Vegetation & Wildlife Evaluations / Revegetation Recommendations

ST. ANTHONY MINE

Prepared for:

United Nuclear Corporation

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1.0 INTRODUCTION

1.1 General

Cedar Creek Associates, Inc. (Cedar Creek) was contracted in 2005 to implement a work plan specific to vegetation, revegetation, and wildlife considerations in support of the "Closeout Plan" for United Nuclear Corporation's (UNC) St. Anthony Mine. This work plan identifies and defines methods and protocols utilized for vegetation and wildlife evaluations required for the Closeout Plan pursuant to mandates of Title 19, Chapter 10, Part 5 of the New Mexico Administrative Code (NMAC) and the Mining Act Reclamation Program (MARP). 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 revegetation plan documents site-specific protocols for monitoring and eventual success evaluation to be used at the mine.

The St. Anthony Mine is located approximately 40 miles West of Albuquerque, New Mexico and exhibits a disturbance area of about 430 acres. Based on preliminary review of black and white satellite imagery, it appeared that mine development occurred within three distinct vegetation communities: 1) grassland, 2) juniper scrub, and 3) bottomland. Following site-specific evaluations in September 2005, it was determined that disturbance to the pre-mining grassland community likely did not occur given its

typical physiographic location. It was also determined that the majority of disturbance involved the bottomland vegetation community (see Map 1).

A fourth type, riparian drainage bottom, was noted to exist in the area (bisecting the disturbance area), but did not appear to have been disturbed by mine facilities. Following site-specific evaluations, it was confirmed that this "riparian" community had largely been avoided by past mining activity (excepting an occasional road crossing) and that this community was both severely disclimatic and subject to frequent and severe natural disturbance (flooding). The disclimatic nature was strongly evident given the nearly ubiquitous dominance by Tamarisk (*Tamarix chinensis*) and similar "weedy" early seral invaders scattered along the entire length of this drainage through the project area. Frequent and severe flooding was evidenced by the omnipresent down-cut, steep-walled water-courses, and heavy sediment depositional pockets.

1.2 Site Description

The general project area exhibits rock outcrop defined mesas dominated by a grassland ecotype on high benches in areas of deeper, finer, and better-drained soil development. On occasion, pockets of the juniper scrub ecotype occur within these areas of grassland (where the soils exhibit elevated coarse fragment content), but more often the juniper scrub community occurs along the grassland margins where the type encounters the steep rocky escarpments and similar areas of rock outcrop. In these rockier areas, soils become more "skeletal" and very well drained which then encourages woody species (junipers and shrubs) over grasses. Because the soil transition is rather abrupt, the ecotone between the grassland and juniper scrub types is quite narrow. The escarpments in the project area are very rocky and steep (occasionally forming 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 juniper scrub type is the bottomland vegetation community. Soils in this area are characterized by deep, finer textured materials that are moderately well-drained sandy loams near the sandstone based juniper scrub type, and poorly drained silty clay loams at lower topographic positions. The ecotone between juniper scrub and the bottomland ecotype is more broadly defined, occurring as a belt of between 5 and 50 feet in width. The bottomland is derived from degraded sandstone and occasional siltstones and shale. Furthermore, the bottomland ecotype usually contains a highly eroded, deeply incised drainage cut by an intermittent or ephemeral stream. This last feature contains the fourth area community, riparian drainage bottom that is dominated by tamarisk and other weedy taxa.

Grasslands are herbaceous communities dominated by 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 of local sites. Grasslands in this part of New Mexico may be dominated by annual

grasses, perennial bunchgrasses, or perennial sod-forming grasses and typically of the warm-season group. In the project area the grasslands are of this latter warm-season perennial sod-forming group.

In contrast to the grasslands, the Juniper scrub ranges between a "savanna" of scattered trees within the high plains grassland to dense woody dominated areas with very poor herbaceous understories. The juniper scrub ecotype is usually associated with rocky more skeletal soils. In the vicinity of disturbances at the project area, the vegetative cover of grasses and forbs is at lower levels due to the well-drained nature of underlying skeletal soils, and that deeper more loamy soils have long since eroded away. Scattered juniper, with an occasional piñon, are found throughout the ecotype.

The Bottomland ecotype 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 valley 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. On occasion, the bottomland community can exhibit areas of shrub domination by four-wing saltbush in areas exhibiting moderately elevated salt accumulations, but can also exhibit areas of dominance by winterfat or Bigelow's sagebrush. Other areas may be nearly absent of shrubs whereby grasses (and rarely forbs) are dominant.

1.3 Soils

As indicated above, the underlying soils heavily influence the nature and dominance of floral assemblages. Because of this importance to reclamation, NRCS soil survey information for the project area (Parham 1993) has been compiled and presented below to provide additional background data on disturbed area soils and surrounding lands (total of six units). In this regard, these six project vicinity soils are indicated on Exhibit 1, along with the following descriptions of each.

Unit 257 - Sparank-San Mateo complex (0-5% Slopes). This unit is contained within floodplains and alluvial fans and largely corresponds to the Bottomland vegetation community type. It also corresponds to the primary soil unit disturbed by the mining operation. Areas of this soil unit are elongated and usually between 100 and 1500 acres in size. The unit contains 50 percent Sparank clay loam (0-3% slopes) and 40 percent San Mateo loam (1-5% slopes). The Sparank and San Mateo soils are deep and well-drained. The Sparank soil has slow permeability, whereas the San Mateo soil has moderate permeability. Both soils have high available water capacity. The potential native plant community is primarily western wheatgrass, alkali sacaton, and four-wing saltbush. According to the NRCS, the average annual air-dry potential production ranges from 3200 pounds per acre in favorable years to 1250 pounds in unfavorable years. However, given professional judgment and site-specific data / observation by Cedar Creek ecologists these values should be reduced by a factor of 4 (800 pounds in favorable years

and 310 pounds in unfavorable years). The soil in a deteriorated condition would exhibit elevated levels of blue grama, galleta, broom snakeweed and rabbitbrush. This soil unit is typically used for livestock grazing and wildlife habitat.

Unit 251 – Skyvillage - Rock outcrop - Bond complex (3-40% slopes). This unit occurs on benches, escarpments, and mesas and most typically corresponds to the Juniper Scrub type in the vicinity of the project. Areas are irregular in shape and between 100 and 600 acres in size. The unit has 40 percent Skyvillage sandy loam (3-40% slopes), 30 percent Rock outcrop, and 20 percent Bond sandy loam (3-8% slopes). The Skyvillage soil occurs mainly on benches, the lee side of mesas, and the edges of mesa tops; the Rock outcrop is manifested as escarpments; and the Bond soil is on benches and the edges of mesas. The Skyvillage soil is shallow and well drained. It has moderate permeability and low available water capacity. The Rock outcrop consists of barren or nearly barren areas of exposed sandstone on benches and escarpments. The Bond soil is shallow and well drained. It has moderate permeability and low available water capacity. The potential native plant community is Indian rice-grass, New Mexico feather-grass, Mormon tea, scattered piñon and one-seed juniper. The average annual air-dry potential production ranges from 700 pounds per acre in favorable years to 250 pounds per acre in unfavorable years. The soil in a deteriorated condition would exhibit blue grama, threeawn, sandhill muhly, and increased densities of shrubs and trees. This unit is used for livestock grazing and wildlife habitat.

Unit 200 – Penistaja fine sandy loam (2-10% slopes). This unit is found on the dip slopes of cuestas and on fan terraces and valley sides. Areas are irregular in shape and are 60 - 1200 acres in size. The soil is deep and well drained and typically corresponds to the Grassland community in the vicinity of the project. It has moderate permeability and high available water capacity. The potential native plant community is blue grama, western wheatgrass, with occasional scattered four-wing saltbush and winterfat. The average annual air-dry potential production ranges from 950 pounds per acre in favorable years to 375 pounds per acre in unfavorable years. The range in a deteriorated state would exhibit elevated amounts of blue grama, ring muhly, and broom snakeweed. Pinyon and one-seed juniper may invade as range condition declines.

Unit 230 – Dumps - Pits Complex (5-90% slopes). Dumps occur as areas of waste rock, mine spoil, and other refuse. Pits consist of open excavations where soil material and some rocks have been removed. The unit is essentially barren of natural vegetation and more typically exhibits patches of ruderal vegetation. This unit essentially defines the existing extent of disturbance to be addressed by this document.

Unit 625 – Hagarman - Bond association (1-10% slopes). This unit is on mesa tops, cuestas, hills, and ridges. Areas are irregular in shape and are 50 to 1500 acres in size. The unit has 55 percent Hagarman fine sandy loam (1-5% slopes), and 30 percent Bond sandy loam (2-10% slopes). The

Hagarman soil is moderately deep and well drained. It has moderate permeability and low available water capacity. The Bond soil is shallow and well drained. It has moderate permeability and low available water capacity. The potential native plant community is blue grama, western wheatgrass, sideoats grama, and four-wing saltbush. The average annual air-dry potential production ranges from 950 pounds per acre in favorable years to 375 pounds per acre in unfavorable years. The soil in a deteriorated condition would exhibit western wheatgrass, elevated levels of sideoats grama, New Mexico feather-grass, blue grama, ring muhly, galleta, and broom snakeweed. This soil unit is typically used for livestock grazing.

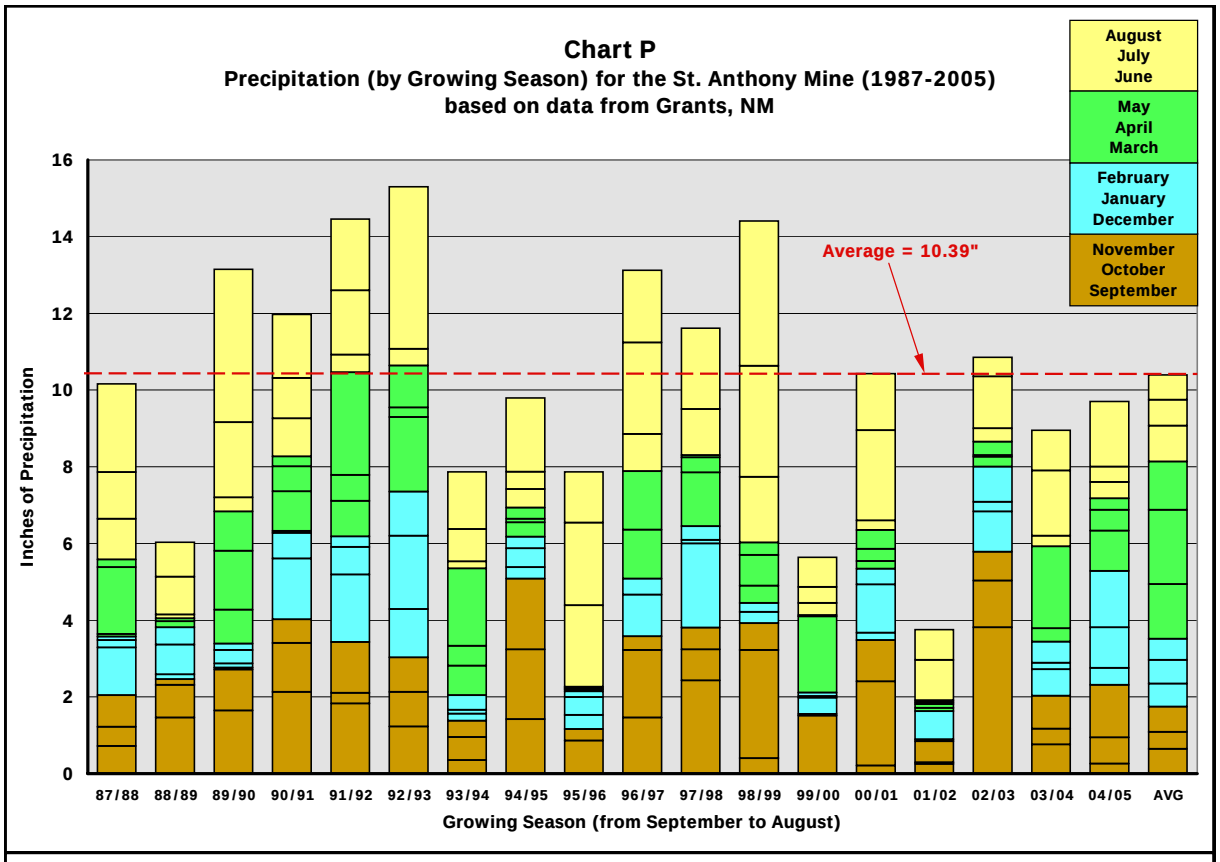
Unit 485 – Rock outcrop – Mion complex (15-65% slopes). This unit is on hills, escarpments, and benches. Areas are irregular in shape and are 75 to 2000 acres in size. The unit has 60 percent Rock outcrop and 35 percent Mion stony loam (15-65% slopes). The Rock outcrop consists of barren or nearly barren areas of exposed sandstone, basalt, limestone, or gypsum as steep escarpments or exposed benches. The Mion soil is shallow and well drained. It has very slow permeability and very low available water capacity. The potential native plant community is blue grama, sideoats grama, New Mexico feathergrass, black grama, sacahuista, and one-seed juniper. The average annual air-dry potential production ranges from 750 pounds per acre in favorable years to 375 pounds per acre in unfavorable years. The soil in a deteriorated condition would exhibit elevated levels of blue grama and threeawn. This unit is used for livestock grazing.

1.4 Precipitation

Based on Western Regional Climate Center precipitation data from Grants, New Mexico the average annual precipitation for the project area over a period of 50 years was determined to be 10.53 inches and over the last 19 years has averaged 10.39 inches. The monthly precipitation from October 2004 to September 2005 (at which time the project area was sampled) was slightly below average at 9.7 inches. In this regard, it can reasonably be assumed that the area was sampled during an average year and resulting values should reflect normal conditions. These circumstances are readily evident on the following Table (P) and Chart (P).

Table P Annual Precipitation for the St. Anthony Mine (by Month) 1987 - 2005 (based on data from Grants, NM)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TOTAL
1987	1.60	1.24	0.54	0.28	0.89	0.26	2.61	3.05	0.72	0.50	0.82	1.25	**10.71**
1988	0.19	0.09	0.07	1.74	0.20	1.06	1.22	2.30	1.46	0.85	0.15	0.13	**9.46**
1989	0.77	0.45	0.16	-	0.08	0.10	0.98	0.90	1.64	1.07	0.05	0.11	**6.31**
1990	0.35	0.17	0.88	1.54	1.02	0.37	1.96	3.99	2.13	1.27	0.62	1.59	**15.89**
1991	0.66	0.05	1.04	0.65	0.26	0.99	1.05	1.66	1.83	0.27	1.33	1.76	**11.55**
1992	0.72	0.27	0.93	0.67	2.68	0.46	1.68	1.86	1.23	0.90	0.90	1.26	**13.56**
1993	1.91	1.15	1.94	0.25	1.10	-	0.43	4.23	0.35	0.60	0.43	0.18	**12.57**
1994	0.10	0.38	0.77	0.52	2.02	0.18	0.84	1.50	1.42	1.82	1.84	0.30	**11.69**
1995	0.49	0.30	0.38	0.09	0.29	0.49	0.45	1.92	0.86	-	0.30	0.37	**5.94**
1996	0.46	0.15	0.05	0.04	0.03	2.13	2.15	1.33	1.46	1.76	0.36	-	**9.92**
1997	1.08	0.42	-	1.28	1.52	0.97	2.39	1.88	2.43	0.81	0.56	2.20	**15.54**
1998	0.09	0.36	1.40	0.39	0.06	-	1.20	2.11	0.40	2.82	0.70	0.29	**9.82**
1999	0.24	-	0.45	0.80	0.32	1.71	2.90	3.78	1.51	0.04	-	0.43	**12.18**
2000	0.04	0.09	1.99	-	0.03	0.32	0.41	0.78	0.21	2.19	1.08	0.19	**7.33**
2001	1.26	0.41	0.20	0.32	0.49	0.25	2.35	1.48	0.25	0.04	0.55	0.05	**7.65**
2002	0.74	-	0.08	0.10	0.05	0.05	1.05	0.79	3.81	1.22	0.75	1.05	**9.69**
2003	0.25	0.92	0.26	0.04	0.35	0.35	1.35	0.50	0.76	0.41	0.86	0.69	**6.74**
2004	0.17	0.55	0.35	2.13	-	0.28	1.70	1.05	0.26	0.68	1.37	0.44	**8.98**
2005	1.06	1.47	1.05	0.54	0.30	0.43	0.40	1.70	1.22	0.55	0.12	0.02	**8.86**
Average	**0.64**	**0.45**	**0.66**	**0.60**	**0.62**	**0.55**	**1.43**	**1.94**	**1.26**	**0.94**	**0.67**	**0.65**	**10.39**



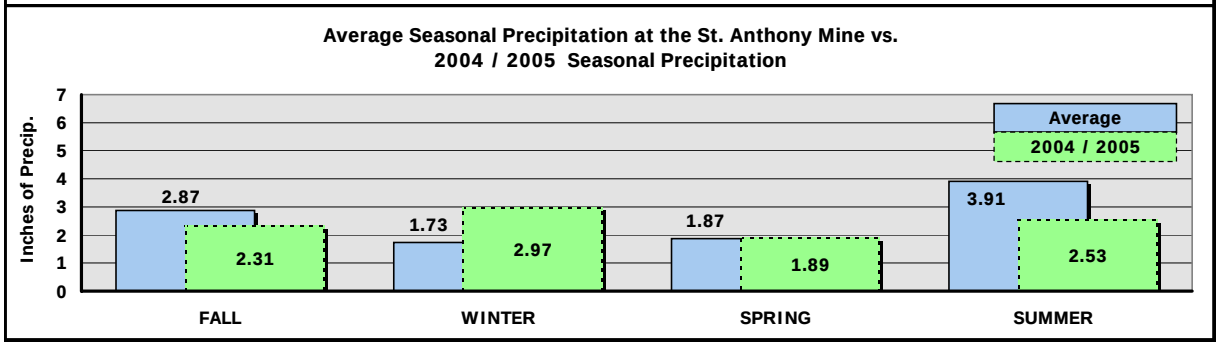
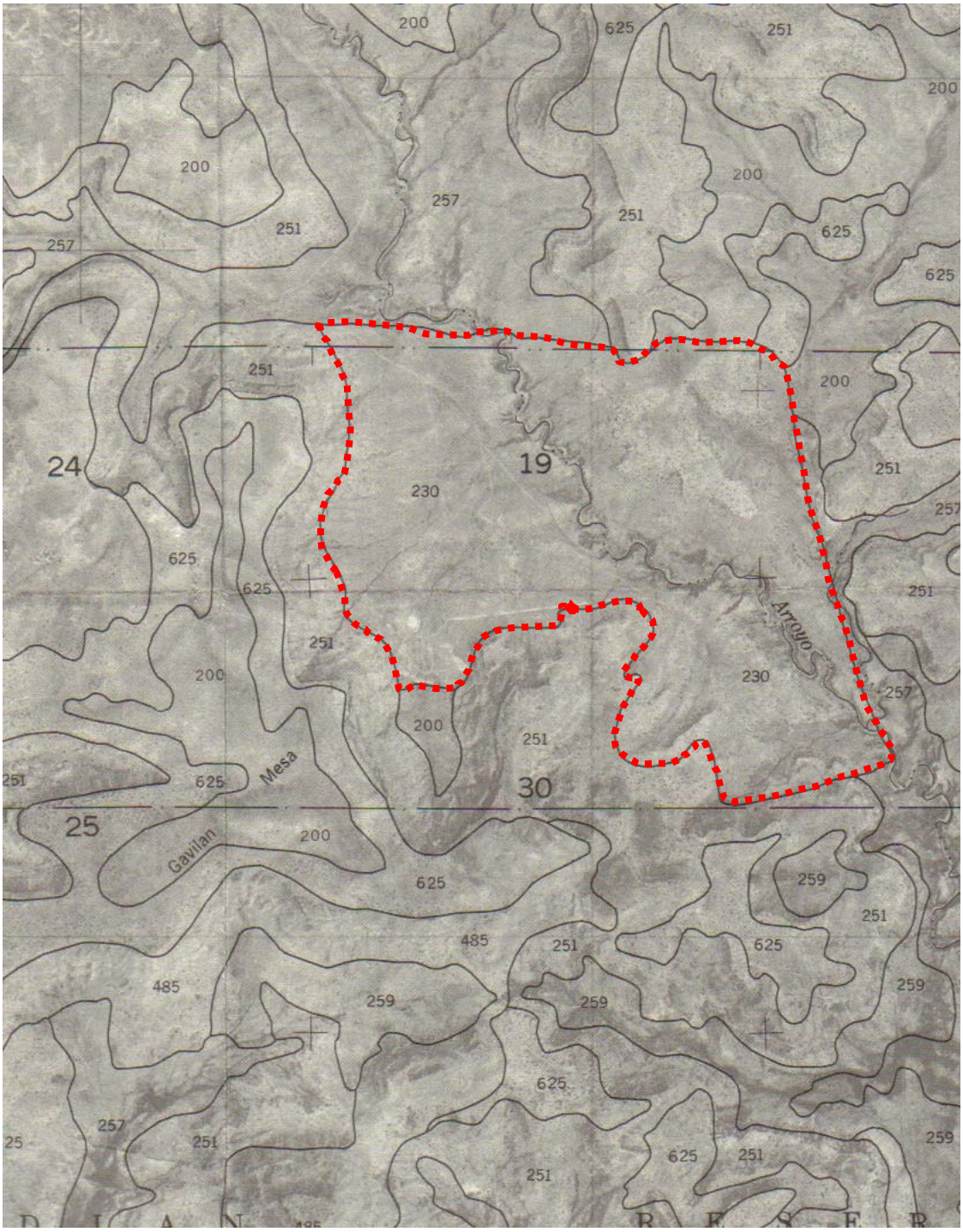


Exhibit 1

Soil Survey of St. Anthony Mine Site NRCS (1993)

Approximate Boundary of Disturbed Area



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 as indicated in Appendix A. 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, New Mexico Mining and Minerals Division (MMD) 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 rectangular quadrats. Since sampling adequacy is not required (nor recommended) for woody plant density or vegetative production samples (as indicated in the work plan), one density belt and one production quadrat were co-located with each ground cover transect evaluated. Resulting data can then be considered reasonable for the evaluation purposes intended.

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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.

2.1 Vegetation Mapping

Vegetation associations observed on and about the project area and adjacent areas (Map 1) were delineated directly on computer-generated high altitude / high resolution aerial imagery files (approximate 2-foot pixel resolution) using ARC GIS 9.1 as a base program. Delineations were based on professional judgment of photographic diagnostic information (unique community signatures) as indicated on the aerial imagery, and as corrected by site-specific field verification points of known types / areas. Approximately 100 pre-verified points of known boundary interface / ground interpretation were located on field maps during field activities which were then utilized to facilitate determinations or corrections of community boundaries and / or wildlife habitats (e.g., rock outcrop).

Within the disturbance footprint of the project, an exact pre-disturbance delineation of expressed vegetation community boundaries was made possible by historic aerial imagery utilized by the NRCS for base mapping (see Exhibit 1). This historic imagery / delineation was scanned as a computer file, translated into an ARC GIS layer, photo-rectified, scaled, and then utilized for interpretation of pre-disturbance community boundaries. Based on this technology, the photographed study area (Map 1) was determined to be approximately 2038 acres (Table A below). Within this area the pre-disturbance Bottomland community occupies 929 acres or 45.6% of the study area. The Juniper Scrub type occupies another 918 acres or 45.0% of the study area. The third type, Grassland, occupies 113 acres or about 5.5% of the area. The last 79 acres (3.9%) is comprised of the undisturbed Riparian Drainage Bottom. Certain wildlife habitat features such as escarpments or seasonal water bodies are included within the community designations as indicated below.

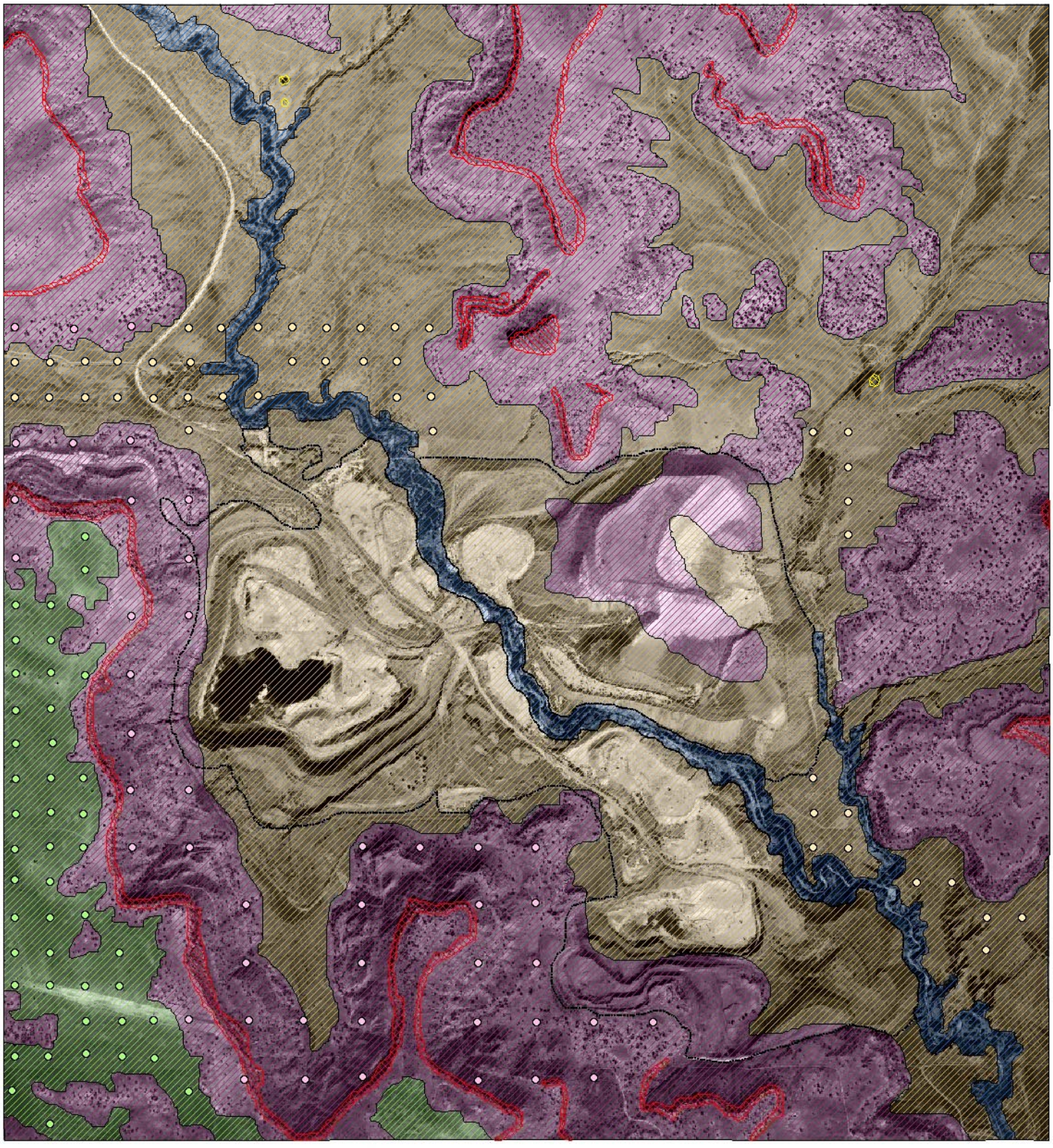
Table A

UNC - St. Anthony Mine - Acreage Estimates

Study Area Boundary	**Acres**	**Percent of Area**
Bottomland Community	929.0	45.6%
Juniper Scrub Community	917.9	45.0%
Grassland Community	112.9	5.5%
Riparian Drainage (Tamarisk)	78.8	3.9%
Total	2038.5	100.0%

Wildlife Habitat Features	**Acres**
Rim Rock & Cliff Faces (Subset of Juniper Scrub Type)	48.9
Seasonal Water Sources (Subset of Bottomland Type)	0.3
Total	49.2

Disturbance Boundary	**Acres**	**Percent**
Bottomland Community	360.2	82.2%
Juniper Scrub Community	78.0	17.8%
Total	438.2	100.0%



Map 1

UNC - St. Anthony Mine

Vegetation Communities &
Extended Reference Area
Sample Point Locations - 2005

Community Types

- Juniper Scrub
- Bottomland
- Grassland
- Riparian Drainage (Tamarisk)

Wildlife Habitat Features

- Cliff Face (Rim Rock)
- Seasonal Water Sources

Boundaries

- Disturbance Boundary

Sample Points

- Juniper Scrub (500' x 500' Grid)
- Bottomland (300' x 300' Grid)
- Grassland (300' x 300' Grid)

1 inch equals 600 feet

0 200 400 800 1,200 1,600 Feet

Within the disturbance footprint of approximately 438 acres, the bottomland historically comprised the majority of the project area prior to mining (360 acres or 82.2%). The remainder was comprised of the Juniper Scrub community (78 acres or 17.8% of the area).

2.2 Sample Site Selection / Location

The original vegetation work plan called for sampling of undisturbed portions of each vegetation community (Bottomland, Juniper Scrub, and Grassland) and the establishment of a reference area for each community (total of 135 samples). However, once in the field, Cedar Creek biologists determined that insufficient undisturbed ground existed in proximity to the St. Anthony mine to facilitate both the sampling of each community as well as establishment of segregate reference areas (due largely to land ownership / trespass considerations). Furthermore, it was observed that much, if not all, of the remaining undisturbed ground within the permit area may be needed for growth media borrow thereby precluding such areas from consideration for establishment of small reference areas. (If an area were needed for borrow, it's utility as a reference area would be compromised.) The logical solution to this difficulty was to take an alternate approach to the collection of baseline data and establishment of a reference area for eventual bond release testing. This alternate approach (which is occasionally utilized in the heavily regulated coal mining industry) was to sample the three vegetation communities on all available land proximal to the disturbed area as a larger "extended reference area" which would then provide some insurance against total loss due to need for growth media borrow. In this manner, the same number of samples (45 within each community type) would be collected so there would be no loss of precision, and data collection would be from a much larger area. This alternate approach was fully discussed with MMD personnel in the field (on or about September 26, 2005) and all parties agreed that it was an acceptable solution to the problem.

Given this change of approach (use of an extended reference area), the three communities believed to have existed prior to disturbance were roughly delineated on field maps. At this point it was noted that the majority of disturbance had occurred to the Bottomland community, with most (if not all) of the remaining disturbances apparently restricted to the Juniper Scrub type. The Grassland community, did not appear to have been disturbed by mine facilities, however, definitive evidence in support of this hypothesis was not available at the time of field sampling. Similarly, it was reasonably verified that the Riparian Drainage Bottom (Tamarisk) community had not been disturbed by mine facilities (except for the occasional road crossing). As indicated on Map 1, the delineations of the three extended reference areas are of sufficient size to offer an appropriate and representative target for future reclaimed communities. The reclamation of the mining disturbance is likely to result in some additional disturbance to these extended reference areas (due to borrow sources) but complete loss should be precluded.

As indicated on Map 1, a systematic procedure initiated in an unbiased manner was then developed for each unique extended reference area for identification of sampling locations. In this manner, "representation" from the entire unit is "forced" rather than risking the chance that significant pockets are entirely missed, or over-emphasized, as may occur in strictly random sampling. This systematic procedure also provides proportionate representation from across the unit for such characteristics as aspect and slope. An example of this procedure is indicated on Figure 1 with the actual results indicated on Map 1.

The systematic procedure for sample location occurred in the following stepwise manner. First, a fixed point of reference was selected for each area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions (e.g., 300' X 300') was selected by Cedar Creek to provide a minimum number (45 for each of the three areas) of coordinate intersections 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). Fourth, unbiased placement of this grid was controlled by selection of two random numbers between 0 and 300 (used as coordinates). Fifth, utilizing a handheld compass and pacing techniques all 45 of the initial sample points for each area 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 45 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 and replaced with another of the systematic points that was entirely within undisturbed vegetation.

2.3 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 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

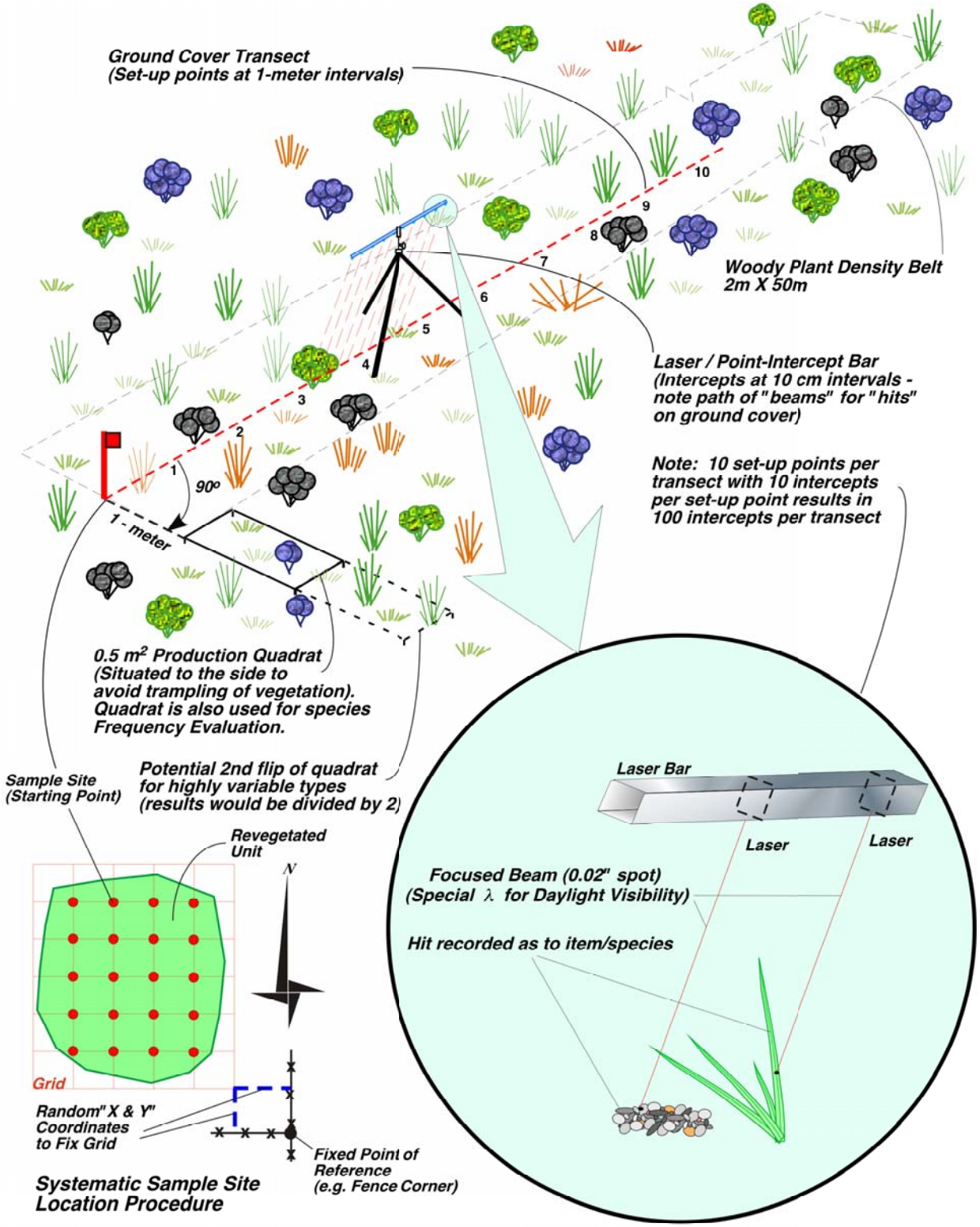


Figure - 1

Sampling Procedure at a Systematic Sample Site Location

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, especially the mining industry, as the protocol of choice for vegetation monitoring and bond release determination.

2.4 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, sub-shrubs, cacti and trees rooted within the boundaries of these belts were counted and classified according to species. Entire plants rather than stems were counted to provide a more accurate representation of actual woody plant density.

2.5 Determination of Vegetative Production

At each production sample site, current annual herbaceous production was collected from a $^1/_2$ m^2 quadrat frame placed one meter and 90º to the right (clockwise) of the ground cover transect to facilitate avoidance of vegetation trampled by investigators during sample site location (see Figure 1). From within each quadrat, all above ground current annual vegetation, with the exception of woody species, within the vertical boundaries of the frame were clipped and bagged separately by life form as follows:

Perennial Grass
Introduced Perennial Grass
Annual Grass
Sub-Shrub
Native Perennial Forbs
Annual Forb
Introduced Forb
Noxious Weeds

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.

2.6 Sample Adequacy Determination

Ground cover sampling within the three extended reference area locations was conducted to a minimum of 45 initial ground cover transects. 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 = 45)

t = the value from the two-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 45 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 extended reference areas of Bottomland, Juniper Scrub and Grassland, was 17.9, 16.6, and, 9.8 respectively, no additional ground cover sampling was deemed necessary.

2.7 Threatened, Endangered, and Rare Species

A list of nine rare and endangered plant species that are known to occur within Cibola County, which contains the study area, was developed from the New Mexico Rare Plants website (http://nmrareplants.unm.edu/). Information regarding habitat requirements and level of state and federal protection was also acquired for each species from standard information databases or published sources.

Based on a review of the known distributions, previous studies in the area, and required habitat requisites for the nine target flora, it was determined that only six had any remote potential for occurrence within the study area.

Prior to implementation of field work, taxonomic descriptions and botanical drawings of these six 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 field work involved search patterns in all portions of appropriate habitat within those portions of the study area exhibiting potential borrow areas. Search procedures involved slow implementation of qualitative pedestrian transects and careful visual scanning of the ground surface for any of the target species. Although all plant species observed within the vegetation study area were identified (with one exception), special attention was given to looking for target sensitive species within appropriate habitats. The one exception was a taxon that did not resemble any of the target sensitive species. It was not identified to species because sufficient flowering or fruiting bodies were not present during the time of field studies.

2.8 Wildlife Evaluations

The approved scope-of-work indicated that the most prudent techniques for site-specific wildlife evaluations would be qualitative in nature and include: 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, two categories of evaluation were implemented, 1) wildlife specific transects, and 2) incidental observations during other biological investigations. This second category of evaluations was 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.

As indicated above, in addition to site-specific "incidental" observations during vegetation evaluations, several pedestrian observation transects were extended radially from the central disturbance area 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 (Total of 6) were only implemented during the early morning hours (Sunrise – 9:30 am) 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 previously, four plant communities and two wildlife habitat features were identified from the St. Anthony study area (see Map 1 and Table A). Of these the Bottomland Community was determined to be the most extensive (45.6% of the study area) and occupied the vast majority of the area disturbed by mine facilities (360.2 of 438.2 acres or 82.2%). This community also contains the 0.3 acres of seasonal water sources (stock tanks) that serve as a wildlife habitat requisite. The Bottomland type is largely underlain by Soils Unit 257. The second most extensive community was determined to be the Juniper Scrub type (45.0% of the study area). It occupied the remaining acreage of the disturbance area (78.0 of 438.2 acres or 17.8%). This community also contains the 48.9 acres of rimrock, escarpment, and boulder-field wildlife habitat features. The Juniper Scrub type is largely underlain by Soils Units 251 and 625. Both of these communities were sampled with 45 sets of co-located samples for ground cover, woody plant density, and current annual production.

A third plant community, Grassland, was sampled with 45 sets of co-located samples for ground cover, woody plant density, and current annual production because initial evaluations could not ascertain whether or not it had been disturbed by mining facilities (although it has since been verified that this community was never disturbed). The Grassland community occupies 5.5% of the study area and is primarily underlain by Soils Unit 200. The fourth community, Riparian Drainage Bottom (Tamarisk) was not sampled for four principal reasons. First and foremost, it was not sampled because it was determined prior to site-specific investigations that the community had not been disturbed by mine related facilities with the minor exception of a couple of road crossings. This community occupies 3.9% of the study area and exists within Soils Unit 257. Second, this vegetation community exists as a result of frequent and extensive erosive forces and therefore, is in a constant state of change. Third, the community is dominated by scattered stands of tamarisk (a noxious weed) and other early seral or ruderal vegetation (such as rabbitbrush). And fourth, because of these first three conditions, there would be little useful reclamation planning information that could be obtained with baseline sampling. If any reclamation of the Riparian Drainage Bottom must occur, it will require defensive armoring to preclude erosion and regardless of taxa planted, tamarisk will overtake such areas in a matter of a year or two.

As indicated, statistically adequate ground cover data was collected from each of the three extended reference areas. In addition, either as a transformation from this ground cover data (Species Composition) or co-located samples (Woody Plant Density and Herbaceous Production), three additional variables were collected in September, 2005. However, these last three variables were not sampled to any specified 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 or at the rear of this document. In addition, a variety of photos (Plates 1-12) document the condition of the sampled area

Plate 1 – Typical pre-mining condition (Looking - Southeast)

Plate 2 – Typical pre-mining condition (Looking - South)

Plate 3 – Typical pre-mining condition (Looking - Southwest)

Plate 4 – Typical pre-mining conditions (Looking -West)

Plate 5 – Bottomland Extended Reference Area - Oblique View

Plate 6 – Bottomland Extended Reference Area – Close Up

Plate 7 – Juniper Scrub Extended Reference Area – Oblique View

Plate 8 – Juniper Scrub Extended Reference Area – Close Up

Plate 9 – Juniper Scrub Extended Reference Area – Oblique View

Plate 10 – Juniper Scrub Extended Reference Area – Close Up

Plate 11 – Grassland Extended Reference Area – Oblique View

Plate 12 – Grassland Extended Reference Area – Close Up

at the time of sampling in September, 2005. The first set of four plates provide a reasonable approximation of the conditions of the disturbed area prior to mining.

Floristic surveys of the three extended reference areas resulted in the identification of a total of 66 taxa including 15 grass or grass-like species, 31 forbs, and 20 trees, shrubs, or succulents (see Table 1). None of these were determined to be sensitive species or otherwise protected by statute. Similarly, none were identified as noxious (excepting the noxious weed tamarisk that was only found in the Riparian Drainage Bottom community).

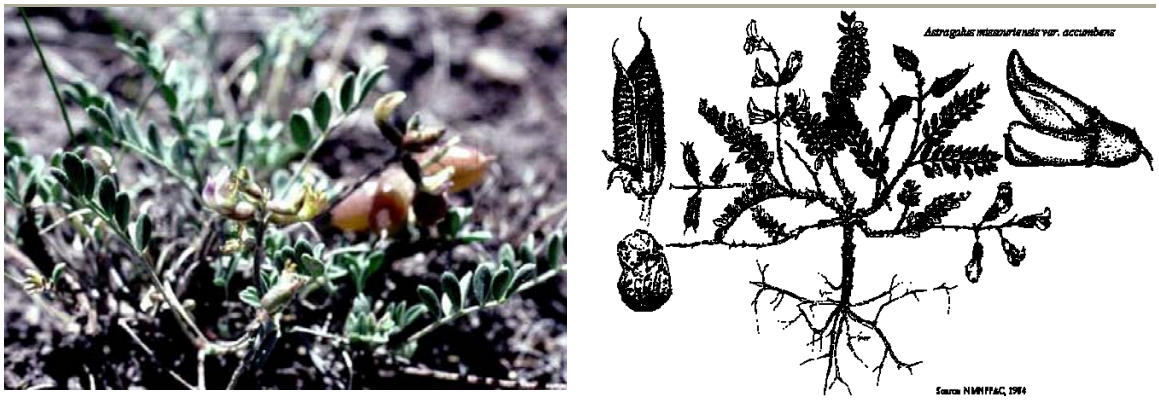
3.1 Threatened, Endangered, and Rare Plant Taxa

According to the New Mexico Rare Plants database, none of the identified six species of concern have been found in the immediate project area. To the contrary, some of the habitats of these taxa can be found in reasonable proximity to the study area, in circumstances sufficient to warrant site-specific searches. These six taxa and their habitats are indicated below.

As a result of Cedar Creek's site-specific field efforts, no rare, threatened or endangered plant species were found on or near the vegetation study area. All taxa were searched for, but with negative results. Given past disturbances at the project area, there is a remote chance that plants existed at one time, however, the probability of such an occurrence is extremely low.

All taxa observed on site were identified to at least genus, if not species level sufficient to facilitate a negative determination of occurrence. This was especially true for *Astragalus missouriensis*. The observed specimen was of a different subspecies as the fruiting bodies did not match those of the var. *accumbens*. Similar logic was used to eliminate the observed *Erigeron* specimen.

Astragalus missouriensis var. accumbens (Zuni milkvetch)



Description: Perennial; plants low, tufted, stemless or with short stem (0-4 (6) cm long), stems prostrate; herbage usually silvery; foliage densely strigose with rather coarse straight and parallel,

Table 1 St. Anthony - Vegetation Cover - 2005

Species List

		Vegetative Community ——>	Bottom-land	Juniper Scrub	Grassland
Grasses and Grass-likes					
P	*Agropyron smithii*	Western Wheatgrass	X	X	X
P	*Aristida longiseta*	Red three - awn	X	X	X
P	*Bouteloua curtipendula*	Side-oats grama	X	X	
P	*Bouteloua gracilis*	Blue grama	X	X	X
A	*Bromus tectorum*	Cheatgrass		X	
P	*Buchloe dactyloides*	Buffalograss		X	
P	*Carex filifolia*	Threadleaf Sedge	X		
P	*Hilaria jamesii*	Galleta	X	X	X
P	*Muhlenbergia torreyi*	Ring muhly	X	X	X
P	*Nolina microcarpa*	Sacahuista		X	
P	*Oryzopsis hymenoides*	Indian ricegrass	X	X	
P	*Sitanion hystrix*	Bottlebrush squirreltail		X	
P	*Sporobolus airoides*	Alkali sacaton	X	X	X
P	*Sporobolus cryptandrus*	Sand dropseed	X	X	
P	*Stipa neomexicana*	New Mexico Feathergrass	X	X	X
Forbs					
A	*Arenaria serpyllifolia*	Thymeleaf Sandwort			X
P	*Asclepias subverticillata*	Horsetail Milkweed			X
P	*Astragalus missouriensis*	Missouri milkvetch		X	
P	*Castilleja chromosa*	Indian-paintbrush		X	
P	*Chenopodium album*	Lambs Quarter	X		
P	*Cirsium sp.*	Thistle	X	X	
A	*Cordylanthus wrightii*	Wright's bird's beak		X	X
A	*Descurainia pinnata*	Western Tansymustard	X		X
P	*Erigeron sp.*	Fleabane		X	
P	*Eriogonum sp.*	Buckwheat		X	X
P	*Eriogonum umbellatum*	Sulphur-flower buckwheat		X	
A	*Euphorbia glyptosperma*	Ridgeseed spurge		X	X
A	*Euphorbia spathulata*	Warty Spurge	X	X	
A	*Helianthus annuus*	Annual Sunflower	X		
P	*Heliomeris multiflora*	Showy Goldeneye		X	
P	*Heterotheca villosa*	Hairy False Goldenaster	X	X	
P	*Ipomopsis longiflora*	Blue Trumpets		X	
A	*Lappula redowskii*	Flatspine Stickseed	X		
A	*Linum rigidum*	Stiffstem Flax			X
A	*Machaeranthera tagetina*	Mesa Tansyaster			X
P	*Mentzelia laevicaulis*	Blazingstar	X		
P	*Mirabilis linearis*	Narrowleaf Four-o'clock		X	
P	*Oenothera sp.*	Evening primrose		X	
P	*Penstemon strictus*	Rocky Mountain penstemon			X

Table 1 (Continued)

Species List

		Vegetative Community ——>	Bottom-land	Juniper Scrub	Grassland
Forbs (continued)					
A	*Plantago patagonica*	Wooly plantain	X	X	
IW	*Salsola tragus*	Russian thistle	X	X	X
P	*Solanum elaeagnifolium*	Silverleaf Nightshade	X		
P	*Solanum triflorum*	Cutleaf Nightshade	X	X	
P	*Sphaeralcea ambigua*	Desert Globemallow			X
P	*Sphaeralcea coccinea*	Scarlet globemallow			X
	Unidentifiable		X	X	X
Shrubs, Sub-shrubs, Succulents & Trees					
P	*Artemisia bigelovii*	Bigelow Sage		X	X
P	*Atriplex canescens*	Fourwing saltbush	X	X	
P	*Ceratoides lanata*	Winterfat	X	X	
P	*Dalea versicolor*	Oakwoods prairie clover		X	
P	*Escobaria vivipara*	Spinystar		X	
P	*Ephedra torreyana*	Torrey's jointfir		X	X
P	*Guttierrezia sarothrae*	Broom snakeweed	X	X	X
P	*Juniperus monosperma*	One-seed Juniper		X	
P	*Leptodactylon pungens*	Granite prickly phlox	X	X	X
P	*Lycium pallidum*	Pale desert-thorn		X	
P	*Mahonia fremontii*	Fremont's mahonia		X	
P	*Mammillaria sp.*	Nipple Cactus		X	X
P	*Opuntia imbricata*	Cholla		X	
P	*Opuntia polyacantha*	Plains pricklypear			X
P	*Opuntia spinosior*	Walkingstick Cactus		X	
P	*Pinus edulis*	Two-needle Pinyon		X	
P	*Psilostrophe tagetina*	Woolly Paperflower	X	X	X
P	*Tamarix chilensis*	Tamarix	X		
P	*Tetradymia canescens*	Spineless horsebrush		X	
P	*Yucca glauca*	Soapweed yucca		X	X
	Total Taxa Observed		**30**	**50**	**28**

appressed, dolabriform hairs; stipules not connate; leaves 2-6.5 cm long; leaflets 7-15, obovate to oval, 2-8 (11) mm long; flower stalks slender, wiry, often long-persistent, 3-6.5 cm long, prostrate in fruit; inflorescence (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°, 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. Flowers (March) May through June (August).

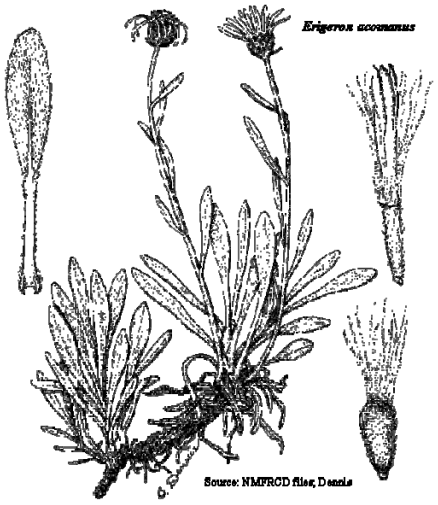
Distribution: New Mexico, northern Catron, Cibola, and southern McKinley counties.

Habitat: Gravelly clay banks and knolls, in dry, alkaline soils derived from sandstone, in piñon-juniper woodlands; 1,890-2,410 m (6,200-7,900 ft).

Status:

Federal: Species of Concern **State:** Species of Concern

Erigeron acomanus (Acoma fleabane)



Description: 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. Flowers in July.

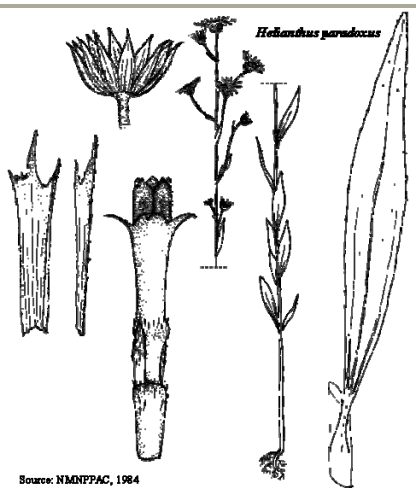
Distribution: New Mexico, McKinley and Cibola counties.

Habitat: Sandy slopes and benches beneath sandstone cliffs of the Entrada Sandstone Formation in piñon-juniper woodland; 2,100-2,170 m (6,900-7,100 ft).

Status:

Federal: Species of Concern **State:** Species of Concern

Helianthus paradoxus (Pecos sunflower)



Description: Annual, 1-2 m tall, branched above, stem glabrous to hispid; leaves opposite below, alternate above, up to 17.5 cm long by 8.5 cm wide, lanceolate with 3 prominent veins, base tapering to a short petiole, margins entire except for a few prominent teeth on larger leaves, surface scabrous; flower heads solitary, terminating branches, 3-5 cm across including ray flowers; ray flowers 12-20, yellow; phyllaries 15-25, 3-4 mm wide, oblong-lanceolate, acuminate, hispid, margins ciliate; pales glabrous at tips; achenes 3-4 mm long, glabrous. Flowers August to October.

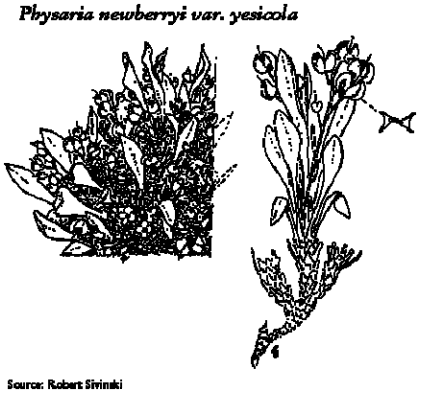
Distribution: New Mexico, Cibola, Valencia, Socorro, Guadalupe, and Chaves counties; Texas, Pecos and Reeves counties.

Habitat: Saturated saline soils of desert wetlands. Usually associated with desert springs (cienegas) or the wetlands created from modifying desert springs; 1,000-2,000 m (3,300-6,600 ft). *Helianthus paradoxus* is a true wetland species that requires saturated soils; adult plants still grow well when inundated.

Status:

Federal: Threatened **State:** Endangered

Physaria newberryi var. *yesicola* (Yeso twinpod)



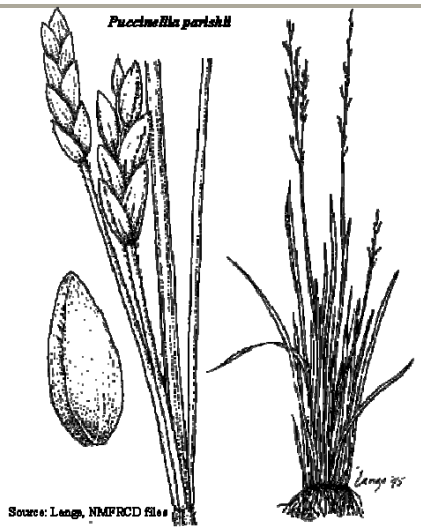
Description: Long-lived, low growing perennial with diffusely branching root crown (caudex) forming mounded clumps 1-3 dm in diameter; herbage densely covered with overlapping gear-shaped (stellate-discoid) trichomes; stems 3-10 cm long; basal leaves narrowly oblanceolate to broadly spatulate, acute or blunt at tips, 3-8 cm long; stem leaves narrow and smaller than basal leaves; inflorescence a few-flowered raceme, 2.5-5 cm long; pedicels 6-11 mm long; flowers about 10 mm wide, petals 4, yellow; fruits (silicles) papery with sharp-angled edges, about 10 mm wide and almost as long, X-shaped in cross-section and with a deep V-shaped notch at the apex; fruiting styles slender, 5-9 mm long. Flowers April and May.

Distribution: New Mexico, southeastern Cibola and western Valencia counties, Sierra Lucero Range (including Mesa Lucero).

Habitat: Sandy gypsum and silty strata of the Yeso Formation in short grass steppe and juniper savanna; 1,750-2,100 m (5,700-6,900 ft).

Status: **Federal:** Species of Concern **State:** Species of Concern

Puccinellia parishii (Parish's alkali grass)



Description: Dwarf annual with 1 to many stems; leaf blades about 1 mm broad, flat or involute, short; culms mostly 5-15 cm tall; panicle narrow, few-flowered, the branches erect-appressed; spikelets 4-6 mm long; glumes shorter than the first floret, broad, strongly nerved, scarious-margined; florets 4-6 per spikelet, disarticulating above the glumes; lemmas about 2 mm long, obtuse to truncate, scarious and somewhat erose at the tip, pubescent on the mid and lateral nerves nearly to the apex, and on the intermediate nerves about half way. Flowers May to June.

Distribution: New Mexico, Catron, Cibola, Grant, Hidalgo, McKinley, Sandoval, and San Juan counties; California, Arizona, and Colorado.

Habitat: Alkaline springs, seeps, and seasonally wet areas that occur at the heads of drainages or on gentle slopes at 800-2,200 m (2,600-7,200 ft) range-wide. The species requires continuously damp soils during its late winter to spring growing period. It frequently grows with *Distichlis stricta* (salt grass), *Sporobolus airoides* (alkali sacaton), *Carex* spp. (sedges), *Scirpus* spp. (bulrushes), *Juncus* spp. (rushes), *Eleocharis* spp. (spike rushes), and *Anemopsis californica* (yerba mansa).

Status:

Federal: Species of Concern **State:** Endangered

Talinum brachypodium **(Laguna fame flower)**

Description: Small, succulent perennial herb; taproot thickened, tuberous, often branched; stems, tufted, few-branched, procumbent; leaves alternate, crowded on stem, nearly terete, usually blunt or obtuse apically, 1.5-2.5 cm long and 1.5-2.5 mm thick, light glaucous green; flowers borne singly (rarely in pairs) on short pedicels from leaf axils, mostly perfect, sometimes pistillate (usually both types on same plant), about 2-2.5 cm in diameter; sepals 2, foliaceous, deciduous in fruit; petals 5-8, lavender-pink (sometimes lighter or darker); stamens numerous; fruit a capsule, nearly globose, 3-valved dehiscing longitudinally and disintegrating at maturity; seeds roughly 1 mm in diameter, nearly discoid, often slightly concave on one or both sides, nearly smooth, black, covered by a thin translucent aril (pellicle) which imparts a grayish or slightly bluish appearance. Flowers June to August.

Distribution: New Mexico, eastern Cibola, western Valencia, and northern Socorro counties.

Habitat: Very shallow pockets of calcareous silt to clay soils overlying limestone or travertine, or fine silty sand overlying calcareous sandstones; open piñon-juniper woodland with little understory and scattered cacti and shrubs or Chihuahuan desert scrub.

Status:

Federal: Species of Concern **State:** Species of Concern

3.2 Vegetation Cover

Ground cover is one of the main variables that must pass revegetation success evaluations according to the MMD rules and regulations applicable to all reclaimed areas. During the 2005 sampling year, extended reference areas were established and sampled to provide baseline data (ground and relative cover) for reclamation planning. These data are summarized on Tables 2 and 3, and Charts 1 and 2 on the following four pages. Raw ground cover data are presented on Tables 4, 5, and 6 at the rear of this document.

The Bottomland extended reference area exhibited a total plant cover of 33.96%. Litter contributed 16.31% to the ground cover and rock exhibited only 0.16%. Bare ground exposure was a significant 49.58%. Dominant taxa were Blue grama (*Bouteloua gracilis*) with 14.46%, Galleta (*Hilaria jamesii*) with 26.05%, Alkali Sacaton (*Sporobolus airoides*) with 20.35%, and Four-wing Saltbush (*Atriplex canescens*) with 14.79% of the plant composition. Perennial grasses made up 65.90% and shrubs comprised 25.0% of the plant composition. It is an important observation that the annual forb composition is only 9.03% with only Russian thistle (*Salsola tragus*), an invasive weed exceeding one percent composition (7.66% of the total relative cover). Perennial and biennial forbs contributed only a negligible amount to the composition (1.37%) and annual grasses were not encountered at all in the Bottomland ecotype. Based on these observations, it can be hypothesized that the Bottomland Community is in reasonably good range condition.

The Juniper Scrub extended reference area exhibited a total plant cover of 24.67%. Other ground cover included litter with 10.51% and rock contributing 11.0% to total ground cover. Bare ground exposure was a significant 53.62%. Dominant taxa in the Juniper Scrub ecotype were Blue grama with 28.29%, New Mexico feathergrass (*Stipa neomexicana*) with 14.86 %, and Bigelow Sage (*Artemisia bigloveii*) with 15.05% of total plant composition. Perennial grasses dominated the plant composition by contributing 61.35%, where as, the second most dominant growth form was shrubs, with 33.42% of plant composition. Perennial and annual forbs contributed only 2.25% and 2.97%, respectively, to the plant composition. Of particular note, Cheatgrass (*Bromus tectorum*) was encountered in the Juniper Scrub ecotype but it did not occur in sufficient quantity to have been intercepted by ground cover

Table 2 St. Anthony - Vegetation Cover - 2005

Average Ground Cover Summary

Percent Ground Cover Based on Point-Intercept Sampling

		Vegetative Community ——>	**Bottomland**	**Juniper Scrub**	**Grassland**
Grasses and Grass-likes					
P	*Agropyron smithii*	Western Wheatgrass	**0.16**	**-**	**-**
P	*Aristida longiseta*	Red three - awn	**0.04**	**0.38**	**3.91**
P	*Bouteloua curtipendula*	Side-oats grama	**0.42**	**0.11**	**-**
P	*Bouteloua gracilis*	Blue grama	**4.91**	**6.98**	**6.67**
P	*Hilaria jamesii*	Galleta	**8.84**	**2.98**	**9.73**
P	*Muhlenbergia torreyi*	Ring muhly	**0.11**	**0.20**	**1.29**
P	*Oryzopsis hymenoides*	Indian ricegrass	**0.20**	**0.40**	**-**
P	*Sitanion hystrix*	Bottlebrush squirreltail	**-**	**0.04**	**-**
P	*Sporobolus airoides*	Alkali sacaton	**6.91**	**0.33**	**0.80**
P	*Sporobolus cryptandrus*	Sand dropseed	**0.16**	**0.04**	**-**
P	*Stipa neomexicana*	New Mexico Feathergrass	**0.62**	**3.67**	**0.13**
Forbs					
P	*Astragalus missouriensis*	Missouri milkvetch	**-**	**0.09**	**-**
A	*Cordylanthus wrightii*	Wright's bird's beak	**-**	**0.29**	**0.11**
P	*Erigeron sp.*	Fleabane	**-**	**0.04**	**-**
P	*Eriogonum sp.*	Buckwheat	**-**	**0.36**	**0.04**
P	*Eriogonum umbellatum*	Sulphur-flower buckwheat	**-**	**0.02**	**-**
A	*Euphorbia glyptosperma*	Ridgeseed spurge	**-**	**0.16**	**0.09**
A	*Lappula redowskii*	Flatspine Stickseed	**0.11**	**-**	**-**
P	*Mentzelia laevicaulis*	Blazingstar	**0.02**	**-**	**-**
P	*Mirabilis glabra*	Smooth Four-o'clock	**-**	**0.02**	**-**
P	*Oenothera sp.*	Evening primrose	**-**	**0.02**	**-**
P	*Penstemon strictus*	Rocky Mountain penstemon	**-**	**-**	**0.16**
A	*Plantago patagonica*	Wooly plantain	**0.04**	**0.04**	**-**
IW	*Salsola tragus*	Russian thistle	**2.60**	**0.20**	**0.16**
P	*Sphaeralcea coccinea*	Scarlet globemallow	**-**	**-**	**0.09**
	Unidentifiable		**0.31**	**0.04**	**0.20**
Shrubs, Sub-shrubs, Cacti & Trees					
P	*Artemisia bigelovii*	Bigelow Sage	**-**	**3.71**	**1.62**
P	*Atriplex canescens*	Fourwing saltbush	**5.02**	**0.56**	**-**
P	*Ceratoides lanata*	Winterfat	**0.47**	**0.07**	**-**
P	*Dalea versicolor*	Oakwoods prairie clover	**-**	**0.11**	**-**
P	*Ephedra torreyana*	Torrey's jointfir	**-**	**0.16**	**0.04**
P	*Guttierrezia sarothrae*	Broom snakeweed	**2.80**	**2.89**	**4.93**
P	*Juniper monosperma*	One seeded Juniper	**-**	**0.09**	**-**
P	*Leptodactylon pungens*	Granite prickly phlox	**0.09**	**0.02**	**0.98**
P	*Lycium pallidum*	Pale desert-thorn	**-**	**0.02**	**-**
P	*Opuntia polyacantha*	Plains pricklypear	**-**	**-**	**0.04**
P	*Psilostrophe tagetina*	Woolly Paperflower	**0.11**	**0.04**	**0.18**
P	*Tetradymia canescens*	Spineless horsebrush	**-**	**0.29**	**-**
P	*Yucca glauca*	Soapweed yucca	**-**	**0.29**	**0.02**

Table 2 (Continued)

Vegetative Community ——>		Bottomland	Juniper Scrub	Grassland
Total Plant Cover		**33.96**	**24.67**	**31.20**
Rock		**0.16**	**11.00**	**3.93**
Litter		**16.31**	**10.51**	**11.07**
Bare ground		**49.58**	**53.82**	**53.80**
Total Perennial & Biennial Cover		**30.89**	**23.93**	**30.64**
No. of Species with > 1% Composition (excluding annuals)		**6**	**0**	**4**
Sample Adequacy Calculations	***t* =**	**1.680**	**1.680**	**1.680**
	n =	**45**	**45**	**45**
	Variance =	**72.97**	**35.82**	**33.72**
	n_{min} =	**17.87**	**16.62**	**9.81**

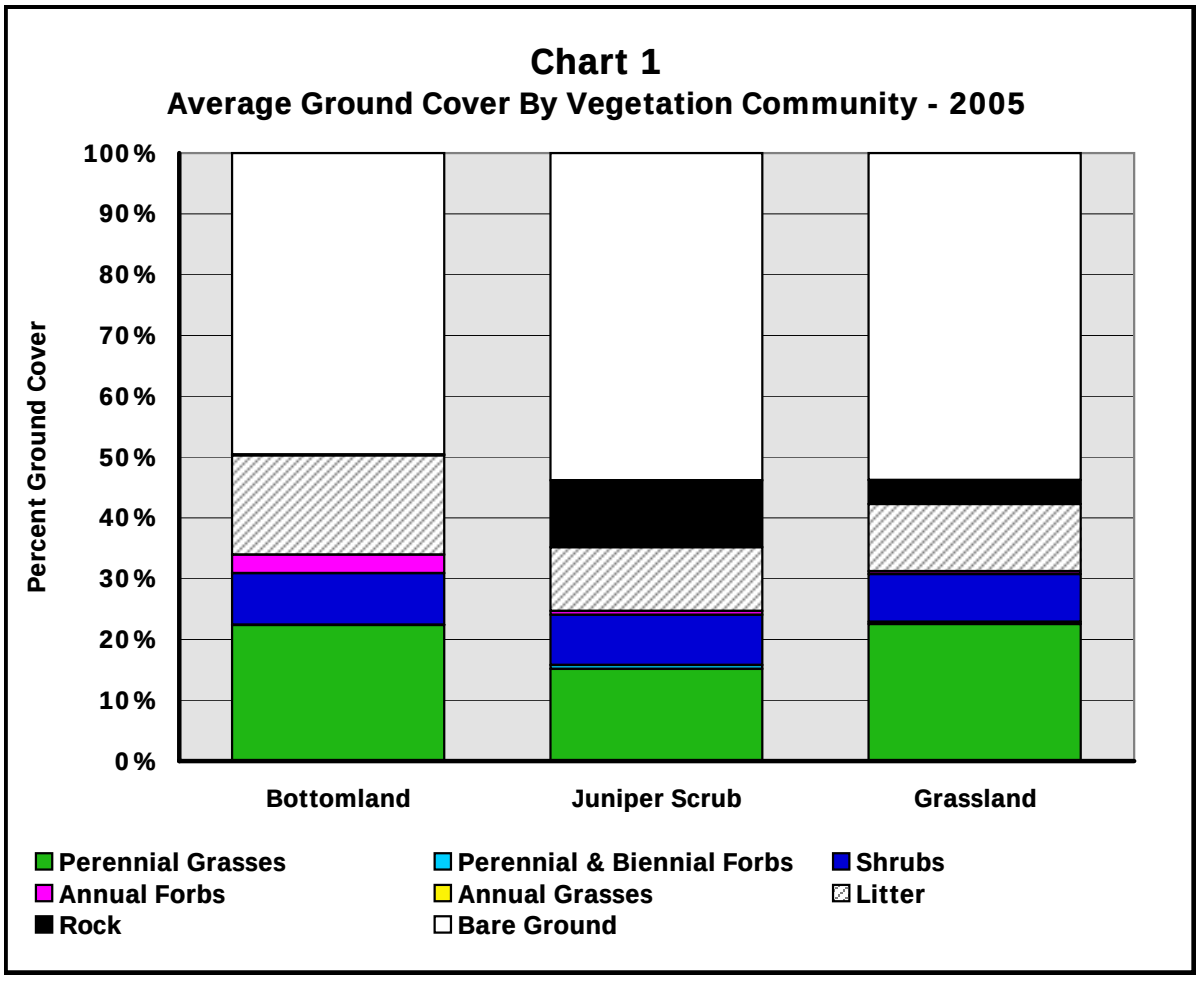


Table 3 St. Anthony - Vegetation Cover - 2005

Relative Cover (Composition) Summary

Percent Ground Cover Based on Point-Intercept Sampling

		Vegetative Community ——>	Bottom-land	Juniper Scrub	Grassland	Average (for Reveg. Target)
Grasses and Grass-likes						
P	*Agropyron smithii*	Western Wheatgrass	**0.46**	**-**	**-**	**0.15**
P	*Aristida longiseta*	Red three - awn	**0.13**	**1.53**	**12.54**	**4.73**
P	*Bouteloua curtipendula*	Side-oats grama	**1.24**	**0.45**	**-**	**0.56**
P	*Bouteloua gracilis*	Blue grama	**14.46**	**28.29**	**21.37**	**21.37**
P	*Hilaria jamesii*	Galleta	**26.05**	**12.07**	**31.20**	**23.11**
P	*Muhlenbergia torreyi*	Ring muhly	**0.33**	**0.81**	**4.13**	**1.76**
P	*Oryzopsis hymenoides*	Indian ricegrass	**0.59**	**1.62**	**-**	**0.74**
P	*Sitanion hystrix*	Bottlebrush squirreltail	**-**	**0.18**	**-**	**0.06**
P	*Sporobolus airoides*	Alkali sacaton	**20.35**	**1.35**	**2.56**	**8.09**
P	*Sporobolus cryptandrus*	Sand dropseed	**0.46**	**0.18**	**-**	**0.21**
P	*Stipa neomexicana*	New Mexico Feathergrass	**1.83**	**14.86**	**0.43**	**5.71**
Forbs			**No. of Taxa with > 1% Rel. Cov. =**			**6**
P	*Astragalus missouriensis*	Missouri milkvetch	**-**	**0.36**	**-**	**0.12**
A	*Cordylanthus wrightii*	Wright's bird's beak	**-**	**1.17**	**0.36**	**0.51**
P	*Erigeron sp.*	Fleabane	**-**	**0.18**	**-**	**0.06**
P	*Eriogonum sp.*	Buckwheat	**-**	**1.44**	**0.14**	**0.53**
P	*Eriogonum umbellatum*	Sulphur-flower buckwheat	**-**	**0.09**	**-**	**0.03**
A	*Euphorbia glyptosperma*	Ridgeseed spurge	**-**	**0.63**	**0.28**	**0.31**
A	*Lappula redowskii*	Flatspine Stickseed	**0.33**	**-**	**-**	**0.11**
P	*Mentzelia laevicaulis*	Blazingstar	**0.07**	**-**	**-**	**0.02**
P	*Mirabilis glabra*	Smooth Four-o'clock	**-**	**0.09**	**-**	**0.03**
P	*Oenothera sp.*	Evening primrose	**-**	**0.09**	**-**	**0.03**
P	*Penstemon strictus*	Rocky Mountain penstemon	**-**	**-**	**0.50**	**0.17**
A	*Plantago patagonica*	Wooly plantain	**0.13**	**0.18**	**-**	**0.10**
IW	*Salsola tragus*	Russian thistle	**7.66**	**0.81**	**0.50**	**2.99**
P	*Sphaeralcea coccinea*	Scarlet globemallow	**-**	**-**	**0.28**	**0.09**
	Unidentifiable		**0.92**	**0.18**	**0.64**	**0.58**
Shrubs, Sub-shrubs, Cacti & Trees			**No. of Taxa with > 1% Rel. Cov. =**			**0**
P	*Artemisia bigelovii*	Bigelow Sage	**-**	**15.05**	**5.20**	**6.75**
P	*Atriplex canescens*	Fourwing saltbush	**14.79**	**2.25**	**-**	**5.68**
P	*Ceratoides lanata*	Winterfat	**1.37**	**0.27**	**-**	**0.55**
P	*Dalea versicolor*	Oakwoods prairie clover	**-**	**0.45**	**-**	**0.15**
P	*Ephedra torreyana*	Torrey's jointfir	**-**	**0.63**	**0.14**	**0.26**
P	*Guttierrezia sarothrae*	Broom snakeweed	**8.25**	**11.71**	**15.81**	**11.92**
P	*Juniper monosperma*	One seeded Juniper	**-**	**0.36**	**-**	**0.12**
P	*Leptodactylon pungens*	Granite prickly phlox	**0.26**	**0.09**	**3.13**	**1.16**
P	*Lycium pallidum*	Pale desert-thorn	**-**	**0.09**	**-**	**0.03**
P	*Opuntia polyacantha*	Plains pricklypear	**-**	**-**	**0.14**	**0.05**
P	*Psilostrophe tagetina*	Woolly Paperflower	**0.33**	**0.18**	**0.57**	**0.36**
P	*Tetradymia canescens*	Spineless horsebrush	**-**	**1.17**	**-**	**0.39**
P	*Yucca glauca*	Soapweed yucca	**-**	**1.17**	**0.07**	**0.41**
			No. of Taxa with > 1% Rel. Cov. =			**4**

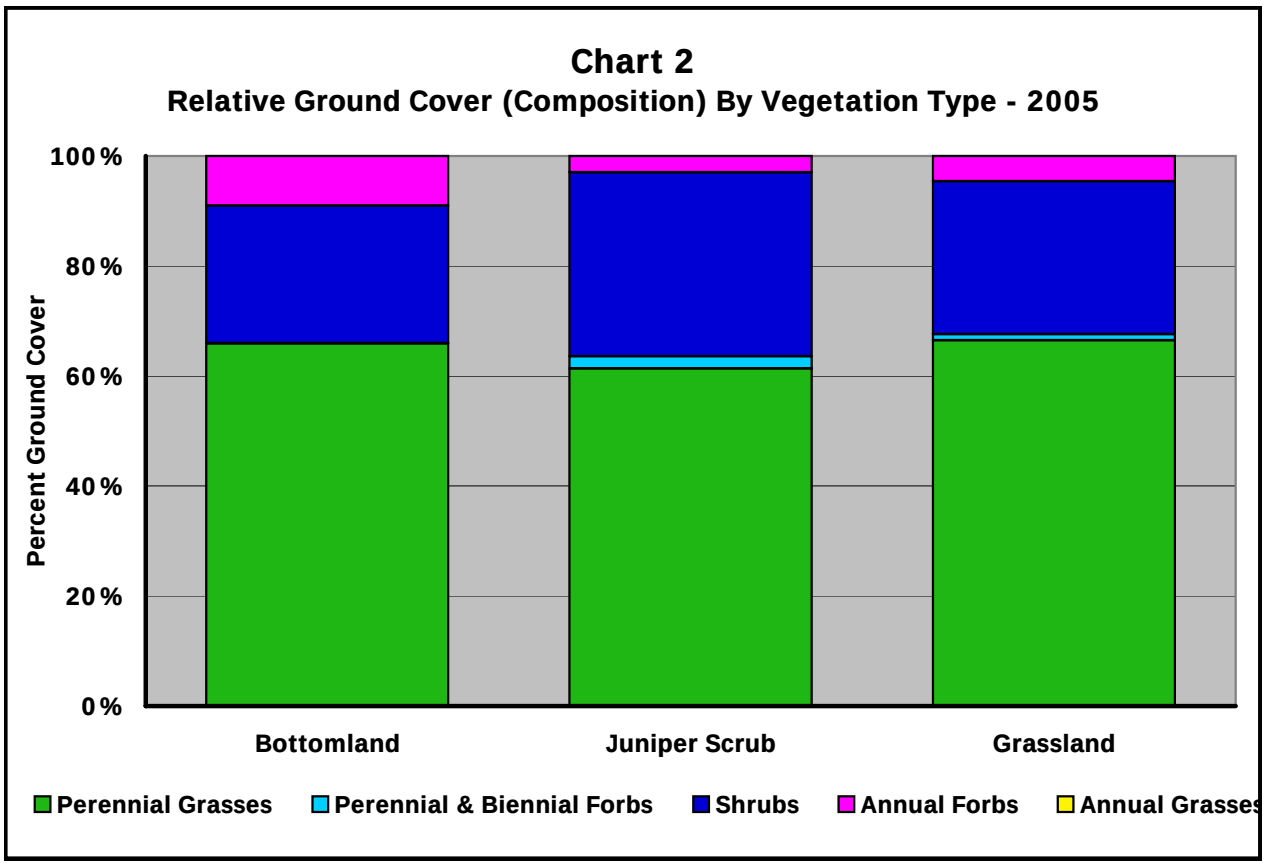


Chart 2
Relative Ground Cover (Composition) By Vegetation Type - 2005
Percent Ground Cover
100 %
80 %
60 %
40 %
20 %
0 %
Bottomland
Juniper Scrub
Grassland
Perennial Grasses
Perennial & Biennial Forbs
Shrubs
Annual Forbs
Annual Grasses

transects. Based on these observations, it can be hypothesized that the Juniper Scrub Community is in reasonably good range condition.

The Grassland extended reference area exhibited a total plant cover of 31.20%. Non-vegetative cover includes litter at 11.07% and rock at 3.93%. Bare ground exposure was a significant 53.80%. Dominant taxa were Red Three-awn (*Artistida longiseta*) with 12.52%, Blue grama with 21.37%, Galleta with 31.20%, and Broom Snakeweed (*Guttierrezia sarothrae*) with 15.81% of the plant composition. The perennial grasses were again the most dominant growth form, comprising of 72.22% of the plant composition. Shrubs were the next most dominant growth form with 25.07% of the composition. Forbs, both perennial and annual, only contributed a negligible amount to relative cover, 0.93% and 1.78%, respectively. Once again, no annual grasses were encountered in the grassland ecotype. Based on these observations, it can be hypothesized that the Grassland Community is in fair or better range condition.

3.3 Woody Plant Density

Woody Plant Density is another of the variables that must be evaluated for revegetation success. During the 2005 sampling year extended reference areas were established and sampled to provide baseline data for reclamation planning. These data are summarized on Table 7 and Chart 3 on the following page. Raw woody plant density data are presented on Tables 8, 9, and 10 at the rear of this document.

The Bottomland extended reference area exhibited a woody plant density of 1839 stems per acre of which the vast majority were shrubs (1,755). Of these four-wing saltbush was dominant with 1,068 plants per acre. The Juniper Scrub extended reference area exhibited a woody plant density of 2,971 plants per acre, again the majority of which were shrubs with 2,792 per acre. Of these Bigelow's sagebrush (*Artemisia bigelovii*) was dominant with over 2,200 plants per acre. The Grassland extended reference area exhibited the least woody plant density with only 874 plants per acre. Again shrubs dominated with 817 per acre, and again Bigelow sagebrush was the dominant plant with 630 per acre. On average, the three communities exhibited 1,788 shrubs per acre, 67 succulents per acre, and 40 trees per acre.

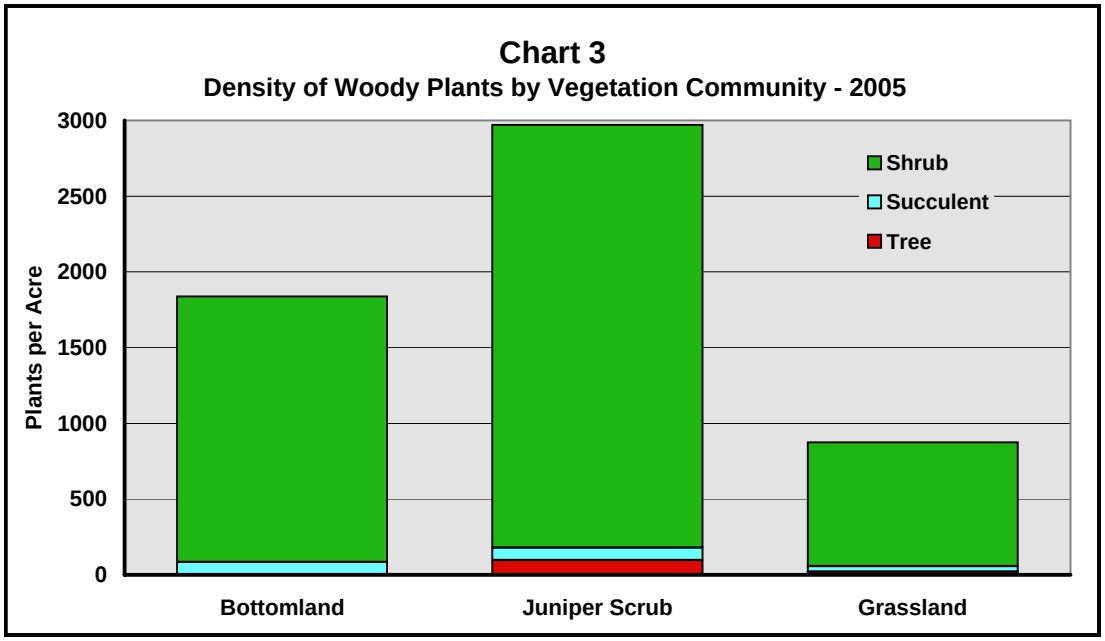
Trees were only recorded in the Juniper scrub and Grassland communities with 97 and 22 per acre, respectively.

Table 7 St. Anthony - Vegetation Information - 2005

Woody Plant Density Summary

Plants per acre

Species		Growth For	Bottomland	Juniper Scrub	Grassland
		Vegetation Community ——>			
Artemisia bigelovii	Bigelow Sage	Shrub	**260.8**	**2,204.2**	**630.4**
Atriplex canescens	Fourwing Saltbush	Shrub	**1,068.4**	**201.4**	**97.1**
Ceratoides lanata	Winterfat	Shrub	**414.6**	**44.1**	**80.9**
Cercocarpus montanus	Mountain Mahogany	Shrub	**-**	**8.1**	**-**
Chrysothamnus nauseosus	Rubber Rabbitbrush	Shrub	**8.1**	**77.3**	**0.9**
Dalea versicolor	Oakwoods Prairie Clover	Shrub	**-**	**31.5**	**-**
Echinocereus melanocanthus	Hedgehog Cactus	Succulent	**-**	**8.1**	**-**
Ephedra torreyana	Torrey's Jointfir	Shrub	**-**	**15.3**	**-**
Eriogonum wrightii	Bastardsage	Shrub	**-**	**0.9**	**-**
Juniper monosperma	Oneseed Juniper	Tree	**-**	**91.7**	**21.6**
Lycium torreyi	Torrey Wolfberry	Shrub	**0.9**	**0.9**	**3.6**
Opuntia polyacantha	Pricklypear Cactus	Succulent	**60.3**	**68.3**	**28.8**
Opuntia spinosior	Walkingstick Cactus	Succulent	**24.3**	**5.4**	**6.3**
Pinus edulis	Twoneedle Pinyon	Tree	**-**	**5.4**	**-**
Rhus trilobata	Skunkbush Sumac	Shrub	**-**	**36.9**	**-**
Senecio sp.	Groundsel	Shrub	**-**	**-**	**2.7**
Tetradymia canescens	Spineless Horsebrush	Shrub	**-**	**1.8**	**-**
Yucca glauca	Soapweed Yucca	Shrub	**1.8**	**150.2**	**1.8**
Unidentifiable		Shrub	**-**	**19.8**	**-**
Total by Lifeform		**Shrub**	**1,755**	**2,792**	**817**
		Succulent	**85**	**82**	**35**
		Tree	**-**	**97**	**22**
Total			**1,839**	**2,971**	**874**



3.4 Vegetative Production

Current annual production is another of the variables that must be evaluated for revegetation success. During the 2005 sampling year extended reference areas were established and sampled to provide baseline data for reclamation planning. These data are summarized on Table 11 and Chart 4 on the following page. Raw production data are presented on Tables 12, 13, and 14 at the rear of this document.

The Bottomland extended reference area exhibited a current annual vegetative production of 480.5 pounds per acre, whereas the Juniper Scrub reference area only exhibited current annual vegetative production of 354.7 pounds per acre. The Grassland extended reference area exhibited a current annual vegetative production of 664.3 pounds per acre. As was demonstrated by the cover values, most of the current annual production for all three reference areas was contributed by perennial grasses. Also, it is important to note that current annual production values presented here fall within values presented for the soil types earlier in this document. Based on a standard calculation for carrying capacity, the three communities (Bottomland, Juniper Scrub, and Grassland) would support an estimated 0.18, 0.116, or 0.209 Animal Unit Months (AUMs) per acre under a properly regulated grazing program.

Of particular note is that the perennial forb components of the three extended reference areas only contribute on average 2.1% of the production or about 10.7 pounds per acre. This is noteworthy because reclamation typically does not re-establish native forb populations with consistent regularity. This finding is corroborated by the observed forb ground cover of 0.75% on average (not including Russian thistle). Forbs (excluding Russian thistle) only comprise 3.5% of the vegetative composition of the three communities combined.

3.5 Species Diversity

Species diversity is another of the variables that must be evaluated for revegetation success. During the 2005 sampling year extended reference areas were established and sampled to provide baseline data for reclamation planning. Composition (relative cover) data are summarized on Table 3 and Chart 2. As indicated on this table, the average number of taxa observed to provide more than 1% relative cover (composition) included 6 perennial grass taxa, 0 forbs (excepting the annual weed Russian thistle), and 4 shrubs (one of which is a weedy invader – broom snakeweed (*Guttierrezia sarothrae*)).

Table 11 Vegetation Production -- 2005

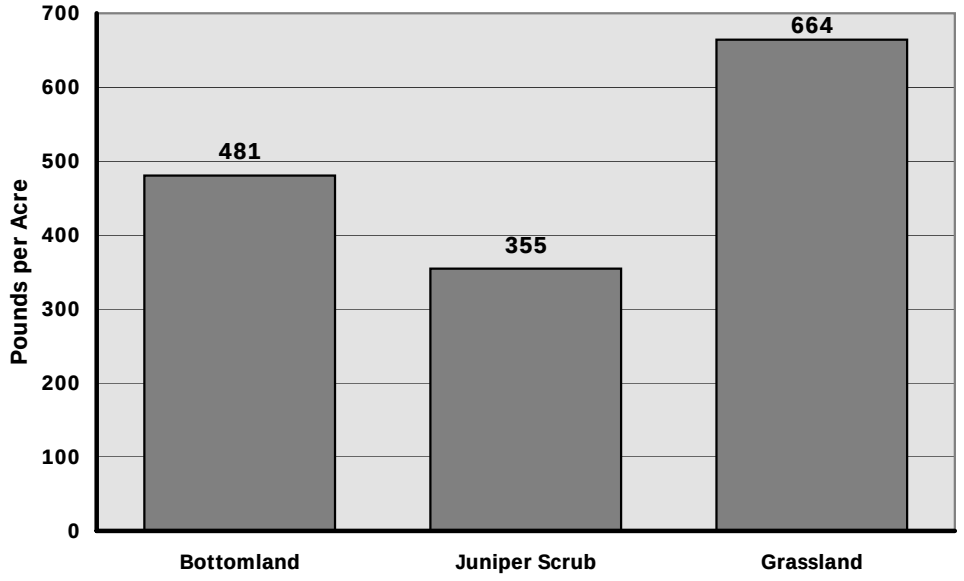
Summary of Current Annual Production - St. Anthony

Oven Dry Weight (grams per 1/2 square meter)

Vegetation Type	*Grasses*		*Forbs*			*Sub-shrubs*	*TOTAL*	
	PG	*Annual*	*NP*	*IP*	*Annual*		g/0.5m^2	lbs / ac
Bottomland	16.2	0.0	0.3	0.0	0.6	9.8	26.9	480.5
Juniper Scrub	10.3	0.0	0.6	0.0	0.2	8.9	19.9	354.7
Grassland	18.7	0.0	0.8	0.1	0.3	17.3	37.2	664.3

Chart 4

Current Annual Production by Vegetation Community - 2005



3.6 Wildlife

As indicated in Section 2.8, a total of 6 pedestrian transects were extended radially from the St. Anthony disturbance footprint over three separate mornings. Weather was crisp and clear with no wind for two of the three mornings. The third morning was breezy and overcast in advance of a rapidly approaching storm front. Transect 1 was oriented to the northwest along a drainage basin and covered a distance of 0.76 miles. Transect 2 was oriented to the north and covered a distance of 0.70 miles. Transect 3 occurred to the West a total of 0.78 miles and then turned southward for an additional 0.5 miles until a deep box canyon was encountered. Transect 4 followed a somewhat sinuous route to the south over a distance of 0.9 miles. Transect 5 was extended up the drainage to the northeast for a distance of 1.12 miles. Finally, Transect 6 was extended eastward with a return leg from the southeast for a total distance of 0.98 miles.

Over the course of these pedestrian transects, Cedar Creek observed a total of six habitat types for indigenous fauna. The first four of these correspond to the four vegetation communities described elsewhere in this document (grassland, bottomland, juniper scrub, riparian drainage bottom [tamarisk]). The remaining two types are physical habitat features: 1) cliff face or rim rock and 2) seasonal water. All six of these habitat features are indicated on Map 1. Only three seasonal water sources (livestock watering facilities or stocktanks) were observed within the study area aside from the ponded water remnant in the bottom of Pits 1 and 2. Shorebird and mule deer tracks were observed along the mudflats of one of these features intercepted by pedestrian transects. The rim rock occurs throughout the study area as indicated on Map 1, and varies from modest elevation rubble piles to vertical cliff faces of 40 to 50 feet in height.

As indicated on Table A, the vast majority (82%) of disturbances occurred to the bottomland vegetation community with only 18% of the disturbance occurring to the somewhat more valuable Juniper Scrub type. In comparison to the other wildlife habitats present within the old disturbance footprint, the bottomland type offers some of the least valuable habitat in the area. The two most important types, rim rock and riparian drainage bottom were largely, if not completely, avoided by mine-related facilities. With regard to the rim rock habitat type, it offers multiple opportunities 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 mining disturbances, Cedar Creek's observations were consistently positive regarding: 1) the quality of area habitats, 2) use of those habitats by indigenous fauna, 3) more distant

mine-related impacts, or 4) any continuing hazards to wildlife. For example, the existing vegetation communities (excepting the riparian drainage bottom) were observed to generally be in good or better range condition and only exhibited light to moderate utilization by domestic livestock. In contrast, the riparian drainage bottom was in very poor condition, but for reasons unrelated to past mining activity. This deteriorated condition was primarily a function of the existence of significant stands of tamarisk (a phreatophytic noxious weed) as well as other early seral and/or ruderal vegetation commonly associated with habitats that are frequently subject to severe perturbation such as flooding. The physical effects associated with frequent flooding along the riparian drainage bottom were readily evident and included features such as deeply incised channels, large deposits of sediment, flood debris at elevated locations, and poorly consolidated soil materials.

Another example of the positive nature of observations was 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. 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 lesser utility).

One final positive observation of note related to the significant amount of wildlife sign evident along the six transects. Observations of both mule deer and elk hoof prints and pellet groups were both common and abundant. Similarly, the quantity of direct bird observations (excepting the grassland habitats) seemed to be greater than expectation. Finally, observation of sign for a species sensitive to human presence (black bear) within 0.12 mile of the disturbance footprint is indicative of the condition that indigenous wildlife have adapted to, and / or transcended past, the adverse effects of mine-related activity. The quality of area habitats and their utilization by indigenous wildlife can be inferred given the following listing of direct sightings, tracks, scat, nests, or burrows. (VC = Very Common, C = Common, U = Uncommon, R = Rare)

Direct Observations:

Mammals:	Elk (C)	Jackrabbit (C)	Burro (U)
	Prairie dog (audible) (C)		
Herpetofauna:	Sagebrush Lizard (C)	W. Diamondback (U)	Amphibian Tadpoles (frog?) (U)
	Horned Lizard (U)		
Avifauna	W. Meadowlark (C)	Common Raven (U)	Sharp-shinned Hawk (U)
	Prairie Falcon (U)	Red-tailed Hawk (U)	Horned Lark (transient (VC))
	Chipping Sparrow (C)	W. Kingbird (U)	Rock Wren (U)
	Canyon Wren (U)	W. Scrub Jay (C)	Mourning Dove (U)
	Canyon Towhee (R)	Black-throated Sparrow (U)	

Observation of Sign:

Mammals:	Elk (VC)	Mule Deer (VC)	Black Bear (R)
	Wild Horse (C)	Badger (burrow ?) (U)	Jackrabbit (C)
	Cottontail (C)	Kangaroo Rat (C)	Mouse (Deer?) (C)
	W-t Prairie Dog (burrows) (C)		
Avifauna	Black-billed Magpie (nest) (U)		

Although a few observations of raptors occurred during Cedar Creek's work at St. Anthony, it is important to note that no evidence of cliff nesting was observed within the rim rock immediately adjacent to the permit area. It is more than likely that the observed cliff nesters (red-tailed hawk and prairie falcon) had nests elsewhere in the general area given the vast number of opportunities for nest construction. Furthermore, there were no obvious nests observable within the junipers about the site with the exception of a few old magpie or raven nests that were in a state of disrepair.

3.7 Threatened, Endangered, and Rare Wildlife Taxa

According to several New Mexico databases, only a single wildlife taxon had even a remote chance of existing on the project area, the endangered Southwestern Willow Flycatcher. However, Cedar Creek has extensive experience with this taxon, especially in Arizona and is quite familiar with its habitat requisites (see detailed description below). Given these habitat requisites and familiarity with the species, the only possible habitat on or near the project would be provided by the stands of tamarisk located in the ephemeral drainage that bisects the project. However, these stands do not provide sufficient cover, areal extent, density, or other requisite parameters to function as habitat for this species. Furthermore, no observations of Southwestern Willow Flycatcher were made during surveys and the closest known critical habitat is within the Gila and Rio Grande River systems located several miles from the project.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*)

Description: Small; usually a little less than 6 inches in length, including tail. Conspicuous light-colored wingbars. Lacks the conspicuous pale eye-ring of many similar Empidonax species. Overall, body brownish-olive to gray-green above. Throat whitish, breast pale olive, and belly yellowish. Bill relatively large; lower mandible completely pale. Best identified by vocalizations. Call a liquid, sharply whistled whit! or a dry sprrit; song a sneezy witch-pew or fitz-bew. While perched, characteristically flicks tail slightly upward.

Habitat: In Arizona, this flycatcher breeds principally in (at low elevations) dense willow, cottonwood, and tamarisk thickets and woodland along streams and rivers, and (at high elevations) pure, streamside stands of Geyer willow. Migrants may occur more widely.

Distribution: The wintering range of *E. t. extimus* is uncertain, but the species is known to winter from west coast of central Mexico to northern South America. The breeding range of *extimus* includes Arizona and adjacent states. In Arizona, *extimus* breeds very locally along the Colorado River, the Alamo Lake area, at the headwaters of the Little Colorado and San Francisco rivers, along the middle Verde River, at Roosevelt Lake, and along the middle Gila and the San Pedro rivers. Many of the breeding sites are occupied by five or fewer pairs.

Biology: Spring arrival in Arizona is in late April; fall migration begins as the breeding season ends in July-August. Males sing repeatedly from exposed perches while on the breeding grounds, and occasionally during migration. The nest is built of shredded bark, cattail tufts, and grasses, and lined with fine grasses and feathers. Usually it is placed in a branch fork in a willow, near water. The eggs are buff with dark spots at one end. The typical clutch of three (sometimes four) eggs is laid in May-June. Incubation lasts 12 to 13 days; nestlings fledge after 12 to 14 days. Breeding success may be heavily affected by predation and brown-headed cowbird egg-parasitism.

Status:

Federal: Endangered

4.0 REVEGETATION CONSIDERATIONS AND RECOMMENDATIONS

The reclamation of the St. Anthony mine must be guided by the primary intended post-reclamation land use. In this regard, the area will primarily target livestock grazing with a secondary and coincidental use as wildlife habitat. However, of utmost importance regardless of the targeted land use is the attainment of erosional stability. Without such stability, the reclaimed landscape will regress along the successional continuum to a point that approximates current conditions of ruderal vegetation that will not support either the primary or coincidental land uses of livestock grazing or wildlife habitat. The principal means to obtain erosional stability is the construction of a stable physical landscape that will then support the establishment and persistence of a reasonably thick herbaceous ground cover. Once such a stable condition is achieved, natural successional processes will take over and advancement along the successional continuum will be positive, eventually leading to a condition that supports the intended post-reclamation land uses. 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. If one or more of the necessary revegetation variables is poor, the attainment of the targeted land uses will take additional time, perhaps 12 to 15 years. In either event, by statute, the soonest that liability release testing can occur is in the twelfth growing season following seeding or significant augmentation.

4.1 Growth Medium Characteristics and Reapplication Depths

Once waste rock piles, highwalls, and / or other steeply sloping mine area features have been graded to final contour, they must be top-dressed with an adequate amount of growth media. Waste material (spoil) alone, is typically not a reasonably suitable surficial growth medium. Soil must be reapplied over waste material to develop an acceptable revegetation conducive profile. Soil depths of 12 inches should be considered a minimally acceptable depth in most cases. A depth of 6 inches, if carefully applied to maintain suitable overall depths, may be considered acceptable in certain situations but should be reserved for the lesser slope angles where a choice of slopes is available. Cheatgrass and Russian thistle populations, at least initially, may be enhanced by the application of soil materials but this must be looked upon as an unavoidable consequence and recommendations stated elsewhere in this document should be utilized to overcome this negative effect. The value of soil with respect to developing viable communities composed of desirable species cannot be overstated. Where soil is not available or in short supply, seed mixes heavily weighted in favor of shrubs should be utilized.

During the field evaluation by Cedar Creek, there appeared to be remnant topsoil stockpiles at two locations that could be used for this purpose. However, a brief visual estimate of these stockpiles indicated that insufficient material exists in these locations to top-dress 430 acres of disturbance. Given

a nominal depth of 12 inches, approximately 700,000 yd^3 of growth media would be necessary. Assuming the observed stockpiles are in fact topsoil, they would only supply about one-quarter to one-third (+/-) of the volume needed. Therefore, borrow sources need to be identified. In this regard, Cedar Creek would recommend consideration of those areas of the bottomland community (see Map 1) proximal to existing disturbances and / or areas of disturbance that only exhibit surficial impact (e.g. old building sites, roads, etc.). These areas of bottomland community typically overlie Soils Unit 257, which should be a deep reasonably productive soil with high water availability. If an average lift of 3 feet of this material were available for growth media borrow, the additional disturbance would total to approximately 100 acres. It's possible however, that more than three feet could be borrowed from portions of these areas thereby reducing the acreage of additional impact.

Another consideration that may be employed is reducing the overall depth of top-dressing to be utilized (i.e. 6 or 8 inches rather than 12 inches). However, to utilize this approach the underlying "spoil" must be comprised of very benign material. In this regard, it is known that Mancos shale and perhaps other heavy clay or poor growth media materials exist in the area. These poor materials need to be identified and then buried with at least five feet of reasonable (plant conducive) spoil to facilitate an adequate rooting zone for revegetation species. Other than being composed of benign materials (e.g., neutral pH, low sodium, etc.) such underlying spoil materials should simply exhibit "loamy" textures (not clay and not sand) and therefore, exhibit elevated water holding / available water capacity for surficial plant life. Because this underlying material is so important to the successful establishment and long-term persistence of revegetated communities, it is recommended that a sampling program be utilized to identify those materials that must be buried versus those materials that can be utilized to develop the "rooting zone" for revegetated species. This rooting zone extends from the bottom of the replaced growth media to a depth of five feet.

4.2 Revegetation Recommendations

4.2.1 Physical Site and Seedbed Preparation Recommendations

Slope Angles / Length: Where possible, slopes should be kept at or under 33 percent (3:1) to enhance revegetation potentials and increase reclamation machinery efficiencies. Where steeper slopes must be constructed, close attention should be paid to the application of revegetation techniques such that the potential for erosion is reduced. On more steeply sloping sites, reclamation techniques should be applied perpendicular to the direction of water flow as machinery access and safety considerations allow. Slope lengths should be broken by terraces such that no slope ever exceeds 400 feet and would

be best if terraced at 100 or 200-foot length intervals. For example, assuming a 3:1 slope, a 40-foot lift would be extended to a slope length of 120 feet with a terrace left in place at the bottom.

Aspect: Although the site-specific information evaluated to date is not totally conclusive, flat, north, and east slopes are preferred to other aspects to decrease evaporation and increase plant establishment potentials. Where south and west aspects must be constructed, the quality and quantity of growth media overlying the surface assumes an even greater importance relative to revegetation success. This is particularly true for steeper slope angles. Furthermore, it is evident that North-facing slopes discourage cheatgrass and other weedy annuals.

Topographic Configuration of Post-reclamation Facilities: As noted above under Slope Angle / Length Recommendation, whenever possible all slopes should be laid back to 3:1 or flatter. Also, as noted under Growth Medium Characteristics and Reapplication Depths Recommendation, growth media application depths should be a minimum of 12 inches wherever possible. Furthermore, as indicated in Aspect Recommendation, flat, north, and east facing aspects result in the best revegetation potential while south and west aspects are more problematic, requiring extra care during construction and re-soiling. Given the typical reclamation situation whereby available topsoil or growth media is in short supply, the following facility configuration, or a variant thereof, could be used to optimize use of limited growth media resources (assuming agency concurrence is obtained).

Assuming available topsoil resources are insufficient to provide a minimum 12-inch depth across the entirety of reclaimed surfaces (at 3:1 slopes or flatter), and assuming that at least some of the topsoil resources are high in coarse fragment content (rocky soil), the following concepts regarding facility configuration could be developed to optimize use of those limited resources. In this regard, the best topsoil is placed to a depth of 12 inches on flat, north, and east-facing slopes. The north-facing slope is graded to 3:1 or flatter, while the east-facing slope (worst case) could be steepened to 2.5:1, depending on the availability of topsoil. These areas would be planted to a grassland type and thereby maximize carrying capacity for grazing animals (e.g., livestock). Similarly, the west-facing slope could be steepened to 2.5:1 and either 12 inches of good topsoil or 6 inches of topsoil high in coarse fragment content (rocky soil) could be placed, again depending on available topsoil resources. If enough topsoil is available, 12 inches on 3:1 slopes would be best. If not, 6 inches of "rocky" soil could be placed. In this latter circumstance, revegetation efforts should target a shrub-dominated community which would primarily target wildlife habitat (shrubland) rather than grazing land. Finally, on south-facing slopes (which, on occasion, could become a modest "sacrifice area" because of incident solar radiation), slopes could be steepened to 2.5:1 although 3:1 is best. These slopes should then receive a minimum of 6 inches of "rocky" soil over a rocky substrate and be revegetated to primarily target a shrub-dominated community. It is important that several erosion control and moisture retention measures be

implemented if this option is selected due to insufficient soil resources. The south-facing slope soils must be high (> 30%) in coarse fragment content to act as a natural "rock mulch" thereby diminishing erosion potential. The substrate material, also high in coarse fragment content, should exhibit "fines" of a material with a strong water holding capacity (e.g., loam texture) to provide moisture for deep-rooted shrubs during the hot summer months. Furthermore, the steeper the slope, the greater the need for mechanical measures to interrupt erosion. Such measures include terracing, contour ripping, dozer tracking, dozer basins, etc. Finally, if such an option appears to be necessary because of insufficient soil resources, a revegetation specialist should be consulted to assist with the final design specifications to maximize the potential for success in the most difficult of revegetation circumstances.

Surface Material Preparation: Once the project area has been regraded to approximate final configuration and growth media placed at appropriate depths, areas of steeper slopes (>3:1) should be deep ripped with a single or double-toothed chisel plow pulled by a D8 or equivalent dozer. Deep ripping must occur along the contour to a minimum depth of 24 inches to break the "slippage" zone between spoil materials and growth media and to create contour ridges to help preclude erosion. Ripping should 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 should again occur on the contour, but the depth can be reduced to 18 inches and the interval between "rip lines" can be increased to 10 or 12 feet. Flat areas (< 5:1 slopes) do not need to be ripped unless haulage traffic has compacted the replaced growth media. In such compacted circumstances, ripping should follow the procedures for steep slopes.

Immediately prior to seeding (see below), the entire surface of the reclaimed area should be drag harrowed or disked with a rubber-tired tractor or light-footprint small dozer to break up any surface crusting that has occurred since distribution of growth media. This activity must occur along the contour to prevent creation of preferred erosional pathways.

4.2.2 Fertilization Recommendations

Higher fertilizer rates can often decrease the success of desirable plant species because most native perennial species have adapted to low-fertility soils. Furthermore, incorrect fertilizer compositions can increase cheatgrass (and other annuals) ground cover percentages primarily due to the inclusion of nitrogen in the mix. Weedy annuals typically take full advantage of any extra nitrogen applied with fertilizer or mulch materials. Therefore, all fertilizer materials should be applied in response to recommendations based on the results of site-specific soil tests less the inclusion of any nitrogen. The following soil sampling methodology is offered as a basis for developing a site-specific sampling program.

General Procedures

The laboratory selected to analyze the samples should be contacted at least 15 days in advance of the sampling period to aid in coordinating sample analysis with the beginning of revegetation activities on site. All samples should be taken with either a tile spade or soil auger. This equipment must be free of all foreign substances and rust and not of galvanized construction. Approximately one quart of material should be collected for each sample.

All samples will be placed in clean polyethylene bags at the time of collection and securely sealed for delivery to the laboratory. All efforts should be made to deliver the samples to the laboratory as soon as possible. When samples cannot be delivered within 24 hours of collection, samples should be air-dried. (Approximately 48 hours can be considered a sufficient time for air-drying.) Samples should be dried in as dust-free of an environment as is possible.

Specific Procedures

Two samples should be collected representing the surface 24 inches of seedbed material at each sampling point. Where soil or growth media has been respread over the surface to be reclaimed, the upper sample should represent the depth of soil applied and the lower sample the sub-base material to a maximum depth of 24 inches. Where soil has not been applied or the seedbed consists entirely of soil material, a single sample should be collected representing the 0 to 24 inch depth of seedbed material. For each set of samples, the average slope and estimated percent coarse fragment content by volume should be noted on the bags and recorded in a notebook.

At least one set of samples should be taken for each specific treatment area to be reclaimed. The number of samples to be collected will be at the discretion of the planting supervisor. Sample compositing for larger acreages is recommended. All sample site locations should be noted on a project map and / or GPS located.

Each sample should be analyzed at a minimum for:

- pH,
- texture (field method),
- percent organic matter,
- NH_4-N and NO_3-N (ppm),
- phosphorus (ppm),
- potassium (ppm),
- electrical conductivity (mmhos/cm),
- lime estimate, and
- sodium adsorption ratio if advisable.

Other parameters may be added where prior sampling results indicate the potential for plant establishment and growth constraints related to growth medium chemical or physical characteristics.

Accompanying each composite sample should be a brief discussion of the area from which the sample was collected. The discussion should include comments concerning:

- plant species to be established,
- type of seedbed preparation techniques to be employed,
- type of mulching practices to be employed, if applicable,
- approximate slope,

- any special problems or conditions such as cheatgrass infestation, and
- past and future land use considerations.

Again, all fertilizer should be applied as a result of laboratory recommendations based on a site-specific soil-sampling program. In evaluating laboratory data / recommendations, it is important to remember that lower (typically zero) nitrogen application rates correlate well with higher desirable (native) species cover percentages and lower cheatgrass / annual cover values. Adequate soil-phosphorus levels must be present at least during the first growing season to promote the establishment of desirable grass species. A split fertilizer application, with the recommended amount of nitrogen being applied the 2nd or 3rd spring following the first growing season could promote desirable plant species growth and inhibit the initial establishment of cheatgrass. However, if cheatgrass or other annuals contribute more than 1% ground cover after two years, **nitrogen should not** be applied.

Fertilizer materials should be applied in operations separate from seeding. To be most efficient and/or effective, fertilizer must be incorporated into the seedbed prior to seeding and not be allowed to remain on the seedbed surface. Surficially applied fertilizer that is not worked into the soil relies on leaching to drive the fertilizer elements into the upper levels of the growth medium thereby enhancing plant availability. It is unlikely that this occurs to the desirable degree under the precipitation conditions characterizing the St. Anthony project site. The need for incorporation is particularly important for phosphorus, which is essential for plant root growth. This element is considered immobile and not subject to leaching to any degree. Fertilizer application would ideally occur immediately prior to growth media placement or the recommended deep ripping activity previously indicated.

4.2.3 Mulching Recommendations

The need for an application of mulch is often a matter of professional judgment dependent upon the site-specific circumstances of the target area. If growth media, seedbed preparation techniques, and precipitation potential are conducive to rapid establishment of selected species, then the need for mulch is minimized. To the contrary, if rapid establishment is questionable, and growth media are subject to excessive erosion, then the need for mulch should be stipulated.

If mulch is utilized at the St. Anthony site, it may take many forms, however, one of the best for arid-land use is a sterile manure (high organic content) applied hydraulically at a rate of between 2 and 4 tons per acre following seeding. However, this procedure tends to be more costly than other mulching techniques and may require road access for spray equipment. A less expensive but highly effective alternative would be the use of 2 tons per acre of a sterile and weed-free straw mulch crimped into the

soil surface following seeding. Crimping is accomplished with a rubber-tired tractor or low ground-pressure small dozer pulling a standard agricultural disk with the coulters set parallel to the direction of travel.

4.2.4 Seeding Recommendations

Seeding Date: Fall (late October / November) is the preferred season for seeding in the Western United States. Early spring (March) is the secondary season assuming that seeding can be completed prior to the most intense spring rains. Late season seeding dates will encourage both cool-season and warm-season grasses. Early spring seeding dates will tend to favor the slower growing warm-season grasses, however the risk of poor emergence is greater with spring seedings.

Specify Species Varieties: Selected varieties of seed should be specified for planting where adapted varieties of desirable species exist. This will go far to insure that the highest quality seed is obtained for planting. Where adapted varieties do not exist, seed collected from sources with environmental conditions similar to the mine site should be obtained.

General Seeding Techniques: Only seeding methods which place the seed in direct contact with the soil should be considered acceptable for use. Seed should not be mixed with mulch or applied over established vegetation stands unless it can be drilled into the seedbed. Most shrub seed will likely have seeding depth requirements different than those of the grass species to be seeded. Shrub and forb seed is usually spread on the surface, and not incorporated into the seed bed.

Regardless of the seeding method employed, provisions should consistently be made for lightly covering seed with soil following seeding operations. This is a basic agronomic practice that should be followed to enhance revegetation success potential. Seed coverage is incorporated as a part of the drill seeding technique. With broadcast seeding or two-step hydromulching, seed coverage can be accomplished with chain drags, small-tined harrows, or other similar implements. Some natural seed coverage will result from broadcasting or hydroseeding into a rough seedbed where soil sloughing occurs. Seed applied to smooth or crusted soil surfaces will simply "disappear" with the winds.

Drill Seeding: Drill seeding is commonly considered to be an efficient, cost-effective means of seeding which has a strong history of success in the western states. With drill seeding, less seed is required for planting than for any form of broadcast seeding, seed is planted at the proper depth, and seed is covered mechanically as a function of the technique. The major drawback to drilling is its typical limitation to slopes of 3:1 or flatter. Drill seeding should occur on the contour with a rangeland drill.

Broadcast Seeding: Broadcast seeding is commonly considered the second most effective means of seeding, especially if performed by an experienced seeding contractor. With broadcast seeding, more seed is required for planting to compensate for the inability to place the seed in direct contact with the soil in the most advantageous manner with consistency. The major advantage of this seeding technique is that it can be used on any slope that is accessible by machinery, or on-foot with the use of personal hand-crank operators. Shrub and some forb seed should be broadcast with the permanent seed mixture during or immediately following initial drilling operations. Shrub seed should not be applied to a seedbed previously mulched or to any seedbed where seed might be prevented from coming into contact with the soil surface. Areas designed to target grasslands will typically reduce shrub establishment potential (due to competition from grasses). However, a small component of shrub seed in the mixture will facilitate formation of shrub patches where conditions favorable to shrub establishment are encountered. Where both shrub and grass seed are spread coincidentally, a broadcaster is often mounted on the seed drill. The drill distributes the grass seed and the broadcaster distributes shrub and forb seeds. A light chain drag is pulled behind to lightly cover the shrub and forb seed.

Establishment of Shrubs: With regard to shrub establishment, the following points should be noted. First, the expensive process of hand-planting live tublings has very limited potential for success in the project area. If it is attempted, points two and three must be given careful attention and a shrub maintenance program must be employed following planting. Second, lesser topsoil depths and rockier topsoil appear better for shrub establishment assuming the underlying material is not toxic or an otherwise poor growth medium. Third, when trying to establish more than a few scattered shrubs, the amount of grass seed to be planted needs to be substantially reduced to reduce moisture competition. Fourth, more droughty exposures with favorable water holding capacity deeper in the soil profile appear to favor shrub establishment with this point again related to the density of competing grasses. For resoiled areas targeting grasslands, it is recommended to always include a small amount of shrub seed in the standard mix to take advantage of climatically advantageous years. Otherwise, attempting to establish stands of shrubs in a short time period may result in certain problematic conditions. Conversely, in areas targeting shrublands, the seed mix should be far more heavily weighted toward shrubs especially when planting seedbeds composed of non-toxic waste materials without topsoil or with rocky growth media.

Plant Candidates / Recommended Seed Mixtures: Tables 15 and 16 on the following two pages exhibit Cedar Creek's recommend mix for two targeted post-reclamation communities at St. Anthony, Grassland (for livestock grazing land uses) and Shrubland (for wildlife habitat land uses). The specific recommendations for placement of these two types are provided in Section 4.2.1 above. Although these two community types will be targeted with regard to their most favorable circumstances,

there can be no guarantee (hence associated success criterion) that grasslands and/or shrublands will evolve where intended. It has been Cedar Creek's experience that natural environmental influences (such as precipitation) will complicate the best designs. For example, if a shrub conducive mix is placed on shrub conducive soils and precipitation over a two-year period is both plentiful and well distributed, the grass seed in the mix will establish, flourish, and out compete the shrubs in the short term. To the contrary, if a grass conducive mix is placed on grass conducive soils and precipitation is sporadic and limited, shrub establishment may be encouraged. Regardless, the two seed mixes have been designed for average precipitation circumstances and expected soils / topographic conditions post-reclamation to give the best probabilities for successful revegetation and eventual release of liabilities.

Review of these two mixes, however, will reveal that the amount of grasses in the shrub conducive mix has been substantially reduced. To the contrary, some shrub seed has been included with the grassland conducive mix to take advantage of climatically favorable years for shrub establishment.

Table 15

UNC St. Anthony - Cedar Creek's Recommended Seed Mix*

For Areas Targeting Grassland - (Livestock Grazing Land Use)

Grassland Mix

No.	Obs. On Site	Common Name	Scientific Nomenclature	Recommendations: PLS/lb.**	Recomd. PLS lbs/ac	PLS / ft²	% of Seeds in Mix	Comment (Based on Site-specific Findings or Professional Judgment)
								This entire mix can be drill seeded
1	XX	Western wheatgrass	*Agropyron smithii*	110,000	1.50	3.8	4.4%	NRCS indicated climax species
2	XX	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.75	30.3	35.3%	NRCS indicated climax species
3	XX	Blue Grama	*Bouteloua gracilis*	825,000	0.50	9.5	11.0%	Stong component of native community
4	XX	Galleta	*Hiliaria jamesii*	159,000	0.50	1.8	2.1%	Stong component of native community
5		Thickspike Wheatgrass	*Agropyron dasystachyum*	154,000	1.00	3.5	4.1%	Good performer - Offers diversity
6	XX	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	3.8%	Should do well in areas of sandy texture
7	XX	Sideoats Grama	*Bouteloua curtipendula*	191,000	1.00	4.4	5.1%	Good performer - Offers diversity
8	XX	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	0.25	1.1	1.3%	Fair performer - Offers diversity
			Subtotal		**6.50**	**57.6**	**67.1%**	
9	XX	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.75	8.6	10.0%	Sufficient performer for diversity
10		Palmer Penstemon	*Penstemon palmeri*	610,000	0.50	7.0	8.2%	Good performer - Offers diversity
11	XX	Rocky Mountain Penstemo	*Penstemon strictus*	592,000	0.25	3.4	4.0%	Fair performer - Offers diversity
12		Lewis Flax	*Linum lewisii*	293,000	1.00	6.7	7.8%	Good performer - Offers diversity
			Subtotal		**2.50**	**25.7**	**30.0%**	
13	XX	Fourwing Saltbush	*Atriplex canescens*	52,000	1.00	1.2	1.4%	NRCS indicated climax species - good forage value
14	XX	Winterfat	*Ceratoides lanata*	56,700	1.00	1.3	1.5%	Excellent performer - good forage value
			Subtotal		**2.00**	**2.5**	**2.9%**	
			Total		**11.00**	**85.8**		This entire mix can be drill seeded

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

Grasses	XX	Sand Dropseed	*Sporobolus cryptandrus*	5,298,000	0.00	0.0		
		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		Small Burnet	*Sanguisorba minor*	55,000	0.00	0.0		
Shrubs		Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.00	0.0		
		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. Substitutions should be: grass for grass, forb for forb, shrub for shrub.

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

* The 11 lb/ac mix is designed for drill seeding. When broadcast and harrow methods are used, 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.

Table 16

UNC St. Anthony - Cedar Creek's Recommended Seed Mix*
For Areas Targeting Shrubland - (Wildlife Habitat Land Use)

Shrubland Mix

No.	Obs. On Site	Common Name	Scientific Name	Recommendations PLS/lb.**	Recomd. PLS lbs/ac	PLS / ft²	% of Seeds in Mix	Comment (Based on Site-specific Findings or Professional Judgment)
								This entire mix can be Broadcast Seeded
1	XX	Western wheatgrass	*Agropyron smithii*	110,000	0.75	1.9	2.4%	NRCS indicated climax species
2	XX	Alkali Sacaton	*Sporobolus airoides*	1,758,000	0.25	10.1	12.7%	NRCS indicated climax species
3	XX	Indian Ricegrass	*Oryzopsis hymenoides*	141,000	1.00	3.2	4.1%	Should do well in areas of sandy texture
4	XX	Sideoats Grama	*Bouteloua curtipendula*	191,000	0.75	3.3	4.2%	Good performer - Offers diversity
			Subtotal		**2.75**	**18.5**	**23.4%**	
5		Lewis Flax	*Linum lewisii*	293,000	1.15	7.7	9.8%	Good performer - Offers diversity
6		Palmer Penstemon	*Penstemon palmeri*	610,000	1.00	14.0	17.7%	Good performer - Offers diversity
			Subtotal		**2.15**	**21.7**	**27.5%**	
7	XX	Fourwing Saltbush	*Atriplex canescens*	52,000	3.00	3.6	4.5%	NRCS indicated climax species
8	XX	Winterfat	*Ceratoides lanata*	56,700	3.00	3.9	4.9%	Excellent performer - good forage value
9		Wyoming Big Sagebrush	*Artemisia tridentata wyo.*	2,500,000	0.35	20.1	25.4%	Occasional performer - Offers diversity
10		Cliffrose	*Purshia mexicana*	64,600	3.00	4.4	5.6%	Fair performer - Offers diversity
11		Rubber Rabbitbrush	*Chrysothamnus naseousus*	400,000	0.75	6.9	8.7%	Fair performer - Offers diversity
			Subtotal		**10.10**	**38.9**	**49.2%**	
			Total		**15.00**	**79.2**		This entire mix can be Broadcast Seeded
Alternative species which may be used as substitutes for tertiary species or added to the overall mix for additional diversity.								
Grasses	XX	Sand Dropseed	*Sporobolus cryptandrus*	5,298,000	0.00	0.0		
	XX	Blue Grama	*Bouteloua gracilis*	825,000	0.00	0.0		
	XX	Galleta	*Hiliaria jamesii*	159,000	0.00	0.0		
	XX	Bottlebrush Squirreltail	*Sitanion hystrix*	192,000	0.00	0.0		
	XX	New Mexico Needlegrass	*Stipa neomexicana*	70,000	0.00	0.0		
Forbs	XX	Desert Globemallow	*Sphaeralcea ambigua*	500,000	0.00	0.0		
	XX	Rocky Mountain Penstemo	*Penstemon strictus*	592,000	0.00	0.0		
		Small Burnet	*Sanguisorba minor*	55,000	0.00	0.0		
Shrubs		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. Substitutions should be: grass for grass, forb for forb, shrub for shrub.

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

* The 15 lb/ac mix is designed for broadcast & harrow seeding. If drill seeding is used the rate should be decreased by 1.5 times. When hydroseeding methods are to be used, the rate should be increased (1.5 times). ** PLS = Pure Live Seed.

5.0 REVEGETATION MONITORING AND BOND RELEASE CONSIDERATIONS

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, Cedar Creek recommends that a qualified revegetation specialist review the revegetated areas on a periodic basis to catch developing problems early in the process. Based on a program that has worked well at other operations, this schedule of monitoring would occur as follows:

Year 1 – Qualitative, semi-quantitative, and/or quantitative evaluations (managerial info. only).
Year 2 – Qualitative and quantitative evaluations (managerial info. only).
Year 5 – Qualitative and quantitative evaluations (managerial info. only).
Year 8 – Qualitative and quantitative evaluations (managerial info. only).
Year 11 – Quantitative evaluations (Statistically defensible, Sufficient for Bond Release).
Year 12 – Quantitative evaluations (Statistically defensible, Sufficient for Bond Release).

As indicated, the final effort during years 11 and 12 would be an evaluation for a bond release determination. Year 11 information will provide verification that bond release testing can and should occur in Year 12, otherwise monitoring would continue once each 3 years. Other than first year efforts, monitoring should be a combination of both qualitative and quantitative efforts to facilitate tracking and progress toward revegetation success standards. Assuming that reseeding takes place over two a two-year period (Fall of 2007 and Fall of 2008) the following schedule (Table 17) would be utilized for revegetation monitoring at St. Anthony.

Table 17
REVEGETATION MONITORING SCHEDULE

Year	For areas reseeded in 2007	For areas reseeded in 2008
2008	Monitor for Year 1	
2009	Monitor for Year 2	Monitor for Year 1
2010		Monitor for Year 2
2011 – No Activity		
2012	Monitor for Year 5	
2013		Monitor for Year 5
2014 – No Activity		
2015	Monitor for Year 8	
2016		Monitor for Year 8
2017 – No Activity		
2018	Monitor for Year 11	
2019	Monitor for Year 12 and Test	Monitor for Year 11
2020		Monitor for Year 12 and Test

5.2 Revegetation Monitoring Procedures

Monitoring and eventual testing will involve sampling of ground cover and where appropriate, production and woody plant density, within each revegetated unit to be evaluated (or under consideration for bond release) and in the two extended reference areas - Bottomland and Juniper Scrub, to provide comparison parameters. (Comparison parameters should be weighted 82% Bottomland and 18% Juniper Scrub based on pre-disturbance acreages for a weighted comparison; or targeted grasslands should be compared to Bottomland parameters and targeted shrublands compared to Juniper Scrub parameters.) 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. Long belt transects [2m x 50m ($100m^2$)] or total population enumeration will be used for woody plant density determination. Production will be evaluated by clipping current annual herbaceous biomass from $^1/_2$ m^2 rectangular quadrat frames.

Sampling

Sampling procedures will closely approximate those used for data developed within this document as discussed in Section 2.0. The first step of the vegetation sampling protocol will be to obtain samples of the ground cover and, where appropriate, co-located woody plant density and current annual production, from each revegetated unit to be evaluated. [A revegetated unit consists of a defined area based on managerial criteria (e.g., areas with common revegetation procedures and initiation times, areas with a defined function such as a borrow area, or areas with other unique designations or segregation)]. Ground cover and production samples, but no woody plant density, will also be obtained from the extended reference areas. (No woody density information is deemed necessary from the extended reference areas as comparisons will be to a fixed standard.) Sampling will occur during the peak biomass period of the year (late summer - September) and sampling locations will be determined utilizing a systematic (bias-free) method with a random start.[1] This systematic procedure also provides proportionate representation from across each reclaimed unit for such characteristics as aspect.

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[1] Systematic sampling is superior to other sample distribution procedures because it forces representation from across the reclaimed unit. It accounts better for heterogeneous expressions of multiple seedings or revegetation conditions by "forcing" a patterned distribution of samples. This method thus minimizes the risk that significant pockets will be either entirely missed or overemphasized.

Sample Site Location. The systematic procedure for sample location in both a revegetated unit and the extended reference areas will occur in the following stepwise manner. First, a fixed point of reference will be selected for the area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions will be selected to provide a reasonable number (e.g., 20) of coordinate intersections that could be used for the initial set of sample sites. Third, a scaled representation of the grid will be overlain on field maps of the target unit extending along north/south and east/west lines. Fourth, the initial placement of this grid will be implemented by selection of two random numbers (an X and Y distance) to be used for locating the first coordinate from the fixed point of reference, thereby making the effort unbiased. Fifth, where an excess number of potential sample points (grid intersections) is indicated by overlain maps, the excess will be randomly chosen for elimination (unless it is later determined that additional samples are necessary for meeting sampling adequacy). Sixth, utilizing a handheld compass and pacing techniques, the sample points will be located in the field.

Ground Cover Determination. Ground cover at each sampling site will be determined utilizing the point-intercept methodology as illustrated on Figure1. This methodology has been utilized for range studies for over seventy (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 (see Figure 1). 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.

Woody Plant Density Determination. Woody plant density will be determined in one of two manners depending upon testing to be used or a visual evaluation of the variability of the expressed population by an experienced field ecologist. If the population of woody plants appears to be sufficiently homogenous across the revegetated unit or reverse-null testing will be used, density will be determined through a systematic sampling protocol utilizing large quadrats or belts. If the population appears to be too heterogeneous, enumeration of the entire population, or nearly the entire population, may be the only reliable means available to determine density of woody plants. (Newly establishing woody plant

communities are often so inherently variable that no sampling protocols presently known to the scientific community could be utilized to obtain a viable estimate of the population's parameters.)

If it is determined that belt sampling can be used, belts will be sized to absorb as much of the "between sample" variability as possible, and then fixed at this size for the duration of the sampling effort. Typical belt dimensions would be 2 meters X 50 meters, however, it is possible that 4 meter X 100 meter belts could be utilized. All woody plants rooted within each belt would be recorded by species.

If total or near-total population enumeration is deemed most appropriate then the following protocol would be initiated. First, the various stands of woody plants within a revegetated unit would be delineated and their respective acreages determined through GPS procedures. Then beginning with the largest stands and working down to the smallest, each will be subjected to total count procedures until all or a large percent of the area (e.g., 90%) has been counted. This procedure maximizes use of personnel and resources, and the vast majority, if not all, of the population will be entirely enumerated with the worst possible error equivalent to the uncounted portion of the population (e.g., 10%). If total enumeration is impractical, sampling with belts and reverse-null testing is the only remaining option.

Enumeration procedures would occur as follows. Once a stand of woody plants is delineated, it would be subdivided into long manageable strips using hip chain thread or similar means and observers would progress slowly across each strip, shoulder to shoulder, recording each plant by species. Use of hand-held "tally meters" facilitate uninterrupted viewing of the subject area and communication among the observers precludes gaps in the field of coverage or duplication of effort (overlapping fields of view).

Production. At each production sample site, current annual herbaceous production will be collected from a $^1/_2$ m^2 quadrat frame placed one meter and 90º to the right (clockwise) of the ground cover transect to facilitate avoidance of vegetation trampled by investigators during sample site location (see Figure 1). From within each quadrat, all above ground current annual herbaceous vegetation within the vertical boundaries of the frame will be clipped and bagged separately by life form as follows:

Perennial Grass
Introduced Perennial Grass
Annual Grass
Sub-Shrub
Native Perennial Forbs
Annual Forb
Introduced Forb
Noxious Weeds

All production samples will be returned to the lab for drying and weighing. Drying will occur at 105º C to a stable weight (after 20 - 24 hours). Samples will then be re-weighed to the nearest 0.1 gram.

Sampling Adequacy. Sampling adequacy will not be necessary for managerial level monitoring data collected prior to Year 11. Data collection for Year 11 and bond release (Year 12) will continue within each discrete sampling unit (revegetated unit or extended reference area) for each variable until a statistically adequate sample has been obtained. Two exceptions are possible. The first exception is if reverse-null hypothesis testing is employed. In this case, use of parameters from an adequate sampling effort is not a statistical requirement. The second exception is that collection of a statistically adequate woody plant density sample will not be necessary given the near impossibility of this circumstance. Instead, one woody density belt will be co-located with each ground cover transect and the resultant data will be deemed sufficient unless reverse-null testing is to occur with woody density data in which case a minimum of 30 samples will be collected.

Adequacy of sampling 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 with 90% confidence (n_{min}), i.e., when $n_{min} \leq n$. Then 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 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 or, in the case of production, "total weight per quadrat". Furthermore, a minimum sample size of twenty (20) samples will be collected from each discrete revegetated unit or extended reference area. 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 or 50 production samples be collected in any given sampling unit.

5.3 Revegetation Testing for Bond Release

Following field evaluations during Years 11 and 12 using the protocols detailed above, the collected parameters (for cover and production) for the extended reference areas will be compared with the target revegetated unit(s) 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 sampling from each of the areas at the level of significance of α = 0.1 with 90% confidence. For production and woody plant density, testing will likely involve a "reverse-null" hypothesis testing procedure, either against reference area data (production) or a proposed standard (woody plant density). (Diversity testing will be a direct mathematical comparison against set standards such as 3 perennial grasses and 1 shrub contributing more than 1% of the composition.) Because the "reverse-null" hypothesis test is not a commonly understood test, the following paragraphs have been provided to more fully explain this process.

For this 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" null 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 90% 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 90% of the reference area or standard. Therefore, once a sample has been collected from both the target area of interest and the extended reference area (or standard), 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:

$$t_c = \frac{\bar{x}_{rv} - 0.9\bar{x}_{ra}}{\sqrt{s_p^2\left(\frac{1}{n_{rv}} + \frac{1}{n_{ra}}\right)}}$$ Where the pooled variance s_p^2 =

$$s_p^2 = \frac{\left[(n_{ra} - 1)0.81s_{ra}^2 + (n_{rv} - 1)s_{rv}^2\right]}{(n_{ra} + n_{rv}) - 2}$$

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

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

$$t_c = \frac{\bar{x}_{rv} - 0.9\bar{x}_{ra}}{\sqrt{w_{rv} - w_{ra}}} \text{ Where } w_{ra} = \frac{0.81 s_{ra}^2}{n_{ra}} \text{ and } w_{rv} = \frac{s_{rv}^2}{n_{rv}}$$

and the degrees of freedom are approximated by :

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

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

For one-sample testing (against a standard), the following test would be performed:

$$t_c = \frac{\bar{x}_{rv} - 0.9Q}{s/\sqrt{n}}$$

Where: Q = the standard (e.g. 200 woody plants per acre).

Then if $t_c > t$ for $t_{(\alpha=0.1,\ n-1\ \text{d.f.})}$ the test is successful.

5.4 Revegetation Success Considerations / Criteria

Revegetation success would take into account the following three factors:

- Comparison would be to an approved extended reference area(s) representative of the adjacent vegetation communities and/or desirable ecological conditions (for the variables of ground cover and production) and to technical standards for woody plant density and diversity;
- Plant species present in the approved (and planted) seed mixes; and
- The post-mining land use (livestock grazing and/or wildlife habitat).

When utilizing extended 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. The two principal allowances involve the density of woody species and the overall species composition. It is for this reason that standards will be the target of reclamation efforts for these variables, rather than comparison to late seral reference areas.

Revegetation success in revegetated units planted primarily as grassland (targeting livestock grazing land uses and grassland wildlife habitats) would concentrate on two primary performance standards (1) vegetative ground cover, and 2) current annual production. To facilitate wildlife habitat considerations on areas planted to specifically target shrublands, two additional, but subordinate performance standards will be added: (3) species diversity and (4) woody plant density. These second two standards must necessarily be subordinate because elevated values for diversity and woody plant density can only be obtained at the expense of the first two primary variables* that would then compromise the intended post-mining land use.

Therefore, revegetation efforts will be considered successful when the following criteria and standards have been met at the end of the 12-year responsibility period.

1. Vegetative Ground Cover Criterion

Vegetative ground cover must meet the following test on all targeted land uses:

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

* It is a commonly understood tenet of reclamation ecology that cover and production tend to be mutually exclusive with the variables of diversity and woody plant density within the typical time frames observed for reclamation. If diversity and density are set too high, success can only be obtained by compromising the two primary variables.

2. Vegetative Production Criterion

Herbaceous production must meet the following test for livestock grazing land uses:

The total herbaceous production (exclusive of annual or listed noxious species) in the revegetated unit equals or exceeds 75 percent of the approved extended reference area's total herbaceous production (exclusive of annual or listed noxious species), with 90 percent statistical confidence.

3. Species Diversity Standard (secondary criterion for wildlife habitat land uses only):

Diversity, as indicated by number of important species[2] (exclusive of listed noxious weeds) in each revegetated unit or combination of units, equals or exceeds the following standard: 3 perennial grasses, 0 perennial forbs, and 1 woody plant with more than 1% relative cover (composition). The "0" perennial forbs is based on the fact that no forbs currently exhibit more than 1% composition in the "baseline" data set (see Table 3).

4. Woody Plant Density Standard (secondary criterion for wildlife habitat land uses only):

The density of live shrubs, succulents, and/or trees (in revegetated units where shrubs and trees are to be specifically planted for wildlife habitat) must be 200 per acre or more.

5.5 Contingency Plan and Conditions for Final Bond Release

If at any time during or after Monitoring 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 MMD 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 MMD for review and approval. Following MMD approval, the corrective action plan will be implemented by the applicant.

[2] An important species is defined as one that provides at least 1 percent relative cover (composition), and therefore, contributes more significantly to the community.

If a revegetated unit fails to meet a performance standard following Year 11 monitoring after the applicant's substantial compliance with the Closeout Plan and after an 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 under 19 NMAC 10.2 Subpart 5, § 507.A (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 under 19 NMAC 10.2 Subpart 5, § 506.C (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 under 19 NMAC Subpart 10 (the standard imposes undue economic burden, and the variance will not result in a significant threat to human health, safety, or the environment).

Once all applicable revegetation performance standards have been met for a revegetated unit, and all other permit-related reclamation requirements for that unit have been satisfied, then conditions for final bond release and release from future liability will also be met and sureties covering that respective unit will be released.

6.0 LITERATURE CITED

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

Parham, Tommie Lee. 1993. Soil survey of Cibola Area, New Mexico, parts of Cibola, McKinley, and Valencia counties. United States Department of Agriculture Soil Conservation Service.

APPENDIX A

VALUE OF GROUND COVER FOR EVALUATING REVEGETATION AND COMPARISON OF COVER MEASUREMENT METHODOLOGIES

Ground cover is at least one of the primary vegetation comparison variables designated for use by nearly all Western regulatory agencies, especially those charged with oversight of revegetation efforts following mining. For example Nevada's "Standards for Successful Revegetation" rely entirely on the variable of ground cover for surety release comparisons. In the coal mining industry, surety release determinations use ground cover as one of the main indices for revegetation establishment and growth. Ground cover represents one of the most accurate, precise and cost-effective floral variables that can be measured on young reclaimed plant communities. Therefore, ground cover is considered one of the best variables, if not the best, to be used to ascertain revegetation success on mined lands. The advantages of using ground cover as a primary success evaluation variable include:

- **Simplicity**-. Concentration on a single variable of plant ecology facilitates improved comprehension and comparability over time or between reclaimed areas, thereby allowing direct and impartial evaluation of revegetation success. Ground cover is a readily measured plant variable that is easily understood and compared. It has the advantage in that both cover and plant diversity (composition) can be evaluated from a single collected data set. Also, surety release evaluations based on multiple variables overly complicate the process. Such evaluations may be inappropriate and / or problematic for early seral comparisons as mutually exclusive tendencies between variables increase the potential for an artificial failure.

- **Temporal and Spatial Comparability**-. Trends in cover can be established and evaluated for a specific reclaimed area over time. Differences and similarities between multiple reclaimed areas of differing ages or treatments can be readily established spatially at a single point in time. Ground cover data facilitate the determination of species composition or diversity (using a simple conversion), relative health (condition), and can be used to track the seral successional status of a sampled area (i.e. whether or not the area is advancing or regressing along the successional continuum). Furthermore, the same data can be utilized to develop a "sister" variable, frequency, if desired.

- **Precision and Accuracy**-. When using bias-free techniques, such as the point-intercept method, it is one of the most repeatable variables among independent observers. No other plant measurement can be recorded as accurately or precisely as ground cover, and given the

advent of modern instrumentation, such precision can be obtained in a very cost-effective manner.

- **Correlation with Production**-. Strong inferences or correlations can be developed between ground cover and annual biomass, since they are both directly influenced by species composition as well as the timing and amount of precipitation received during the growing season.

- **Sample Population Requirements / Statistical Adequacy**-. Ground cover is a preferred variable for revegetation success determination because a significant amount of cover data can be readily obtained in a statistically adequate, acceptable, and cost-effective manner (assuming use of unbiased procedures). This relates to the inherently lower variability of ground cover.

- **Sediment and Erosion Control Modeling / Design**-. Ground cover data has direct application and is readily used for a number of purposes in erosion and sediment modeling and design. For example, it is one of the primary input variables for use in the Revised Universal Soil Loss Equation (RUSLE).

- **Species Dominance and Diversity**-. Ground cover data (determined using the point-intercept procedure) provides some of the most important information regarding community variability that can be obtained and evaluated. Ground cover data closely reflects species dominance within the evaluated area.

While ground cover is often the preferred variable for evaluating the success of reclaimed mined lands, it is important to note that ground cover estimation methods are not equally precise or reliable. To further complicate the overall process, various ground cover measurement methods and practices may be more appropriate to specific vegetation community structure or conditions. In this regard, it is generally accepted that there are four principal groups of techniques available to field biologists for the determination of ground cover including: 1) plotless or variable plot (a form of 2 – dimensional), 2) quadrat (2-dimensional), 3) line-intercept (1-dimensional), and 4) point-intercept (0-dimensional).

Plotless (or variable plot) techniques are used most frequently in forestry applications for the inventory of timber stands and are, therefore, of little value for revegetation monitoring of mining disturbances in the arid and semi-arid West. A good example of such a technique is the use of a wedge prism for determination of tree basal area.

Quadrat techniques are based on 2 – dimensional frames of a specific size and shape and are highly dependent upon the judgment of an observer who may or may not be experienced in their use. Most commonly, the observer must mentally integrate all vegetation by species into a single portion of a quadrat and compare this mental picture to demarcations on the quadrat frame. Although an experienced biologist can "read" a quadrat frame relatively quickly, the procedure automatically incorporates three additional, and often substantial, sources of variation beyond that which is natural. These include: 1) observer bias because of the "judgment" involved; 2) variation due to the size of the quadrat; and 3) variation due to the shape of the quadrat. These additional sources of "artificial" variation are often significant and can result in highly variable data of low value (i.e. comparisons made with such data are of limited utility). Up to 30% or more sampling error can occur with this technique.

Line-intercept (1 – dimensional) techniques are generally considered to be the second best method for measuring ground cover (Bonham, 1989) although these exhibit at least four negative attributes. First, to be implemented properly, the procedure is very time-intensive. Second, data regarding other ground cover features such as litter, rock, and bare soil exposure are usually not collected due to the inordinate time it takes to collect such data. Third, a moderate amount of bias is possible as the observer must make judgments regarding which portions of the plant canopy actually intercept the line (tape). Fourth, the technique tends to somewhat overstate vegetation cover as observations typically involve the perimeter of a plant's canopy despite the fact that such canopies are not solid cover (i.e., underlying material can often be seen through the gaps in the canopy). Between 5 and 15% sampling error can typically occur with this technique.

This leads to the final and best method for measuring ground cover, the "dimensionless" point-intercept procedure. According to the most knowledgeable professionals active in the reclamation industry as well as academicians, it is the most objective and repeatable technique for estimating ground cover because decisions (judgment) by an observer are virtually eliminated. If historic instrumentation (pin frame) is utilized, the technique can be time consuming, limited to short herbaceous species, and if not properly implemented can lead to an overstatement of cover similar to that which occurs with line-intercept. However, use of modern instrumentation such as optics with fine cross-hairs or finely-focused specialized lasers practically eliminates these difficulties leaving only the positive attributes of the technique -- precision, objectivity, repeatability, and cost-effectiveness. In comparison to the other techniques, statistically adequate data can be collected as much as 10 times more quickly, and such data exhibit maximum utility, especially for success evaluations. Sampling error can typically be held to under 2% with this technique.

Primary Raw Data at "Rear of Document"

Table 4 St. Anthony - Vegetation Cover - 2005

Bottomland Extended Reference Area

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**
Grasses and Grass-likes																											
P	*Agropyron smithii*	Western Wheatgrass			7																						
P	*Aristida longiseta*	Red three - awn								1																	
P	*Bouteloua curtipendula*	Side-oats grama											10	1	1	4	3										
P	*Bouteloua gracilis*	Blue grama	4	6				20	2	22	7	26												2			
P	*Hilaria jamesii*	Galleta		17			19			14	15	18	5	12	13	6		5	16	7		3	4	8	3	20	1
P	*Muhlenbergia torreyi*	Ring muhly																									
P	*Oryzopsis hymenoides*	Indian ricegrass												2													
P	*Sporobolus airoides*	Alkali sacaton	24	25	13	13	25		9				8		1	15	37				4	3	7	16	15		26
P	*Sporobolus cryptandrus*	Sand dropseed		1									1		1												
P	*Stipa neomexicana*	New Mexico Feathergrass						12		1	12																
Forbs																											
A	*Lappula redowskii*	Flatspine Stickseed																	2	1					1		
P	*Mentzelia laevicaulis*	Blazingstar																									
A	*Plantago patagonica*	Wooly plantain																									
IW	*Salsola tragus*	Russian thistle	7		11	3			13	4		4	6		1	6							9	1	1		1
	Unidentifiable					3	7						1														
Shrubs, Sub-shrubs, Cacti & Trees																											
P	*Atriplex canescens*	Fourwing saltbush			3	12	15		11				2			5		25	15	8	12	11	7	7	6	14	
P	*Ceratoides lanata*	Winterfat									2																
P	*Guttierrezia sarothrae*	Broom snakeweed			3						7	2		12	11			5	2	6	16	9		1		4	
P	*Leptodactylon pungens*	Granite prickly phlox																									
P	*Psilostrophe tagetina*	Woolly Paperflower										1		3	1												
		Total Plant Cover	**35**	**49**	**37**	**31**	**66**	**32**	**35**	**42**	**43**	**51**	**33**	**30**	**29**	**36**	**40**	**35**	**35**	**22**	**32**	**26**	**27**	**35**	**26**	**38**	**28**
		Rock																	1			1		1		1	
		Litter	7	21	7	17	11	12	21	14	6	17	24	15	22	22	9	28	12	12	14	15	17	13	31	13	10
		Bare ground	58	30	56	52	23	56	44	44	51	32	43	55	49	42	51	37	52	66	54	58	56	51	43	48	62
		Total Perennial & Biennial Cover	**28**	**49**	**26**	**25**	**59**	**32**	**22**	**38**	**43**	**47**	**26**	**30**	**28**	**30**	**40**	**35**	**33**	**21**	**32**	**26**	**18**	**34**	**24**	**38**	**27**

Sample Adequacy Calculations				
	t **=**	**1.6802**	**n =**	**45**
	Variance =	**72.97**	**n_{min} =**	**17.87**

Table 4 (Continued)

Bottomland Extended Reference Area

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.——>	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Average Cover	Relative Cover	Frequency
Grasses and Grass-likes																										
P	*Agropyron smithii*	Western Wheatgrass																						**0.16**	**0.46**	**2**
P	*Aristida longiseta*	Red three - awn												1										**0.04**	**0.13**	**4**
P	*Bouteloua curtipendula*	Side-oats grama																						**0.42**	**1.24**	**11**
P	*Bouteloua gracilis*	Blue grama		1				5	8	4	12	12	15	12	5	17	15	4	4	12	6		**4.91**	**14.46**	**42**
P	*Hilaria jamesii*	Galleta	1	2	8	18	10	12	11	23	7	10	17	12	6	14	7	4	11	15	10	14	**8.84**	**26.05**	**73**
P	*Muhlenbergia torreyi*	Ring muhly								2						3							**0.11**	**0.33**	**4**
P	*Oryzopsis hymenoides*	Indian ricegrass									3		2		2								**0.20**	**0.59**	**9**
P	*Sporobolus airoides*	Alkali sacaton	2	25	3			10	1	1				2	1		1				2	8	14	**6.91**	**20.35**	**56**
P	*Sporobolus cryptandrus*	Sand dropseed						2			1			1										**0.16**	**0.46**	**13**
P	*Stipa neomexicana*	New Mexico Feathergrass													3									**0.62**	**1.83**	**9**
Forbs																										
A	*Lappula redowskii*	Flatspine Stickseed												1										**0.11**	**0.33**	**9**
P	*Mentzelia laevicaulis*	Blazingstar													1									**0.02**	**0.07**	**2**
A	*Plantago patagonica*	Wooly plantain									1	1												**0.04**	**0.13**	**4**
IW	*Salsola tragus*	Russian thistle			10	7	1			3	3	4		1	2		2	3	6	1	5	2	**2.60**	**7.66**	**49**
	Unidentifiable								2	1													**0.31**	**0.92**	**11**
Shrubs, Sub-shrubs, Cacti & Trees																										
P	*Atriplex canescens*	Fourwing saltbush	20			6	9		4			10	3			10			1		7	3	**5.02**	**14.79**	**49**
P	*Ceratoides lanata*	Winterfat							2						2		2	13					**0.47**	**1.37**	**9**
P	*Guttierrezia sarothrae*	Broom snakeweed	7	1			7	8	3		1	2	2	1				11	3			2	**2.80**	**8.25**	**47**
P	*Leptodactylon pungens*	Granite prickly phlox								2	1			1									**0.09**	**0.26**	**7**
P	*Psilostrophe tagetina*	Woolly Paperflower																					**0.11**	**0.33**	**7**
																							Mean		
		Total Plant Cover	**30**	**29**	**21**	**31**	**27**	**37**	**31**	**36**	**29**	**39**	**40**	**31**	**22**	**44**	**27**	**35**	**25**	**30**	**36**	**35**	**33.96**		
		Rock					1					1										1	**0.16**		
		Litter	14	16	16	3	15	12	23	14	13	24	13	18	13	14	18	25	23	40	18	12	**16.31**		
		Bare ground	56	55	63	66	57	51	46	50	58	36	47	51	65	42	55	40	52	30	46	52	**49.58**		
		Total Perennial & Biennial Cover	**30**	**29**	**11**	**24**	**26**	**37**	**29**	**32**	**25**	**34**	**40**	**29**	**20**	**44**	**25**	**32**	**19**	**29**	**31**	**33**	**30.89**		

Diversity	**No. of Important (>1% Relative Cover) Perennial Sps. = 7**

Table 5 St. Anthony - Vegetation Cover - 2005

Juniper Scrub Extended Reference Area

			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
Grasses and Grass-likes																												
P	*Aristida longiseta*	Red three - awn					4									2	6	2								3		
P	*Bouteloua curtipendula*	Side-oats grama																										
P	*Bouteloua gracilis*	Blue grama			3		14	5	13	18	15	11		14	10	6	8	11	3	5	8	3	1	1	16	13		21
P	*Hilaria jamesii*	Galleta							1		13		3				2	3		5				8	7	8	6	9
P	*Muhlenbergia torreyi*	Ring muhly																	2		1	1			1	2		
P	*Oryzopsis hymenoides*	Indian ricegrass	4	1		1					1								1	1			2					
P	*Sitanion hystrix*	Bottlebrush squirreltail																						1		1		
P	*Sporobolus airoides*	Alkali sacaton		2							2			1	4	2									3			
P	*Sporobolus cryptandrus*	Sand dropseed																										
P	*Stipa neomexicana*	New Mexico Feathergrass	12	20	13	8	17	11	12		7	15	3					1	5	4		7	6				2	
Forbs																												
P	*Astragalus missouriensi*	Missouri milkvetch																										
A	*Cordylanthus wrightii*	Wright's bird's beak										1																
P	*Erigeron sp.*	Fleabane	2																									
P	*Eriogonum sp.*	Buckwheat													3		4											
P	*Eriogonum umbellatum*	Sulphur-flower buckwheat																								1		
A	*Euphorbia glyptosperma*	Ridgeseed spurge					2	1				1	2			1												
P	*Mirabilis glabra*	Smooth Four-o'clock																										1
P	*Oenothera sp.*	Evening primrose																						1				
A	*Plantago patagonica*	Wooly plantain																										
IW	*Salsola tragus*	Russian thistle																										
	Unidentifiable													2														
Shrubs, Sub-shrubs, Succulents & Trees																												
P	*Artemisia bigelovii*	Bigelow Sage	5	4				3			13						12		9	15	5	14	10	13			9	
P	*Atriplex canescens*	Fourwing saltbush																										
P	*Ceratoides lanata*	Winterfat																2										
P	*Dalea versicolor*	Oakwoods prairie clover			1																							
P	*Ephedra torreyana*	Torrey's jointfir										5											2					
P	*Guttierrezia sarothrae*	Broom snakeweed	7	1		1				1		2	12	14				12	5		1	3		9			4	
P	*Juniper monosperma*	One seeded Juniper														4												
P	*Leptodactylon pungens*	Granite prickly phlox																								1		
P	*Lycium pallidum*	Pale desert-thorn																						1				
P	*Psilostrophe tagetina*	Woolly Paperflower			2																							
P	*Tetradymia canescens*	Spineless horsebrush																										
P	*Yucca glauca*	Soapweed yucca																					2					
		Total Plant Cover	**30**	**31**	**16**	**28**	**24**	**29**	**30**	**32**	**31**	**27**	**34**	**31**	**15**	**32**	**31**	**25**	**30**	**15**	**28**	**23**	**34**	**27**	**28**	**22**	**31**
		Rock	6		14	4	1	4	1			24	3	1	64	12	9	23	32	26	16	8	6	7	3	8	1
		Litter	12	5	5	11	5	11	11	13	11	7	9	11	13	6	11	7	9	4	3	5	14	11	16	12	10
		Bare ground	52	64	65	57	70	56	58	55	58	42	54	57	8	50	49	45	29	55	53	64	46	55	53	58	58
		Total Perennial & Biennial Cover	**30**	**31**	**16**	**28**	**22**	**28**	**30**	**32**	**31**	**25**	**30**	**31**	**14**	**32**	**31**	**25**	**30**	**15**	**28**	**23**	**34**	**27**	**28**	**22**	**31**

Sample Adequacy Calculations				
	t = 1.6802		n = 45	
	Variance = 30.07		n_{min} = 13.95	

Table 5 (Continued)

Juniper Scrub Extended Reference Area

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.——>	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Average Cover	Relative Cover	Freq.
Grasses and Grass-likes																										
P	*Aristida longiseta*	Red three - awn																						**0.38**	**1.53**	**11**
P	*Bouteloua curtipendula*	Side-oats grama													4	1								**0.11**	**0.45**	**4**
P	*Bouteloua gracilis*	Blue grama	15		11		18	5	2	1			1	4	3	14	3	2	12	12	8	4	**6.98**	**28.29**	**71**
P	*Hilaria jamesii*	Galleta	7	3	6	1	3	7	5	4	2	4	7	4	1	1	3	5	2	2		2	**2.98**	**12.07**	**58**
P	*Muhlenbergia torreyi*	Ring muhly																				2	**0.20**	**0.81**	**11**
P	*Oryzopsis hymenoides*	Indian ricegrass		1	2										1	1		2					**0.40**	**1.62**	**24**
P	*Sitanion hystrix*	Bottlebrush squirreltail																					**0.04**	**0.18**	**4**
P	*Sporobolus airoides*	Alkali sacaton																1					**0.33**	**1.35**	**13**
P	*Sporobolus cryptandrus*	Sand dropseed						2															**0.04**	**0.18**	**2**
P	*Stipa neomexicana*	New Mexico Feathergrass			9	7			1	1	3	1											**3.67**	**14.86**	**49**
Forbs																										
P	*Astragalus missouriensi*	Missouri milkvetch	4																				**0.09**	**0.36**	**2**
A	*Cordylanthus wrightii*	Wright's bird's beak							3	1		2	4		2								**0.29**	**1.17**	**13**
P	*Erigeron sp.*	Fleabane																					**0.04**	**0.18**	**2**
P	*Eriogonum sp.*	Buckwheat							2	3		1	1	1				1					**0.36**	**1.44**	**16**
P	*Eriogonum umbellatum*	Sulphur-flower buckwheat																					**0.02**	**0.09**	**2**
A	*Euphorbia glyptosperma*	Ridgeseed spurge																					**0.16**	**0.63**	**11**
P	*Mirabilis glabra*	Smooth Four-o'clock																					**0.02**	**0.09**	**2**
P	*Oenothera sp.*	Evening primrose																					**0.02**	**0.09**	**2**
A	*Plantago patagonica*	Wooly plantain						2															**0.04**	**0.18**	**2**
IW	*Salsola tragus*	Russian thistle							1								3	1		1	2	1	**0.20**	**0.81**	**7**
	Unidentifiable																						**0.04**	**0.18**	**2**
Shrubs, Sub-shrubs, Succulents & Trees																										
P	*Artemisia bigelovii*	Bigelow Sage		13		8	5		5		5	2		1							8	8	**3.71**	**15.05**	**42**
P	*Atriplex canescens*	Fourwing saltbush											1					12	2		10		**0.56**	**2.25**	**2**
P	*Ceratoides lanata*	Winterfat															1						**0.07**	**0.27**	**4**
P	*Dalea versicolor*	Oakwoods prairie clover								4													**0.11**	**0.45**	**4**
P	*Ephedra torreyana*	Torrey's jointfir																					**0.16**	**0.63**	**4**
P	*Guttierrezia sarothrae*	Broom snakeweed			4			6			5	1	5	2	8	9	13			1	3	1	**2.89**	**11.71**	**49**
P	*Juniper monosperma*	One seeded Juniper																					**0.09**	**0.36**	**2**
P	*Leptodactylon pungens*	Granite prickly phlox																					**0.02**	**0.09**	**2**
P	*Lycium pallidum*	Pale desert-thorn																					**0.02**	**0.09**	**2**
P	*Psilostrophe tagetina*	Woolly Paperflower																					**0.04**	**0.18**	**2**
P	*Tetradymia canescens*	Spineless horsebrush								8		3	2										**0.29**	**1.17**	**7**
P	*Yucca glauca*	Soapweed yucca		6		4						1											**0.29**	**1.17**	**9**
																								Mean		
		Total Plant Cover		**26**	**23**	**32**	**20**	**26**	**22**	**19**	**22**	**15**	**15**	**21**	**16**	**16**	**28**	**21**	**23**	**17**	**17**	**30**	**17**		**24.67**	
		Rock		12	6		13		12	14	21	5	30	19	8	3	1	2	24	22	13	6	11		**11.00**	
		Litter		12	9	15	11	24	18	4	12	14	12	4	11	9	16	13	11	15	5	13	13		**10.51**	
		Bare ground		50	62	53	56	50	48	63	45	66	43	56	65	72	55	64	42	46	65	51	59		**53.82**	
		Total Perennial & Biennial Cover		**26**	**23**	**32**	**20**	**26**	**20**	**15**	**21**	**15**	**13**	**17**	**16**	**14**	**25**	**20**	**23**	**16**	**15**	**29**	**17**		**23.93**	

Diversity — **No. of Important (>1% Relative Cover) Perennial Sps. = 12**

Table 6 St. Anthony - Vegetation Cover - 2005

Grassland Extended Reference Area

			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
Grasses and Grass-likes																												
P	*Aristida longiseta*	Red three - awn				3	3		3				3	8	6	4	5	4				2	1	4	19	3	2	2
P	*Bouteloua gracilis*	Blue grama	2	6	15	17	1	1	1		2	12	2	8		4	15				2	1	33	25	7	4	5	8
P	*Hilaria jamesii*	Galleta	22	19	5		14	8	13	4	8	5	7	4	7	3	1	11	14	11	23		5	5	14	17	17
P	*Muhlenbergia torreyi*	Ring muhly										4						1	1						2	1		
P	*Sporobolus airoides*	Alkali sacaton						5	4		2		4		6			4		1								5
P	*Stipa neomexicana*	New Mexico Feathergrass							2																			
Forbs																												
A	*Cordylanthus wrightii*	Wright's bird's beak								5																		
P	*Eriogonum sp.*	Buckwheat			1												1											
A	*Euphorbia glyptosperma*	Ridgeseed spurge												2														
P	*Penstemon strictus*	Rocky Mountain penstemon																				1			1			
IW	*Salsola tragus*	Russian thistle																								2		
P	*Sphaeralcea coccinea*	Scarlet globemallow					1																					
	Unidentifiable						2															1						
Shrubs, Sub-shrubs, Succulents & Trees																												
P	*Artemisia bigelovii*	Bigelow Sage	6					1	8	3	2		4	8	4	9										4		
P	*Ephedra torreyana*	Torrey's jointfir								2																		
P	*Guttierrezia sarothrae*	Broom snakeweed	1	5	3	7	7	6				6	1		7	12	14	20	11	14	14				5		2
P	*Leptodactylon pungens*	Granite prickly phlox	1	1		3		2	1	3	4	1	2			3	1	1		1			2	1		5	1	3
P	*Opuntia polyacantha*	Plains pricklypear				1																						
P	*Psilostrophe tagetina*	Woolly Paperflower		1								4																
P	*Yucca glauca*	Soapweed yucca				1																						
		Total Plant Cover		**32**	**32**	**27**	**32**	**25**	**26**	**29**	**17**	**18**	**35**	**28**	**28**	**28**	**37**	**35**	**37**	**26**	**29**	**42**	**36**	**35**	**34**	**34**	**29**	**37**
		Rock		1	5	2	6		2		5	1	3	10	17	7	11	11	6	3		2	4	6	5		3	14
		Litter		14	13	13	11	14	15	7	11	10	5	16	5	16	7	9	9	7	14	12	8	7	5	7	13	17
		Bare ground		53	50	58	51	61	57	64	67	71	57	46	50	49	45	45	48	64	57	44	52	52	56	59	55	32
		Total Perennial & Biennial Cover		**32**	**32**	**27**	**32**	**23**	**26**	**29**	**12**	**18**	**35**	**28**	**26**	**28**	**37**	**35**	**37**	**26**	**29**	**41**	**36**	**35**	**34**	**32**	**29**	**37**

Sample Adequacy Calculations				
	t **=**	**1.6802**	**n =**	**45**
	Variance =	**34.46**	$\mathbf{n_{min}}$ **=**	**9.99**

Table 6 (Continued)

Grassland Extended Reference Area

Percent Ground Cover Based on Point-Intercept Sampling

			Transect No.——>	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	Average Cover	Relative Cover	Freq.
Grasses and Grass-likes																										
P	*Aristida longiseta*	Red three - awn			1		1		2	1	11	16	5	4	11	1	3	4	11	11		17	5	**3.91**	**12.54**	**62**
P	*Bouteloua gracilis*	Blue grama	23	4	27	2	14				17	6		1	1			2	2	4	10	5	11	**6.67**	**21.37**	**69**
P	*Hilaria jamesii*	Galleta		3	2	14	16	17	31	1	1	13	4	14	23	14	20	4	2	14	3	5		**9.73**	**31.20**	**82**
P	*Muhlenbergia torreyi*	Ring muhly		1					4		1	3	11	3	11	3	2	3	3	3	1			**1.29**	**4.13**	**31**
P	*Sporobolus airoides*	Alkali sacaton	1				2						2											**0.80**	**2.56**	**24**
P	*Stipa neomexicana*	New Mexico Feathergrass																4						**0.13**	**0.43**	**2**
Forbs																										
A	*Cordylanthus wrightii*	Wright's bird's beak																						**0.11**	**0.36**	**2**
P	*Eriogonum sp.*	Buckwheat																						**0.04**	**0.14**	**4**
A	*Euphorbia glyptosperma*	Ridgeseed spurge																1				1		**0.09**	**0.28**	**2**
P	*Penstemon strictus*	Rocky Mountain penstemon										1			1			1	2					**0.16**	**0.50**	**9**
IW	*Salsola tragus*	Russian thistle										1		2		1			1					**0.16**	**0.50**	**9**
P	*Sphaeralcea coccinea*	Scarlet globemallow											2				1							**0.09**	**0.28**	**7**
	Unidentifiable						1								1			1		3				**0.20**	**0.64**	**11**
Shrubs, Sub-shrubs, Succulents & Trees																										
P	*Artemisia bigelovii*	Bigelow Sage		5												2			7			4	6	**1.62**	**5.20**	**27**
P	*Ephedra torreyana*	Torrey's jointfir																						**0.04**	**0.14**	**2**
P	*Guttierrezia sarothrae*	Broom snakeweed	8	26	6	11	4	2	3		2	11	6							2	5	1		**4.93**	**15.81**	**60**
P	*Leptodactylon pungens*	Granite prickly phlox				1				1	1	1	3				1							**0.98**	**3.13**	**53**
P	*Opuntia polyacantha*	Plains pricklypear																			1			**0.04**	**0.14**	**2**
P	*Psilostrophe tagetina*	Woolly Paperflower										3												**0.18**	**0.57**	**7**
P	*Yucca glauca*	Soapweed yucca																						**0.02**	**0.07**	**2**
																									Mean	
			Total Plant Cover	**32**	**40**	**35**	**30**	**36**	**21**	**39**	**30**	**29**	**38**	**33**	**31**	**38**	**21**	**30**	**33**	**28**	**33**	**32**	**27**		**31.20**	
			Rock	1	3	4	1	5	2	1		2	1				2	2	4	4	4	7	10		**3.93**	
			Litter	12	12	10	10	13	20	13	7	12	17	9	11	8	18	12	10	5	15	13	6		**11.07**	
			Bare ground	55	45	51	59	46	57	47	63	57	44	58	58	54	59	56	53	63	48	48	57		**53.80**	
			Total Perennial & Biennial Cover	**32**	**40**	**35**	**29**	**36**	**21**	**39**	**30**	**28**	**38**	**31**	**30**	**37**	**21**	**29**	**32**	**24**	**33**	**31**	**27**		**30.64**	

Diversity — **No. of Important (>1% Relative Cover) Perennial Sps. = 8**

Table 8 Woody Plant Density - 2005

Bottomland Extended Reference Area

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
Artemisia bigelovii	Bigelow Sage																				
Atriplex canescens	Fourwing Saltbush	1	13	63	68	39	16	63	40	16	16	29	14	21	3	46	37	23	49	34	23
Ceratoides lanata	Winterfat	5	1	1		14	3	10	13	8	5	2	4	7							
Chrysothamnus nauseosus	Rubber Rabbitbrush																	1			
Lycium torreyi	Torrey Wolfberry																				
Opuntia polyacantha	Pricklypear Cactus	4			2			5	1		3			3							
Opuntia spinosior	Walkingstick Cactus					1	1	1			2			1		3				1	
Yucca glauca	Soapweed Yucca																				
		10	**14**	**64**	**70**	**54**	**20**	**79**	**54**	**24**	**26**	**31**	**18**	**32**	**3**	**49**	**37**	**24**	**49**	**35**	**23**

		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Artemisia bigelovii	Bigelow Sage											7	30	39	29	63	77	5	4		1
Atriplex canescens	Fourwing Saltbush	38	27	43	24	38	22	70	42	81	60	14	13		9	1	2	4	6	3	15
Ceratoides lanata	Winterfat											4	8	25	34	22	27	32	33	49	30
Chrysothamnus nauseosus	Rubber Rabbitbrush														1		6				
Lycium torreyi	Torrey Wolfberry																1				
Opuntia polyacantha	Pricklypear Cactus			2							1	11		2	2	1	3	12	2	3	
Opuntia spinosior	Walkingstick Cactus						1					1			2				1	2	2
Yucca glauca	Soapweed Yucca																2				
		38	**27**	**45**	**24**	**38**	**23**	**70**	**42**	**81**	**61**	**37**	**51**	**66**	**77**	**87**	**118**	**53**	**46**	**57**	**48**

		41	42	43	44	45	Total Count	Per Acre
Artemisia bigelovii	Bigelow Sage	4	22	7		2	**290**	**261**
Atriplex canescens	Fourwing Saltbush	3	10	5	21	23	**1188**	**1,068**
Ceratoides lanata	Winterfat	50	10	14	19	31	**461**	**415**
Chrysothamnus nauseosus	Rubber Rabbitbrush			1			**9**	**8**
Lycium torreyi	Torrey Wolfberry						**1**	**1**
Opuntia polyacantha	Pricklypear Cactus	3	1	1	3	2	**67**	**60**
Opuntia spinosior	Walkingstick Cactus	2		2	1	3	**27**	**24**
Yucca glauca	Soapweed Yucca						**2**	**2**
	Overall Total =	**62**	**43**	**30**	**44**	**61**	**2045**	**1,839**

Sample Adequancy Calc.

t = 1.680

mean = 102.25

var. = 524.3

n = 45

n_{min} = 14.16

Table 9 Woody Plant Density - 2005

Juniper Scrub Extended Reference Area

Sampling Method: 2m x 50m Belt Transects

Species		Transect # --->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Artemisia bigelovii	Bigelow Sage		39	9	24	28	6	15	6	1	29	32	11	6	37	72	48	72	54	85	30	149
Atriplex canescens	Fourwing Saltbush		11	5	5	2	18	12	10	28		8	16	12	7	11						
Ceratoides lanata	Winterfat		1	3	1	4	5	1			5	4	2	4	3	1	2					1
Cercocarpus montanus	Mountain Mahogany																					
Chrysothamnus nauseosus	Rubber Rabbitbrush																					
Dalea versicolor	Oakwoods Prairie		5	10	15	2		1	1	1												
Echinocereus melanocanthus	Hedgehog Cactus			6	2			1														
Ephedra torreyana	Torrey's Jointfir																					
Eriogonum wrightii	Bastardsage																					
Juniper monosperma	Oneseed Juniper				2	2	1	1		2	4		1	2	7		4		1	5	3	1
Lycium torreyi	Torrey Wolfberry																1					
Opuntia polyacantha	Pricklypear Cactus		2		4	1		1	2	4	1	2	3	1		1	7					1
Opuntia spinosior	Walkingstick Cactus				1									2		1						
Pinus edulis	Twoneedle Pinyon																					
Rhus trilobata	Skunkbush Sumac																1					
Tetradymia canescens	Spineless Horsebrush																					
Yucca glauca	Soapweed Yucca					10					8	2		2						2	2	
Unidentifiable																						
			58	**33**	**54**	**49**	**30**	**32**	**19**	**36**	**47**	**48**	**33**	**29**	**54**	**86**	**63**	**72**	**55**	**92**	**35**	**152**

Species		Transect # --->	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Artemisia bigelovii	Bigelow Sage		63	32	20	14	12	13	121	59	105	35	47	95	81	94	97	84	35	183	58	31
Atriplex canescens	Fourwing Saltbush						1						8	13	6	16	8	6	3	2	1	2
Ceratoides lanata	Winterfat																				7	
Cercocarpus montanus	Mountain Mahogany																		1	5	3	
Chrysothamnus nauseosus	Rubber Rabbitbrush							1							2			1			13	64
	Oakwoods Prairie																					
Dalea versicolor	Clover																					
Echinocereus melanocanthus	Hedgehog Cactus																					
Ephedra torreyana	Torrey's Jointfir								3		2	1						1				
Eriogonum wrightii	Bastardsage								1													
Juniper monosperma	Oneseed Juniper		4	1	2	3	1	2	3		4	2	3	1	1	2	3	3	8	3	1	
Lycium torreyi	Torrey Wolfberry																					
Opuntia polyacantha	Pricklypear Cactus		1				2		1	12	4	7	1	1	1	6	4	2		1		
Opuntia spinosior	Walkingstick Cactus										1							1				
Pinus edulis	Twoneedle Pinyon																		1	1		
Rhus trilobata	Skunkbush Sumac																			4	2	
Tetradymia canescens	Spineless Horsebrush										2											
Yucca glauca	Soapweed Yucca						2		1	12	4	7	7	2	3	3		6	7	5	14	8
Unidentifiable															20			2				
			68	**33**	**22**	**17**	**18**	**16**	**130**	**83**	**122**	**52**	**66**	**112**	**114**	**121**	**112**	**106**	**55**	**204**	**99**	**105**

Species		Transect # --->	41	42	43	44	45	Total Count	Per Acre
Artemisia bigelovii	Bigelow Sage		125	76	93	62	63	**2451**	**2,204**
Atriplex canescens	Fourwing Saltbush			2	2	6	3	**224**	**201**
Ceratoides lanata	Winterfat				3		2	**49**	**44**
Cercocarpus montanus	Mountain Mahogany							**9**	**8**
Chrysothamnus nauseosus	Rubber Rabbitbrush			3	2			**86**	**77**
	Oakwoods Prairie								
Dalea versicolor	Clover							**35**	**31**
Echinocereus melanocanthus	Hedgehog Cactus							**9**	**8**
Ephedra torreyana	Torrey's Jointfir		1	1	4	1	3	**17**	**15**
Eriogonum wrightii	Bastardsage							**1**	**1**
Juniper monosperma	Oneseed Juniper		3	5	4	3	4	**102**	**92**
Lycium torreyi	Torrey Wolfberry							**1**	**1**
Opuntia polyacantha	Pricklypear Cactus		2		1			**76**	**68**
Opuntia spinosior	Walkingstick Cactus							**6**	**5**
Pinus edulis	Twoneedle Pinyon		1		1	1	1	**6**	**5**
Rhus trilobata	Skunkbush Sumac		1	25	7		1	**41**	**37**
Tetradymia canescens	Spineless Horsebrush							**2**	**2**
Yucca glauca	Soapweed Yucca		23	11	23		3	**167**	**150**
Unidentifiable								**22**	**20**
	Overall Total =		**156**	**123**	**140**	**73**	**80**	**3304**	**2,971**

Sample Adequancy Calc.

t = 1.680

mean = 165.20

var. = 1943.4

n = 45

n_{min} = 20.10

Table 10 Woody Plant Density - 2005

Grassland Extended Reference Area

Sampling Method: 2m x 50m Belt Transects

Species	Transect # --->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Artemisia bigelovii	Bigelow Sage	36	3	7	35	18	23	7	41	81	54	4	1	9	47	7		1	1	7	
Atriplex canescens	Fourwing Saltbush			2				1			10		5	3		2	1	1			1
Ceratoides lanata	Winterfat	7	4	1	2	2	4	1	2	2	10	1	2	3	3	3	1	1	1		
Chrysothamnus nauseosus	Rubber Rabbitbrush								1												
Juniper monosperma	Oneseed Juniper			2	1	1				1									3	1	
Lycium torreyi	Torrey Wolfberry							1	3												
Opuntia polyacantha	Pricklypear Cactus	1	1			4	5										4		5		
Opuntia spinosior	Walkingstick Cactus										2					3					
Senecio sp.	Groundsel																				
Yucca glauca	Soapweed Yucca					1															
		44	**8**	**12**	**38**	**26**	**32**	**10**	**47**	**84**	**76**	**5**	**8**	**15**	**50**	**15**	**6**	**3**	**10**	**8**	**1**

	Transect # --->	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Artemisia bigelovii	Bigelow Sage	3	15	109	19	4	9	21	1	1		1	3	17	19	2	3	6	35	3	2
Atriplex canescens	Fourwing Saltbush	1			1	6	17	10	2			3		7	9			8			6
Ceratoides lanata	Winterfat		4	6	4	2	1		3					1	3			8			6
Chrysothamnus nauseosus	Rubber Rabbitbrush																				
Juniper monosperma	Oneseed Juniper		1	5	1	2	2	2	1		1										
Lycium torreyi	Torrey Wolfberry																				
Opuntia polyacantha	Pricklypear Cactus										2						3	2	1		1
Opuntia spinosior	Walkingstick Cactus										1										
Senecio sp.	Groundsel					1									1						
Yucca glauca	Soapweed Yucca				1																
		4	**20**	**120**	**26**	**15**	**29**	**33**	**7**	**1**	**4**	**4**	**3**	**25**	**32**	**2**	**6**	**24**	**36**	**3**	**15**

	Transect # --->	41	42	43	44	45	Total Count	Per Acre
Artemisia bigelovii	Bigelow Sage		9	24	13		**701**	**630**
Atriplex canescens	Fourwing Saltbush	6		5		1	**108**	**97**
Ceratoides lanata	Winterfat			1	1		**90**	**81**
Chrysothamnus nauseosus	Rubber Rabbitbrush						**1**	**1**
Juniper monosperma	Oneseed Juniper						**24**	**22**
Lycium torreyi	Torrey Wolfberry						**4**	**4**
Opuntia polyacantha	Pricklypear Cactus	1				2	**32**	**29**
Opuntia spinosior	Walkingstick Cactus					1	**7**	**6**
Senecio sp.	Groundsel				1		**3**	**3**
Yucca glauca	Soapweed Yucca						**2**	**2**
	Overall Total =	**7**	**9**	**30**	**15**	**4**	**972**	**874**

Sample Adequancy Calc.

t = 1.680

mean = 48.60

var. = 579.2

n = 45

n_{min} = 69.24

Table 12 Vegetation Production -- 2005

Bottomland Extended Reference Area

Oven Dry Weight (grams per 1/2 square meter)

Sample No.	Grasses			Forbs			Sub-shrubs	Noxious	TOTAL	
	PG	IPG	Annual	NP	IP	Annual			g/0.5m^2	lbs / ac
1	32.9								**32.9**	**587.1**
2	7.4								**7.4**	**132.0**
3	24.4					2.0			**26.4**	**471.1**
4	15.3					4.0			**19.3**	**344.4**
5	29.3								**29.3**	**522.8**
6	28.9						1.0		**29.9**	**533.5**
7	34.0					1.0			**35.0**	**624.5**
8	4.5						16.2		**20.7**	**369.4**
9	13.1						13.1		**26.2**	**467.5**
10	22.5					3.0	7.7		**33.2**	**592.4**
11	17.8						2.0		**19.8**	**353.3**
12	35.2								**35.2**	**628.1**
13	8.0					1.0	37.1		**46.1**	**822.6**
14	10.9					0.5			**11.4**	**203.4**
15	27.2								**27.2**	**485.3**
16	6.0					0.5			**6.5**	**116.0**
17	4.5					1.0	15.6		**21.1**	**376.5**
18	6.8					1.0			**7.8**	**139.2**
19	3.9						25.8		**29.7**	**530.0**
20							22.9		**22.9**	**408.6**
21	17.8						3.0		**20.8**	**371.1**
22	14.6								**14.6**	**260.5**
23				1.0		4.0	19.8		**24.8**	**442.5**
24	28.5					1.5			**30.0**	**535.3**
25						0.5	25.4		**25.9**	**462.1**
26	22.1								**22.1**	**394.3**
27	3.2					0.5	14.2		**17.9**	**319.4**
28						3.0	27.8		**30.8**	**549.6**
29	16.4					0.5			**16.9**	**301.6**
30						0.5	31.3		**31.8**	**567.4**
31	26.7			1.5					**28.2**	**503.2**
32	18.1			0.5					**18.6**	**331.9**
33	12.7			1.0			8.0		**21.7**	**387.2**
34	4.5					2.0	29.9		**36.4**	**649.5**
35	25.1			1.0			2.0		**28.1**	**501.4**
36	13.6						8.2		**21.8**	**389.0**
37	5.0						39.3		**44.3**	**790.5**
38	24.4								**24.4**	**435.4**
39	38.2			1.0					**39.2**	**699.5**
40	28.4						14.1		**42.5**	**758.3**
41	26.2			2.5			1.0		**29.7**	**530.0**
42	4.5			1.5			39.6		**45.6**	**813.7**
43	32.2			1.5					**33.7**	**601.3**
44	3.5						38.2		**41.7**	**744.1**
45	30.8					1.5			**32.3**	**576.3**
Avg.	**16.2**	**0.0**	**0.0**	**0.3**	**0.0**	**0.6**	**9.8**	**0.0**	**26.9**	**480.5**

Sampling Adequacy **t = 1.680** **Variance = 95.856**

n= 45 **Mean = 26.93** **n_{min} = 37.318**

Table 13 Vegetation Production -- 2005

Juniper Scrub Extended Reference Area

Oven Dry Weight (grams per 1/2 square meter)

Sample No.	Grasses			Forbs			Sub-shrubs	Noxious	TOTAL	
	PG	IPG	Annual	NP	IP	Annual			g/0.5m^2	lbs / ac
1	14.4						5.0		**19.4**	**346.2**
2	1.1						22.0		**23.1**	**412.2**
3	4.5					2.0			**6.5**	**116.0**
4	14.5						3.0		**17.5**	**312.3**
5	22.3								**22.3**	**397.9**
6	24.0						1.5		**25.5**	**455.0**
7	29.7								**29.7**	**530.0**
8	16.3								**16.3**	**290.8**
9	11.2								**11.2**	**199.8**
10	30.6								**30.6**	**546.0**
11	3.0						21.0		**24.0**	**428.2**
12	5.0						15.2		**20.2**	**360.4**
13	3.2						15.0		**18.2**	**324.8**
14				10.8					**10.8**	**192.7**
15	7.8								**7.8**	**139.2**
16	11.1								**11.1**	**198.1**
17	6.6						8.0		**14.6**	**260.5**
18	12.3								**12.3**	**219.5**
19	15.5						7.6		**23.1**	**412.2**
20	3.0						20.6		**23.6**	**421.1**
21	16.7						2.0		**18.7**	**333.7**
22	24.1						5.5		**29.6**	**528.2**
23	2.0						29.1		**31.1**	**554.9**
24	16.2								**16.2**	**289.1**
25	16.6						3.0		**19.6**	**349.7**
26	23.5						7.0		**30.5**	**544.2**
27	24.9						2.0		**26.9**	**480.0**
28	15.1						7.0		**22.1**	**394.3**
29	3.0						24.2		**27.2**	**485.3**
30	16.1						1.0		**17.1**	**305.1**
31	7.9					1.5	2.0		**11.4**	**203.4**
32	2.5			5.9			10.4		**18.8**	**335.5**
33	1.0			1.5		1.0	21.5		**25.0**	**446.1**
34	4.6								**4.6**	**82.1**
35							21.7		**21.7**	**387.2**
36	8.0						5.9		**13.9**	**248.0**
37	2.0			7.2			18.2		**27.4**	**488.9**
38	9.0								**9.0**	**160.6**
39	12.9					2.5	0.5		**15.9**	**283.7**
40	1.5			0.5			35.0		**37.0**	**660.2**
41	1.3						21.0		**22.3**	**397.9**
42	8.0								**8.0**	**142.7**
43						0.5	16.4		**16.9**	**301.6**
44	7.1						10.3		**17.4**	**310.5**
45	1.5						36.9		**38.4**	**685.2**
Avg.	**10.3**	**0.0**	**0.0**	**0.6**	**0.0**	**0.2**	**8.9**	**0.0**	**19.9**	**354.7**

Table 14 Vegetation Production -- 2005

Grassland Extended Reference Area

Oven Dry Weight (grams per 1/2 square meter)

Sample No.	Grasses			Forbs			Sub-shrubs	Noxious	TOTAL	
	PG	IPG	Annual	NP	IP	Annual			g/0.5m^2	lbs / ac
1	18.6			4.0			6.0		**28.6**	**510.3**
2	34.6						3.0		**37.6**	**670.9**
3	39.2						1.0		**40.2**	**717.3**
4	18.1						35.2		**53.3**	**951.1**
5	21.7			3.0					**24.7**	**440.7**
6	15.1					5.0	4.0		**24.1**	**430.0**
7	4.0						40.6		**44.6**	**795.8**
8	18.7						31.9		**50.6**	**902.9**
9	20.5					2.0			**22.5**	**401.5**
10	12.1						33.3		**45.4**	**810.1**
11	22.0						14.0		**36.0**	**642.4**
12							49.3		**49.3**	**879.7**
13	2.0						27.5		**29.5**	**526.4**
14	24.3						5.0		**29.3**	**522.8**
15	38.3								**38.3**	**683.4**
16	5.2			2.5			33.8		**41.5**	**740.5**
17	4.0			3.9			17.3		**25.2**	**449.7**
18	27.0			1.0		0.5			**28.5**	**508.5**
19	7.0						25.7		**32.7**	**583.5**
20	22.5						53.0		**75.5**	**1347.2**
21	7.0						54.8		**61.8**	**1102.7**
22	23.1								**23.1**	**412.2**
23	21.7					1.5			**23.2**	**414.0**
24	25.7						0.5		**26.2**	**467.5**
25	27.1			0.5					**27.6**	**492.5**
26	36.2						2.0		**38.2**	**681.6**
27	28.1			0.8					**28.9**	**515.7**
28	6.0						38.4		**44.4**	**792.3**
29	7.5			1.0	3.3		14.6		**26.4**	**471.1**
30	3.4						20.3		**23.7**	**422.9**
31	25.0			2.9		0.5			**28.4**	**506.8**
32	1.0						55.7		**56.7**	**1011.7**
33	29.4			1.0		0.5			**30.9**	**551.4**
34	27.3						1.5		**28.8**	**513.9**
35	33.3			1.0					**34.3**	**612.0**
36	3.0			0.5			69.1		**72.6**	**1295.4**
37	5.0			2.0			33.2		**40.2**	**717.3**
38	14.3					3.5	0.5		**18.3**	**326.5**
39	21.6			4.0					**25.6**	**456.8**
40	0.5			0.5			53.3		**54.3**	**968.9**
41	29.9			1.0		2.0	4.0		**36.9**	**658.4**
42	1.7						48.3		**50.0**	**892.2**
43	27.9			7.1			0.5		**35.5**	**633.4**
44	39.9								**39.9**	**712.0**
45	42.0								**42.0**	**749.4**
Avg.	**18.7**	**0.0**	**0.0**	**0.8**	**0.1**	**0.3**	**17.3**	**0.0**	**37.2**	**664.3**

Sampling Adequacy **t = 1.680** **Variance = 173.579**

n= 45 **Mean = 37.23** **n_{min} = 35.357**