INHERENT SIMILARITY OF VEGETATION TYPES AS A STANDARD FOR REVEGETATION SUCCESS[1]

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Abstract.--Inherent similarity of vegetation types was evaluated using a PC-based computer program, and used to determine a standard for species composition of reclaimed areas. This technique effectively provides a quantitative means to evaluate species composition using only affected area data.

INTRODUCTION

Similarity indices have been proposed as potential objective and quantitative means of evaluating revegetation success in terms of species composition and diversity. Based on indices calculated between affected area vegetation types and corresponding control or reference areas, 80% similarity (using lifeform groupings for the calculation) has been suggested as a reasonable level of postmining similarity for affected (baseline) and reclaimed areas (WDEQ, 1983). This method is highly dependent on the level of lifeform grouping used for the calculations.

An alternative approach using the inherent similarity of a given type was suggested by D. G. Steward (1983), who also reviewed theoretical and statistical aspects of the use of similarity indices in revegetation evaluation. Determining inherent, or internal, similarity requires calculation of a large matrix of similarity indices between each pair of individual samples from a vegetation type. For a sample size of 20, the resulting matrix requires 190 calculations using a lifeform sorting process which is difficult to perform manually from unreduced vegetation data. To simplify use of inherent similarity for revegetation evaluation, a PC-based computer program was developed to perform the necessary lifeform sorting and calculate the matrices required.

Previous use of similarity indices in the literature has generally been at the species level as an intermediate step in vegetation ordination (Bray and Curtis, 1957). Such ordinations were based on mean community values rather than individual sample data, and often required mainframe computer systems. This PC-based version allows selection of the desired level of species or lifeform detail and can calculate similarities for plant communities or individual samples.

INHERENT SIMILARITY OF VEGETATION TYPES

Using this program, inherent similarity was evaluated for six vegetation types identified during baseline studies for a Wyoming coal mine. Matrices were developed for each vegetation type at three levels of lifeform differentiation. On the basis of nine lifeforms, mean internal similarity in the six types ranged from 52.8 percent in the Mixed Grass Prairie to 82.7 percent in the Playa Grassland type (Table 1). When calculated based on four lifeform groups, mean internal similarity values were higher (ranging from 67 to 86 percent), while detailed comparison by species resulted in much lower values (31 to 68 percent).

Eight or nine lifeform groups have been suggested as providing the appropriate level of detail for revegetation evaluation of similarity. At this level, it is fairly common to establish 80% similarity between affected and control areas, however most vegetation types do not show 80% inherent similarity

Table 1.--Mean inherent similarity of six Wyoming vegetation types based on three levels of lifeform sorting. Based on cover data.

Vegetation Type	Species Level	9 Lifeform	4 Lifeform
Mixed Grass	32.3	52.8	75.8
Bunchgrass	44.6	70.4	77.1
Lowland Prairie	31.5	56.6	82.0
Big Sagebrush	54.8	67.9	75.4
Rough Breaks	30.7	64.4	67.8
Playa Grassland	68.5	82.7	85.8

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(Table 2). Only one community, the homogeneous Playa Grassland type, exceeded the suggested 80% similarity when its individual samples were compared to each other at the desired level of detail. Mean inherent similarity for all types combined was only 65% for nine lifeforms.

Table 2.--Inherent similarity of six Wyoming vegetation types compared to control vs. affected area similarity. Based on cover data at the nine lifeform level of detail.

Vegetation Type	Inherent Similarity	Affected vs. Control Area
Mixed Grass Prairie	52.8	82.0
Bunchgrass Community	70.4	84.9
Lowland Prairie	56.6	55.9
Big Sagebrush	67.9	88.3
Rough Breaks	64.4	80.4
Playa Grassland	82.7	43.0[1]

[1]Mixed Grass Prairie Control Area was used for this type; no suitable playa control was available.

Use of a similarity index appears to provide a direct means of evaluating species composition, however establishing an appropriate level of similarity becomes a concern. Mean inherent similarity techniques overcome this by establishing a direct revegetation standard based solely on site-specific affected area data, rather than an arbitrary value which may not reflect community variability. Usefulness of this approach may ultimately depend on the degree of heterogeneity encompassed in the original vegetation type definition. A Mixed Grass Prairie, for example, may appear relatively uniform, but may encompass considerable variety as a result of its extent and localized inclusions. In this case, two samples dominated by crested wheatgrass have lowered the mean inherent similarity from 64% to 53%. At the four-lifeform level, which doesn't distinguish introduced grasses, the similarity is relatively high at 76%. Determining degree of similarity of any one sample to all other samples in the set, a calculation also performed by the program, creates a mechanism for easily identifying such anomalous samples. Their effect on statistical parameters such as variance and confidence level can then be evaluated.

METHODS FOR EVALUATING REVEGETATION SIMILARITY

Once an appropriate level of reclaimed/affected similarity is determined, several systems could be used to evaluate whether a revegetated area has achieved this species composition standard. The simplest of these would be a comparison of the affected area mean cover with the revegetated area mean cover using the similarity index program. Using preliminary revegetation cover data, such a comparison is made in Table 3. Only one calculation, rather than a large matrix, is required for this comparison. In this case, two areas are shown to have achieved adequate species composition in comparison to the

Table 3.--Example of similarity comparisons of reclaimed areas to affected areas used as a the revegetation standard.

Mixed Grass Prairie Affected Area Inherent Similarity[1] = 52.8%
(species composition standard)

Reclaimed Area	Similarity vs. standard[1]	Conclusion
R#81-1	60.4	Successful recl.
R#81-2	10.5	Evaluation failed
R#82-14	41.0	More time needed
R#82-12	66.9	Successful recl.

[1]All comparisons based on nine lifeform groups.

Mixed Grass Prairie used as a standard, even though the plantings have had only a few years to become established.

Reasons for failure of the other areas would have to be investigated outside the similarity matrix, based on other knowledge of the areas. In the example in Table 3, sample R#81-2 fails the test because of the inclusion of an introduced grass species in the seed mix. At the four-lifeform level, this area may be evaluated as successful revegetation as a result of all perennial grasses being combined for the comparison. This demonstrates the effect of lifeform detail on evaluation results. In contrast, sample R#82-14 may simply require more time before it can be evaluated as successful.

The level of similarity considered acceptable here would depend on agreement with the regulatory authority. For example, any similarity comparison between reclaimed and affected area data might be accepted if it was within 5 percentage points of the standard or higher, in this case 47.8% or more. Any lower value might be subject to statistical evaluation to determine acceptability of revegetation from a species composition standpoint.

A second method would be to insert data from a revegetated area into an inherent similarity matrix of individual samples of the vegetation type to be used as the standard. The effect of the added sample (or possibly samples) on a known matrix would determine adequacy of species composition for that sample. If mean inherent similarity of the matrix is not lowered appreciably, it may be concluded, for purposes of evaluation, that the revegetated area is part of the population comprising the original matrix for that type. An evaluation of this type is demonstrated in Table 4. The original affected area matrix, shown below in the table, has a mean inherent similarity of 59.5%. When the revegetated area data are added, the mean for the matrix becomes 59.0%. The matrix shown is only a portion of the Mixed Grass Prairie matrix. For the entire matrix of 20 samples, and the addition of the same revegetation sample, the matrix changes from 52.8% to 52.5% in mean similarity.

The determination of whether or not this represents a significant difference can be made ob-

Table 4.-- Evaluation of species composition by determining effect of the addition of a revegetated area on a known affected area similarity matrix. Based on cover data at the nine-lifeform level of detail.

Mixed Grass Prairie Affected Area Similarity Matrix
Partial Matrix with Baseline Data Only

Sample No.	M01A	M28A	M21A	M14A	M32A	M06A	M04A	M16A	M12A	M31A
M01A										
M28A	69.7									
M21A	73.1	67.9								
M14A	62.9	81.1	70.0							
M32A	65.3	67.9	76.9	63.2						
M06A	53.3	56.3	56.0	58.8	72.3					
M04A	47.5	50.8	61.2	53.7	65.2	80.7				
M16A	58.8	61.1	69.0	65.8	54.5	51.5	52.3			
M12A	56.1	55.7	72.3	70.8	50.0	40.0	48.1	76.2		
M31A	71.0	51.5	38.5	48.6	49.0	60.0	47.5	41.2	35.1	

Mean Similarity for Matrix = 59.52%

Mixed Grass Prairie Revegetation Evaluation Similarity Matrix
Partial Matrix with One Revegetation Sample Added

Sample No.	M01A	M28A	M21A	M14A	M32A	M06A	M04A	M16A	M12A	M31A
M01A										
M28A	69.7									
M21A	73.1	67.9								
M14A	62.9	81.1	70.0							
M32A	65.3	67.9	76.9	63.2						
M06A	53.3	56.3	56.0	58.8	72.3					
M04A	47.5	50.8	61.2	53.7	65.2	80.7				
M16A	58.8	61.1	69.0	65.8	54.5	51.5	52.3			
M12A	56.1	55.7	72.3	70.8	50.0	40.0	48.1	76.2		
M31A	71.0	51.5	38.5	48.6	49.0	60.0	47.5	41.2	35.1	
R#81-1	63.4	58.7	79.0	54.7	58.7	41.2	50.5	61.9	72.5	27.7

Mean Similarity for Matrix = 59.03%

jectively through the use of statistical analysis, or may be negotiated in advance with the regulatory authority. For example, a company and regulator may agree to accept a conclusion of successful revegetation based on a decrease of no more than one percentage point in the matrix mean. In actual practice, most affected area matrices will be comprised of fifteen to twenty cover samples or more, rather than the ten illustrated here. The size of the matrix will determine the amount of change in matrix mean one sample can cause, and therefore must be taken into account in evaluating results.

A third evaluation technique might take advantage of the mean similarity calculated for each sample by the program. If the mean similarity of a revegetated sample compares favorably with that of other samples from the matrix, the area may be considered adequately revegetated (Table 5). In this example, using the matrix in Table 4, revegetated area #81-1 has a mean similarity within the range of the other samples, and could be considered adequate for species composition. When using the entire Mixed Grass Prairie matrix for comparison,

Table 5.--Evaluation of species composition through comparison of mean matrix similarity of baseline and revegetated samples. Based on cover data at the nine lifeform level of detail.

Mean Baseline Matrix Similarity		Mean Matrix Similarity for Revegetated Sample	
M01A	62.0		
M28A	62.4	R#81-1	51.9
M21A	65.0		
M14A	63.9		
M32A	62.7		
M06A	58.8		
M04A	56.3		
M16A	58.9		
M12A	56.0		
M31A	49.2		

this revegetated samples places seventeenth among the 21 samples.

These examples demonstrate the flexibility of this technique for species composition analysis, and the variety of approaches which might be used by revegetation specialists to document attainment of this standard. Additional experience with this method will provide a better understanding of its usefulness in field situations, and how it may most effectively be used to enhance species composition evaluation.

CONCLUSION

As techniques for evaluating vegetation cover and production become more standardized, attention of revegetation specialists and regulatory authorities is focusing on more elusive vegetation parameters, such as species composition and diversity. Most methods suggested for evaluation of these qualities have not been tested using data from revegetated areas, and the usefulness of these techniques has not been demonstrated.

Use of the internal similarity matrix calculations presented here enables a revegetation specialist to evaluate the internal consistency of premining vegetation types and set a species composition standard based directly on premining vegetation data.

From our evaluation of this technique, inherent similarity appears to provide a valuable tool for species composition analysis, in that premining values are directly used in determining the standard, the methods used may be adapted to individual site situations, and a variety of approaches may be used. Because of the large matrices involved, the method provides objective, quantitative and defensible standards subject to statistical analysis. The PC-computer program used makes the method accessible to most revegetation specialists. Inherent similarity thus provides both companies and regulators the opportunity to ensure successful attainment of a species composition standard, and the ability to document adequacy of postmining species composition at the desired level of detail.

LITERATURE CITED

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