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Scientific data visualization and biological diversity: new tools for spatializing multimedia observations of species and ecosystems

Michael P. Hamilton and Michael Flaxman
University of California, James San Jacinto Mountains Reserve, P.O. Box 1775, Idyllwild, CA 92349, USA

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ABSTRACT

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Current knowledge of the biodiversity of protected ecosystems is often limited to museum collection specimen data, outdated or cursory inventories and anecdotal accounts. Beyond the inventory of biological diversity comes the need to monitor changes of many parameters and at many scales, and the need to incorporate this knowledge into an accessible information system for biodiversity management planning and conservation education. This paper briefly describes our continuing research efforts to develop new ways to collect, analyze, organize and distribute biodiversity data.

INTRODUCTION

Numerous papers, books, films and programs have described the issues surrounding the causes and consequences of reducing our global biodiversity (Wilson and Peter, 1988). Rapidly accelerating global changes are placing impossible demands on the scientific community to inventory and assess the world's remaining species and important ecosystems (National Science Board, 1990). There are simply not enough experts trained in the fields of biological systematics and ecology to acquire rapidly sufficient biodiversity data necessary to influence land development policies (Soule and Kohm, 1989; Higher Education Panel, 1990).

At the University of California, James San Jacinto Mountains Reserve (a member biological field station of the statewide UC Natural Reserve System) we have incorporated a range of data management approaches to document biological diversity studies conducted within the San Jacinto Mountains (Riverside County, California). Our databases include species inventories, bibliographic and research studies stored in Macintosh HyperCard format, multiple GIS coverages running on Workstation ARC/INFO and PC ARC/INFO, 35 000 video images of photomonitoring plots and species photography stored on laser disc, and bioacoustical recordings on audio tape. The integration of all these databases and records into a single computer environment has been the subject of our current research in data management for biological field stations (Hamilton, 1989).

Correspondence to: M.P. Hamilton, University of California, James San Jacinto Mountains Reserve, P.O. Box 1775, Idyllwild, CA 92349, USA.

BIODIVERSITY VISUALIZATION

Biodiversity visualization is a concept we have coined to employ visualization techniques in order to unify the various biodiversity data sets stored at our field station. We consider visualization to encompass the technologies of electronic imaging, remote sensing, geographic information systems, interactive multimedia, and three-dimensional volume rendering. Research is continuing to integrate many, if not all, of these technologies under a single-user interface. Our methodology will be important to field station data management throughout the world, as well as to land managers who specifically recognize the importance of managing for biological values (e.g. wilderness areas, national and state parks, and private natural preserves). We are currently combining the two-dimensional graphical display capabilities of our ARC/INFO databases with ground-based video monitoring imagery and hypermedia species/ecosystems inventories. Our system, called the MACROSCOPE, combines these data representations with a consistent user interface. Biodiversity visualization becomes a process for spatializing multimedia observations of biological diversity at many scales using computer-based scientific data visualization tools.

MULTIMEDIA DATA COLLECTION

Our field studies team consists of University of California, Riverside and California State University at Pomona graduate students, as well as staff biologists at the UC James Reserve. We have been involved in collecting multimedia data sets in the San Jacinto Mountains and at several field stations in Venezuela since 1985. Standard collecting methods for invertebrates, vertebrates and plants are generally employed and specimens deposited at museums in California and Venezuela. Quantitative data sets describing plant communities and animal populations are also generated as a component of our field courses. In addition, multimedia data in the form of 35 mm color slide film, 16 mm color movie film, still video images, videotape recordings and audio tape recordings are routinely collected. We use a variety of techniques for standardizing multimedia observations. For instance, Canon still video cameras are mounted on a survey transet and images are recorded in an overlapping format (in all directions and angles) in order to provide a video viewmap of each of our vegetation plots. We recently began using a Magellan global positioning receiver, and if this tool provides sufficient accuracy in our tropical ecosystem localities, we plan to interface the camera, a palm-top computer, portable aircraft gyroscope, and an electronic altimeter in order to automate the recording of camera position and geographic position. Audio recordings of vocalizing animals will be similarly documented (microphone position and geoposition). Video still and motion imagery are stored in analog formats on laser disc, tape and video floppy disk, and in digital format using compressed Quicktime utilities.

Using multimedia data to augment quantitative measurements provides a very informative way to document observations and to validate field measurements in order to conduct time series and change detection studies. Our field course returns to the same locations every two years in order to reconstruct past studies and investigations. Because our biodiversity visualization system is reasonably portable, it travels with us to our field localities, and the database provides a simple way to relocate study plots, thus providing our students with a visual history of past observations.

GEOGRAPHIC INFORMATION SYSTEMS

Integrating the ground-level multimedia observations with our ARC/INFO coverages, involves building appropriate coverages, defined by geo-coordinates and content, within ARC/

INFO, and converting an image of the coverage to a Macintosh-compatible graphical format. The remainder of our visualization system relies on Macintosh-based software. The MACROSCOPE is organized into five principal databases. These are: (1) Observations Database; (2) Species Database; (3) Habitat/Community Database; (4) Landscape (GIS) Database; and (5) Global Index. Each level is viewed in two modes, as a primary window and as a secondary window. When the information being viewed in the primary window is changed (e.g. a new species is displayed) then each of the other four secondary windows will be automatically updated to show the appropriate relationships. HyperCard takes an object-oriented approach to programming which we have found to be extremely useful in linking our five primary databases and supporting stacks. HyperCard also makes use of hypertext, allowing key words or phrases to be hard linked directly to supplemental information, or dynamically linked using HyperCard's built-in searching algorithms. Our system of linked windows showing multiple representations of biodiversity is essentially a prototype of a visualization approach which is leading to extremely rapid data collection, processing and display of ecological information.

APPLICATIONS

Computer-based tools for describing biological complexity promise to expand the capacity for observing and describing biological diversity rapidly. Visualization techniques such as GIS and interactive multimedia are only now being applied to the effort to document our rapidly changing world. The MACROSCOPE has provided one approach to connecting different databases which share a geographic position. Our data-management model is in a rapid state of development and refinement so that easy-to-use tools can be made available to field biologists, educators and other committed people worldwide, who share a need to accelerate our knowledge of biodiversity. Over the next 5 years we plan to exploit the rapid increases in performance of computer hardware and intelligent software to design biodiversity visualization tools appropriate for research, education and biological resource management.

We invite inquiries from all interested people who would like to learn more about this project.

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