APPENDIX A6.1

BASELINE VEGETATION SURVEY

IRA AREA

MWH, 2010

United Nuclear Corporation (UNC)

Northeast Church Rock Mine

Vegetation & Wildlife Evaluations / Revegetation Recommendations

2009 Evaluations and Planning

PIÑON-JUNIPER COMMUNITY BASELINE AND REFERENCE AREA

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Vegetation & Wildlife Evaluations / Revegetation Recommendations

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Northeast Church Rock Mine
2009 Evaluations and Planning

PIÑON-JUNIPER COMMUNITY BASELINE AND REFERENCE AREA

1.0 INTRODUCTION

1.1 General

Cedar Creek Associates, Inc. (Cedar Creek) was contracted in 2009 to implement a work plan specific to vegetation, revegetation, and wildlife considerations in support of an Interim Removal Action (IRA) for United Nuclear Corporation's (UNC) Northeast Church Rock Mine (NECR). This work plan identifies and defines methods and protocols utilized for vegetation and wildlife evaluations required for the interim action pursuant to mandates of the US Environmental Protection Agency (EPA) – Region 9. The purpose of the effort documented herein is to facilitate a determination of: 1) current floral and faunal conditions extant in the vicinity of the permit area, 2) quality of habitat for indigenous wildlife, and 3) revegetation potential along with revegetation plan development and recommendations to optimize the ability of reclamation to meet post-mining land use considerations. A component of the final revegetation plan will document site-specific protocols for monitoring and eventual success evaluation to be used at the mine.

Floral and fauna surveys were conducted twice in 2009 with the first effort occurring May 1 – 2, and the second effort from August 16 – 20. These surveys were conducted by or under the direct supervision of Cedar Creek's Senior Range/Wildlife Ecologist, Mr. Steven R. Viert, and/or Range Ecologist Mr. Jesse H. Dillon.

1.2 Site Description

NECR is located approximately 16 miles northeast of Gallup, New Mexico at an elevation ranging between 7,000 and 7,200 feet above mean sea level and occupies a permit area of about 125 acres. This area occurs primarily on lands administered by the Bureau of Indian Affairs on behalf of the Navajo Nation, but also includes a component of private lands. Access agreements exist for the property for the conduct of site work. Remediation activities also include a small area of adjacent lands to the north on the Navajo Indian Reservation (see Maps 1 and 2 - the focus of the IRA activity).

Based on field reconnaissance by Cedar Creek biologists, it appears that there are three distinct vegetation communities on or in close proximity to where activities for the IRA will occur: 1) piñon-juniper woodland, 2) mined-land reclamation and/or disturbance vegetation (ruderal) communities, and 3) grassland. This latter community only exists on Navajo Nation lands to the north of the permit area.

As indicated in the work plan for NECR, only undisturbed vegetation communities are subject to sampling for the primary field effort. As a result, the historic mine reclamation and disturbance (ruderal) communities were also excluded from this quantitative sampling effort. It should be noted that a few small pockets of mixed shrubland exist within the piñon-juniper woodland, but can effectively be considered a sub-component (or understory) of the piñon-juniper community and therefore was included within the overall piñon-juniper woodland sampling effort without segregation. In addition, an ancillary protocol (total enumeration of trees) was implemented within the "step-out" area owing to the importance of these trees to the Navajo Nation.

The general project area exhibits rock outcrop defined low-elevation mesas and shallow canyons dominated by the piñon-juniper ecotype where the soils are very shallow over bedrock and/or exhibit elevated coarse fragment content where the type encounters the steeper rocky escarpments. In these rockier areas, soils become more "skeletal" and are very well drained which then encourages woody species (piñons, junipers, and shrubs) over grasses and forbs. Because the soil transition is rather abrupt, the ecotone between the deeper soils of the canyon bottoms (ruderal vegetation and reclamation) and piñon-juniper types is quite narrow. The escarpments in the project area are very rocky and steep (occasionally forming shallow but vertical cliff faces). This feature of the landscape offers significant habitat for nesting or loafing by those avian and rodent species that require the afforded protection from predators. Below the piñon-juniper woodland within the canyon bottoms would normally be a bottomland vegetation community dominated by grasses and shrubs, but currently exhibits either revegetated grassland or ruderal vegetation. Soils in this area are characterized by deep, finer textured materials that are moderately well-drained sandy loams near the sandstone based piñon-juniper

woodland, and more poorly drained sandy silt loams at lower topographic positions. The ecotone between piñon-juniper woodland and the bottomland area is more broadly defined, occurring as a belt of between 5 and 50 feet in width. The bottomland is derived from weathered sandstone and occasional siltstones.

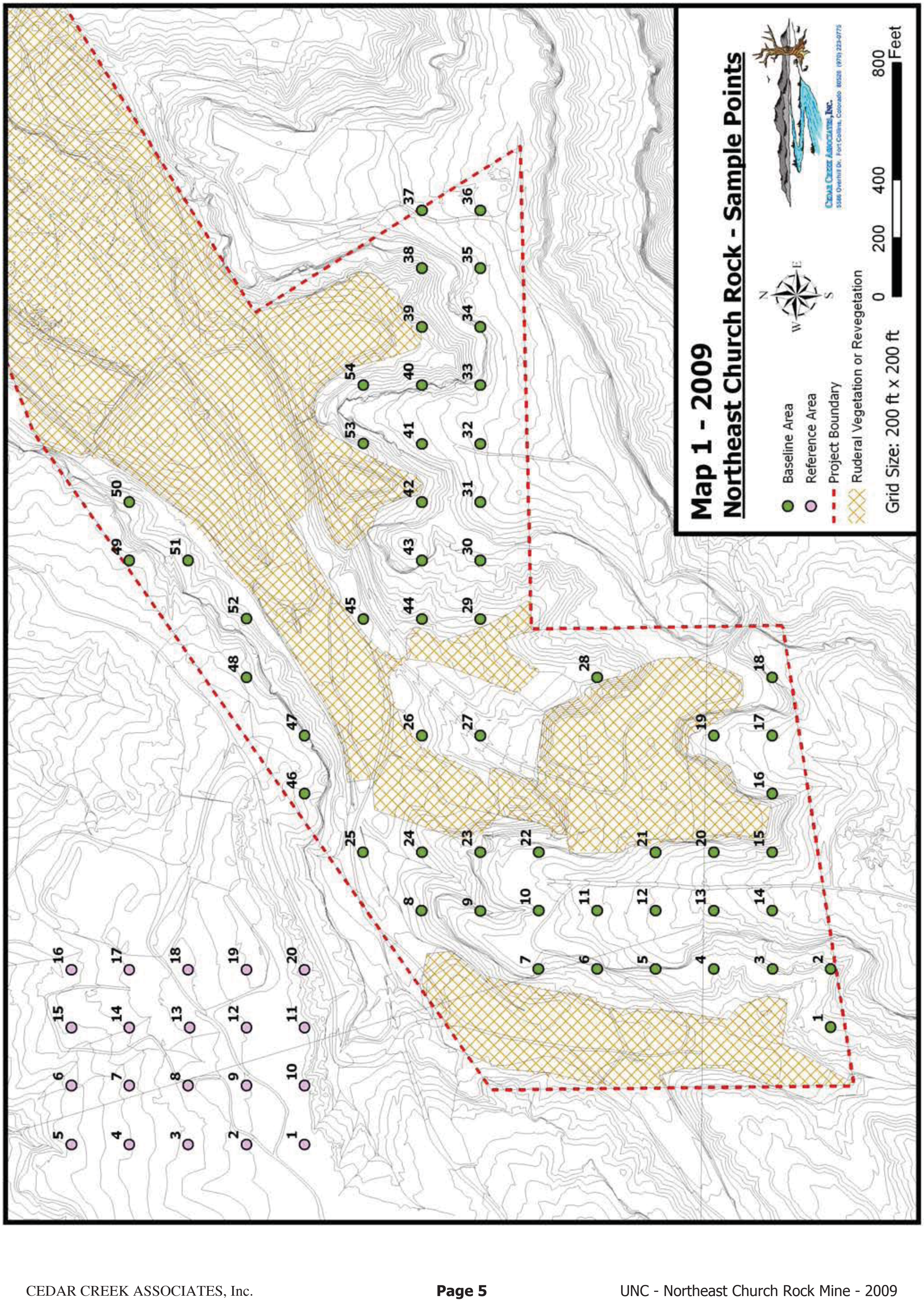
Grasslands (to the north of the IRA work area, intermittently within the "step-out" area) are herbaceous communities dominated by "short" grasses and occasional forbs that can sometimes be seasonally dominant. Trees and larger shrubs are largely absent from this type except for the occasional invader from neighboring sites. Grasslands in this part of New Mexico are typically dominated by perennial sod-forming "short" grasses and typically of the warm-season group. In the "step-out" area the grasslands are of this latter warm-season perennial sod-forming group [primarily blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*)].

In contrast to the grasslands, the dominant piñon-juniper woodland ranges between a "savanna" of scattered trees where the type is ecotonal with grassland to dense woody dominated areas with an occasionally dense shrubby understory and/or poor herbaceous understory. The piñon-juniper woodland is strongly associated with the more rocky, skeletal and shallow soils. In the vicinity of the project area, the vegetative cover of grasses and forbs within the piñon-juniper woodland is at lower levels primarily for two reasons. First, the shallow and well-drained nature of underlying skeletal soils (because the deeper more loamy soils have long since eroded away) do not favor herbaceous taxa. Second, the project area and environs exhibit evidence of extensive livestock grazing resulting in notable damage to the herbaceous component of the understory. Range condition ranged from "poor" to "fair" and native habitats show evidence of substantial impact, although, signs of recovery within the mine permit area were evident given completion of recent fencing.

The bottomland ecotype (currently exhibiting revegetation and/or ruderal vegetation) is primarily characterized as having higher available water within the soil profile (more loamy, less sandy). Also, the higher available water is due to the ecotype being physically located in canyon bottoms that tend to collect surface runoff and fine-textured erodible materials. The increased soil moisture and loamy texture leads to increased vegetative cover from herbaceous taxa.

1.3 Precipitation

Based on Western Regional Climate Center precipitation data from Gallup, New Mexico the average annual precipitation for the project area over a period of 11 years was determined to be 10.36 inches. The total monthly precipitation from September 2008 to August 2009 (at which time the project area was sampled) was well below average at only 6.9 inches. In this regard, it can reasonably be assumed that the area was sampled during a sub-average year and resulting values should reflect below-normal conditions. These circumstances are readily evident on the following Table (P) and Chart (P).


Map 1 - 2009
Northeast Church Rock - Sample Points
Baseline Area
Reference Area
Project Boundary
Ruderal Vegetation or Revegetation
Grid Size: 200 ft x 200 ft
N
S
E
W
0
200
400
800
Feet
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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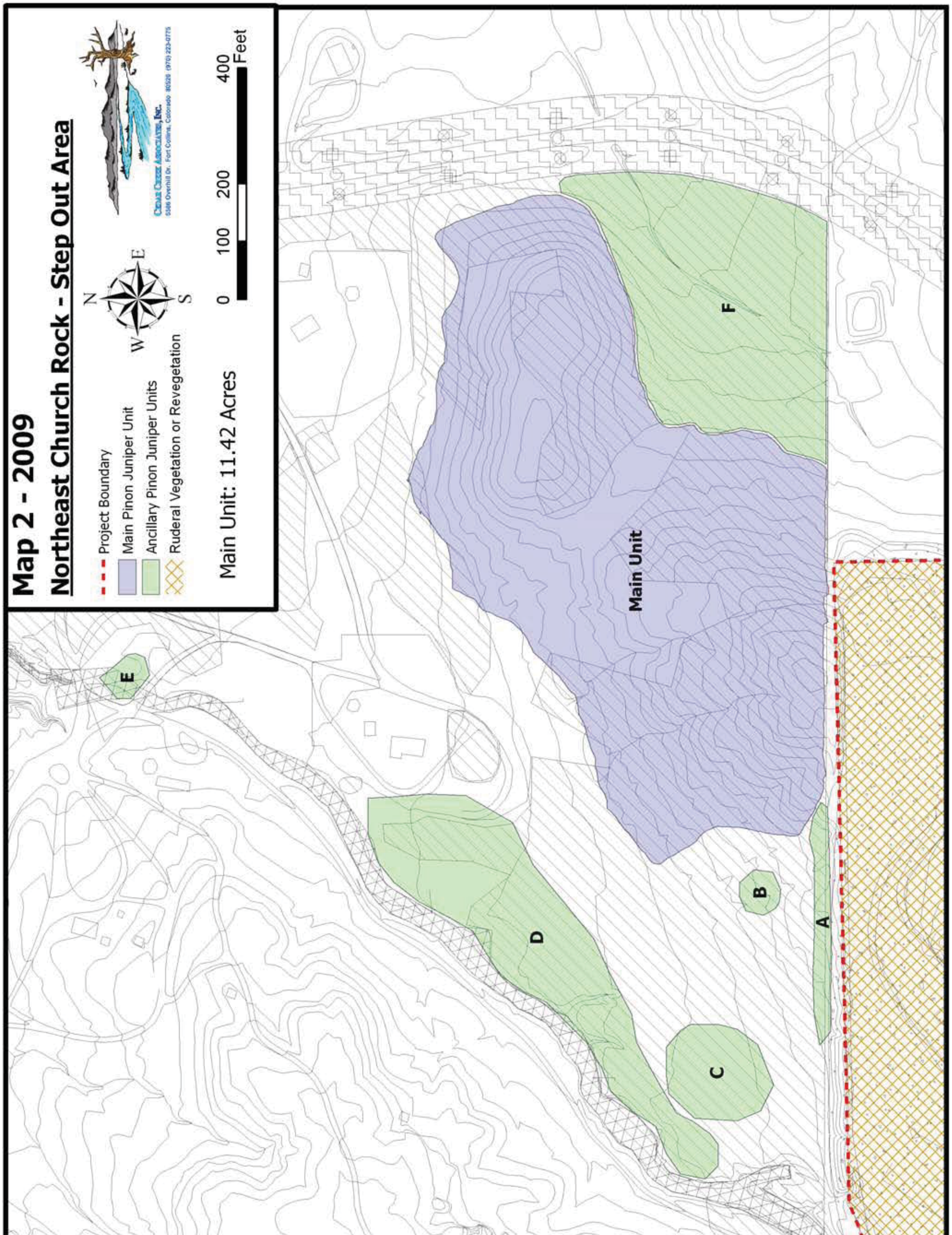
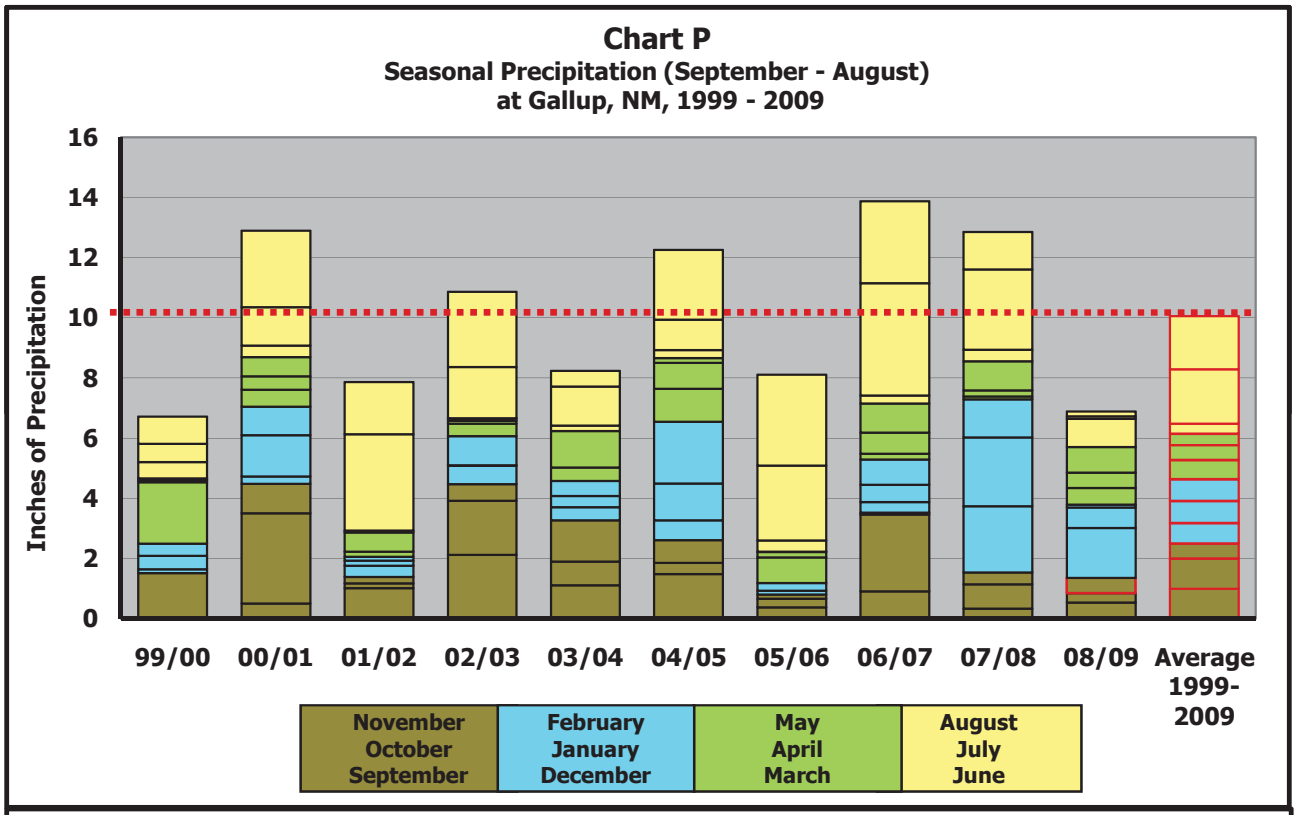
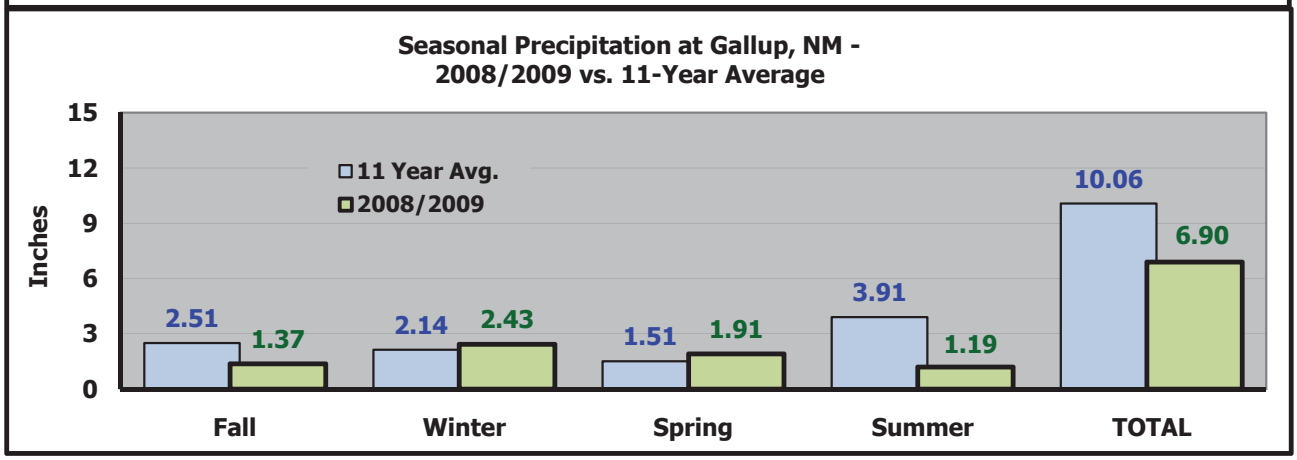

Map 2 - 2009
Northeast Church Rock - Step Out Area
Project Boundary
Main Pinon Juniper Unit
Ancillary Pinon Juniper Units
Ruderal Vegetation or Revegetation
N
E
S
W
0
100
200
400
Feet
Main Unit: 11.42 Acres
Main Unit
A
B
C
D
E
F

Table P - Annual Precipitation at Gallup, NM, 1999 - 2009													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0.26	0.35	0.08	0.89	0.88	0.13	2.13	6.09	1.53	0.00	0.00	0.12	**12.46**
2000	0.45	0.40	2.05	0.07	0.05	0.55	0.60	0.90	0.52	2.99	0.98	0.25	**9.81**
2001	1.37	0.95	0.56	0.44	0.64	0.39	1.27	2.54	1.03	0.15	0.22	0.37	**9.93**
2002	0.17	0.13	0.17	0.64	0.06	0.00	3.20	1.73	2.13	1.80	0.55	0.62	**11.20**
2003	0.01	0.97	0.41	0.10	0.07	0.01	1.70	2.50	1.12	0.79	1.37	0.44	**9.49**
2004	0.37	0.5	0.44	1.22	0.00	0.18	1.29	0.53	1.49	0.38	0.75	0.66	**7.81**
2005	1.22	2.05	1.1	0.86	0.16	0.27	1.01	2.32	0.39	0.28	0.14	0.13	**9.93**
2006	0.26	0	0.85	0.18	0.01	0.37	2.49	3.02	0.92	2.55	0.06	0.36	**11.07**
2007	0.57	0.84	0.19	0.70	0.97	0.27	3.73	2.72	0.35	0.80	0.40	2.20	**13.74**
2008	2.28	1.27	0.1	0.20	0.97	0.38	2.67	1.24	0.55	0.31	0.51	1.66	**12.14**
2009	0.67	0.1	0.55	0.51	0.85	0.94	0.09	0.16	2.53	1.01	0.50	0.68	**8.58**
1999-2009 Avg.	**0.69**	**0.69**	**0.59**	**0.53**	**0.42**	**0.32**	**1.83**	**2.16**	**1.14**	**1.01**	**0.50**	**0.68**	**10.56**

Values in red are estimates





2.0 SAMPLING METHODS

Cedar Creek's vegetation sampling protocols involve an emphasis upon ground cover* to facilitate repeatable future statistical comparisons among treatment areas (or unique revegetation units) as well as a multitude of additional reasons. In brief, concentration on a single variable of plant ecology facilitates improved comprehension and comparability over time and among treatment scenarios. Second, ground cover data, especially when determined using a very precise method such as the point-intercept procedure, provides some of the most important information regarding community variability that ecologists can evaluate. Such data facilitate the determination of true species composition, relative health (condition), and successional status of the sampled area. Furthermore, the same data can be utilized to develop the "sister" variables of frequency and species composition if desired. Third, strong inferences can be developed with other reasonably correlated variables such as production when species composition is factored into the analysis. Fourth, ground cover is a preferred variable for revegetation monitoring because cover data can be readily obtained in a statistically adequate and cost-effective manner (using the proper procedures), has broad application for evaluation (including erosion control modeling), precisely reflects species' dominance of a given area, and when collected using bias-free techniques such as the point-intercept procedure is one of the most repeatable variables among independent observers.

In addition to ground cover evaluations, the work plan required evaluation of woody plant density and current annual vegetative production to facilitate a broader analysis. In this regard, it was determined most appropriate to document woody plant populations (for wildlife habitat considerations) by utilizing long quadrats or belts as detailed below. The most appropriate method of measuring current annual herbaceous production was use of long rectangular quadrats. Since sampling adequacy is not required (nor recommended) for woody plant density or vegetative production samples (as indicated in

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* To avoid confusion, the term "ground cover" is utilized to indicate the variable of non-overlapping foliar cover (the percent of the ground occupied by all above ground plant material) in addition to the ground surface covered by litter or rock. Non-overlapping means that only that cover which would be wetted by a light mist would be counted as opposed to that plant material which would not get wet due to overshadowing plant material. In this manner, total ground cover cannot exceed 100%. Other forms of "cover" would include: basal cover (the percent of the ground surface occupied by the living base of plants), crown or canopy cover (the percent of the ground occupied by the canopies of plants), or overlapping foliar cover (the percent of the ground occupied by all plant material allowing for overlapping vegetation - i.e., such cover can exceed 100%). Non-overlapping foliar cover is preferred because of its inherent repeatability among observers, resulting data are directly applicable to erosion control modeling efforts, and significant precedent has already been set in the mining industry. In contrast, the determination of the live portion of the base of a plant (as necessary for basal cover) becomes increasingly difficult and subjective given life forms such as certain bunch grasses and sod-formers.

the work plan), one density belt and one production quadrat were co-located with each ground cover transect evaluated. Resulting data are then considered reasonable for the evaluation purposes intended.

2.1 Sample Site Selection / Location

The primary field effort for vegetation called for sampling of undisturbed portions of the piñon-juniper woodland community and the establishment and sampling of a corresponding reference area. The reference area selected is northwest of the project area (see Map 1) in an area used for other project-related background or reference data. The systematic procedure for the determination of sample locations occurred in the following stepwise manner. First, a fixed point of reference was selected for the entire area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions (i.e., 200' X 200') was selected by Cedar Creek to provide a minimum number of coordinate intersections (~50 samples in the piñon-juniper baseline community and 20 in the reference area) within the vegetative unit that could then be used for the initial set of sample sites. Third, a scaled representation of the grid was overlain on field maps extending parallel to major compass points (see Map 1) to facilitate field location. Fourth, unbiased placement of this grid was controlled by selection of two random numbers between 0 and 200 (used as coordinates). Fifth, utilizing a handheld compass and pacing techniques or a GPS all 54 (or 20 in the reference area) of the initial sample points were located in the field. The result of this activity is provided on Map 1 whereby the selected sample locations are indicated. If the initial 54 (or 20) systematic samples had not been sufficient to provide an adequate ground cover sample, an "intergrid" would have been selected to provide additional systematically determined sample points. Furthermore, if a selected sample point was found to exist within a disturbed area exhibiting ruderal vegetation, it was discarded. This latter circumstance occurred on six occasions: 1) the point north of sample 7; 2) the point between samples 21 and 22; 3) the point south of sample 27; 4) the point north of sample 28; the point east of sample 45; and 6) the point east of sample 47. Prior to these points being discarded, a total of 60 potential sample sites had been indicated.

2.2 Determination of Ground Cover

Ground cover at each sampling site was determined utilizing the point-intercept methodology (Bonham 1989) as illustrated on Figure 1. This methodology has been utilized for range studies for over eighty (80) years, however, Cedar Creek utilizes state-of-the-art instrumentation that it has pioneered to facilitate much more rapid and accurate collection of data. Implementation of the technique for the sampling effort occurred as follows: First, a transect of 10 meters length was extended from the starting

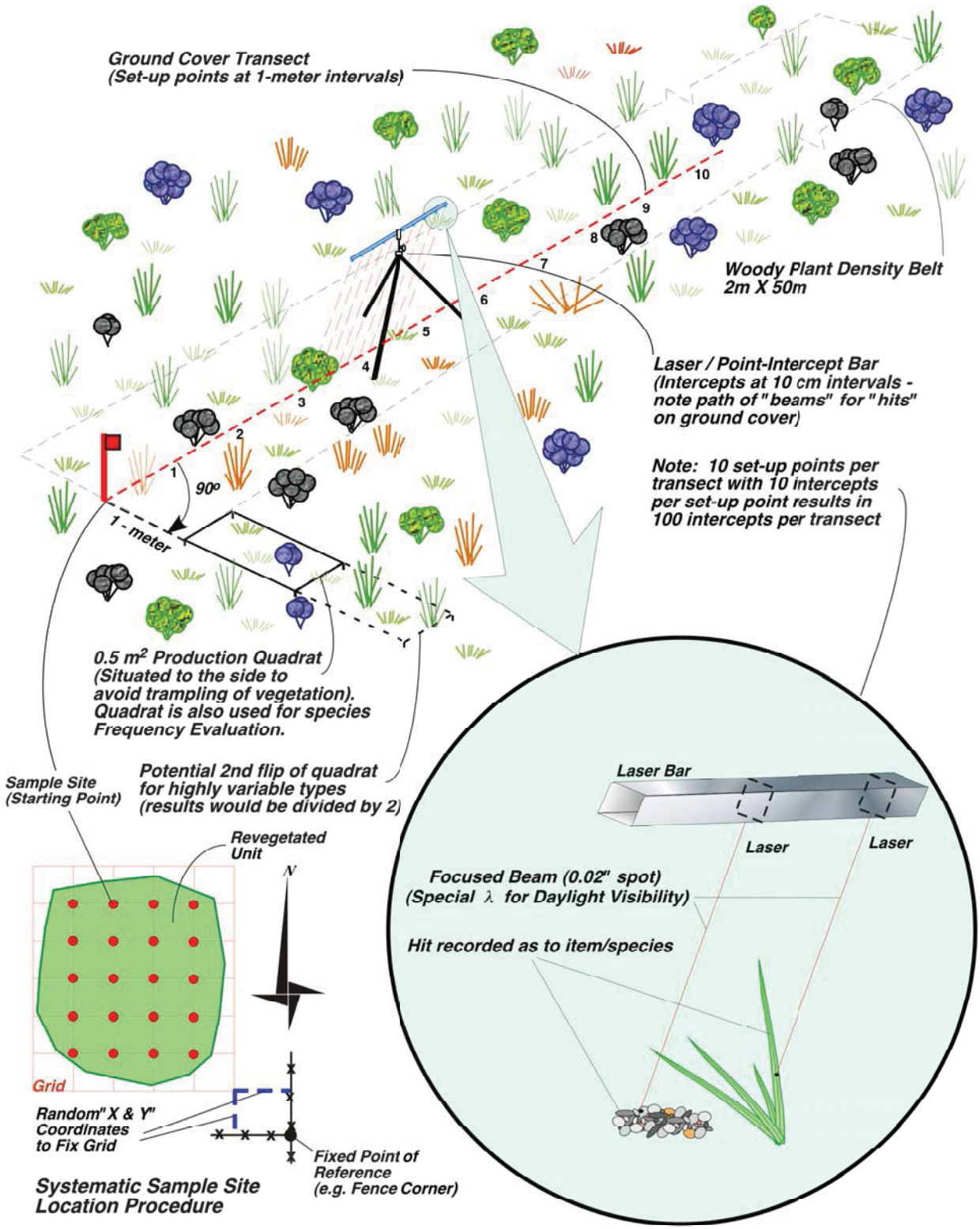


Figure - 1

Sampling Procedure at a Systematic Sample Site Location

point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a "laser point bar" was situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>2mm), or bare soil. Hits were determined at each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10 centimeter intervals and recording the variable intercepted by each of the narrow (0.02") focused beams (see Figure 1). In this manner, a total of 100 intercepts per transect were recorded resulting in 1 percent cover per intercept. This methodology and instrumentation facilitates the collection of the most unbiased, repeatable, precise, and cost-effective ground cover data possible. Furthermore, the point-intercept procedure has been widely accepted in the scientific community as the protocol of choice for vegetation monitoring and is used within the mining industry in connection with bond release determinations.

2.3 Determination of Woody Plant Density

Woody plant density at each sampling site was determined using fixed length / width belt transects oriented parallel to, and co-located with, each ground cover transect. Each belt was 2 meters in width and extended from the beginning of the sample point for a distance of 50 meters (see Figure 1). All shrubs, succulents, and trees rooted within the boundaries of these belts were counted and classified according to species (sub-shrubs were not counted). Entire plants rather than stems were counted to provide a more accurate representation of actual woody plant density.

2.4 Determination of Vegetative Production

At each sample site, current annual production was collected from a $^1/_2$ m^2 quadrat frame flipped once (end to end – see Figure 1) to facilitate less variable data, therefore sampling a total of 1 m^2 at each sampling location. The quadrat was initially placed one meter and 90º to the right (clockwise) of the ground cover transect to avoid vegetation trampled by investigators during sample site location (see Figure 1). From within each quadrat, all above ground current annual vegetation within the vertical boundaries of the frame was clipped and bagged separately by life form as follows:

Native Perennial Grass
Introduced Perennial Grass
Annual Grass
Sub-Shrub
Shrub
Native Perennial Forb
Annual / Biennial Forb
Introduced Perennial Forb
Noxious Weed

All production samples were returned to the lab for drying and weighing. Drying occurred at 105º C until a stable weight was achieved (24 hours). Samples were then re-weighed to the nearest 0.1 gram.

2.5 Sample Adequacy Determination

Ground cover sampling was conducted to a minimum of 54 initial ground cover transects for the baseline area and a minimum of 20 initial ground cover transects for the reference area. Production and woody plant density samples were co-located with each ground cover transect but were not subject to a determination of sampling adequacy. From these preliminary efforts for ground cover, a sample mean and standard deviation for total non-overlapping vegetation ground cover was calculated. These parameters were calculated in the field to insure collection of an adequate sample and once again by computer during final data analyses for each area. Sampling continued until an adequate ground cover sample, $\mathbf{n_{min}}$, had been collected in accordance with the Cochran formula (below) for determining sample adequacy, whereby the population would be estimated to within 10% of the true mean (μ) with 90% confidence. Sampling to these limits facilitates a very strong estimate of target populations.

When the inequality ($\mathbf{n_{min}} \leq \mathbf{n}$) is true, sampling is adequate and $\mathbf{n_{min}}$ is determined as follows:

$$\mathbf{n_{min} = (t^2 s^2) / (0.1\ \bar{x}\ )^2}$$

where: n = the number of actual samples collected (initial size = 54 or 20)

t = the value from the one-tailed t distribution for 90% confidence with n-1 degrees of freedom;

s^2 = the variance of the estimate as calculated from the initial samples;

$\bar{x}$ = the mean of the estimate as calculated from the initial samples.

If any of the initial 54 or 20 ground cover samples from each area had not provided a suitable estimate of the mean (i.e., the inequality was false), additional samples would have been collected until the inequality ($\mathbf{n_{min}} \leq \mathbf{n}$) became true. However, because n_{min} for the baseline and reference areas of the piñon-juniper community were 16.7 and 19.5 respectively, no additional ground cover sampling was deemed necessary.

2.6 Threatened, Endangered, and Rare Species

A list of rare and endangered plant and animal species that are known to occur within McKinley County and the piñon-juniper ecotype, which contains the study area, was developed from several sources including New Mexico Natural Heritage Program, New Mexico Rare Plant Website, and Navajo

Nation EPA. Information regarding habitat requirements and level of state and federal protection was also acquired for each species from standard information databases or published sources (see Appendices B and C at the rear of this report).

Prior to implementation of fieldwork, taxonomic descriptions and botanical drawings of these target species were carefully reviewed and committed to memory. In this manner a definitive search image was attained and the unique characteristics facilitating field identification of suspect plants would be most marked. Actual fieldwork involved search patterns in all portions of appropriate habitat within those portions of the study area exhibiting potential project activities. Search procedures involved slow implementation of qualitative pedestrian transects and careful visual scanning of the ground surface for any of the target terrestrial species. Observation stations were utilized for avian taxa. Although all plant and animal specimens observed within the project area were identified (with one exception), special attention was given to looking for target sensitive species within appropriate habitats. The one exception was a plant species that did not resemble any of the target sensitive plants. It was not identified to species because sufficient flowering or fruiting bodies were not present on the observed specimen.

2.7 Wildlife Evaluations

It is most prudent for site-specific wildlife evaluations to largely be limited to the qualitative techniques of direct observation, observation of sign, and/or evaluation of habitat owing to the modest size of disturbance footprints and the potential complication of livestock grazing. In this regard, these observations were made while Cedar Creek biologists were on site for vegetation investigations. All observations of wildlife, either directly or by sign, were recorded in a manner to facilitate an indication of abundance and/or use of project area habitats. In addition to site-specific "incidental" observations during vegetation evaluations, several pedestrian observation transects were extended radially from the central disturbance area approximately one hundred meters to provide a better indication of: 1) wildlife use of the overall vicinity and habitats, 2) any remaining mine-related impacts, and 3) any continuing hazards to wildlife. These transects were only implemented during the early morning hours to maximize opportunity for observing indigenous wildlife. A GPS was utilized for spatial orientation and to facilitate documentation of any pertinent observations. Furthermore, project area habitats were evaluated with regard to their capability to provide life requisites for anticipated indigenous wildlife, including sensitive or special status species.

3.0 RESULTS

As indicated, statistically adequate ground cover data was collected from both a piñon-juniper baseline community adjacent to the mining disturbance and a piñon-juniper reference area established for future comparisons. In addition, either as a transformation from this ground cover data (Species Composition) or co-located samples (Woody Plant Density and Current Annual Production), three additional floral variables were collected in August, 2009. However, these last three variables were not sampled to any specific level of statistical adequacy (in accordance with the approved work plan). All variables sampled are summarized, and presented on a variety of tables and charts either within the main text or at the rear of this document (Appendix A). In addition, a total enumeration of trees found on Navajo Nation land included with the interim action (step-out area) was implemented for informational purposes. Furthermore, a few photos were collected (Plates 1-8) to document the condition of the sampled area at the time of sampling in August, 2009.

Floristic surveys of the baseline and reference areas resulted in the identification of a total of 46 taxa including 9 grass or grass-like species, 18 forbs, and 19 trees, shrubs, sub-shrubs, or succulents (see Tables 1 and 3). None of these were determined to be sensitive species or otherwise protected by statute. Similarly, none were identified as noxious weeds (the invasive weed Russian thistle was found in the baseline area, but is not considered problematic).

3.1 Threatened, Endangered, and Rare Plant Taxa

According to the New Mexico Rare Plants database, none of the identified species of concern have historically been found in the immediate vicinity of the project area. The taxa of primary concern and their habitats are indicated in Appendix B of this report.

Site-specific field efforts have verified that no rare, threatened or endangered plant species occur on or near the project area. All taxa were searched for, but with negative results. Searches covered over 12,000 linear feet of transect (~13 acres of observed belt) in August of 2009, and over 3,000 linear feet (3.5 acres) in early May of 2009. Given past disturbances at the project area, there is a slight chance that plants existed at one time; however, the probability of such an occurrence is extremely low.

3.2 Baseline Area - Flora

The baseline area received 54 samples within undisturbed portions of the piñon-juniper woodland community with each sample consisting of a 10-meter ground cover transect as well as a co-located woody plant density belt (2m x 50m) and a $1m^2$ production quadrat (see Figure 1 and Map 1). Perusal of Table 1 and Chart 1 indicate that total plant cover was 22.6% with an average perennial cover of 22.3%, while rock and litter cover were 14.1% and 25.4%, respectively. Bare ground exposure was a significant 37.9%. Shrubs, sub-shrubs, cacti and trees provided the majority of the cover with 12.6% followed by grasses (6.7%) and forbs (3.0%). Dominant taxa were Stansbury cliffrose (*Purshia stansburiana*), indian ricegrass (*Oryzopsis hymenoides*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and blue grama with 4.1%, 3.4%, 1.7%, and 1.7% cover, respectively. (It should be noted that ground cover above a height of 1.5 meters was not recorded.) The relative cover values (composition) of observed flora are presented on Table 2 and Chart 2. Review of Table 3 and Chart 3 reveal that woody plant density in this area averaged 1,091 woody plants per acre with an average of 578 shrubs per acre, 225 succulents per acre, and 288 trees per acre. Dominant woody plants were Stansbury cliffrose and big sagebrush (*Artemisia tridentata*) with 213 and 180 plants per acre, respectively. Table 4 and Chart 4 exhibit the current annual production of the baseline area with 161.3 pounds per acre of total production (159.1 pounds per acre of perennial production). This translates to an estimated carrying capacity of 0.05 AUMs (Animal Unit Months) per acre or conversely 20 acres per AUM. Dominant lifeform categories are native perennial forb, native perennial grass, and sub-shrub with an average of 53.9, 45.7, and 39.9 pounds per acre, respectively. With regard to species diversity, the baseline area exhibited a total of 13 species with either greater than 1% average cover or greater than 2% relative cover (Table 2).

3.3 Reference Area - Flora

The reference area was sampled with 20 ground cover transects and 20 co-located woody plant density belts and production quadrats in 2009 (Map 1). Perusal of Table 1 and Chart 1 indicate that total cover was 19.0% with an average perennial cover of 18.9%, while rock and litter cover were 7.2% and 25.2%, respectively. Bare ground exposure was a significant 48.7%. Shrubs, sub-shrubs, cacti and trees provided the majority of the cover with 11.6% followed by perennial grasses (5.8%) and perennial forbs (1.5%). Dominant taxa were big sagebrush, blue grama, longflower rabbitbrush (*Chrysothamnus depressus*), and broom snakeweed (*Gutierrezia sarothrae*), with 5.6%, 4.7%, 3.0%, and 1.7% cover, respectively. Review of Table 3 and Chart 3 reveals that woody plant density in this area averaged 1,621 woody plants per acre with an average of 1,275 shrubs per acre, 168 succulents per acre, and 178 trees per acre. Dominant woody plants were big sagebrush and yellow rabbitbrush (*Chrysothamnus*

viscidiflorus) with 927 and 263 plants per acre, respectively. Table 4 and Chart 4 exhibit the current annual production of the reference area with 145.4 pounds per acre of total production (145.3 pounds per acre of perennial production). This translates to an estimated carrying capacity of 0.045 AUMs per acre or conversely 22 acres per AUM. Dominant categories are sub-shrubs, shrubs, and native perennial forbs with an average of 86.9, 26.8, and 18.8 pounds per acre, respectively. With regard to species diversity, the reference area exhibited 7 species with either greater than 1% average cover or greater than 2% relative cover (Table 2).

Plate 1 – Baseline Area – Circa #12

Plate 2 – Baseline Area – Circa #12 – Close-up

Plate 3 – Baseline Area – Circa #29

Plate 4 – Baseline Area – Circa #29 – Close-up

Plate 5 – Reference Area – Circa #2

Plate 6 – Reference Area – Circa #2 – Close-up

Plate 7 – Reference Area – Circa #5

Plate 8 – Reference Area – Circa #5– Close-up

Table 1 Northeast Church Rock - Vegetation Cover - 2009

Average Cover Summary

Percent Ground Cover Based on Point-Intercept Sampling

		Area ——>	**Baseline**	**Reference**
Grasses				
P	*Aristida purpurea*	Purple Three-awn	0.20	0.10
P	*Bouteloua gracilis*	Blue Grama	1.70	4.70
A	*Bromus tectorum*	Cheatgrass	0.04	-
P	*Hilaria jamesii*	Galleta	0.56	0.35
P	*Muhlenbergia pauciflora*	New Mexico Muhly	0.19	0.05
P	*Oryzopsis hymenoides*	Indian Ricegrass	3.41	0.60
P	*Poa secunda*	Sandberg's Bluegrass	0.09	-
P	*Sitanion hystrix*	Bottlebrush Squirreltail	0.07	-
P	*Stipa neomexicana*	New Mexico Feathergrass	0.43	-
Forbs				
P	*Astragalus missouriensis var. mimetes*	Milkvetch	0.02	-
P	*Astragalus mollissimus var. thompsonia*	Woolly Locoweed	0.02	-
P	*Astragalus tenellus*	Looseflower Milkvetch	0.02	-
P	*Eriogonum umbellatum*	Sulphur-flower Buckwheat	0.39	0.05
P	*Euphorbia brachycera*	Horned Spurge	0.02	-
P	*Heterotheca villosa*	Hairy Golden Aster	0.48	0.85
A	*Kochia scoparia*	Burningbush	0.06	-
P	*Mirabilis multiflora*	Colorado Four o'clock	0.11	-
P	*Penstemon eatonii*	Firecracker Penstemon	0.02	-
P	*Penstemon strictus*	Rocky Mtn. Penstemon	0.07	-
P	*Phlox hoodii ssp. canescens*	Spiny Phlox	-	0.15
IW	*Salsola tragus*	Russian Thistle	0.19	-
P	*Sedum lanceolatum*	Spearleaf Stonecrop	-	0.15
P	*Sphaeralcea ambigua*	Desert Globemallow	0.02	-
P	*Stanleya pinnata*	Desert Princesplume	0.13	-
P	*Stenotus armerioides*	Thrift Mock Goldenweed	1.70	0.25
B	*Tragopogon dubius*	Yellow Salsify	0.02	-
	Unidentifiable		0.06	0.15
Shrubs, Sub-shrubs, Cacti & Trees				
P	*Artemisia tridentata*	Big Sagebrush	1.17	5.55
P	*Chrysothamnus depressus*	Longflower Rabbitbrush	0.56	3.00
P	*Chrysothamnus nauseosus*	Rubber Rabbitbrush	1.72	-
P	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush	0.19	0.25
P	*Gutierrezia sarothrae*	Broom Snakeweed	1.57	1.70
P	*Juniperus monosperma*	One-seeded Juniper	1.04	-
P	*Opuntia polyacantha*	Plains Pricklypear	0.28	0.15
P	*Pinus edulis*	Two-needle Pinyon	1.20	0.90
P	*Purshia stansburiana*	Stansbury Cliffrose	4.13	-
P	*Quercus gambelii*	Gambels Oak	0.69	0.05
P	*Yucca baccata*	Banana Yucca	0.02	-
P	*Yucca glauca*	Soapweed Yucca	0.07	-
		Total Plant Cover	**22.63**	**19.00**
		Rock	14.07	7.20
		Litter	25.44	25.15
		Bare ground	37.85	48.65
		Total Perennial Cover	**22.28**	**18.85**
Summary by Lifeform:				
		Perennial Grasses (P)	**6.65**	**5.80**
		Annual Grasses (A)	0.04	-
		Perennial Forbs (P)	**3.00**	**1.45**
		Annual & Biennial Forbs (A / B)	0.13	0.15
		Noxious / Invasive Weeds (NW / IW)	0.19	-
		Shrubs, Sub-shrubs, Cacti & Trees	**12.63**	**11.60**
Sample Adequacy Calculations:				
		Mean =	22.63	19.00
		Variance =	50.917	40.029
		n =	54	20
		n_{min} =	**16.74**	**19.55**

Table 2 Northeast Church Rock - Vegetation Cover - 2009

Relative Cover Summary

Percent Ground Cover Based on Point-Intercept Sampling

		Area ——>	**Baseline**	**Reference**
Grasses				
P	*Aristida purpurea*	Purple Three-awn	0.90	0.53
P	*Bouteloua gracilis*	Blue Grama	**7.53**	**24.74**
A	*Bromus tectorum*	Cheatgrass	0.16	-
P	*Hilaria jamesii*	Galleta	**2.45**	1.84
P	*Muhlenbergia pauciflora*	New Mexico Muhly	0.82	0.26
P	*Oryzopsis hymenoides*	Indian Ricegrass	**15.06**	**3.16**
P	*Poa secunda*	Sandberg's Bluegrass	0.41	-
P	*Sitanion hystrix*	Bottlebrush Squirreltail	0.33	-
P	*Stipa neomexicana*	New Mexico Feathergrass	1.88	-
Forbs				
P	*Astragalus missouriensis var. mimetes*	Milkvetch	0.08	-
P	*Astragalus mollissimus var. thompsoniae*	Woolly Locoweed	0.08	-
P	*Astragalus tenellus*	Looseflower Milkvetch	0.08	-
P	*Eriogonum umbellatum*	Sulphur-flower Buckwheat	1.72	0.26
P	*Euphorbia brachycera*	Horned Spurge	0.08	-
P	*Heterotheca villosa*	Hairy Golden Aster	**2.13**	**4.47**
A	*Kochia scoparia*	Burningbush	0.25	-
P	*Mirabilis multiflora*	Colorado Four o'clock	0.49	-
P	*Penstemon eatonii*	Firecracker Penstemon	0.08	-
P	*Penstemon strictus*	Rocky Mtn. Penstemon	0.33	-
P	*Phlox hoodii ssp. canescens*	Spiny Phlox	-	0.79
IW	*Salsola tragus*	Russian Thistle	0.82	-
P	*Sedum lanceolatum*	Spearleaf Stonecrop	-	0.79
P	*Sphaeralcea ambigua*	Desert Globemallow	0.08	-
P	*Stanleya pinnata*	Desert Princesplume	0.57	-
P	*Stenotus armerioides*	Thrift Mock Goldenweed	**7.53**	1.32
B	*Tragopogon dubius*	Yellow Salsify	0.08	-
	Unidentifiable		0.25	0.79
Shrubs, Sub-shrubs, Cacti & Trees				
P	*Artemisia tridentata*	Big Sagebrush	**5.16**	**29.21**
P	*Chrysothamnus depressus*	Longflower Rabbitbrush	**2.45**	**15.79**
P	*Chrysothamnus nauseosus*	Rubber Rabbitbrush	**7.61**	-
P	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush	0.82	1.32
P	*Gutierrezia sarothrae*	Broom Snakeweed	**6.96**	**8.95**
P	*Juniperus monosperma*	One-seeded Juniper	**4.58**	-
P	*Opuntia polyacantha*	Plains Pricklypear	1.23	0.79
P	*Pinus edulis*	Two-needle Pinyon	**5.32**	**4.74**
P	*Purshia stansburiana*	Stansbury Cliffrose	**18.25**	-
P	*Quercus gambelii*	Gambels Oak	**3.03**	0.26
P	*Yucca baccata*	Banana Yucca	0.08	-
P	*Yucca glauca*	Soapweed Yucca	0.33	-
Summary by Lifeform:				
		Perennial Grasses (P)	**29.38**	**30.53**
		Annual Grasses (A)	0.16	-
		Perennial Forbs (P)	**13.26**	**7.63**
		Annual & Biennial Forbs (A / B)	0.57	0.79
		Noxious / Invasive Weeds (NW / IW)	0.82	-
		Shrubs, Sub-shrubs, Cacti & Trees	**55.81**	**61.05**
Diversity (Number of Species with >1% Average Cover or 2% Relative Cover)**:**				
		Number of Species =	**13**	**7**

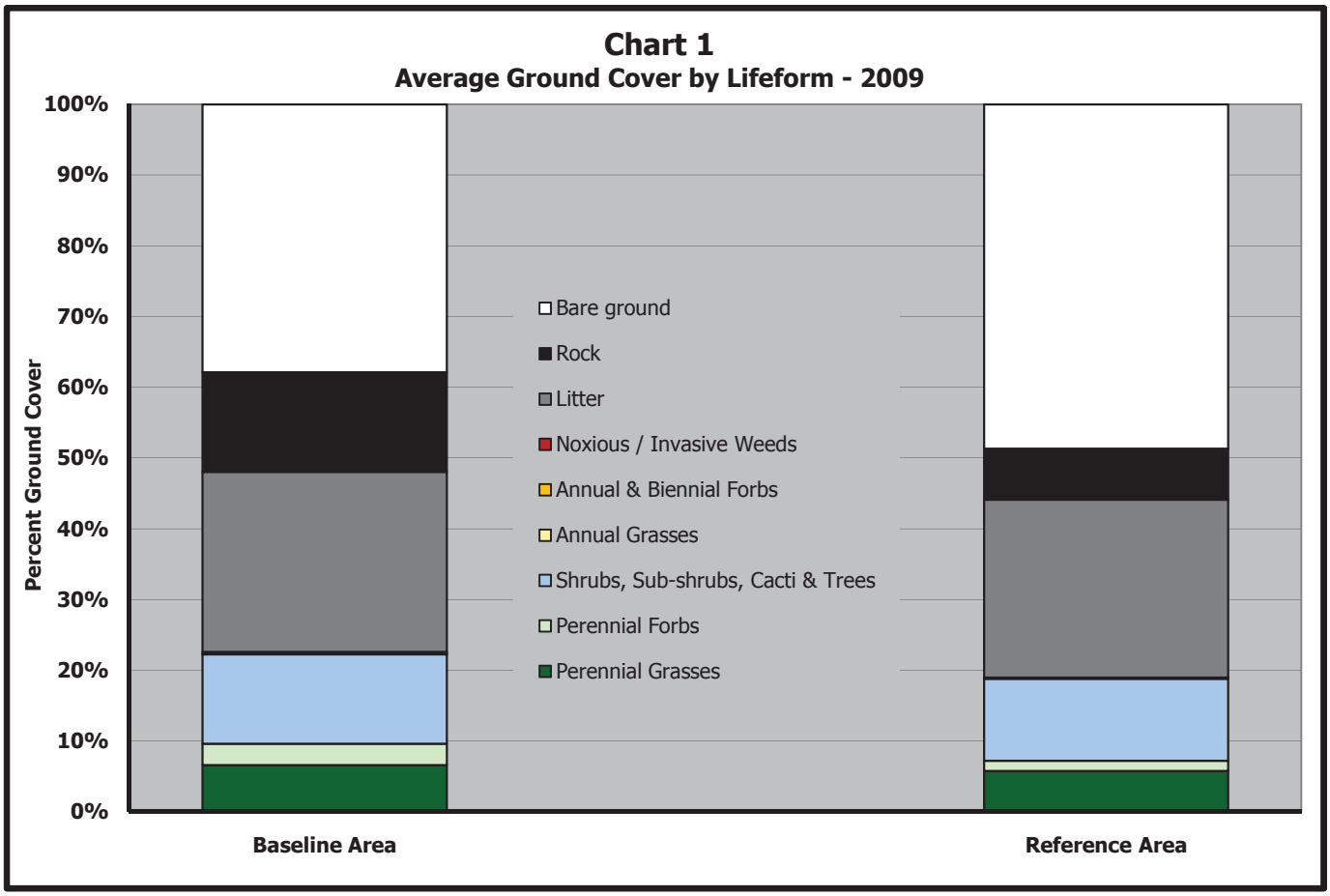


Chart 1
Average Ground Cover by Lifeform - 2009
Percent Ground Cover
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Bare ground
Rock
Litter
Noxious / Invasive Weeds
Annual & Biennial Forbs
Annual Grasses
Shrubs, Sub-shrubs, Cacti & Trees
Perennial Forbs
Perennial Grasses
Baseline Area
Reference Area

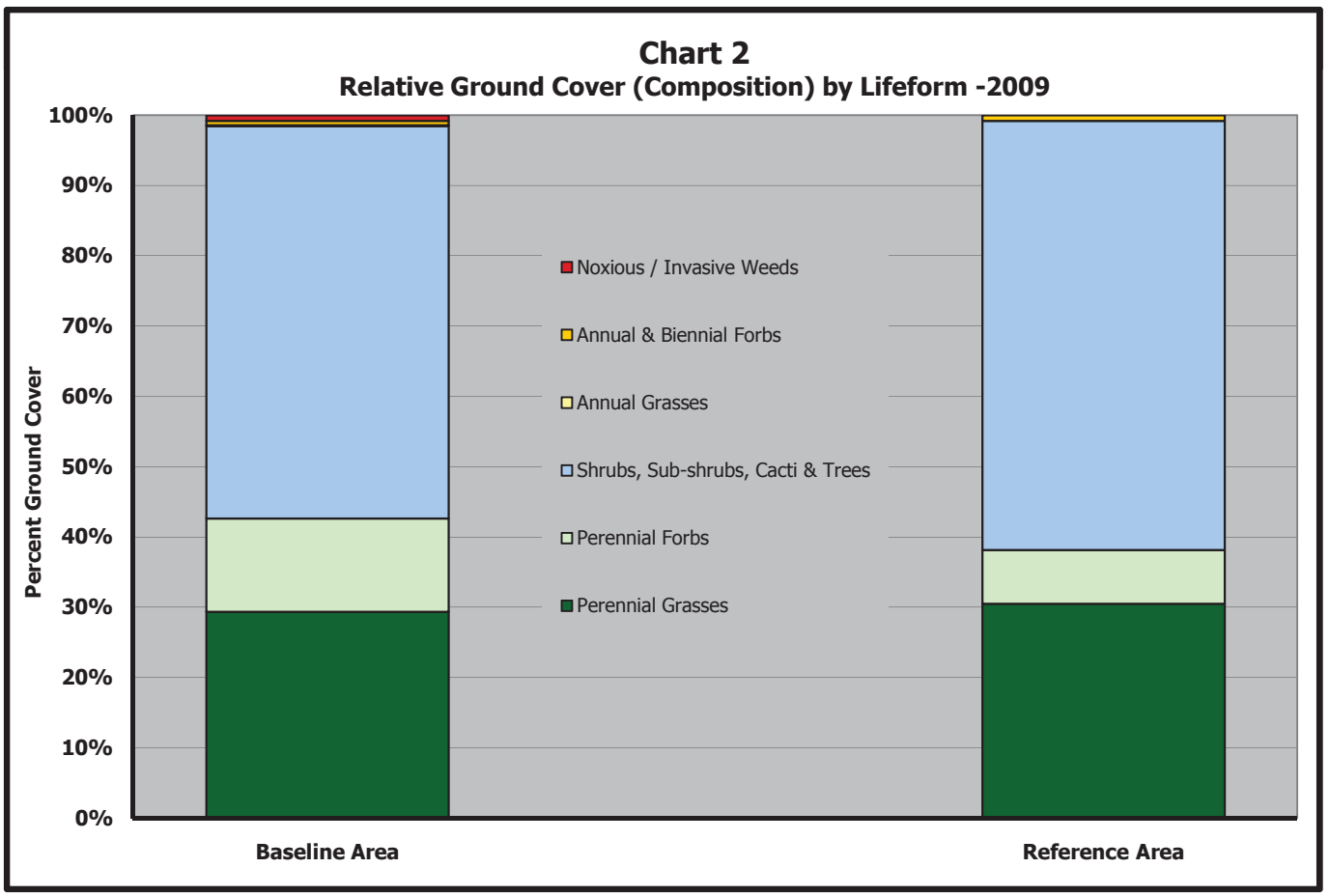


Chart 2
Relative Ground Cover (Composition) by Lifeform -2009
Percent Ground Cover
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Noxious / Invasive Weeds
Annual & Biennial Forbs
Annual Grasses
Shrubs, Sub-shrubs, Cacti & Trees
Perennial Forbs
Perennial Grasses
Baseline Area
Reference Area

Table 3 Northeast Church Rock - Woody Plant Density - 2009

Summary of Woody Plant Density

Woody Plants per Acre

Lifeform	Scientific name	*Area Sampled -->* Common Name	Baseline	Reference
S	*Artemisia tridentata*	Big Sagebrush	179.9	926.7
S	*Cercocarpus montanus*	Mountain Mahogany	4.5	-
S	*Chrysothamnus nauseosus*	Rubber Rabbitbrush	111.7	76.9
S	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush	65.9	263.0
Su	*Echinocereus sp.* *	Hedgehog Cactus	1.5	-
T	*Juniperus monosperma*	One-seeded Juniper	101.9	60.7
S	*Mahonia repens*	Creeping Barberry	3.7	-
Su	*Escobaria vivipara*	Spinystar	0.7	2.0
Su	*Opuntia polyacantha*	Plains Pricklypear	152.1	163.9
T	*Pinus edulis*	Two-needle Pinyon	140.9	115.3
T	*Pinus ponderosa*	Ponderosa Pine	-	2.0
S	*Psilostrophe tagetina*	Wooly Paperdaisy	-	6.1
S	*Purshia stansburiana*	Stansbury Cliffrose	212.8	2.0
T	*Quercus gambelii*	Gambels Oak	44.97	-
Su	*Yucca baccata*	Banana Yucca	22.5	2.0
Su	*Yucca glauca*	Soapweed Yucca	48.0	-
Life Form		**Shrub (S)**	**578.6**	**1,274.8**
		Succulent (Su)	**224.8**	**167.9**
		Tree (T)	**287.8**	**178.1**
Total Woody Plants per Acre			**1,091.2**	**1,620.8**

* There are two taxa within this genus found on site, neither of which is listed as a taxon of concern.

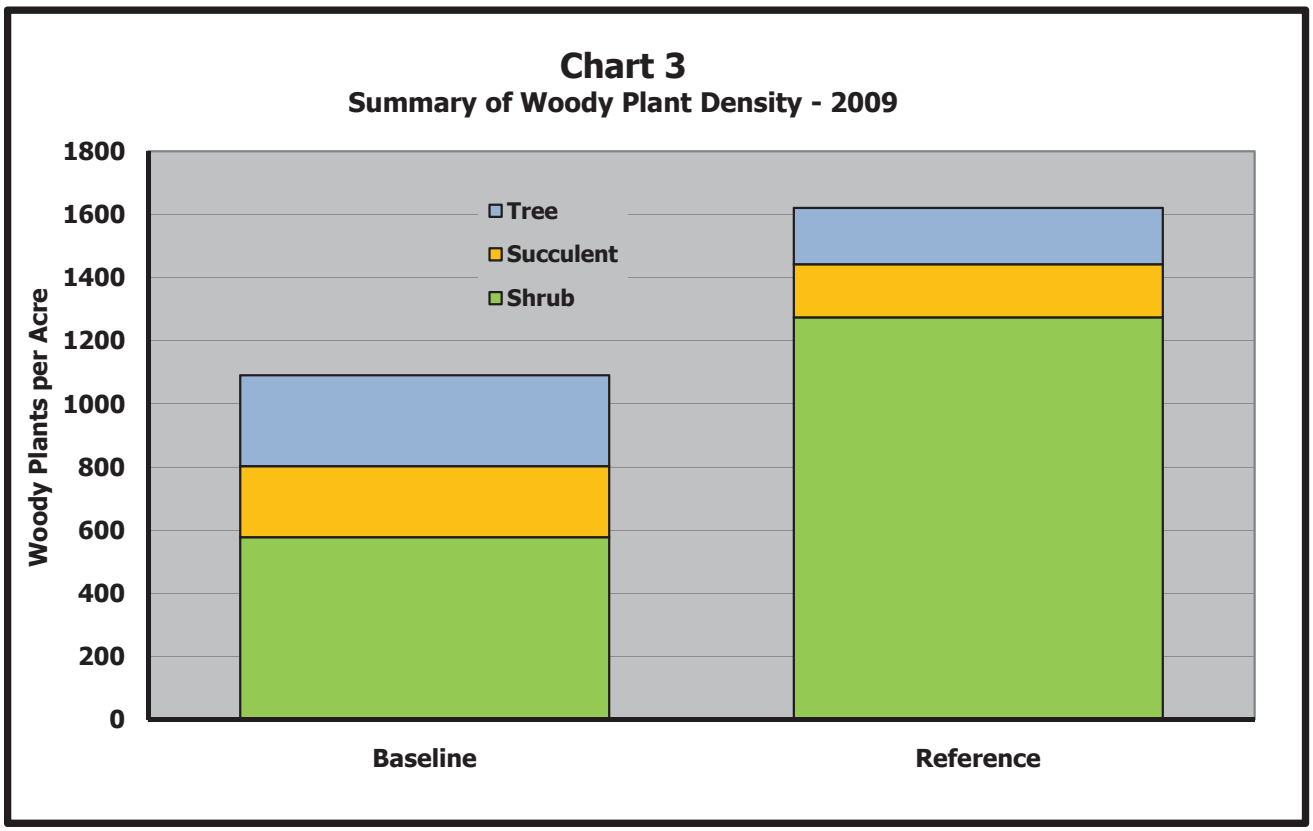
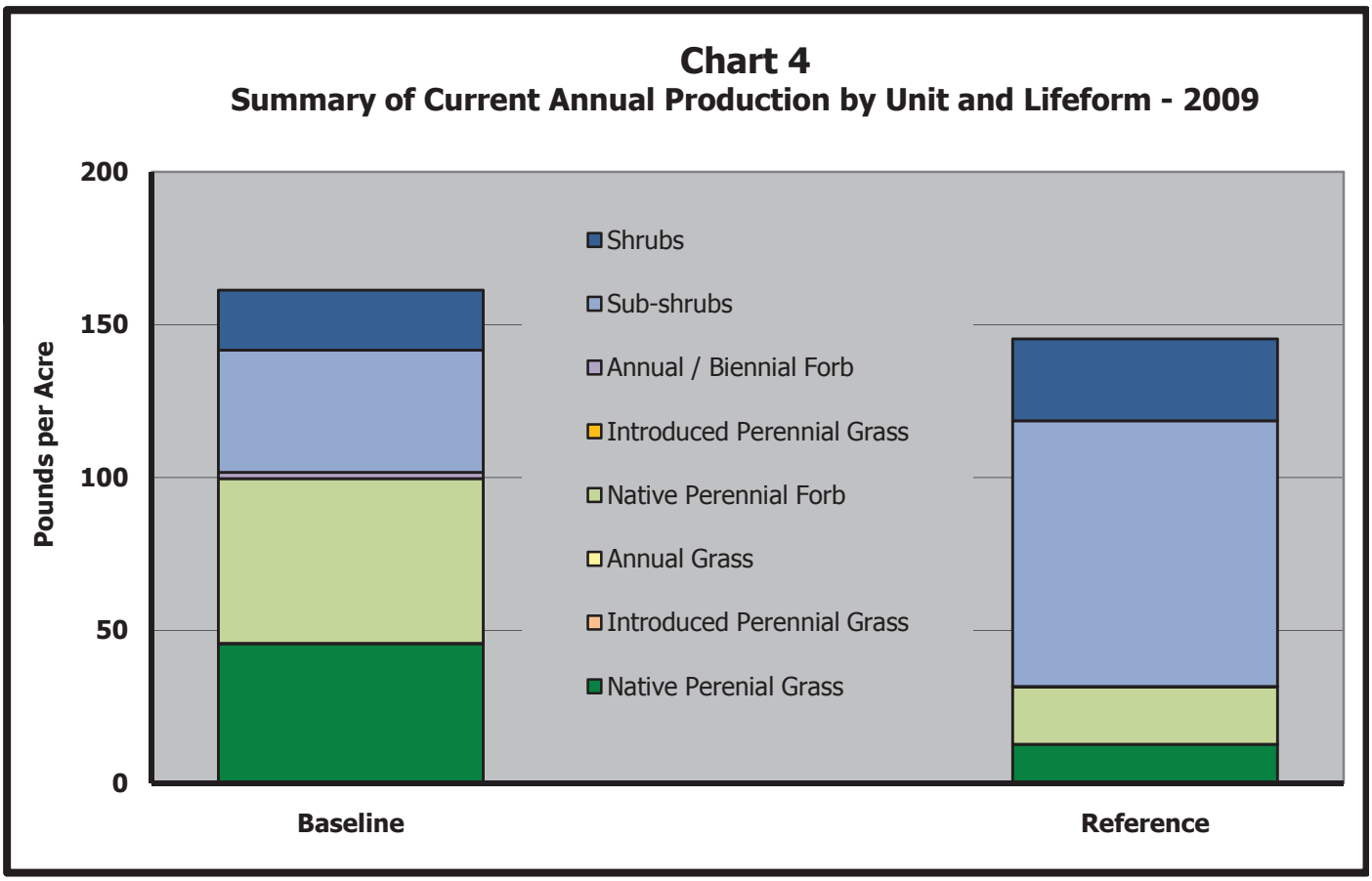


Table 4 Northeast Church Rock - Vegetation Production - 2009

Production Summary

Pounds per Acre

Area	Grasses			Forbs			Sub-shrubs	Shrubs	Noxious Weeds	All Perennial	Total
	Perennial		Annual	Perennial		Annual / Biennial					
	Native	Introduced		Native	Introduced						
Baseline	45.7	-	0.2	53.9	-	2.0	39.9	19.7		**159.1**	**161.3**
Reference	12.8	-	-	18.8	-	0.1	86.9	26.8	-	**145.3**	**145.4**



A standard students "t" test comparison of the means (baseline vs. reference area) with regard to the three variables measured (ground cover, production, and woody plant density) indicates that these two areas can be considered to be from the same population with regard to ground cover and production. Therefore, the reference area can be considered as an adequate comparator for future testing of reclamation in this regard. Since the reference area woody density is greater than the baseline area, the reference area will still suffice as an adequate comparator for future testing of reclamation for this variable even though it does not pass a "t" test comparison. Furthermore, it is likely that a fixed standard will be developed for this variable and woody density comparisons with the reference area will not be necessary.

3.4 Step-Out Area - Flora

The step-out area (Map 2) contains several small pockets of trees along with one main population contained on the two small hills adjacent to the project area. These trees were entirely enumerated by species and age class (seedling, young, and mature) for informational purposes. Locations of the units counted can be seen on Map 2, and on Table 5 below, which exhibits the results from these counts. Because the smaller units (A-F) are small and variable, tree density can only be pertinent for the "Main Unit". In this regard, the main unit presents a density of 59.7 junipers per acre, 32.8 piñons per acre, and 0.3 Gambel's oaks per acre for a total of 92.8 total trees per acre.

Table 5 Northeast Church Rock - Woody Plant Density - 2008

Step-Out Area - Tree Density

Total Enumeration on Each Unit

	Unit --->	A	B	C	D	E	F	Main	Total
Juniperus monosperma	Seedling	7						18	**25**
	Young	6	1					103	**110**
	Mature	8	6	6	7	3	9	561	**600**
Pinus edulis	Seedling	10						19	**29**
	Young	3	1				1	39	**44**
	Mature	9	2					317	**328**
Quercus gambelii	Seedling								**0**
	Young								**0**
	Mature							3	**3**
Total		**43**	**10**	**6**	**7**	**3**	**10**	**1060**	**1139**

* Unit Locations Shown on Map 2

3.5 Wildlife

As indicated previously, several 100-meter pedestrian transects were extended radially from the project disturbance footprint as well as 15,000 feet of transect extended between the 74 vegetation sample points. Weather was crisp and clear with no wind during the morning surveys. Over the course of these pedestrian surveys, Cedar Creek observed only three habitats for indigenous fauna: piñon-juniper woodland (with an occasional Ponderosa pine); shallow canyons with peripheral rock ledges, rim rock and cliffs; and narrow canyon bottoms exhibiting revegetation species or ruderal vegetation. The rim rock occurs throughout the project area and varies from modest elevation rubble piles to vertical cliff faces of 20 to 30 feet in height. The first two of these habitats correspond to the piñon-juniper ecotype described elsewhere in this document. In addition, there were no areas of standing or seasonal water sources observed on site, although several sediment traps exist among the old workings, but these have not seen consistent water in several years. As a result, attendant wildlife taxa were not observed.

With regard to the rim rock habitat type, multiple opportunities are offered for cliff nesting raptors as well as smaller avifauna, and the nearly ubiquitous boulder and cobble fields below the escarpments offer excellent escape cover to several species of small mammals and herpetofauna. Excepting the existing mine-related disturbances, Cedar Creek's observations were largely positive regarding: 1) the quality of area habitats (excepting livestock-grazed understories), 2) potential use of those habitats by indigenous fauna, 3) more distant mine-related impacts, or 4) any continuing hazards to wildlife. The existing piñon-juniper woodland was observed to generally be in poor to fair condition in the understory given past moderate to heavy utilization by domestic livestock. However, multiple signs of recovery were noted within the mine permit area given the advent of recent project fencing. In contrast, the overstory was consistently in good condition and well used by avian wildlife (i.e., the quantity of direct bird observations seemed to be significantly greater than expectation).

As indicated, additional positive observations included the lack of more distant mine-related effects and a similar lack of continuing hazards to wildlife. The vast majority of mine-related perturbations were confined to the permit area, and further confined to the canyon bottoms. Other than access roads that were in a significant state of disrepair (typical of rangeland two-tracks), there was little evidence of mining activity external to the permit area. Furthermore, within the permit area, there were no observable continuing hazards to wildlife other than the conversion of natural habitats (that originally were of modest utility).

One final observation of significant note related to the paucity of mule deer sign evident along the various transects. Observations of mule deer hoof prints and especially pellet groups were very uncommon given expectation for these habitats. In fact, only four pellet groups were observed in the 15,000 linear feet of transect and given that an area approximately 10 feet wide was under observation, a density of one group per 0.86 acres resulted. It is commonly recognized that, on average, mule deer defecate 13 times per day in occupied habitat. Using this rate as a general estimate, and assuming the "age" of observed pellet groups to be less than one year, the population of mule deer in the vicinity of the project area is estimated to be one animal per 6.5 square miles. If the age of observed pellet groups was more realistically limited to two years, the estimated density of mule deer would be one animal per 13 square miles. This reduced population level can be explained by one of three possible causes. First, it is possible that a life requisite for mule deer is in short supply. This requisite cannot be escape cover, thermal cover, or forage as all of these are abundant within the project vicinity. It is possible that water may be limiting as free-water sources were not readily observed in the area. A second possible cause is a natural population fluctuation (low point in the cycle) due to excessively cold winters, disease, or similar perturbation. The third possible cause is elevated predation, either by natural or man-related sources.

Another measure of the quality of area habitats and their utilization can be inferred given the following listing of direct sightings, tracks, scat, nests, or burrows of indigenous wildlife. (VC = Very Common, C = Common, U = Uncommon, R = Rare)

Direct Observations:

Mammals:	Cliff Chipmunk (C)	Rock Squirrel (U)	Cottontail (U)
	Mexican Woodrat (U)	Black-tailed Jackrabbit (U)	
Herpetofauna:	Horned Lizard (C)	Plateau Whiptail (U)	Sagebrush Lizard (U)
Avifauna	Turkey Vulture (C)	Common Raven (C)	Rock Wren (VC)
	Mourning Dove (U)	Unk. Hummingbird (U)	Cassin's Flycatcher (U)
	Chipping Sparrow (C)	Juniper Titmouse (R)	W. Scrub Jay (C)
	Lark Sparrow (U)	Wilson's Warbler (R)	Orange-crowned Warbler (R)
	Northern Flicker (C)	Say's Phoebe (R)	Violet-green Swallow (C)

Observation of Sign:

Mammals:	Mule Deer (R)	Cottontail (U)	Jackrabbit (U)
	Kangaroo Rat (U)	Woodrat (U)	Mouse (VC)

Although raptors occur in the area, it is important to note that no evidence of cliff nesting was observed within the rim rock immediately adjacent to the permit area. Furthermore, there were no obvious nests observable within the piñons and junipers about the site with the exception of a few old magpie or raven nests that were in a state of disrepair.

3.6 Threatened, Endangered, and Rare Wildlife Taxa

According to several New Mexico databases, 19 wildlife taxa had a remote chance of existing within or near the project area. The taxa of primary concern and their habitats are indicated in Appendix C of this report. The mountain lion's home range (often greater than 200 square miles) predisposes minimal potential impact from small areal disturbances. The paucity of mule deer would have a far greater effect on this species. Therefore, the potential for this taxon to even exist in the area would be near zero (except as an occasional transient). Similarly, detection of Merriam's shrew would take a significant concentrated trapping effort, but it is unlikely that this taxon would occur in the project area with any significance. It's distribution is widespread across the western U.S., but is very unlikely to exhibit elevated populations anywhere within its range.

With regard to the ten species of avifauna, the most significant potential for any of these to be observed within the project area could be rated as "very unlikely" given the transient nature of their habits. For example, the Bald Eagle (a Federally "threatened" species would typically be associated with large water bodies, and is only seen over terrestrial habitats when hunting for secondary sources of food. Similarly, there is a remote chance the other avian taxa could occur in the vicinity of the project area, however, given their large home ranges and/or abilities to disperse across large distances significantly reduces any potential for adverse impact from small areal disturbances such as those associated with project reclamation activities. Furthermore, all observed avifauna were identified to species (excepting hummingbirds), and none of the sensitive species were among those taxa observed.

With regard to the seven species of herpetofauna, only the sagebrush lizard was observed (two specimens) on site. It's state status is that of S4 (apparently secure), and of little concern. In fact, the sagebrush lizard is a commonly observed species across most of it's range. Therefore, though this taxon was observed on site, it should not be problematic for project activities and eventual reclamation will actually be of benefit to this specie's habitat.

4.0 IRA REVEGETATION PLAN

Following completion of the IRA interim site status survey, and placement / preparation of growth media at the NECR-1 temporary stockpile, the work area will be prepped and seeded. Final revegetation of the mine permit and step-out areas will be conducted following implementation of the final action and completion of a final site survey. A revegetation plan will be developed for the final revegetation effort and provided to EPA for review and approval.

The objective of the initial IRA revegetation effort is attainment of erosional stability and the preclusion of off-site transport of generated sediments from the mine permit area. The principal means to obtain erosional stability will be use of stability enhancing metrics and the construction of a stable physical landscape that can then support the establishment and persistence of a reasonable herbaceous ground cover (that also provides enhanced protection against erosion). Once such a stable condition is achieved, natural successional processes will be enabled leading to advancement along the successional continuum and eventually to a condition that fully supports the interim revegetation effort. If adequate growth media, precipitation, and other related factors are available, such progression will occur in a relatively short period of time, perhaps as few as 3 to 5 years.

Determination of final actions in the mine permit area is currently in progress and may include the requirement for additional actions in the step-out area. Final revegetation of the mine permit and step-out areas including any required woody seedling planting will be conducted following implementation of the final action and completion of a final site status survey. A revegetation plan will be developed at that time as part of the design process following selection of a final action.

4.1 Growth Medium Characteristics

To assess the suitability of the existing soils and backfill sources for use as a growth media, following backfilling and grading, soil samples were collected for agronomic analysis from the step-out area, the stockpiled soils from the Pine Dale Chapter House, and the background reference area (see Appendix D). A summary of the agronomic properties of the soils in the step-out area, the stockpiled soils from the Pine Dale Chapter House, and the reference area are also included in Appendix D. The soil textures range from Clay Loam to Sandy Loam. Chemical analysis indicates that the soils from the step-out area are not significantly different from the Pine Dale Chapter House stockpile. To improve potential for revegetation success, sterile organic mulch (sterile cow manure) will be applied to the step-out area to increase organic content and improve agronomic properties of the soils.

Once mine area features as well as the step-out area have been graded to final contour, remaining growth media will be prepared for subsequent revegetation activities. The step-out area, outside the berm will receive four tons per acre of sterile organic mulch. Mulch will be spread uniformly across the area immediately prior to discing and seeding discussed below. NECR-1 will largely be composed of native growth media removed from the step-out area as well as additional C horizon material where contamination is identified deeper in the soil profile. It will be capped with a layer of uncontaminated material from the designated borrow area.

4.2 Surface Material Preparation:

Once the project area has been regraded to approximate final configuration and capped with the previously described native surface soil components, areas of steeper slopes (>3:1) will be deep ripped, where possible, with a single or double-toothed chisel plow pulled by a D8 or equivalent dozer. Deep ripping will occur along the contour to create contour ridges to help preclude erosion. Ripping will occur at nominal intervals of 4 feet (but no more than 6 feet) between the ripper teeth. On flatter slopes between 3:1 and 5:1 ripping will again occur on the contour, but the depth will be reduced and the interval between "rip lines" will be increased to 10 or 12 feet. Flat areas (< 5:1 slopes) will not be ripped unless haulage traffic has compacted the growth media, or it is naturally compacted. In such compacted circumstances, ripping will follow the procedures for steep slopes.

Following deep ripping, the upper 3 to 6 inches of remaining growth media will be prepared for seeding through fragmentation into a fine-grained unconsolidated material by use of a heavy disc or heavy harrow. This process oxygenates the media and opens up inter-grain poor spaces facilitating moisture retention. If the surface is extraordinarily hard, multiple passes may be necessary to gain adequate depth of preparation. Final passes will be oriented parallel to the contour to preclude creation of preferential erosion pathways.

It is best that seeding occur immediately following this deep discing / harrowing step. If seeding cannot occur immediately following this step, then a light harrowing immediately in advance of seeding will occur to break up any crusting that may have developed during the interim. This final harrowing will occur along the contour, should use "light-footprint" equipment, and is necessary to maximize opportunities for "seed to soil" contact.

4.3 Seeding

The final reclamation step for the IRA will be planting of the designated seed mix (Table 6). Planting will take place in March or as soon as possible after the ground is no longer frozen and the surface preparation is completed. As indicated on this table, distribution of seed is best accomplished by a mix of two planting techniques. In this regard, seed designated for broadcasting will be applied first, to be followed by seed designated for drilling. This can be best accomplished by placing a cyclone spreader on the front of the equipment (tractor) that pulls the seed drill. The cyclone should be adjusted to spread seed the approximate width of the drill. The action of the seed drill then acts as a harrow to lightly cover the broadcast seed thereby eliminating the need for the final step - harrowing. If, broadcasting occurs in any other manner or timing, the area just seeded should be lightly harrowed before drilling of grass seed. Harrowing must be very light so as not to overly bury distributed seed (the majority of seed should be covered no deeper than 2 to 3 mm). A very short length of chain-link fencing dragged over the broadcast area is often used for such light harrowing. Drilling of grass seed is best accomplished by setting depth bands on a seed drill to place seed 5 to 8 mm below the surface. Furthermore, an experienced seed applicator will be used so as to obtain proper distribution of the indicated amount of seed on a per acre basis.

Drill seeding techniques cannot be used on steep slopes (steeper than 3:1) nor on extremely rough surfaces (such as areas that have been contour furrowed with deep ripping equipment). These areas, including the slopes of NECR-1 and any other area where the seeding contractor is unable to safely operate drill seeding equipment, will only be broadcast seeded (including grasses) followed by a light harrowing. All seeding and harrowing activity will occur along the contour within the limitations of safe equipment operation. Worst case, hand seeding techniques may be necessary followed by a light hand raking to cover seed.

4.4 Mulching

Areas exhibiting flatter slopes (<3:1) shall not be mulched unless deemed necessary by site management personnel. Steeper areas (e.g., temporary NECR-1 stockpile) shall receive 2 tons per acre of certified weed-free straw mulch that will be "crimped-into" the surface by use of a standard agricultural disc with the coulters set parallel to the direction of travel (within the limitations of safe equipment operation). (If such "crimping" cannot be accomplished in the manner indicated due to slope angle contour furrowing, or similar reclamation metric, an alternate procedure will be used. The first alternate measure that may be used would involve a small dozer (e.g., D6 or equivalent) operating up and down the slope. In this manner the growlers will crimp the straw into the soil surface in much the same manner as coulters on a disk. A second alternate procedure would involve application of 2 tons per acre of wood fiber mulch applied hydraulically (hydromulching) from the top of the structure and/or from the base.

In lieu of topsoil use in certain portions of the step-out area, 4 tons per acre of a sterile organic mulch (cow manure) shall be applied in accordance with findings presented in Appendix D. This material shall be applied prior to seed bed preparation, and therefore, will be incorporated into the soil profile with disking activities.

4.5 Amendments

As indicated on Table 6, the seed mix is comprised entirely of native species that should be adapted to low-fertility soils and to the climactic regime of the project area. Because weedy annuals typically take greater advantage of inorganic fertilizers that will then result in significant problematic circumstances, no inorganic fertilizers will be used.

Furthermore, because the seed mix is comprised of species adapted to the climactic conditions of the project area, no irrigation will be used in this revegetation project. Irrigation will cause an artificial climactic regime that will overly encourage the wrong species versus the desired ones (e.g, annual weeds). Also, under the influence of irrigation, the adapted plants that do come up will develop above ground biomass at the expense of below ground biomass. Thus once the irrigation stops, those plants have essentially become "accustomed" to artificial circumstances and will typically die during a normally tolerated drought. Over approximately the last 20 years, practical applications of arid land reclamation

science have abandoned the use of irrigation. Where currently used in modern reclamation, irrigation typically has one of several finitely specific purposes, none of which are applicable to the IRA environs.

4.6 Fencing

Range fencing, cattle guards, and gates will be installed around the perimeter of the step-out area to exclude grazing livestock from revegetated areas (See Figure 2). The fencing will consist of metal t-posts (uninstalled length of 7 feet), 4 feet hog wire (4 feet from ground surface to top), and finished with two top strands of barbed wire. Top of posts are to be 5 feet, 2 inches tall once installed. Posts are to be on approximately 10-foot centers. Posts are to be driven into the ground where feasible and holes drilled into sandstone bedrock for posts as needed. If the posts in the drilled holes aren't tight, they will be cemented in place. Where deemed necessary by the contractor, corner posts and bracings will be installed. This fence is the same design as previously approved by EPA and Navajo Nation EPA for use at NECR mine. Residents will be notified that grazing of the restored area will not be permitted until approved by a qualified revegetation specialist (biologist).

5.0 REVEGETATION MONITORING AND SUCCESS EVALUATIONS

5.1 Revegetation Monitoring Schedule

Based on Cedar Creek's previous experience, especially with reclamation that may be subject to livestock grazing impacts, a vegetation monitoring program is necessary to maximize the potential for eventual success. In this regard, a qualified revegetation specialist will review the revegetated areas on an annual basis (during the peak of the growing season in September or shortly thereafter) to catch developing problems early in the process. The annual site visits will be as follows:

Year 1 – Qualitative and semi-quantitative evaluations (managerial info. only).
Year 2 – Qualitative and quantitative evaluations (managerial info. only).
Year 3 – Qualitative and quantitative evaluations (managerial info. only).
Year 4 – Qualitative and quantitative evaluations (managerial info. only).

Year 5 – Qualitative and quantitative evaluations (final success evaluation).

As indicated, the final effort during year 5 would be an evaluation for success determination. Year 5 information will be collected in such a manner as to provide defensible verification that success has been achieved. If it is determined that vegetation needs additional time to mature, monitoring will continue once every 2 years, thereafter, until success evaluations are positive. Other than first year efforts, annual monitoring would be a combination of both qualitative and quantitative efforts to facilitate tracking and progress toward revegetation success standards.

To facilitate additional views of the revegetation for visual evaluation, a program of quarterly photographic monitoring will be initiated to coincide with the Erosion and Sedimentation Surveys prescribed as part of the post removal site controls in the NECR IRA Construction Plan. This quarterly monitoring will be implemented over the first five years, or until the Erosion and Sedimentation Surveys are completed, whichever occurs first.

All monitoring within the "step-out" area will be segregated into two groups of observational or quantitative data. The first group will consist of those data and observations specific to the portion of the step-out area that is north of the "buffer zone". The second group will consist of data and observations specific to the buffer zone.

Once per year, results from site-specific surveys and photo-documentation will be compiled into a brief report for submittal to the EPA.

5.2 Revegetation Monitoring Procedures

5.2.1 Physical and Biotic Attributes / Emergent Plant Density

During the first growing season following seeding each reclaimed unit will be subjected to a relatively brief one-time evaluation to document plant establishment as well as other reclamation considerations. This evaluation consists of a qualified observer traversing the subject area and evaluating vegetation establishment and related physical and biotic conditions. Approximately 1 hour of qualitative review time per 20 acres will be expended. During the traverses, the observer will note, among other items: 1) areas of poor seedling emergence, 2) pervasively weak or stressed seedlings, 3) indicators of soil fertility problems (e.g. certain anthocyanine colorations), 4) noxious weeds or invasive plant infestation, 5) evidence of unintended livestock grazing, 6) excessive erosion and type, 7) "pockets" of the aforementioned, and 8) any other similar revegetation / reclamation related problems.

In addition to the physical and biotic attributes evaluation, the surveying observer will collect semi-quantitative samples to document the emergent density of seeded species. In this regard, a total of 20 samples will be collected from each reclaimed unit (two units). Each sample will consist of a cluster of five 1.0 ft^2 quadrats distributed in an unbiased manner (total of 100 quadrats). The number of emergent plants rooted within the perimeter of each quadrat will be recorded accordingly into one of five classes: perennial grass, perennial forb, shrub/tree, annual grass, or annual forb. This procedure typically takes only a few minutes per sample point (5 quadrats) yet yields valuable information on the success of the seeding effort. Efforts that result in an average of fewer than 1 perennial emergent per 1.0 ft^2 should be considered to be poor and a possible candidate for remediation. Efforts with 1 – 2 perennial emergents per 1.0 ft^2 are considered to be fair, 2 - 3 perennial emergents per 1.0 ft^2 are considered good, and 3 - 5 perennial emergents per 1.0 ft^2 are considered to be very good. Finally, greater than 5 perennial emergents per 1.0 ft^2 are considered to be excellent.

The results of the qualitative, and semi-quantitative emergent density survey will form an initial basis for recommendations for future needs of the reclaimed unit. It is most probable that a recommendation to proceed to Year 2 monitoring will be made. Other possible recommendations may include:

1. Allow additional time for seed to emerge and re-evaluate using Year 1 Protocols. The amount of additional time may be one or two years.

2. Retreat all or parts of a unit by resoiling, reseeding, fertilizing, or weed control efforts.

An important concept that must be taken into account is that precipitation is not always favorable for reclamation efforts in any given year or environment, just as occurs for agricultural practices. Also, species selected, growth form, depredation by granivores, and mold or fungus may impact emergence. Therefore, as indicated above, a second growing season is occasionally necessary to achieve the desired seedling emergence. If however, after two growing seasons emergence is still unsatisfactory, reseeding may be necessary to replenish the seed bank. If such mitigation occurs, the area should be monitored again the following growing season using Year 1 protocols.

5.2.2 Photo monitoring points

As indicated above, photo monitoring will occur once per quarter for the first five years during the Erosion and Sedimentation Surveys, or until those surveys are terminated. Two permanent photo-points (marked with a fence post or rock cairn and GPS coordinates) will be established within the area north of the buffer zone and two points will be established within the buffer zone (total of 4 permanent photo-points). At each point, four photos will be exposed, one each in a cardinal compass direction (N-E-S-W) using a photo board to indicate photo-point and direction visible in each frame. Photos will be exposed in "portrait" orientation (as opposed to landscape) with the horizon at the very top of each photo. In this manner, all vegetation from very close to very far will be observable. Following collection of these photos, they will be provided to the range scientist or revegetation specialist for evaluation and inclusion in reporting.

5.2.3 Qualitative and Quantitative Vegetation Monitoring

During years 2, 3, and 4, monitoring will involve brief qualitative and quantitative evaluations of each of the two reclaimed units. Qualitative monitoring will consist of a repeat of those observations of physical and biotic attributes discussed in Section 5.2.1 above. Quantitative monitoring will involve collection of ground cover data, by species, within each revegetated unit to be evaluated and in the reference area to provide comparison parameters. A total of 10 transects shall be established in an unbiased manner within each of the revegetated areas and the reference area established in 2009 (total of 30 transects). Species diversity (composition) information will be calculated from ground cover data. Sampling for ground cover will be accomplished utilizing the point-intercept procedure using modern instrumentation (e.g. lasers or optics) along transects of 100 intercepts each.

Sampling procedures will closely approximate those presented in the "NE Church Rock Mine, Vegetation Evaluations Contributory to Development of Final Reclamation Considerations" work plan (Work Plan) previously submitted to EPA. The first step of the vegetation sampling protocol will be to obtain samples of the ground cover from each revegetated unit to be evaluated (two units - areas north of the buffer zone vs. areas within the buffer zone). Ground cover will also be obtained from the reference area. Sampling will occur during the peak biomass period of the year (late summer - September) and sampling locations will be determined utilizing a visually-based systematic method. This systematic procedure also provides proportionate representation from across each reclaimed unit for such characteristics as aspect and slope.

Ground Cover Determination. Ground cover at each sampling site will be determined utilizing the point-intercept methodology as illustrated in the Work Plan. This methodology has been utilized for range studies for over eighty (80) years and will occur as follows: First, a transect of 10 meters length will be extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a "laser point bar" or "optical point bar" will be situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species), litter, rock (>2mm), or bare soil. Hits will be determined at each meter interval as follows. When a laser point bar is used, a battery of 10 tightly focused specialized lasers situated along the bar at 10 centimeter intervals will be activated and the variable intercepted by each of the narrow (0.02") focused beams will be recorded. If an optical point bar is used, intercepts will be recorded based on the item intercepted by fine crosshairs situated within each of 10 optical scopes located at 10-centimeter intervals. In either situation, a total of 100 intercepts per transect will be recorded resulting in 1 percent cover per intercept. This methodology and instrumentation facilitates the collection of the most unbiased, repeatable, precise, and cost-effective ground cover data possible.

Because data are for managerial information in Years 2, 3, and 4, sample adequacy calculations will only be calculated for informational purposes. Only in Year 5 (or thereafter as necessary) would collection of an adequate sample be necessary.

Depending on the results of data analyses and interpretation of observations, appropriate management recommendations will be generated for the target units in each of Years 2, 3, and 4. For most efforts on a reasonable path to growth and development, it is anticipated that a recommendation to proceed to the next year of monitoring or success evaluation will be forthcoming. Other possible recommendations include:

1. Allow additional time for the establishing community to mature and then re-evaluate using monitoring protocols.

2. Retreat all or parts of a unit by reseeding, fertilizing, weed control efforts, etc. and continue monitoring using Section 5.2.3 protocols as necessary.

Advancement to success evaluation would be based on both age of the reclamation (at least 5 years of age) and the estimated amount of expressed vegetation in the target reclamation unit(s) in comparison to the success criterion based on reference area data. When it is determined the amount of vegetation cover is approaching and will likely exceed the success threshold the following year, or presently exceeds the success criterion, then the following program will commence.

5.3 Revegetation Success Criteria

A determination of revegetation success will take into account the following three factors:

- Comparison will be to an established reference area representative of the adjacent vegetation community and/or desirable ecological conditions (for the variables of ground cover and diversity);

- Plant species present in the approved (and planted) seed mixes; and

- The post-mining land use (livestock grazing with coincidental wildlife habitat) has been established and the vegetation is capable of being grazed at proper grazing intensity.

When utilizing reference areas (that are late seral by definition) for determinations of revegetation success, certain allowances must be made when comparing them to early seral revegetated communities; otherwise comparisons would be scientifically invalid. Furthermore, precedent has been set in this regard in both the coal and hard-rock industry's reclamation regulatory mandates. These allowances are a reduction in the amount of ground cover and diversity from late-seral values.

Revegetation success in revegetated units planted primarily as grassland or shrub steppe (targeting livestock grazing land uses with coincidental wildlife habitats) will concentrate on two performance standards (1) vegetative ground cover, and 2) diversity. Therefore, revegetation efforts will be

considered successful when the following criteria have been met following at least five years of growth and development.

1. Vegetative Ground Cover Criterion

The total vegetative ground cover (exclusive of listed noxious species) below breast height (1.25 meters) in the target revegetated unit equals or exceeds 75 percent of the reference area's total vegetative ground cover (exclusive of listed noxious species) below breast height (1.25 meters), with 90 percent statistical confidence.

2. Species Diversity Standard:

Diversity, as indicated by number of "important species" (exclusive of listed noxious weeds) in each revegetated unit equals or exceeds 50% of the "important species" found in the reference area. An important species is defined as any taxon that equals or exceeds 1% absolute ground cover.

5.4 Revegetation Testing for Success Determination

Following field evaluations during Year 5 using the protocols detailed above, the collected parameters (for ground cover) for the reference area will be compared with the target revegetated units' values to provide an indication of revegetation success. This testing will involve the commonly accepted statistical student's "t-test" of the means for ground cover from each of the areas at the level of significance of a = 0.1 with 90% confidence. Diversity testing will be a direct mathematical comparison. In both cases, testing will be against criteria developed from reference area data as indicated in the preceding section (5.3).

Sampling Adequacy. Sampling adequacy will not be necessary for managerial level monitoring data collected prior to Year 5. However, data collection for success evaluation will continue within each discrete sampling unit (revegetated unit or reference area) until a statistically adequate sample has been obtained. One exception is possible - if reverse-null hypothesis testing is employed. In this case, use of parameters from an adequate sampling effort is not a statistical requirement.

Adequacy of sampling in Year 5 will be achieved when, for each discrete unit, the number of samples actually collected (n) provides a level of precision within 10% of the true mean (μ) with 90% confidence (n_{min}), i.e., when $n_{min} \leq n$. And n_{min} is calculated as follows:

$$n_{min} = (t^2 s^2) / (0.1 \bar{x})^2$$

where: **n** = the number of actual samples collected with a minimum of 20 in each unit;

t = the one-tailed value from the *t* distribution for 90% confidence with n-1 degrees of freedom;

s^2 = the variance of the estimate as calculated from the initial samples;

$\bar{x}$ = the mean of the estimate as calculated from the initial samples.

As indicated above, this formula provides an estimate of the sample mean to within 10% of the true population mean (μ) with 90% confidence. Calculations of the mean and variance will be based on "total vegetation ground cover" exclusive of litter. Furthermore, a minimum sample size of twenty (20) samples will be collected from each discrete revegetated unit or the reference area in Year 5. If the initial 20 samples do not provide an adequate estimate of the mean (e.g., the inequality above is false), additional samples will be collected until the inequality is satisfied. However, in no case will more than 40 ground cover transects be collected in any given sampling unit.

As indicated above, ground cover will be assessed using a classical "t" test comparison of the means and diversity will be assessed using a straight-forward mathematical comparison. With regard to the ground cover evaluation, the decision rule will be:

If $t_c \leq t$ for $t_{(a=0.1,\ nra+nrv-2\ d.f.)}$ the test can be considered successful.

For the diversity evaluation, if the number of "important" species of the reclaimed area is equal to or greater than 0.5 times the number of "important" species of the reference area, then the test can be considered successful. On occasion, a classical "t" test comparison may be inappropriate. In such circumstances, a "reverse null" "t" test will be performed.

For the reverse null procedure, collection of an "adequate" sample (where $\mathbf{n_{min}} \leq \mathbf{n}$) is not necessary as it is in the operator's best interest to sample until a "tight" estimate of the mean is obtained (i.e., sampling should continue until the variance is more "narrowly" defined). Typically, a sample size of 30 or greater provides such an estimate (due to the Central Limit Theorem). In the "classical" hypothesis test, rejection of H_o means failure as the hypothesis being tested is that the target area variable is greater than or equal to 75% of the reference area or standard. However, in the reverse null test,

rejection of H_o means success as the hypothesis being tested is that the target area variable is less than or equal to 75% of the reference area or standard. Therefore, once a sample has been collected from both the target area of interest and the reference area, the means and variances ($\bar{x}$ and s^2) of those samples will be utilized for testing success or failure as follows:

For two-sample testing (with a reference area) for equal variances (usual case), the following test would be performed (rv = revegetated unit, ra = reference area):

$$t_c = \frac{\bar{x}_{rv} - 0.75\bar{x}_{ra}}{\sqrt{s_p^2\left(\frac{1}{n_{rv}} + \frac{1}{n_{ra}}\right)}} \quad \text{Where the pooled variance } s_p^2 =$$

$$s_p^2 = \frac{\left[(n_{ra} - 1)0.5625s_{ra}^2 + (n_{rv} - 1)s_{rv}^2\right]}{(n_{ra} + n_{rv}) - 2}$$

Then if $t_c \geq t$ for $t_{(a=0.1,\ nra+nrv-2\ d.f.)}$ the test is successful.

For two-sample testing (with a reference area) for unequal variances (infrequent case), the following test would be performed

$$t_c = \frac{\bar{x}_{rv} - 0.75\bar{x}_{ra}}{\sqrt{w_{rv} - w_{ra}}} \quad \text{Where } w_{ra} = \frac{0.5625s_{ra}^2}{n_{ra}} \text{ and } w_{rv} = \frac{s_{rv}^2}{n_{rv}}$$

and the degrees of freedom are approximated by:

$$\frac{(w_{ra} + w_{rv})^2}{\frac{w_{ra}^2}{n_{ra} - 1} + \frac{w_{rv}^2}{n_{rv} - 1}}$$

Then if $t_c \geq t$ for $t_{(a=0.1,\ approx.\ d.f.)}$ the test is successful.

5.5 Contingency Plan and Conditions for Final Relinquishment

If at any time before, during, or after Year 5 for a revegetated unit, monitoring indicates significant potential for failure to meet any of the foregoing revegetation performance standards, the applicant will document such findings in a report to the appropriate agencies within 90 days of problem identification. The report will describe the area of concern, the perceived problem, and the probable causes. Within 60 days of submission of the report, the applicant will submit a corrective action plan, with an implementation schedule, to the EPA for review and approval. Following EPA approval, the corrective action plan will be implemented by the applicant.

If a revegetated unit continues to fail to meet a performance standard following another 5 years after the applicant's substantial compliance with the Reclamation Plan and after application of any appropriate corrective action procedures as described above, the applicant may request a revision of the performance standard for any revegetated unit(s) on the grounds that either:

(a) a revised performance standard is appropriate as the permit area will be reclaimed to a condition that allows for re-establishment of a self-sustaining ecosystem appropriate for the life zone of the surrounding areas; or

(b) the applicant qualifies for a waiver in that the unit will meet all applicable federal and state laws, regulations and standards for air, surface water and ground water protection and will not pose a current or future hazard to public health or safety; or

(c) the applicant qualifies for a variance as the standard imposes undue economic burden, and the variance will not result in a significant threat to human health, safety, or the environment.

To the contrary, if it is determined that any failure to achieve a performance standard is due to human or livestock-related damage to reclamation as a result of actions by outside parties, or their livestock, in the form of compromised exclusionary fencing or other human-related detrimental actions, then it will be assumed that standards would have been achieved and liabilities will be released.

Table 6 NE Church Rock - Cedar Creek's Recommended Seed Mix*

For Areas Targeting Grassland - (Livestock Grazing Land Use) - with an Incidental Wildlife Habitat Component

Seed Mix				Specifications / Recommendations					This entire mix can be drill seeded very shallow
No.	Obs. On Site	Common Name	Scientific Nomenclature	PLS / lb.**	Recommd. PLS lbs/ac	PLS / ft^2	% of Seeds in Mix	Preferred Method of Seeding	Comment (Based on Site-specific Findings or Professional Judgment)
1	XX	Western Wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	3.8%	Drill	NRCS indicated climax species
2	XX	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.75	30.3	30.0%	Drill	NRCS indicated climax species
3	XX	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	9.4%	Drill	Stong component of native community
4	XX	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	1.8%	Drill	Stong component of native community
5		Thickspike Wheatgrass	*Agropyron dasystachyum*	154,000	0.75	2.7	2.6%	Drill	Fair performer - Offers diversity
6	XX	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.2%	Drill	Should do well in areas of sandy texture
7	XX	Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	4.4%	Drill	Good performer - Offers diversity
8	XX	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	0.25	1.1	1.1%	Drill	Fair performer - Offers diversity
		Grass Subtotal			**6.25**	**56.7**	**56.3%**		
9	XX	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	8.5%	B-cast/Harrow	Sufficient performer for diversity
10		Palmer Penstemon	*Penstemon palmeri*	610,000	0.50	7.0	6.9%	B-cast/Harrow	Good performer - Offers diversity
11	XX	Rocky Mtn. Penstemon	*Penstemon strictus*	592,000	0.25	3.4	3.4%	B-cast/Harrow	Fair performer - Offers diversity
12		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	6.7%	B-cast/Harrow	Good performer - Offers diversity
		Forb Subtotal			**2.50**	**25.7**	**25.5%**		
13	XX	Fourwing Saltbush	*Atriplex canescens*	52,000	1.00	1.2	1.2%	Drill	NRCS indicated climax species - good forage value
14	XX	Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.25	14.3	14.2%	B-cast/Harrow	Occasional performer - Offers diversity
15	XX	Cliffrose	*Purshia stansburiana*	64,600	1.00	1.5	1.5%	B-cast/Harrow	Fair performer - Offers diversity
16		Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.3%	Drill	Good performer - good forage value
		Shrub Subtotal			**3.25**	**18.3**	**18.2%**		
		Total			**12.00**	**100.8**			

Alternative species which may be used as substitutes for secondary or tertiary species or added to the overall mix for additional diversity.

Grasses	XX	Sand Dropseed	*Sporobolus cryptandrus*	5,298,000	0.00	0.0	When one of these taxa are used, the amount of PLS seed should be approximately the same as the species being sub-stituted, unless there is a large disparity in the number of seeds / pound. In which case, the amount should be adjusted up or down accordingly.	
		Arizona Fescue	*Festuca arizonica*	550,000	0.00	0.0		Use in moist areas only, likes 14" of precip.
	XX	New Mexico Needlegrass	*Stipa neomexicana*	70,000	0.00	0.0		
	XX	Purple Three-awn	*Aristida purpurea*	250,000	0.00	0.0		
Forbs	XX	White Prarie Clover	*Dalea candidum*	354,000	0.00	0.0		
		Small Burnet	*Sanguisorba minor*	55,000	0.00	0.0		
Shrubs	XX	Rubber Rabbitbrush	*Chrysothamnus naseousus*	400,000	0.00	0.0		
		Black Sagebrush	*Artemisia nova*	907,200	0.00	0.0		

Primary Species - Should not be substituted.

Secondary Species - Substitute only when seed is not available or strong preference is given. Substitutions should be: grass for grass, forb for forb, shrub for shrub. PLS lbs may change.

Tertiary Species - May be substituted, but recommendation is to plant as indicated.

* The 12 lb/ac mix is designed for drill seeding of grasses. If broadcast and harrow methods are used for grass seed distribution, the rate should be increased 1.5 times. When hydroseeding methods are to be used, the rate should be doubled (2X). ** PLS = Pure Live Seed. Note: This entire mix may be drill seeded, but depth bands must be set to very shallow seed placement (e.g. 1/8 inch). If hydroseeding occurs, seed must not be mixed with a mulch for application. They must be applied in two passes: first pass seed, second pass mulch.

6.0 LITERATURE CITED

Bonham, Charles D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons. 338 pp.

Appendix A

Primary Raw Data Tables

Table A1 Northeast Church Rock - Vegetation Cover - 2009

Baseline Area

Raw Data

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.——>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Grasses																																	
P	*Aristida purpurea*	Purple Three-awn												3				3									3						
P	*Bouteloua gracilis*	Blue Grama	1	7							4	1	2		2	1	1		1				1						2	1		7	
A	*Bromus tectorum*	Cheatgrass																															
P	*Hilaria jamesii*	Galleta									2												16				9						
P	*Muhlenbergia pauciflora*	New Mexico Muhly																													7		
P	*Oryzopsis hymenoides*	Indian Ricegrass	8		3	15	1		2	6					7	8	9	18	1				6	15	1	2	4		2	8		3	
P	*Poa secunda*	Sandberg's Bluegrass																										2	2	1			
P	*Sitanion hystrix*	Bottlebrush Squirreltail								2																			1				
P	*Stipa neomexicana*	New Mexico Feathergrass		8											4		3		2														
Forbs																																	
P	*Astragalus missouriensis var. mimetes*	Milkvetch							1																								
P	*Astragalus mollissimus var. thompsonii*	Woolly Locoweed																				1											
P	*Astragalus tenellus*	Looseflower Milkvetch																												1			
P	*Eriogonum umbellatum*	Sulphur-flower Buckwheat							2				3											1							2		
P	*Euphorbia brachycera*	Horned Spurge																								1							
P	*Heterotheca villosa*	Hairy Golden Aster		1			5						2	2		2	1					3		4									
A	*Kochia scoparia*	Burningbush		3																													
P	*Mirabilis multiflora*	Colorado Four o'clock																6															
P	*Penstemon eatonii*	Firecracker Penstemon					1																										
P	*Penstemon strictus*	Rocky Mtn. Penstemon													2																		
IW	*Salsola tragus*	Russian Thistle				10																											
P	*Sphaeralcea ambigua*	Desert Globemallow																					1										
P	*Stanleya pinnata*	Desert Princesplume																													7		
P	*Stenotus armerioides*	Thrift Mock Goldenweed			5						3			7	2	3	5		6	11	1	4		10	7	1	1						3
B	*Tragopogon dubius*	Yellow Salsify				1																											
	Unidentifiable																							1									
Shrubs, Sub-shrubs, Cacti & Trees																																	
P	*Artemisia tridentata*	Big Sagebrush		2		6					4						10													6			4
P	*Chrysothamnus depressus*	Longflower Rabbitbrush	2		5														2														
P	*Chrysothamnus nauseosus*	Rubber Rabbitbrush		5	6	17	2	7	6									1			5	10		6			5						
P	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush						3		6																				1			
P	*Gutierrezia sarothrae*	Broom Snakeweed	2			1			1	1	1	3			2	1	4	1	7										5			3	1
P	*Juniperus monosperma*	One-seeded Juniper		13										10		10																	
P	*Opuntia polyacantha*	Plains Pricklypear																						1									
P	*Pinus edulis*	Two-needle Pinyon					3					3									7			11						3			
P	*Purshia stansburiana*	Stansbury Cliffrose	10				18	14	17		15										4					21		20			9		16
P	*Quercus gambelii*	Gambels Oak																		3									13				
P	*Yucca baccata*	Banana Yucca													1																		
P	*Yucca glauca*	Soapweed Yucca		2								2																					
		Total Plant Cover	**23**	**41**	**19**	**50**	**30**	**24**	**29**	**21**	**24**	**15**	**19**	**23**	**25**	**33**	**29**	**19**	**14**	**17**	**18**	**24**	**37**	**20**	**25**	**22**	**22**	**25**	**21**	**18**	**20**	**24**
		Rock	15	1	13	2	7	3	5	7	26	28	43	8	10	11	34	33	6	28	22	27	19	18	22	35	2	2	12	42	11	19
		Litter	23	16	6	18	16	23	18	64	26	47	28	32	39	36	16	15	16	6	20	11	21	29	22	16	24	41	39	7	55	25
		Bare ground	39	42	62	30	47	50	48	8	24	10	10	37	26	20	21	33	64	49	40	38	23	33	31	27	52	32	28	33	14	32
		Total Perennial Cover	**23**	**38**	**19**	**39**	**30**	**24**	**29**	**21**	**24**	**15**	**19**	**23**	**25**	**33**	**29**	**19**	**14**	**17**	**18**	**24**	**36**	**20**	**25**	**22**	**22**	**25**	**21**	**18**	**20**	**24**

Sample Adequacy Calculations

Plant Cover Mean = 22.63 **t= 1.30** **n = 54**

Variance = 50.92 **n_{min} = 16.74**

Table A1 Continued

Baseline Area

Raw Data

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.——>	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Average Cover	Relative Cover	Freq.
Grasses																														
P	*Aristida purpurea*	Purple Three-awn																				2					**0.20**	**0.90**	**7**
P	*Bouteloua gracilis*	Blue Grama				1	1	2	16	2		1	2	3		9		9	6		4			2		3	**1.70**	**7.53**	**50**
A	*Bromus tectorum*	Cheatgrass														1									1		**0.04**	**0.16**	**4**
P	*Hilaria jamesii*	Galleta																					3				**0.56**	**2.45**	**7**
P	*Muhlenbergia pauciflora*	New Mexico Muhly										2		1													**0.19**	**0.82**	**6**
P	*Oryzopsis hymenoides*	Indian Ricegrass						1		2	12		1	1			3		1	9		5	6	7	5	12	**3.41**	**15.06**	**59**
P	*Poa secunda*	Sandberg's Bluegrass																									**0.09**	**0.41**	**6**
P	*Sitanion hystrix*	Bottlebrush Squirreltail																			1						**0.07**	**0.33**	**6**
P	*Stipa neomexicana*	New Mexico Feathergrass												2	4												**0.43**	**1.88**	**11**
Forbs																														
P	*Astragalus missouriensis var. mimetes*	Milkvetch																									**0.02**	**0.08**	**2**
P	*Astragalus mollissimus var. thompsonii*	Woolly Locoweed																									**0.02**	**0.08**	**2**
P	*Astragalus tenellus*	Looseflower Milkvetch																									**0.02**	**0.08**	**2**
P	*Eriogonum umbellatum*	Sulphur-flower Buckwheat																3	3						5	2	**0.39**	**1.72**	**15**
P	*Euphorbia brachycera*	Horned Spurge																									**0.02**	**0.08**	**2**
P	*Heterotheca villosa*	Hairy Golden Aster																			1		5				**0.48**	**2.13**	**19**
A	*Kochia scoparia*	Burningbush																									**0.06**	**0.25**	**2**
P	*Mirabilis multiflora*	Colorado Four o'clock																									**0.11**	**0.49**	**2**
P	*Penstemon eatonii*	Firecracker Penstemon																									**0.02**	**0.08**	**2**
P	*Penstemon strictus*	Rocky Mtn. Penstemon			1	1																					**0.07**	**0.33**	**6**
IW	*Salsola tragus*	Russian Thistle																									**0.19**	**0.82**	**2**
P	*Sphaeralcea ambigua*	Desert Globemallow																									**0.02**	**0.08**	**2**
P	*Stanleya pinnata*	Desert Princesplume																									**0.13**	**0.57**	**2**
P	*Stenotus armerioides*	Thrift Mock Goldenweed	2	5		1		2		1		1	3	4	3						1						**1.70**	**7.53**	**46**
B	*Tragopogon dubius*	Yellow Salsify																									**0.02**	**0.08**	**2**
	Unidentifiable										1													1			**0.06**	**0.25**	**6**
Shrubs, Sub-shrubs, Cacti & Trees																														
P	*Artemisia tridentata*	Big Sagebrush				4	1	12	1	5								6						2			**1.17**	**5.16**	**24**
P	*Chrysothamnus depressus*	Longflower Rabbitbrush				7	2			1		3		1					2		5						**0.56**	**2.45**	**19**
P	*Chrysothamnus nauseosus*	Rubber Rabbitbrush									2						16			2				3			**1.72**	**7.61**	**28**
P	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush																									**0.19**	**0.82**	**6**
P	*Gutierrezia sarothrae*	Broom Snakeweed			1				2	1	9	13	3				9			9	3				1	1	**1.57**	**6.96**	**46**
P	*Juniperus monosperma*	One-seeded Juniper			12		4							5			2										**1.04**	**4.58**	**13**
P	*Opuntia polyacantha*	Plains Pricklypear	2			5								3	2			1	1								**0.28**	**1.23**	**13**
P	*Pinus edulis*	Two-needle Pinyon	5		4	5	5			5			3		9										2		**1.20**	**5.32**	**24**
P	*Purshia stansburiana*	Stansbury Cliffrose			9			19														16	14	15	6		**4.13**	**18.25**	**30**
P	*Quercus gambelii*	Gambels Oak	13				8																				**0.69**	**3.03**	**7**
P	*Yucca baccata*	Banana Yucca																									**0.02**	**0.08**	**2**
P	*Yucca glauca*	Soapweed Yucca																									**0.07**	**0.33**	**4**
																											Mean		
			Total Plant Cover	**22**	**19**	**25**	**15**	**18**	**36**	**19**	**17**	**24**	**20**	**12**	**20**	**18**	**26**	**14**	**19**	**13**	**20**	**15**	**23**	**25**	**33**	**20**	**18**		**22.63**	
			Rock	15	19	1	12	13	0	0	24	5	8	14	16	16	5	5	6	14	18	3	2	11	25	9	8		**14.07**	
			Litter	18	15	11	30	29	8	28	29	26	35	31	36	54	16	48	28	30	37	30	6	20	17	27	10		**25.44**	
			Bare ground	45	47	63	43	40	56	53	30	45	37	43	28	12	53	33	47	43	25	52	69	44	25	44	64		**37.85**	
			Total Perennial Cover	**22**	**19**	**25**	**15**	**18**	**36**	**19**	**17**	**23**	**20**	**12**	**20**	**18**	**25**	**14**	**19**	**13**	**20**	**15**	**23**	**25**	**32**	**19**	**18**		**22.28**	

Diversity — Number of Species with >1% Average Cover or 2% Relative Cover = **13**

Table A2 Northeast Church Rock - Vegetation Cover - 2009

Reference Area

Raw Data

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.—>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average Cover	Relative Cover	Freq.
Grasses																										
P	*Aristida purpurea*	Purple Three-awn						1			1													**0.10**	**0.53**	**10**
P	*Bouteloua gracilis*	Blue Grama	3	4	2	4	7	10	2	6	2	4	2	6	7	6	2	8	3	2	13	1	**4.70**	**24.74**	**100**
P	*Hilaria jamesii*	Galleta					2						5										**0.35**	**1.84**	**10**
P	*Muhlenbergia pauciflora*	New Mexico Muhly					1																**0.05**	**0.26**	**5**
P	*Oryzopsis hymenoides*	Indian Ricegrass	2	1						2		3	1		1		1					1	**0.60**	**3.16**	**40**
Forbs																										
P	*Eriogonum umbellatum*	Sulphur-flower Buckwheat							1														**0.05**	**0.26**	**5**
P	*Heterotheca villosa*	Hairy Golden Aster	2	1		3		4				4							3				**0.85**	**4.47**	**30**
P	*Phlox hoodii ssp. canescens*	Spiny Phlox															3						**0.15**	**0.79**	**5**
P	*Sedum lanceolatum*	Spearleaf Stonecrop				1	1		1														**0.15**	**0.79**	**15**
P	*Stenotus armerioides*	Thrift Mock Goldenweed			4	1																	**0.25**	**1.32**	**10**
	Unidentifiable				1		1					1											**0.15**	**0.79**	**15**
Shrubs, Sub-shrubs, Cacti & Trees																										
P	*Artemisia tridentata*	Big Sagebrush		9						21	13			24	4	3	5	9		1	5	17	**5.55**	**29.21**	**55**
P	*Chrysothamnus depressus*	Longflower Rabbitbrush			10		4	5	15			9							10	7			**3.00**	**15.79**	**35**
P	*Chrysothamnus viscidiflorus*	Yellow Rabbitbrush												5									**0.25**	**1.32**	**5**
P	*Gutierrezia sarothrae*	Broom Snakeweed	2	2		9		1		1	6	4			1		5	2	1				**1.70**	**8.95**	**55**
P	*Opuntia polyacantha*	Plains Pricklypear									3												**0.15**	**0.79**	**5**
P	*Pinus edulis*	Two-needle Pinyon								2			10						1	5			**0.90**	**4.74**	**20**
P	*Quercus gambelii*	Gambels Oak																		1			**0.05**	**0.26**	**5**
																							Mean		
			Total Plant Cover	**9**	**17**	**17**	**18**	**17**	**20**	**19**	**33**	**24**	**25**	**18**	**35**	**13**	**12**	**13**	**19**	**18**	**16**	**18**	**19**	**19.00**		
			Rock	20	3	4	3	27	2	13	1	2	12	22	0	3	1	6	8	2	13	2	0	**7.20**		
			Litter	4	31	10	2	9	0	9	37	41	5	8	6	44	84	49	23	64	38	4	35	**25.15**		
			Bare ground	67	49	69	77	47	78	59	29	33	58	52	59	40	3	32	50	16	33	76	46	**48.65**		
			Total Perennial Cover	**9**	**17**	**16**	**18**	**16**	**20**	**19**	**33**	**24**	**24**	**18**	**35**	**13**	**12**	**13**	**19**	**18**	**16**	**18**	**19**	**18.85**		

Sample Adequacy Calculations	**Plant Cover Mean = 19.00** **t= 1.33** **n = 20** **Variance = 40.00** **n_{min} = 19.53**
Diversity	Number of Species with >1% Average Cover or 2% Relative Cover = **7**

Table A3 Northeast Church Rock - Woody Plant Density - 2009

Baseline Area

Raw Data

Sampling Method: 2m x 50m Belt Transects

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
S	*Artemisia tridentata*	20	7	3	4		1						2	2	4	14			3		1		1					1		2	18		3	33	25	37
S	*Cercocarpus montanus*												1								1	1	1									1				
S	*Chrysothamnus nauseosus*	2	27	6	6	9	15	16								2	1	1	2	2					4		2	1		5			1				
S	*Chrysothamnus viscidiflorus*																										5			3						5
Su	*Echinocereus sp.* *											1																				1				
T	*Juniperus monosperma*		5	3	4	1			2	3	3		5	4	1	3	1	1	2	1	5	4	2	4	1	1	4	4	3	1		4	3	3	5	1
S	*Mahonia repens*								5																											
Su	*Escobaria vivipara*													1																						
Su	*Opuntia polyacantha*					8			3	3		7	14				1	9	3				8	8						2	26	10	5	3	2
T	*Pinus edulis*			3	2	8	4	1	2	1	8	3		2			4	5	5	7	2	4	1	5	2	5	7	7	6	4	4	3	1	4	5	1
S	*Purshia stansburiana*	7	11	1	14	5		8	12	2	6				10		2			3	2		9	3	23	3		7		23	2				1	12
T	*Quercus gambelii*	1							5		1						2			1		5	4		3	7			5		10	3				
Su	*Yucca baccata*										6		3						3												3	3		3	5	
Su	*Yucca glauca*		5						6																	18	5		1	4						
	Total	**30**	**55**	**16**	**30**	**31**	**20**	**25**	**35**	**9**	**24**	**11**	**25**	**9**	**15**	**19**	**11**	**16**	**18**	**14**	**11**	**14**	**26**	**20**	**33**	**34**	**23**	**20**	**15**	**42**	**39**	**41**	**18**	**48**	**44**	**58**

	Species	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	Total Count	Per Acre	Shrubs per Acre by Lifeform
S	*Artemisia tridentata*	24	1	1		1	10	5	1	1				8			3		1	3	**240**	**179.9**	
S	*Cercocarpus montanus*							1													**6**	**4.5**	
S	*Chrysothamnus nauseosus*	14		2					5	5	6	1		1		1		1	8	3	**149**	**111.7**	**Shrub (S) =**
S	*Chrysothamnus viscidiflorus*			4					8	22	29					6	6				**88**	**65.9**	**578.6**
Su	*Echinocereus sp.* *																				**2**	**1.5**	
T	*Juniperus monosperma*	1	5	4	1	5	7	4			4	1	3	2	3	2	3	4	1	2	**136**	**101.9**	
S	*Mahonia repens*																				**5**	**3.7**	**Succulent (Su) =**
Su	*Escobaria vivipara*																				**1**	**0.7**	**224.8**
Su	*Opuntia polyacantha*		2	3	9	12	12	16	1	1	6	2	2	19	1	2				3	**203**	**152.1**	
T	*Pinus edulis*	2	3	1	6	2	3	4	4	3	4	9	3	5	5	5	5	2	3	3	**188**	**140.9**	
S	*Purshia stansburiana*	13	1						26	17			1	3	1	21	10	5	19	1	**284**	**212.8**	**Tree (T) =**
T	*Quercus gambelii*			1		11						1									**60**	**45.0**	**287.8**
Su	*Yucca baccata*						2						2								**30**	**22.5**	
Su	*Yucca glauca*			6						11										8	**64**	**48.0**	
	Total	**54**	**12**	**22**	**16**	**31**	**34**	**30**	**45**	**60**	**49**	**14**	**11**	**38**	**10**	**37**	**27**	**12**	**32**	**23**	**1,456**	**1,091.2**	

Sample Adequancy Calc. **t = 1.298** **mean = 26.96** **var. = 192.2** **n_{min} = 44.5**

* Two species of *Echinocereus* were observed on site, neither of which is classified as a sensitive taxon.

Table A4 Northeast Church Rock - Woody Plant Density - 2009

Reference Area

Raw Data

Sampling Method: 2m x 50m Belt Transects

	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Count	Per Acre	Shrubs per Acre by Lifeform
S	*Artemisia tridentata*	26	5		9	12	2	9	49	14	4	21	56	42	21	52	25		25	42	44	**458**	**926.7**	
S	*Chrysothamnus nauseosus*		3							1			2	32								**38**	**76.9**	
S	*Chrysothamnus viscidiflorus*												106			4	10			2	8	**130**	**263.0**	**Shrub (S) =**
T	*Juniperus monosperma*	2			3			4		1	4	1		1	2	2	4	1	3	1	1	**30**	**60.7**	**1,274.8**
Su	*Escobaria vivipara*																	1				**1**	**2.0**	
Su	*Opuntia polyacantha*	8	2	1	10	6	2	5	6		5	4	2		1	2	22	1			4	**81**	**163.9**	**Succulent (Su) =**
T	*Pinus edulis*	2	5	3	6	4	2	5	3	1	2	1		1	5	2	2	8	5			**57**	**115.3**	**167.9**
T	*Pinus ponderosa*			1																		**1**	**2.0**	
S	*Psilostrophe tagetina*																		1	2		**3**	**6.1**	**Tree (T) =**
S	*Purshia stansburiana*											1										**1**	**2.0**	**178.1**
Su	*Yucca baccata*									1												**1**	**2.0**	
	Total	**38**	**15**	**5**	**28**	**22**	**6**	**23**	**58**	**18**	**15**	**28**	**166**	**76**	**29**	**62**	**63**	**11**	**34**	**47**	**57**	**801**	**1,620.8**	

Sample Adequancy Calc.	**t = 1.328**	**mean = 40.05**	**var. = 1308.7**	**n_{min} = 143.8**

Table A5 Northeast Church Rock - Vegetation Production - 2009

Baseline Area

Raw Data

Oven Dry Weight (grams per 1 square meter)

Sample No.	Grasses			Forbs			Sub-shrubs	Shrubs	Noxious Weeds	PERENNIAL		TOTAL	
	Perennial		Annual	Perennial		Annual / Biennial							
	Native	Introduced		Native	Introduced					gr./m^2	lbs./ac.	gr./m^2	lbs./ac.
1	0.7			5.5				4.8		11.0	**98.1**	11.0	**98.1**
2	0.4			12.0						12.4	**110.6**	12.4	**110.6**
3	2.3			8.7						11.0	**98.1**	11.0	**98.1**
4	23.4					12.4				23.4	**208.8**	35.8	**319.4**
5	12.5			1.1				13.0		26.6	**237.3**	26.6	**237.3**
6	29.4		0.2							29.4	**262.3**	29.6	**264.1**
7			0.8					29.3		29.3	**261.4**	30.1	**268.5**
8	4.0			4.7			3.8			12.5	**111.5**	12.5	**111.5**
9				7.2						7.2	**64.2**	7.2	**64.2**
10	0.4			13.9			5.6			19.9	**177.5**	19.9	**177.5**
11	0.2			7.7			0.3			8.2	**73.2**	8.2	**73.2**
12	1.3			4.8						6.1	**54.4**	6.1	**54.4**
13	5.6			3.3			0.8			9.7	**86.5**	9.7	**86.5**
14	3.3						36.9			40.2	**358.7**	40.2	**358.7**
15	11.2			7.0			0.5			18.7	**166.8**	18.7	**166.8**
16							18.6			18.6	**165.9**	18.6	**165.9**
17				10.4			1.6			12.0	**107.1**	12.0	**107.1**
18				1.6				16.1		17.7	**157.9**	17.7	**157.9**
19				8.6						8.6	**76.7**	8.6	**76.7**
20	26.0		0.1	1.5						27.5	**245.3**	27.6	**246.2**
21	1.9			22.6			2.8			27.3	**243.6**	27.3	**243.6**
22	0.2			8.6						8.8	**78.5**	8.8	**78.5**
23							32.5			32.5	**290.0**	32.5	**290.0**
24	0.3			8.7				0.1		9.1	**81.2**	9.1	**81.2**
25	19.6			0.2			0.3			20.1	**179.3**	20.1	**179.3**
26	2.6						23.0			25.6	**228.4**	25.6	**228.4**
27	0.4			13.3						13.7	**122.2**	13.7	**122.2**
28	8.7			9.3						18.0	**160.6**	18.0	**160.6**
29	4.4						6.9			11.3	**100.8**	11.3	**100.8**
30				15.1						15.1	**134.7**	15.1	**134.7**
31				8.3						8.3	**74.1**	8.3	**74.1**
32				14.8			3.1			17.9	**159.7**	17.9	**159.7**
33				16.2						16.2	**144.5**	16.2	**144.5**
34				14.0						14.0	**124.9**	14.0	**124.9**
35	15.9			2.7						18.6	**165.9**	18.6	**165.9**
36	17.9									17.9	**159.7**	17.9	**159.7**
37	0.6			0.1			4.6			5.3	**47.3**	5.3	**47.3**
38	20.2			0.3						20.5	**182.9**	20.5	**182.9**
39							38.4			38.4	**342.6**	38.4	**342.6**
40				12.7			1.9			14.6	**130.3**	14.6	**130.3**
41							16.4			16.4	**146.3**	16.4	**146.3**
42				15.2						15.2	**135.6**	15.2	**135.6**
43				9.9						9.9	**88.3**	9.9	**88.3**
44								25.1		25.1	**223.9**	25.1	**223.9**
45							13.4			13.4	**119.6**	13.4	**119.6**
46				17.7						17.7	**157.9**	17.7	**157.9**
47	0.3						34.2			34.5	**307.8**	34.5	**307.8**
48	25.3			0.7						26.0	**232.0**	26.0	**232.0**
49				18.2						18.2	**162.4**	18.2	**162.4**
50								12.8		12.8	**114.2**	12.8	**114.2**
51	28.1			8.5			0.6			37.2	**331.9**	37.2	**331.9**
52	11.6			9.4						21.0	**187.4**	21.0	**187.4**
53	2.8			7.7						10.5	**93.7**	10.5	**93.7**
54								20.0		20.0	**178.4**	20.0	**178.4**
Average	**5.2**	**0.0**	**0.0**	**6.2**	**0.0**	**0.2**	**4.6**	**2.2**	**0.0**	**18.2**	**162.1**	**18.4**	**164.3**

Sampling Adequacy	t = 1.298	Variance = 6324.9	n= 54
	Mean = 164.3		n_{min} = 39.447

Table A6 Northeast Church Rock - Vegetation Production - 2009

Reference Area

Raw Data

Oven Dry Weight (grams per 1 square meter)

Sample No.	Grasses			Forbs			Sub-shrubs	Shrubs	Noxious Weeds	PERENNIAL		TOTAL	
	Perennial		Annual	Perennial		Annual / Biennial							
	Native	Introduced		Native	Introduced					gr./m^2	lbs./ac.	gr./m^2	lbs./ac.
1	6.5			5.8						12.3	**109.7**	12.3	**109.7**
2	0.6			0.3			28.5			29.4	**262.3**	29.4	**262.3**
3							30.3			30.3	**270.3**	30.3	**270.3**
4	0.5			3.6			8.2			12.3	**109.7**	12.3	**109.7**
5	1.4						11.6			13.0	**116.0**	13.0	**116.0**
6	0.4			3.9			4.5			8.8	**78.5**	8.8	**78.5**
7	1.1			9.3						10.4	**92.8**	10.4	**92.8**
8	2.1			6.7			25.0			33.8	**301.6**	33.8	**301.6**
9	2.8							6.1		8.9	**79.4**	8.9	**79.4**
10	1.3					0.1	22.5			23.8	**212.3**	23.9	**213.2**
11	2.9						19.3			22.2	**198.1**	22.2	**198.1**
12	0.6							15.6		16.2	**144.5**	16.2	**144.5**
13	1.9			0.2				6.2		8.3	**74.1**	8.3	**74.1**
14							5.8	0.9		6.7	**59.8**	6.7	**59.8**
15	0.9					0.1	29.9			30.8	**274.8**	30.9	**275.7**
16	0.7							31.2		31.9	**284.6**	31.9	**284.6**
17	0.4			6.3			0.3			7.0	**62.5**	7.0	**62.5**
18				6.1						6.1	**54.4**	6.1	**54.4**
19	2.9									2.9	**25.9**	2.9	**25.9**
20	1.6						9.0			10.6	**94.6**	10.6	**94.6**
Average	**1.4**	**0.0**	**0.0**	**2.1**	**0.0**	**0.0**	**9.7**	**3.0**	**0.0**	**16.3**	**145.3**	**16.3**	**145.4**

Sampling Adequacy	**t = 1.328**	**Variance = 8254.7**	**n= 20**
	Mean = 145.4		**n_{min} = 68.851**

Appendix B

Field Guide to Sensitive Plant Species

Potentially Found on Northeast Church Rock Mine

Sensitive Plant Species Field Guide

A list of rare and sensitive vascular plant species believed to occur within or near Navajo Nation lands was acquired for the determination of potential species that may occur in the vicinity of the Northeast Church Rock Mine (NECR). A total of 63 species were indicated on the list with an additional 9 species added because they had been identified as rare. The list of 63 was reduced to 14 potential species based on incompatibility of habitat requisites with conditions existing in the project area. The additional nine species brings the overall list to 23 possible sensitive plant species that have some potential to be encountered in the vicinity of the NECR project area (see table below). Status Codes are indicated in Appendix C.

Scientific Name	Common Name	Global Status	Federal Status	NM State Status	Navajo Nation Status
Aliciella haydenii	San Juan Gilia	-	-	-	-
Artemisia pygmaea	Pigmy Sagebrush	G4	-	-	S1
Astragalus chuskanus	Chuska Milk-vetch	G3	SoC	SoC	S3
Astragalus cliffordii	Clifford's Milk-vetch	GNR	SoC	SoC	S1
Astragalus heilii	Heil"s Milk-vetch	G1	SoC	SoC	S4
Astragalus micromerius	Chaco Milk-vetch	G2	SoC	SoC	S2
Astragalus missouriens var. accumbens	Zuni Milk-vetch	G3	SoC	SoC	-
Astragalus naturitensis	Naturit Milk-Vetch	G2G3	SoC	SoC	S3
Astragalus oocalycis	Arboles Milk-vetch	G4	SoC	SoC	-
Erigeron acomanus	Acoma fleabane	G1G2	SoC	SoC	S3
Erigeron rhizomatus	Zuni Fleabane	G2	T	E	S2
Erigeron sivinskii	Sivinski's fleabane	G2	SoC	SoC	S4
Eriogonum lachnogynum var. sarahiae	Sarah's wild buckwheat	SNR	SoC	SoC	S4
Fritilaria atropurpurea	Spotted Fritillary	-	-	-	-
Mammillaria wrightii var. wrightii	Wright Fishhook Cactus	-	-	-	-
Muhlenbergia arsenei	Tough Muhly, Navajo Muhly	G5	SoC	SoC	-
Parthenium alpinum var. alpinum	Alpine Fever-few	G3	-	-	SNR
Phacelia splendens	Patch Phacelia	-	-	-	-
Phlox cluteana	Navajo Mountain Phlox	G2	SoC	SoC	-
Physaria navajoensis	Navajo Bladderpod	GNR	SoC	SoC	S3
Psorothamnus scoparius	Broom Pea	-	-	-	-
Puccinellia parishii	Parish's alkali grass	G2	SoC	E	S4
Senecio cliffordii	Clifford's Groundsel	GNR	SoC	SoC	-

All line drawings, photographs, and descriptions were acquired from the New Mexico Rare Plant website (http://nmrareplants.unm.edu/index.html maintained by the New Mexico Rare Plant Technical Council) unless cited otherwise. This guide was designed with the intention of being used in the field to identify potentially sensitive species.

Aliciella haydenii (syn. *Gilia haydenii*) (San Juan Gilia)

Habitat: Dry places, often on clay knolls or on shaley sandstone outcrops, from the sagebrush of saltbush plains up to the oak and ponderosa pine zones, often in the pinyon-juniper community (Cronquist et al, 1984).

Flowering/Fruiting Period: May to July (sometimes as late as Aug) (Cronquist et al, 1984)

Diagnostic Characteristics: Biennial, 1 – 5 dm tall from an often stout taproot, freely branched (sometimes even from the base) when well developed, the stem coarsely but rather sparsely stipulate-glandular throughout, varying to subglabrous; principal leaves forming a compact, persistent rosette at the base, mostly 1.5 – 6 cm long and 0.5 – 1.5 cm wide, coarsely few-toothed to more often pinnately lobed or cleft, with a broad undivided midstrip, crisp-puberulent above (varying to finely glandular), glabrous or nearly so, up to about 3 cm long, or the lower ones transitional to those of the rosette; flowers mostly crowded toward the tips of the branches, some of them virtually sessile, others on pedicels of varying length, up to about 1 cm long; calyx 2.5 – 4.5 mm long, stipitate-glandular, the lobes 1/3 – 1/2 as long as the tube; corolla anthocyanic, rose-purple to pink lavender (or the tube more maroon), but becoming more blue-purple in drying, narrowly funnel-form to salver-form, with spreading lobes, mostly 12-20 mm long overall, the tube and throat collectively 9 – 14 mm long (or smaller in the last-formed flowers); anthers 1 – 1.5 mm long, blue, borne on very short filaments at the sinuses; style elongate, commonly just reaching the orifice of the corolla; capsules 2.5 – 6 mm long; seeds (1) 2 – 4 per locule, 1.5 – 3 mm long, unchanged when wet (Cronquist et al, 1984).

No line drawing available

Artemisia pygmaea (Pigmy Sagebrush)

Habitat: Pigmy sagebrush is found on barren knolls with soil derived from the Evacuation Creek member of the Green River formation. Pygmy sage occupies extremely dry sites, often with black sagebrush (*A. nova*). "It occurs in peculiar edaphic situations on Green River Shale, in clay soils forming the matrix in igneous gravels, on calcareous gravels, and on dolomitic outcrops and gravels, where it is often the dominant species in local areas. It is often a component of communities that support rare plant species." (Welsh et al, 1993).

Flowering/Fruiting Period: Not available

Diagnostic Characteristics: A small, woody sagebrush. Unlike many of the other sagebrushes, which have 3-toothed leaves, pygmy sagebrush has crowded stiff linear leaves that are green and glandular. It has a massive root system, much larger than the above-ground parts. The main branches seldom stand over 5 cm, while the narrow, erect inflorescence rises above them to 20 cm. The smallest of our woody sagebrushes, pygmy sage occupies some of the most harsh, dry sites in the state (Lyon, 2008).

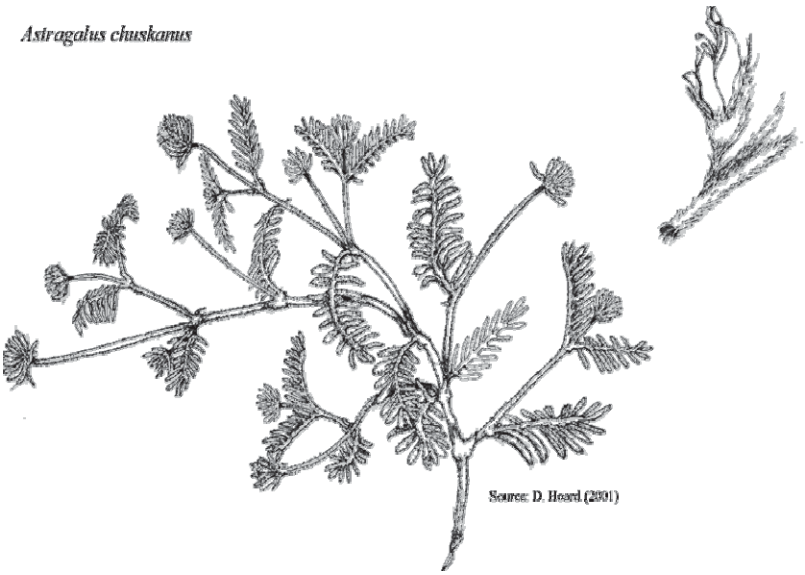
No line drawing available

Astragalus chuskanus (Chuska Milk-vetch)

Habitat: Degraded Chuska sandstone in openings in montane coniferous forest above 5,500 ft.

Flowering/Fruiting Period: Flowers late May through July.

Diagnostic Characteristics: Matted perennial herb; stems spreading on ground (humistrate), freely branching, densely leafy, to 4 dm long; herbage densely hairy with soft, fine, basifixed hairs; stipules connate; leaves silvery-gray, 1.5-4 cm long; leaflets 9-15, obovate or oblong-elliptic, 2.5-9 mm long, 1-3 mm wide; racemes shortly but loosely 4-10 flowered; flowers pea-like; calyx about 5.5 mm long; petals whitish, fading to ochroleucous, often blushed with lilac or dull purple; pods lying on the ground, twisted on the stalk and ascending, sessile, obliquely semi-ovoid, pilosulous, 6 mm long (excluding the persistent style base), 3 mm wide.



Astragalus cliffordii (Clifford's Milk-vetch)

Habitat: Rim rock ledges of the Mesa Verde Group, in sagebrush and pinyon-juniper woodland; 6,800 ft.

Flowering/Fruiting Period: Flowers in June.

Diagnostic Characteristics: Caulescent perennial, 3.5-6.5 dm tall; basifixed pubescent; stems buried for 1-6 cm, erect-ascending, forming diffuse clumps; stipules 1.5-4.5 mm long, some connate-sheathing; leaves 3.5-6.5 cm long; leaflets 5-7 (occasionally 9), linear, acute, strigose, 8-28 mm long, 0.4-1 mm wide; peduncles 1.2-12 cm long, racemes loosely 5-19 flowered, ascending; flowers pea-like; calyx 1.8-3 mm long, the tube 1.2-1.8 mm long; petals pale, faintly suffused with purple, 4.3-6.1 mm long; pods declined, 9-12 mm long, the body elliptic to oblong, straight or slightly curved, sub-inflated, 9-9.8 mm long, 2.5-3 mm wide, compressed, glabrous, unilocular; ovules 4 or 5.

Source: Dorothy Hoard, 2007

Astragalus heilii (Heil's Milk-vetch)

Habitat: Rim rock ledges of the Mesa Verde Group, in pinyon-juniper woodland; 7,200 ft. *Astragalus heilii* is a very narrow endemic known only from the type location on the Navajo Nation near Borrego Pass. Additional field surveys are needed to determine its abundance and distribution.

Flowering/Fruiting Period: Flowers in May.

Diagnostic Characteristics: Low, subcaulescent perennial; basifixed pubescent; stems mostly 2-4 cm long, obscured by stipules and leaf bases; stipules 2-3 mm long, merely amplexicaul or the lowermost connate-sheathing; leaves 1-2.5 cm long; leaflets mostly 7-13, elliptic, obtuse, strigulose on both sides 2-3.5 mm long, 1-1.6 mm wide; peduncles 1-7 cm long, racemes with 2-4 (occasionally only 1) ascending flowers; flowers pea-like; calyx 2.3-3 mm long, the tube 0.9-1.7 mm long; petals whitish or tinged violet; pods spreading or pendulous, the body ellipsoid, sub-inflated, 9-9.8 mm long, 4.5-4.6 mm thick, slightly dorsiventrally compressed, thin-walled, red-mottled, unilocular; ovules 8-10.

Photograph by Steve O'Kane.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=213

Astragalus hallii

Source: Dorothy Hoard, 2007

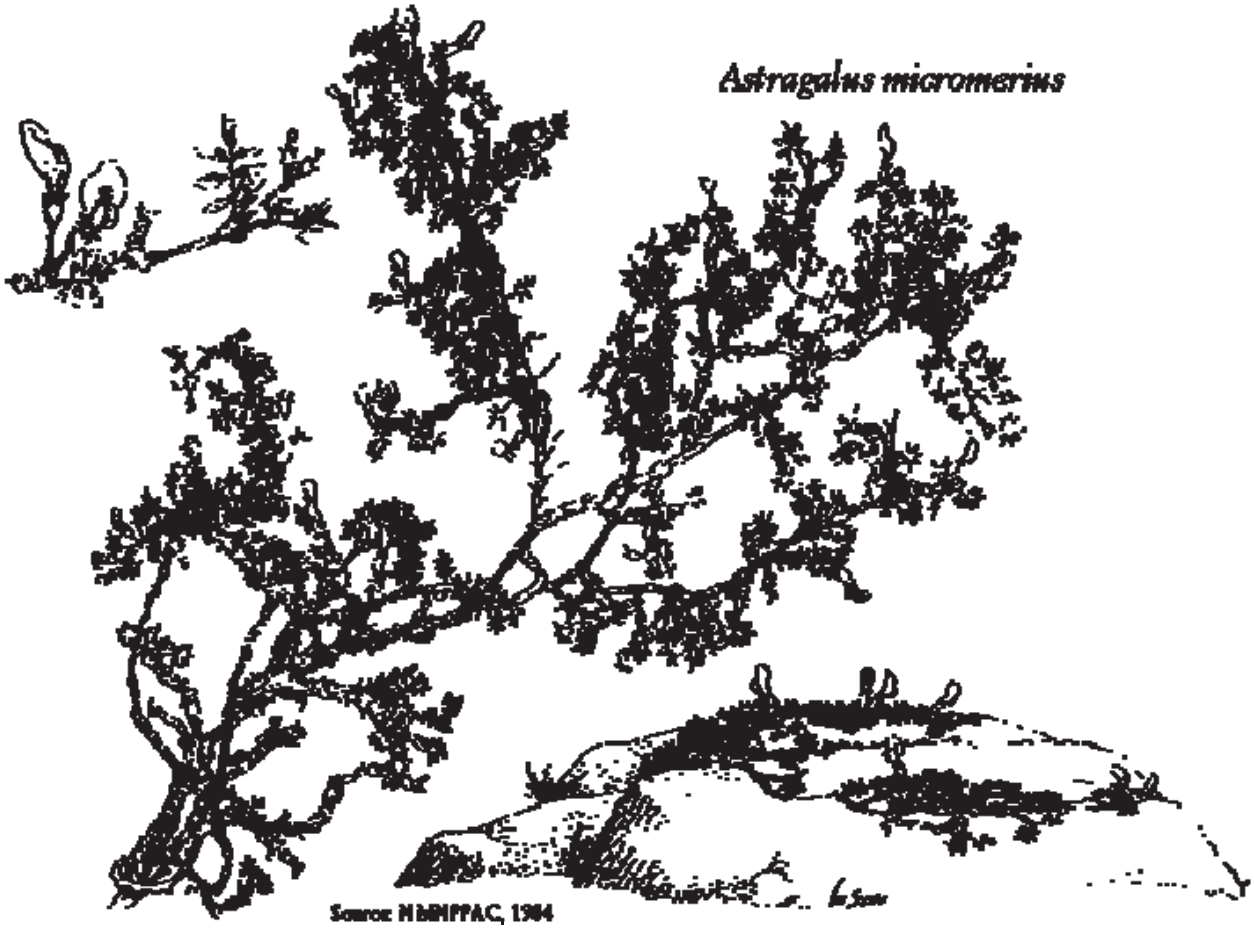
Astragalus micromerius (Chaco Milk-vetch)

Habitat: Gypseous or limy sandstones in pinyon-juniper woodland or Great Basin desert scrub; 6,600-7,300 ft.

Flowering/Fruiting Period: Flowers July and August.

Diagnostic Characteristics: Perennial herb; stems 5-30 cm long, prostrate, silvery-hairy, bearing densely crowded small leaves; leaves 4-20 mm long, pinnately compound with 3-9 leaflets; flowers usually solitary or in pairs, pea-like, about 6 mm long, petals greenish-white with pale purple veins or tips; pods ovoid, 4-5 mm long, slightly longer than broad, unilocular, the tip forming a flattened beak.

Photograph by Ken Heil. http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=28



Source: NRMPPAC, 1984

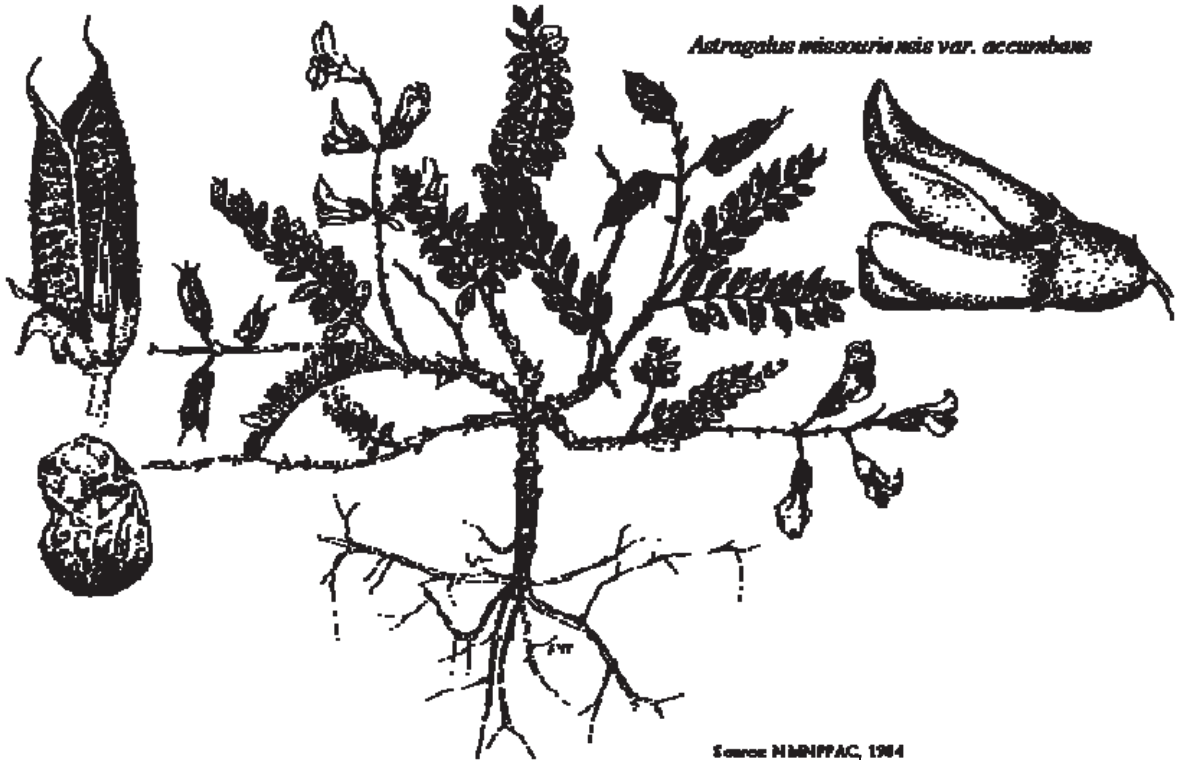
Astragalus missouriensis var. accumbens

(Zuni Milk-vetch)

Habitat: Gravelly clay banks and knolls, in dry, alkaline soils derived from sandstone, in pinyon-juniper woodlands; 6,200-7,900 ft.

Flowering/Fruiting Period: Flowers as early as March, but typically May through June or as late as August.

Diagnostic Characteristics: Perennial; plants low, tufted, stemless or with short stem (0-4 (occasionally 6) cm long), stems prostrate; herbage usually silvery; foliage densely strigose with rather coarse straight and parallel, appressed, dolabriform hairs; stipules not connate; leaves 2-6.5 cm long; leaflets 7-15, obovate to oval, 2-8 (occasionally 11) mm long; flower stalks slender, wiry, often long-persistent, 3-6.5 cm long, prostrate in fruit; inflorescence (can be 3) 5-14-flowered, axis little elongating in fruit; calyx 4.5-5 mm long, with mixed black and white or sometimes all white hairs; flowers pea-like; petals ochroleucous with indistinct lilac veins, or banner and wings distally tinged with dull lilac, longest petals (wings) 7.5-9 mm long; banner abruptly recurved 90-100 degrees, 7-8.3 mm long; pod spreading or ascending, long-persistent, plumply ovoid or oblong-ellipsoid, straight, 9-18 mm long, 4-7(8) mm in diameter, rounded at base, abruptly contracted at tip into a stout cusp, exterior fleshy, green, smooth, strigulose, becoming leathery, brown or black, roughly netlike, either no septum or a rudimentary one up to 1.2 mm wide, dehiscing apically and ultimately through the length of the ventral (adaxial or upper) suture, the tips curling backward and gaping to release the seeds.


Astragalus missouriensis var. accumbens
Source: NRMNPPAC, 1984

Astragalus naturitensis (Naturita Milk-vetch)

Habitat: Sandstone ledges and rimrock along canyons in pinyon-juniper woodland; 5,400-6,200 ft.

Flowering/Fruiting Period: Flowers late April and May.

Diagnostic Characteristics: Low, subacaulescent perennial, about 10 cm tall; stems 2-6 cm long; leaves to 6 cm long; leaflets 9-15 , strigose with straight, overlapping hairs; flowers 1, pea-like, less than 14 mm long; petals bi-colored, banner white with lilac streaks, wings and keel-tips purple; pods leathery, strigose, curved.

Photograph by Daniela Roth.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=30

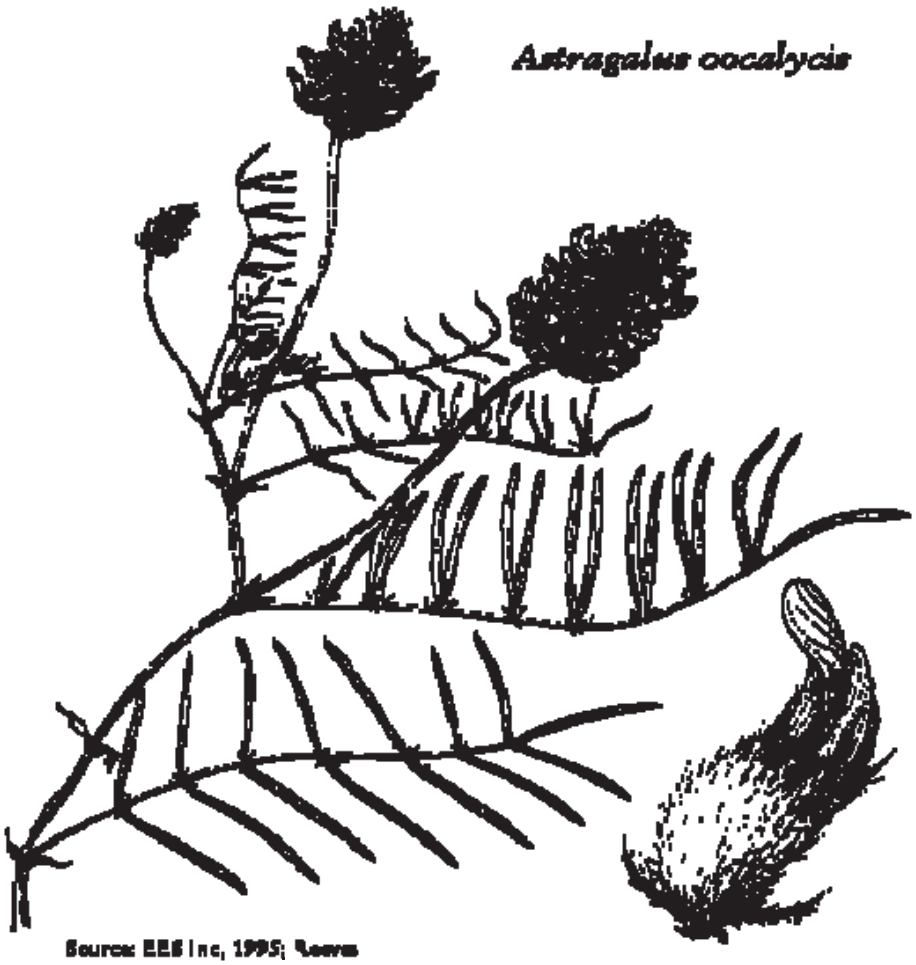
Source: NMNPPAC, 1984

Astragalus oocalycis (Arboles Milk-vetch)

Habitat: Seleniferous clay soils (e.g. Mancos Formation) with sagebrush, pinyon-juniper woodland, and transitional areas between pinyon-juniper woodland and ponderosa pine forest; often on roadsides, road cuts, and in other disturbed areas; 5,600-7,200 ft. This species has a relatively limited distribution of approximately 65 km (40 mi) north/south by 80 km (50 mi) east/west, centered on Navajo Reservoir. Although this species has a restricted area of occurrence, populations may be locally abundant.

Flowering/Fruiting Period: Flowers May to July.

Diagnostic Characteristics: Perennial; stems erect or ascending, 20-40 cm long; herbage green to gray-green; leaves pinnately compound, 5-15 cm long; leaflets 19-27, 2-4 cm long, nearly glabrous above; flowers ochroleucus (yellow-white), in dense 35-60-flowered racemes; calyx densely hirsute with straight or spreading hairs, with age becoming papery and inflated, ovoid or subglobose, up to 14 mm long, 11 mm wide, contracted at the mouth; pods 6-7 mm long, declined, glabrous, grooved on lower side, becoming leathery as they mature.



Source: EEB Inc, 1995; Reeves

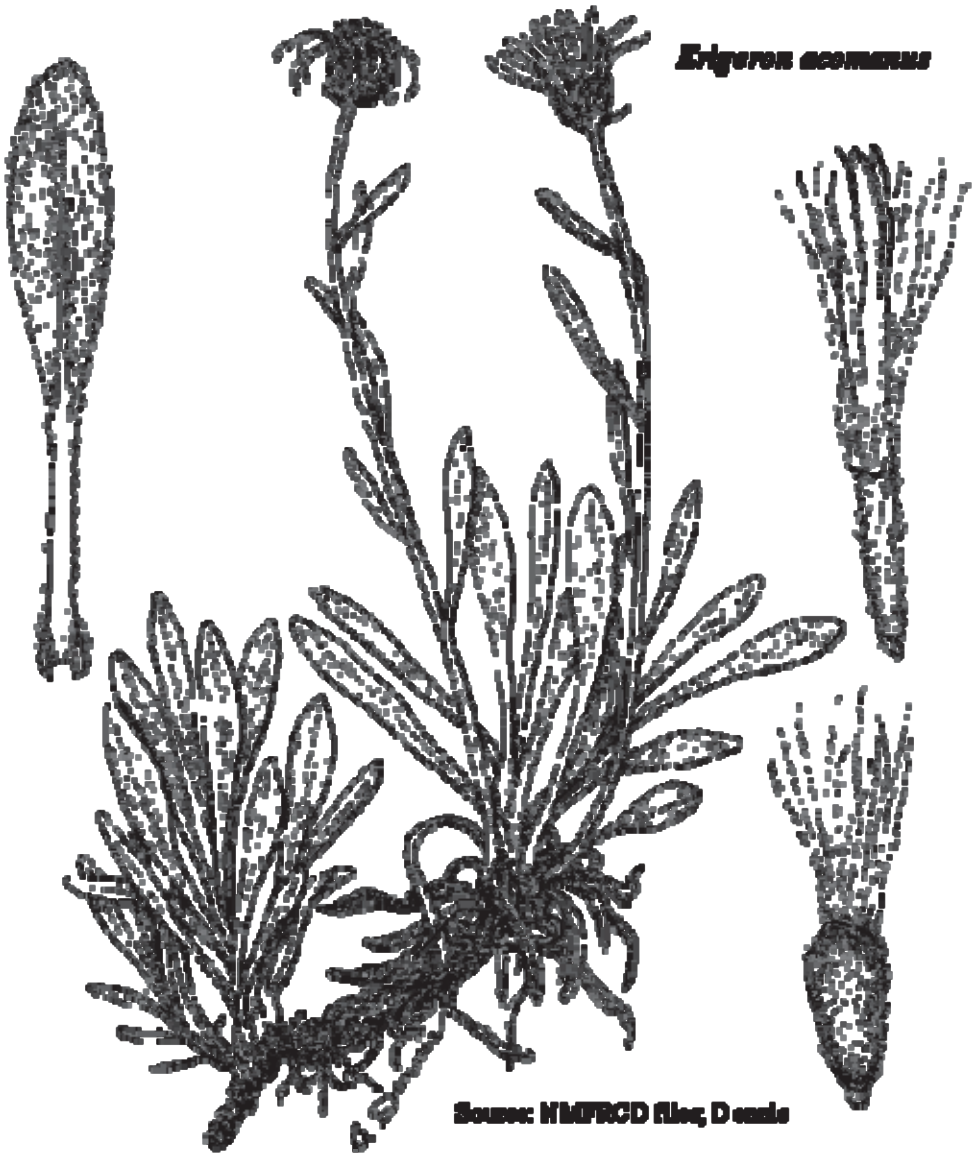
Erigeron acomanus (Acoma fleabane)

Habitat: Sandy slopes and benches beneath sandstone cliffs of the Entrada Sandstone Formation in pinyon-juniper woodland; 6,900-7,100 ft.

Flowering/Fruiting Period: Flowers in July.

Diagnostic Characteristics: Taprooted perennial, mat-forming, 10-70 cm in diameter; leaves mostly basal, spreading or ascending, 8-30 in rosettes at ends of caudex branches, oblanceolate to narrowly obovate or spatulate, 8-23 mm long, 2-7 mm wide, round or obtuse at the tip, moderately puberulent on both surfaces; flowering stems erect, 4.5-15 cm tall, bearing 4-10 reduced leaves; heads solitary, pendulous in bud, erect in flower and fruit; involucre 5 mm high; phyllaries 25-38, lanceolatate, 2.5-4 mm long, purplish on the margins; ray flowers 16-30, white, 4.5-9 mm long; disk corollas 2.5-3 mm long, yellowish; achenes somewhat flattened, lightly hirsute; pappus of fine barbellate bristles.

Photograph by Robert Sivinski.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=73


Erigeron acomanus
Source: NMFRCD files, Dennis

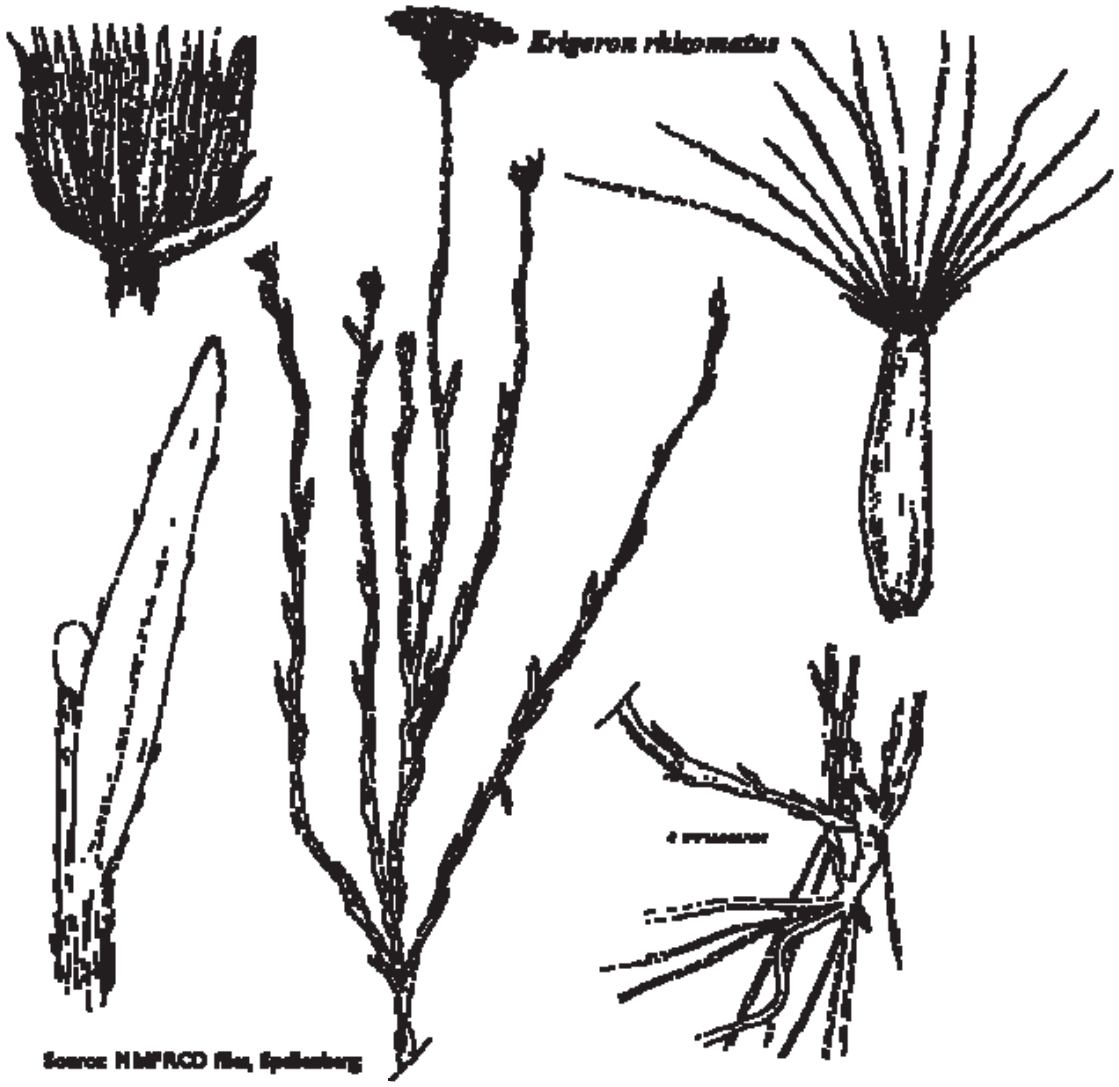
Erigeron rhizomatus (Zuni Fleabane)

Habitat: Nearly barren detrital clay hillsides with soils derived from shales of the Chinle or Baca formations (often seleniferous); most often on north or east-facing slopes in open pinyon-juniper woodlands at 7,300-8,000 ft.

Flowering/Fruiting Period: Flowers May and June.

Diagnostic Characteristics: Herbaceous perennial with creeping rhizomes; stems 2.5-4.5 dm tall, sparsely branching from near the base, growing in clumps to about 3 dm in diameter; leaves alternate, oblong, about 1.0 cm long, glabrous except for occasional ciliate hairs on the margins; flower heads solitary terminating the branches, 13-16 mm wide, involucral bracts in several series; ray flowers 25-45, white or tinged with blue-violet, 6-7 mm long and 1.3-1.5 mm wide; disk flowers yellow; achenes 5-6 nerved, nearly glabrous, pappus 25-35 fragile bristles with a few short outer setae.

Photograph by Robert Sivinski.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=75


Erigeron rhizomatus
Source: NMFRCD files, Spokesburg

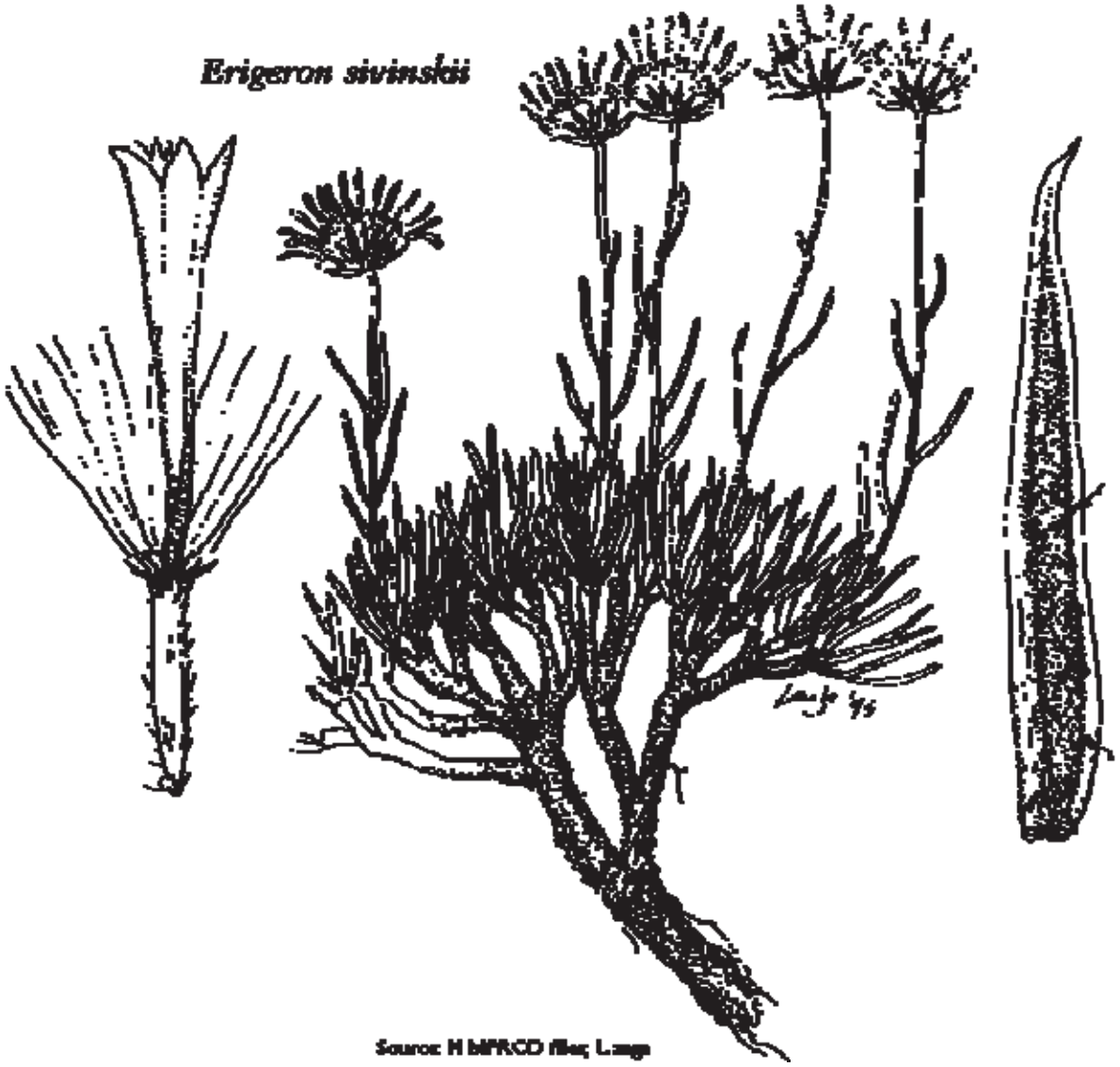
Erigeron sivinskii (Sivinski's Fleabane)

Habitat: Chinle shale in pinyon-juniper woodland and Great Basin desert scrub; 6,100-7,400 ft.

Flowering/Fruiting Period: Flowers primarily in May and June.

Diagnostic Characteristics: Perennial herb arising from a thick taproot with numerous, short (1-3 cm), ascending-erect caudex branches, the upper portion of these with persistent old leaf bases; stems erect, 5-8 cm tall, unbranched, green, sparsely short-strigose with white, stiff, closely appressed trichomes, evenly distributed, even in length, 0.2-0.3 mm long; leaves green, similar in vestiture to the stems, arising in dense basal clusters from the caudex apices, erect to ascending, linear, 9-34 mm long, 0.5-0.8 mm wide, thickened, slightly flaring at the very base; stem leaves strictly ascending and continuing relatively unreduced in size half way to nearly all the way up the stems; heads solitary, terminal, involucre cup-shaped, 10-14 mm wide (pressed); phyllaries in 2-3 subequal series, 5-7 mm long, narrowly lanceolate with attenuate-filiform apices, minutely but prominently granular-glandular, the outer also sparsely pilose with a few crisped-spreading hairs arising centrally; ray florets 21-33, the corollas 7-10 mm long, 1.0-2.4 mm wide, white, drying pinkish, distinctly coiling from the apices with maturity; disk corollas 3.6-4.2 mm long, narrowly funnel-form, glabrate; style branches 0.5-0.6 mm long, the collecting appendages deltate to shallowly triangular, 0.1-0.2 mm long; achenes 2(-3) nerved, narrowly oblong, 2.8-3.1 mm long, the faces glabrous, the margins sparsely ciliate; pappus of 20-27 barbellate bristles.

Photograph by Robert Sivinski.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=78&FileName=eris iv_h.jpg&Phototype=N&Photographer=Robert+Sivinski



Source: HMPRCD files; Lange

Eriogonum lachnogynum var. sarahiae

(Sarah's Wild Buckwheat)

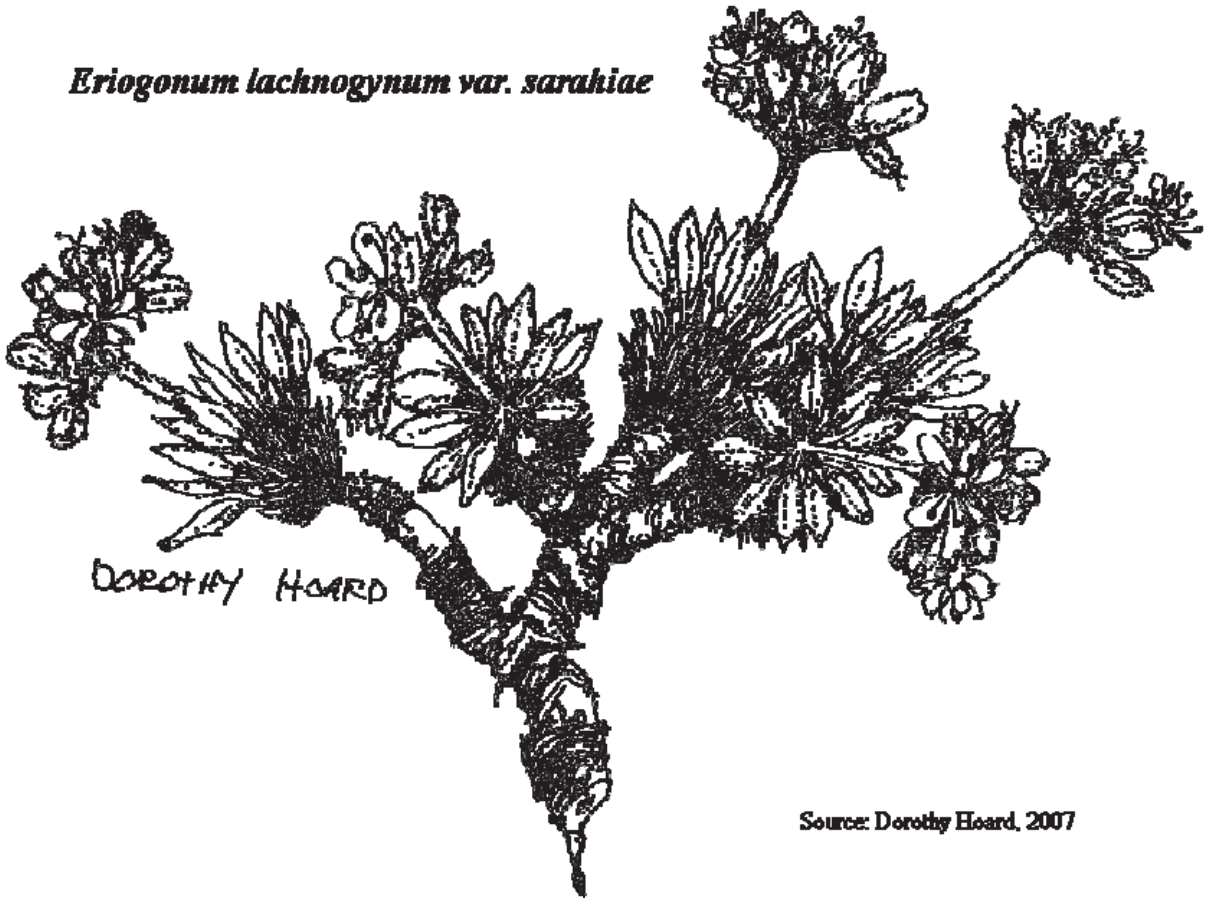
Habitat: Open sandy limestone ridges and edges of mesas in pinyon-juniper woodland; about 5,900-7,540 ft.

Flowering/Fruiting Period: Flowers late May and June.

Diagnostic Characteristics: Perennial herb forming hemispheric mounds up to 3 dm across from an intricately branching caudex; leaves all basal, short-petiolate, the blade narrowly elliptic, 4-12 mm long, 1.5-4 mm wide, silky-tomentose below, green and strigose above, the margins revolute; inflorescence stems up to 40 or more per plant, 1.5-5.5 cm long, silky tomentose; inflorescences capitate; involucres 5-lobed, 3-5 mm high, 5-6.5 mm wide; flowers yellow, 2.5-4.5 mm long, 5-12 per involucre; petals villous pubescent on outer surface; ovaries and seeds villous.

Photograph by Robert Sivinski.
http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=218&FileName=erisar_h.jpg&Phototype=N&Photographer=Robert+Sivinski

Eriogonum lachnogynum var. sarahiae



Source: Dorothy Hoard, 2007

Fritillaria atropurpurea (Spotted Fritillary)

Habitat: Grassy slopes and hills to coniferous montane forests in New Mexico. Open woodlands throughout most of the Intermountain Region, but infrequent and widely scattered (Cronquist et al, 1977).

Flowering/Fruiting Period: Flowers April to July (Cronquist et al, 1977).

Diagnostic Characteristics: Erect, slender perennial herbs 1 – 6 dm tall with leafy stems arising from tannish bulbs 1–1.5 (occasionally 2) cm long with a few, small, thin scales and few (if any) bulblets; leaves several, mostly 7 – 14, linear, (4) 6 – 10 (12) cm long, 2 – 4 (occasionally 7) mm wide, alternate or whorled and scattered on the upper half of the stem; flowers commonly 1 – 4, spreading or nodding, broadly campanulate, greenish-brown to chocolate brown with white or yellow spots or mottling, the tepals oblong to rhombic and tapering abruptly at the base, 10 – 20 mm long, 3 – 8 mm wide, the gland an indistinct brownish-yellow spot at the base; stamens 6 – 15 mm long, the filament slender, the anther 3 -4 mm long; styles connate only 1 – 2 mm, the branches 6 – 9 mm long, acutely angled (Cronquist et al, 1977).

Mammillaria wrightii var. wrightii

(Wright Fishhook Cactus)

Habitat: Gravelly hills or sandy hills or plains, desert grassland to pinyon-juniper 3,000-7,000 ft (NMNPPAC, 1984).

Flowering/Fruiting Period: Flowers from May through August (NMNPPAC, 1984).

Diagnostic Characteristics: Stems solitary, to about 10 cm tall and 5 cm wide; spines 10-15 per cluster, the outer spines tan or gray, the central ones reddish brown and hooked, 10-13 mm long; flowers pink to purple or tinged with white or yellow, mostly 2.5–5 cm long and somewhat wider than long; fruit rounded to ovoid, rust red color (NMNPPAC, 1984).

No line drawing available

Muhlenbergia arsenei (Tough Muhli, Navajo Muhli)

Habitat: On limestone rock outcrops in pinyon-juniper woodland; 4,600-6,500 ft.

Flowering/Fruiting Period: Flowers August to September.

Diagnostic Characteristics: Loosely tufted perennial, the spreading base sometimes appearing rhizomatous; stems wiry, 1.0-4.5 dm tall, decumbent at base; leaf blade 1-5 cm long, less than 2 cm wide, inrolled; ligule 1-2 mm long; inflorescence 4-12 cm long, less than 3 cm wide, branches ascending to appressed; spikelets 3.5-5.0 mm long excluding the awn; glumes 2-3 mm long, tips acute to very short-awned; lemma short-soft hairy on the lower half, awn flexuous, 4-12 mm long.

Photograph by Kelly Allred. http://nmrareplants.unm.edu/rarelist_single_photo.php?SpeciesID=210