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STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF OIL, GAS AND MINING
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VEGETATION INFORMATION GUIDELINES FOR PERMANENT PROGRAM SUBMISSIONS FOR COAL MINES

* *

Pursuant to SMC 779.19 and UMC 783.19 Requirements

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

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

1. To approximate and describe the condition of the land prior to mining.
2. To identify and describe important wildlife habitat in the mine plan area and the development of corresponding mitigation plans.
3. Identify and provide protection for any threatened and/or endangered species.
4. To aid in the prediction of revegetation potential for the site.
5. To establish the standards which must be utilized to measure the success of revegetation for the purpose of bond release. Standards must be set up for each vegetation type which has been or will be disturbed at the mine. Measurements must be taken to describe species composition, cover, density (of woody plants) and production.

These vegetation information guidelines have been drawn up at the request of coal operators in Utah. They may best be utilized as a checklist for the submittal of required information.

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

For the purposes of vegetation studies the following definitions apply:

Baseline Data: The data collected to describe the "original" (pre-disturbed) community of a vegetation type or range site. It is collected using sound scientific methods and should meet statistical adequacy.

Composition: The species that occur in a given vegetation type. Species lists may be compiled from observations made while sampling other parameters.

Cover: 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. Total cover differs in that it cannot equal more than 100%, including cover by rock, litter, crytogams and bare ground).

Density: The number of plants per unit of area.

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 of the last month of the effective precipitation period for the same time period. Effective precipitation is that which falls from October 1 of the previous year to the end of the month prior to sampling. (If productivity was to be sampled during July, 1982, the effective precipitation period would be from October 1, 1981 to June 30, 1982).

Productivity (Production): The amount of vegetation (dry weight) per unit of area (pound/acre or kilograms/hectare), 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.

Range Site Method: A way in which the rangeland is inventoried and classified, including not only vegetation, but soils, water, animal life, climate, topography, historical use, and the interrelationship of these components. The data and description should be correlated with the data compiled by the Soil Conservation Service for each range site.

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.

Vegetation Type: A plant community that is distinguished by its visually dominant species and should be described by not more than the two apparently dominant species.

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

There are options for vegetation studies pursuant to existing conditions of the permit area:

1. Existing mine (pre-law disturbance areas): The applicant may utilize the Reference Areas Method or the Range Sites Method for the revegetation standards.

2. Existing mine (new disturbance areas): The applicant may use the Baseline Data Method from the proposed disturbance sites provided that the operator demonstrates the data was collected during a "normal" precipitation year. Otherwise the Reference Area Method or the Range Site Method should be utilized.

3. New mines (new disturbance areas): Same as #2 above.

Follow the steps indicated for the method(s) you select to follow:

I. For the "Baseline Data" method, follow steps 1, 2, 3, 4, 9 and 10.

II. For the "Reference Area" method, follow steps 1, 2, 3, 4, 5, 6, 7, 9 and 10.

III. For the "Range Site" method, follow steps 1*, 2*, 3*, 4, 5**, 8, 9 and 10.

*See step 8-b.
**See step 8-e.

SUGGESTED STEPS IN PREPARING VEGETATION INFORMATION

1. Map the existing vegetation types found within the permit area and adjacent areas* (scale of 1:12,000 or larger UMC 771.23(e)). The use of aerial photography would be preferred, but should be ground truthed. Show the locations and boundaries of the presently disturbed areas as well as any areas proposed to be disturbed (UMC 784.23(b)(2)). Vegetation types should overlay the disturbance areas.

*Adjacent areas are those areas within 1 km. of any proposed disturbance. Map requirements may be altered on a case by case basis by contacting the Division in advance.

2. Map all potentially disturbed areas on contour maps of a scale approved by the Division, preferably at a scale of 1:2,400 (1"=200') scale or larger. Mark these maps so that referral may be made back to the permit area (1:12,000) map (see step 1).

3. Determine and list the acreage of each vegetation type to be disturbed (or areas of existing disturbance) and the total acreage of each type in the permit area. Also, note the total acreage of surface disturbance within the permit area.

   Vegetation types should be correlated with Wildlife Habitat Types and/or Wildlife Use Areas.

4. For each vegetation type which is found within any of the areas to be disturbed (new mines or new disturbance on existing mines):

a. Randomly sample the proposed disturbance area for cover (by species to establish diversity, and total cover, total cover is not to exceed 100%), density (of woody plants), and productivity[1]. For stands of trees, basal diameter measurements should be made[2]. Productivity measurements need not include the following: trees, officially designated weeds or noxious plants* and dense mountain shrub thickets. Number sample sites and show numbered sample locations on the map.

   Sampling methods should be approved in advance by the Division. (See Appendix 1).

   *A list of noxious plants may be obtained from the County Weed Supervisor, U.S.U. Extension Service or the District Agriculture Inspector.

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1. For the baseline data method and range site method (when a reference area is not to be used): production measurements for all community types that are or will be disturbed is needed and should meet statistical adequacy. For shrubs, measure only the current year's growth. (Report production according to life form). Productivity measurements should not be taken prior to the latter part of June.

It should also be demonstrated that the year of sampling was a "normal" precipitation year; otherwise, reference areas should be used.

For reference areas (and the associated baseline data): productivity measurements are not critical until the time of comparison with the revegetated areas and do not need to meet statistical adequacy until that time. However, a statement of productivity should be supplied (preferably by the U.S. Soil Conservation Service). Reference areas should be in fair range condition or better.

2. If there is a noticeable stump swell, then the measurement should be taken immediately above the swell.

b. Demonstrate sample adequacy for cover, density (woody plants) and productivity. A minimum and maximum sample size has been established for each acceptable sampling method (see Appendix 1).

It is recommended that the formula, $\frac{t^2 s^2}{(d\bar{x})^2}$ be used, where:

t = the t value for a 2-tailed test,
(t = 1.645 for 90% confidence, t = 1.282 for 80% confidence)
s = the sample standard deviation,
d = the desired change in the mean,
x = the sample mean of the parameter in question.

Other formulae should be approved by the Division in advance.

All parameters should be tested at the 90% confidence level with a 10% change in the mean (d=.1) with the exception of shrublands (where shrubs contribute over 20% of the total cover) and forestlands when 80% confidence with a 10% change in the mean for all parameters should be met.

c. In a narrative, describe each vegetation type 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.

d. List the species present within each vegetation type by common and botanical name. List the species by plant groupings, i.e., trees, shrubs, forbs, grasses, etc.

e. Identify, describe and show on the map the location of any endangered or threatened plants. Make a negative declaration if these are not found in the permit or disturbance areas.

5. For each vegetation type which was determined to have existed within the disturbed areas prior to mining:

Describe each by visually dominant species and list the major species assumed to have been present within each vegetation type by common and botanical name. List the species by life form of plant groupings, i.e., trees, shrubs, forbs, grasses, etc. Mark all disturbed or potentially disturbed areas on the map. (See step 2).

6. Indentify reference areas, preferably within the permit area, which will not be disturbed but which are of the same vegetation type as those which occurred on the areas of previous disturbance or areas of proposed disturbance. (RA's 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 post-mining landuse.) Reference areas should be at least 1 acre in size unless otherwise approved by the Division in advance.

a. Sample randomly for cover, density (woody plants) and species composition.

b. Demonstrate sample adequacy. One reference area may represent more than one disturbance site if the reference area meets the requirements for each site. Labeled sites would allow for simplified referral between the maps and text. (UMC 700.5).

c. List the species present within each reference area by common and botanical name. List the species by life form or plant groupings, i.e., trees, shrubs, forbs, grasses, etc.

d. Productivity measurements on reference areas are not critical until they are compared to the revegetated areas. However, a statement of productivity (preferably a letter from the Soil Conservation Service) is necessary.

e. Mark off the proposed reference areas in the field with permanent markers so that they can be relocated.

f. Mark the location of the reference area(s) on the 1:12,000 vegetation map.

g. Reference areas should be in fair* or better range condition.

Range condition should be determined according to Soil Conservation Service guidelines.

*If the reference area is not in fair or better condition, describe management practices (i.e., fencing) that will be employed so that it is in fair or better condition when comparisons are made with the revegetated area.

7. Demonstrate by table, or other simplified format, the similarity between reference areas and areas of disturbance (or proposed disturbance)*. Similarity must be shown between:

a. Species composition (by a similarity index, see appendix 2), similarity should be 70% unless otherwise approved by the Division.

b. Density (woody plants) and total aerial cover (by a t-test).

c. Geology, soils, slope and aspect.

*See attached data summary sheet.

8. Range Site Method.

a. Range sites will be described in accordance with the Soil Conservation Service, 1975, National Range Handbook, U.S. Department of Agriculture.

b. Range sites will be mapped for the entire permit area and areas to be disturbed will be delineated separately (See steps 1, 2 and 3, substituting range site for vegetation type).

c. Range sites to be sampled will be in fair condition or better and representative of areas to be disturbed. They may be either within or outside the permit area.

d. Samples will not be taken in a year of below average precipitation.

e. Vegetative parameters to be measured will be:*

i. Cover,

ii. Density (for shrubs and/or trees as applicable),

iii. Productivity,

iv. Species composition.

*Follow the procedures outline in 5(a-f) substituting range site for vegetation type.

f. These measures (baseline data) will be considered the success standard for revegetation.

9. Upon request, submit to the Division the copies of the data sheets from the sampling of areas to be disturbed and potential reference sites.

Approval of reference areas by the Division may be obtained prior to approval of the permit application. If prior approval is desired, submittals should be made to allow time for field verification by the Division.

10. 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 the collection and analysis.

c. Descriptions of methodology used to collect and analyze the data (including means, standard deviations, formulae used, etc.).

d. The name, address and position of officials of each private or academic agency consulted by the applicant in preparation of the information (UMC 771.23).

SUMMARY TABLE OF SAMPLING ADEQUACY REQUIREMENTS

		Cover	Density (Woody Plants)	Productivity*
Base-line Data	Grass & Herb Lands	90% Confidence/d=.1	90%/d=.1	90%/d=.1
	Shrub & Forest Lands	80%/d=.1	80%/d=.1	80%/d=.1
Range Sites	Grass & Herbs	90%/d=.1	90%/d=.1	90%/d=.1
	Shrubs & Forest Lands	80%/d=.1	80%/d=.1	80%/d=.1
Refer-ence Areas	Grass & Herbs	90%/d=.1	90%/d=.1	A statement of productivity (preferably a letter from the SCS). RA should be in fair range condition or better.
	Shrub & Forest Lands	80%/d=.1	80%/d=.1	

*Production measurements need not include trees, officially designated weeds and noxious plants and dense mountain shrub thickets.

SUMMARY OF MAP GUIDELINES

A vegetation map of the entire permit area on a scale of 1:12,000 should be submitted if not otherwise exempted by the Division. Include sufficient adjacent areas to the permit area to allow for evaluation of wildlife habitat. The use of aerial photography taken prior to site disturbance would be most helpful in mapping the site. A 1:2,400 scale map should be submitted for areas of present or potential disturbance.

1. The 1:12,000 contour map should:

   a. Show the legal description of the permit area.

   b. Show the boundaries of the permit area.

   c. Show the location and boundaries of any surface area(s) already disturbed by mining and any which are proposed to be disturbed. Labeled sites would allow for simplified referral between the maps and text.

   d. Show the location and boundaries of proposed reference area(s). If reference areas will be located outside of the permit area, then submit a separate map for the reference area(s). Label the sites for referral to text.

   e. Show the boundaries of existing vegetation types, including riparian habitats, for the entire permit and adjacent areas.

   f. Show the locations of any threatened and/or endangered plants.

   g. Show the numbered locations of sampling sites.

2. The 1:2,400 (1" = 200'), or larger, contour map for the areas to be disturbed should:

   a. Give reference points back to the 1:12,000 map, including the legal description.

   b. Show the existing vegetation types. Label the sites for referral to text.

   c. Show the numbered locations of sampling sites.

The applicant is encouraged to arrange a meeting with the Division if any portion of these guidelines need further clarification.

REVISED March, 1982.
By Lynn M. Kunzler and Susan C. Linner, Reclamation Biologists.

DATA SUMMARY SHEET

VEGETATION TYPE: _____

	AFFECTED (Disturbance) AREA				REFERENCE AREA				
	$\bar{X}$	S	N	N_{min}	$\bar{X}$	S	N	N_{min}	t - value
Cover									
Density (plants/acre)									
Productivity									
Aspect									
Slope									
Soils									
Geology									

% Similarity: _____

$\bar{X}$ = Sample Mean

S = Sample Standard Deviation

N = Sample Size

N_{min} = Minimum Sample Size (for statistical adequacy)

Appendix 1

ACCEPTABLE METHODS FOR BASELINE VEGETATION STUDIES

Minimum and maximum sample sizes have been established for the various sampling methods below. One should select the most appropriate sampling method for the community to be sampled. Although a maximum sample size has been established, it may be to the company's advantage to meet sample adequacy, especially if sample adequacy will be met with just a few additional samples.

I. COVER

1. Occular Estimation

The preferred method is to estimate the percent of ground covered by vegetation (by species, life form, etc.) to the nearest 1 percent. Total vegetation cover should not exceed 100% (including cover by rock, litter, and bare ground). Each quadrat is considered one sampling unit.

Quadrat size and shape is not fixed, however the most use is made of either 1/4 M^2, M^2 or 20 x 50 cm, square or rectangle or a 1/4 M^2 circular plot. Select the quadrat size and shape that is best suited to the community being sampled.

Quadrats should be randomly placed within the study area.

Minimum sample size = 10
Maximum sample size = 40

2. Cover Classes

Cover classes may be used provided they are at least as small (range) as those listed below. One visually estimates the cover in a randomly placed quadrat and records it according to the class. 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%	40%
2 =	1.1-3.0%	2.0%	9 =	45.1-55%	50%
3 =	3.1-5.0%	4.0%	10 =	55.1-65%	60%
4 =	5.1-10%	7.5%	11 =	65.1-75%	70%
5 =	10.1-15%	12.5%	12 =	75.1-85%	80%
6 =	15.1-25%	20.0%	13 =	85.1-95%	90%
7 =	25.1-35%	30.0%	14 =	95.1-100%	97.5%

Minimum sample size = 20
Maximum sample size = 40

3. Point Methods

This method employs a small frame with a rod (pin) that drops through the vegetation. Hits are recorded accordingly to what the pin intersects first (i.e., vegetation, litter, rock, bare ground). Transects of usually 50 points are counted as one sample unit. The location of the frame along the transect may be randomly or regularly placed. The location and orientation of the transect within the study site should be randomly placed.

Minimum sample size = 15
Maximum sample size = 50

4. Line Interception

Percent cover is obtained using the line intercept method 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).

Minimum sample size = 15
Maximum sample size = 50

II. DENSITY (SHRUBS AND/OR TREES)

1. For Semi-Dense to Dense Stands

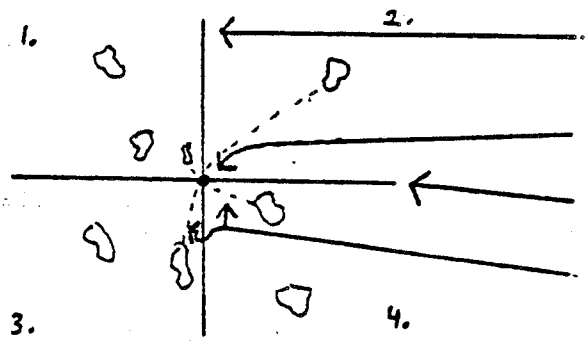
The point-quarter method as described by Cottom and Curtis (1956) is usually the preferred method.

At each point, two lines are made to divide the area into four quarters (see diagram) with the point being the center. Then, the distance from the point to the nearest plant in each quarter is 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). To determine plants per acre, sum the mean area per plant of each point and divide by the number of points sampled, then divide 43,560 by this number (formulas summarized below).

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

Minimum sample size = 10
Maximum sample size = 40

DIAGRAM NO. 1



First line is usually parallel to transect or a fixed compass direction.

Center point.

Second line perpendicular to the first.

Measure distance to nearest plant in each quarter.

Formula:

$$\text{For each point} \left(\frac{Y1 + Y2 + Y3 + Y4}{4}\right)^2 = Aj$$

$$\text{Density} = 43,560 \div \frac{\Sigma Aj}{n}$$

Where: Yi = measurement from point to nearest plant in the ith quarter.

Aj = mean area/plant at the jth point.

n = sample size (number of points sampled).

Density = plants/acre.

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

2. For Low Density Areas

Belt transects or plots are randomly placed in the stand and the number of plants that are rooted in each plot are counted. The size of the plot is not fixed, however, those sizes commonly used are: 5'-10' x 100', 1/10 acre, 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.

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
Maximum sample size = 40

3. For Extremely Small Stands (Usually Less than 1 Acre) or Very Low Density Areas

An exact count may be preferred as the use of an exact count is not subject to statistical tests of sample adequacy.

III. 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. For the Range Site Method and Reference Area Method:

It is prefered 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.

3. Clippping

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. grass and grasslike, forbs, sub-shrubs, and shrubs). For grasses and forbs, clip all standing biomass; for shrubs, clip only current year's growth.

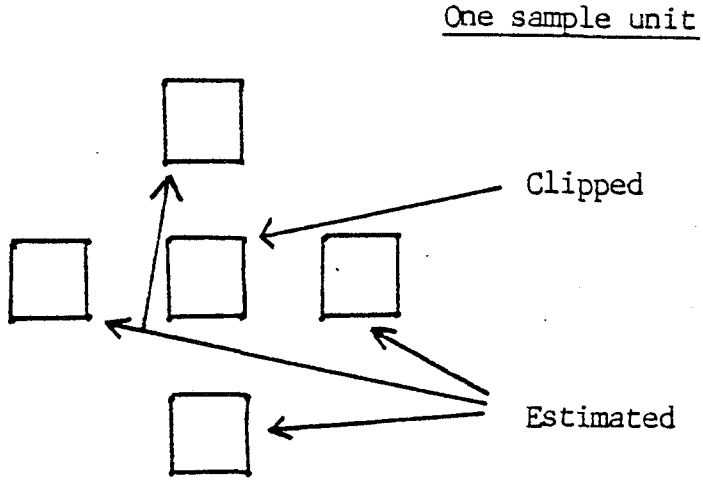
Oven dry samples and weigh to the nearest .1 gram for sample adequacy, use the combined weight of each life form at each plot. Report productivity as pounds/acre or kilograms/hectare.

Minimum sample size = 10 quadrats.
Maximum sample size = 40 quadrats.

4. Double Sampling

Select the quadrat size that is best suited to the community being sampled. 2-4 quadrats are clustered regularly around a central, randomly located quadrat. The center quadrat is clipped by life form and the "clustered quadrats are estimated (by percent) based on the clipped plot (it is necessary to estimate the other quadrats before the central quadrat is clipped). For testing purposes, each cluster is counted as one sample unit. Report productivity as pounds/acre or kilograms/hectare.

Minimum sample size = 10
Maximum sample size = 40



Appendix II

ACCEPTABLE SIMILARITY AND DIVERSITY INDICIES

A. Similarity Indicies

1. Jaccard's Community Coefficient

$$\frac{\text{common species}}{\text{total species}} \times 100 \text{ or } I.S. = \frac{c}{a + b - c} \times 100$$

Where: I.S. = Index of similarity
a = Total number of species in community a
b = Total number of species in community b
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*

$$I.S. = \frac{\Sigma \text{min}}{\Sigma \text{max}} \times 100$$

Where: ΣMin = Minimum values for any species in the two communities (zero is possible)

ΣMax = Maximum values for any species in the two communities

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

3. Sorensen's Similarity Index

$$I.S. = \frac{2C}{A + B} \times 100$$

Where: A = Total number of species in community A
B = Total number of species in community B
C = Total 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.

*One must have quantitative data (i.e., frequency, cover by species, etc.) to use this index.

B. Diversity Index

1. Shannon - Wiener Index

$$H' = \Sigma Pi \log Pi$$

Where: H' = Diversity measure

$Pi = \frac{Ni}{N}$

Ni = Cover value of species i

N = The sum of all species cover values.