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Vegetation parameters for judging the quality of reclamation on coal mine spoils in the Southwest

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VEGETATION PARAMETERS FOR JUDGING THE QUALITY OF RECLAMATION ON COAL MINE SPOILS IN THE SOUTHWEST

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Abstract.— Mining reclamation specialists and government regulators need sound criteria for judging when reclamation is complete and expensive bonds can be released. Values are given for five easily measured plant parameters that can be used for judging success on native species that are growing on semiarid grasslands and sagebrush lands.

The federal Surface Mining Control and Reclamation Act of 1977, along with the many state reclamation laws and Indian tribal regulations, have done much to protect the areas whose jurisdiction they encompass. Some additional needs remain: How are these reclaimed areas to be managed after mining and reclamation are complete? And just when is reclamation complete? This latter question is of no small consequence. Often thousands of dollars are tied up in bonding requirements mandated by law. Mining companies are acutely aware of these costs for they must bear them until "reclamation is complete" and their bonds are released. Land managers are concerned, for it is they who must decide when the area has been restored to a condition that can safely perpetuate itself for years to come with minimum adverse effects. Some information based on research and field experience is available at present for making these decisions. More such information is needed. This paper outlines a range of several vegetation parameters, found on unmined areas of the Four Corners coal province of the United States, that should assist managers working in this area in deciding when vegetation on reclaimed lands has reached unmined levels.

Some Constraints

The vegetation component of an ecosystem is dynamic, and subject to a wide variety of forces. To freeze this movement with a single value and call that number final would be misleading. The range of numbers reported here are to be used as guides, not absolutes. These data can be used to tell whether a reclaimed stand is far below what might be expected from natural, but not protected, stands.

The vegetation parameters chosen and reported on here (cover, density, frequency, importance value, and diversity) are the ones used presently in the course of a study (Rio Puerco, see below) on understanding the effect of grazing systems on semiarid vegetation changes. Other valid parameters used in ecological research could have been chosen and reported on from the literature. The ones used here are common to rangeland research and easily obtained in the field.

Native species only are reported here. There are many other species being used in reclamation in the Southwest at present. To make comparisons between importance values of differing species would be hazardous. Care must be taken when any comparisons are made. Cover and density comparisons between stands are less likely to lead to problems.

Age of stands are not considered here. The number of growing seasons required to be assured of stability is not certain, but it has been reported two growing seasons are needed for stand establishment and seven years to demonstrate long-term survival (Aldon 1981).

The only vegetation associations considered here are the sagebrush series in the Great Basin desertscrub biome and the sacaton series in the Great Basin shrub-grasslands biome (Brown et al. 1979). Two other vegetation types, pinyon-juniper series in the Great

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Basin conifer-woodland biome, and the shadscale series of the Great Basin desertscrub biome, are widespread in the Southwest and will need additional data.

Methods

Vegetation sampling.— The Community Structure Analysis (CSA) method has been used throughout (Pase 1980). The CSA method was used to estimate the relative position of a plant species within the community by an Importance Value (IV). The IV is based on the sum of the relative values for cover, density, and frequency for each species in the stand. The sum of the IVs for all species in a stand, then, is 3. The computed IV is little affected by year-to-year fluctuations in precipitation, shows minor differences between observers, and changes indicate change in range

Table 1. Cover, density, diversity values for two vegetation types.

	1979	1980	1981	All years
		Vegetation type 1 Semiarid grassland		
	128	122	124	374 transects
Cover (%)				
Median	17.6	14.9	18.6	17.3
Mean	19.6	16.8	18.8	18.4
Standard deviation	8.2	7.3	7.1	7.6
Minimum value*	6.5	5.3	5.6	5.3
Maximum value*	47.5	50.4	40.2	50.4
Density (plants/m²)				
Median	27.3	40.5	29.2	31.2
Mean	32.8	47.6	32.1	37.4
Standard deviation	19.0	29.1	20.4	24.2
Minimum value	2.3	3.6	5.3	2.3
Maximum value	104.8	171.2	105.7	171.2
Diversity (Index Values)				
Median	1.3	1.2	1.2	**
Mean	1.3	1.2	1.2	
Standard deviation	0.4	0.4	0.3	
Minimum value	0.4	0.4	0.4	
Maximum value	2.1	2.4	2.1	
		Vegetation type 2 Sagebrush grass		
	48	53	53	154 transects
Cover (%)				
Median	23.2	20.9	23.2	21.8
Mean	22.0	20.7	22.6	21.8
Standard deviation	7.3	5.4	6.9	6.6
Minimum value	0.1	10.8	6.1	0.1
Maximum value	37.0	35.3	43.5	43.5
Density (plants/m²)				
Median	43.8	57.4	29.8	41.2
Mean	46.3	56.8	31.7	44.9
Standard deviation	22.8	27.5	14.3	24.4
Minimum value	1.9	3.3	8.3	1.9
Maximum value	105.8	124.9	60.4	124.9
Diversity (Index Values)				
Median	1.6	1.6	1.4	**
Mean	1.5	1.5	1.3	
Standard deviation	0.5	0.4	0.5	
Minimum value	0.5	0.6	0.3	
Maximum value	2.3	2.3	2.1	

*Actual values used throughout

**Data not subject to averaging

condition (Pase 1980). Cover is based on 100 measurements taken along a 200-m transect randomly located in the field using a 5 x 10 cm rated microplot (Morris 1973). Cover is determined by rating or scoring the area occupied by plants inside this small plot. Density is based on individual plants per m^2 taken on 10 circular plots along the same transect. Frequency is the relative number of "stocked" m^2 circular plots. Rock, litter, and bare soil values are also estimated in the microplot. These latter values are not reported here, but are available from the author.

The diversity index is calculated for each plant array based on absolute density. The index, as used here, is computed from the density of individual species as a proportion of the total density and the total number of species in the community (MacArthur and MacArthur 1961).

The CSA method and diversity index are computerized, and this program is available from the author. Detailed field methods are also available.

SAMPLING AREAS.— Data presented here are taken from a long-term grazing study located on the Rio Puerco drainage in north central New Mexico (for a complete discussion, see USDI Bureau of Land Management 1978). The 159,199 hectares of public lands in this area are divided into 75 grazing allotments, varying in size from 39 hectares to more than 2,025 hectares. Nine representative allotments, distributed evenly over the entire area, were selected for detailed study. Each allotment is divided into three to five pastures. Most pastures have four or five CSA transects located randomly on key grazing areas or primary range lands within them, giving a total of 177 transects placed on the nine study allotments. Of these, 176 are used in this paper. The transects were installed and read in the summer of 1979. They were reread in the summers of 1980 and 1981. Most of the sampling areas are considered in fair to poor range condition at present; thus the values will be on the lower end of a continuum. But precipitation over the area was considered above average for 1979 and 1981, and average in 1980, thus providing maximum vegetation outputs in those better years.

STUDY ALLOTMENT DESCRIPTION.— The allotments range from pinyon-juniper woodlands with a scattering of ponderosa pine at higher elevations down to semiarid grasslands. The area is composed of mesas or uplands, steep rocky breaks, and alluvial grasslands. A layer of Mesa Verde sandstone overlies Mancos shale. The sandstone breaks

TABLE 2. Importance Value for three plant species.

	Vegetation type 1			Vegetation type 2		
	1979	1980	1981	1979	1980	1981
ALKALI SACATON						
Median	0.451	0.517	0.420	0.114	0.065	0.027
Mean	0.614	0.613	0.626	0.105	0.062	0.083
Standard deviation	0.536	0.516	0.588	0.095	0.044	0.122
Minimum value	0.001	0.002	0	0.010	0.001	0.004
Maximum value	2.322	1.981	2.319	0.249	0.121	0.357
Number of transects	91	81	83	5	9	9
GALLETA						
Median	0.692	0.686	0.561	0.152	0.260	0.261
Mean	0.754	0.712	0.670	0.222	0.292	0.288
Standard deviation	0.496	0.469	0.491	0.183	0.207	0.210
Minimum value	0.002	0.001	0.001	0.004	0.006	0.008
Maximum value	2.112	1.862	1.805	0.663	0.660	0.815
Number of transects	106	104	105	32	34	33
BLUE GRAMA						
Median	0.432	0.493	0.513	0.914	0.795	0.778
Mean	0.608	0.666	0.659	0.905	0.762	0.881
Standard deviation	0.540	0.572	0.542	0.506	0.441	0.532
Minimum value	0.004	0.001	0.003	0.089	0.045	0.013
Maximum value	1.904	1.946	2.028	1.890	1.683	2.144
Number of transects	108	105	108	46	50	49

and underlying shales form the parent soil material, the texture of which varies from sandy loam to silty clay. Coal seam outcrops are prevalent, and there is one active surface mine in operation on the area. Precipitation ranges from 38 cm per year at higher elevations, 2300 m, to 20 cm at the lower elevations, 1500 m.

The areas of pastures sampled in this study fall into two vegetation types: a sagebrush-grass mixture and a semiarid grassland type. The sagebrush-grass type consists of big sagebrush (*Artemisia tridentata* Nutt. ssp. *tridentata*), blue grama (*Bouteloua gracilis* [H.B.K.] Lag. ex Steud.), alkali sacaton (*Sporobolus airoides* [Torr.] Torr.), western wheatgrass (*Agropyron smithii* Rydb), with some black greasewood (*Sarcobatus vermiculatus* [Hook.] Torr.) and *Opuntia* spp. scattered throughout. The semiarid type consists mostly of al-

TABLE 3. Frequency for three plant species.

	1979	1980	1981	All years
		Vegetation type 1		
ALKALI SACATON				
Median	0.3	0.3	0.3	0.3
Mean	0.4	0.4	0.3	0.4
Standard deviation	0.3	0.3	0.3	0.3
Minimum value	0	0	0	0
Maximum value	1.0	1.0	1.0	1.0
Number of transects	91	81	83	255
GALLETA				
Median	0.5	0.5	0.4	0.5
Mean	0.5	0.5	0.4	0.5
Standard deviation	0.3	0.3	0.3	0.3
Minimum value	0	0	0	0
Maximum value	1.0	1.0	1.0	1.1
Number of transects	106	104	105	315
BLUE GRAMA				
Median	0.4	0.4	0.4	0.4
Mean	0.4	0.4	0.4	0.4
Standard deviation	0.3	0.3	0.3	0.3
Minimum value	0	0	0	0
Maximum value	1.1	1.0	1.0	1.1
Number of transects	108	105	108	321
		Vegetation type 2		
ALKALI SACATON				
Median	0.1	0.1	0	0.1
Mean	0.1	0.1	0.1	0.1
Standard deviation	0.1	0.1	0.1	0.1
Minimum value	0	0	0	0
Maximum value	0.2	0.2	0.3	0.3
Number of transects	5	9	9	23
GALLETA				
Median	0.3	0.4	0.3	0.3
Mean	0.3	0.4	0.4	0.4
Standard deviation	0.3	0.3	0.3	0.3
Minimum value	0	0	0	0
Maximum value	0.9	0.8	0.9	0.9
Number of transects	32	34	33	99
BLUE GRAMA				
Median	0.8	0.8	0.7	0.8
Mean	0.7	0.7	0.7	0.7
Standard deviation	0.3	0.3	0.3	0.3
Minimum value	0.1	0	0	0
Maximum value	1.0	1.0	1.0	1.0
Number of transects	46	50	49	145

kali sacaton, blue grama, and galleta (*Hilaria jamesii* [Torr.] Benth.) Fourwing saltbush (*Atriplex canescens* [Pursch] Nutt.) and broom snakeweed (*Gutierrezia sarothrae* [Pursh] Britt.) are the principal shrubs. All species occur to some extent in both types, but sagebrush is less in evidence in the semiarid grassland type. For the purposes of this study, the importance values of alkali sacaton, blue grama, and galleta will be listed, for these three species are commonly used in reclamation plantings. Other species IV values are available from the author.

Results

The usual statistics for cover, density, and diversity for individual years and all years combined are shown in Table 1. These are listed so a land manager's field data can be compared with those found in this study to see where the data fall along the continuum. The diversity data are not properly subject to averaging. Table 2 lists the importance values for alkali sacaton, galleta, and blue grama for individual years, and Table 3 the frequency values measured for the same three species.

To arrive at a mean or median value and a range of values that might be used as guides, data used to compile Tables 1, 2, and 3 for each of the three years were pooled and 0.95 nonparametric tolerance limits were computed. The lower and upper bounds of these limits contain at least 95% of the population as represented by the sample data. Table 4 gives these tolerance limits.

Based on tolerance limits data, computed median and mean data, and standard deviation values, the values in Table 4 show both the limits and mean data, representing reasonable approximations of field conditions on semiarid grassland and sagebrush grassland unmined sites in the Southwest.

Discussion

A wide variety of data is needed in decision making, but these tables should help a land manager judge the plant components of the reclaimed stands. For example, these values should be of help to land managers as they continually monitor reclaimed stands prior to bond release. If initial seedings fall below these values, replanting should be contemplated. If a dry year occurs and measured values from a reclaimed stand are at the low end of these tables, the stand could still be considered acceptable and able to sustain itself. If several "wet" growing seasons occur in a row and stands are still at the low end of these tables or if importance values shift downward drastically, careful examination of the stands should be made and problems corrected.

Acknowledgment

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Table 4. Tolerance limits and means for cover, density, diversity, importance value, and frequency.

	Vegetation type 1 (semiarid grasslands)		Vegetation type 2 (sagebrush grasslands)	
	Limits	Mean	Limits	Mean
Cover (%)	8 to 37	18	11 to 37	22
Density (plants/m^2)	7 to 99	35	8 to 112	42
Diversity	0.57 to 1.92	1.20	0.51 to 2.24	1.45
Importance value (IV)				
Alkali sacaton	0.005 to 1.98	.50	0.001 to 0.36	.27
Galleta	0.016 to 1.75	.70	0.006 to 0.66	.24
Blue grama	0.007 to 1.81	.60	0.067 to 1.89	.85
Frequency				
Alkali sacaton	0 to 1.0	.4	0 to 0.3	.1
Galleta	0 to 1.0	.5	0 to 0.9	.3
Glue grama	0 to 1.0	.4	0 to 1.0	.7

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