Report of Findings
Revegetation Monitoring Studies
Castlegate Mine Complex
Carbon County, Utah

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF PHOTOGRAPHS

Photographs	
1 through 4	General Views, Goose Island Reclaimed Area
5 through 8	General Views, Gilson Gulch AML Area
9 and 10	General Views, Sow Belly South AML Area
11 and 12	General Views, Sow Belly North AML Area
13	Permanent Photo Point A, West View
14	Permanent Photo Point A, East View
15	Permanent Photo Point B, North View
16	Permanent Photo Point B, South View
17	Permanent Photo Point C, South View
18	Permanent Photo Point C, North View
19	Permanent Photo Point D West View
20	Permanent Photo Point D, East View
21 through 35	Soil Pit Photographs

INTRODUCTION

ESCO Associates was contracted in September 1993 to conduct studies of certain revegetated areas of the AMAX Coal West Castlegate Mine complex in Carbon County, Utah. The vegetation cover of the Goose Island parcel was to be sampled and compared to that present on selected nearby areas that had been revegetated by contractors to the State of Utah under the Abandoned Mine Land (AML) Program. The AML areas to be sampled had been selected during a field review of potential sites on August 30, 1993 in the company of Paul Baker representing the Utah Department of Oil Gas and Mining (UDOGM). In order to understand the relation between observed vegetational characteristics and substrate, "soil" samples were also taken in each of the areas evaluated for vegetational conditions.

The Goose Island reclaimed area is located in Hardscrabble Canyon approximately 2 1/2 miles northwest of Martin, Utah (Map 1). The Goose Island reclaimed area sampled covered approximately 8.6 acres. The AML areas sampled included an approximately 1.1 acre area at Gilson Gulch to the west and two small areas in Sow Belly Canyon (Map 1).

METHODS

Sample Areas

The reclaimed area to be sampled at Goose Island was delineated by AMAX and is shown on Map 1 and in Photos 1 through 4. The area sampled at Gilson Gulch (Photos 5 through 8) is shown on Map 2. Vegetation of both of these areas was sampled at sites selected randomly as described below. At the two small Sow Belly sites (designated as Sow Belly North and Sow Belly South, Map 1), two vegetation samples and two soil pits were subjectively located as representative in each. Sow Belly North (Photos 9 and 10) was an area in which the revegetated area was dominated by grasses, while the Sow Belly South area (Photos 11 and 12) was situated on steeper slopes and was dominated by grasses and shrubs.

Vegetation Sample Locations

At the Goose Island and Gilson Gulch sites, the areas to be sampled were delineated on maps of the areas. For the Goose Island site, the map was photo-based at a scale of 1" = 200' and was gridded into 100 foot cells. At Gilson Gulch, the map was hand-drawn at a scale of 1" = 50' (Map 3) and gridded into 50 foot cells. In both cases, the grid cells more than one-half included within the study area were numbered sequentially. Random

numbers between 1 and the maximum number were chosen to identify particular cells that were then numbered in order of their selection.

Cover Sampling

Cover data were collected using a point intercept method in which data are tabulated as interceptions of a point with plant species, soil, litter, or rock. The fifty points in each sample were optically projected using a Cover-Point Model 3 Optical Point Projector. The sample was taken at a randomly located and randomly oriented 50 m transect. The numbers of cover transects that were placed in each reclaimed area or reference area were as follows:

Reclaimed Area	Number of Transects
Goose Island	20
Gilson Gulch	15
Sow Belly - North	2
Sow Belly - South	2

First hit interceptions were used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (50). First hit relative vegetation cover was calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover was calculated by dividing all hits for a particular species by the total number of points taken (50). In addition, all-layer relative cover was calculated using all hits for a particular species divided by the total hits accumulated during sampling of the transect.

Production Sampling

Production sampling was done in the Goose Island and Gilson Gulch study areas. Herbaceous production sampling was accomplished using one-half square meter (0.5 m^2) circular quadrats located at the sample points 1 through 10 (Maps 2 and 4) within which all herbaceous growth in a vertical projection was removed by clipping, separated by species, and placed in labeled paper bags.

Production samples within each reclaimed area numbered as follows:

Reclaimed Area	Number of 0.5 sq. m. Plots
Goose Island	10
Gilson Gulch	10
Sow Belly - North	None
Sow Belly - South	None

Clipped material was returned to the ESCO laboratory and dried at 105 ^{o}C for 24 hours, then weighed to the nearest 0.1 gm.

Plant Species Frequency and Density Measurements

During the course of cover sampling, all plant species occurring within one meter on either side of the cover sample transect were noted as present within each sample. Frequency for each plant species observed during sampling was calculated by dividing the number of sample transects in which the species was observed by the total number of samples (see cover sample distribution by area above). As such, this value is more probably correctly known as "constancy". Relative vegetation cover was calculated by dividing the absolute cover of each species by the total vegetation cover and expressing the result as a percent.

The total number of species (within each lifeform) observed in each sample provide a measure of "species density", indicating relative species richness of different areas. These measures reflect progress toward return of diverse species composition in the reclaimed areas from a different perspective than is available from examination of cover data alone.

Plant Species Listing

During the course of the field work, a list of all plant species encountered (quantitative plus incidental observations) was compiled for each reclamation area and the two reference areas. Scientific names used follow Welsh et al. (1987); common names cited may be found in Beetle (1970), Nickerson et al. (1976), or SCS (1979). Of plant species observed, only common bindweed (Convolvulus arvensis) is listed state-wide as a noxious weed (Utah Noxious Weed Act, Rule R68-09-02).

Soil / Refuse Sampling

At the locations shown in Maps 3 and 5, as well as at the Sow Belly North and Sow Belly South sites, soil samples were taken to assess the general character of the material used as topdressing at the various refuse sites. In addition, at Goose Island and at Sow Belly South, the underlying refuse was sampled to assess its general character. Samples were analyzed for:

- 1/3 bar and 15 bar water holding capacity (as well as available water capacity, or field capacity = 1/3 bar minus 15 bar values)
- Total organic carbon percent
- Cation exchange capacity (CEC)
- Exchangeable sodium
- Soluble sodium, calcium, and magnesium; sodium adsorption ratio (SAR) calculated
- Particle size analysis by hydrometer
- Coarse fragments percentage
- Percent organic matter
- Electrical conductivity
- pH
- Nitrate nitrogen (DTPA extract)
- Phosphorous (DTPA extract)
- Potassium (DTPA extract)
- Zinc (DTPA extract)
- Iron (DTPA extract)
- Manganese (DTPA extract)
- Copper (DTPA extract)
- Lime estimate
- Total nitrogen (Kjeldahl)

In the graphical depiction of the results of these soils analyses (Figure 1), the samples were divided by area and type (topsoil or refuse). To assess the variability of the results, standard errors were calculated (see below) and used to show error bars above and below the top of the graphed collumns. Although the soil sample locations were not located using a grid and random numbers, as were the vegetation samples, they were deemed to be randomly enough distributed to calculate a standard error for rough comparison purposes.

Statistical Methods

Sample adequacy calculations were carried out using the formula as prescribed by UDOGM(1992):

$$N_{min} = \frac{t^2 s^2}{(d x)^2}$$

where:

t = one-tailed t-value with n-1 degrees of freedom (n = present sample size)

s^2 = sample variance (based s_{n-1})

d = 0.1 (level of precision or desired detectable reduction)

x = sample mean

Confidence limits for comparisons of means of reference areas and reclaimed areas were calculated using the formula at the bottom of page 52 of Snedecor and Cochran (1980), employing a one-tailed t-value with n-1 degrees of freedom:

$$\text{conf. interval} = t \frac{s}{\sqrt{n}}$$

Erosion Condition Classification

Erosion conditions on the various sites sampled for vegetational characteristics during this study were assessed using a technique described in a draft Federal Office of Surface Mining Reclamation and Enforcement (OSM) document (Humphrey 1990). Dr. David Buckner of ESCO was instructed in the use of the technique in the field at Goose Island by Paul Baker of UDOGM. Since it is a largely subjective rating system, the results may vary between observers. The rating titled "Surface Rock Fragments" was omitted because it did not appear to address a process that was operating at these particular locations. Fortunately, the system can proceed with the rating of whatever characters can confidently be rated. In this case the overall erosion condition classification ratings were based on use of six of the seven potential parameters (Soil Movement, Surface Litter Mulch, Pedestaling, Flow Patterns, Rills, and Gullies).

RESULTS

Goose Island Reclaimed Area (Photos 1 through4)

Vegetation of the Goose Island site was dominated by cool-season grasses with about 85.2 percent of total vegetation cover, evenly divided between native and introduced species (Table 1). The most abundant native species were slender wheatgrass (Elymus trachycaulus) and Indian ricegrass (Oryzopsis hymenoides). The most abundant introduced species were standard crested wheatgrass (Agropyron cristatum, including A. desertorum) and intermediate wheatgrass (Elymus hispidus). Minor native species present included basin wildrye (Elymus cinereus), Montana wheatgrass (Elymus lanceolatus fm. albicans), thickspike wheatgrass (Elymus lanceolatus fm. dasystachyus), western wheatgrass (Elymus smithii), bluebunch wheatgrass (Elymus spicatus), fescue (Festuca cf. ovina), foxtail barley (Hordeum jubatum), Canada bluegrass (Poa compressa), Agassiz bluegrass (Poa pratensis fm. agassizensis), and green needlegrass (Stipa viridula). Minor introduced grass species present included smooth brome (Bromus inermis), orchardgrass (Dactylis glomerata), and tall fescue (Festuca arundinacea).

Annual and biennial plants were minor in abundance with only 3.1 percent of total vegetation cover. Included were cheatgrass (Bromus tectorum), houndstongue (Cynoglossum officinale), summer cypress (Kochia scoparia), perfoliate pepperweed (Lepidium perfoliatum), Russian thistle (Salsola iberica), and salsify (Tragopogon dubius). The native annual sunflower (Helianthus annuus) was also present.

Native perennial forbs accounted for 11.2 percent of total vegetation cover, most of which was comprised of Louisiana sage (Artemisia ludoviciana), curlycup gumweed (Grindelia squarrosa), and hoary aster (Machaeranthera canescens). Minor species included blueleaf aster (Aster glaucodes), perennial blue flax (Linum perenne ssp. lewisii), curly dock (Rumex crispus), and showy goldeneye (Viguiera multiflora). Introduced perennial forbs accounted for 5.1 percent of total vegetation cover, all the measurable part of which was alfalfa (Medicago sativa). Minor species present included Cicer milkvetch (Astragalus cicer), common bindweed (Convolvulus arvensis), and common dandelion (Taraxacum officinale).

Although shrubs and trees were only 1.5 percent of total vegetation cover, nine species were present, including, in order of decreasing frequency, rubber rabbitbrush (Chrysothamnus nauseosus), broom snakeweed (Gutierrezia sarothrae), Wood's rose (Rosa woodsii), Utah juniper (Juniperus osteosperma), skunkbrush (Rhus aromatica

var. trilobata), chokecherry (Prunus virginiana), big sagebrush (Artemisia tridentata), Oregon grape (Mahonia repens), and ponderosa pine (Pinus ponderosa). Mean total vegetation cover at Goose Island was 17.5 +/- 1.97 percent; vegetation cover including overlap (first and second hits) was only slightly higher at 17.6 percent. Species density in the Goose Island area averaged 14.9 species per 100 sq. m. (Table 9).

Biomass production in the Goose Island site totaled about 833 pounds per acre (Table 2), most of which was native perennial grasses (582 pounds per acre). Although introduced perennial grasses, mainly in the form of crested wheatgrass, provided as much cover as native species, the associated biomass was proportionately less abundant, with only 184 pounds of oven-dry forage per acre. Native perennial forbs amounted to about 54 pounds per acre, and introduced perennial forbs totaled 16 pounds per acre.

Gilson Gulch AML Area (Photos 5 through 8)

Vegetation of the Gilson Gulch sample area was dominated by shrubs that comprise 63.3 percent of total vegetation cover (Table 3). The major contributors to this total were fourwing saltbush (Atriplex canescens) and rubber rabbitbrush. Other shrub species present in minor amounts included big sagebrush, shadscale saltbush (Atriplex confertifolia), and winterfat (Ceratoides lanata). Besides shrubs, the only other lifeform comprising substantial cover (25.3 percent of total vegetation cover) was introduced perennial grasses, the bulk of which at the Gilson Gulch site was comprised of orchardgrass and intermediate wheatgrass. Standard crested wheatgrass, so abundant at Goose Island, is minor in abundance at Gilson Gulch. Introduced annual and biennial forbs comprised only 2.5 percent of total vegetation cover, all of which was yellow sweetclover (Melilotus officinalis). Minor species present included summer-cypress (Kochia scoparia), devil's shoestrings (Polygonum arenastrum), and Russian thistle. Native perennial forbs at the Gilson Gulch site comprised only 1.3 percent of total vegetation cover and included tarragon (Artemisia dracunculus), Louisiana sage, blueleaf aster, blue flax, hoary aster, and Palmer penstemon (Penstemon palmeri). Alfalfa was the lone introduced perennial forb present and totaled 5.7 percent of total vegetation cover.

Native perennial grasses at the Gilson Gulch site totaled only 1.8 percent cover; species present included western wheatgrass, slender wheatgrass, and Indian ricegrass. Mean total vegetation cover at Gilson Gulch was 21.1 +/- 1.96 percent; vegetation cover including overlap amounted to 21.7 percent, indicating that there was a small amount of

additional overlap compared to Goose Island due to the abundance of shrubs and herbaceous growth beneath those shrubs. Species density averaged 11.9 species per 100 sq. m. at Gilson Gulch, 3 species or 20 percent less than the species density at Goose Island.

Biomass production at the Gilson Gulch site totaled about 1,383 pounds per acre (Table 4), 501 pounds per acre of which was attributable to shrubs. The bulk of herbaceous production (882 pounds per acre) was introduced perennial grasses (528 pounds per acre) as well as native perennial grasses (136 pounds per acre) and introduced perennial forbs (134 pounds per acre). Introduced annual and biennial forbs (45 pounds per acre) and native perennial forbs (41 pounds per acre) were minor contributors to overall production.

Sow Belly South AML Area (Photos 9 and 10)

Vegetation of the Sow Belly South site was dominated by shrubs (54.7 percent of total vegetation cover), in similar proportions to the Gilson Gulch site. The bulk of shrub cover was provided by fourwing saltbush and rubber rabbitbrush; big sagebrush was also present sparingly. The remainder of the total vegetational cover was rather equally divided between native perennial forbs, native perennial grasses and introduced perennial grasses. Native perennial forbs totaled 13.2 percent of total vegetation cover, most of which was blueleaf aster and Palmer penstemon. Minor species present included Louisiana sage, hoary aster, and showy goldeneye. Native perennial grasses present totaled 17.0 percent of total vegetation cover, comprised entirely of slender wheatgrass and Indian ricegrass. Introduced perennial grasses totaled 15.1 percent of total vegetation cover, most of which was orchardgrass and intermediate wheatgrass. Minor species present include standard crested wheatgrass and smooth brome. Yellow sweetclover was the lone introduced annual forb, providing no measureable cover. Likewise, alfalfa was the lone introduced perennial forb and had no measured cover.

Mean total vegetation cover in the two samples at the Sow Belly South site was 46.0 percent, much higher than any other site sampled. This is mostly due to the great abundance of shrub cover on this site. Even compared to Gilson Gulch, the next most shrubby site, where absolute cover by shrubs was 13.3 percent, the Sow Belly South shrub cover was 28.0 percent, nearly 15 percent greater. Because of the super-abundance of shrub cover at Sow Belly South, total cover including overlap was 53.0

percent, a 7 percent increase over non-overlapped cover, which compares with a difference of less than one percent at Gilson Gulch.

Sow Belly North AML Area (Photos 11 and 12)

Vegetation of the Sow Belly North site was dominated by introduced perennial grasses that comprised 54.5 percent of total vegetation cover, virtually all of which was intermediate wheatgrass; orchardgrass and smooth brome were also present in minor amounts. Compared to the Gilson Gulch site, Sow Belly North was less heavily covered by shrub growth which, at 27.3 percent of total vegetation cover, totaled less than one-half of the 63 percent of vegetation cover that shrubs represented at Gilson Gulch. Shrubs present at Sow Belly North included big sagebrush, fourwing saltbush, winterfat, and rubber rabbitbrush.

Introduced annual and biennial forbs comprised 4.5 percent of total vegetation cover, nearly all of which was yellow sweetclover. White sweetclover (Melilotus alba) was also present in very small amounts. Native perennial forbs amounted to 9.1 percent of total vegetation cover, nearly all of which was blueleaf aster. Tarragon, Louisiana sage, blue flax, hoary aster, and Palmer penstemon were also present in small amounts. Introduced perennial forbs, entirely represented by alfalfa, amounted to 4.5 percent of total vegetation cover. Native perennial grasses of the Sow Belly North site were represented by western wheatgrass, slender wheatgrass, and Indian ricegrass, but accounted for no measurable cover.

Total vegetation cover in the two sample transects at Sow Belly North averaged 21.0 percent, with total cover including overlap of 22.0 percent. Species density averaged 16.0 species per 100 sq. m.

Permanent Photo Points

Permanent photographic points were established at Goose Island at the locations shown on Map 2. At each point, a pair of photos with location and year indicated were taken in opposing directions. 1993 photos are present as Photographs 13 through 20.

DISCUSSION

Vegetation Cover

Comparison of total vegetation cover between the Goose Island reclaimed area and the Gilson Gulch AML site is summarized as follows:

Area	Arithmetic Mean	Range of True Means (one-tailed, 90% conf.)	90% of Potential True Means
Goose Island (reclaimed)	17.5 %	17.5 to 19.1 %	NA
Gilson Gulch ("reference")	21.1 %	19.5 to 21.1 %	17.6 to 19.0 %

As can be seen in the above table, the "reference area" at Gilson Gulch has a true mean percent total vegetation cover that ranges between the arithmetic mean of 21.1 and 19.5, when the confidence interval used is calculated using a one-tailed t-value of 1.345 (14 degrees of freedom, 90 percent confidence). Thus, the revegetation success standard would be within the range of true means of the reference area total vegetation cover as estimated by the one-sided test and 0.10 alpha error required in Section 356.120 of the UDOGM regulations. This mean, then is in the above-stated range of 19.5 to 21.1 percent. As stated in 356.120, ground cover of the reclaimed area will be considered equal to the approved success standard when it is not less than 90 percent of the success standard. Thus, if ground cover of the reclaimed area exceeds 90 percent of a mean between 19.5 and 21.1, it will be considered successful. The minimum threshold of success then is 0.9 x 19.5 = 17.6 percent.

The mean percent ground cover in the Goose Island reclaimed area lies somewhere between 17.5 and 19.1 percent, when calculated using a one-tailed t-value (1.328: 19 degrees of freedom, 90 percent confidence), as required in Section 356.120. Thus, the true mean of the reclaimed area with 90 percent confidence lies within a range that exceeds the threshold of success, and success is indicated.

Production

Although production is not a revegetation performance standard at the Goose Island site, it was sampled and compares as follows:

Area	Arithmetic Mean	Range of True Means (one-tailed, 90% conf.)	90% True Means
Goose Island (reclaimed)	833 lbs/ac (herbaceous)	833 to 962	NA
Gilson Gulch ("reference")	1383 lbs/ac (shrub & herbaceous)	1258 to 1383	1133 to 1245
	882 lbs/ac (herbaceous)		

As can be seen above, based on total production, the Goose Island site has statistically less production than the Gilson Gulch site. However, Goose Island is a grassland (shrubs were 1.5 percent of total vegetation cover; Table 8) and Gilson Gulch is a shrubland (shrubs were 63.3 percent of total vegetation cover; Table 8). If the shrub component of production at Gilson Gulch is ignored, and herbaceous production compared to herbaceous production, the levels are very similar and statistically inseparable. It is not possible to know with certainty, but if shrubs as well as grasses had been planted at Goose Island, as they were at Gilson Gulch, the outcome may have been very similar.

Plant Species Composition

A total of 49 plant species were observed in the Goose Island reclaimed area; by comparison, the Gilson Gulch site had a total of 23 species (Table 11). In every lifeform, the number of species found at Goose Island exceeded that of Gilson Gulch. With reference specifically to native perennial species, the numbers were as follows:

Area	Native perennial forbs	Native perennial grasses	Native shrubs
Goose Island	10 species	12 species	9 species
Gilson Gulch	6 species	3 species	5 species

Although it is not known what seed mix was used at Gilson Gulch, it seems likely that a mixture heavy in intermediate wheatgrass and orchardgrass, along with fourwing saltbush, was utilized and that early aggressive growth of these introduced grasses severely limited growth of native species from the seed mix or from local dispersal . By contrast, the seed mix at Goose Island, besides apparently having no shrubs included, was probably heavier in native species. The species richness at the Goose Island site is likely to have developed as a result of less intensive interspecies competition over the

years because native species are generally substantially less aggressive than introduced species.

The difference observable in overall species richness between the two areas is also observable in species density data (Table 9). Total species density at the Goose Island site exceeds that at Gilson Gulch by 25 percent (14.9 species per 100 sq.m. versus 11.9 species per 100 sq.m.). At Goose Island, average density of native grass species was 4.65 species per 100 sq.m., while at Gilson Gulch it was 1.40 species per 100 sq.m. On the other hand, shrub species density was 1.75 species per 100 sq.m. at Goose Island and 3.90 species per 100 sq.m. at Gilson Gulch. Despite the advantage that Gilson Gulch held in shrubs, total native species density was 9.50 versus 7.60 species per 100 sq.m. in favor of Goose Island.

Topsoil/Refuse Comparison

Applied topsoil of the vegetation study areas was examined both quantitatively and qualitatively in soil pits. Results are graphically presented in Figure 1; laboratory data are presented in Appendix A. Photographs 21 through 35 show details of the soil sampling locations. Depth to refuse in the soil pits were as fololows:

Area/Pit	Depth to Refuse (in.)
Goose Island/A	11
" /B	7
" /C	11
" /D	0
Gilson Gulch/A	4.5
" /B	11
" /C	26
" /D	9
Sow Belly North/A	19
" /B	12
Sow Belly South/A	10
" /B	13

Average depth to refuse at Goose Island was about 7 inches, while at Gilson Gulch it was about 13 inches. Much of this difference is accounted for by the extremes -- pit D with no topsoil at Goose Island and the ultra-deep 26 inch topsoil in pit C at Gilson Gulch. Without these extremes, the means are about 10 and 8 inches, respectively. Thus,

overall, the difference in topsoil depth between Goose Island and Gilson Gulch may be minimal. Topsoil depth at the Sow Belly sites appeared to be somewhat greater than Goose Island or Gilson Gulch sites. However, even though total percent plant cover at the Sow Belly South site was twice that of any other site sampled, the topsoil depth is only slightly greater there.

With regard to Goose Island versus Gilson Gulch, the parameters for topsoil samples in which there appear to be significant differences include total organic carbon, percent organic matter, and total nitrogen, for which Goose Island is higher than Gilson Gulch. For calcium, magnesium, electrical conductivity, and iron, the opposite relationship prevails.

Total Organic Carbon/ Organic Matter Percent

Higher organic matter content in the Goose Island soils may reflect slightly higher abundance of coal/carbonaceous shale fragments in the topsoil. It is not known how this may have developed, and the difference is very slight, less than one percent. It is unlikely that it has a substantial effect on plant growth at Goose Island.

Total (Kjeldahl) Nitrogen

Higher values for total nitrogen in the Goose Island soils is probably related to the organic carbon content. This interpretation is reinforced by noting that for the Goose Island refuse samples, where organic matter percent is much higher than the topsoil samples, the total nitrogen levels are also much higher. It is also instructive that nitrate nitrogen levels are not different between any of these samples (topsoils or refuse), suggesting that the nitrogen involved is bound in the complex organic form, perhaps in the coal fraction of these substrates.

Calcium and Magnesium

Soluble calcium and magnesium are lower in the Goose Island topsoils compared to the Gilson Gulch topsoils. It is possible that the soil material used at Goose Island by chance came from a subsoil with less calcium/magnesium accumulation (i.e. less "caliche" development) than the materials used at Gilson Gulch.

Electrical Conductivity

With less calcium and magnesium (and perhaps less sodium as well, see Figure 1), it is not unexpected that electrical conductivity would be lower. The amount of difference in

free cation abundance at the two sites is not likely to be of biological significance; neither is above the commonly used threshold of 4 mmhos/cm.

Erosion Condition Classification

Areas subjected to erosion condition classification at Goose Island are shown on Map 3. At the Goose Island site, seven areas differing in slope, exposure, or substrate rockiness were identified and rated separately. At Gilson Gulch, topography was much less complex, and only two areas required separation (Map 5). At the Sow Belly sites, the small areas involved and their uniform slope necessitated no subdivision. The data sheets showing the ratings from each of these sites are included as Appendix B. Overall rating factors came out as follows:

Area	Overall Score	Erosion Condition Class
Goose Island, Area 1	50.0	MODERATE
Goose Island, Area 2	40.7	SLIGHT to MODERATE
Goose Island, Area 3	32.6	SLIGHT
Goose Island, Area 4	39.5	SLIGHT
Goose Island, Area 5	44.2	MODERATE
Goose Island, Area 6	45.3	MODERATE
Goose Island, Area 7	32.6	SLIGHT
Gilson Gulch, Area 1 (upper bench)	50.0	MODERATE
Gilson Gulch, Area 2 (slopes)	66.2	CRITICAL
Sow Belly North	76.7	CRITICAL
Sow Belly South	50.0	MODERATE

Scores from the Goose Island sites were generally lower than those from any of the AML sites at Gilson Gulch and Sow Belly. This partly relates to the fact that the AML sites were more steeply sloped than the Goose Island areas. Slopes at the Gilson Gulch AML sample area ranged mostly from 23 to 34 %, while at the Sow Belly North sites slopes were about 35 % and at Sow Belly South slopes ranged from 32 to 60 % (Table 12). By comparison, the Goose Island slopes varied about equally between areas from 2 to 10 % slope and areas from 10 to 25 % slope, with a few areas around 30 % and higher.

Besides the difference in slopes, there is a difference in the erosion control characteristics of the vegetation cover in the different areas. The Goose Island area vegetation has greater cover by rhizomatous grass in the form of western wheatgrass and thickspike wheatgrass. The AML sites are mostly vegetated by strong bunchgrasses such as intermediate wheatgrass or orchardgrass. Although highly productive (see discussions of production data, above), these grasses offer little inter-tussock erosion control and slopes occupied by such bunchgrasses are often subject to erosion between the tussocks. By comparison, rhizomatous grass species often produce less above-ground biomass, but spread their rooting biomass more evenly through the upper soil along rhizomes.

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Figure 1. Selected Soil Analysis Results

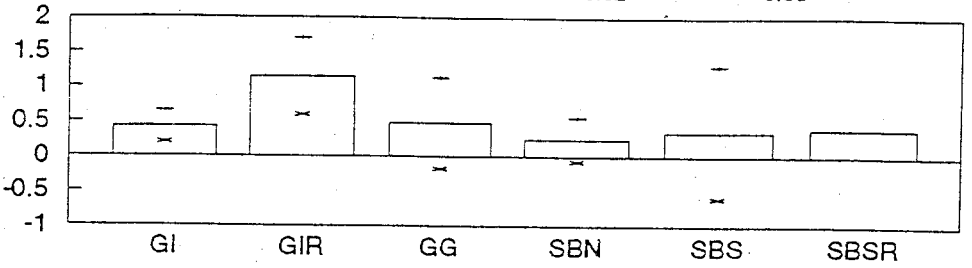
(based on data presented in Appendix A) (one standard error shown above and below mean)

GI=Goose Island Topsoil (n=4) GIR=Goose Island Refuse (n=5) GG=Gilson Gulch Topsoil (n=5)

SBN=Sow Belly North Topsoil(n=2)SBS=Sow Belly South Topsoil(n=2)SBSR=Sow Belly South Refuse(n=1)

Sodium Adsorption Ratio (SAR)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.43	1.14	0.48	0.25	0.35	0.40
HIGH	0.65	1.69	1.13	0.57	1.30	
LOW	0.20	0.59	-0.17	-0.07	-0.60	
STD	0.19	0.57	0.68	0.07	0.21	
STD ERROR	0.22	0.55	0.65	0.32	0.95	



Total Nitrogen (Kjeldahl)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.09	0.18	0.05	0.26	0.18	0.25
HIGH	0.09	0.22	0.06	0.29	0.33	
LOW	0.08	0.14	0.05	0.22	0.02	
STD	0.01	0.04	0.01	0.01	0.04	
STD ERROR	0.01	0.04	0.01	0.03	0.16	

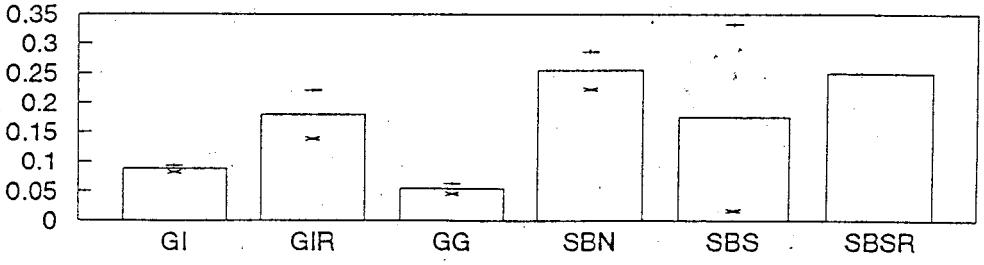
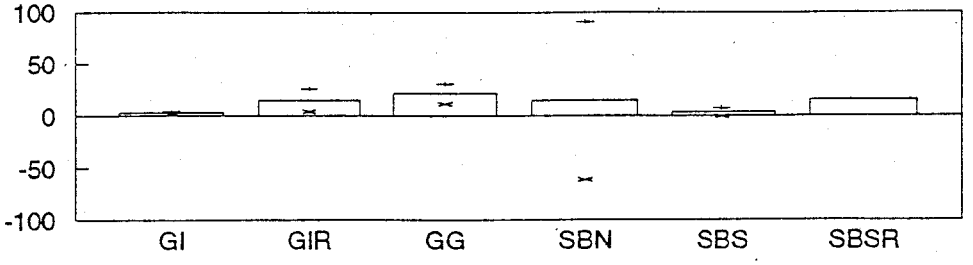


Figure 1. Selected Soil Analysis Results (continued)

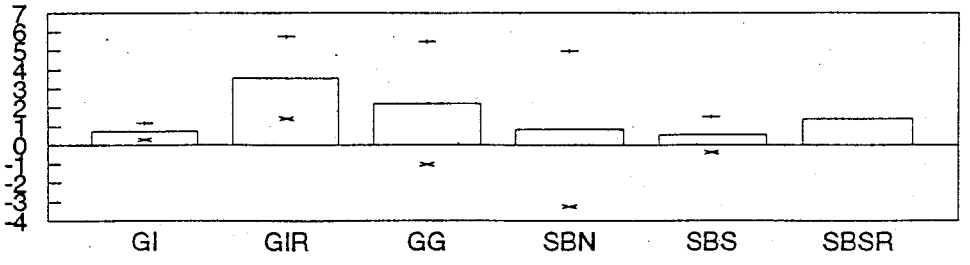
Soluble Calcium

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	3.18	15.02	21.30	14.85	3.55	15.50
HIGH	4.38	26.08	31.12	90.93	7.65	
LOW	1.97	3.96	11.48	-61.23	-0.55	
STD	1.02	11.60	10.30	17.04	0.92	
STD ERROR	1.21	11.06	9.82	76.08	4.10	



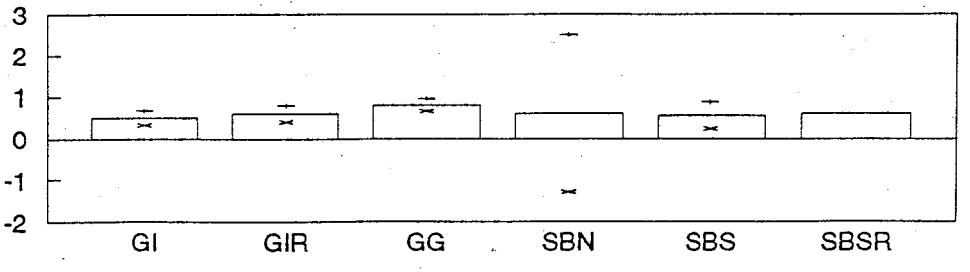
Soluble Sodium

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.75	3.58	2.22	0.85	0.55	1.40
HIGH	1.20	5.73	5.47	4.95	1.50	
LOW	0.30	1.43	-1.03	-3.25	-0.40	
STD	0.38	2.26	3.41	0.92	0.21	
STD ERROR	0.45	2.15	3.25	4.10	0.95	



Soluble Potassium

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.50	0.60	0.80	0.60	0.55	0.60
HIGH	0.67	0.79	0.95	2.49	0.87	
LOW	0.33	0.41	0.65	-1.29	0.23	
STD	0.14	0.20	0.16	0.42	0.07	
STD ERROR	0.17	0.19	0.15	1.89	0.32	



Soluble Magnesium

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	2.40	9.50	11.84	6.50	1.70	6.20
HIGH	2.91	15.38	21.28	38.07	2.96	
LOW	1.89	3.62	2.40	-25.07	0.44	
STD	0.43	6.17	9.90	7.07	0.28	
STD ERROR	0.51	5.88	9.44	31.57	1.26	

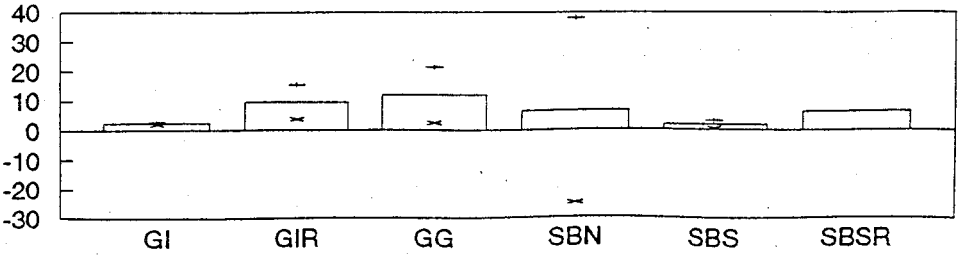
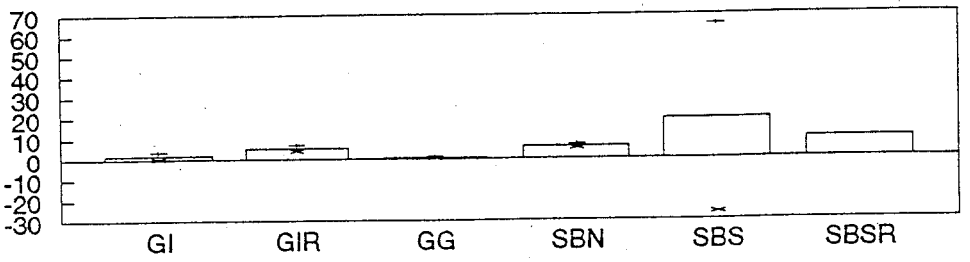


Figure 1. Selected Soil Analysis Results (continued)

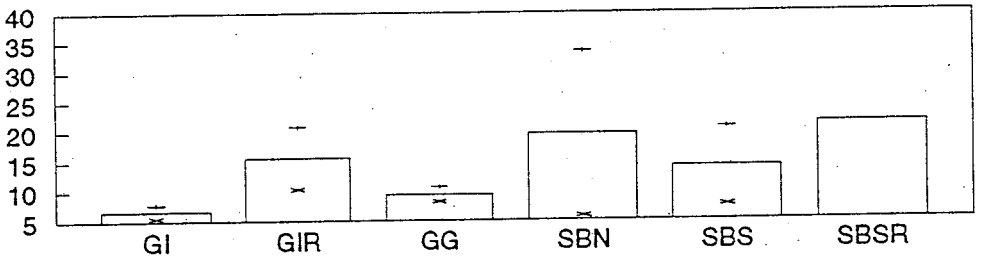
Zinc (DTPA extractable)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	1.98	5.38	0.74	5.95	19.25	9.70
HIGH	3.72	6.75	1.09	6.90	65.03	
LOW	0.23	4.01	0.39	5.00	-26.53	
STD	1.48	1.44	0.37	0.21	10.25	
STD ERROR	1.75	1.37	0.35	0.95	45.78	



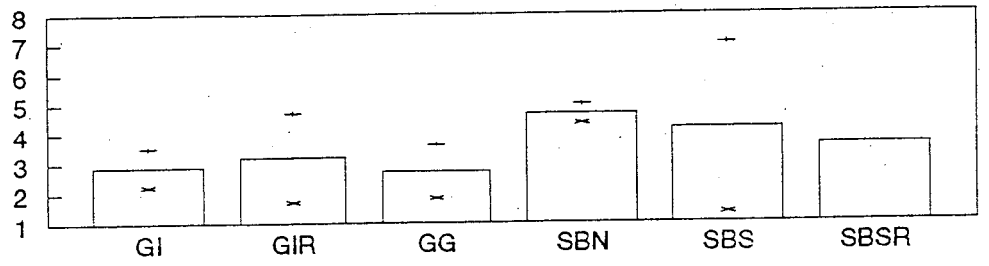
Iron (DTPA extractable)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	6.65	15.58	9.36	19.60	14.05	21.40
HIGH	7.74	20.85	10.63	33.49	20.68	
LOW	5.56	10.31	8.09	5.71	7.42	
STD	0.93	5.52	1.33	3.11	1.48	
STD ERROR	1.09	5.27	1.27	13.89	6.63	



Manganese (DTPA extractable)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	2.88	3.20	2.72	4.65	4.15	3.60
HIGH	3.52	4.70	3.62	4.97	6.99	
LOW	2.23	1.70	1.82	4.33	1.31	
STD	0.55	1.58	0.94	0.07	0.64	
STD ERROR	0.65	1.50	0.90	0.32	2.84	



Copper (DTPA extractable)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	1.93	2.60	1.04	21.65	51.70	14.60
HIGH	2.94	3.30	1.09	87.63	73.17	
LOW	0.91	1.90	0.99	-44.33	30.23	
STD	0.87	0.73	0.05	14.78	4.81	
STD ERROR	1.02	0.70	0.05	65.98	21.47	

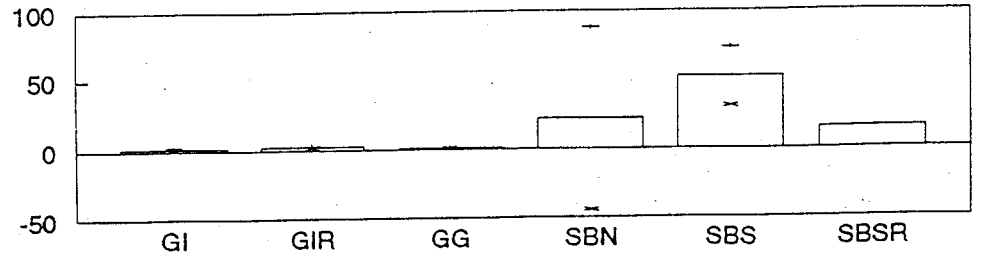
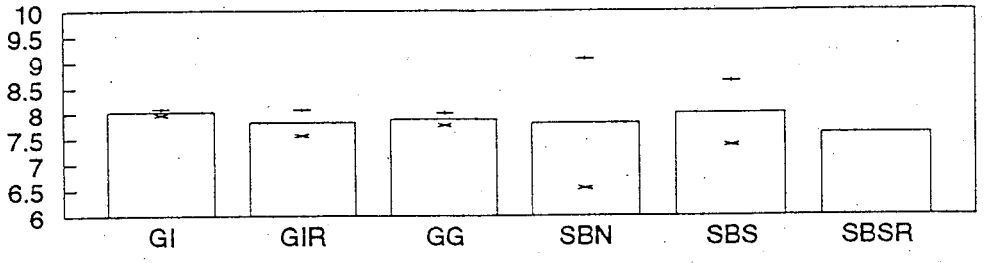


Figure 1. Selected Soil Analysis Results (continued)

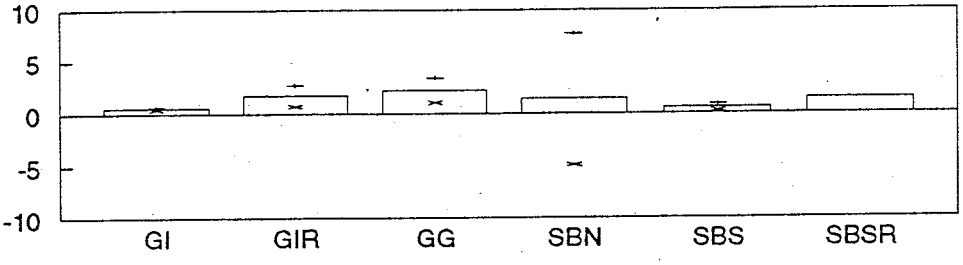
pH

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	8.03	7.82	7.88	7.80	8.00	7.60
HIGH	8.08	8.08	8.00	9.06	8.63	
LOW	7.97	7.56	7.76	6.54	7.37	
STD	0.05	0.27	0.13	0.28	0.14	
STD ERROR	0.06	0.26	0.12	1.26	0.63	



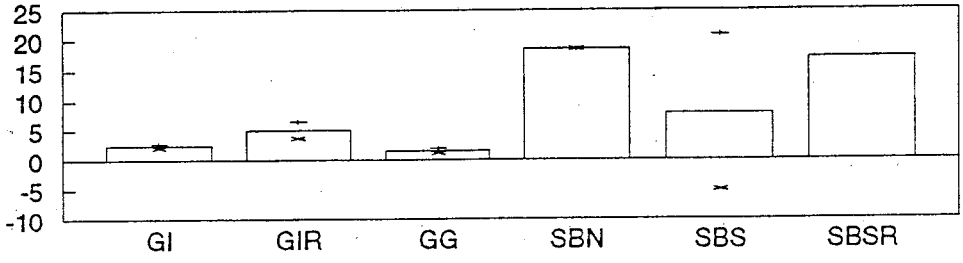
Conductivity (mmhos/cm)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.55	1.72	2.24	1.40	0.55	1.40
HIGH	0.67	2.72	3.43	7.71	0.87	
LOW	0.43	0.72	1.05	-4.91	0.23	
STD	0.10	1.05	1.25	1.41	0.07	
STD ERROR	0.12	1.00	1.19	6.31	0.32	



Percent Organic Matter

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	2.43	5.02	1.58	18.50	7.85	17.10
HIGH	2.76	6.40	1.96	18.50	20.79	
LOW	2.09	3.64	1.20	18.50	-5.09	
STD	0.29	1.44	0.40	0.00	2.90	
STD ERROR	0.34	1.38	0.38	0.00	12.94	



Phosphorous (DTPA extractable)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	3.60	2.36	2.32	3.80	2.15	0.30
HIGH	6.33	3.61	6.37	13.27	3.10	
LOW	0.87	1.11	-1.73	-5.67	1.20	
STD	2.32	1.31	4.24	2.12	0.21	
STD ERROR	2.73	1.25	4.05	9.47	0.95	

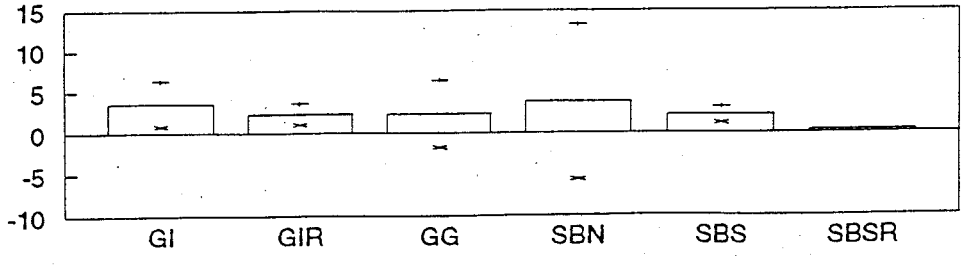
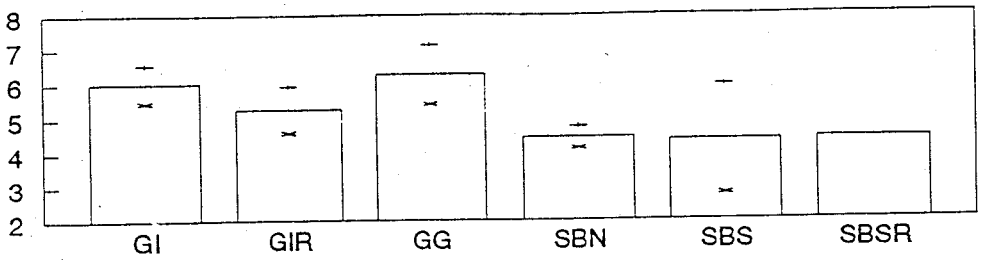


Figure 1. Selected Soil Analysis Results (continued)

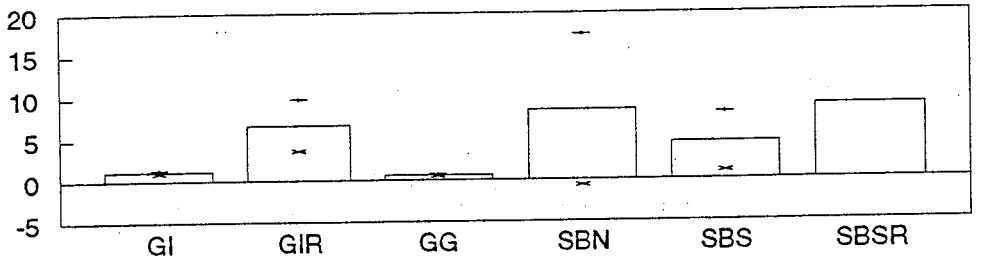
Available Water Capacity (%)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	6.03	5.26	6.26	4.45	4.35	4.40
HIGH	6.56	5.93	7.12	4.77	5.93	
LOW	5.49	4.59	5.40	4.13	2.77	
STD	0.46	0.70	0.90	0.07	0.35	
STD ERROR	0.54	0.67	0.86	0.32	1.58	



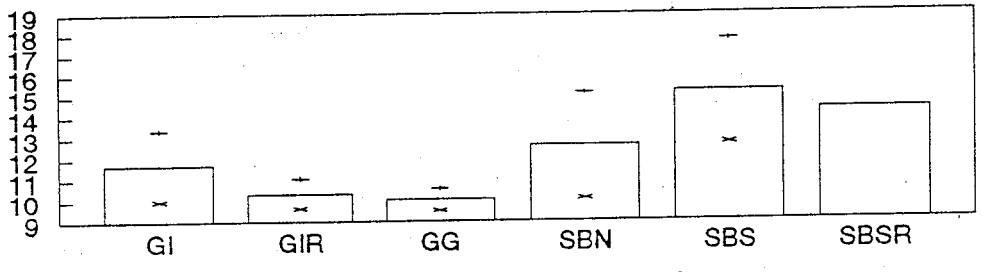
Total Organic Carbon (%)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	1.19	6.69	0.63	8.40	4.52	8.93
HIGH	1.39	9.80	0.76	17.46	8.06	
LOW	0.99	3.58	0.51	-0.67	0.98	
STD	0.17	3.27	0.13	2.03	0.79	
STD ERROR	0.20	3.11	0.13	9.06	3.54	



Cation Exchange Capacity (meq/100gm.)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	11.68	10.34	10.04	12.60	15.20	14.30
HIGH	13.36	11.05	10.57	15.13	17.73	
LOW	9.99	9.63	9.51	10.07	12.67	
STD	1.43	0.74	0.55	0.57	0.57	
STD ERROR	1.69	0.71	0.53	2.53	2.53	



Exchangeable Sodium (meq/100gm.)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	0.22	0.34	0.21	0.14	0.11	0.12
HIGH	0.30	0.45	0.34	0.33	0.33	
LOW	0.13	0.22	0.08	-0.05	-0.12	
STD	0.07	0.12	0.14	0.04	0.05	
STD ERROR	0.08	0.11	0.13	0.19	0.22	

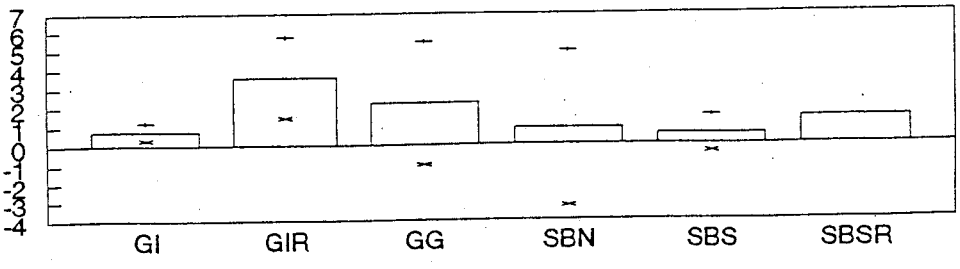
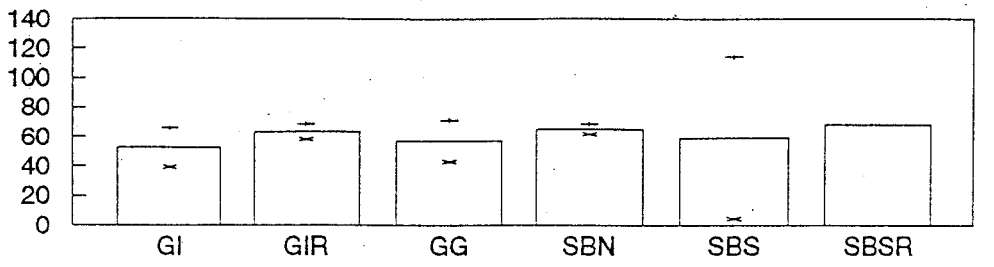


Figure 1. Selected Soil Analysis Results (continued)

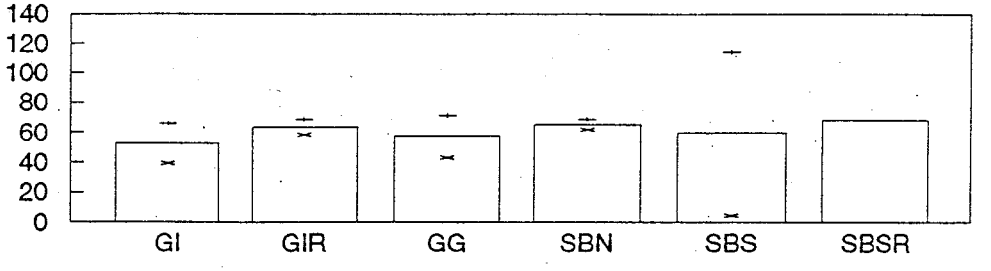
Percent Gravel (>2000)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	52.68	63.52	57.24	65.25	59.40	68.40
HIGH	65.97	68.81	71.35	68.72	114.33	
LOW	39.38	58.23	43.13	61.78	4.47	
STD	11.30	5.55	14.80	0.78	12.30	
STD ERROR	13.30	5.29	14.11	3.47	54.93	



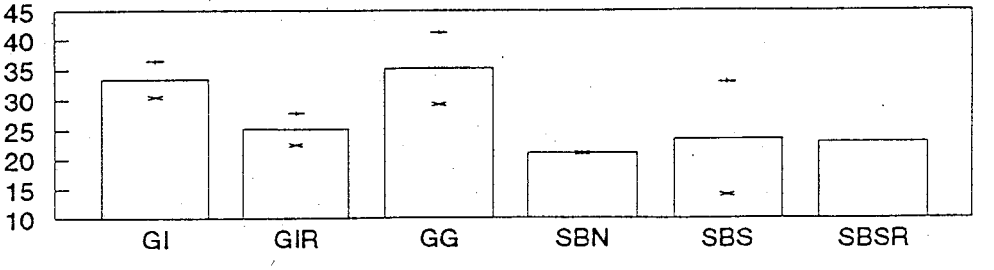
Percent Sand (50 to 2000 microns)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	47.50	58.20	48.20	68.50	65.50	66.00
HIGH	52.72	62.84	57.28	71.66	81.29	
LOW	42.28	53.56	39.12	65.34	49.72	
STD	4.43	4.87	9.52	0.71	3.54	
STD ERROR	5.22	4.64	9.08	3.16	15.79	



Percent Silt (2 to 50 microns)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	33.50	25.20	35.20	21.00	23.50	23.00
HIGH	36.46	27.85	41.25	21.00	32.97	
LOW	30.54	22.55	29.15	21.00	14.03	
STD	2.52	2.77	6.34	0.00	2.12	
STD ERROR	2.96	2.65	6.05	0.00	9.47	



Percent Clay (<2 microns)

	GI	GIR	GG	SBN	SBS	SBSR
MEAN	19.00	16.60	16.60	10.50	11.00	11.00
HIGH	22.04	18.80	19.66	13.66	17.31	
LOW	15.96	14.40	13.54	7.34	4.69	
STD	2.58	2.30	3.21	0.71	1.41	
STD ERROR	3.04	2.20	3.06	3.16	6.31	

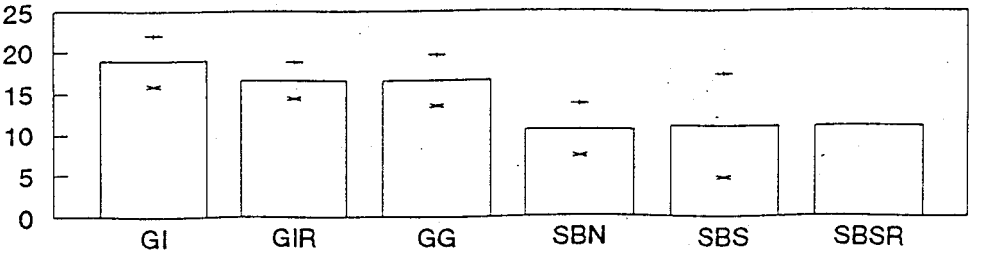


Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
NATIVE ANNUAL & BIENNIAL FORBS					
Helianthus annuus	0.00	5.00	0.00	0.00	0.00
TOTAL NATIVE ANN. & BIEN. FORBS	0.0	5.0	0.0	0.0	0.0
INTRODUCED ANNUAL & BIENNIAL FORBS					
Cynoglossum officinale	0.10	40.00	0.57	0.10	0.57
Kochia scoparia	0.10	40.00	0.57	0.10	0.57
Lepidium perfoliatum	0.00	10.00	0.00	0.00	0.00
Salsola iberica	0.00	10.00	0.00	0.00	0.00
Tragopogon dubius	0.00	45.00	0.00	0.00	0.00
TOTAL INTRO. ANN. & BIEN. FORBS	0.2	85.0	1.1	0.2	1.1
INTRODUCED ANNUAL GRASSES					
Bromus tectorum	0.20	40.00	1.14	0.20	1.14
TOTAL INTRO. ANN. GRASSES	0.2	40.0	1.1	0.2	1.1
NATIVE PERENNIAL FORBS					
Artemisia ludoviciana	0.20	75.00	1.14	0.20	1.14
Aster glaucodes	0.00	5.00	0.00	0.00	0.00
Grindelia squarrosa	0.60	100.00	3.43	0.60	3.41
Linum perenne ssp. lewisii	0.00	5.00	0.00	0.00	0.00
Machaeranthera canescens	0.10	100.00	0.57	0.20	1.14
Rumex crispus	0.00	10.00	0.00	0.00	0.00
Viguiera multiflora	0.00	5.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL FORBS	0.9	100.0	5.1	1.0	5.7
INTRODUCED PERENNIAL FORBS					
Astragalus cicer	0.00	15.00	0.00	0.00	0.00
Convolvulus arvensis	0.00	5.00	0.00	0.00	0.00
Medicago sativa	0.90	85.00	5.14	0.90	5.11
Taraxacum officinale	0.00	5.00	0.00	0.00	0.00
TOTAL INTRO. PERENNIAL FORBS	0.9	95.0	5.1	0.9	5.1
NATIVE PERENNIAL GRASSES (cool)					
Elymus cinereus	0.60	85.00	3.43	0.60	3.41
Elymus lanceolatus fm. albicans	0.00	5.00	0.00	0.00	0.00
Elymus lanceolatus fm. dasystachyus	0.60	10.00	3.43	0.60	3.41
Elymus smithii	0.80	20.00	4.57	0.80	4.55
Elymus spicatus	0.40	40.00	2.29	0.40	2.27
Elymus trachycaulus	2.20	75.00	12.57	2.20	12.50
Festuca sp.	0.50	40.00	2.86	0.50	2.84
Hordeum jubatum	0.00	15.00	0.00	0.00	0.00
Oryzopsis hymenoides	2.10	95.00	12.00	2.10	11.93
Poa compressa	0.10	15.00	0.57	0.10	0.57
Poa pratensis fm. aggassizensis	0.00	30.00	0.00	0.00	0.00
Stipa viridula	0.10	35.00	0.57	0.10	0.57
TOTAL NATIVE PERENNIAL GRASSES (c)	7.4	100.0	42.3	7.4	42.0
INTRODUCED PERENNIAL GRASSES (cool)					
Agropyron cristatum and A. desertorum	5.60	95.00	32.00	5.60	31.82
Bromus inermis	0.20	30.00	1.14	0.20	1.14
Dactylis glomerata	0.10	15.00	0.57	0.10	0.57
Elymus hispidus	1.60	75.00	9.14	1.60	9.09
Festuca arundinacea	0.10	30.00	0.57	0.10	0.57
TOTAL INTRO. PERENNIAL GRASSES (c)	7.6	100.0	43.4	7.6	43.2
NATIVE SHRUBS					
Artemisia tridentata	0.00	10.00	0.00	0.00	0.00
Chrysothamnus nauseosus	0.20	60.00	1.14	0.20	1.14
Gutierrezia sarothrae	0.10	35.00	0.57	0.10	0.57
Mahonia repens	0.00	5.00	0.00	0.00	0.00
Prunus virginiana	0.00	10.00	0.00	0.00	0.00
Rhus aromatica var. trilobata	0.00	15.00	0.00	0.00	0.00
Rosa woodsii	0.00	25.00	0.00	0.00	0.00
TOTAL NATIVE SHRUBS	0.3	95.0	1.7	0.3	1.7

Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
NATIVE TREES					
Juniperus osteosperma	0.00	15.00	0.00	0.00	0.00
Pinus ponderosa	0.00	5.00	0.00	0.00	0.00
TOTAL NATIVE TREES	0.0	15.0	0.0	0.0	0.0
Standing dead	0.50	20.00		0.50	
Litter	19.50	100.00		19.50	
Bare soil	37.00	100.00		37.00	
Rock	25.50	100.00		25.50	
TOTALS	100.0			100.1	
TOTAL VEGETATION COVER	17.5		100.0	17.6	100.0
GROUND COVER (Litter+Rock+Veg+St.Dead)	63.0			63.1	
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 14.9 Std.Dev.= 3.2)					

Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

Percent Foliar Cover*

PLANT SPECIES	----- SAMPLE NUMBER -----									
	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS										
Helianthus annuus								P		
TOTAL NATIVE ANN. & BIEN. FORBS	---	---	---	---	---	---	---	P	---	---
INTRODUCED ANNUAL & BIENNIAL FORBS										
Cynoglossum officinale						P	P			
Kochia scoparia		P					P			P
Lepidium perfoliatum							P	P		
Salsola iberica										
Tragopogon dubius	P		P				P	P	P	
TOTAL INTRO. ANN. & BIEN. FORBS	P	P	P	---	---	P	P	P	P	P
INTRODUCED ANNUAL GRASSES										
Bromus tectorum	P						P	P		
TOTAL INTRO. ANN. GRASSES	P	---	---	---	---	---	P	P	---	---
NATIVE PERENNIAL FORBS										
Artemisia ludoviciana	P	P	2	P			P	P	P	P
Aster glaucodes	P									
Grindelia squarrosa	P	P	P	P	P	P	4	P	P	2
Linum perenne ssp. lewisii										
Machaeranthera canescens	P	P	2	P	P	P	P	P	P	P
Rumex crispus						P				
Viguiera multiflora			P							
TOTAL NATIVE PERENNIAL FORBS	P	P	4	P	P	P	4	P	P	2
INTRODUCED PERENNIAL FORBS										
Astragalus cicer							P			
Convolvulus arvensis							P			
Medicago sativa	2	P	P	2	P	P			2	P
Taraxacum officinale				P						
TOTAL INTRO. PERENNIAL FORBS	2	P	P	2	P	P	P	---	2	P
NATIVE PERENNIAL GRASSES (cool)										
Elymus cinereus	P	P	P	2	P	P	2		P	2
Elymus lanceolatus fm. albicans	P									
Elymus lanceolatus fm. dasystachyus	6				6					
Elymus smithii	4				12			P		
Elymus spicatus		P					P		P	
Elymus trachycaulus		8	P			6	2	P	2	4
Festuca sp.		4	P	4					P	P
Hordeum jubatum									P	
Oryzopsis hymenoides	P	P	P	P	2	4	2	6	P	
Poa compressa			P							
Poa pratensis fm. aggassizensis			P	P			P			
Stipa viridula	P			P		P	P			
TOTAL NATIVE PERENNIAL GRASSES (c)	10	12	P	6	20	10	6	6	2	6
INTRODUCED PERENNIAL GRASSES (cool)										
Agropyron cristatum and A. desertorum	P	4	6	14	2	4	4	4	16	4
Bromus inermis										
Dactylis glomerata				2		P				
Elymus hispidus	4	P	2	P		2	2		P	
Festuca arundinacea	P									
TOTAL INTRO. PERENNIAL GRASSES (c)	4	4	8	16	2	6	6	4	16	4
NATIVE SHRUBS										
Artemisia tridentata		P								
Chrysothamnus nauseosus	2		P	P		P	2			P
Gutierrezia sarothrae								P		
Mahonia repens										P
Prunus virginiana										
Rhus aromatica var. trilobata	P				P					
Rosa woodsii										P
TOTAL NATIVE SHRUBS	2	P	P	P	P	P	2	P	---	P

Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* ----- SAMPLE NUMBER -----									
	1	2	3	4	5	6	7	8	9	10
NATIVE TREES										
Juniperus osteosperma	P						P			
Pinus ponderosa	P									
TOTAL NATIVE TREES	P	---	---	---	---	---	---	---	---	---
Standing dead						4	2			
Litter	8	28	34	26	10	16	24	12	18	26
Bare soil	50	28	30	24	58	28	22	58	38	34
Rock	24	28	24	26	10	36	34	20	24	28
TOTALS	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	18	16	12	24	22	16	18	10	20	12
GROUND COVER (Litter+Rock+Veg+St.Dead)	50	72	70	76	42	72	78	42	62	66
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 14.9 Std.Dev.= 3.2)	20	13	15	14	9	13	20	12	13	12

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* ----- SAMPLE NUMBER -----									
	11	12	13	14	15	16	17	18	19	20
NATIVE ANNUAL & BIENNIAL FORBS										
Helianthus annuus										
TOTAL NATIVE ANN. & BIEN. FORBS	---	---	---	---	---	---	---	---	---	---
INTRODUCED ANNUAL & BIENNIAL FORBS										
Cynoglossum officinale	P	P		2	P			P	P	
Kochia scoparia	2		P			P		P	P	
Lepidium perfoliatum										
Salsola iberica	P			P						
Tragopogon dubius					P	P		P		P
TOTAL INTRO. ANN. & BIEN. FORBS	2	P	P	2	P	P	---	P	P	P
INTRODUCED ANNUAL GRASSES										
Bromus tectorum	2		2	P	P	P				
TOTAL INTRO. ANN. GRASSES	2	---	2	P	P	P	---	---	---	---
NATIVE PERENNIAL FORBS										
Artemisia ludoviciana		P		2	P	P	P	P		P
Aster glaucodes										
Grindelia squarrosa	P	P	P	4	P	P	2	P	P	P
Linum perenne ssp. lewisii							P			
Machaeranthera canescens	P	P	P	(2)	P	P	P	P	P	P
Rumex crispus								P		
Viguiera multiflora										
TOTAL NATIVE PERENNIAL FORBS	P	P	P	6(2)	P	P	2	P	P	P
INTRODUCED PERENNIAL FORBS										
Astragalus cicer	P						P			
Convolvulus arvensis										
Medicago sativa		P	P	2	P	2	4	2	P	2
Taraxacum officinale										
TOTAL INTRO. PERENNIAL FORBS	P	P	P	2	P	2	4	2	P	2
NATIVE PERENNIAL GRASSES (cool)										
Elymus cinereus	2	P		2	P	P	2	P	P	
Elymus lanceolatus fm. albicans										
Elymus lanceolatus fm. dasystachyus										
Elymus smithii	P									
Elymus spicatus	2			P	2		2	2		
Elymus trachycaulus	8	2	6	2		P	2	2	P	
Festuca sp.					2	P	P			
Hordeum jubatum						P			P	
Oryzopsis hymenoides	2	P	P	6	2	8	2	4	4	P
Poa compressa					2					P
Poa pratensis fm. aggassizensis				P	P	P				
Stipa viridula							P	2	P	
TOTAL NATIVE PERENNIAL GRASSES (c)	14	2	6	10	8	8	8	10	4	P
INTRODUCED PERENNIAL GRASSES (cool)										
Agropyron cristatum and A. desertorum	6	12	6		2	2	2	4	12	8
Bromus inermis	P	2	P			P		P	2	
Dactylis glomerata								P		
Elymus hispidus	6	2	4	6		P	2	2	P	
Festuca arundinacea	P	2	P	P			P			
TOTAL INTRO. PERENNIAL GRASSES (c)	12	18	10	6	2	2	4	6	14	8
NATIVE SHRUBS										
Artemisia tridentata										P
Chrysothamnus nauseosus			P	P	P	P	P	P	P	
Gutierrezia sarothrae				P		P	P		P	2
Mahonia repens										P
Prunus virginiana					P					
Rhus aromatica var. trilobata				P						
Rosa woodsii	P	P		P		P				
TOTAL NATIVE SHRUBS	P	P	P	P	P	P	P	P	P	2

Table 1. Cover Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* ----- SAMPLE NUMBER -----									
	11	12	13	14	15	16	17	18	19	20
NATIVE TREES										
Juniperus osteosperma	P									
Pinus ponderosa										
TOTAL NATIVE TREES	---	---	---	---	---	---	---	---	---	---
Standing dead	2			2						
Litter	24	20	6	22	18	12	22	28	8	28
Bare soil	24	44	42	24	34	58	38	24	46	36
Rock	20	16	34	26	38	18	22	30	28	24
TOTALS	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	30	20	18	26(2)	10	12	18	18	18	12
GROUND COVER (Litter+Rock+Veg+St.Dead)	76	56	58	76(2)	66	42	62	76	54	64
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 14.9 Std.Dev.= 3.2)	18	13	12	18	16	19	17	18	15	11

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 2. Production Data - Goose Island Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE PRODUCTION (gm/0.5 sq.m.)	AVERAGE PRODUCTION (lb/acre)	FREQUENCY (%)	PRODUCTION (gm/0.5 sq.m.)* ----- SAMPLE NUMBER ----- 1	2	3	4	5	6	7	8	9	10
NATIVE PERENNIAL FORBS													
Grindelia squarrosa	1.96	35.0	20.00			7.7				11.9			
Machaeranthera canescens	1.01	18.0	10.00			10.1							
TOTAL NATIVE PERENNIAL FORBS	3.0	53.5	20.0	---	---	17.8	---	---	---	11.9	---	---	---
INTRODUCED PERENNIAL FORBS													
Medicago sativa	0.86	15.3	10.00		8.6								
TOTAL INTRO. PERENNIAL FORBS	0.9	16.1	10.0	---	8.6	---	---	---	---	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)													
Elymus cinereus	7.76	138.5	40.00	17.4	13.5	16.0	30.7						
Elymus lanceolatus fm. dasystachyus	7.28	129.9	50.00	8.7	18.7			13.3	23.7		8.4		
Elymus smithii	14.19	253.2	100.00	9.1	9.7	11.2	8.2	14.6	21.3	13.7	21.7	7.3	25.1
Oryzopsis hymenoides	3.32	59.2	30.00				10.7			15.9		6.6	
TOTAL NATIVE PERENNIAL GRASSES (c)	32.6	581.7	100.0	35.2	41.9	27.2	49.6	27.9	45.0	29.6	30.1	13.9	25.1
INTRODUCED PERENNIAL GRASSES (cool)													
Agropyron cristatum	10.34	184.5	30.00							40.4		50.6	12.4
TOTAL INTRO. PERENNIAL GRASSES (c)	10.3	183.8	30.0	---	---	---	---	---	---	40.4	---	50.6	12.4
TOTAL PRODUCTION	46.7	833.3		35.2	50.5	45.0	49.6	27.9	45.0	81.9	30.1	64.5	37.5
	16.4 = Std.Dev.	292.6 = Std.Dev.											
SPECIES DENSITY (# of species/0.5 sq.m.) (AVERAGE= 2.9 Std.Dev.= 0.9)				3	4	4	3	2	2	4	2	3	2

Table 3. Cover Data - Gilson Gulch Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
INTRODUCED ANNUAL & BIENNIAL FORBS					
Kochia scoparia	0.00	6.67	0.00	0.00	0.00
Melilotus officinalis	0.53	100.00	2.53	0.53	2.45
Polygonum arenastrum	0.00	6.67	0.00	0.00	0.00
Salsola iberica	0.00	6.67	0.00	0.00	0.00
TOTAL INTRO. ANN. & BIEN. FORBS	0.5	100.0	2.5	0.5	2.5
NATIVE PERENNIAL FORBS					
Artemisia dracunculus	0.00	6.67	0.00	0.00	0.00
Artemisia ludoviciana	0.13	20.00	0.63	0.13	0.61
Aster glaucodes	0.00	26.67	0.00	0.00	0.00
Linum perenne ssp. lewisii	0.00	80.00	0.00	0.00	0.00
Machaeranthera canescens	0.00	46.67	0.00	0.00	0.00
Penstemon palmeri	0.13	53.33	0.63	0.13	0.61
TOTAL NATIVE PERENNIAL FORBS	0.3	100.0	1.3	0.3	1.2
INTRODUCED PERENNIAL FORBS					
Medicago sativa	1.20	86.67	5.70	1.20	5.52
TOTAL INTRO. PERENNIAL FORBS	1.2	86.7	5.7	1.2	5.5
NATIVE PERENNIAL GRASSES (cool)					
Elymus smithii	0.00	6.67	0.00	0.00	0.00
Elymus trachycaulus	0.40	66.67	1.90	0.40	1.84
Oryzopsis hymenoides	0.00	66.67	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL GRASSES (c)	0.4	93.3	1.9	0.4	1.8
INTRODUCED PERENNIAL GRASSES (cool)					
Agropyron cristatum	0.00	26.67	0.00	0.00	0.00
Dactylis glomerata	1.20	93.33	5.70	1.20	5.52
Elymus hispidus	4.13	100.00	19.62	4.27	19.63
TOTAL INTRO. PERENNIAL GRASSES (c)	5.3	100.0	25.3	5.5	25.2
NATIVE SHRUBS					
Artemisia tridentata	0.53	86.67	2.53	0.53	2.45
Atriplex canescens	6.40	100.00	30.38	6.53	30.06
Atriplex confertifolia	0.00	6.67	0.00	0.00	0.00
Ceratoides lanata	1.33	100.00	6.33	1.33	6.13
Chrysothamnus nauseosus	5.07	100.00	24.05	5.47	25.15
TOTAL NATIVE SHRUBS	13.3	100.0	63.3	13.9	63.8
Standing dead	1.47	66.67		1.60	
Litter	19.60	100.00		19.60	
Bare soil	42.67	100.00		42.67	
Rock	15.20	100.00		15.20	
TOTALS	100.0			100.8	
TOTAL VEGETATION COVER	21.1		100.0	21.7	100.0
GROUND COVER (Litter+Rock+Veg+St.Dead)	57.3			58.1	
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 11.9 Std.Dev.= 1.9)					

Table 3. Cover Data - Gilson Gulch Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* ----- SAMPLE NUMBER ----- 1	2	3	4	5	6	7	8	9
INTRODUCED ANNUAL & BIENNIAL FORBS									
Kochia scoparia									
Melilotus officinalis	P	P	P	4	P	P	P	P	P
Polygonum arenastrum									
Salsola iberica									
TOTAL INTRO. ANN. & BIEN. FORBS	P	P	P	4	P	P	P	P	P
NATIVE PERENNIAL FORBS									
Artemisia dracunculus		P							
Artemisia ludoviciana		P						P	
Aster glaucodes			P	P				P	
Linum perenne ssp. lewisii	P	P	P		P	P	P		P
Machaeranthera canescens		P			P			P	
Penstemon palmeri		P			P	P			P
TOTAL NATIVE PERENNIAL FORBS	P	P	P	P	P	P	P	P	P
INTRODUCED PERENNIAL FORBS									
Medicago sativa	P	4	P	2		P	P	P	6
TOTAL INTRO. PERENNIAL FORBS	P	4	P	2	---	P	P	P	6
NATIVE PERENNIAL GRASSES (cool)									
Elymus smithii			P						
Elymus trachycaulus			P	P	P		P	P	
Oryzopsis hymenoides	P	P	P			P		P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	P	P	P	P	P	P	P	P	P
INTRODUCED PERENNIAL GRASSES (cool)									
Agropyron cristatum	P								
Dactylis glomerata	P	P	P	4		P	2	2	4
Elymus hispidus	8	2	2	4	8	4	2	4	P
TOTAL INTRO. PERENNIAL GRASSES (c)	8	2	2	8	8	4	4	6	4
NATIVE SHRUBS									
Artemisia tridentata		6	P	P	P	P	P	P	P
Atriplex canescens	6	10	2	6	10	10	4	12	2
Atriplex confertifolia				P					
Ceratoides lanata	2	P	4	P	P	2	2	P	P
Chrysothamnus nauseosus	P	6	6(2)	6	P	6	12	2	P
TOTAL NATIVE SHRUBS	8	22	12(2)	12	10	18	18	14	2
Standing dead		2	4		2(2)	2	2	2	2
Litter	32	16	16	20	22	18	18	26	20
Bare soil	40	38	60	40	30	30	48	42	46
Rock	12	16	6	14	28	28	10	10	20
TOTALS	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	16	28	14(2)	26	18	22	22	20	12
GROUND COVER (Litter+Rock+Veg+St.Dead)	60	62	40(2)	60	70(2)	70	52	58	54
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 11.9 Std.Dev.= 1.9)	10	14	13	11	10	11	10	13	11

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 3. Cover Data - Gilson Gulch Area, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* ----- SAMPLE NUMBER ----- 10	11	12	13	14	15
INTRODUCED ANNUAL & BIENNIAL FORBS						
Kochia scoparia	P					
Melilotus officinalis	2	P	2	P	P	P
Polygonum arenastrum	P					
Salsola iberica	P					
TOTAL INTRO. ANN. & BIEN. FORBS	2	P	2	P	P	P
NATIVE PERENNIAL FORBS						
Artemisia dracunculus						
Artemisia ludoviciana	2					
Aster glaucodes	P					
Linum perenne ssp. lewisii	P	P	P		P	P
Machaeranthera canescens	P	P	P		P	
Penstemon palmeri		P		P	2	P
TOTAL NATIVE PERENNIAL FORBS	2	P	P	P	2	P
INTRODUCED PERENNIAL FORBS						
Medicago sativa		P	2	P	2	2
TOTAL INTRO. PERENNIAL FORBS	---	P	2	P	2	2
NATIVE PERENNIAL GRASSES (cool)						
Elymus smithii						
Elymus trachycaulus	4	P	2	P	P	
Oryzopsis hymenoides		P	P	P	P	
TOTAL NATIVE PERENNIAL GRASSES (c)	4	P	2	P	P	---
INTRODUCED PERENNIAL GRASSES (cool)						
Agropyron cristatum	P		P		P	
Dactylis glomerata	P	2	2	P	2	P
Elymus hispidus	4	P	2	12	8	2(2)
TOTAL INTRO. PERENNIAL GRASSES (c)	4	2	4	12	10	2(2)
NATIVE SHRUBS						
Artemisia tridentata	P	P	2		P	P
Atriplex canescens	4(2)	10	4	2	6	8
Atriplex confertifolia						
Ceratoides lanata	P	6	2	2	P	P
Chrysothamnus nauseosus	4(2)	8	6	4	4(2)	12
TOTAL NATIVE SHRUBS	8(4)	24	14	8	10(2)	20
Standing dead				2	2	2
Litter	20	18	14	14	28	12
Bare soil	52	34	40	48	38	54
Rock	8	22	22	16	8	8
TOTALS	100	100	100	100	100	100
TOTAL VEGETATION COVER	20(4)	26	24	20	24(2)	24(2)
GROUND COVER (Litter+Rock+Veg+St.Dead)	48(4)	66	60	52	62(2)	46(2)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 11.9 Std.Dev.= 1.9)	16	13	13	10	14	10

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 4. Production Data - Gilson Gulch, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE PRODUCTION (gm/0.5 sq.m.)	AVERAGE PRODUCTION (lb/acre)	FREQUENCY (%)	PRODUCTION (gm/0.5 sq.m.)* ----- SAMPLE NUMBER ----- 1	2	3	4	5	6	7	8	9	10
INTRODUCED ANNUAL & BIENNIAL FORBS													
Melilotus alba	0.85	15.2	10.00										8.5
Melilotus officinalis	1.60	28.6	20.00			8.1	7.9						
TOTAL INTRO. ANN. & BIEN. FORBS	2.5	44.6	30.0	---	---	8.1	7.9	---	---	---	---	---	8.5
NATIVE PERENNIAL FORBS													
Linum perenne ssp. lewisii	1.54	27.5	20.00					7.7			7.7		
Machaeranthera canescens	0.76	13.6	10.00	7.6									
TOTAL NATIVE PERENNIAL FORBS	2.3	41.0	30.0	7.6	---	---	---	7.7	---	---	7.7	---	---
INTRODUCED PERENNIAL FORBS													
Medicago sativa	7.52	134.2	90.00	10.1	0.1		9.8	9.9	9.2	8.1	8.1	12.0	7.9
TOTAL INTRO. PERENNIAL FORBS	7.5	133.8	90.0	10.1	0.1	---	9.8	9.9	9.2	8.1	8.1	12.0	7.9
NATIVE PERENNIAL GRASSES (cool)													
Elymus smithii	1.77	31.6	20.00		8.4			9.3					
Elymus trachycaulus	5.78	103.1	60.00	8.5	7.7	11.3	9.3			11.5	9.5		
TOTAL NATIVE PERENNIAL GRASSES (c)	7.6	135.6	70.0	8.5	16.1	11.3	9.3	9.3	---	11.5	9.5	---	---
INTRODUCED PERENNIAL GRASSES (cool)													
Agropyron cristatum	2.51	44.8	30.00	8.1							9.0		8.0
Dactylis glomerata	8.24	147.0	90.00	8.4	11.1	10.2	8.4	8.7	8.1	9.7		8.3	9.5
Elymus hispidus	18.86	336.5	100.00	13.2	12.9	21.8	20.8	21.8	12.2	19.8	13.7	30.5	21.9
TOTAL INTRO. PERENNIAL GRASSES (c)	29.6	528.2	100.0	29.7	24.0	32.0	29.2	30.5	20.3	29.5	22.7	38.8	39.4
NATIVE SHRUBS													
Artemisia tridentata	3.68	65.7	50.00	8.2	12.4	7.7		8.4					0.1
Atriplex canescens	6.94	123.8	80.00	8.2	7.6	12.5	7.8	8.8	7.6	8.3	8.6		
Ceratoides lanata	7.58	135.3	70.00	14.6	7.8	11.4		8.5	10.0	7.8	15.7		
Chrysothamnus nauseosus	9.90	176.7	70.00	7.7	9.8	24.1			8.3	20.1		7.8	21.2
TOTAL NATIVE SHRUBS	28.1	501.4	100.0	38.7	37.6	55.7	7.8	25.7	25.9	36.2	24.3	7.8	21.3
TOTAL PRODUCTION	77.5 16.0 = Std.Dev.	1382.9 285.5 = Std.Dev.		94.6	77.7	107.1	64.0	83.1	55.4	85.3	72.3	58.6	77.0
TOTAL HERBACEOUS PRODUCTION	49.41 8.7 = Std.Dev.	881.7 155.2 = Std.Dev.		55.9	40.1	51.4	56.2	57.4	29.5	49.1	48	50.8	55.7
SPECIES DENSITY (# of species/0.5 sq.m.) (AVERAGE= 7.2 Std.Dev.= 1.7)				10	9	8	6	8	6	7	7	4	7

Table 5. Cover Data - Sow Belly North, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
INTRODUCED ANNUAL & BIENNIAL FORBS					
Melilotus alba	0.00	50.00	0.00	0.00	0.00
Melilotus officinalis	1.00	100.00	4.76	1.00	4.55
TOTAL INTRO. ANN. & BIEN. FORBS	1.0	100.0	4.8	1.0	4.5
NATIVE PERENNIAL FORBS					
Artemisia dracunculus	0.00	100.00	0.00	0.00	0.00
Artemisia ludoviciana	0.00	50.00	0.00	0.00	0.00
Aster glaucodes	2.00	100.00	9.52	2.00	9.09
Linum perenne ssp. lewisii	0.00	50.00	0.00	0.00	0.00
Machaeranthera canescens	0.00	100.00	0.00	0.00	0.00
Penstemon palmeri	0.00	100.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL FORBS	2.0	100.0	9.5	2.0	9.1
INTRODUCED PERENNIAL FORBS					
Medicago sativa	1.00	50.00	4.76	1.00	4.55
TOTAL INTRO. PERENNIAL FORBS	1.0	50.0	4.8	1.0	4.5
NATIVE PERENNIAL GRASSES (cool)					
Elymus smithii	0.00	50.00	0.00	0.00	0.00
Elymus trachycaulus	0.00	50.00	0.00	0.00	0.00
Oryzopsis hymenoides	0.00	100.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL GRASSES (c)	0.0	100.0	0.0	0.0	0.0
INTRODUCED PERENNIAL GRASSES (cool)					
Bromus inermis	0.00	100.00	0.00	0.00	0.00
Dactylis glomerata	0.00	100.00	0.00	0.00	0.00
Elymus hispidus	11.00	100.00	52.38	12.00	54.55
TOTAL INTRO. PERENNIAL GRASSES (c)	11.0	100.0	52.4	12.0	54.5
NATIVE SHRUBS					
Artemisia tridentata	1.00	100.00	4.76	1.00	4.55
Atriplex canescens	3.00	100.00	14.29	3.00	13.64
Ceratoides lanata	0.00	100.00	0.00	0.00	0.00
Chrysothamnus nauseosus	2.00	100.00	9.52	2.00	9.09
TOTAL NATIVE SHRUBS	6.0	100.0	28.6	6.0	27.3
Litter	22.00	100.00		22.00	
Bare soil	38.00	100.00		38.00	
Rock	19.00	100.00		19.00	
TOTALS	100.0			101.0	
TOTAL VEGETATION COVER	21.0		100.0	22.0	100.0
GROUND COVER (Litter+Rock+Veg+St.Dead)	62.0			63.0	
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 16.0 Std.Dev.= 0.0)					

Table 5. Cover Data - Sow Belly North, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* SAMPLE NUMBER 1	2
INTRODUCED ANNUAL & BIENNIAL FORBS		
Melilotus alba		P
Melilotus officinalis	P	2
TOTAL INTRO. ANN. & BIEN. FORBS	P	2
NATIVE PERENNIAL FORBS		
Artemisia dracunculus	P	P
Artemisia ludoviciana	P	
Aster glaucodes	2	2
Linum perenne ssp. lewisii	P	
Machaeranthera canescens	P	P
Penstemon palmeri	P	P
TOTAL NATIVE PERENNIAL FORBS	2	2
INTRODUCED PERENNIAL FORBS		
Medicago sativa	2	
TOTAL INTRO. PERENNIAL FORBS	2	---
NATIVE PERENNIAL GRASSES (cool)		
Elymus smithii		P
Elymus trachycaulus		P
Oryzopsis hymenoides	P	P
TOTAL NATIVE PERENNIAL GRASSES (c)	P	P
INTRODUCED PERENNIAL GRASSES (cool)		
Bromus inermis	P	P
Dactylis glomerata	P	P
Elymus hispidus	12(2)	10
TOTAL INTRO. PERENNIAL GRASSES (c)	12(2)	10
NATIVE SHRUBS		
Artemisia tridentata	P	2
Atriplex canescens	2	4
Ceratoides lanata	P	P
Chrysothamnus nauseosus	P	4
TOTAL NATIVE SHRUBS	2	10
Litter	22	22
Bare soil	46	30
Rock	14	24
TOTALS	100	100
TOTAL VEGETATION COVER	18(2)	24
GROUND COVER (Litter+Rock+Veg+St.Dead)	54(2)	70
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 16.0 Std.Dev.= 0.0)	16	16

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 6. Cover Data - Sow Belly South, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)
INTRODUCED ANNUAL & BIENNIAL FORBS					
Melilotus officinalis	0.00	100.00	0.00	0.00	0.00
TOTAL INTRO. ANN. & BIEN. FORBS	0.0	100.0	0.0	0.0	0.0
NATIVE PERENNIAL FORBS					
Artemisia ludoviciana	0.00	100.00	0.00	0.00	0.00
Aster glaucodes	6.00	100.00	13.04	6.00	11.32
Machaeranthera canescens	0.00	50.00	0.00	0.00	0.00
Penstemon palmeri	1.00	50.00	2.17	1.00	1.89
Viguiera multiflora	0.00	50.00	0.00	0.00	0.00
TOTAL NATIVE PERENNIAL FORBS	7.0	100.0	15.2	7.0	13.2
INTRODUCED PERENNIAL FORBS					
Medicago sativa	0.00	100.00	0.00	0.00	0.00
TOTAL INTRO. PERENNIAL FORBS	0.0	100.0	0.0	0.0	0.0
NATIVE PERENNIAL GRASSES (cool)					
Elymus trachycaulus	4.00	100.00	8.70	7.00	13.21
Oryzopsis hymenoides	2.00	100.00	4.35	2.00	3.77
TOTAL NATIVE PERENNIAL GRASSES (c)	6.0	100.0	13.0	9.0	17.0
INTRODUCED PERENNIAL GRASSES (cool)					
Agropyron cristatum	0.00	50.00	0.00	0.00	0.00
Bromus inermis	0.00	100.00	0.00	0.00	0.00
Dactylis glomerata	0.00	100.00	0.00	2.00	3.77
Elymus hispidus	5.00	100.00	10.87	6.00	11.32
TOTAL INTRO. PERENNIAL GRASSES (c)	5.0	100.0	10.9	8.0	15.1
NATIVE SHRUBS					
Artemisia tridentata	0.00	100.00	0.00	0.00	0.00
Atriplex canescens	21.00	100.00	45.65	22.00	41.51
Chrysothamnus nauseosus	7.00	50.00	15.22	7.00	13.21
TOTAL NATIVE SHRUBS	28.0	100.0	60.9	29.0	54.7
Litter	15.00	100.00		15.00	
Bare soil	18.00	100.00		18.00	
Rock	21.00	100.00		21.00	
TOTALS	100.0			107.0	
TOTAL VEGETATION COVER	46.0		100.0	53.0	100.0
GROUND COVER (Litter+Rock+Veg+St.Dead)	82.0			89.0	
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 13.5 Std.Dev.= 2.1)					

Table 6. Cover Data - Sow Belly South, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

PLANT SPECIES	Percent Foliar Cover* SAMPLE NUMBER 1	2
INTRODUCED ANNUAL & BIENNIAL FORBS		
Melilotus officinalis	P	P
TOTAL INTRO. ANN. & BIEN. FORBS	P	P
NATIVE PERENNIAL FORBS		
Artemisia ludoviciana	P	P
Aster glaucodes	10	2
Machaeranthera canescens	P	
Penstemon palmeri	2	
Viguiera multiflora	P	
TOTAL NATIVE PERENNIAL FORBS	12	2
INTRODUCED PERENNIAL FORBS		
Medicago sativa	P	P
TOTAL INTRO. PERENNIAL FORBS	P	P
NATIVE PERENNIAL GRASSES (cool)		
Elymus trachycaulus	6(6)	2
Oryzopsis hymenoides	4	P
TOTAL NATIVE PERENNIAL GRASSES (c)	10(6)	2
INTRODUCED PERENNIAL GRASSES (cool)		
Agropyron cristatum		P
Bromus inermis	P	P
Dactylis glomerata	P	(4)
Elymus hispidus	6	4(2)
TOTAL INTRO. PERENNIAL GRASSES (c)	6	4(6)
NATIVE SHRUBS		
Artemisia tridentata	P	P
Atriplex canescens	8	34(2)
Chrysothamnus nauseosus	14	
TOTAL NATIVE SHRUBS	22	34(2)
Litter	12	18
Bare soil	20	16
Rock	18	24
TOTALS	100	100
TOTAL VEGETATION COVER	50(6)	42(8)
GROUND COVER (Litter+Rock+Veg+St.Dead)	80(6)	84(8)
SPECIES DENSITY (# of species/100 sq.m.) (AVERAGE= 13.5 Std.Dev.= 2.1)	15	12

*P=Present within 1 m. on either side of the cover transect, but not quantitatively encountered.

Table 7. Data Summary - Cover and Production, Castle Gate Mine, AMAX Coal, Carbon Co.,UT - 1993

AREA	FOLIAR COVER (%)	STANDING DEAD (%)	LITTER (%)	ROCK (%)	SOIL (%)	HERBACEOUS PRODUCTION (Oven-dry lbs./acre)
Gilson Gulch	21.1	1.5	19.6	15.2	42.7	1,382.9
Goose Island	17.5	0.5	19.5	25.5	37.0	833.3
Sow Belly South	46.0	0.0	15.0	21.0	18.0	Not Collected
Sow Belly North	21.0	0.0	22.0	19.0	38.0	Not Collected

Table 8. Data Summary - Relative Vegetation Cover by Lifeform, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

		RELATIVE VEGETATION COVER - ALL HITS (%)													
			INTRODUCED					NATIVE							
AREA	TOTAL*	TOTAL INTRO.	--- FORBS --- ANNUAL	--- FORBS --- PERENN.	--- GRASSES --- ANNUAL	--- GRASSES --- PERENN.		TOTAL NATIVE	--- FORBS --- ANNUAL	--- FORBS --- PERENN.	--- GRASSES --- ANNUAL	--- GRASSES --- PERENN.	SUB-SHRUBS	SHRUBS	OTHERS**
Gilson Gulch	**100.0**	**33.5**	2.5	5.7	0.0	25.3		**66.5**	0.0	1.3	0.0	1.9	0.0	63.3	0.0
Goose Island	**99.8**	**50.7**	1.1	5.1	1.1	43.4		**49.1**	0.0	5.1	0.0	42.3	0.0	1.7	0.0
Sow Belly East	**100.0**	**10.9**	0.0	0.0	0.0	10.9		**89.1**	0.0	15.2	0.0	13.0	0.0	60.9	0.0
Sow Belly West	**100.1**	**62.0**	4.8	4.8	0.0	52.4		**38.1**	0.0	9.5	0.0	0.0	0.0	28.6	0.0

* May sum to 100.0+ or - 0.2 due to rounding errors.

** Trees, succulents (cactus), lower plants (moss, lichen, ferns).

Table 9. Data Summary - Species Density, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

SPECIES DENSITY (average no. of species / 100 sq.m.)

			---------- INTRODUCED ----------					---------- NATIVE ----------							
AREA	TOTAL*	TOTAL INTRO. SP.	--- FORBS --- ANNUAL+	PERENN.	--- GRASSES --- ANNUAL	PERENN.		TOTAL NATIVE SP.	--- FORBS --- ANNUAL+	PERENN.	--- GRASSES --- ANNUAL	PERENN.	SUB-SHRUBS	SHRUBS	OTHERS**
Gilson Gulch	**11.9**	**4.30**	1.20	0.90	0.00	2.20		**7.60**	0.00	2.30	0.00	1.40	0.00	3.90	0.00
Goose Island	**14.9**	**5.40**	1.45	1.10	0.40	2.45		**9.50**	0.05	3.00	0.00	4.65	0.00	1.75	0.05
Sow Belly South	**13.5**	**5.50**	1.00	1.00	0.00	3.50		**8.00**	0.00	3.50	0.00	2.00	0.00	2.50	0.00
Sow Belly North	**16.0**	**5.00**	1.50	0.50	0.00	3.00		**11.00**	0.00	5.00	0.00	2.00	0.00	4.00	0.00

* Table values may not exactly sum to this figure due to rounding errors.

** Lower plants (mosses, lichens, ferns), trees, and succulents.

+ Annual category includes biennials.

Table 10. Sample Adequacy - Cover and Production, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

	--------- COVER ---------				-------- PRODUCTION --------			
AREA	(Percent)	Std. Dev.	N*	N-min**	(gm/0.5 sq.m.)	Std. Dev.	N*	N-min**
Gilson Gulch	21.1 (±1.6)	4.6	15	8.55	77.5 (±7.0)	16.0	10	7.66
Goose Island	17.5 (±1.6)	5.34	20	16.35	46.7 (±7.2)	16.4	10	23.21

*N = Sample Size

**N-min = Minimum sample size necessary to detect a 10% reduction in the mean with 90% confidence (one-tailed).

Table 11. Species Presence Summary, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

Scientific Name	Synonym	Common Name	COMMON VS. UNCOMMON	GILSON GULCH	GOOSE ISLAND	SOW BELLY SOUTH	SOW BELLY NORTH
NATIVE ANNUAL FORB							
Helianthus annuus		COMMON SUNFLOWER	U		X		
INTRODUCED ANNUAL & BIENNIAL FORBS							
Cynoglossum officinale		HOUND'S TONGUE	U		X		
Kochia scoparia	CHENOPODIUM SCOPARIUM	SUMMER-CYPRESS		X	X		
Lepidium perfoliatum		PERFOLIATE PEPPERGRASS	U		X		
Melilotus alba		WHITE SWEETCLOVER		X			X
Melilotus officinalis		YELLOW SWEETCLOVER		X		X	X
Polygonum arenastrum		DEVIL'S SHOESTRINGS	U	X			
Salsola iberica		RUSSIAN THISTLE		X	X		
Tragopogon dubius		SALSIFY	U		X		
INTRODUCED ANNUAL GRASSES							
Bromus tectorum		CHEATGRASS	U		X		
NATIVE PERENNIAL FORBS							
Artemisia dracunculus		TARRAGON		X			X
Artemisia ludoviciana		LOUISIANA SAGE	C	X	X	X	X
Aster glaucodes		BLUELEAF ASTER	C	X	X	X	X
Grindelia squarrosa		CURLYCUP GUMWEED	U		X		
Linum perenne ssp. lewisii	LINUM LEWISII	BLUE FLAX		X	X		X
Machaeranthera canescens	ASTER CANESCENS	HOARY ASTER	C	X	X	X	X
Penstemon palmeri		PALMER PENSTEMON		X		X	X
Rumex crispus		CURLY DOCK	U		X		
Viguiera multiflora	HELIOMERIS MULTIFLORA	SHOWY GOLDENEYE			X	X	
INTRODUCED PERENNIAL FORBS							
Astragalus cicer		CICER MILKVETCH	U		X		
Convolvulus arvensis		BINDWEED	U		X		
Medicago sativa		ALFALFA	C	X	X	X	X
Taraxacum officinale		COMMON DANDELION	U		X		

Table 11. Species Presence Summary, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

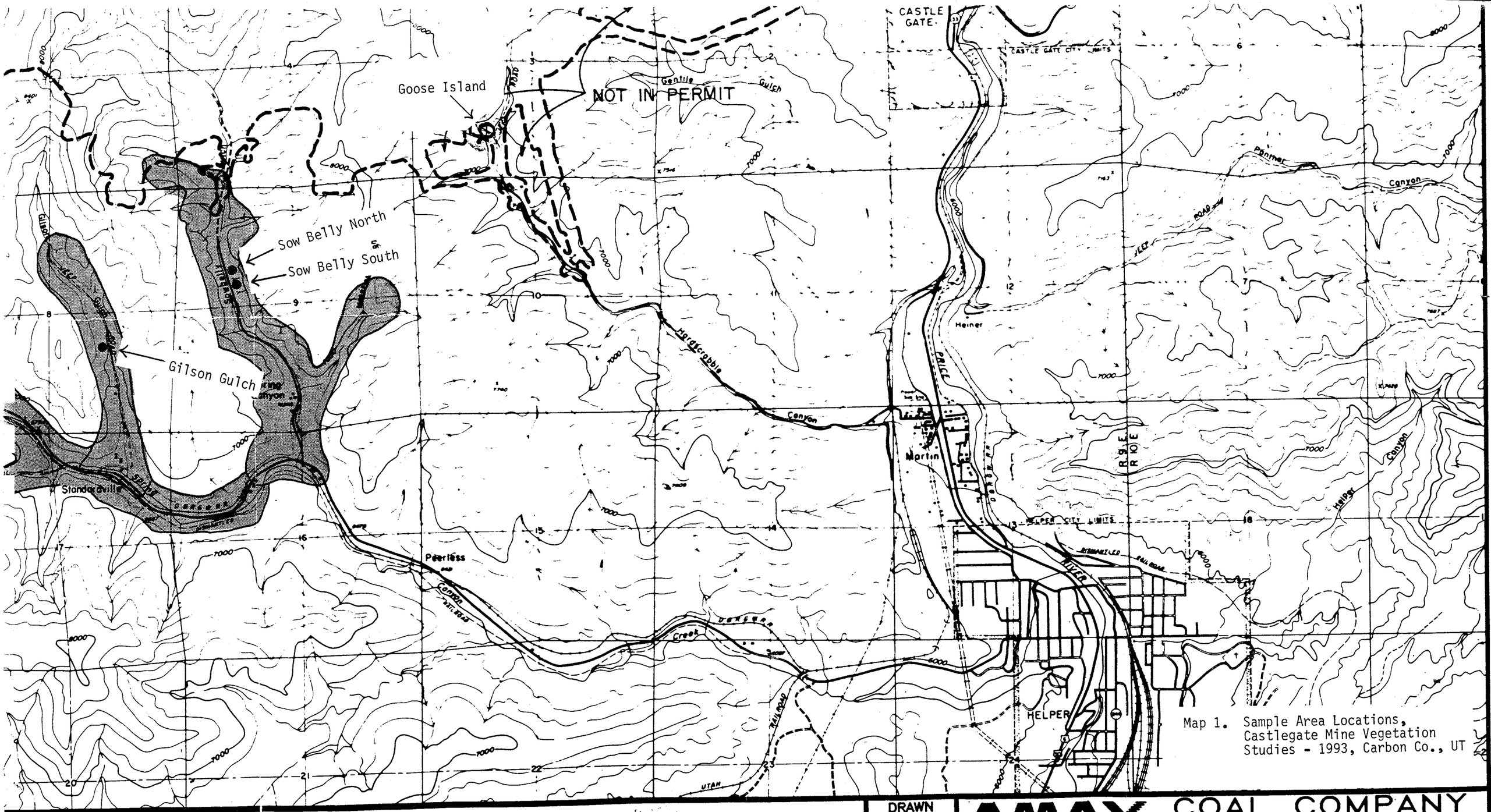
Scientific Name	Synonym	Common Name	COMMON VS. UNCOMMON	GILSON GULCH	GOOSE ISLAND	SOW BELLY SOUTH	SOW BELLY NORTH
NATIVE PERENNIAL GRASSES (COOL SEASON)							
Elymus cinereus	LEYMUS CINEREUS	BASIN WILDRYE	U		X		
Elymus lanceolatus fm. albicans	AGROPYRON ALBICANS	MONTANA WHEATGRASS	U		X		
Elymus lanceolatus fm. dasystachyus	AGROPYRON DASYSTACHYUM, ELYTRIGIA DASYSTACHYA	THICKSPIKE WHEATGRASS	U		X		
Elymus smithii	AGROPYRON SMITHII	WESTERN WHEATGRASS		X	X		X
Elymus spicatus	AGROPYRON SPICATUM	BLUEBUNCH WHEATGRASS	U		X		
Elymus trachycaulus	AGROPYRON TRACHYCAULUM	SLENDER WHEATGRASS	C	X	X	X	X
Festuca sp.		FESCUE	U		X		
Hordeum jubatum	CRITESION JUBATUM	FOXTAIL BARLEY	U		X		
Oryzopsis hymenoides	STIPA HYMENOIDES	INDIAN RICEGRASS	C	X	X	X	X
Poa compressa		CANADA BLUEGRASS	U		X		
Poa pratensis fm. aggassizensis	POA AGGASSIZENSIS	KENTUCKY BLUEGRASS	U		X		
Stipa viridula		GREEN NEEDLEGRASS	U		X		
INTRODUCED PERENNIAL GRASSES (COOL SEASON)							
Agropyron cristatum and A. desertorum		STANDARD CRESTED WHEATGRASS		X	X	X	
Bromus inermis	BROMOPSIS INERMIS	SMOOTH BROME			X	X	X
Dactylis glomerata		ORCHARD GRASS	C	X	X	X	X
Elymus hispidus	AGROPYRON INTERMEDIUM	INTERMEDIATE WHEATGRASS	C	X	X	X	X
Festuca arundinacea	FESTUCA ELATIOR SSP. ARUNDINACEA	TALL FESCUE	U		X		
NATIVE SHRUBS							
Artemisia tridentata		BIG SAGEBRUSH	C	X	X	X	X
Atriplex canescens	CALLIGONUM CANESCENS	FOURWING SALTBUSH	C	X		X	X
Atriplex confertifolia		SHADSCALE SALTBUSH	U	X			
Ceratoides lanata		WINTERFAT		X			X
Chrysothamnus nauseosus		RUBBER RABITBRUSH	C	X	X	X	X
Gutierrezia sarothrae		BROOM SNAKEWEED	U		X		
Mahonia repens	BERBERIS REPENS	OREGON HOLLYGRAPE	U		X		
Prunus virginiana		CHOKECHERRY	U		X		
Rhus aromatica var. trilobata		SKUNKBRUSH	U		X		
Rosa woodsii		WOOD'S ROSE	U		X		
NATIVE TREES							
Juniperus osteosperma		UTAH JUNIPER	U		X		
Pinus ponderosa		PONDEROSA PINE	U		X		
Standing dead				X	X		
Litter			C	X	X	X	X
Bare soil			C	X	X	X	X
Rock			C	X	X	X	X

Table 12. Site Information Summary, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

AREA	STAND	ORIENT°	SLOPE%	ASPECT°	INITIALS	DATE
GILSON GULCH COVER	1	220	29	68	WM	13-Sep-93
GILSON GULCH COVER	2	120	29	68	WM	13-Sep-93
GILSON GULCH COVER	3	106	23	82	DB	13-Sep-93
GILSON GULCH COVER	4	294	27	82	DB	13-Sep-93
GILSON GULCH COVER	5	142	23	72	WM	13-Sep-93
GILSON GULCH COVER	6	278	29	68	WM	13-Sep-93
GILSON GULCH COVER	7	306	23	82	DB	13-Sep-93
GILSON GULCH COVER	8	75	23	82	DB	13-Sep-93
GILSON GULCH COVER	9	346	19	68	WM	13-Sep-93
GILSON GULCH COVER	10	345	12	82	DB	13-Sep-93
GILSON GULCH COVER	11	4	29	110	WM	13-Sep-93
GILSON GULCH COVER	12	212	27	82	DB	13-Sep-93
GILSON GULCH COVER	13	52	34	68	WM	13-Sep-93
GILSON GULCH COVER	14	2	29	98	WM	13-Sep-93
GILSON GULCH COVER	15	193	12	82	DB	13-Sep-93
GILSON GULCH PRODUCTION	1	22	29	68	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	2	120	29	68	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	3	106	23	82	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	4	294	27	82	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	5	142	23	72	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	6	278	29	68	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	7	306	23	82	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	8	75	23	82	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	9	346	19	68	PG/MS	13-Sep-93
GILSON GULCH PRODUCTION	10	345	12	82	PG/MS	13-Sep-93
GOOSE ISLAND COVER	1	232	9	184	DB	14-Sep-93
GOOSE ISLAND COVER	2	142	21	38	WM	14-Sep-93
GOOSE ISLAND COVER	3	46	21	66	WM	14-Sep-93
GOOSE ISLAND COVER	4	344	21	68	WM	14-Sep-93
GOOSE ISLAND COVER	5	120	25	18	DB	14-Sep-93
GOOSE ISLAND COVER	6	4	23	120	WM	14-Sep-93
GOOSE ISLAND COVER	7	74	29	250	WM	14-Sep-93
GOOSE ISLAND COVER	8	342	7	142	WM	14-Sep-93
GOOSE ISLAND COVER	9	210	9	135	WM	14-Sep-93
GOOSE ISLAND COVER	10	191	14	148	WM	14-Sep-93
GOOSE ISLAND COVER	11	112	31	234	WM	14-Sep-93
GOOSE ISLAND COVER	12	20	2313	298	WM	14-Sep-93
GOOSE ISLAND COVER	13	57	12	122	WM	14-Sep-93
GOOSE ISLAND COVER	14	78	31	222	WM	14-Sep-93
GOOSE ISLAND COVER	15	168	36	166	WM	14-Sep-93
GOOSE ISLAND COVER	16	179	11	138	WM	14-Sep-93
GOOSE ISLAND COVER	17	47	2	258	WM	14-Sep-93
GOOSE ISLAND COVER	18	2	21	90	WM	14-Sep-93
GOOSE ISLAND COVER	19	328	19	109	WM	14-Sep-93
GOOSE ISLAND COVER	20	224	19	65	WM	14-Sep-93

Table 12. Site Information Summary, Castle Gate Mine, AMAX Coal, Carbon Co., UT - 1993

AREA	STAND	ORIENT°	SLOPE%	ASPECT°	INITIALS	DATE
GOOSE ISLAND PRODUCTION	1	232	9	184	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	2	142	21	38	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	3	46	21	66	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	4	344	21	68	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	5	120	25	18	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	6	4	23	120	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	7	74	29	250	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	8	342	7	142	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	9	360	9	96	PG/AP	13-Sep-93
GOOSE ISLAND PRODUCTION	10	191	14	148	PG/AP	13-Sep-93
SOW BELLY SOUTH COVER	1	114	32	60	WM	13-Sep-93
SOW BELLY SOUTH COVER	2	358	60	244	WM	13-Sep-93
SOW BELLY NORTH COVER	1	60	35	248	DB	13-Sep-93
SOW BELLY NORTH COVER	2	9	35	248	DB	13-Sep-93



Map 1. Sample Area Locations, Castlegate Mine Vegetation Studies - 1993, Carbon Co., UT

LEGEND

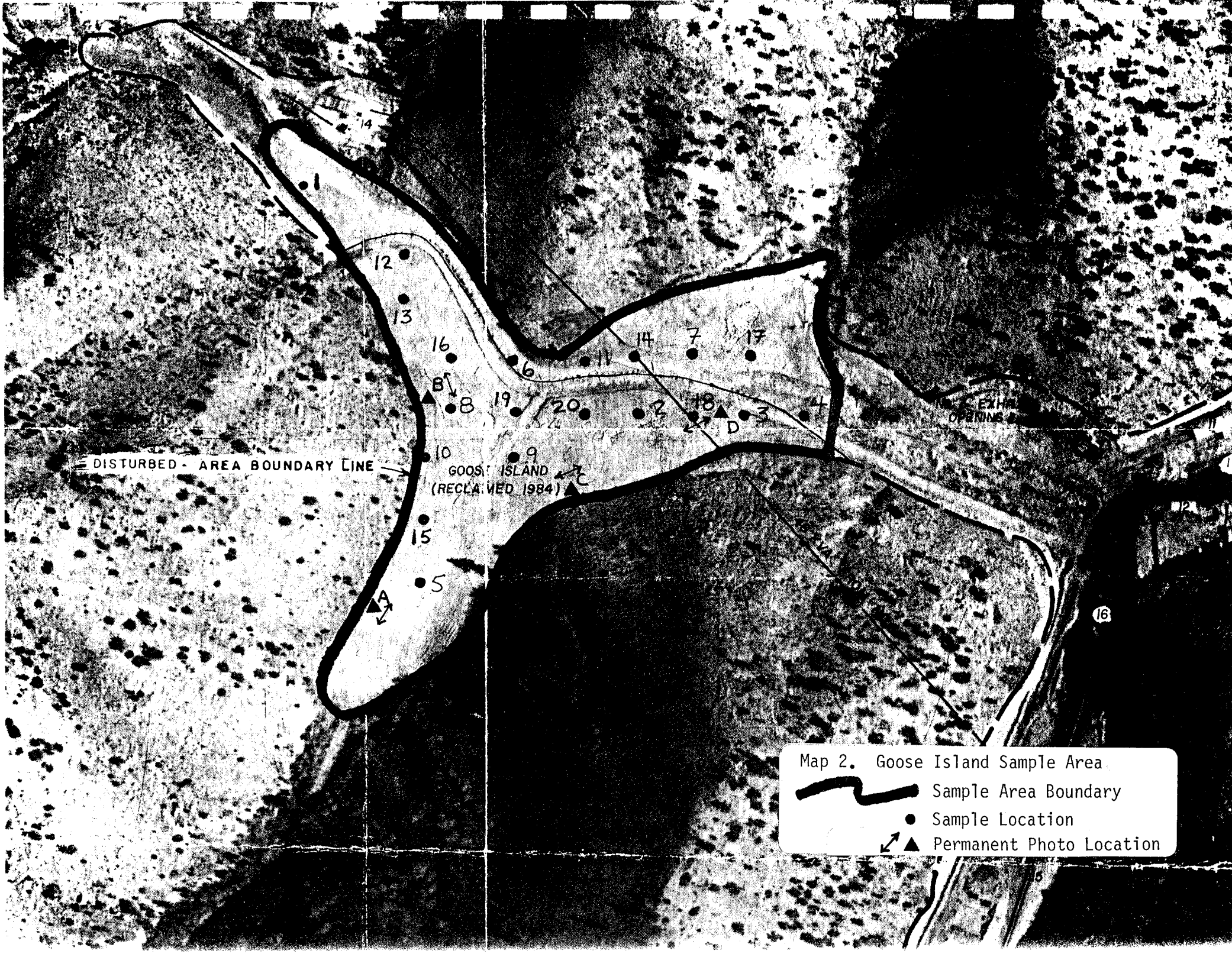
PERMIT BOUNDARY

AML REFERENCE AREA

DRAWN	
DATE	BY
3-15-93	LJS
REVISED	
APPROVED	

AMAX COAL COMPANY
A Subsidiary of AMAX Coal Industries, INC.

CASTLE GATE MINE
AML REFERENCE AREA
LOCATIONS

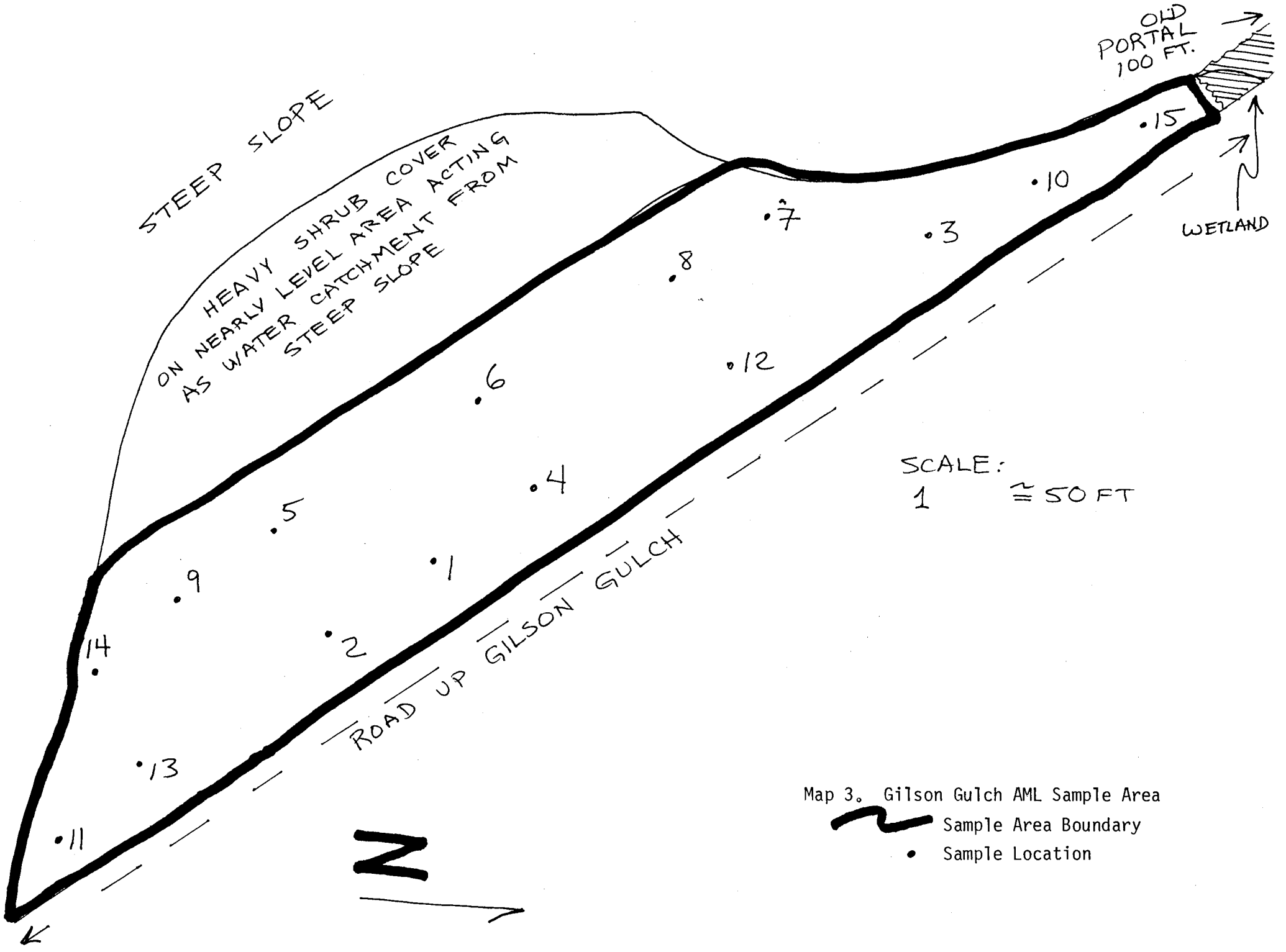


Map 2. Goose Island Sample Area

Sample Area Boundary

Sample Location

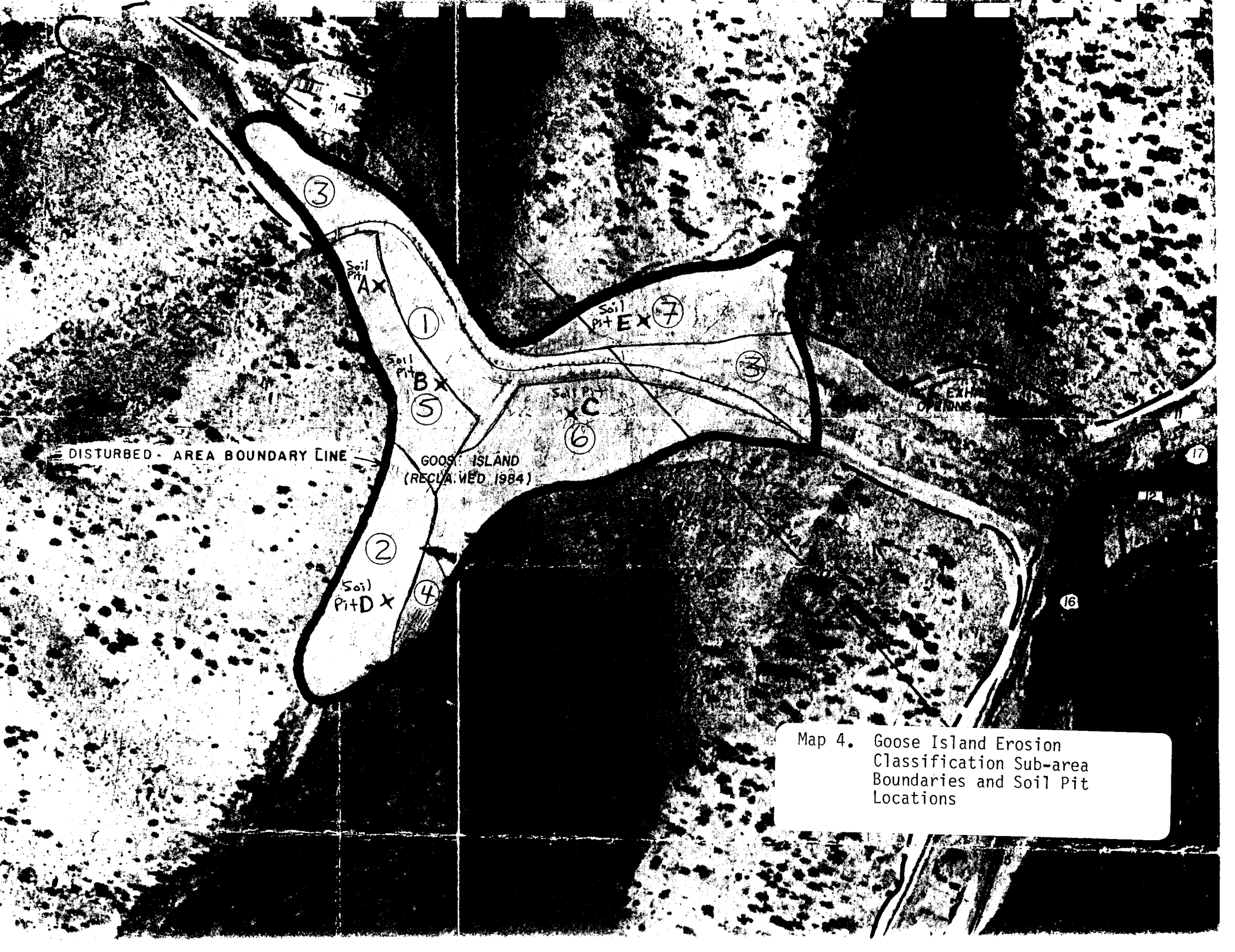
Permanent Photo Location



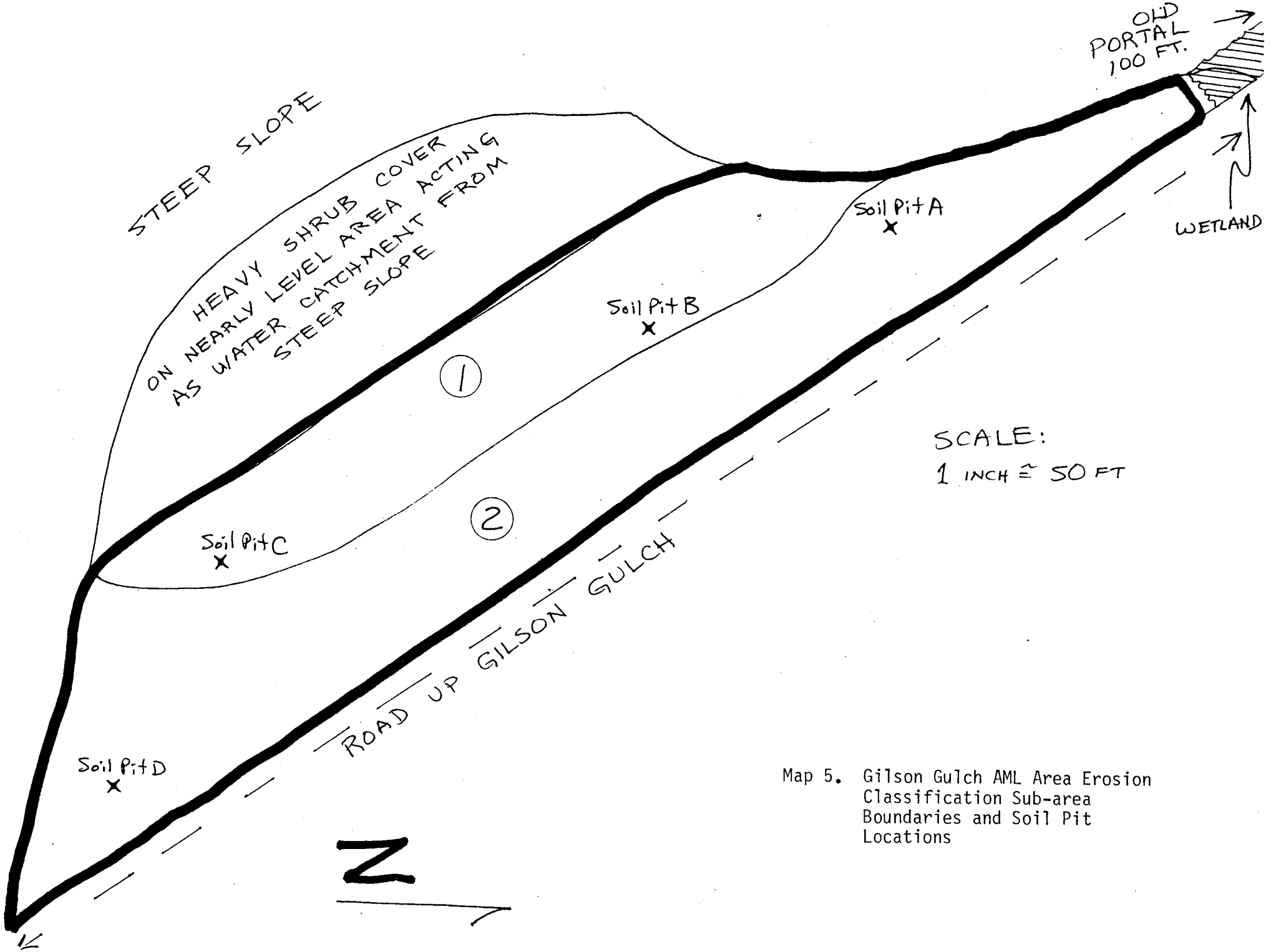
Map 3. Gilson Gulch AML Sample Area

Sample Area Boundary

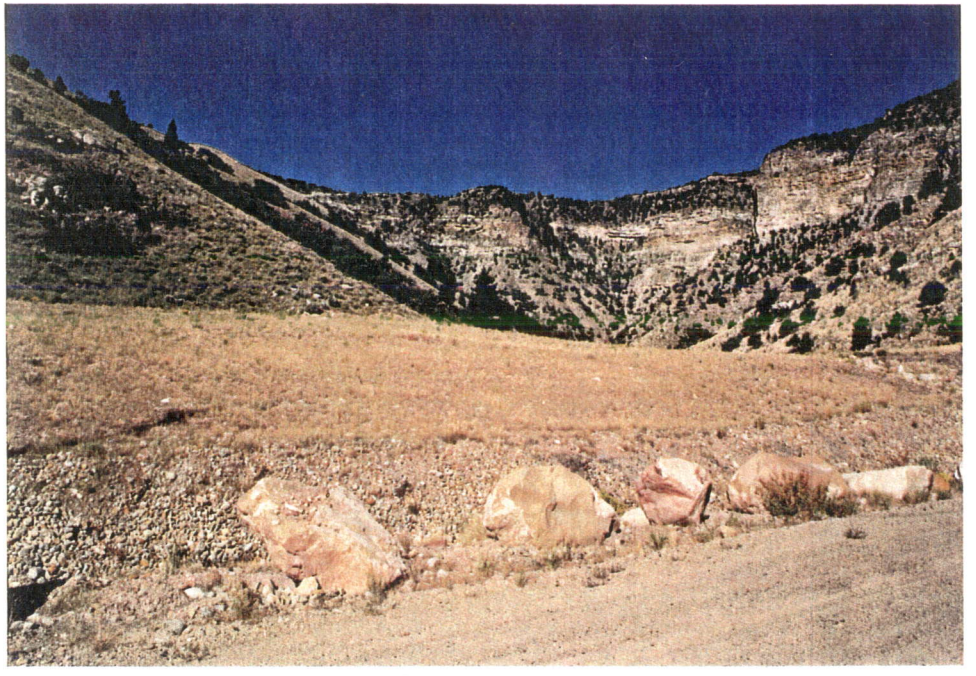
• Sample Location



Map 4. Goose Island Erosion Classification Sub-area Boundaries and Soil Pit Locations



Map 5. Gilson Gulch AML Area Erosion Classification Sub-area Boundaries and Soil Pit Locations



Photograph 1.

Photograph 2.

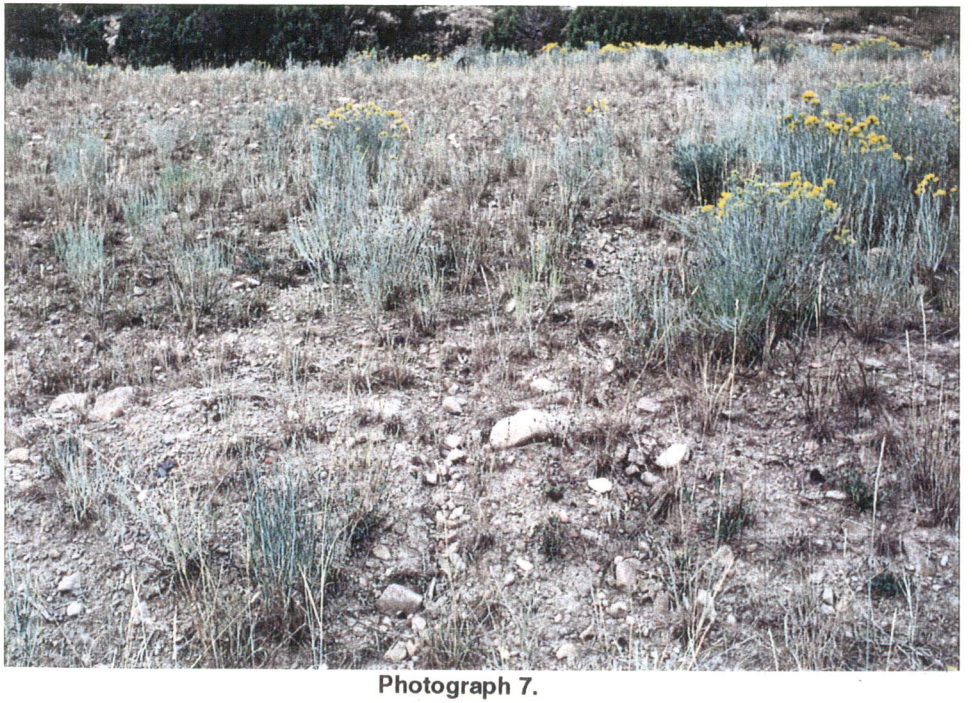
Photograph 3.

Photograph 4.

Photographs 1-4 General Views, Goose Island Reclaimed Area, Carbon Co., Utah 9-93

Photograph 5.

Photograph 6.

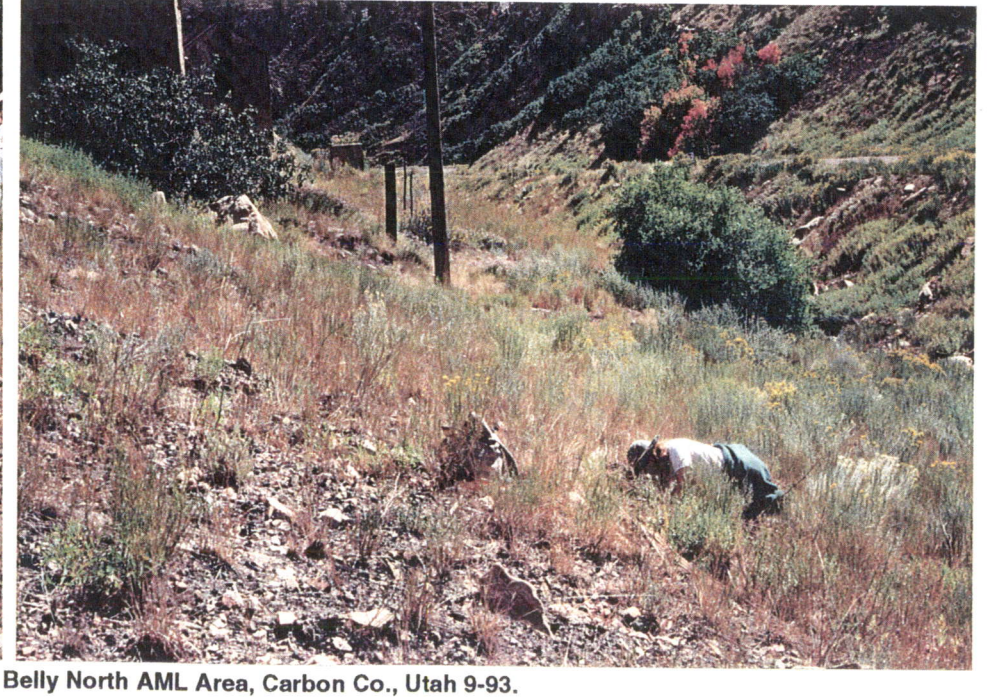


Photograph 7.

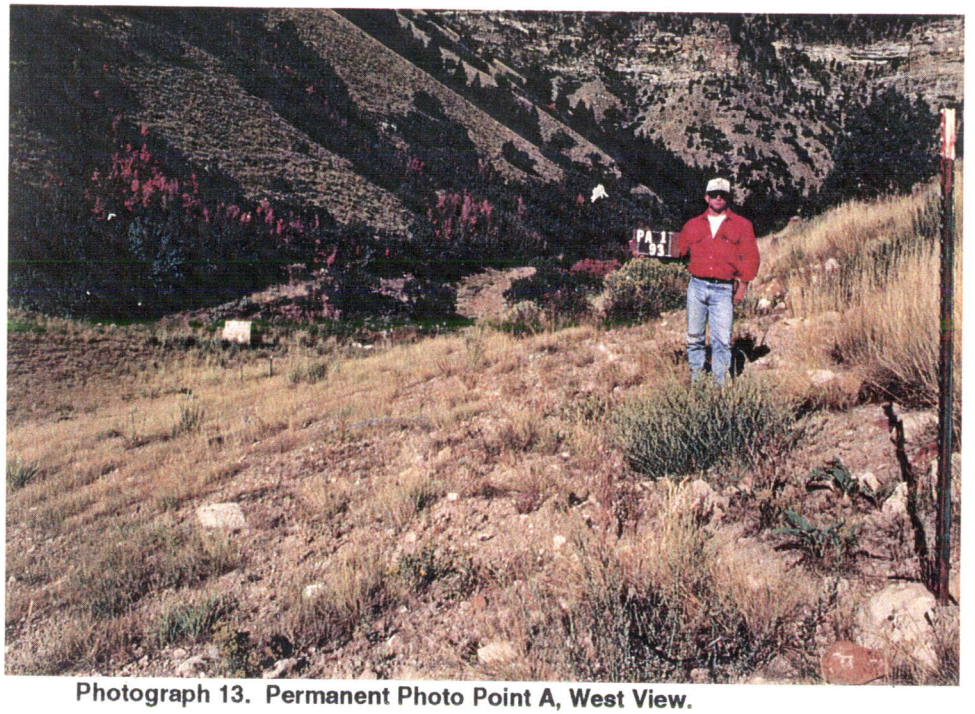
Photograph 8.

Photographs 5-8. General Views, Gilson Gulch AML Area, Carbon Co., Utah - 9-93

Photographs 9 and 10, General Views, Sow Belly South AML Area, Carbon Co., Utah 9-93.



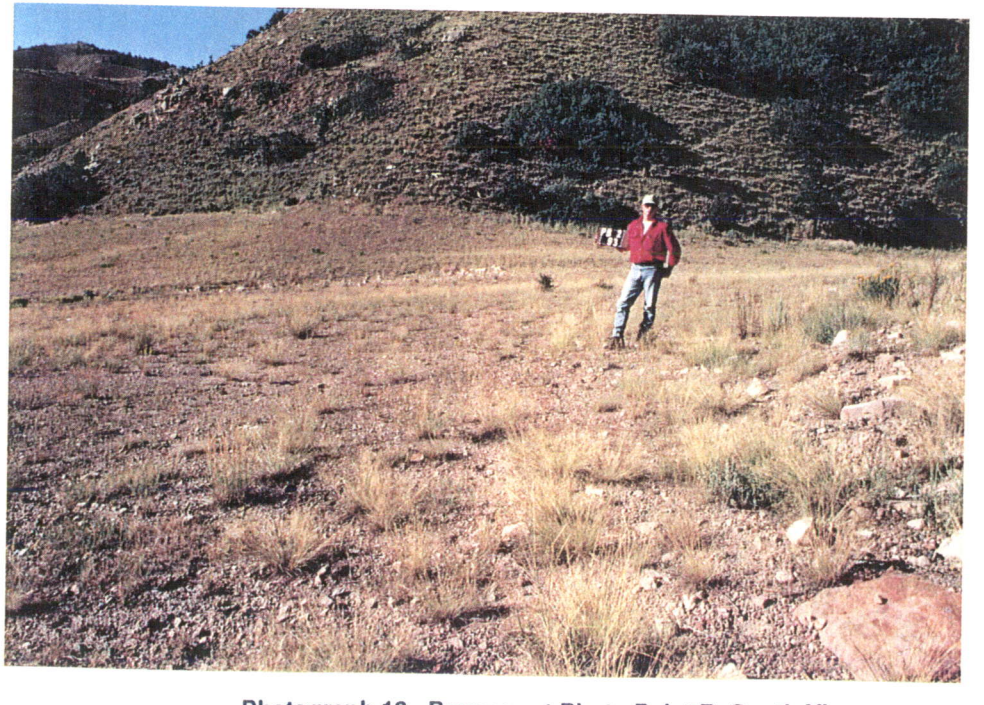
Photographs 11 and 12, General Views, Sow Belly North AML Area, Carbon Co., Utah 9-93.



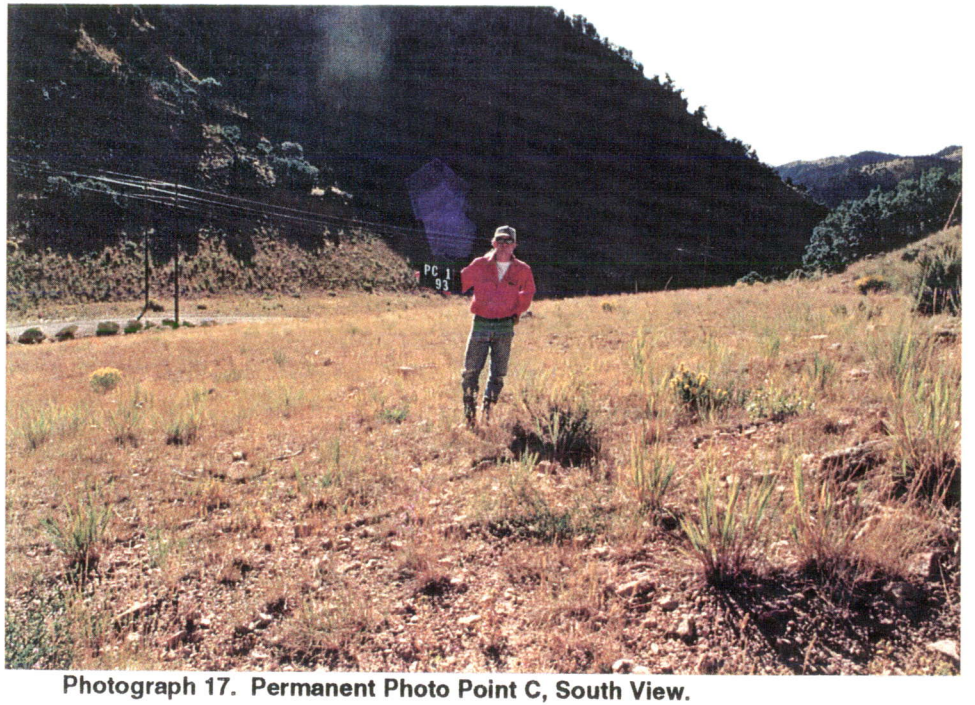
Photograph 13. Permanent Photo Point A, West View.

Photograph 14. Permanent Photo Point A, East View.

Photograph 15. Permanent Photo Point B, North View.



Photograph 16. Permanent Photo Point B, South View.



Photograph 17. Permanent Photo Point C, South View.

Photograph 18. Permanent Photo Point C, North View.

Photograph 19. Permanent Photo Point D, West View.

Photograph 20. Permanent Photo Point D, East View.