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LENDING LANDSCAPE PERSPECTIVE TO
NATURAL RESOURCES EDUCATION

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ABSTRACT: One of the more challenging aspects of natural resources education is to impart a landscape perspective to students in the course of professional instruction. This is one of the more subtle but important aspects of ecosystem-oriented forestry. The old adage that a picture is worth a thousand words pertains to this context, as does "water, water everywhere but not a drop to drink." There is abundant technological potential embodied in the several satellite remote sensors continually adding to an already vast warehouse of image data, but casting this digital image raw material in a form for ready viewing by students has heretofore required technically sophisticated infrastructure and run afoul of copyright restrictions on sharing of such data. Recent developments in compressing image data for viewing and redistribution can resolve much of this difficulty. A "PHASE" compression of satellite data reduces it to a fraction of its media requirement, frees it from copyright restrictions, and makes it compatible with web downloadable no-cost viewers. Landsat thematic mapper data for the entire state of Pennsylvania have been compresssed in this manner to fit on a single CD-ROM and still leave room for a host of other data. An individual diskette will accommodate a chunk of landscape large enough to provide a backdrop for most settings in natural resources education. The PHASE software is shareware, and a little help from local remote sensing specialists should be sufficient for getting started.

INTRODUCTION

Natural resources education has tended to be locality oriented as opposed to vicinity oriented. In forestry, for example, silviculture and management usually focus on the stand as the unit of analysis and operation. For aquatics the stream reach, pond, lake or wetland is the unit of discourse for analysis and operation. For wildlife a patch of cover as a habitat component is often the unit of attention and prescription. On the other hand, we extoll the virtues of forests, wetlands, etc. in stabilizing and ameliorating environments more generally. Given a reasonably high level of environmental awareness among the general public, we shouldn't be surprised if the latter messages are taken to heart with consequent public concern for what transpires in the more naturalistic components of their environs where they lack direct land tenure. Our locality-oriented training, however, leaves neophyte natural resource professionals rather ill-prepared for objective public exchange regarding the likely implications of natural resource interventions at a specific place relative to other localities in the vicinity. Even many natural resource professionals with more experience in the field are little better prepared in this regard.

Cognizance of vicinity effects is implicit in the idea of ecosystem-oriented forest management, and is likewise central to landscape ecology (Forman and Godron, 1986). If a forester may not wish to subscribe to all of the formalisms and tenets of landscape ecology, the essentials of vicinity influence by forest can be considered in terms of stands and "standscapes." Landscapes (and standscapes) typically have the character of mosaics (Forman, 1995) in which there is greater or lesser degree of differentiation between and within the elements of the mosaic. The more similar the surrounding elements are to a stand, the greater will be the propensity for first-order effects such as fire and insects to propagate from the stand through the vicinity. The more dissimilar the elements in the vicinity, the more different kinds of potential spatial interactions must be considered along with distance decay curves for such influences. The problem is that vicinity issues remain obscure in the minds of students when considered in the abstract. It thus becomes critical to be able to present patterns of real landscapes in a visual manner to provide instructional context. Ability to depict the landscape following an intervention would also be helpful.

While considering one particular standscape will not sufficiently prepare students to deal with vicinity effects generally, having had explicit exposure to the process will help sensitize them to need for anticipating and mitigating influences of management actions that may extend beyond the target stand. Primary concern here is with technology for extracting landscape renditions from multiband satellite image data in a manner that makes visual presentations for vicinity context broadly and economically available. A mode of building upon this technology for depicting prospective management interventions is also considered.

LANDSCAPE VIEWS AS IMAGE-MAPS FROM PHASE-COMPRESSED IMAGE DATA

Regularly updated multiband satellite data having resolution of 20-30 meters over most of the globe have existed for a number of years. Therefore, technology for acquiring earth image data from orbit has not been the constraining factor. However, society has not been reaping the full measure of benefits from this technological investment for several reasons. First is that acquiring a copy of recent satellite based image data has been costly, to the tune of something on the order of $6K per scene. Second is that preparatory computer processing, analysis, and image generation has required hardware and software capability beyond the ordinary and also expensive. Third is that the level of technical sophistication required to work with the hardware and software has been relatively high. Fourth is that satellite data are generally copyrighted with a prohibition on redistribution except for derivative products that do not permit restoration of the original image data files. Thus printed images can be distributed, but not original data on which printed images are often based. But printing is fairly expensive both to do and reproduce. Finally, a large media requirement for multiband image data has required special storage facilities for use on any given computer installation.

Several recent breakthroughs have combined to make routine creation, usage, and even mass distribution of landscape image-mapping capability both feasible and economical. First is an exponential increase in both processing speed and disk storage capacity of personal class computers, which enables handling of image datasets that formerly required special computer configurations. Second is rapid evolution and decreasing cost of writable CD-ROM technology and accelerated readers. Third is some opening of the GIS and image data software arena in conjunction with the Internet and WorldWide Web that makes reasonably sophisticated software for viewing downloadable without charge. Fourth is a method of image data compression that not only reduces dataload but also transcends conventional copyrights on the original image data, to which attention now turns.

Most landscapes exhibit pattern when viewed from above, as when looking out the window of a rising aircraft. Such pattern, in turn, implies that there are areas of evident uniformity juxtaposed with areas having notable contrast. The areas of uniformity and contrast may or may not have definite geometric shape and repetition, since those are added qualities of some patterns. Since digital image data acquired from satellite sensors usually covers and often surpasses the spectral sensitivity of our vision, one can assume that pattern information is implicit to the data for landscapes where we experience visual perception of pattern from above.

The spatial layout for digital image data is a grid of cells, with the cells being called pixels which is short for picture elements. Pixels situated in more uniform areas must

therefore have a pronounced degree of similarity relative to those for contrasting areas. In statistics, the extraction of unspecified similarities/dissimilarities is accomplished via a host of disparate mathematical heuristics that are generically called cluster analysis. Since implicit pattern in image data also implies redundancy, it is reasonable to expect that suitably conceived clustering should provide a basis for compression of image data. Clusters should thus correspond to (unnamed) cover types.

By way of some further background, clustering has long played a role in analysis of multiband image data. Its primary use has been in thematic mapping by the so-called "unsupervised analysis" approach. This entails first clustering, and then empirical investigation of cluster instances to determine how each cluster should be designated on the map. A rather modest number of clusters is usually sought in this context so that the empirical investigation involved in labeling does not become overly burdensome.

Kelly and White (1993) advocated considerably more clusters, and developed software for computer-aided labeling so as not to increase the overall workload excessively. The proliferation of clusters led them to call this "hyperclustering." Noting substantial expression of lanscape pattern in their hyperclusters led to the present development of a special hyperclustering methodology for image data compression which is specifically geared to capturing salient landscape features. This landscape oriented clustering has been dubbed PHASE, which stands for Pixel Hyperclusters Approximating Spatial Ensembles (Myers et al., 1997). PHASE formulation extracts as many clusters as can be handled by the chosen viewer software, up to the 255 maximum that byte binary image data formats will accommodate. Cluster mean values are used to approximate image data for the respective clusters. The software for PHASE formulation and analysis is treated as shareware (Myers, 1997). Since the within-cluster variability is expressed only statistically, distributing a PHASE formulation does not infringe on copyright for the original image data. A PHASE formulation has the further advantage that it can be used in GIS as a pseudocolor digital map.

PHASE compression obviously cannot take place without an image dataset to serve as raw material, and image data is still costly. Given one purchased copy, however, PHASE compression can provide landscape views to a number of others that is limited only by cooperative spirit and financing of distribution. There is a stipulation that the PHASE software not be sold for profit, but PHASE compressions are value-added products that can be a basis for commerce. The cost of procuring original data can be spread by group purchase, or financial inducement for PHASE formulation can be offered to a laboratory that has procured image data for other purposes.

A biodiversity research effort in Pennsylvania had access to satellite data for the entire state, and one goal of the research was to make spatially explicit information available to the

public. A computer vendor provided supplemental funding to assist in producing CD-ROMs containing PHASE compressions for general distribution. A single CD-ROM not only accommodated PHASE compressions for the whole state, but a variety of other GIS data like roads, hydrology, and county boundaries as well. Since a PHASE formulation compacts an earth view in several image bands down to a byte, this compact disk is called a Terrabyte CD. The Terrabyte CD is configured for viewing and analysis via the commercial ArcView GIS by Environmental Systems Research Institute (ESRI) of Redlands, CA. Among its many other potential uses, the Terrabyte CD offers the computer vendor a good promotional for running GIS systems on its line of computers. Several other partners also contributed buy-in and in-kind support to this production effort.

In a spirit of open GIS, ESRI has also recently made its new ArcExplorer GIS viewing facility available for downloading on the Web at the www.esri.com/arcexplorer address. ArcExplorer handles GeoTIFF image-map files. Plans are in place to reformat the Terrabyte files from grid coverages to GeoTIFF on another CD-ROM so that they become accessible to organizations such as public schools that cannot normally mount substantial GIS capability.

Another possibility for viewing in the absence of a regular GIS lies in the MultiSpec software that the LARS group at Purdue University makes available under NASA sponsorship for downloading via the Web at the http://dynamo.ecn.purdue.edu/~biehl/MultiSpec/ address. The MultiSpec viewer accommodates PHASE files as a thematic form, with a current limit of 230 clusters. It should also be mentioned that the PHASE software provides for partitioning and reassembly of image files to allow transport when high capacity removable media are not available.

MODELING LANDSCAPE VIEWS UNDER PROSPECTIVE MANAGEMENT SCENARIOS

The PHASE approach would also enable a relatively simple and straightforward adaptation of cellular (raster) GIS for modeling overhead views of landscapes under alternative management scenarios. This possibility arises from PHASE generation of several different color renderings for a landscape.

Some investigation of a PHASE landscape view in the manner of unsupervised classification analysis should serve to determine cluster identification number for a sample of each land cover type under study. The PHASE files can then be consulted to determine the corresponding color scheme for each of the land types. The next step would be to set up a parcel identification grid for the landscape under study. Each parcel could then be assigned to a land cover type in accordance with the prospective management, and a lookup table used to colorize the respective parcels accordingly.

Such modeled landscape views could go a long way toward lending spatial perspective to linear programming exercises as typically conducted in forest management classes. They would be especially valuable for considering the effects of management strategies on habitat integrity and connectivity. When used in conjunction with topographic maps or digital terrain models, they would likewise help to reveal the visual impacts of management on landscapes.

PHASE formulations further support adaptations of most analyses that are conventionally conducted on multiband digital image datasets. PHASE compression also has the effect of inducing explicit spatial structure, whereas spatial structure is only implicit in the original image data. The explicit spatial structure can be analyzed directly with the FRAGSTATS software of McGarigal and Marks (1995), which would not be possible for the original data without doing an intermediate classification.

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