

SPATIAL MODELING AND MONITORING OF BIODIVERSITY USING BIOPHYSICAL LAND UNITS (BLU)

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ABSTRACT

Biophysical Land Units (BLU) are ecological response units, modeled with an image-based Geographic Information System (GIS). BLUs represent a data model, and a strategy, for enhancing analysis techniques to support decision making in natural resource management.

Initial, or "core" BLU data are derived from: satellite remote sensing data, Digital Elevation Models (DEM), soils data, and surface water data. The hierarchal concept of BLUs, both in scale and attribute detail, contained in a GIS framework allows: addition or deletion of data layers, integration of multi-temporal datasets, and analysis of change detection and multiple scenarios.

Spatial change detection analysis of the distribution of biophysical attributes (biodiversity), and ecological responses, is tied to site specific data, for enhanced resolution of detail and analysis capabilities. Site data includes such things as: observed assemblages of flora and fauna, rain gauge data, or a particular use or management practice.

KEY WORDS: Biodiversity, Biophysical, Spatial modeling, Ecological response

INTRODUCTION

The Bureau of Land Management (BLM) is a United States Department of the Interior agency, responsible for managing over 270 million acres of public lands, and more than 570 million acres of federally owned minerals. BLM management is guided by principles of multiple use and sustained yield, and the need to protect, preserve, and enhance the natural environment. Resource management decisions are increasingly complex due to escalating demands for the use of public lands, and resulting allocation conflicts. The Biophysical Land Unit (BLU) model represents an effort to provide improved data, and analysis methods to support management decision making for large areas of land with complex resources, and management mandates.

BLUs are homogeneous, ecological response units derived using a Geographic Information System (GIS). The term "biophysical" represents the combination of biological and physical attributes, and is almost a substitution term for ecoscape. There are several emphases of BLUs, which separate the concept from other land inventory and mapping methods. Amongst these emphases are: the ability to use the BLU model to consider the responses (or lack of responses) of the units to both natural and

manipulated influences through time; the spatial extent of an ecological response, using BLUs, can be mapped and analyzed without necessarily being visually discernible in the field; and the amount of detail or scale of a BLU, (the level in the hierarchy of the model where analysis is accomplished), can be adapted to fit the question asked.

Initial, or "core" BLU data are derived from: satellite remote sensing data, Digital Elevational Models (DEM), soils data, and surface water data. The hierarchal concept of BLUs, both in scale and attribute detail, contained in a GIS framework allows: addition or deletion of data layers, integration of multi-temporal datasets, and analysis of change detection and multiple scenarios.

BLUs are also a strategy for developing methods that are consistent, flexible, quantifiable, and cost-effective (which due to space will not be addressed here), to spatially analyze ecological indicators. This includes the ability to assess, monitor, and predict change in landscape condition and capability.

MODELING CONCEPTS

BLUs can be used to spatially model biodiversity by recognizing divisions of the existing environment,

based on ecological responses. In other words, biodiversity can be assessed across a region by the differentiation and location of separate BLUs - homogeneous response units defined spatially by attribute composition.

Another important spatial modeling concept of BLUs for biodiversity is the desirable effect of retaining the "patchy" detail of existing environments. BLUs provide spatial definition of complex ecologic details in a form that can be graphically displayed in a single map layer. This single layer can display the first level of analysis - the "core components" of existing environments, to which a few other defining layers (like administrative boundaries or cultural features) can be added for reference, without confusing displayed information beyond the point of recognition and interpretation. Focus is on spatial patterns and the assemblages of those patterns (communities) and the ecotones which provide the transition between homogeneous areas. The approach allows the analyst to better understand the dynamics occurring in the ecological system and not become overwhelmed with specifics of multiple data layers. As previously mentioned, the spatial patterns of homogeneous BLUs may not always be visually distinct, (without GIS), but defined rather by ecological responses.

The emphasis, therefore, becomes one of dynamics, anomalies, edge conditions, seral stages(s), stability, and sustainability. Inferred information derived from the interface of components of the BLU are tested with field visits and comparable landscapes to better understand the natural system in any locality.

ASSESSMENTS AND ENHANCEMENTS

When areas of anomalies have been identified, field verified and found to require more detailed analysis, another step in the hierarchy of BLU resolution is added. Additional spatial data layers can be overlaid to isolate possible contributing dynamics, or site specific data can be collected, geocode and analyzed.

Work is currently underway to enhance BLU modeling methods using site specific data. Site data, like transects, correlate detailed snapshots in time to the broader scope, more generalized spatial snapshots in time provided by satellite remote sensing data. Satellite data, along with subsequently derived layers like BLUs, provide total area coverage. It has long been recognized that one of the most practical uses of satellite data is the identification of areas where more specific data collection and evaluation methods are required. This same simple notion supports the BLU concept of hierarchal scales of detail, allowing bi-directional flow of information between generic, regional dynamics, and local, more specific dynamics.

An ultra simple, practical example is an effort to automate and link transect data to satellite data, and BLUs. The approach is to use: transect data collected into polycorder files, Global Positioning System

(GPS) data for geocoding transect location, and at those transect points, use of a simple compass for determining the vector of transects in relationship to spectral classes and BLUs.

Attempts to correlate historic transect data digitized into GIS has revealed only a weak correlation with satellite spectral data. Many historic transects appear to have been selected within, and parallel to ecotone areas, probably in an effort to get the best possible representation of diversity, while trying to conserve in numbers of personnel and field time. This makes it very difficult to relate site specific data to generic alternatives management is forced to choose between on a regional scale. These choices could easily be confounded by shifts in ecotone areas, which are areas most sensitive to change. Further, if it were determined that changes were occurring, it would be difficult to determine the extent or percent of change in an area, and what the change represents.

The current effort using the previously mentioned technologies would use BLUs to locate sites for transects. Locations would include sites well within a homogeneous area, allowing a clear definition of the community assemblages. Locations could also include transects perpendicular to ecotones, and thus spectral or community boundaries. Transects could also be long enough to bisect the boundary and allow for boundary shift through time. With a reasonable correlation of transect data to BLUs, it should be possible to track subtle shifts in local ecological dynamics.

MONITORING AND APPLICATIONS

In the El Malpais National Conservation Area (NCA), (at a 30 meter cell sampling scale), BLUs have already been used to detect change, and consider: the rate, amount, and direction of change; as well as the relationship of change to management manipulations and fluctuations in weather patterns. For example, habitat patchiness, difficult to quantify without GIS derived BLUs, and a critical component in management of biodiversity, has been recognized as becoming more homogeneous in some areas of the El Malpais NCA. One possible management response to this change may be relaxation of "full suppression" in fire management.

Another use of BLU tracking of change in biodiversity is the delineation and monitoring of ecological components that represent only a small percentage of a protected area. Tracking these areas, and using GIS to overlay management alternatives, could eliminate the areas from consideration for incompatible uses like a camping area, interpretive trail, or range improvement. GIS graphic representation of BLUs and the conflict resolutions are then useful for policy implementation within an agency, and for public information, especially when use restrictions are necessary.

The hierarchal framework of BLUs, besides providing flexibility in scale and detail of components of current conditions, is meant to facilitate correlation

with other historic, and continuously collected datasets. This facet of the BLU concept is not meant to establish a totally new perspective, but rather to provide a methodology to link past and present datasets with future predictions. Improving methods of relating historic and current environmental data is crucial to identifying past patterns, and developing analysis models for predicting change. These data relationships are also useful in evaluating historic manipulations of natural resources, and projecting preferred management alternatives.

BLUs are thus meant to be a database of natural and cultural resources providing "common ground" amongst scientific and management disciplines or specialties. This BLU concept is an effort to gain a holistic approach to consider a wide array of dynamics comprising natural and manipulated responses, while providing a tool for conflict analysis.

For example, one of the most widely known and used systems of defining and mapping biodiversity is Kuchler's (1964) system of "potential natural vegetation". Kuchler's scale is low resolution for use on a regional scale. BLUs can be sampled to a compatible scale for comparison with Kuchler classifications, allowing a familiar perspective, reference, and scale for some users. Since the BLU scaling structure is flexible to the greatest resolution of input data components, refined analysis (to that level of detail) can be accomplished. Thus, with both Kuchler and BLUs contained in GIS, spatial analysis and dataset comparison retains a link to historic data and a "specialized" or standard, familiar, disciplinary perspective. Of course, this concept would not be limited to Kuchler, but could be considered for any database that could be automated.

As another example, Davis et al (1991) have documented progress on an ambitious approach to "biodiversity assessment", known as "GAP Analysis". The term "GAP Analysis" has been defined as "the evaluation of the protection status of plant communities, animal species and vertebrate richness by GIS overlay of biological distribution data on a map of existing biological reserves". GAP maps are described as being produced at "relatively low spatial detail (1:100,000 - 1:250,000 map scale), and include datasets on "land ownership, topography, species ranges, location of rare, threatened, and endangered species", as well as vegetation produced from Landsat Thematic Mapper satellite data.

Since GAP is being mapped using GIS, comparison or incorporation with a BLU model could help refine GAP research, especially where unprotected "hot spots" are defined on a regional scale. Davis et al (1990) state that it is "desired to produce a map of spatial location of the richest and rarest components of biodiversity and indications of greatest risk... where surveys are most urgently needed". BLUs have been used in similar analyses by the BLM, and refined detail using BLUs could help further define, and identify possible reasons for "gaps" in biodiversity. BLUs are being used to model protection and preservation alternatives in the El Malpais National

Conservation Area (NCA), and might be useful in GAP Analysis as research continues.

BLUs have been used in the El Malpais NCA to help define and monitor "potential" plant communities. Definition of potential plant communities includes an evaluation of the capability of a geographic area to support different plant species and assemblages. As potentials and capabilities are defined and understood, progress can be made toward managing for "desired" plant communities. "Desired" plant communities considers not only the "capability" of the land, but the social, economic, and political parameters that define land management alternatives.

With BLUs, more than the surficial layer of vegetation is examined. By incorporating other ecological components into a homogeneous response unit, BLUs "weed out" superficial fluctuations in land-cover, to focus on the actual dynamics of ecological energies. Recognition or delineation of potential plant communities takes into consideration other components of "system" function as BLUs do, so BLUs can be used in a GIS to intersect and quantify the area and percentage of area currently existing (in that snapshot in time) of what is "potential". Likewise, as "desired" plant communities are defined, the same quantification of area and percent of coverage, or existing correlation with desired qualities, can be determined. As management prescriptions are implemented, change detected with different "snapshots in time" of vegetation modeled into BLUs, can be tracked according to levels of "desired" results.

Beyond the BLU applications mentioned or discussed, (inventories, monitoring, capability assessment), applications in progress or development include: compatibility analysis (between resource "programs"), suitability analysis (alternative selection by value based criteria), feasibility analysis (alternative selection dependent upon land capability and fiscal resources), and problem analysis (issue specific, solution driven study to support an action).

LOOKING TO THE FUTURE

Spatial analysis technology is expanding and improving so rapidly that field applications seem largely to be confined to a continuum of "prototypes". BLUs have been shown to be a useful "on the ground" prototype in a variety of resource management applications (like forage allocations), in the El Malpais NCA. Current expansion of BLUs into other project areas, however, is moving the concept beyond prototype stage and into conventional use.

Foreseeable improvements to the BLU concept are numerous and evolving. Two desirable areas of future improvements may incorporate "resource atlases" and "expert systems". Statewide or agency-wide resource atlases could be developed which incorporate land capability, planning initiatives, and monitoring data. Expert systems could be developed as (standardized) query language capable of determining the highest and best use of the land, environmental and human-induced stress classification

scenarios, with possible industry interface for standard development action, where the query would sort the best location/route based upon predefined parameters. The possibilities for alternative analysis using BLUs seem limitless, without sacrificing attention to analysis of ecological responses and biodiversity.

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