EVALUATING BIODIVERSITY OF MINERAL LANDS[1]

by

Gary L. Wade and Louise M. Tritton[2]

Abstract. Increasingly, lands intended for mining, or lands that have been mined and reclaimed, are being evaluated in terms of biological diversity (biodiversity). The concept of biodiversity includes the variety and number of living organisms, their organizations, and the environments that support them. This paper presents a framework for discussing and evaluating biodiversity and for constructing checklists for evaluating biodiversity before and after mining. This framework identifies some of the different types of biodiversity applicable to mineral lands, the ranges of scale at which they are applicable, and the social stakes and stakeholders relevant across scale and diversity types.

Additional Key Words: diversity, scale, social stakes, stakeholders, heuristic model

Introduction

Biodiversity is an increasingly important issue in the planning and reclamation of large mines. Evaluation of the diversity of lands before and after mining is required by federal and state regulations (Endangered Species Act of 1973, Surface Mining Control and Reclamation Act of 1977). Mining industries, landowners, state and federal regulatory agencies, environmental groups, and other stakeholders may be involved in discussing and evaluating biodiversity.

The concept of biodiversity commonly embraces the variety and number of living organisms, the ways in which they are organized, and the environments that support them. From an ecological perspective, greater diversity usually (although not always) confers stability to reconstructed ecosystems and increases their resilience--the ability to recover from disturbance (Elton 1958, Frank and McNaughton 1991, May 1973, McNaughton 1967, 1968, Herben et al. 1993, Rodriquez and Gomezsal 1994, Tilman and Downing 1994). From a political perspective, land managers and regulatory agencies are increasingly subject to public scrutiny concerning their competence at mining, reclamation and land management. Thus, besides its economic and ecological contexts, biodiversity is a political and an ethical issue (Noss 1992).

The term "biodiversity" also has become a popular buzzword used in various connotations by people with different concerns and agendas. As a result, individuals and organizations discussing it often talk past one another (Iyengar 1994, Kuhlmann 1990). These individuals and organizations need a framework for organizing and defining the concept of biodiversity at the outset of their discussions or actions.

The purpose of this paper is to present a conceptual framework (a heuristic model) that can facilitate identification of:

- the kinds of diversity that are at stake or of interest,
- the scales at which they are relevant, and
- the social stakes and stakeholders.

This framework can be used to help determine:

- what kinds of diversity are important or relevant and to whom they are relevant,
- who will manage selected kinds of biodiversity at different scales,
- the criteria for biodiversity goal-setting, management, and evaluation,
- the values which underlie these criteria, and
- for any given project, what items should be included on a biodiversity evaluation checklist.

Scale

Scale is a hierarchical factor central to the concept of biodiversity (Noss 1992, Tritton and Wade

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1996, Lewis et al. 1996). The organizations responsible for management, decision making, and evaluation of biodiversity vary according to scale. Figure 1 illustrates different denominations (levels) of scale, and it shows examples of organizations with stakes in biodiversity at different levels of scale. Low-level organizations include private landowners and towns with, generally, local interests. A high-level organization (such as a state government) has an interest in the effects of large-scale activities as well as common small-scale activities with cumulative off-site effects.

Types of Diversity

Several types of diversity may be considered when evaluating biodiversity of mineral lands before mining and when evaluating reclamation success after mining (Figure 2).

Inventory diversity describes the total number of different ecological units and the numbers of each unit present in an area to be mined or that has been reclaimed. These ecological units may include the following examples at different levels of scale:

- the number of species or functional groups of species,
- the number of taxa included on special concerns lists,
- the number or rarity of community types present, and
- the number or rarity of ecosystem types present, etc.

Inventory diversity is often described by species richness, alpha- and gamma-diversity, evenness of species, community or patch distribution, and other measures (Magurran 1988).

Structural diversity describes the different kinds of physical structure available, such as:

- open grasslands, shrubs, and multiple tree canopy layers used by various bird species,
- deep open water, shallow open water with submerged vegetation, and emergent wetlands, and
- landscape topography, cliffs and highwalls, and rock or brush piles.

Structural diversity may be evaluated by methods ranging from tallying types of environments or vegetation height classes present to complex geographic information systems (GIS) methods of landscape analysis.

Differentiation diversity is the amount of difference among ecological units. Unmined mineral lands may include communities of significantly different composition. Similar differences might be desirable in reclaimed lands also. This may be quantified by beta-diversity or other measures (Magurran 1988).

Functional diversity encompasses the ecologically quantifiable functions of eco-units at any level. It is a complex dimension of biodiversity. The single functional diversity line in Figure 2 could be replaced by many lines representing different functions inclusive of different scales. The set of functions appropriate for consideration varies with scale and ecosystem type. Examples of function on unmined or reclaimed lands at different levels of scale include:

- functions of particular species in providing wildlife food or habitat requirements of birds, nitrogen fixation, etc.,
- functions of particular community types in preventing erosion, providing wildlife habitat, moderating water quality, etc., and
- products of various ecosystem types such as forests, agricultural lands, etc.

Functional diversity can include ecosystem functions having both on- and off-site effects such as holding soils in place that would otherwise fill sediment basins and off-site stream beds, or the functions of wetlands both on-site and in the larger landscape. A wetland of a few acres may have function at the ecosystem level if it is used as a habitat, corridor, or way point in migrations of amphibians between metapopulations. A wetland has a function at the continental scale if it is used by long-distance migratory waterfowl. Cumulative effects of various functions may be considered through time and across large areas.

There are four types of pattern diversity:

1. spatial pattern of units repeated across the landscape - such as the distribution and connection of wetlands or particular wildlife cover types,
2. temporal patterns - such as spatial relations of mature successional stages (sources of species) to young invasible seral stages,
3. compositional pattern in the presence and variationof species richness and evenness of distribution, and
4. nestedness - the tendency of reclaimed areas to exhibit a subset of species present in reference areas.

Figure 3 illustrates two landscapes with the same

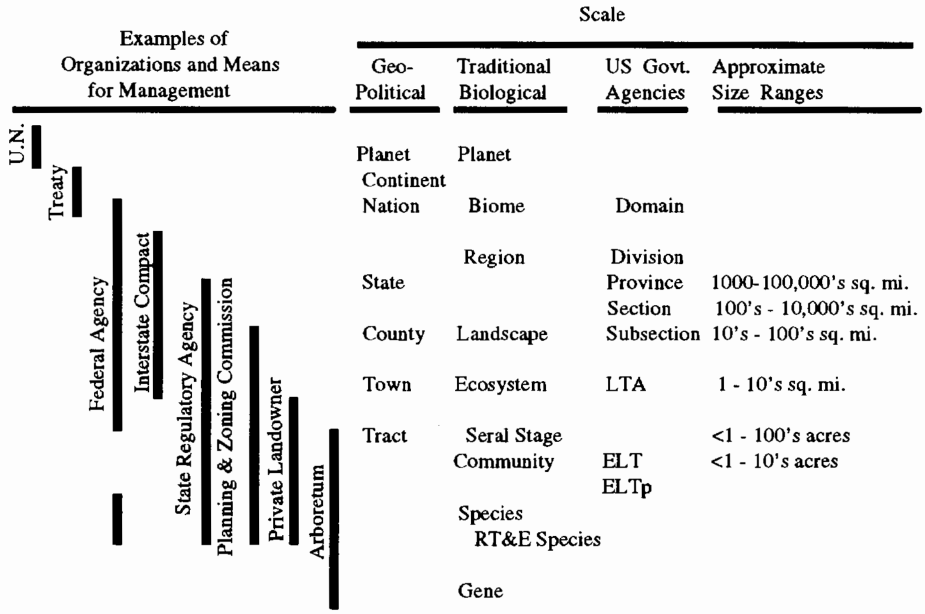

Figure 1. Denominations of scale and examples of organizations with an interest in preservation or management of biodiversity. Abbreviations: RT&E is Rare, Threatened and Endangered; LTA is Land Type Association; ELT is Ecological Land Type; andELTp is Ecological Land Type phase.

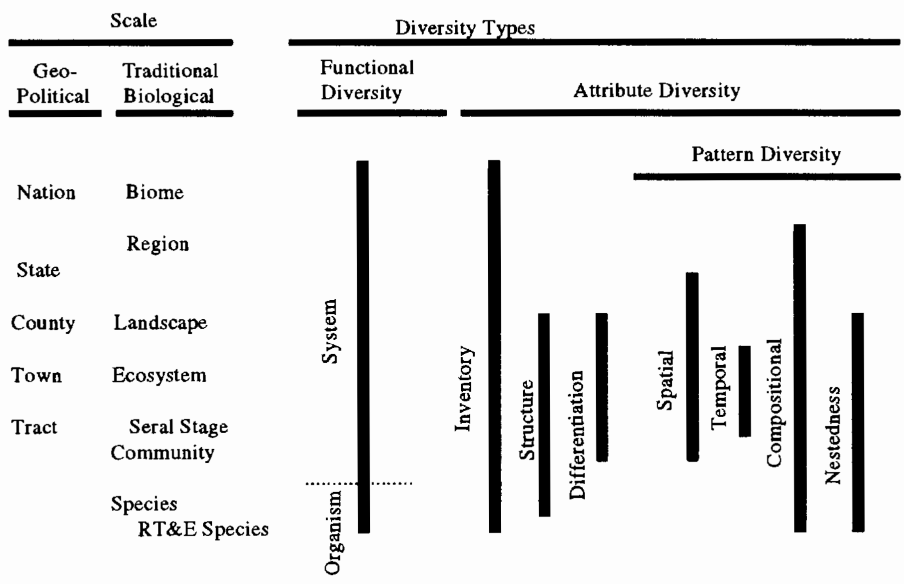

Figure 2. Different types of diversity that may be related to mineral lands and their relationship to scale.

structural elements but different pattern diversities. Landscape analysis methods can be used to quantify characteristics and differences among areas at the ecosystem and larger units of scale (Forman and Godron 1986). Nestedness is reviewed succinctly by Worthen (1996).

Examples of pattern diversities used together include their application to:

- determine the intended use of water impoundments (e.g., sediment control, groundwater recharge, and aquatic wildlife habitats) and their roles in short-, intermediate-, and long-distance migrations,
- determine the spatial relationships of mesic and drought-tolerant plant communities that together may strongly influence reclaimed mined-land ecosystem stability, and
- re-creation of special topography-plant population relationships.

When evaluating biodiversity of mineral lands, a tract of interest may have a particular function at a low scale, none at the next higher scale, but again have a function at an even higher level of scale. For example, a mine wetland may serve local year-round resident amphibian and bird populations. It may also serve as a stopover point for other waterfowl during northern to southern hemisphere migrations without having a role in intermediate-range amphibian migrations.

Biodiversity also must be considered in the context of time. Duration of events affecting environments may be critical. Modest events of limited duration may have little ecological significance; however, such events can become important if they are chronic for many years. For example, a native salmon population that uses a particular stream for spawning might recover from a serious one-year degradation of water quality. But serious pollution lasting beyond the life span of the last salmon generation to leave that stream for maturation in the sea might well extirpate the wild salmon population that originates and spawns there.

Cumulative effects are important at higher levels of scale. The environmental effects of one coal mine are generally small when one is considering the environmental quality of an entire state. But cumulative effects of all coal mines in a state, past and present, can have significant environmental impact on streams, land use and biodiversity. Thus, local biodiversity considerations must be considered in the context of cumulative effects across scale.

Social Stakes and Stakeholders

Not all of the types of diversity listed are relevant in all areas. A reasonable question to ask at the outset of an evaluation process is, "Who is interested in this type of diversity and why is it important?" The same framework (Figure 2) used for identifying types of diversity may be used in identifying stakeholders and the scales (Figure 4) at which they have stakes (interests, responsibilities, or roles) in biodiversity (Decker et al. 1991). The following examples of potential stakes and stakeholder groups are meant to illustrate the application of the framework to the biodiversity of mineral lands.

- Products with an economic value are referred to as utilitarian. Examples are timber from a forested area, an antibiotic extracted from a particular plant species, or minerals removed from an ecological unit. Stakeholders, ranging from local landowners to global corporations, include those who produce, harvest, or use the timber; harvest or market the antibiotic; or mine and use the minerals.

- Local residents may have a stake in "making a living" or subsistence on a particular ecological unit, such as reclaimed land. These stakeholders may be farmers and miners, communities dependent upon the farming and mining industries, and corporations involved in farming and mining.

- Ecosystem integrity encompasses ecosystem health, ability to recover from disturbance, and ability to perform the usual functions of the ecosystem in the greater landscape. The integrity of ecosystems on reclaimed lands is of special concern in mined areas. Although all human society has a stake in ecosystem integrity at various scales, the organizations with legal responsibility for maintaining ecosystem integrity are government agencies such as the Bureau of Land Management, the Forest Service, and the Office of Surface Mining.

- Aesthetics include the scenic values of ecological units ranging from particular species (such as red-tailed hawks) to landscapes. Because mining is often regarded as an unsightly practice, those who visit or live near mineral lands have a stake in reestablishing the beauty of the landscapes and the organisms they support after mining.

- Legacy value is based upon the idea that an ecological unit (from species to landscape) should be preserved for posterity. Elk grazing on mineral lands or the landscapes themselves have a strong

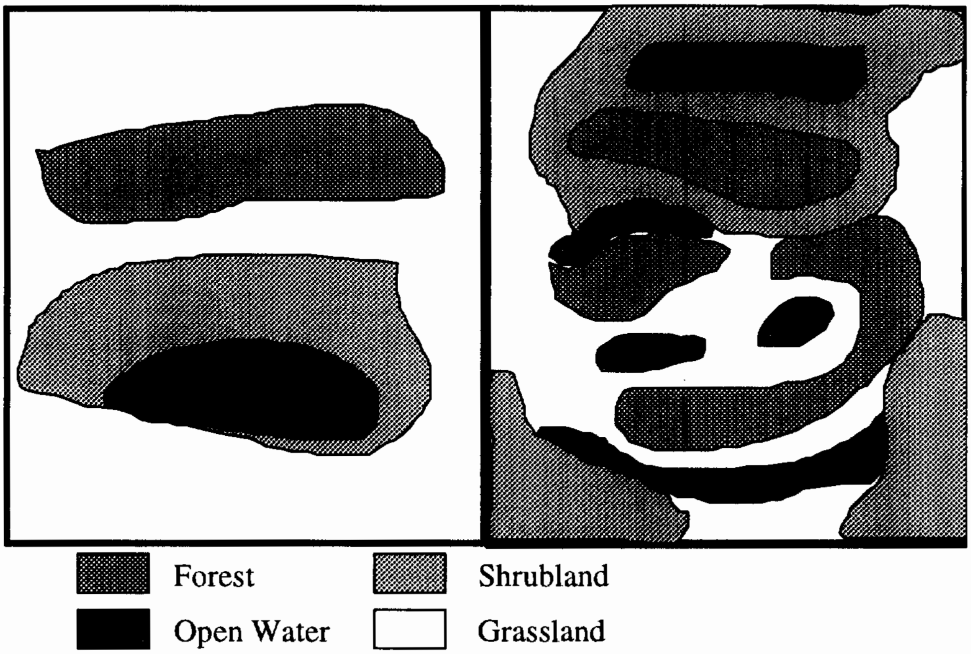

Figure 3. An example of two landscapes that have the same structural elements but different pattern diversities.

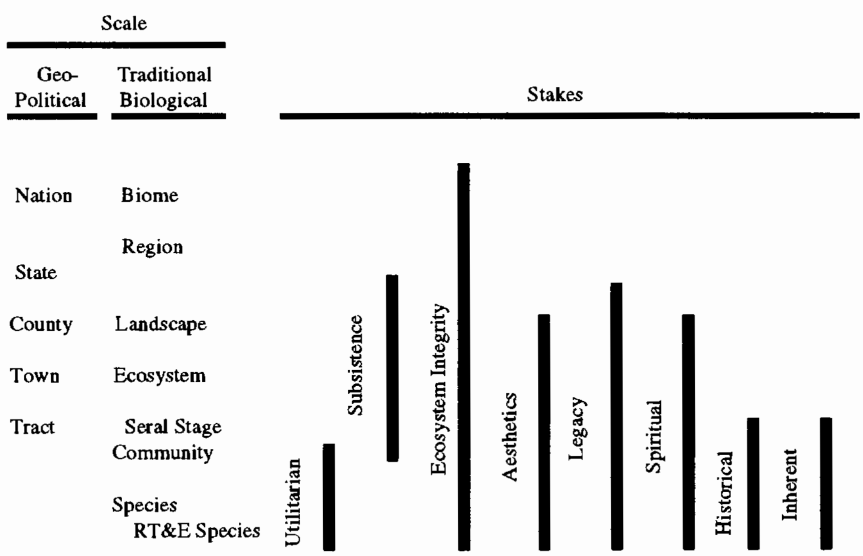

Figure 4. Different types of social stakes that may be related to mineral lands and their relationships to scale.

legacy value to many people. Legacy stakeholders include people not yet born.

- Spiritual values of mineral lands may be related to particular species, sacred grounds, or particular community or ecosystem types such as old-growth forest stands. Native Americans, especially, have voiced concerns about the spiritual value of certain sites.

- Archeological sites, structures, or preserved natural areas left to us by our forebears are valued for their history. Historical values are sometimes attributed to mine workings (termed cultural artifacts) from the pioneering period in the West. Both current and future generations are stakeholders.

- The inherent stake is based on the idea that all species, and possibly even communities, have an inherent right to exist. In contrast to the above, which are based on human needs or standards, this is a belief that values of ecological units transcend human interests. Do nonhuman species or organisms have inherent rights to existence? This topic is well-reviewed by Sagoff (1996).

Social stakes are based on the values humans place on ecological units or attribute to their diversity. Stakeholders involved in biodiversity issues have different authorities, responsibilities, and standings; therefore, they may assign different weights to the same social values. For example, long-term, low-income residents of an economically-depressed area may view subsistence and utilitarian stakes as being more important than aesthetic qualities, particularly in mining communities. Newer residents who were attracted by the aesthetic qualities of life in the region may disagree. Such conflicts surrounding the effects of mining on biodiversity may be understood, within our framework, as a consequence of different types of stakeholders concerned with different types of diversity at different scales.

Application of this Framework to Mineral Land Biodiversity Evaluation

This heuristic framework for evaluating biodiversity has several possible applications. The most important of them is to direct the focus of planners toward consideration of more dimensions of biodiversity than many have dealt with to date. It can be also used to develop a checklist of considerations for particular mineral land tracts or mining regions.

For example, regulatory agencies can examine biodiversity of selected unmined and reclaimed lands across various scales. By comparing biodiversities in these two land classes they may determine which regulations and procedures are impacting biodiversity conservation or restoration.

Mining companies and their reclaimers, in partnership with regulatory agencies and interested publics, can determine what aspects of biodiversity most need to be considered during premining environmental assessments and reclamation evaluation in each mining region.

Depending on the objectives, resources and time available, construction of checklists for evaluating biodiversity of a mine or mining complex might proceed as follows:

1. Compile an inventory of the biological organisms, habitats, and communities present on mineral lands and associated reference areas.

2. Examine the above inventories and determine whether any elements are state- or federally-listed or rare at any of the scales listed in Figure 1. Rarity adds a special concern and value to a species, habitat, community or ecosystem.

3. Determine whether the species richness is great enough in itself to warrant special attention or protection of the area.

4. Determine whether exotic species are present and have potential to cause problems.

5. Determine the quality of "naturalness" of the environments and communities if this may be of concern to social stakeholders.

6. Determine whether any mineral-lands species have a keystone function within any of the included or larger habitats.

7. Determine what community changes are expected and compare these to changes that are occurring.

8. Determine the identifiable functions of each of the above ecosystems, communities, and habitats within their own borders, and within the context of higher levels of scale.

9. Determine what structural elements are contributed by the different species, habitats, communities, and landscape features.

10. Use landscape analysis techniques to determine what spatial patterns are present and how reclaimed sites differ from "natural" sites.

11. Determine what seral stages are present in each ecosystem and their spatial relationships to other seral stages in the landscape. On reclaimed lands, relationships to off-site late seral stages may need to be considered.

12. Determine what species compositional patterns are present, how they may change with time and various expected types of disturbance. For example, are drought tolerant species present near enough to mesic areas that they may stabilize the latter areas during a prolonged period of moderate drought? Are populations of significant species close enough for interpatch migrations to replace patchwise extirpations? This type of analysis could be carried out using guilds of similar species rather than individual species.

13. Determine whether species distribution is nested. For example, are the species present in reclaimed habitats representative of the species present in similar habitats of the larger landscape or are they repetitive subsets of the species found in a reference area? Are the habitat types available on a reclaimed land unit only a subset of the habitat types available in the larger landscape or a reference area? Conversely, a mineral land tract may have a unique floristic and faunal assemblage for the region, and new environments may be formed by the mining-reclamation process.

For all of the above types of diversity at each scale level where biodiversity is quantifiable or differences among land units are observed, the next step is to ask:

- What values (relative or absolute) are associated with this aspect of biodiversity? Some values can be quantified in economically-meaningful terms. Other values, particularly those that are ethical in nature (Kantian values), lie beyond the confines of economic valuation (Sagoff 1996). For example, we don't consider surface-mining irreplaceable national parklands as being within the pale of economic consideration.

- Who are the stakeholders in this and what is the importance of their interest?

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The type of analysis that we have suggested appears to be a lot of work, and it is. However, for similar tracts in the same area, most of the steps need to be done only once. For a particular tract, only the unique features (i.e. the on-site biological inventory, the inventory of habitats and communities present) need be repeated. Relationships to greater scale would need to be reviewed only for new and unique features or important differences.

The result of stepping through these considerations is a list of characteristics and values that may be used for focused consideration of the biodiversity and values of unmined or mined and reclaimed mineral lands. The greatest value of this process is educational -- what we learn from it. Using this framework may lead to regulations and reclamation practices that more effectively protect our environment as well as delivering mineral products to the human society in need of them.

Summary

The evaluation of biodiversity can be complex, involving many different stakeholders concerned about a variety of types of biological diversity. The framework presented in this paper uses different levels of scale to relate the ecological, organizational, and social dimensions of biodiversity of mineral lands. This framework is intended to aid in defining and understanding the scope of diversities relevant to particular lands, and in identifying measures of biodiversity that are meaningful to the stakeholders.

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