

0017



State of Utah

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING

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Jch

INSPECTION REPORT

INSPECTION DATE & TIME: 6/24/91
12:30pm - 3:30pm

Permittee and/or Operator's Name: Soldier Creek Coal Co.
Business Address: P.O. Box 1; Price UT 84501
Mine Name: Soldier Canyon Mine Permit Number: ACT 007/018
Type of Mining Activity: Underground X Surface Other
County: Carbon Company Official(s): John Pappas
State Officials(s): Priscilla Burton
Federal Official(s): none
Partial: X Complete Date of last Inspection: 5/7/91
Weather Conditions: mostly cloudy, 75 F
Acreage: Permitted 4910 Disturbed 18.3 Regraded Seeded
Bonded 22.8 Enforcement Action: None

COMPLIANCE WITH PERMITS AND PERFORMANCE STANDARDS

	YES	NO	N/A	COMMENTS
1. PERMITS	(x)	()	()	(x)
2. SIGNS AND MARKERS	()	()	()	()
3. TOPSOIL	(x)	()	()	(x)
4. HYDROLOGIC BALANCE:				
a. STREAM CHANNEL DIVERSIONS	()	()	()	()
b. DIVERSIONS	(x)	()	()	(x)
c. SEDIMENT PONDS AND IMPOUNDMENTS	()	()	()	()
d. OTHER SEDIMENT CONTROL MEASURES	(x)	()	()	()
e. SURFACE AND GROUNDWATER MONITORING	()	()	()	()
f. EFFLUENT LIMITATIONS	()	()	()	()
5. EXPLOSIVES	()	()	()	()
6. DISPOSAL OF DEVELOPMENT WASTE & SPOIL	(x)	()	()	(x)
7. COAL PROCESSING WASTE	()	()	()	()
8. NONCOAL WASTE	()	()	()	()
9. PROTECTION OF FISH, WILDLIFE AND RELATED ENVIRONMENTAL VALUES	()	()	()	()
10. SLIDES AND OTHER DAMAGE	()	()	()	()
11. CONTEMPORANEOUS RECLAMATION	()	()	()	()
12. BACKFILLING AND GRADING	()	()	()	()
13. REVEGETATION	()	()	()	(x)
14. SUBSIDENCE CONTROL	()	()	()	()
15. CESSATION OF OPERATIONS	()	()	()	()
16. ROADS				
a. CONSTRUCTION	()	()	()	()
b. DRAINAGE CONTROLS	()	()	()	()
c. SURFACING	()	()	()	()
d. MAINTENANCE	()	()	()	()
17. OTHER TRANSPORTATION FACILITIES	(x)	()	()	(x)
18. SUPPORT FACILITIES UTILITY INSTALLATIONS	()	()	()	()

INSPECTION REPORT

(Continuation sheet)

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PERMIT NUMBER: ACT 007/018

DATE OF INSPECTION: 6/24/91

(Comments are Numbered to Correspond with Topics Listed Above)

1. PERMITS

A revised State permit was issued to Soldier Creek Coal Co. on May 28, 1991. This revision was included the topsoil storage site and carried one stipulation. The stipulation, to revise the permanent reclamation seed mix was complied with on June 11, 1991.

3. TOPSOIL

The topsoil storage site is being developed. The fence has been constructed. The undisturbed diversion ditch has been dug. Silt fences have been installed along the highway access road. Berms have been formed of topsoil to create a roadway. Topsoil has been removed to prepare for the placement of boulders gained from sorting the substitute topsoil mix.

Substitute topsoil can be carted from the mine site to the storage site. However, the operator must have approved sediment control prior to moving the topsoil storage pile and the "in situ" topsoil storage materials on the east side of the Soldier Creek Culvert.

4. HYDROLOGIC BALANCE

a. diversions

All diversions are well maintained.

6. DISPOSAL OF WASTE AND SPOIL

Portal construction has finished. Excess spoil is being stored on the surface and will be for an undetermined length of time. The operator was advised to sample the spoil according to Table #6 of the Utah Guidelines, in particular for acid/toxic forming constituents (selenium, boron, pyritic sulfur acid formation, CaCO₃ neutralization potential & Sodium Adsorption Ratio).

This material will be used as backfill in the future development of the coal processing facilities, although Soldier Creek Coal Co. recently withdrew the coal processing facility amendment from the Division's review.

The operator must take precautions to control runoff from the spoil piles when the design of ASCA #5 sediment control is re-routed during road relocation work.

13. REVEGETATION

In response to John Pappas' question about monitoring of reference areas. The regulation citation is R614-301-356.110 which refers the operator to the Utah "Vegetation Information and Monitoring Guidelines." These guidelines require that a

reference area is monitored every five years in the field season prior to permit renewal (page 5, paragraph b). A copy of these guidelines are being sent with this report.

17. OTHER TRANSPORTATION FACILITIES

Work on the removal of the underground fuel storage tanks is underway. The contractor sampled the soil around the storage tank prior to its removal. Contaminated soil was removed to a sanitary landfill with the approval of the State Dept of Health. (I requested a copy of the soils analysis.)

Uncontaminated soil is being stored at the mine site storage yard to be used as backfill.

The new above ground storage will contain approximately 8,000 gallons of diesel and 4-6,000 gallons of unleaded gas. The operator is in the process of rewriting the SPCC plan for this facility.

Copy of this Report:

Mailed to: John Kathman-OSM, John Pappas-SCCC

Given to: Daron Haddock-DOGM, Joe Helfrich-DOGM

Inspector's Signature & Number:  #37 Date: 6/25/91

VEGETATION INFORMATION AND MONITORING GUIDELINES

UTAH DIVISION OF OIL, GAS AND MINING
3 Triad Center, Suite 350
Salt Lake City, Utah 84180
(801) 538-5340

Revised, July, 1990

by

L.M. Kunzler, Senior Reclamation Biologist

INTRODUCTION:

Please read these guidelines carefully and completely before initiating any vegetation studies.

These guidelines are intended to provide a suggested format for the submittal of vegetation information to be included in the mining and reclamation plans for coal mining operations. The purpose of submitting such information is as follows:

1. To approximate and describe the vegetative resources prior to mining,
2. To identify and describe important wildlife habitat areas,
3. To identify and provide protection for any listed or proposed threatened and/or endangered plant species,
4. To aid in the prediction of revegetation potential for the site,
5. To identify the standards or methodology by which the success of revegetation will be measured for the purpose of bond release, and
6. To outline monitoring procedures for revegetated areas.

Should problems or questions arise concerning these guidelines, contact the Division of Oil, Gas and Mining.

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DEFINITIONS:

Adjacent Areas: Areas outside the permit area that are within 1/2 mile of areas that will be affected by mining operations.

Baseline Data: Data collected to describe the "original" (pre-disturbed) condition of a vegetation type or range site.

Cover by Species: The percent of ground covered by a species or life form (cover by species may and often does add up to more than 100% and is used to establish plant diversity).

Density: The number of plants per unit of area.

Ground Cover: The percent of ground covered by vegetation, regardless of species. Ground cover cannot exceed 100% when added to the percent of aerial projection of rock, litter, and bare ground.

Normal Precipitation Year: A year where the effective precipitation is 90% of the 10-year average and within 90% of the 10-year monthly average for the month prior to sampling. Effective precipitation is that which falls from October 1 of the previous year to the end of the month prior to sampling.

Productivity (Production): The average yeild of food, fiber, forage and/or wood products per unit of area per year.

Random Sample: A sample taken such that any point in the sample area has an equal chance of being sampled at any time during the sampling sequence.

Range Site: The concept of a site as an ecological entity based on climax plant communities; a distinctive kind of rangeland that has a certain potential for producing range plants.

Reference Area: An area that is similar to the community to be disturbed with respect to vegetation (cover, density, composition), soils, aspect, climate, and elevation that will be maintained and used as the standard for comparisons with the reclaimed "disturbed" area.

Species Composition: The species found within a given area.

Vegetation Type: A plant community that is distinguished by its visually dominant species and should be described by two or more dominant species.

Woody Plants: Those plants which are classified as sub-shrubs, shrubs, half-trees or trees.

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SUGGESTED STEPS IN PREPARING PREMINING VEGETATION INFORMATION:

1. Map the existing vegetation types (or range sites) found within the permit area and adjacent areas (scale of 1:6,000 (1"=500') or larger). Show the locations and boundaries of current disturbed areas as well as any areas proposed to be disturbed, the locations of any listed or proposed threatened or endangered plant species, the locations of sample points and the locations and boundaries of any proposed vegetation reference areas. Vegetation type boundaries should overlay the disturbance areas. Map all potentially disturbed areas on contour maps of a scale approved by the Division (1:2,400 (1"=200') scale or larger). Mark these maps so that referral may be made back to the permit area map. Aerial photographs of sufficient scale would be acceptable for mapping requirements. Map requirements may be altered on a case by case basis by contacting the Division in advance.
2. Determine and list the acreage of each vegetation type (or range site) to be disturbed or that has been disturbed. Note the total acreage of surface disturbance (existing and proposed) within the permit area.
3. In a narrative, describe each vegetation type (or range site) by visually dominant species, and describe the condition and relative stage of maturity of the vegetation type. Note any past perturbations in the area such as fire, chaining, reseeding, previous mining, cultivation, etc. Discuss any present use by wildlife or livestock and correlate each vegetation type with wildlife habitat types or wildlife use areas. Provide a statement of productivity (a letter of assessment from the U.S. Soil Conservation Service would suffice). For forest types, provide an estimate of wood volume.
4. Identify proposed revegetation success standards (vegetation reference areas or range sites, and woody plant stocking standards) and correlate the success standard(s) with each existing vegetation type, proposed revegetation plans, and proposed postmining land use plans. The revegetation success standard should be representative of the intended postmining land use.
5. Sample each vegetation type (or range site) which exists within the proposed disturbed areas or was assumed to have existed within existing disturbed areas according to the methodology selected for determining revegetation success (reference areas or range sites). Approved sampling techniques must be used (see Appendix A). Sampling should be done during the height of the growing season (usually late June to late August). It is highly recommended that a site visit be arranged between the Division and the persons responsible for data collection prior to vegetation sampling.
6. List the species present within each vegetation type (or range site) or any proposed reference area by common and botanical name. List the species by plant groupings, i.e., trees, shrubs, forbs, grasses, etc.
7. Identify any listed or proposed threatened or endangered plant species that occur on the permit or adjacent areas. Make a negative declaration if these are not found. A current list of listed or proposed threatened or endangered species can be obtained from the U.S Fish and Wildlife Service.

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8. As per R614-301-356.231, if fish and/or wildlife habitat, recreation, shelterbelts or forest products are to be a primary or secondary use, provide evidence of consultation and acceptance of proposed woody plant stocking densities with DOGM, Utah Division of State Lands and Forestry and the Utah Division of Wildlife Resources.
9. All technical data submitted in the application shall be accompanied by:
 - a. The names of persons or organizations which collected and analyzed such data,
 - b. The dates of data collection and analysis,
 - c. Descriptions of methodology used to collect and analyze data (including means, standard deviations, formulae used, etc.), and
 - d. The name, address and position of officials of each private or academic agency consulted by the applicant in preparation of the information.

METHODS:

1. Reference Areas:

The use of vegetation reference areas for establishing revegetation success standards are applicable to all mining situations. For mines with new disturbance (either new mines or existing mines with proposed new disturbance), reference areas are selected and compared with the vegetation existing on the area to be disturbed and the proposed postmining land use. For areas of existing disturbance, the reference areas are selected on the basis of the vegetation that most likely existed prior to disturbance. Generally, a reference area is needed for each major vegetation type that has been or will be disturbed. All reference areas must be approved by the Division prior to using them for revegetation success standards (This may be done prior to permit approval). Separate reference areas do not need to be established for types where less than 1 acre will be disturbed or where the community type will be greatly altered by an approved postmining land use. However, a revegetation success standard must still be established for these areas. Reference areas should be at least 1 acre in size unless otherwise approved by the Division in advance.

For each vegetation type that will be disturbed and the corresponding proposed reference area (or any proposed reference areas for existing disturbed areas):

- a. Randomly sample for ground cover, cover by species, woody plant density and productivity. Productivity measurements need not include noxious weeds (A list of noxious weeds may be obtained from the County Weed Supervisor, U.S.U. Extension Service or the District Agriculture Inspector).

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- b. Assess the current range condition of the affected areas as well as all proposed reference areas (Range condition should be re-assessed every 5 years, during the field season prior to permit renewal). Reference areas must be in fair or better range condition at the time of bond release sampling. For reference areas not meeting this criteria, describe management practices (i.e., fencing) that will be employed to improve range condition. Range condition should be determined according to Soil Conservation Service guidelines.
- c. Demonstrate sample adequacy for ground cover, density (woody plants) and productivity (see Appendix A).
- d. Demonstrate by table (see attached summary table example), or other simplified format, the similarity between proposed disturbed sites and the corresponding proposed reference area according to the following parameters:
 1. Species composition (by a similarity index, see Appendix B), similarity should be 70% unless otherwise approved by the Division.
 2. Ground cover and woody plant density (by a t-test).
 3. Productivity, soils, slope, aspect and land use.
- e. One reference area may represent more than one disturbance site if the reference area meets the requirements for each site.
- f. Mark the proposed reference areas in the field with permanent, readily visible markers (i.e., t-posts) so that they can be easily located.
- g. Upon request, submit to the Division copies of the data sheets from sampling of areas to be disturbed and potential reference areas.

2. Range Sites:

In order to use range sites as an alternative to vegetation reference areas for revegetation success standards, the following criteria must be met:

- a. Range sites must be described in accordance with the Soil Conservation Service, 1976, National Range Handbook, U.S. Department of Agriculture, as amended.
- b. Range sites to be sampled must be in fair or better condition and representative of areas to be disturbed.
- c. Sampling must be done during a normal precipitation year.
- d. The range site area to be sampled must be at least one acre in size.

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For each range site that will be or has been disturbed:

- a. Randomly sample for ground cover, cover by species, woody plant density and productivity. Productivity need not include noxious weeds.
- b. Assess the current range condition (if the condition is not fair or better, the range site method cannot be used). Range condition is determined according to Soil Conservation Service guidelines.
- d. Demonstrate sample adequacy for ground cover, density (woody plants) and productivity (see Appendix A).

Since the results of this sampling will be considered the values for the success standard for revegetation success, a legible copy of all data sheets must be submitted to the Division.

SUMMARY OF PREMINING MAP GUIDELINES:

A vegetation map of the entire permit area and adjacent areas on a scale of 1:6,000 (1"=500') or larger should be submitted if not otherwise exempted by the Division. A contour map (scale of 1:2,400 (1"=200') or larger) should be submitted for all areas of present or potential disturbance.

The permit area map should show the boundaries and/or locations of:

1. The permit area and give the legal description (i.e. township, range, and section(s)),
2. Any surface areas which are disturbed by mining or any areas proposed to be disturbed,
3. Any proposed vegetation reference areas,
4. Existing vegetation types or range sites,
5. Any listed or proposed threatened or endangered plant species, and
6. Sampling sites.

The disturbed area map(s) should:

1. Provide reference points back to the permit area map, including legal description,
2. Show the vegetation types or range sites which currently exist in areas of proposed disturbance or which are assumed to have existed in current disturbed areas, and
3. Show the locations of sampling sites.

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REVEGETATION MONITORING:

Introduction:

This section will provide information to develop a monitoring plan to determine the success or failure of reclamation work and ultimately, bond release.

All revegetated areas, whether they are interim or permanent revegetation efforts, should be monitored. The frequency and type of sampling depends on the purpose of the revegetation. For example, reconnaissance monitoring for interim reclamation implemented solely for temporary land stabilization may be sufficient. Frequent, quantitative sampling is needed for test plots or interim reclamation areas being used to test the permanent reclamation seed mix.

Essential Elements of a Monitoring Plan:

A. Schedule:

The monitoring schedule should include frequency and season of monitoring. In general, monitoring should be conducted at least once during the growing season, preferably when the vegetation stand is at its peak which is usually during late June to August. In order to compare results between years, monitoring should occur on approximately the same dates each year. See Table 1 for recommended monitoring schedule.

B. Monitoring Methods and Parameters:

Methods employed need to be consistent from year to year. Plots or transects can be either randomly located each year, or randomly located and permanently marked with rebar or roof bolts to ensure that the same plots are measured each year. Individual plants can be permanently tagged and checked yearly to determine survival rate. Permanent plots are particularly useful for species composition and shrub survival data.

Two types of monitoring should occur, those being 'qualitative' or 'reconnaissance' surveys and 'quantitative' sampling. These are discussed in detail below.

1. **Reconnaissance Survey.** Visit each reclamation site and qualitatively record observations. No formal sampling or statistical analysis is necessary. However, the following observations are to be made:
 - a. All species which are growing on the site, whether seeded (planted) or invading from surrounding areas (this would also include all species observed outside of individual sample plots).
 - b. Note whether or not grazing or browsing has occurred by wildlife or domestic animals and, if so, which species are being utilized.
 - c. Note wind, water and mechanical (e.g. trampling) erosion.

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- d. Record any special problem areas or unusual plant development as a result of disease, insects or other pests, etc. or areas of poor vegetation, due to toxic or acidic materials, lack or excess of fertilizer, etc.
 - e. Note special conditions or circumstances, e.g., drought year or unusually wet year, plot disturbed by ORV's, etc.
2. **Quantitative Sampling.** Measure each specific parameter to be tested for the given year. Parameters sampled (cover, frequency, woody plant density, survival, etc.) depend on both the objective of a specific sampling period and the post mining land use of the revegetated area (refer to appendix A for approved sampling methods).
 3. **Bond Release Monitoring.** Reclaimed areas must be quantitatively sampled for the appropriate parameters and compared to the success standard (must meet or exceed 90% of the value for each parameter) for each area. The reclaimed area is sub-divided into smaller units on the basis of different seed mixes, other major reclamation treatments, exposure, slope, year of reclamation, etc. A statistically adequate sample must be obtained from each area and the corresponding reference area (or original baseline studies if range site method was used) for the last 2 years of the liability period. An evaluation of species composition (which includes species present, form, and diversity) must also be made.

C. Evaluation of Data:

The monitoring plan must indicate the level at which revegetation would be deemed unsuccessful during early monitoring and would, therefore, prompt remedial action. The plan should refer to contingency or maintenance plans to correct problem areas.

The plan should describe reference areas or other standards to be used to determine revegetation success and indicate the level of statistical confidence which will be met.

D. Monitoring Report:

The operator must include a summary of all reclamation activities as part of the annual report. This includes a monitoring report for all revegetated areas. The monitoring report should include at a minimum:

1. A map showing revegetated areas and/or test plots;
2. A table which identifies each revegetated area, the year it was seeded, and the seed mix, mulch, methods used, etc.;
3. An analysis of the data collected or the results of the reconnaissance survey; and
4. Recommendations to correct any problem areas.

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TABLE 1 - SUGGESTED MONITORING SCHEDULE

QUALITATIVE OBSERVATIONS:

Reclamation type	YEAR									
	1	2	3	4	5	6	7	8	9	10
Permanent Reclamation	X	X	X	X	X	X	X	X	X	X
Trial Plantings	X	X	X	X	X	X	X	X	X	X
Test Plots	X	X	X	X	X	X	X	X	X	X
Interim Stabilization	X	X	X	X	X	X	X	X	X	X

QUANTITATIVE OBSERVATIONS:

Parameter	YEAR									
	1	2	3	4	5	6	7	8	9	10
Cover		X	X		X				X	X
Frequency		X	X		X				X	X
Woody Plant Density		X ¹	X		X				X	X
Transplant Survival	X ²	X	X							
Productivity:										
Test plots			X		X				X	X
All Other Revegetation ³									X	X

¹ 80% of the shrubs (from standard) must be in place for 80% of the liability period (4 or 8 years for 5- or 10- year liability period).

² For spring planting, "year 1" sampling would occur in the fall of the planting year.

³ For croplands, submit actual crop production each year (1-10).

Note: This schedule is for mines with a 10-year extended liability period. For mines with a 5-year period, years 9 and 10 sampling would occur during years 4 and 5 respectively.

VEGETATION DATA SUMMARY

(- Company -)
 (- Mine Name -)
 (- Permit Number -)

VEGETATION TYPE: _____ Date Data Collected: _____

% Similarity between Reference and Affected Areas: _____ Index used: _____

REFERENCE AREA					CORRESPONDING AREA TO BE AFFECTED					
	\bar{X}	S	N	N_{min}		\bar{X}	S	N	N_{min}	't'
Ground Cover										
Density										
Productivity										
Soil Type										
% Slope										
Aspect										
Land use										

\bar{X} = Sample Mean
 S = Standard Deviation
 N = Sample Size

N_{min} = Minimum Sample Size (for statistical adequacy)
 't' = Calculated t - value from t - test

VEGETATION INFORMATION GUIDELINES

APPENDIX A

(July, 1990)

ACCEPTABLE SAMPLING METHODS FOR VEGETATION STUDIES

Pursuant to R614.301.356-110, the following sampling methods as described below have been selected and approved by the Utah Division of Oil, Gas and Mining for conducting vegetation studies for permitting purposes and for determining revegetation success of reclaimed areas. One should select the most appropriate sampling method for the community to be sampled. Sampling methods other than those described herein must not be used without first being reviewed by the Division and receiving written approval to do so. Any sampling method used, whether identified in this guideline or approved as an alternative method, must be described in detail and approved as part of the permit application package or as an amendment thereto.

For sampling methods that require the use of quadrats, please note that quadrat size and shape are not fixed. However, common use is made of rectangular or square plots of M^2 , $1/4M^2$ or 20 x 50cm in size or a $1/4M^2 - M^2$ circular plot.

I. Sample Adequacy.

Sample adequacy of all statistical sampling will be determined by the formula:

$$N_{\min} = \frac{t^2 S^2}{25}$$

where: t = the value from appropriate t -table*, and
 S = the sample standard deviation,

- * All parameters are to be tested at the 90% confidence level. A 2-tailed test is to be used to compare proposed reference areas with areas proposed to be disturbed. A 1-tailed test is acceptable for all other sampling, including bond release studies.

Regardless of sample size requirements determined from this formula, the minimum sample size listed for each method must be achieved. Samples are to be randomly located throughout the study areas.

II. COVER.

1. Occular Estimation:

Estimate the percent of ground covered by vegetation (by species, total vegetation, litter, rock, etc.) to the nearest percent. Values should be reported by species (and could potentially exceed 100% due to overlap) and by total vegetation cover. Total vegetation cover, when added to vertical projection of exposed rock, litter and bare ground will equal 100%. Each quadrat is considered one sampling unit. Since ocular estimation is more subjective than exact measurement methodologies, ideally, sampling would be done by the same individual to promote consistency between monitoring years.

Quadrats should be randomly placed within the study area.

Minimum sample size = 15

2. Cover Classes:

Cover classes may be used, provided they are at least as small (in range) as those listed below. Utilizing quadrats as discussed above, estimate the percent of ground covered by vegetation to the nearest class. Values should be reported by species and total vegetation cover. Each quadrat is considered one sampling unit. When analyzing the data, the mid-point of each class is used to calculate the mean and standard deviation.

Cover Class	Range	Mid-Point	Cover Class	Range	Mid-Point
1 =	0-1.0%	.5%	8 =	35.1-45.0%	40.0%
2 =	1.1-3.0%	2.0%	9 =	45.1-55.0%	50.0%
3 =	3.1-5.0%	4.0%	10 =	55.1-65.0%	60.0%
4 =	5.1-10.0%	7.5%	11 =	65.1-75.0%	70.0%
5 =	10.1-15.0%	12.5%	12 =	75.1-85.0%	80.0%
6 =	15.1-25.0%	20.0%	13 =	85.1-95.0%	90.0%
7 =	25.1-35.0%	30.0%	14 =	95.1-100%	97.5%

Minimum sample size = 20

3. Point Methods:

Vegetation cover is identified at a pre-determined 'point' and recorded as vegetation, litter, rock or bare ground. Points may be located systematically or randomly along a transect, using a mechanical or ocular pin frame. Total vegetation cover is determined by the first interception or hit (i.e., vegetation, rock, litter, etc.). Cover by species is determined by subsequent hits of vegetation as the point (pin) is lowered through the vegetation. Transects of 50 points minimum are counted as one sample unit. The location and orientation of the transect within the study site should be randomly placed.

Minimum sample size = 15

4. Line Interception:

Using the line intercept method, percent cover is obtained by summing the distances of the transect that are covered by vegetation, litter, rock, bare ground. Transects are commonly 10-100m. long. Each transect is counted as one sampling unit. Transects should be randomly placed within the study area. (This method is best used in sparse, low vegetation, it is not recommend for obtaining cover by species in areas where there is vegetation overlap).

Minimum sample size = 15

III. DENSITY (SHRUBS AND/OR TREES).

1. Point-Quarter Method:

Randomly locate sample points within the study area. At each point, two lines are made to divide the area into four quarters, with the point being the center. The distance from the point to the base of the nearest plant in each quarter is then measured and recorded. To determine the density, sum the 4 distances measured at each point and divide by 4. This mean distance is then squared to give the mean area per plant (this is done for each sampling point). Sum the mean area per plant of each point and divide by the number of points sampled. Divide 43,560 by this number to obtain plants per acre (formulas summarized below). This is the preferred method for semi-dense to dense stands.

Points may be randomly located in the stand or along randomly located transects.

Minimum sample size = 10

Density Formula:

For each point:

$$A_j = \left(\frac{\sum Y_i}{4}\right)^2; \quad D = 43,560 \div \frac{\sum A_j}{n}$$

where: Y_i = distance from point to nearest plant in the i^{th} quarter.
 A_j = mean area/plant at the j^{th} point.
 n = sample size (number of points sampled).
 D = plants/acre.

Reference: G. Cottam and J.T. Curtis, 1956. The Use of Distance Measures in Phytosociological Sampling. Ecology 37(3):451-460.

2. Belt Transects or Plots:

Belt transects or plots are randomly placed in the study area and the number of plants that are rooted in each plot are counted, even if all of the plant canopy is not within the plot. Likewise, plants that overlap the plot but are not rooted within the plot are not counted. The size of the plot is not fixed, however, those sizes commonly used are: M^2 , 5ft-10ft x 100ft, .1 acre, or 1-5m x 50m. Each plot is counted as one sample unit. Select the plot size that is best suited to the community being sampled. This method is better adapted for low to semi-dense stands.

To obtain the number of plants/acre, multiply the number of plants counted in the plot by 43,560 and divide the product by the size of the plot (in square feet).

Minimum sample size = 15

3. Exact Count:

For Extremely Small Stands (Usually Less than 1 Acre) or Very Low Density Areas, An exact count may be preferred since the use of an exact count is not subject to statistical tests of sample adequacy.

IV. PRODUCTIVITY MEASUREMENTS.

1. Exclosures:

The use of exclosures for productivity measurements is optional where domestic livestock will not be in the study area prior to sampling. If livestock are to be in the study area prior to sampling, then exclosures should be used.

When used, exclosures should be large enough to prevent animals from reaching through and grazing on the plot to be sampled. Exclosures should be randomly placed and anchored to the ground, before the growing season begins. It is recommended that the number of exclosures located in the field equal the maximum number of samples required for the method which is used even though when sampling occurs some exclosures may not be sampled because sample adequacy was met with fewer samples. Exclosures should be numbered in the order of the random numbers generated for their placement. Sampling should follow the number sequence until sample adequacy is met or all exclosures have been sampled.

2. Clipping:

Select the quadrat size that is best suited to the community being sampled. Randomly locate the quadrat and clip plants by life form (e.g. herbaceous or woody). For grasses and forbs, clip all standing biomass; for shrubs, clip only current year's growth. Oven dry samples and weigh to the nearest .1 gram. For sample adequacy, use the combined weight of each life form at each plot. Report productivity as pounds/acre or kilograms/hectare.

Minimum sample size = 10 quadrats.

3. Double Sampling:

Select the quadrat size that is best suited to the community being sampled. 2-4 quadrats are clustered systematically around a central, randomly located quadrat. The amount of biomass in the clustered quadrats is estimated as a percent of the biomass of the center quadrat. The center quadrat is then clipped, dried and weighed. A weight is then calculated for the clustered plots based on the percent recorded. For testing purposes, the mean weight for the cluster is used with each cluster being counted as one sample unit. Report productivity as pounds/acre or kilograms/hectare.

Minimum sample size = 10

4. Soil Conservation Service Estimation:

For establishing references areas, it is preferred that the Soil Conservation Service be contacted to estimate productivity and evaluate range condition. Their signed statement will be sufficient for the pre-mining inventory for production on the affected area and reference area.

VEGETATION INFORMATION GUIDELINES

APPENDIX B

(July, 1990)

ACCEPTABLE SIMILARITY / DIVERSITY INDICIES

1. Jaccard's Community Coefficient:

$$SI = \frac{\text{common species}}{\text{total species}} \times 100 \quad \text{or} \quad SI = \frac{c}{a + b - c} \times 100$$

Where: SI = Similarity index,
a = Total number of species in community a,
b = Total number of species in community b, and
c = Number of species common to both communities.

Reference: Jaccard P. 1912. The Distribution of the Flora of the Alpine Zone. *New Phytologist* 11:37-50.

2. Ruzicka's Index of Quantitative Similarity:

(quantitative data is required for this index, i.e., cover or productivity by species)

$$SI = \frac{\sum \text{min}}{\sum \text{max}} \times 100$$

Where: SI = Similarity index,
 $\sum \text{min}$ = Sum of minimum values for any species in the two communities (zero is possible), and
 $\sum \text{max}$ = Sum of maximum values for any species in the two communities.

Reference: Ruzicka, M. 1958. Anuendung Mathematisch - Statistischer Methoden in Der Geobotanik (Synthetische Bearbeitung von Aufnahmen). *Biologia, Bratisl.* 13:647-661.

3. Sorensen's Similarity Index:

$$SI = \frac{2C}{A + B} \times 100$$

Where: SI = Similarity index,
A = Total number of species in community A,
B = Total number of species in community B, and
C = Number of species common to both communities.

Reference: Sorensen, T. 1948. A Method of Establishing Groups of Equal Amplitude in Plant Sociology Based on Similarity of Species Content. *Det Kong. Danske Vidensk. Selsk. Biol. Skr. (Copenhagen)* 5:1-34.