Ason Ben Yazz.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	38
F035XF627AZ	97
R035XF601AZ	1
Total	**136**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 10**. Not all soil types, and thus potential ecological sites, were sampled in this unit. The current sheep units in this unit are 117, which is well above the unit-wide carrying capacity estimate.

Table 10. Stocking rates and carrying capacities for Ason Ben Yazz unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	268	161	47	6	5
Unit wide		**411**	**161**	**47**	**9**	**5**

4.4 David Kedelty

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 4**.

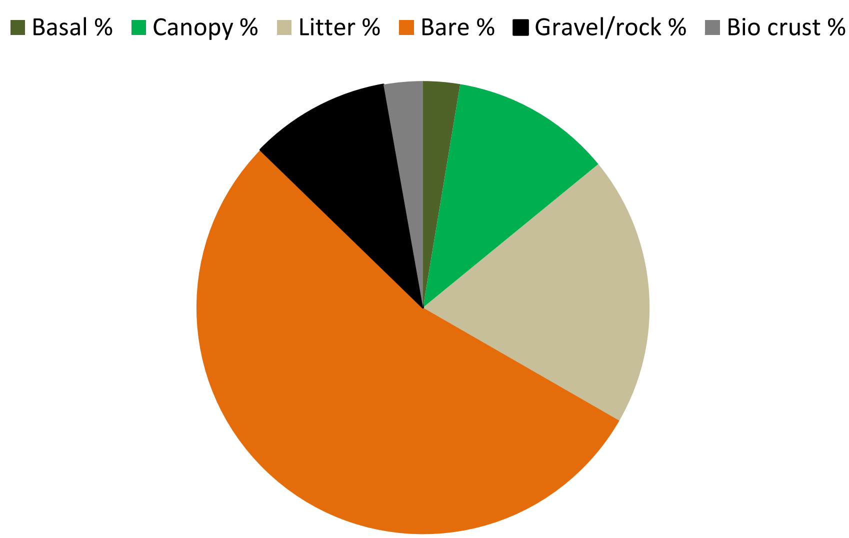

Figure 4. Mean ground cover David Kedelty unit.

Species Frequency

Species frequencies are shown in **Table 11**. *Artemisia tridentata*, *Gutierrezia sarothrae*, *Bouteloua gracilis*, and *Ephedra* spp. were the most frequent species.

Table 11. Species frequency of common plants in David Kedelty unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	20%
Hesperostipa comata	20%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	0%
Poa fendleriana	0%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	100%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	60%
Ephedra spp.	40%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	20%
Purshia stansburiana	20%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	0%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	0%

Species	Frequency
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	100%
Opuntia spp.	0%
Senecio spp. sensu lato	0%
Salsola tragus	20%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**40%**
Total increasers	**240%**
Total invaders	**120%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to the high frequency of increasers, followed by invaders. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 12**. Range conditions range from poor to fair. Unsampled ecological sites are shown in **Table 13**.

Table 12. Reconstructed production, potential production, similarity indices, and range conditions for David Kedelty unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	479	314	132.1	495	27	Fair	4
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	127	80	11.2	545	2	Poor	1

Table 13. Unsampled ecological sites and total acreage of barren land in David Kedelty.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	58
R035XF601AZ	4
Total	**62**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 14**. Not all soil types, and thus potential ecological sites, were sampled in this unit. The current sheep units in this unit are 25, which is just above the unit-wide carrying capacity.

Table 14. Stocking rates and carrying capacities for David Kedelty unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	479	285	27	18	4
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	127	71	107	1	1
Total		**606**	**242**	**0**	**19**	**5**

4.5 John Smith

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 5**. This unit had high ground cover of biocrust compared to other units.

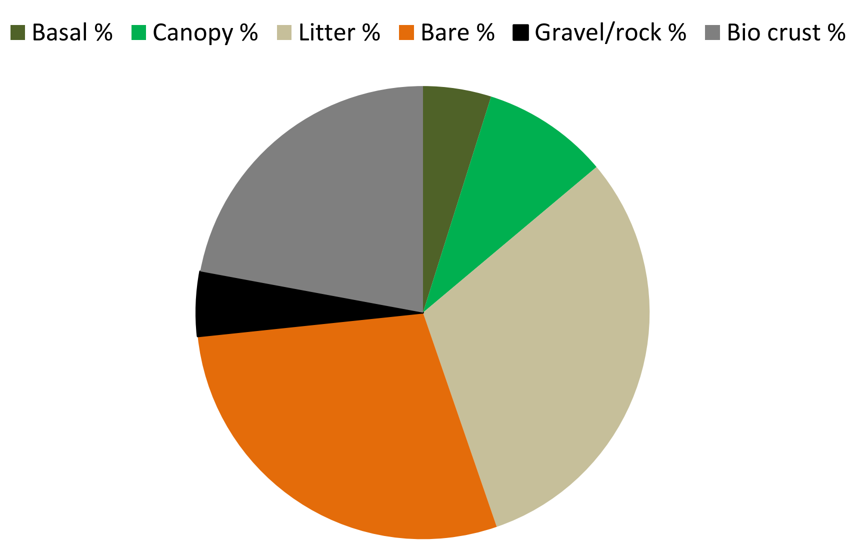

Figure 5. Mean ground cover John Smith unit.

Species Frequency

Table 15 shows species frequencies. The cool-season grasses *Elymus longifolius* and *Poa fendleriana* had high frequencies.

Table 15. Species frequency of common plants in John Smith unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	17%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	67%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	0%
Poa fendleriana	100%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	100%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	50%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	0%
Purshia stansburiana	17%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	0%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%

Species	Frequency
Astragalus spp.	0%
Bromus tectorum	17%
Chrysothamnus depressus	0%
Chrysothamnus greenei	17%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	17%
Ericameria nauseosa	0%
Gutierrezia sarothrae	100%
Opuntia spp.	17%
Senecio spp. sensu lato	0%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**183%**
Total increasers	**167%**
Total invaders	**167%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend could not be determined and so was classified as *not apparent*. Frequency of decreasers, increasers, and invaders was similar. The one ecological site in the John Smith sampled area has poor range condition. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 16**. Unsampled ecological sites are shown in **Table 17**.

Table 16. Reconstructed production, potential production, similarity indices, and range conditions for John Smith unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17” p.z. (Provisional)	600	114	84.5	495	17	Poor	6

Table 17. Unsampled ecological sites and total acreage of barren land in John Smith.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	1
F035XF627AZ	250
F035XF629AZ	6
F035XF633AZ	4
R035XC313AZ	64
R035XC317AZ	14
Total	**339**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 18**. The current sheep units in this unit are 65, which is well above the unit-wide carrying capacity.

Table 18. Stocking rates and carrying capacities for John Smith unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	600	101	75	8	6
Total		**961**	**101**	**75**	**13**	**6**

4.6 Keyoni

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. This analysis unit had some of the lowest canopy closure with only 2%. Mean ground covers are shown in **Figure 6**.

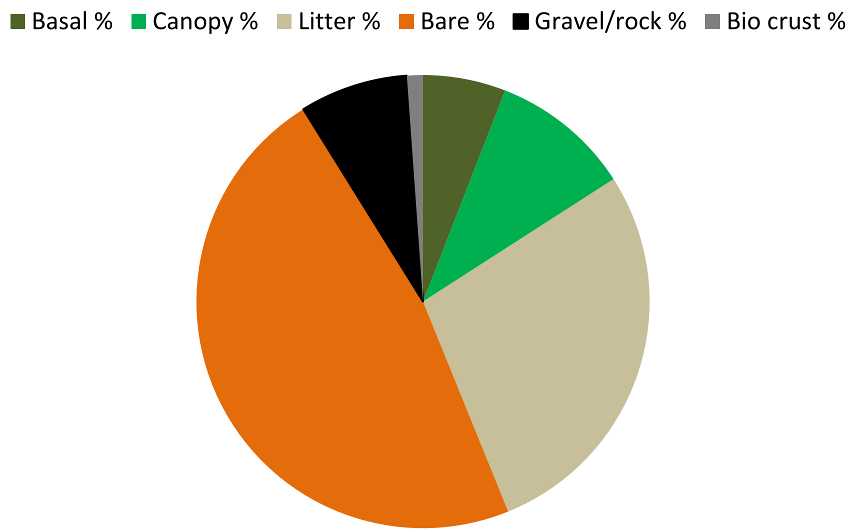

Figure 6. Mean ground cover Keyoni unit.

Species Frequency

This unit had a variety of frequent species, including warm- and cool-season grasses. Frequencies are shown in **Table 19**.

Table 19. Species frequency of common plants in Keyoni unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	9%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	45%
Hesperostipa comata	18%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	9%
Poa fendleriana	0%
Sporobolus contractus	0%
Sporobolus cryptandrus	27%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%

Species	Frequency
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	100%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	64%
Ephedra spp.	9%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	36%
Purshia stansburiana	9%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	27%
Invaders	
Antennaria spp.	18%
Asteraceae annual forb (unknown)	27%
Astragalus spp.	27%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	27%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	18%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	82%
Opuntia spp.	9%
Senecio spp. sensu lato	9%
Salsola tragus	36%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**109%**
Total increasers	**245%**
Total invaders	**255%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be moving *away* from reference conditions due to the high frequency of increasers and invaders. Range conditions range poor to fair, with one similarity index resulting as zero for one ecological site. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 20**. Unsampled ecological sites are shown in **Table 21**.

Table 20. Reconstructed production, potential production, similarity indices, and range conditions for Keyoni unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	553	306	194.7	495	39	Fair	2
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	921	175	108.3	675	16	Poor	8
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	75	6	0.6	375	0	Poor	1

Table 21. Ecological sites not sampled and total acreage of barren land in Keyoni.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	24
F035XF627AZ	230
R035XC312AZ	7
R035XC314AZ	45
R035XC317AZ	197
R035XC328AZ	4
Total	**507**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 22**. The majority of ecological sites in this unit contained at least one transect. The current sheep units in this unit are 110, which is well above the unit-wide carrying capacity.

Table 22. Stocking rates and carrying capacities for Keyoni unit based on nine months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	553	243	23	24	2
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	921	138	41	22	8
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	75	5	1,090	0	1
Total		**2,102**	**145**	**39**	**46**	**11**

4.7 Litson

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 7**. This unit had high ground cover of litter compared to most other units.

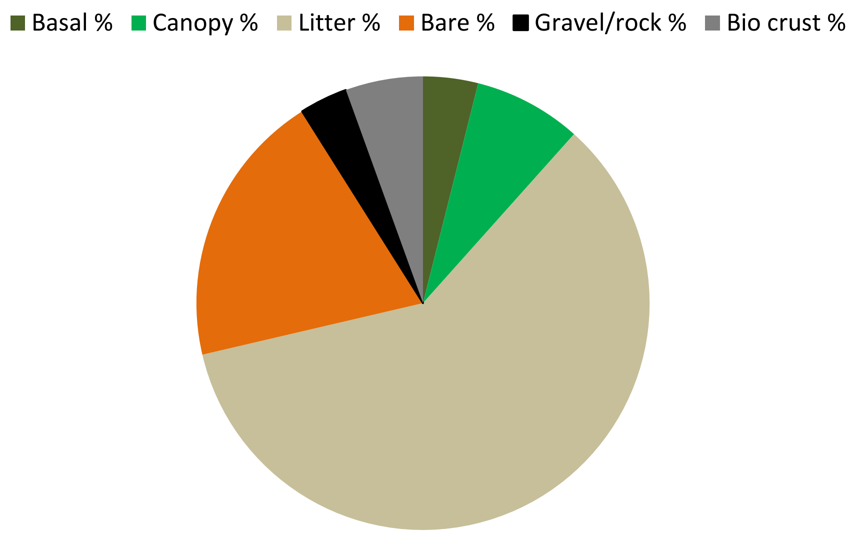

Figure 7. Mean ground cover Litson unit.

Species Frequency

This site had high frequencies of numerous grasses. *Artemisia tridentata* and *Gutierrezia sarothrae* frequencies were low in this unit compared to many others. Species frequencies are shown in **Table 23**.

Table 23. Species frequency of common plants in Litson unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	9%
Amelanchier utahensis	0%
Carex spp.	18%
Elymus longifolius	32%
Hesperostipa comata	0%
Kraschenninnikovia lanata	0%
Muhlenbergia montana	50%
Pascopyrum smithii	5%
Poa fendleriana	36%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%

Species	Frequency
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	27%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	55%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	5%
Pleuraphis jamesii	5%
Purshia stansburiana	5%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	5%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	9%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	32%
Opuntia spp.	0%
Senecio spp. sensu lato	32%
Salsola tragus	5%
Sarcobatus vermiculatus	0%
Yucca spp.	5%
Total decreasers	**150%**
Total increasers	**100%**
Total invaders	**82%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *toward* reference conditions due to the high frequency of decreasers, while all range conditions are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 24**. Unsampled ecological sites are shown in **Table 25**.

Table 24. Reconstructed production, potential production, similarity indices, and range conditions for Litson unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	1,490	163	33.0	495	7	Poor	18
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	704	8	0.3	545	0	Poor	1
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	38	97	15.0	285	5	Poor	1
R035XF601AZ	Sedimentary Cliffs 13–17" p.z. (Provisional)	72	47	7.6	609	1	Poor	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	169	325	101.8	620	16	Poor	1

Table 25. Ecological sites not sampled and total acreage of barren ground in Litson.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	182
F035XF633AZ	23
R035XF603AZ	135
R035XF605AZ	14
Total	**354**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 26**. This site had the lowest forage production of all analysis units. The estimated unit-wide carrying capacity is low, with one sheep requiring an average of 115 acres for a year. The majority of ecological sites in this unit were sampled. The current sheep units in this unit are 135, which is well above the unit-wide carrying capacity. The BIA identified pasture units for the Litson unit as this report was being finalized. Carrying capacities and stocking rates by pasture only are presented in Appendix D.

Table 26. Stocking rates and carrying capacities for Litson unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	1,490	56	137	11	18
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	704	8	955	1	1
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	38	97	79	0	1
R035XF601AZ	Sedimentary Cliffs 13–17" p.z. (Provisional)	72	47	163	0	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	169	300	25	7	1
Total		**2,890**	**66**	**115**	**25**	**22**

4.8 Lukachukai

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 8**.

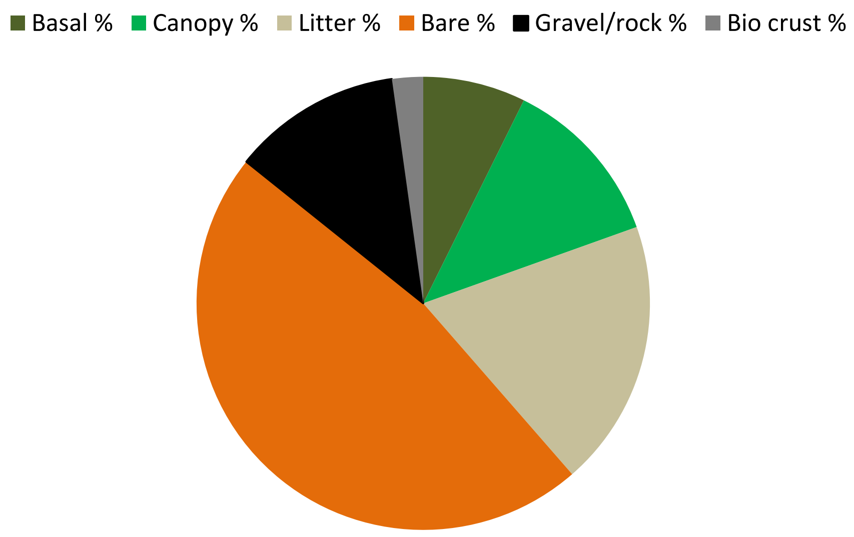

Figure 8. Mean ground cover in Lukachukai unit.

Species Frequency

Species frequencies are shown in **Table 27**. This site had high frequencies of numerous species and appears more diverse than some of the other units. This may be due to the large size of this analysis unit.

Table 27. Species frequency of common plants in Lukachukai unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	14%
Amelanchier utahensis	1%
Carex spp.	2%
Elymus longifolius	31%
Hesperostipa comata	26%
Krascheninnikovia lanata	6%
Muhlenbergia montana	1%
Pascopyrum smithii	16%
Poa fendleriana	4%
Sporobolus contractus	0%
Sporobolus cryptandrus	5%
Sporobolus spp.	0%
Increasers	
Aristida spp.	14%
Artemisia spp. (forb)	2%
Artemisia bigelovii	16%
Artemisia cana	0%
Artemisia filifolia	4%
Artemisia nova	0%
Artemisia tridentata	68%
Atriplex canescens	1%
Atriplex confertifolia	1%
Bouteloua gracilis	57%
Ephedra spp.	11%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	40%
Purshia stansburiana	9%
Purshia tridentata	1%
Rhus trilobata	2%
Sphaeralcea spp.	12%
Invaders	
Antennaria spp.	1%
Asteraceae annual forb (unknown)	33%

Species	Frequency
Astragalus spp.	5%
Bromus tectorum	28%
Chrysothamnus depressus	7%
Chrysothamnus greenei	42%
Chrysothamnus spp.	7%
Chrysothamnus viscidiflorus	1%
Cordylanthus wrightii	4%
Ericameria nauseosa	17%
Gutierrezia sarothrae	85%
Opuntia spp.	11%
Senecio spp. sensu lato	5%
Salsola tragus	1%
Sarcobatus vermiculatus	4%
Yucca spp.	1%
Total decreasers	**106%**
Total increasers	**238%**
Total invaders	**254%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to high frequencies of increasers and invaders. Range condition is poor in all ecological sites. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 28**. Unsampled ecological sites are shown in **Table 29**.

Table 28. Reconstructed production, potential production, similarity indices, and range conditions for Lukachukai unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	3,423	366	50.9	495	10	Poor	6
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	1,501	70	20.5	285	7	Poor	3
F035XH818AZ	Sandy Loam Slopes (PIPO, POTR5) 17–25" p.z. Cobbly (Provisional)	2,562	321	10.0	360	3	Poor	4
R035XC309AZ	Clay Loam Terrace 10–14" p.z. Saline–Sodic (Provisional)	1,611	363	60.3	1,100	5	Poor	5
R035XC312AZ	Cobbly Slopes 10–14" p.z. (Provisional)	2,259	5	0.4	480	0	Poor	1
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	18,298	200	104.5	675	15	Poor	35

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	7,795	101	15.6	410	4	Poor	17
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	15,328	119	30.6	630	5	Poor	9
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	1,461	188	10.5	375	3	Poor	1

Table 29. Ecological sites not sampled and total acreage of barren land in Lukachukai.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	3,075
F035XF627AZ	1,426
F035XF633AZ	901
F035XH804AZ	31
F035XH808AZ	398
F035XH811AZ	47
F035XH812AZ	23
F035XH827AZ	269
R035XC328AZ	1,412
R035XH821AZ	10
Total	**7,591**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 30**. The majority of soil units, and thus ecological sites, were sampled in this unit. Some soil units, however, may have contained more than one ecological site. The current sheep units in this unit are 3,347, which is well above the unit-wide carrying capacity.

Table 30. Stocking rates and carrying capacities for Lukachukai unit based on nine months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	3,423	358	16	216	6
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	1,501	57	100	15	3
F035XH818AZ	Sandy Loam Slopes (PIPO, POTR5) 17–25" p.z. Cobbly (Provisional)	2,562	302	19	136	4

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
R035XC309AZ	Clay Loam Terrace 10–14" p.z. Saline–Sodic (Provisional)	1,611	338	17	96	5
R035XC312AZ	Cobbly Slopes 10–14" p.z. (Provisional)	2,259	4	1,305	2	1
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	18,298	184	31	593	35
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	7,795	82	69	112	17
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	15,328	100	57	269	9
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	1,461	182	31	47	1
Total		**63,195**	**175**	**33**	**1,941**	**81**

4.9 Ram Pasture

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. This analysis unit had the lowest mean canopy closure at 0%. Mean ground covers are shown in **Figure 9**. There were no biocrusts.

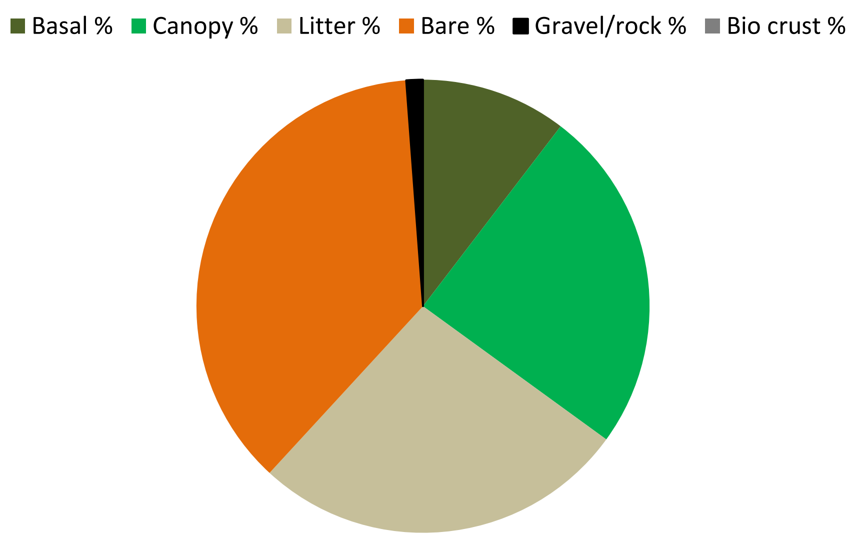

Figure 9. Mean ground cover in Ram Pasture unit.

Species Frequency

Species frequencies are shown in **Table 31**. This unit had high frequencies of warm- and cool-season grasses.

Table 31. Species frequency of common plants in Ram Pasture unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	5%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	42%
Hesperostipa comata	5%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	32%
Poa fendleriana	0%
Sporobolus contractus	0%
Sporobolus cryptandrus	42%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	5%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	74%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	68%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	5%
Pleuraphis jamesii	58%
Purshia stansburiana	0%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	63%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	79%

Species	Frequency
Astragalus spp.	0%
Bromus tectorum	5%
Chrysothamnus depressus	0%
Chrysothamnus greenei	26%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	100%
Opuntia spp.	5%
Senecio spp. sensu lato	0%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**126%**
Total increasers	**274%**
Total invaders	**216%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions, while all range conditions are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 32**. Unsampled ecological sites are shown in **Table 33**.

Table 32. Reconstructed production, potential production, similarity indices, and range conditions for Ram Pasture unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	2,692	248	99.4	675	15	Poor	16
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	304	218	15.6	410	4	Poor	2
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	165	224	20.9	375	6	Poor	1

Table 33. Unsampled ecological sites and total acreage of barren ground in Ram Pasture.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	49
R035XC317AZ	928
Total	**976**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 34**. The majority of ecological sites were sampled in this unit. The current sheep units in this unit are unknown.

Table 34. Stocking rates and carrying capacities for Ram Pasture unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	2,692	113	67	40	16
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	304	140	54	6	2
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	165	206	37	4	1
Total		**4,218**	**121**	**63**	**67**	**19**

4.10 Round Rock

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. This analysis unit had some of the lowest canopy closure with only 1%. This part of District 11 has few large shrubs or trees. Mean ground covers are shown in **Figure 10**. Biocrust cover was quite low.

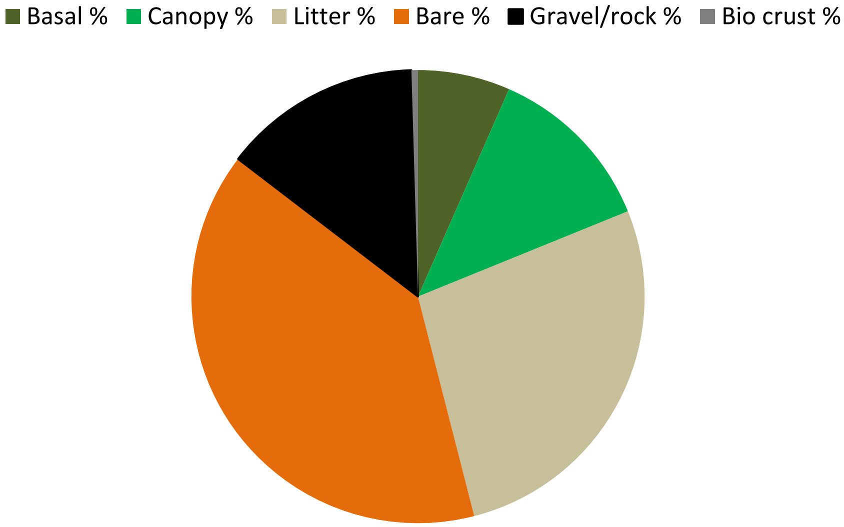

Figure 10. Mean ground cover in Round Rock unit.

Species Frequency

Species frequencies are shown in **Table 35**. The northern portion of this unit is different than much of the rest of District 11 in terms of species composition. Sandy soils host productive grasses and low shrubs such as *Atriplex confertifolia*, while *Artemisia tridentata* and *Bouteloua gracilis* are less frequent.

Table 35. Species frequency of common plants in Round Rock unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	48%
Amelanchier utahensis	1%
Carex spp.	0%
Elymus longifolius	5%
Hesperostipa comata	14%
Krascheninnikovia lanata	1%
Muhlenbergia montana	3%
Pascopyrum smithii	1%
Poa fendleriana	0%
Sporobolus contractus	3%
Sporobolus cryptandrus	30%
Sporobolus spp.	4%
Increasers	
Aristida spp.	12%
Artemisia spp. (forb)	7%
Artemisia bigelovii	4%
Artemisia cana	0%

Species	Frequency
Artemisia filifolia	11%
Artemisia nova	0%
Artemisia tridentata	17%
Atriplex canescens	8%
Atriplex confertifolia	46%
Bouteloua gracilis	10%
Ephedra spp.	32%
Eriogonum corymbosum	0%
Eriogonum spp.	1%
Pleuraphis jamesii	66%
Purshia stansburiana	2%
Purshia tridentata	3%
Rhus trilobata	1%
Sphaeralcea spp.	27%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	36%
Astragalus spp.	8%
Bromus tectorum	28%
Chrysothamnus depressus	14%
Chrysothamnus greenei	12%
Chrysothamnus spp.	2%
Chrysothamnus viscidiflorus	1%
Cordylanthus wrightii	0%
Ericameria nauseosa	17%
Gutierrezia sarothrae	82%
Opuntia spp.	1%
Senecio spp. sensu lato	7%
Salsola tragus	7%
Sarcobatus vermiculatus	6%
Yucca spp.	2%
Total decreasers	**111%**
Total increasers	**250%**
Total invaders	**223%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to high frequencies of increasers and invaders, while all range conditions are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 36**. Unsampled ecological sites are shown in **Table 37**.

Table 36. Reconstructed production, potential production, similarity indices, and range conditions for Round Rock unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS)13–17" p.z. (Provisional)	181	23	23.2	495	5	Poor	2
F035XH804AZ	Shallow Sandy Loam (PIPO) 17–25" p.z. (Provisional)	90	142	27.6	570	5	Poor	1
F035XH818AZ	Sandy Loam Slopes (PIPO, POTR5) 17–25" p.z. Cobbly (Provisional)	3,004	111	5.0	360	1	Poor	3
R035XB201AZ	Mudstone/Sandstone Hills 6–10" p.z. (Provisional)	8,282	183	48.3	360	13	Poor	1
R035XB204AZ	Sandstone Upland 6–10" p.z. (Provisional)	547	103	12.1	150	8	Poor	1
R035XB215AZ	Sandstone/Shale Upland 6–10" p.z. (Provisional)	27	111	72.5	350	21	Poor	1
R035XB216AZ	Sandy Wash 6–10" p.z. (Provisional)	1,235	52	8.7	880	1	Poor	3
R035XB217AZ	Sandy Upland 6–10" p.z. (Provisional)	12,785	407	63.2	490	13	Poor	18
R035XB219AZ	Sandy Loam Upland 6–10" p.z. (Provisional)	9,145	145	95.7	663	14	Poor	10
R035XB220AZ	Shale Upland 6–10" p.z. (Provisional)	3,897	154	13.6	139	10	Poor	22
R035XB227AZ	Sandy Loam Upland 6–10" p.z. Saline–Sodic (Provisional)	34,182	133	51.6	445	12	Poor	17
R035XB233AZ	Limestone/Sandstone Upland 6–10" p.z. Saline (Provisional)	8,965	191	70.0	350	20	Poor	44
R035XB238AZ	Sandy Terrace 6–10" p.z. Sodic (Provisional)	2,349	59	27.8	490	6	Poor	5
R035XB267AZ	Sandy Loam Upland 6–10" p.z. Limy (Provisional)	5,169	275	85.5	400	21	Poor	1
R035XC302AZ	Sedimentary Cliffs 10–14" p.z. (Provisional)	4,593	106	18.4	570	3	Poor	11
R035XC309AZ	Clay Loam Terrace 10–14" p.z. Saline–Sodic (Provisional)	2,297	135	44.0	1,100	4	Poor	3
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	1,266	68	45.8	675	7	Poor	2
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	17,355	240	18.4	410	4	Poor	11
R035XC315AZ	Sandy Upland 10–14" p.z. (Provisional)	2,002	943	39.8	580	7	Poor	6
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	19,367	272	99.5	630	16	Poor	23
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	8,598	198	19.1	375	5	Poor	3
R035XC326AZ	Sandy Loam Upland 10–14" p.z. Saline (Provisional)	2,386	1,050	55.5	420	13	Poor	14
R035XF606AZ	Sandy Loam Upland 13–17" p.z. (Provisional)	1,554	245	93.4	645	14	Poor	1
R035XF607AZ	Sandy Upland 13–17" p.z. (Provisional)	777	74	12.7	780	2	Poor	2

Table 37. Unsampled ecological sites and total acreage of barren land.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	10,739
F035XF627AZ	1,047
F035XG134NM	816
F035XH808AZ	13
F035XH811AZ	135
F035XH827AZ	9
F036XA001NM	38
F039XA002NM	51
F039XA007NM	157
R035XA113NM	1
R035XA117AZ	17
R035XA118NM	14
R035XB003NM	25
R035XB030NM	63
R035XB035NM	163
R035XB210AZ	837
R035XB211AZ	168
R035XB229AZ	8
R035XB237AZ	1,774
R035XB273AZ	253
R035XB283AZ	11,629
R035XC312AZ	190
R035XC316AZ	30
R035XC328AZ	119
R035XH821AZ	30
R039XA108AZ	17
Water	54
Total	**28,396**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 38**. This is one of the more productive sampling units in District 11, although it is important to note that production varies widely by ecological site. The current sheep units in this unit are 2,526, which is well above the unit-wide carrying capacity.

Table 38. Stocking rates and carrying capacities for Round Rock unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS)13–17" p.z. (Provisional)	181	2	3,590	0	2
F035XH804AZ	Shallow Sandy Loam (PIPO) 17–25" p.z. (Provisional)	90	142	53	2	1

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XH818AZ	Sandy Loam Slopes (PIPO, POTR5) 17–25" p.z. Cobbly (Provisional)	3,004	61	124	24	3
R035XB201AZ	Mudstone/Sandstone Hills 6–10" p.z. (Provisional)	8,282	183	41	200	1
R035XB204AZ	Sandstone Upland 6–10" p.z. (Provisional)	547	88	86	6	1
R035XB215AZ	Sandstone/Shale Upland 6–10" p.z. (Provisional)	27	90	85	0	1
R035XB216AZ	Sandy Wash 6–10" p.z. (Provisional)	1,235	52	147	8	3
R035XB217AZ	Sandy Upland 6–10" p.z. (Provisional)	12,785	309	25	520	18
R035XB219AZ	Sandy Loam Upland 6–10" p.z. (Provisional)	9,145	137	56	164	10
R035XB220AZ	Shale Upland 6–10" p.z. (Provisional)	3,897	87	88	45	21
R035XB227AZ	Sandy Loam Upland 6–10" p.z. Saline–Sodic (Provisional)	34,182	107	71	481	17
R035XB233AZ	Limestone/Sandstone Upland 6–10" p.z. Saline (Provisional)	8,965	171	44	202	44
R035XB238AZ	Sandy Terrace 6–10" p.z. Sodic (Provisional)	2,349	46	164	14	5
R035XB267AZ	Sandy Loam Upland 6–10" p.z. Limy (Provisional)	5,169	171	44	117	1
R035XC302AZ	Sedimentary Cliffs 10–14" p.z. (Provisional)	4,593	98	77	59	11
R035XC309AZ	Clay Loam Terrace 10–14" p.z. Saline–Sodic (Provisional)	2,297	113	67	34	3
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	1,266	54	142	9	2
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	17,355	178	43	406	11
R035XC315AZ	Sandy Upland 10–14" p.z. (Provisional)	2,002	331	23	87	6
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	19,367	234	32	596	23
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)	8,598	189	40	214	3
R035XC326AZ	Sandy Loam Upland 10–14" p.z. Saline (Provisional)	2,386	1,018	7	320	14

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
R035XF606AZ	Sandy Loam Upland 13–17" p.z. (Provisional)	1,554	245	31	50	1
R035XF607AZ	Sandy Upland 13–17" p.z. (Provisional)	777	35	217	4	2
Total		**182,236**	**222**	**34**	**5,334**	**204**

4.11 Sam Johnny 1

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 11**. Sam Johnny 1, 2, 3, and 4 units all had high covers of litter compared to other units, likely due to high canopy closure.

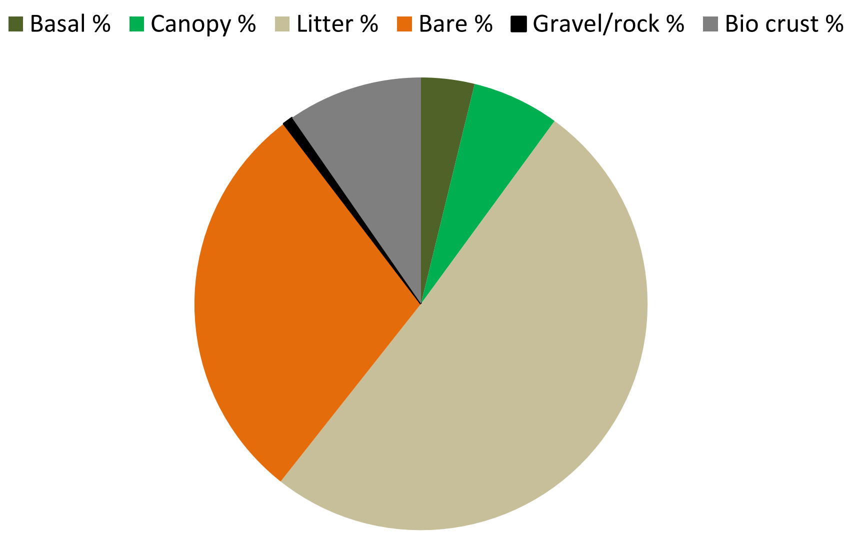

Figure 11. Mean ground cover in Sam Johnny 1 unit.

Species Frequency

Species frequencies are shown in **Table 39**. Of note is high frequency of *Carex* spp., which typically grows in the shade of piñon pine and juniper in such habitat.

Table 39. Species frequency of common plants in Sam Johnny 1 unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%
Amelanchier utahensis	0%

Species	Frequency
Carex spp.	43%
Elymus longifolius	43%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	43%
Poa fendleriana	29%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	14%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	29%
Artemisia tridentata	0%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	57%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	14%
Pleuraphis jamesii	14%
Purshia stansburiana	43%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	43%
Invaders	
Antennaria spp.	43%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	14%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	14%
Ericameria nauseosa	0%
Gutierrezia sarothrae	71%

Species	Frequency
Opuntia spp.	0%
Senecio spp. sensu lato	43%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**157%**
Total increasers	**214%**
Total invaders	**186%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to the high frequency of increasers. All range conditions are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 40**. Unsampled ecological sites are shown in **Table 41**.

Table 40. Reconstructed production, potential production, similarity indices, and range conditions for Sam Johnny 1 unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,049	102	12.2	458	3	Poor	5
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	312	98	5.0	340	1	Poor	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	417	232	47.4	620	8	Poor	1

Table 41. Unsampled ecological sites and total acreage of barren land in Sam Johnny 1.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	4
F035XF637AZ	24
F035XH826AZ	352
R035XF603AZ	333
Total	**713**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 42**. The majority of ecological sites were sampled in this unit. The current sheep units in all the Sam Johnny units combined are 838, which is well above the combined 273 carrying capacity estimate.

Table 42. Stocking rates and carrying capacities for Sam Johnny 1 unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,049	90	84	12	5
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	312	87	88	4	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	417	215	35	12	1
Total		**2,519**	**108**	**71**	**36**	**7**

4.12 Sam Johnny 2

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 12**. Sam Johnny 1, 2, 3, and 4 units all had high covers of litter compared to other units, likely due to high canopy closure.

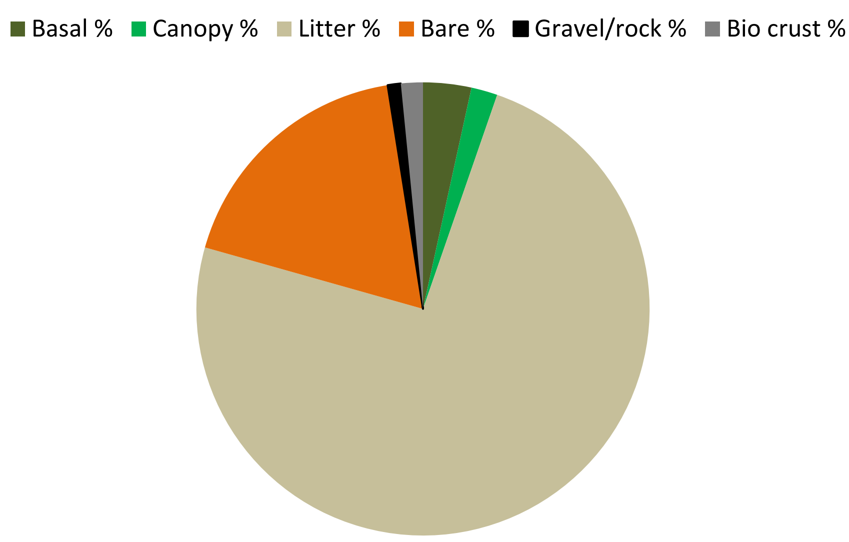

Figure 12. Mean ground cover in Sam Johnny 2 unit.

Species Frequency

Table 43 shows species frequencies. This unit had high frequencies of multiple grass species.

Table 43. Species frequency of common plants in Sam Johnny 2 unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%
Amelanchier utahensis	0%
Carex spp.	13%
Elymus longifolius	63%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	38%
Pascopyrum smithii	25%
Poa fendleriana	38%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	25%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	25%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	63%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	13%
Pleuraphis jamesii	0%
Purshia stansburiana	0%
Purshia tridentata	13%
Rhus trilobata	0%
Sphaeralcea spp.	25%
Invaders	
Antennaria spp.	38%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	13%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	13%

Species	Frequency
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	50%
Opuntia spp.	13%
Senecio spp. sensu lato	38%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**175%**
Total increasers	**163%**
Total invaders	**163%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

The trend could not be determined due to the similar frequencies of decreasers, increasers, and invaders; thus, it was classified as *not apparent*. All range conditions, however, are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 44**. All ecological sites in Sam Johnny 2 were sampled; no barren ground was mapped as a soil type.

Table 44. Reconstructed production, potential production, similarity indices, and range conditions for Sam Johnny 2 unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,309	109	20.0	458	4	Poor	1
F035XH826AZ	Sandstone Upland (PIPO) 17–25" p.z. (Provisional)	263	141	24.0	525	5	Poor	3
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	600	44	11.0	340	3	Poor	3
R035XH813AZ	Silty Upland 17–25" p.z. (Provisional)	144	1,150	126.4	915	14	Poor	1

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 45**. The majority of ecological sites were sampled in this unit. The current sheep units in all the Sam Johnny units combined are 838, which is well above the combined 273 carrying capacity estimate.

Table 45. Stocking rates and carrying capacities for Sam Johnny 2 unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,309	58	132	10	1
F035XH826AZ	Sandstone Upland (PIPO) 17–25" p.z. (Provisional)	263	62	123	2	3
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	600	25	309	2	3
R035XH813AZ	Silty Upland 17–25" p.z. (Provisional)	144	1,132	7	21	1
Total		**2,352**	**181**	**42**	**56**	**8**

4.13 Sam Johnny 3

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 13**. Sam Johnny 1, 2, 3, and 4 units all had high covers of litter compared to other units, likely due to high canopy closure.

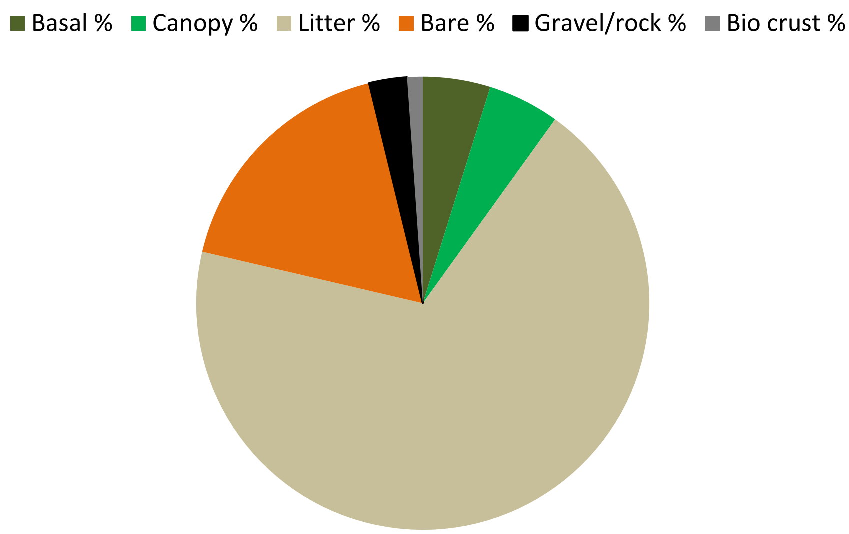

Figure 13. Mean ground cover in Sam Johnny 3 unit.

Species Frequency

Species frequencies are shown in **Table 46**. This unit had a high frequency of *Muhlenbergia montana* compared to other units.

Table 46. Species frequency of common plants in Sam Johnny 3 unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	17%
Amelanchier utahensis	0%
Carex spp.	0%
Elymus longifolius	33%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	67%
Pascopyrum smithii	17%
Poa fendleriana	17%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	17%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	0%
Artemisia tridentata	33%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	83%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	0%
Purshia stansburiana	0%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	17%
Invaders	
Antennaria spp.	33%
Asteraceae annual forb (unknown)	0%

Species	Frequency
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	17%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	0%
Ericameria nauseosa	0%
Gutierrezia sarothrae	33%
Opuntia spp.	0%
Senecio spp. sensu lato	83%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**150%**
Total increasers	**150%**
Total invaders	**167%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

The trend could not be determined due to the similar frequencies of decreasers, increasers, and invaders; thus, it was classified as *not apparent*. All range conditions, however, are poor. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 47**. Unsampled ecological sites are shown in **Table 49**.

Table 47. Reconstructed production, potential production, similarity indices, and range conditions for Sam Johnny 3 unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS)13–17" p.z. (Provisional)	858	50	8.1	495	2	Poor	2
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	506	60	40.0	458	9	Poor	1
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	354	21	1.9	340	1	Poor	1
R035XH813AZ	Silty Upland 17–25" p.z. (Provisional)	511	252	74.0	915	8	Poor	2

Table 48. Unsampled ecological sites and total acreage of barren land in Sam Johnny 3.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	55
F035XF627AZ	401
R035XF601AZ	1
R035XF605AZ	13
Total	**470**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 49**. Not all ecological sites were sampled in this unit. The current sheep units in all the Sam Johnny units combined are 838, which is well above the combined 273 carrying capacity estimate.

Table 49. Stocking rates and carrying capacities for Sam Johnny 3 unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS)13–17" p.z. (Provisional)	858	37	204	4	2
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	506	37	208	2	1
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	354	17	447	1	1
R035XH813AZ	Silty Upland 17–25" p.z. (Provisional)	511	226	34	15	2
Total		**2,750**	**97**	**78**	**35**	**6**

4.14 Sam Johnny 4

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 14**. Sam Johnny 1, 2, 3, and 4 units all had high covers of litter compared to other units.

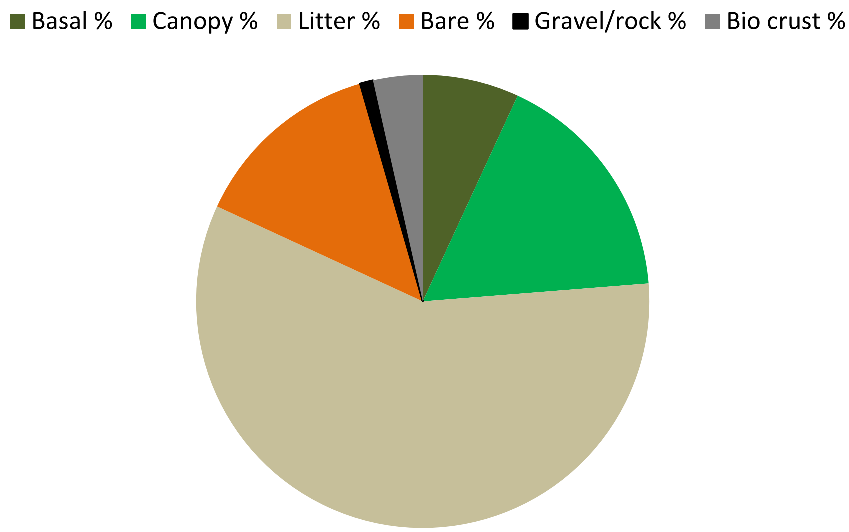

Figure 14. Mean ground cover in Sam Johnny 4 unit.

Species Frequency

Species frequencies are shown in **Table 50**.

Table 50. Species frequency of common plants in Sam Johnny 4 unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	0%
Amelanchier utahensis	0%
Carex spp.	13%
Elymus longifolius	38%
Hesperostipa comata	0%
Kraschenninikovia lanata	0%
Muhlenbergia montana	13%
Pascopyrum smithii	25%
Poa fendleriana	38%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	13%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%

Species	Frequency
Artemisia nova	13%
Artemisia tridentata	25%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	75%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	0%
Pleuraphis jamesii	0%
Purshia stansburiana	13%
Purshia tridentata	13%
Rhus trilobata	0%
Sphaeralcea spp.	13%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	13%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	13%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	13%
Ericameria nauseosa	0%
Gutierrezia sarothrae	38%
Opuntia spp.	13%
Senecio spp. sensu lato	25%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**125%**
Total increasers	**163%**
Total invaders	**113%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to higher frequency of increasers compared to decreasers. One ecological site is in fair condition; the rest are in poor condition. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 51**. Unsampled ecological sites are shown in **Table 52**.

Table 51. Reconstructed production, potential production, similarity indices, and range conditions for Sam Johnny 4 unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,388	132	20.0	458	4	Poor	1
F035XH826AZ	Sandstone Upland (PIPO) 17–25" p.z. (Provisional)	58	27	2.7	525	1	Poor	1
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	902	145	39.0	340	11	Poor	5
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	59	909	288.2	625	46	Fair	1

Table 52. Unsampled ecological sites in Sam Johnny 4.

Ecological site	Acres
F035XF625AZ	13
F035XF627AZ	5
R035XF604AZ	73
R035XH813AZ	111
Total	**202**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 53**. Most ecological sites in this unit were sampled. The current sheep units in all the Sam Johnny units combined are 838, which is well above the combined 273 carrying capacity estimate.

Table 53. Stocking rates and carrying capacities for Sam Johnny 4 unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	1,388	79	96	14	1
F035XH826AZ	Sandstone Upland (PIPO) 17–25" p.z. (Provisional)	58	27	286	0	1
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	902	141	54	17	5
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	59	904	8	7	1

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
Total		**2,661**	**214**	**35**	**75**	**8**

4.15 Sam Johnny 5

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 15**.

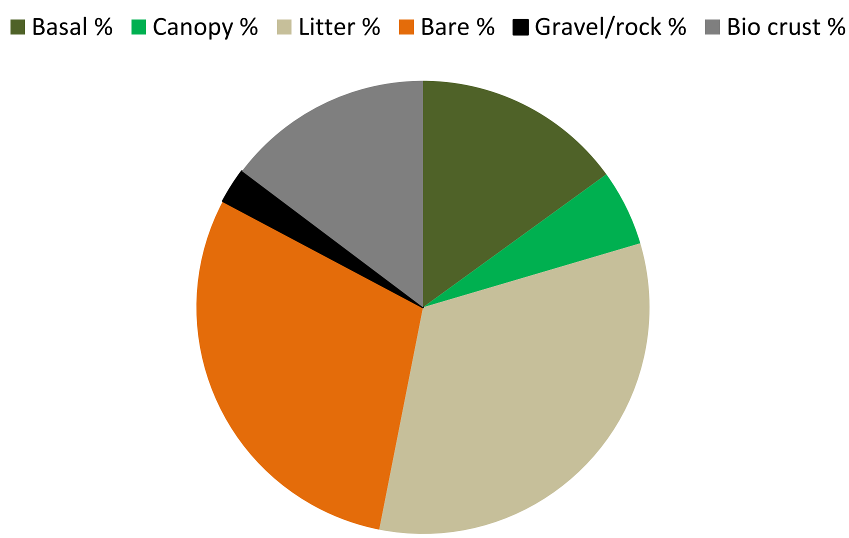

Figure 15. Mean ground cover in Sam Johnny 5 unit.

Species Frequency

Species frequencies are shown in **Table 54**. This site has high frequencies of cool-season grasses and *Carex*.

Table 54. Species frequency of common plants in Sam Johnny 5 unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	17%
Amelanchier utahensis	0%
Carex spp.	33%
Elymus longifolius	50%
Hesperostipa comata	0%
Kraschenninnikovia lanata	0%

Species	Frequency
Muhlenbergia montana	0%
Pascopyrum smithii	33%
Poa fendleriana	67%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	17%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	17%
Artemisia tridentata	67%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	67%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	17%
Pleuraphis jamesii	0%
Purshia stansburiana	33%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	33%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	17%
Ericameria nauseosa	0%
Gutierrezia sarothrae	67%
Opuntia spp.	17%
Senecio spp. sensu lato	17%
Salsola tragus	0%
Sarcobatus vermiculatus	0%

Species	Frequency
Yucca spp.	0%
Total decreasers	**200%**
Total increasers	**250%**
Total invaders	**117%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions. Note, however, that the frequency of invaders is lower than decreasers and increasers. Two of the five ecological sites are in fair condition, while the rest are in poor condition. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 55**. Unsampled ecological sites are shown in **Table 56**.

Table 55. Reconstructed production, potential production, similarity indices, and range conditions for Sam Johnny 5 unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	55	50	41.5	545	8	Poor	1
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	705	66	55.2	458	12	Poor	2
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	493	87	68.2	340	20	Poor	1
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	200	492	159.7	625	26	Fair	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	251	754	250.6	620	40	Fair	1

Table 56. Unsampled ecological sites and total acreage of barren land in Sam Johnny 5.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	29
F035XF625AZ	133
F035XF629AZ	159
F035XF633AZ	95
Total	**416**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 57**. Not all ecological sites were sampled in this unit. This site has the highest unit-wide forage production of all sampling units. The current sheep units in all the Sam Johnny units combined are 838, which is well above the combined 273 carrying capacity estimate.

Table 57. Stocking rates and carrying capacities for Sam Johnny 5 unit based on 12 months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	55	49	156	0	1
F035XH808AZ	Loamy Upland (PIPO) 17–25" p.z. (Provisional)	705	64	119	6	2
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	493	86	89	6	1
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	200	467	16	12	1
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	251	754	10	25	1
Total		**2,162**	**247**	**31**	**70**	**6**

4.16 Wheatfields

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 16**.

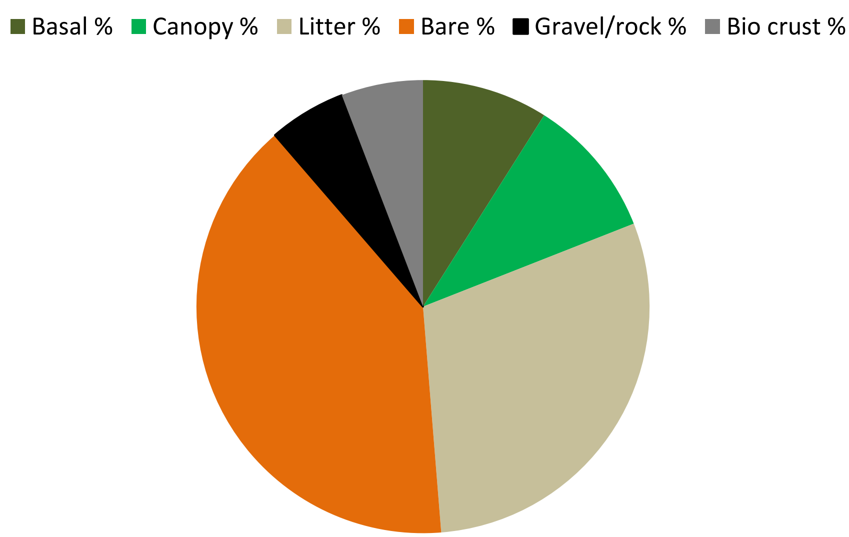

Figure 16. Mean ground cover in Wheatfields unit.

Species Frequency

Species frequencies are shown in **Table 58**. This site had high frequencies of cool-season grasses.

Table 58. Species frequency of common plants in Wheatfields unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	17%
Amelanchier utahensis	0%
Carex spp.	33%
Elymus longifolius	50%
Hesperostipa comata	0%
Krascheninnikovia lanata	0%
Muhlenbergia montana	0%
Pascopyrum smithii	33%
Poa fendleriana	67%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	17%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%
Artemisia nova	17%
Artemisia tridentata	67%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	67%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	17%
Pleuraphis jamesii	0%
Purshia stansburiana	33%
Purshia tridentata	0%
Rhus trilobata	0%
Sphaeralcea spp.	33%
Invaders	
Antennaria spp.	0%
Asteraceae annual forb (unknown)	0%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	0%
Chrysothamnus spp.	0%

Species	Frequency
Chrysothamnus viscidiflorus	0%
Cordylanthus wrightii	17%
Ericameria nauseosa	0%
Gutierrezia sarothrae	67%
Opuntia spp.	17%
Senecio spp. sensu lato	17%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**200%**
Total increasers	**250%**
Total invaders	**117%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

Apparent trend was determined to be *away* from reference conditions due to high frequencies of increasers. However, note that decreaser frequency was much higher than invader frequency. Range conditions are mostly poor, but with some fair and one in good condition. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 59**. Unsampled ecological sites are shown in **Table 60**.

Table 59. Reconstructed production, potential production, similarity indices, and range conditions for Wheatfields unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	21,654	171	60.0	495	12	Poor	55
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	10,974	124	41.1	545	8	Poor	7
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	2,852	115	12.9	285	5	Poor	6
F035XF633AZ	Colluvial Slopes (PIED) 13–17" p.z. (Provisional)	1,711	62	34.8	429	8	Poor	1
F035XF637AZ	Loamy Bottom 13–17" p.z. (Provisional)	571	253	6.2	310	2	Poor	3
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	6,830	207	85.3	675	13	Poor	11
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	3,636	231	15.7	410	4	Poor	12

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	3,936	489	335.0	630	53	Good	1
R035XC328AZ	Cobbly Slopes 10–14" p.z. (Provisional)	357	161	45.3	480	9	Poor	1
R035XF601AZ	Sedimentary Cliffs 13–17" p.z. (Provisional)	559	770	13.0	609	2	Poor	2
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	3,702	144	78.9	625	13	Poor	6
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	3,825	271	166.7	620	27	Fair	3
R035XF605AZ	Loamy Upland 13–17" p.z. (Provisional)	733	480	160.7	530	30	Fair	2

Table 60. Unsampled ecological sites and total acreage of barren land in Wheatfields.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	5,402
F035XH804AZ	1
F035XH808AZ	363
F035XH812AZ	52
F035XH827AZ	232
R035XC302AZ	76
R035XC312AZ	571
R035XC320AZ	638
R035XF606AZ	11
R035XH807AZ	2
Water	171
Total	**7,520**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 61**. Not all ecological sites were sampled in this large unit. The current sheep units for this unit are 4,578, which more than double the estimated unit-wide carrying capacity.

Table 61. Stocking rates and carrying capacities for Wheatfields unit based on nine months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	21,654	148	38	565	55

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF627AZ	Sandstone Upland (JUOS, PIED) 13–17" p.z. (Provisional)	10,974	113	50	219	7
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	2,852	105	54	53	6
F035XF633AZ	Colluvial Slopes (PIED) 13–17" p.z. (Provisional)	1,711	50	115	15	1
F035XF637AZ	Loamy Bottom 13–17" p.z. (Provisional)	571	248	23	25	3
R035XC313AZ	Loamy Upland 10–14" p.z. (Provisional)	6,830	141	40	169	11
R035XC314AZ	Sandstone Upland 10–14" p.z. (Provisional)	3,636	205	28	131	12
R035XC317AZ	Sandy Loam Upland 10–14" p.z. (Provisional)	3,936	438	13	303	1
R035XC328AZ	Cobbly Slopes 10–14" p.z. (Provisional)	357	137	42	9	1
R035XF601AZ	Sedimentary Cliffs 13–17" p.z. (Provisional)	559	722	8	71	2
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	3,702	131	43	85	6
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)	3,825	260	22	175	3
R035XF605AZ	Loamy Upland 13–17" p.z. (Provisional)	733	465	12	60	2
Total		**70,758**	**172**	**33**	**2,140**	**110**

4.17 Willie Shirley

Cover and Canopy Closure

The mean canopy closure is shown in **Table 1**. Mean ground covers are shown in **Figure 17**.

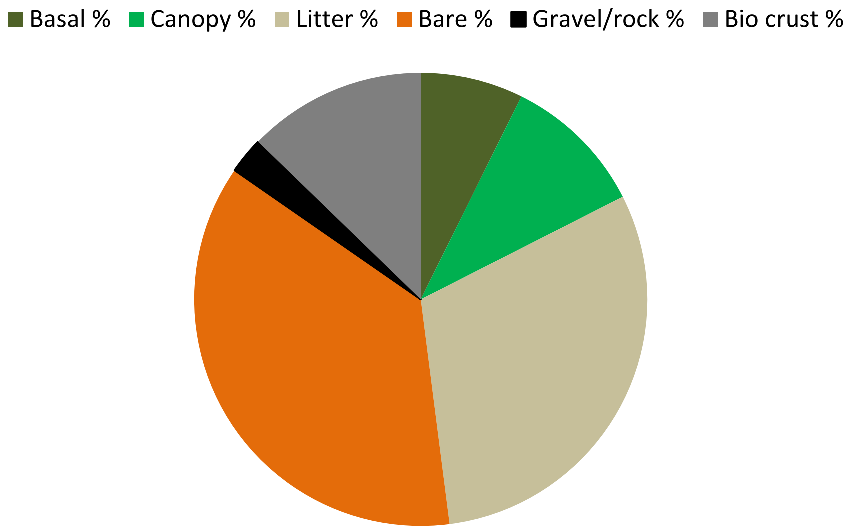

Figure 17. Mean ground cover in Willie Shirley unit.

Species Frequency

Species frequencies are shown in **Table 62**. This unit had high frequencies of cool-season grasses.

Table 62. Species frequency of common plants in Willie Shirley unit.

Species	Frequency
Decreasers	
Achnatherum hymenoides	19%
Amelanchier utahensis	0%
Carex spp.	35%
Elymus longifolius	46%
Hesperostipa comata	8%
Krascheninnikovia lanata	0%
Muhlenbergia montana	8%
Pascopyrum smithii	19%
Poa fendleriana	62%
Sporobolus contractus	0%
Sporobolus cryptandrus	0%
Sporobolus spp.	0%
Increasers	
Aristida spp.	0%
Artemisia spp. (forb)	0%
Artemisia bigelovii	0%
Artemisia cana	0%
Artemisia filifolia	0%

Species	Frequency
Artemisia nova	0%
Artemisia tridentata	81%
Atriplex canescens	0%
Atriplex confertifolia	0%
Bouteloua gracilis	62%
Ephedra spp.	0%
Eriogonum corymbosum	0%
Eriogonum spp.	23%
Pleuraphis jamesii	4%
Purshia stansburiana	12%
Purshia tridentata	4%
Rhus trilobata	0%
Sphaeralcea spp.	15%
Invaders	
Antennaria spp.	4%
Asteraceae annual forb (unknown)	12%
Astragalus spp.	0%
Bromus tectorum	0%
Chrysothamnus depressus	0%
Chrysothamnus greenei	19%
Chrysothamnus spp.	0%
Chrysothamnus viscidiflorus	4%
Cordylanthus wrightii	4%
Ericameria nauseosa	0%
Gutierrezia sarothrae	85%
Opuntia spp.	8%
Senecio spp. sensu lato	31%
Salsola tragus	0%
Sarcobatus vermiculatus	0%
Yucca spp.	0%
Total decreasers	**196%**
Total increasers	**200%**
Total invaders	**165%**

Production, Potential, Similarity Indices, Trends, and Range Conditions

The trend could not be determined and was thus classified as *not apparent*. The range conditions for most ecological sites are poor, but one site is fair. Reconstructed production, potential production, similarity indices, and range conditions are shown in **Table 63**. Unsampled ecological sites are shown in **Table 64**.

Table 63. Reconstructed production, potential production, similarity indices, and range conditions for Willie Shirley unit.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Mean allowable lbs./ac.	Potential lbs./ac.	Similarity index (%)	Range condition	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	5,307	154	67.7	495	14	Poor	20
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	548	100	12.6	285	4	Poor	2
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	591	48	19.4	340	6	Poor	2
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	269	601	203.4	625	33	Fair	2

Table 64. Unsampled ecological sites and total acreage of barren land in Willie Shirley.

Ecological site	Acres
Bare (rock outcrop, gullied land, river wash)	651
F035XF627AZ	2,449
F035XF633AZ	329
F035XF637AZ	6
F035XH808AZ	879
F035XH826AZ	21
R035XF601AZ	120
R035XF604AZ	247
R035XF605AZ	210
Total	**4,911**

Stocking Rates and Carrying Capacities

Stocking rates and carrying capacities are shown in **Table 65**. Not all ecological sites were sampled in this unit. The current sheep units for this unit are 206, which is below the estimated unit-wide carrying capacity.

Table 65. Stocking rates and carrying capacities for Willie Shirley unit based on nine months.

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XF625AZ	Loamy Upland (PIED, JUOS) 13–17" p.z. (Provisional)	5,307	139	54	97	20
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)	548	98	78	7	2

ESD site ID	ESD site	Total ac.	Mean reconstructed lbs./ac.	Stocking rate (ac./sheep)	Carrying capacity (sheep)	# transects
F035XH827AZ	Sandstone Hills (PIPO) 17–25" p.z. (Provisional)	591	28	270	2	2
R035XF603AZ	Clay Loam Upland 13–17" p.z. (Provisional)	269	572	13	20	2
Total		**11,881**	**161**	**47**	**252**	**26**

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Study Limitations

Some of the Chinle analysis units contained few transects, which limits the reliability of biomass estimates in terms of how well they represent the actual vegetation. Moreover, not all ecological sites were sampled in every analysis unit. Production estimates for ecological sites are based on averages across transects, but in many cases, an ecological site was only sampled once within an analysis unit. A single transect does not adequately capture the natural variation in production, species composition, or the way ungulates graze the landscape. Inference is limited.

The methods used to calculate production rely on multiple correction factors. Production estimates are just that, estimates. The methods described in the National Range and Pasture Handbook (USDA Natural Resources Conservation Service and Grazing Lands Technology Institute 2003) are based on decades of range science and attempt to account for factors that can bias production estimates. Accounting for such factors is important, but one must keep in mind that data collected on a transect are transformed and adjusted multiple times to produce the final reconstruction weights. The estimated weights of many species are corrected based on the double sampling method, but these corrections are not 100% accurate. Species weights are also adjusted with air-dry weight conversions based on the actual drying of species from transects and by using published air-dry weight percentages. These conversions are not completely accurate for all sampled species, and they are bound add their own unique error to estimates. In addition, production estimates are adjusted for season of sampling and percent utilization, which are difficult to determine accurately and introduce error. Lastly, production estimates are normalized by adjusting them with departure-from-normal precipitation factors. Thus, the final reconstructed weights are not the actual production values for the sampling year, but instead, they represent annual production for a normal precipitation year. In District 11, precipitation data for many areas are taken from distant rain gauges. Most of these gauges are from mountainous areas that receive more precipitation than lowland areas, and some gauges may not capture isolated summer monsoons that contribute to vegetation production. Gauge maintenance is also an issue, and some gauge precipitation data for certain months within a year may be missing.

The methods used to calculate similarity indices rely on assumptions that may not be met. The first major assumption is that the ecological sites associated with the soil map unit in which a transect occurs are in fact the correct historical climax community or reference site. This was not the case on some transects, where none of the ecological sites options appeared to accurately represent the likely historical climax community, regardless of the departure from reference conditions or transitional state. The second assumption, similar to the first, is that the correct ecological site was assigned to a transect when there was more than one option. In some cases, either all choices seemed possible or none seemed likely.

Efforts were taken to choose the most probable site based on soil texture, plant community, and other descriptive factors, but the accuracy of assigned sites cannot be determined. The calculation of similarity indices is based on the species that occurred on a transect and their allowable production. The accuracy of this depends on the accuracy of species detection and identification. At no time of the year can 100% species detection be assured on a transect. Spring-flowering annuals may be gone by summer or fall, and fall-flowering plants may not be present early in the season. Even if plants are growing during sampling, proper identification may be difficult if they lack flowers. Many species lacking flowers can be identified to family or genus, but this may not facilitate proper calculation of similarity indices if they depend on species-level composition. In conclusion, similarity indices and associated range conditions should be considered loosely.

5.2 Stocking Rates and Carrying Capacities

In all but the Willie Shirley and David Kedelty units, current sheep unit stocking rates are vastly higher than the unit-wide estimated stocking rates. It may be difficult to know if people are stocking as many sheep as the grazing permits allow, but even so, many of the current stocking rates are multiple times higher than the carrying capacity.

Managers should set stocking rates based on the production variation that occurs within a management area (analysis unit) and knowledge of grazing patterns within the unit. Stocking rates and carrying capacities were calculated for entire analysis units and for the majority of ecological sites occurring within those units. Unit-wide stocking rates are based on the average reconstructed production for the unit, while stocking rates for ecological sites represent the variation of production across the unit's range. Not all areas within a unit are grazed, and areas open to grazing will experience uneven grazing pressure due to herding patterns, water availability, and topography, among other factors. Managers can use their local wisdom and knowledge of these factors, along with recommended stocking rates for specific ecological sites, to determine the best stocking rates for analysis units. **Table 71** in Appendix B shows ecological sites and their associated soil map units and analysis units. This table can be used in conjunction with soil survey maps to relate recommended stocking rates to the geography and spatial variation of ecological sites across range units. Water sources and feral horses (see below), grazing-limiting topography, and general knowledge of the area should also be accounted for when determining rates.

As discussed above, production estimates are normalized by departure-from-normal precipitation for the year of sampling, so final reconstructed weights are not actual productions for that year but represent the annual production for a normal precipitation year. Managers should adjust stocking rates based on annual precipitation. Some areas may be stocked higher in wet years if more forage is available. Stocking rates should particularly be adjusted during times of drought. This will be increasingly important with climate change as warmer, drier summers become the norm.

Adverse impacts from grazing on the landscape can increase an ecosystem's vulnerability to climate change. Grazing-induced disturbance of vegetation and soil has negatively impacted biological crusts, reduced soil carbon and nitrogen stocks, and lead to increased rates of soil erosion, all of which weaken an ecosystem's ability to respond to warmer, drier climates and drought (Schwinning et al. 2008). During drought or times of environmental stress, which are likely to increase with climate change in the West (Schwinning et al. 2008, Anderson et al. 2010), impacted rangeland vegetation often requires a rest period to recover (Brown and Stuth 1986). Impacted range should be given time to recover following droughts, fires, and other disturbances before stocking rates are returned to those applied during normal conditions. Overgrazing during times of environmental stress can increase weeds and undesirable species (Loeser et al. 2007) and thus alter the productivity of forage species even if conditions improve (Rawlings et al. 1997).

5.2.1 Water Source Adjustments

Grazing pressure typically decreases as distance to water increases, and conversely, pressure is highest around water sources (Valentine 1947). Beyond certain distances from water, utilization becomes highly reduced even if good forage is abundant. Thus, stocking rates can be too high when based on total production for an area that lacks adequate water sources because some of the vegetation is not likely to be utilized when too far from water. Livestock tend to forage farther from water in spring, summer, and fall when temperatures are cooler (Valentine 1947). **Table 72** in Appendix B presents the number of water sources by analysis unit and the average distance of sample transects to the nearest water sources. **Table 73** presents recommended stocking rate/carrying capacity adjustments based on the average distance to water presented in **Table 72**. The percent adjustments were based on the example shown in USDA Natural Resources Conservation Service and Grazing Lands Technology Institute (2003) and the study conducted by Valentine (1947) in New Mexico. This adjustment factor assumes that water sources contain available water and are not fenced off to livestock. If water sources are ephemeral, distance to windmills can be used.

For example, say the stocking rate for an ecological site in an analysis unit is determined to be = 0.18 sheep/ac./9 months, and the carrying capacity for this area is 90 sheep/9 months (based on 502.5 acres of the ecological site in the analysis unit). Now say the average minimal distance from a windmill or other water source is 1.42 miles. Using **Table 73**, the adjustment would be 50%. So, 90 sheep/9 months multiplied by 0.5 equals a 45-sheep/9 month carrying capacity. The results are the same weather the adjustment is applied to the carrying capacity or the stocking rate.

Hauling water, which is the only source of water for some areas, complicates the use of this adjustment. Adjustments should be made based on managers' local knowledge of water locations and estimated distance to water, which will vary with ESD-specific stocking rates. It is recommended that water-hauling deposit locations be moved around during the year to reduce overgrazing around water and encourage utilization in underutilized areas with adequate forage.

5.2.2 Feral Horse Adjustments

Stocking rates should be adjusted to account for feral horses. The animal unit equivalent (AUE) for a mature sheep is 0.20; the AEU for a mature horse is 1.25. Thus, a mature horse eats 6.25 times as much as a mature sheep in an equal period of time. Hence, it is recommended that for every mature horse (feral or free ranging, regardless of ownership) in a given area, the carrying capacity be reduced by about six sheep mature sheep.

For example, if an area has a carrying capacity of 108 sheep (established for a one-year grazing period), and it is estimated that five feral horses graze the area. Five horses times six would be a reduction in 30 sheep, so the carrying capacity would be 78 sheep.

5.3 Range Condition and Potential

The majority of sampled range areas in District 11 are in poor condition. This means that plant species composition and production are very different than reference sites or the historical plant climax communities (assuming assigned ecological sites are correct). Across all analysis units/ecological sites, the estimated allowable productions—which represent the plant compositions that would occur in the historical climax communities—are lower than the sites' potential production. Thus, most of the range is far from its potential. The majority of ecological sites/analysis units (7 of 86) have lower reconstructed production values than the site's potential production, and only five sites have higher forage reconstructed production values (non-edible species removed) than the site's potential production. Only two units

(Albert Lee and Litson) were determined to be trending toward reference condition, based on their high frequencies of decreaser species compared to increaser and invader species. These units are in poor range condition, but they may be improving. Managers could look at the grazing practices and grazing history in these units to see if they differ from units trending away from reference conditions.

Directly relating range condition and forage quantities is difficult because a site with good forage may still score a low similarity index if it does not match the assigned ecological site. However, sites with high production of dominant encroaching species like *Artemisia tridentata*, *Bouteloua gracilis*, and *Gutierrezia sarothrae* are likely to result in low similarity indices. Forage quantities for carrying capacities were calculated after dominant non-edible species were removed, so the resulting reconstructed production largely represents edible plants and reflects better range condition. However, if the bulk of the original production was contributed to non-edible species, than range condition (and similarity index) will likely be low. **Table 74** in Appendix B shows the percentage of lbs./ac. non-edible plants removed to calculate carrying capacities for each analysis unit/ecological site. Many sites lacking non-edible species still have low similarity indices. Carrying capacities would undoubtedly increase under improved range conditions.

5.4 Range Restoration

A reduction in stocking rate numbers that are closer to carrying capacity is needed in all but the Willie Shirley range unit. Even this unit, however, may be overstocked depending on which ecological sites are mostly grazed and by how many sheep. Effects of overgrazing to the range from sheep and feral horses are likely to have lasting effects despite reductions in sheep units.

Efforts can be made to improve range conditions, although some areas may never reach their full potential. Past grazing practices and nonnative species can have long-lasting effects on range condition. For example, Rawlings et al. (1997) found that the part of Canyonlands National Park that had been grazed most intensively prior to elimination of grazing became highly invaded by cheatgrass (*Bromus tectorum*). Once invaders have become established on a range, a reduction in grazing pressure is not likely to return the range to pre-invader conditions (Vallentine 2001 and references therein). The high frequencies of *Bouteloua gracilis* and *Pleuraphis jamesii* are indicators of long-term grazing. Both of these species increase with long-term grazing (Bock and Bock 1986, Monsen et al. 2004). *Bouteloua gracilis* has two growth forms: an upright form and a less productive sod-form. Grazing tends to remove the upright growth forms and encourages selection for the less productive sod-forming grasses; heavy grazing can cause *B. gracilis* to become totally sod-bound and lead to decline in production (Monsen et al. 2004). Restoring the productivity of *B. gracilis* would require long-term resting of the range, which is not likely to occur in most areas. Active restoration efforts such as seeding and use of prescribed fire are unrealistic in most of District 11 due to limited budgets and the size of grazing units. The most realistic options that should be considered along with a reduction in sheep units are resting range units, or parts of units, and feral horse management.

5.4.1 Range Rest

Continuous grazing is probably the most common type in the District. Herders typically let the sheep roam (accompanied by sheep dogs) unimpeded by fences or other artificial barriers. Controlled grazing systems are difficult to apply due to the need of movable fences or barriers, which are expensive and difficult to setup in shrubby terrain, and limited water. Moreover, enclosures would need to encapsulate large areas to include adequate forage in overgrazed areas. However, herders may be able to limit areas in which sheep graze, which would allow portions of the range to rest.

Long-term resting of the range would allow for recovery of vegetation. Rested areas may eventually trend toward reference conditions and come closer to reaching their potential production. Resting allows plants to restock on total available carbohydrate reserves in the spring when they are lowest and plants are most vulnerable to defoliation and trampling, take advantage of spring regrowth, maximize production of seeds (especially important for annuals) in summer and fall, and allow for total available carbohydrate buildup and storage in fall (Booysen and Tainton 1978).

Resting ranges in the spring may benefit range recovery the most if year-long resting is not an option. Spring grazing is generally considered the season with the most potential impact on vegetation. Total available carbohydrates concentrations in perennial plants typically occur before fall dormancy. They decrease throughout dormancy and are lowest in spring during initial growth, which draws heavily from total available carbohydrate reserves. Reserves are built back up as leaves mature and photosynthesis improves during summer (Vallentine 2001). Thus, defoliation of early spring growth in perennials will delay a plant's ability to photosynthesize and restock energy reserves. Desert plants, especially shrubs, are impacted by spring defoliation because they cannot restock reserves during hot, dry summers (Vallentine 2001). Cook and Stoddart (1963) found that spring grazing in salt-desert ranges in western Utah was detrimental to plants (high mortality) unless forage utilization was kept under 30%. Impacts to plants were worse with increasing grazing intensity (Cook and Stoddart 1963). A multi-decade study in salt-desert shrub habitats in western Utah on sheep grazing found March to early April grazing reduced the vigor in many grasses and *Krascheninnikovia lanata* (Holmgren and Hutchings 1972). Clary and Holmgren (1982) concluded from the same data that multi-year grazing in March through April, regardless of intensity, is damaging to the range.

Recovery of vegetation can take time, and will vary by species, degree of previous disturbance, and environmental conditions. Long-term protection from grazing can benefit plant cover, production, vigor, and diversity, but this is highly variable by species and ecological site. For example, Kleiner (1983) found a significant increase in litter and vegetation cover in Canyonlands National Park after a ten-year rest. Floyd et al. (2003), working in San Juan County, New Mexico, studied vegetation recovery in grazed, short-term non-grazed (≤ 5 yrs.), and long-term non-grazed areas (> 50 yrs.) at six sites. They found that plant species richness was higher at all long-term sites, and both grass and shrub covers differed by treatment and site, with a significant interaction between the two. Cook and Child (1971), working in western Utah desert range, found that after a seven-year rest from hand clipping, recovery rates varied by species. *Atriplex confertifolia* recovered faster than *Artemisia tridentata*, and *Krascheninnikovia lanata* production was still lower in clipped plants than non-clipped individuals after seven years. *Achnatherum hymenoides* and *Elymus elymoides* cover recovery varied greatly by previous amount of defoliation. A study in Canyonlands National Park, Utah, compared vegetation after a five- and 15-year rest and to similar vegetation in reference sites with minimal departure from reference conditions (Kleiner 1983). The researcher found that conditions after 15 years of rest were trending toward reference site conditions. This was most evident in response of perennial grasses: *Oryzopsis hymenoides*, *Hesperostipa comata*, *Sporobolus cryptandrus,* and *Bouteloua gracilis* were all recovering, while *Pleuraphis jamesii* was not. Cryptobiotic crusts were also recovering (Kleiner 1983).

Range rest will also indirectly benefit plants by improving soil conditions. Grazing can lead to erosion, compaction, crusting, and destruction of biotic crusts. Biological crusts affect soil stability, moisture, nutrients, and seedling establishment (Harper and Belnap 2001, Belnap 1992 and references therein). Heavy grazing and destruction of biological crusts have been shown to cause a reduction in some grass species in northern Arizona (Brotherson et al. 1983). Recovery rates of crusts can take over 40 years (Belnap 1993).

5.4.2 Feral Horse Management

Horses are unique in their grazing impacts compared to other ungulates in the Southwest. Horses are termed cecal digesters, which places more time–energy constraints on the animals. This means that horses are non-selective in their grazing habits and will eat a larger variety of plant species than cattle, sheep, and native ungulates, which leads to fewer ungrazed species (Beever 2003). Horses also have flexible lips and upper front incisors. This allows them to trim vegetation closer to the ground than cattle, which can delay recovery of plants (Symanski 1994, Menard et al. 2002). Thus, the low-quality diets on which horses live means they consume 20–65% more forage than would a cow of equivalent body mass (Hanley 1982, Wagner 1983, Menard et al. 2002). Compared to sheep, the larger, heavier hooves of horses can lead to trampling of soils and associated impacts.

Studies have shown that areas in which feral horses graze are different than areas ungrazed by horses. A study in the Great Basin comparing actively grazed areas to areas excluded from horses for 10–14 years found that excluded sites exhibited 1.1–1.9 times greater shrub cover, 1.2–1.5 times greater total plant cover, 2–12 greater plant species richness, and 1.9–2.9 and 1.1–2.4 times greater cover and frequency of native grasses, respectively. In contrast, horse sites tended to have more grazing-resistant forbs and exotic plants (Beever et al. 2008). Feral horses impact vegetation around water sources. Another study in the Great Basin in Nevada found that vegetation around springs excluded from feral horse grazing had higher plant species richness, percent cover, and abundance of grasses and shrubs (Beever and Brussard 2000).

Control and management of feral horses would perhaps contribute the most toward range improvement. Range rest will have little affect if feral horses are continually allowed to graze range units. As mentioned above, stocking rates should be adjusted for feral horses. Accurate adjustments will depend on accurate estimates of horse numbers. Feral horse surveys are recommended, and they should correspond to planned adjustments of stocking rates for sheep. Monitoring and control of feral horses is required to reduce grazing impacts and improve the range for the use of native ungulates and livestock.

5.5 Special Management Areas

Navajo Nation Department of Fish and Wildlife classify Navajo Nation into biological sensitive areas based on the biological resources of the area. This is termed the Biological Resource Land Clearance Policies and Procedures (RCP). **Figure 20** in Appendix A shows these areas across District 11. Areas 1 and 2 are the most sensitive and typically provide habitat for and contain species protected under the U.S. Endangered Species Act and/or on the Navajo Nation Endangered Species List. Habitat for raptors may also be included. Managers can communicate with Navajo Nation Department of Fish and Wildlife to determine the biological resources in these areas and how range management decisions may affect them.

6.0 CONCLUSIONS

Grazing management involves more than assessing range conditions and carrying capacities. Grazing management plans should be developed for management units. Developing a grazing management plan involves five steps:

1. Inventory the resource
2. Define goals
3. Determine grazing units
4. Develop a grazing schedule
5. Develop a monitoring and evaluation plan (Montana Department of Natural Resources and Conservation 1999)

This inventory report is just the first step in developing a grazing management plan. Although grazing units may be defined, smaller units may need to be defined to adequately manage grazing in a sustainable fashion. It is imperative that one of the goals in any management plan be control of feral horses.

Monitoring and evaluation is the most neglected component of range management (Rinehart 2008). Range production and species composition should be sampled at standard intervals, and the same general transect locations should be used repeatedly. Changes in production, but more importantly, species composition can be compared over time. Important questions include: Is grass production increasing or decreasing? Are invasive and undesirable species increasing or decreasing? Data among sampling years can be analyzed more efficiently using spreadsheet software and other free statistical software than in the past when data were maintained on paper copies. Digital records of transect photo points should also be maintained and used to assess changes in range condition. Records of grazing methods, actual stocking numbers (not just those on paper), and any treatment methods should be maintained to allow for association with and analysis of monitoring results. Other important records include feral horse monitoring, large-scale fire documentation, precipitation data, and any major vegetation treatment such as chaining.

Monitoring for noxious weed encroachment should be included in grazing management plans. Common invasives such as *Salsola tragus* are here to stay, but other species not yet fully established in an area should be controlled. *Acroptilon repens* is one example. This species is common in the town of Chinle and should not be allowed to spread into natural areas.

Another important part of a grazing management plan, especially in the Southwest, is a drought-response plan. This is increasingly important as frequency and severity of droughts are predicted to increase with climate change. One option is to maintain stocking rates at lower numbers (~75%) than carrying capacity will allow for normal years. This will allow for the accumulation of forage, and a given range may be better able to sustain the same stocking rate during droughts (Rinehart 2008).

7.0 LITERATURE CITED

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Appendix A. Figures

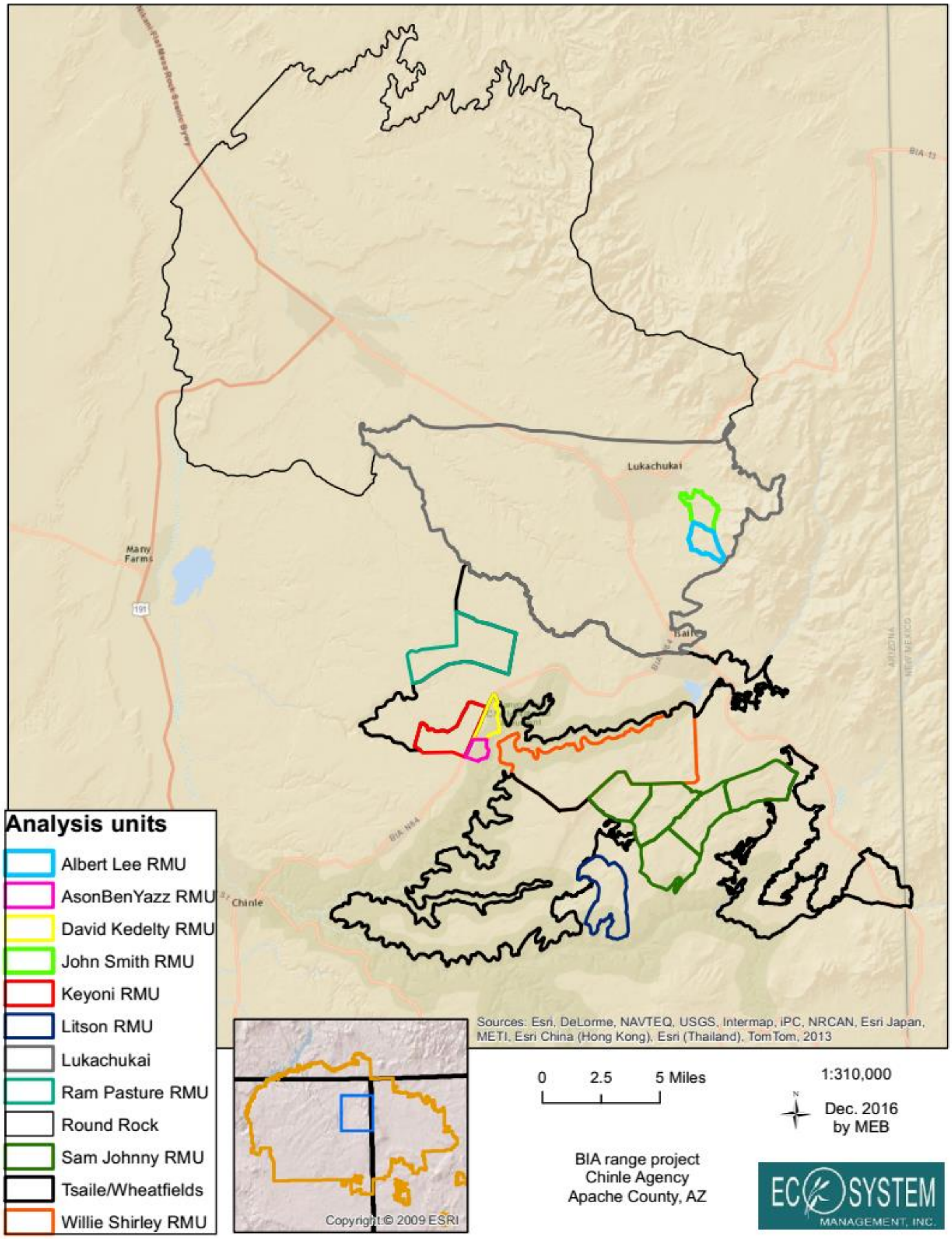

Figure 18. Sampling area and analysis units.

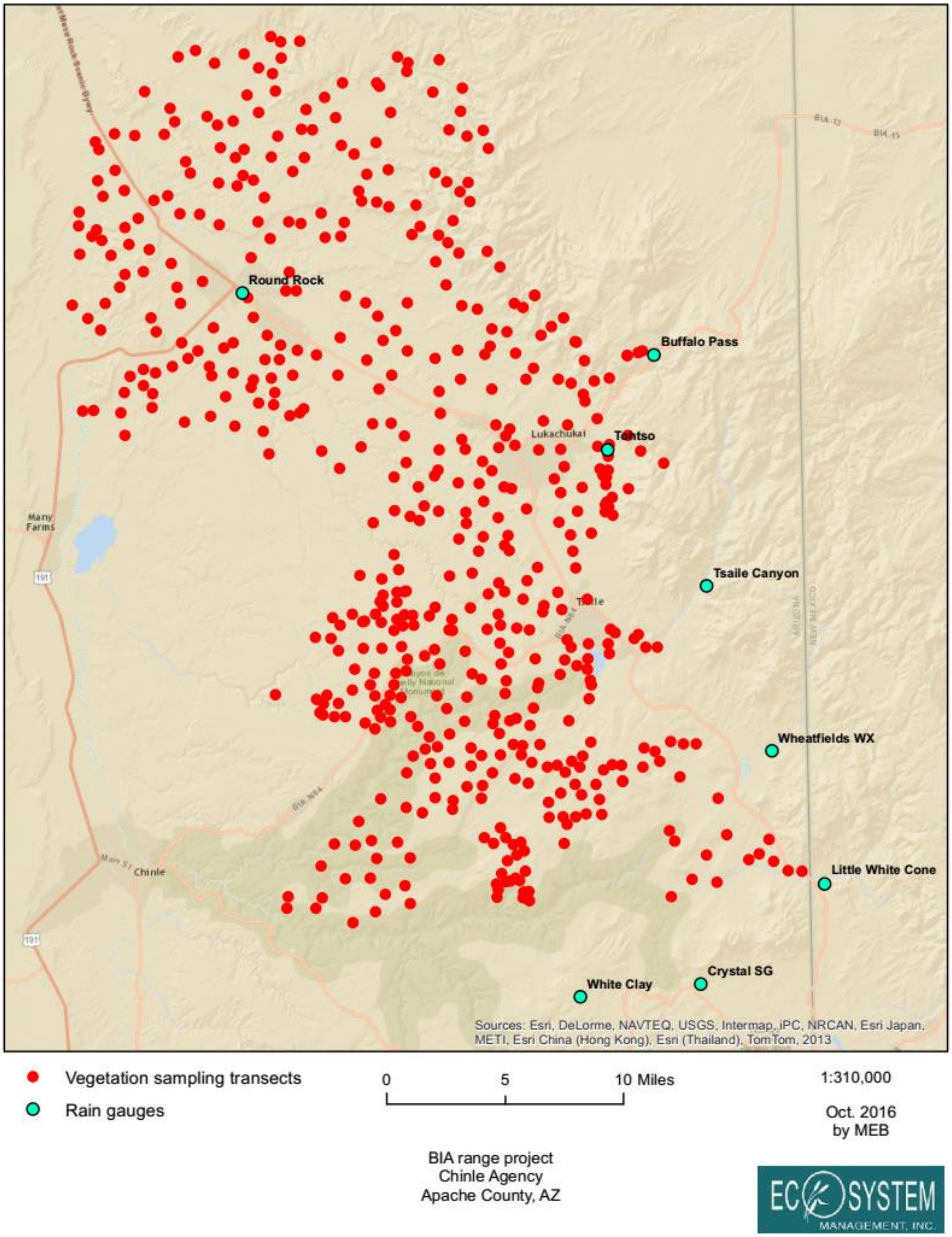

Figure 19. Transect and rain gauge locations.

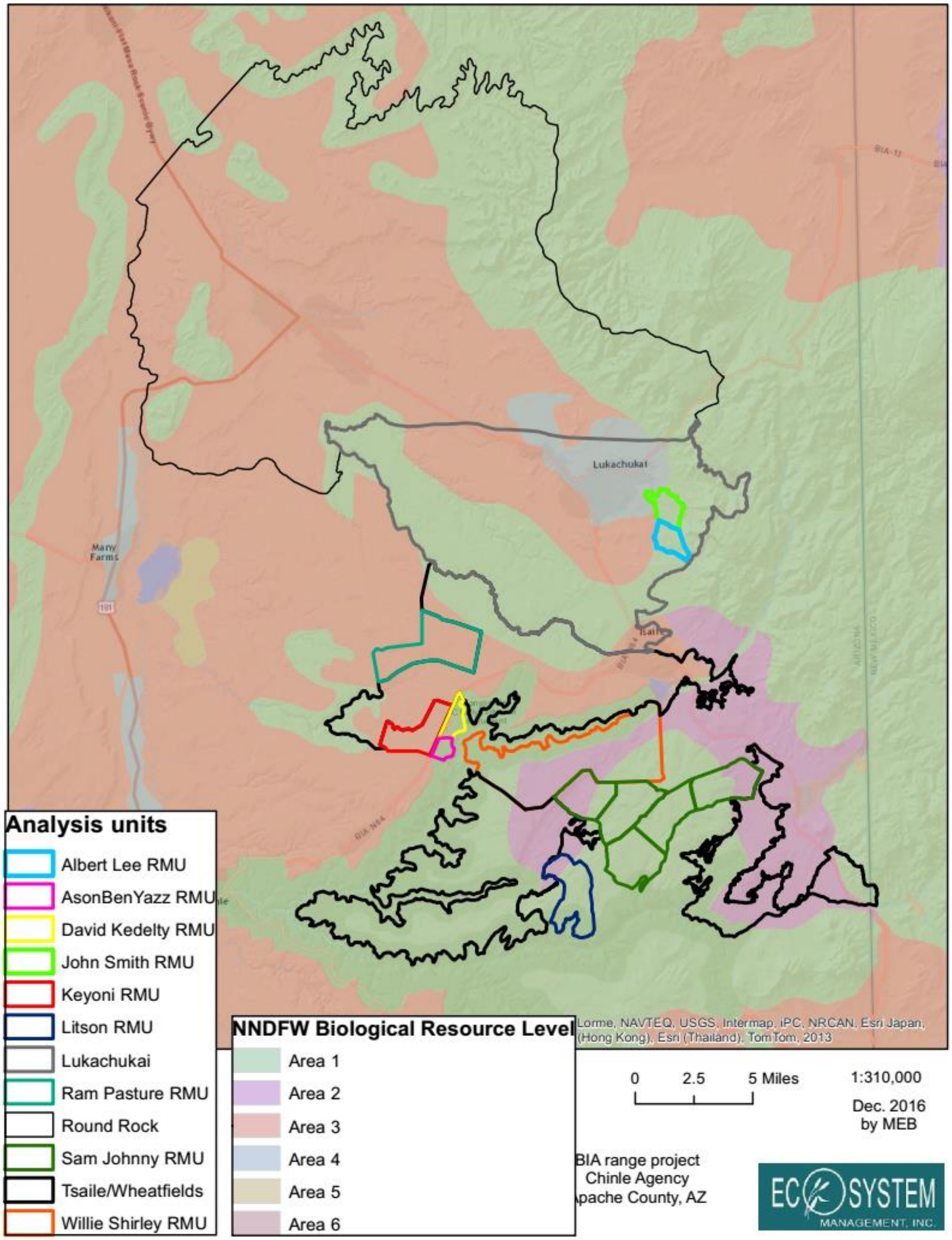

Figure 20. Biological resource areas in District 11. Area 1 is most sensitive; Areas 3 and higher are low sensitivity.

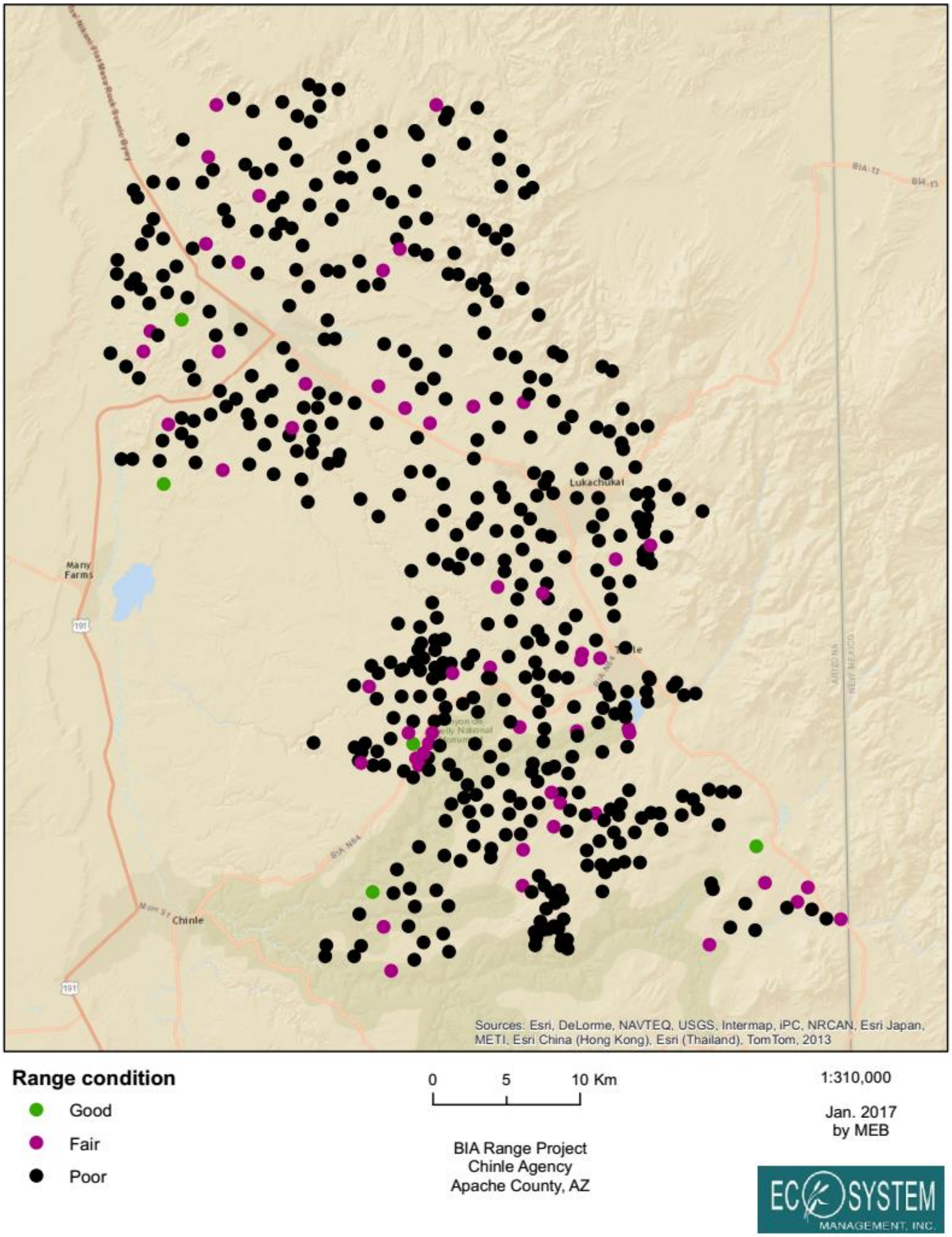

Figure 21. Range conditions based on sampling transects across District 11.

Appendix B. Tables

Table 66. Summary of analysis units.

Chapter/RMU	Analysis acres*	# transects	# grazing permit	# sheep unit	Grazing months
Round Rock Chapter	182,236	205	74	2,526	12
Lukachukai Chapter	63,195	81	142	3,347	9
Tsaile/Wheatfields Chapter	70,758	110	193	4,578	9
Albert Lee	849	5	1	41	12
John Smith	961	6	3	65	12
Ason Ben Yazz	411	5	3	117	12
David Kedelty	679	5	1	25	12
Keyoni	2,102	11	2	110	9
Litson	2,890	22	5	135	12
Ram Pasture	4,218	19	unknown	unknown	12
Willie Shirley	11,881	26	4	206	12
Sam Johnny 1	2,519	7	16	838	12
Sam Johnny 2	2,352	8			
Sam Johnny 3	2,750	6			
Sam Johnny 4	2,661	8			
Sam Johnny 5	2,162	6			
Total Chapters	*316,189*	*396*	*409*	*10,451*	
Total RMUs	*36,435*	*134*	*35*	*1,537*	
Total	**352,624**	**530**	**444**	**11,988**	

*For Chapters, this is the chapter acreage minus commercial forest and nested RMU acreage.

Table 67. List of undesirable plant species excluded from production estimates.

Code	Scientific name
ACMI2	*Achillea millefolium*
ANTEN	*Antennaria* spp.
Asteraceae1	Asteraceae annual forb
ASTRA	*Astragalus* spp.
DELPH	*Delphinium* spp.
ERCI6	*Erodium cicutarium*
EUPHO	*Euphorbia* spp.
GUSA2	*Gutierrezia sarothrae*
HORDE	*Hordeum* spp.
LUPIN	*Lupinus* spp.
MARE11	*Mahonia repens*
SENEC	*Senecio* spp. sensu lato

Table 68. Mapped soil units on which transects occur.

Soil survey	Soil map unit	Soil survey	Soil map unit	Soil survey	Soil map unit	Soil survey	Soil map unit
AZ712	1	AZ713	3	AZ713	24	AZ713	43
AZ712	3	AZ713	4	AZ713	25	AZ713	46
AZ712	6	AZ713	6	AZ713	26	AZ713	48
AZ712	9	AZ713	8	AZ713	27	AZ713	49
AZ712	10	AZ713	9	AZ713	28	AZ713	50
AZ712	12	AZ713	10	AZ713	29	AZ713	53
AZ712	13	AZ713	13	AZ713	32	AZ713	56
AZ712	20	AZ713	17	AZ713	34	AZ713	58
AZ713	1	AZ713	20	AZ713	36	AZ713	61
AZ713	2	AZ713	21	AZ713	40	AZ713	64

Table 69. Precipitation departure from averages for range stations.

Rain station	2016 % of 12-yr. mean
Blue Canyon Dam	1.13
Bowl Canyon SC	1.01
Buffalo Pass	1.08
Crystal SG	1.25
Crystal WX	1.14
Deza Bluff	1.31
Fluted Rock SC	1.01
Ft. Defiance-WMB	1.10
Klagetoh 9 NE	1.10
Little White Cone	0.87
Mexican Springs	1.05
Oak Ridge	1.07
Round Rock	1.38
Summit South	1.09
Summit WX	1.02
Tohtso	1.33
Tsaile Canyon	1.17
Tsaile Snow Course #1	0.95
Vicenti Spring	1.11
Wheatfields WX	0.78
White Clay	1.15

Table 70. Ecological sites assigned to transects.

ESD site ID	ESD site name
F035XF625AZ	Loamy Upland (PIED, JUOS)1317" p.z. (Provisional)
F035XF627AZ	Sandstone Upland (JUOS, PIED) 1317" p.z. (Provisional)
F035XF629AZ	Sandstone Hills (PIED) 13–17" p.z. (Provisional)
F035XF633AZ	Colluvial Slopes (PIED) 13–17" p.z. (Provisional)
F035XF637AZ	Loamy Bottom 13–17" p.z. (Provisional)
F035XH804AZ	Shallow Sandy Loam (PIPO) 17–25" p.z. (Provisional)
F035XH808AZ	Loamy Upland (PIPO) 1725" p.z. (Provisional)
F035XH818AZ	Sandy Loam Slopes (PIPO, POTR5) 1725" p.z. Cobbly (Provisional)
F035XH826AZ	Sandstone Upland (PIPO) 1725" p.z. (Provisional)
F035XH827AZ	Sandstone Hills (PIPO) 1725" p.z. (Provisional)
R035XB201AZ	Mudstone/Sandstone Hills 610" p.z. (Provisional)
R035XB204AZ	Sandstone Upland 6–10" p.z. (Provisional)
R035XB215AZ	Sandstone/Shale Upland 6–10" p.z. (Provisional)
R035XB216AZ	Sandy Wash 610" p.z. (Provisional)
R035XB217AZ	Sandy Upland 610" p.z. (Provisional)
R035XB219AZ	Sandy Loam Upland 6–10" p.z. (Provisional)
R035XB220AZ	Shale Upland 6–10" p.z. (Provisional)
R035XB227AZ	Sandy Loam Upland 6–10" p.z. Saline–Sodic (Provisional)
R035XB233AZ	Limestone/Sandstone Upland 6–10" p.z. Saline (Provisional)
R035XB238AZ	Sandy Terrace 6–10" p.z. Sodic (Provisional)
R035XB267AZ	Sandy Loam Upland 610" p.z. Limy (Provisional)
R035XC302AZ	Sedimentary Cliffs 10–14" p.z. (Provisional)
R035XC309AZ	Clay Loam Terrace 10–14" p.z. Saline–Sodic (Provisional)
R035XC312AZ	Cobbly Slopes 10–14" p.z. (Provisional)
R035XC313AZ	Loamy Upland 1014" p.z. (Provisional)
R035XC314AZ	Sandstone Upland 1014" p.z. (Provisional)
R035XC315AZ	Sandy Upland 10–14" p.z. (Provisional)
R035XC317AZ	Sandy Loam Upland 1014" p.z. (Provisional)
R035XC320AZ	Shale Hills 10–14" p.z. (Provisional)
R035XC326AZ	Sandy Loam Upland 10–14" p.z. Saline (Provisional)
R035XC328AZ	Cobbly Slopes 10–14" p.z. (Provisional)
R035XF601AZ	Sedimentary Cliffs 1317" p.z. (Provisional)
R035XF603AZ	Clay Loam Upland 1317" p.z. (Provisional)
R035XF604AZ	Clayey Upland 13–17" p.z. (Provisional)
R035XF605AZ	Loamy Upland 1317" p.z. (Provisional)
R035XF606AZ	Sandy Loam Upland 13–17" p.z. (Provisional)
R035XF607AZ	Sandy Upland 13–17" p.z. (Provisional)
R035XH813AZ	Silty Upland 17–25" p.z. (Provisional)
R035XH821AZ	Meadow 17–25" p.z. (Provisional)

Table 71. Ecological sites and associated soil map units by analysis unit.

Analysis Unit	Soil survey	Soil map unit	Assigned ESD	Analysis Unit	Soil survey	Soil map unit	Assigned ESD
Albert Lee	AZ713	49	F035XF629AZ	Round Rock	AZ713	6	R035XC314AZ
Ason Ben Yazz	AZ713	25	F035XF625AZ	Round Rock	AZ713	10	R035XC315AZ
Ason Ben Yazz	AZ712	9	F035XF625AZ	Round Rock	AZ713	6	R035XC315AZ
David Kedelty	AZ712	9	F035XF625AZ	Round Rock	AZ713	3	R035XC317AZ
David Kedelty	AZ712	13	F035XF625AZ	Round Rock	AZ713	10	R035XC317AZ
David Kedelty	AZ712	9	F035XF627AZ	Round Rock	AZ713	6	R035XC317AZ
John Smith	AZ713	25	F035XF625AZ	Round Rock	AZ713	50	R035XC320AZ
Keyoni	AZ713	25	F035XF625AZ	Round Rock	AZ713	61	R035XC320AZ
Keyoni	AZ713	4	R035XC313AZ	Round Rock	AZ713	27	R035XC326AZ
Keyoni	AZ713	50	R035XC320AZ	Round Rock	AZ713	40	R035XF606AZ
Litson	AZ712	9	F035XF625AZ	Round Rock	AZ713	40	R035XF607AZ
Litson	AZ712	13	F035XF625AZ	Sam Johnny 1	AZ713	26	F035XH808AZ
Litson	AZ713	25	F035XF625AZ	Sam Johnny 1	AZ713	21	F035XH808AZ
Litson	AZ712	9	F035XF627AZ	Sam Johnny 1	AZ713	26	F035XH827AZ
Litson	AZ713	49	F035XF629AZ	Sam Johnny 1	AZ713	53	R035XF604AZ
Litson	AZ712	1	R035XF601AZ	Sam Johnny 2	AZ713	26	F035XH808AZ
Litson	AZ713	53	R035XF604AZ	Sam Johnny 2	AZ713	21	F035XH826AZ
Lukachukai	AZ713	25	F035XF625AZ	Sam Johnny 2	AZ713	26	F035XH827AZ
Lukachukai	AZ713	49	F035XF629AZ	Sam Johnny 2	AZ713	20	R035XH813AZ
Lukachukai	AZ713	58	F035XH818AZ	Sam Johnny 3	AZ713	25	F035XF625AZ
Lukachukai	AZ713	1	F035XH818AZ	Sam Johnny 3	AZ713	26	F035XH808AZ
Lukachukai	AZ713	9	R035XC309AZ	Sam Johnny 3	AZ713	26	F035XH827AZ
Lukachukai	AZ713	48	R035XC309AZ	Sam Johnny 3	AZ713	20	R035XH813AZ
Lukachukai	AZ713	64	R035XC312AZ	Sam Johnny 4	AZ713	26	F035XH808AZ
Lukachukai	AZ713	4	R035XC313AZ	Sam Johnny 4	AZ713	21	F035XH826AZ
Lukachukai	AZ713	8	R035XC313AZ	Sam Johnny 4	AZ713	26	F035XH827AZ
Lukachukai	AZ713	48	R035XC313AZ	Sam Johnny 4	AZ713	53	R035XF603AZ
Lukachukai	AZ713	3	R035XC314AZ	Sam Johnny 5	AZ713	25	F035XF627AZ
Lukachukai	AZ713	50	R035XC314AZ	Sam Johnny 5	AZ713	26	F035XH808AZ
Lukachukai	AZ713	3	R035XC317AZ	Sam Johnny 5	AZ713	26	F035XH827AZ
Lukachukai	AZ713	4	R035XC317AZ	Sam Johnny 5	AZ713	53	R035XF603AZ
Lukachukai	AZ713	50	R035XC320AZ	Sam Johnny 5	AZ713	53	R035XF604AZ
Ram Pasture	AZ713	4	R035XC313AZ	Wheatfields	AZ713	25	F035XF625AZ
Ram Pasture	AZ713	50	R035XC314AZ	Wheatfields	AZ712	9	F035XF625AZ
Ram Pasture	AZ713	3	R035XC314AZ	Wheatfields	AZ712	13	F035XF625AZ
Ram Pasture	AZ713	50	R035XC320AZ	Wheatfields	AZ712	12	F035XF625AZ
Round Rock	AZ713	25	F035XF625AZ	Wheatfields	AZ713	25	F035XF627AZ
Round Rock	AZ713	56	F035XH804AZ	Wheatfields	AZ712	9	F035XF627AZ
Round Rock	AZ713	58	F035XH818AZ	Wheatfields	AZ713	49	F035XF629AZ
Round Rock	AZ713	13	R035XB201AZ	Wheatfields	AZ713	49	F035XF633AZ
Round Rock	AZ713	29	R035XB204AZ	Wheatfields	AZ713	36	F035XF637AZ
Round Rock	AZ713	17	R035XB215AZ	Wheatfields	AZ713	4	R035XC313AZ
Round Rock	AZ713	2	R035XB216AZ	Wheatfields	AZ713	3	R035XC314AZ
Round Rock	AZ713	32	R035XB217AZ	Wheatfields	AZ713	50	R035XC314AZ
Round Rock	AZ713	46	R035XB217AZ	Wheatfields	AZ712	20	R035XC314AZ
Round Rock	AZ713	2	R035XB217AZ	Wheatfields	AZ713	43	R035XC314AZ

Analysis Unit	Soil survey	Soil map unit	Assigned ESD	Analysis Unit	Soil survey	Soil map unit	Assigned ESD
Round Rock	AZ713	32	R035XB219AZ	Wheatfields	AZ712	6	R035XC317AZ
Round Rock	AZ713	46	R035XB219AZ	Wheatfields	AZ713	64	R035XC328AZ
Round Rock	AZ713	28	R035XB220AZ	Wheatfields	AZ712	1	R035XF601AZ
Round Rock	AZ713	28	R035XB227AZ	Wheatfields	AZ713	53	R035XF603AZ
Round Rock	AZ713	34	R035XB227AZ	Wheatfields	AZ712	3	R035XF603AZ
Round Rock	AZ713	34	R035XB233AZ	Wheatfields	AZ713	53	R035XF604AZ
Round Rock	AZ713	46	R035XB238AZ	Wheatfields	AZ712	10	R035XF605AZ
Round Rock	AZ713	24	R035XB238AZ	Willie Shirley	AZ712	13	F035XF625AZ
Round Rock	AZ713	13	R035XB267AZ	Willie Shirley	AZ713	25	F035XF625AZ
Round Rock	AZ713	61	R035XC302AZ	Willie Shirley	AZ712	9	F035XF625AZ
Round Rock	AZ713	9	R035XC309AZ	Willie Shirley	AZ713	49	F035XF629AZ
Round Rock	AZ713	4	R035XC313AZ	Willie Shirley	AZ713	26	F035XH827AZ
Round Rock	AZ713	3	R035XC314AZ	Willie Shirley	AZ713	53	R035XF603AZ
				Willie Shirley	AZ712	3	R035XF603AZ

Table 72. Water sources and mean distance to closest water source by analysis unit. SD is standard deviation.

Chapter/RMU	# windmills	# non-windmill water sources	Total water sources	$\bar{x}$ distance closest windmills (miles)	SD windmills	$\bar{x}$ distance to closest non-windmill water (miles)	SD non-windmill water
Albert Lee	0	0	**0**	-	-	-	-
Ason Ben Yazz	0	0	**0**	-	-	-	-
David Kedelty	0	0	**0**	-	-	-	-
John Smith	0	0	**0**	-	-	-	-
Keyoni	0	0	**0**	-	-	-	-
Litson	0	2	**2**	-	-	0.86	0.34
Lukachukai	4	9	**13**	3.22	2.03	1.99	1.69
Ram Pasture	2	0	**2**	1.13	0.73	-	-
Round Rock	9	9	**18**	3.11	1.79	3.14	1.73
Sam Johnny 1	0	1	**1**	-	-	1.28	0.85
Sam Johnny 2	0	1	**1**	-	-	1.53	0.69
Sam Johnny 3	0	2	**2**	-	-	0.95	0.52
Sam Johnny 4	0	0	**0**	-	-	-	-
Sam Johnny 5	0	1	**1**	-	-	0.76	0.47
Tsaile/Wheatfields	6	16	**22**	2.98	1.98	2.61	2.86
Willie Shirley	0	7	**7**	-	-	1.02	0.63

Table 73. Stocking rate/carrying capacity adjustments for water distribution.

Distance from water (miles)	% adjustment
0–1	0
1–2	50
>2	75

Table 74. Percentage of lbs./ac. non-edible plants removed to calculate carrying capacities for each analysis unit/ecological site.

Analysis unit	ESD site ID	Mean reconstructed lbs./ac.	Mean reconstructed lbs./ac. (non-edible species removed)	Lbs./ac. removed non-edible species	% removed lbs./ac. non-edible species	Similarity index (%)
Albert Lee	F035XF629AZ	141	128	13	9	8
Ason Ben Yazz	F035XF625AZ	181	161	20	11	24
David Kedelty	F035XF625AZ	314	285	29	9	27
David Kedelty	F035XF627AZ	80	71	10	12	2
John Smith	F035XF625AZ	114	101	13	12	17
Keyoni	F035XF625AZ	306	243	63	21	39
Keyoni	R035XC313AZ	175	138	37	21	16
Keyoni	R035XC320AZ	6	5	1	11	0
Litson	F035XF625AZ	163	56	108	66	7
Litson	F035XF627AZ	8	8	0	0	0
Litson	F035XF629AZ	97	97	0	0	5
Litson	R035XF601AZ	47	47	0	0	1
Litson	R035XF604AZ	325	300	25	8	16
Lukachukai	F035XF625AZ	366	358	8	2	10
Lukachukai	F035XF629AZ	70	57	13	18	7
Lukachukai	F035XH818AZ	321	302	19	6	3
Lukachukai	R035XC309AZ	363	338	24	7	5
Lukachukai	R035XC312AZ	5	4	0	8	0
Lukachukai	R035XC313AZ	200	184	16	8	15
Lukachukai	R035XC314AZ	101	82	20	19	4
Lukachukai	R035XC317AZ	119	100	20	16	5
Lukachukai	R035XC320AZ	188	182	5	3	3
Ram Pasture	R035XC313AZ	248	113	135	54	15
Ram Pasture	R035XC314AZ	218	140	77	35	4
Ram Pasture	R035XC320AZ	224	206	18	8	6
Round Rock	F035XF625AZ	23	2	21	91	5
Round Rock	F035XH804AZ	142	142	0	0	5
Round Rock	F035XH818AZ	111	61	50	45	1
Round Rock	R035XB201AZ	183	183	0	0	13
Round Rock	R035XB204AZ	103	88	15	15	8
Round Rock	R035XB215AZ	111	90	21	19	21
Round Rock	R035XB216AZ	52	52	0	0	1
Round Rock	R035XB217AZ	407	309	98	24	13
Round Rock	R035XB219AZ	145	137	9	6	14

Analysis unit	ESD site ID	Mean reconstructed lbs./ac.	Mean reconstructed lbs./ac. (non-edible species removed)	Lbs./ac. removed non-edible species	% removed lbs./ac. non-edible species	Similarity index (%)
Round Rock	R035XB220AZ	154	87	68	44	10
Round Rock	R035XB227AZ	133	107	26	20	12
Round Rock	R035XB233AZ	191	171	20	10	20
Round Rock	R035XB238AZ	59	46	13	22	6
Round Rock	R035XB267AZ	275	171	104	38	21
Round Rock	R035XC302AZ	106	98	7	7	3
Round Rock	R035XC309AZ	135	113	22	16	4
Round Rock	R035XC313AZ	68	54	14	21	7
Round Rock	R035XC314AZ	240	178	63	26	4
Round Rock	R035XC315AZ	943	331	612	65	7
Round Rock	R035XC317AZ	272	234	38	14	16
Round Rock	R035XC320AZ	198	189	9	4	5
Round Rock	R035XC326AZ	1050	1018	32	3	13
Round Rock	R035XF606AZ	245	245	0	0	14
Round Rock	R035XF607AZ	74	35	39	52	2
Sam Johnny 1	F035XH808AZ	102	90	12	12	3
Sam Johnny 1	F035XH827AZ	98	87	11	11	1
Sam Johnny 1	R035XF604AZ	232	215	17	7	8
Sam Johnny 2	F035XH808AZ	109	58	51	47	4
Sam Johnny 2	F035XH826AZ	141	62	80	56	5
Sam Johnny 2	F035XH827AZ	44	25	20	44	3
Sam Johnny 2	R035XH813AZ	1150	1132	18	2	14
Sam Johnny 3	F035XF625AZ	50	37	13	25	2
Sam Johnny 3	F035XH808AZ	60	37	24	40	9
Sam Johnny 3	F035XH827AZ	21	17	4	18	1
Sam Johnny 3	R035XH813AZ	252	226	26	10	8
Sam Johnny 4	F035XH808AZ	132	79	53	40	4
Sam Johnny 4	F035XH826AZ	27	27	1	3	1
Sam Johnny 4	F035XH827AZ	145	141	3	2	11
Sam Johnny 4	R035XF603AZ	909	904	5	1	46
Sam Johnny 5	F035XF627AZ	50	49	2	4	8
Sam Johnny 5	F035XH808AZ	66	64	2	4	12
Sam Johnny 5	F035XH827AZ	87	86	1	1	20
Sam Johnny 5	R035XF603AZ	492	467	25	5	26
Sam Johnny 5	R035XF604AZ	754	754	0	0	40
Wheatfield	F035XF625AZ	171	148	22	13	12
Wheatfield	F035XF627AZ	124	113	10	8	8
Wheatfield	F035XF629AZ	115	105	10	9	5
Wheatfield	F035XF633AZ	62	50	12	20	8
Wheatfield	F035XF637AZ	253	248	5	2	2
Wheatfield	R035XC313AZ	207	141	66	32	13
Wheatfield	R035XC314AZ	231	205	26	11	4
Wheatfield	R035XC317AZ	489	438	51	10	53
Wheatfield	R035XC328AZ	161	137	25	15	9

Analysis unit	ESD site ID	Mean reconstructed lbs./ac.	Mean reconstructed lbs./ac. (non-edible species removed)	Lbs./ac. removed non-edible species	% removed lbs./ac. non-edible species	Similarity index (%)
Wheatfield	R035XF601AZ	770	722	48	6	2
Wheatfield	R035XF603AZ	144	131	13	9	13
Wheatfield	R035XF604AZ	271	260	11	4	27
Wheatfield	R035XF605AZ	480	465	15	3	30
Willie Shirley	F035XF625AZ	154	139	15	10	14
Willie Shirley	F035XF629AZ	100	98	2	2	4
Willie Shirley	F035XH827AZ	48	28	20	42	6
Willie Shirley	R035XF603AZ	601	572	29	5	33

Appendix C. Plant species list

Species	Symbol
Achillea millefolium	ACMI2
Achnatherum hymenoides	ACHY
Agave	AGAVE
Agropyron cristatum	AGCR
Allium	ALLIU
Allium cernuum	ALCE2
Amelanchier utahensis	AMUT
Antennaria	ANTEN
Arctostaphylos	ARCTO3
Arctostaphylos uva-ursi	ARUV
Aristida	ARIST
Aristida divaricata	ARDI5
Aristida oligantha	AROL
Artemisia	ARTEM
Artemisia bigelovii	ARBI3
Artemisia cana	ARCA13
Artemisia filifolia	ARFI2
Artemisia frigida	ARFR4
Artemisia nova	ARNO4
Artemisia tridentata	ARTR2
Asclepiadaceae	Asclepiadaceae
Asclepias	ASCLE
Asteraceae	Asteraceae
Asteraceae annual forb	Asteraceae1
Astragalus	ASTRA
Atriplex	ATRIP
Atriplex canescens	ATCA2
Atriplex confertifolia	ATCO
Atriplex corrugata	ATCO4
Avena fatua	AVFA
Boraginaceae	Boraginaceae
Bouteloua gracilis	BOGR2
Brassica	BRASS2
Brassicaceae	Brassicaceae
Bromus	BROMU
Bromus tectorum	BRTE
Calochortus	CALOC
Calochortus kennedyi	CAKE
Carex	CAREX
Castilleja	CASTI2

Species	Symbol
Ceanothus	CEANO
Cercocarpus montanus	CEMO2
Chamaesyce fendleri	EUFE2
Chenopodiaceae	Chenopodiaceae
Chrysothamnus	CHRYS9
Chrysothamnus depressus	CHDE2
Chrysothamnus greenei	CHGR6
Chrysothamnus viscidiflorus	CHVI8
Cirsium	CIRSI
Coleogyne ramosissima	CORA
Convolvulus arvensis	COAR4
Cordylanthus wrightii	COWR2
Cryptantha	CRYPT
Cryptantha crassisepala	CRCR3
Cylindropuntia	CYLIN2
Dalea	DALEA
Delphinium parishii	DEPA
Elymus	ELYMU
Elymus longifolius	ELELB2
Ephedra	EPHED
Ephedra viridis	EPVI
Equisetum	EQUIS
Eremopyrum triticeum	ERTR13
Ericameria nauseosa	ERNA10
Ericameria parryi var. *parryi*	ERPAP10
Erigeron	ERIGE2
Erigeron divergens	ERDI4
Eriogonum	ERIOG
Eriogonum corymbosum var. *corymbosum*	ERDI13
Eriogonum nummulare	ERNU4
Erodium cicutarium	ERCI6
Euphorbia	EUPHO
Fabaceae	Fabaceae
Fallugia paradoxa	FAPA
Fendlera rupicola	FERU
Festuca	FESTU
Festuca arizonica	FEAR2
Forb	2FA
Geranium caespitosum	GECA3
Geranium richardsonii	GERI
Gilia	GILIA

Species	Symbol
Grusonia	GRUSO
Gutierrezia sarothrae	GUSA2
Heliotropium	HELIO3
Hesperostipa comata	HECO26
Heterotheca villosa	HEVI4
Hymenoxys	HYMEN7
Ipomopsis	IPOMO2
Ipomopsis aggregata	IPAG
Krascheninnikovia lanata	KRLA2
Lamiaceae	Lamiaceae
Lepidium	LEPID
Lepidium densiflorum	LEDE
Lesquerella	LESQU
Linum	LINUM
Lotus wrightii	LOWR
Lupinus	LUPIN
Lupinus argenteus	LUAR3
Lycium	LYCIU
Mahonia repens	MARE11
Maianthemum stellatum	MAST4
Malvaceae	Malvaceae
Melilotus	MELIL
Melilotus officinalis	MEOF
Mentzelia multiflora	MEMU3
Muhlenbergia	MUHLE
Muhlenbergia montana	MUMO
Muhlenbergia richardsonis	MURI
Oenothera coronopifolia	OECO2
Opuntia	OPUNT
Orobanche fasciculata	ORFA
Orobanche ludoviciana	ORLU
Orthocarpus purpureoalbus	ORPU2
Packera	PACKE
Packera neomexicana var. *neomexicana*	SENE4
Pascopyrum smithii	PASM
Pedicularis centranthera	PECE
Penstemon	PENST
Penstemon linarioides	PELI2
Physaria	PHYSA2
Plantago	PLANT
Pleuraphis	PLEUR12

Species	Symbol
Pleuraphis jamesii	PLJA
Poa	POA
Poa fendleriana	POFE
Poa pratensis	POPR
Poaceae	Poaceae
Populus tremuloides	POTR5
Portulaca	PORTU
Potentilla	POTEN
Prunus	PRUNU
Pteridium aquilinum	PTAQ
Purshia tridentata	PUTR2
Purshia stansburiana	PUST
Rhus trilobata	RHTR
Rosa	ROSA5
Rosa woodsii var. *woodsii*	ROWOF
Salix	SALIX
Salsola tragus	SATR12
Sarcobatus vermiculatus	SAVE4
Scrophulariaceae	Scrophulariaceae
Senecio	SENEC
Shrub	2SHRUB
Sphaeralcea	SPHAE
Sphaeralcea coccinea	SPCO
Sporobolus	SPORO
Sporobolus contractus	SPCO4
Sporobolus cryptandrus	SPCR
Sporobolus flexuosus	SPFL2
Suaeda moquinii	SUMO
Sub-shrub	2SUBS
Symphoricarpos oreophilus	SYOR2
Taraxacum	TARAX
Thalictrum fendleri	THFE
Townsendia	TOWNS
Townsendia exscapa	TOEX2
Townsendia fendleri	TOFE
Trifolium	TRIFO
Trifolium repens	TRRE3
Vicia americana	VIAM
Vulpia octoflora	VUOC
Yucca	YUCCA
Yucca baccata	YUBA

Species	Symbol
Yucca baileyi	YUBA2
Zinnia	ZINNI

Appendix D. Carrying capacities for Litson pastures.

Pasture	Total ac.	Mean reconstructed lbs./ac.	# transects	Stocking rate (Sheep/ac/12 months)	Ac./sheep	Carrying capacity (sheep/pasture/12 months)
A	107	300	1	0.04	25	4
B	140	169	1	0.02	45	3
C	162	61	1	0.01	124	1
D	737	47	6	0.01	163	5
E	752	47	7	0.01	161	5
F	991	52	6	0.01	147	7