Museum Collections Data and Online Mapping Applications

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A New Resource for Land Managers

The Mountain and Plains Spatio-Temporal Database Informatics Initiative (MaPSTeDI) is a collaborative effort between the University of Colorado Museum, Denver Museum of Nature and Science, and Denver Botanic Gardens to convert their separate collections into one distributed biodiversity database and research toolkit using online mapping applications. The 3 participating museums are all located just east of the Rocky Mountains in the United States and have extensive natural history collections data covering the southern and central Rockies and adjacent plains. MaPSTeDI's efforts will result in an online mapping application with access to over 200,000 georeferenced specimens. Once this application is in production, MaPSTeDI will provide access to valuable data that can be used by researchers for biodiversity analyses and land use planning over a 6-state region that includes Colorado, Montana, Nebraska, North Dakota, South Dakota, and Wyoming.

Information to prevent ecosystem erosion and biodiversity loss

The Rocky Mountains, located in the western United States, are world renowned for their breathtaking scenery. Not as well known, however, is the diverse array of ecosystems and biological diversity found in the area. The Rocky Mountain region incorporates many different ecosystems including grasslands, shrublands, wetlands, coniferous and deciduous forests, and alpine tundra, to name a few. Popular wildlife species, such as elk, bighorn sheep, bald eagles, and peregrine falcons, are found in the region, as are less visible species such as the Abert's squirrel, Northern Leopard frog, and White-tailed ptarmigan. However, the Rockies are also being increasingly threatened. The region includes some of the most rapidly growing urban areas in the United States; Colorado ranked third in population growth from 1990–2000, according to the Social Science Data Analysis Network. The urban development and water control projects associated with this growth are modifying critical wildlife habitat. Biodiversity loss in the region has been documented for amphibians as well as crayfish and mollusks. At the same time, introduced species such as cheatgrass (*Bromus tectorum*) and the Russian olive (*Elaeagnus angustiflia*) are replacing native species. Although these changes are taking place, the lack of accessible data and the variety of data formats are hampering efforts to document, analyze, and understand these changes.

"The ability to access museum collections data in a spatial format would be an invaluable enhancement to ecoregional planning efforts at The Nature Conservancy." (Tyrone Guthrie, GIS Specialist with The Nature Conservancy's Rocky Mountain Division)

The MaPSTeDI project

Because there has been a lack of datasets and tools that assist in identifying areas of important biological diversity, the Mountain and Plains Spatio-Temporal Database Informatics Initiative (MaPSTeDI) project's goal is to provide a means for researchers, land managers, and the general public to access baseline biodiversity data stored in museums. Museums are storehouses of baseline biodiversity data because of their long history of collecting and storing specimens and metadata about those specimens. If biological diversity is to be maintained in the Rocky Mountain region, land management decisions that minimize these ecosystem changes will be necessary, and part of this decision-making should include incorporation of historical and current data about species richness and diversity. Using this information, organizations responsible for land management such as The Nature Conservancy may be better able to facilitate sustainable development by protecting additional areas of critical habitat or modifying existing land use practices that are detrimental to species of concern.

To address problems related to the lack, accessibility, and usability of biodiversity data, the University of Colorado Museum (CU Museum) is spearheading a collaborative effort to make natural history collections data on the Rocky Mountain region available online. This effort also involves the participation of the Denver Museum of Nature and Science and the Denver Botanic Gardens. These institutions have combined collections of over 1,700,000 specimens that have been collected over the past 130 years (and, in the case of fossils, represent specimens dating back over hundreds of millions of years) and, therefore, represent a major source of current and historical data on biodiversity in the Rocky Mountain region.

To allow access to this important biodiversity information resource, a number of steps are required to convert natural history museum collections data into a format more usable by the public and researchers. MaPSTeDI has developed the following processes to accomplish this goal:

1. Collect new specimens or access historical records of collected specimens.
2. Assign spatial coordinates (georeference) to collected material.
3. Record spatial coordinates and other relevant data associated with the collected specimen in a database.
4. Load the database into a geographic information system–compatible format.
5. Develop an Internet-based mapping application to allow access to the data.

When collecting new specimens, most researchers are now equipped with handheld Global Positioning System devices and are able to georeference collected data while still in the field (Figure 1). With historical collections data, georeferencing is accomplished retrospectively on the basis of locality information available with most specimens. Typically, initial localities can be located with the assistance of the US Geological Survey's Geographic Names Information System

FIGURE 1 Researchers collect freshwater specimens (*Gyraulus parvus* and *Pisidium casertanum*) at Monarch Lake, west of Rocky Mountain National Park in Colorado. (Photo courtesy of John Sovell with the Colorado Natural Heritage Program)

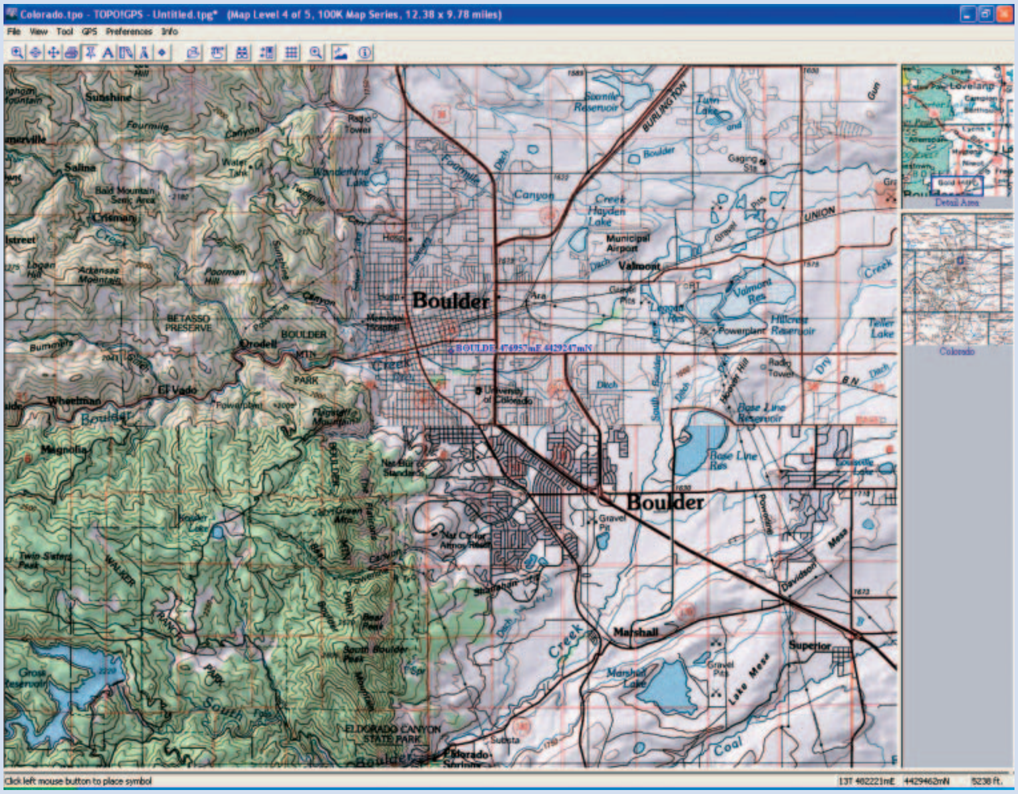

FIGURE 2 Screen capture of the topographic mapping software. (Provided by J.R. Allen and courtesy of National Geographic)

and then further refined using topographic mapping software from National Geographic (Figure 2). The coordinate data are then stored in the database along with other relevant data such as species name, name of collector, date collected, and field notes. Through the retrospective georeferencing process, MaPSTeDI will have digitized over 200,000 specimens by the end of the project.

Equally important is the development of easy-to-use tools to access the digitized collections data. To this end, MaPSTeDI is building a distributed mapping system for the online display of georeferenced specimens. The application currently being developed provides a means to observe and analyze distributed biodiversity data using client–server mapping interfaces. These easy-to-use mapping tools provide a mechanism to query and visualize specific species distributions against a backdrop of spatially referenced environmental datasets such as vegetation, hydrography, and roads (Figure 3).

A particularly difficult challenge in distributed mapping applications lies in how to move relatively large amounts of geospatial data over the Internet without the loss of application performance. MaPSTeDI has developed a novel solution that relies on quickly transferring large amounts of geospatial data using images rather than vector-based coordinate data. This solution, which utilizes Java's Advanced Imaging libraries, allows compression of distributed datasets that may be thousands of kilobytes (Kb) in size, into images that are only 10–20 Kb in size. The compressed data can then be transferred across the Internet with significant improvements in application performance. Once an image is retrieved from a distributed map server, positional information is extracted and included in the local image generated by the CU Museum's map server. The distributed data, can also be overlaid with local reference data, such as hydrology, before delivering the image to a web browser, creating a seamless client interface to display multiple distributed geospatial datasets. Smaller chunks of attribute data from partner institutions are also passed from distributed servers with extensible mark up language (XML) allowing for the presentation of descriptive information in tabular format. The current beta version of the application is available online at www.geomuse.org.

Future steps

In the final year of the MaPSTeDI project (September 2003–August 2004), we will focus on developing new partnerships to expand the amount of biodiversity data available and on producing new tools for more detailed analyses of the data. In terms of new partnerships, MaPSTeDI is exploring the possibility of linking our mapping system with other distributed databases such as the Mammal Networked Information System (MaNIS). MaNIS is a network of 17 partner institutions in North America which is making its mammal collections data available online using a common XML protocol. This partnership and others similar to it would greatly increase the amount of data available for visualizing and analyzing within MaPSTeDI's mapping environment. In terms of new tools, MaPSTeDI will focus on the development of analysis tools such as on-the-fly species richness or species diversity measures, as well as predicting species distributions. Ultimately, we hope that by providing easier access to the tools and datasets necessary for biodiversity research and conservation planning, land managers may be better able to make decisions that reduce habitat loss and its associated impacts on biodiversity.

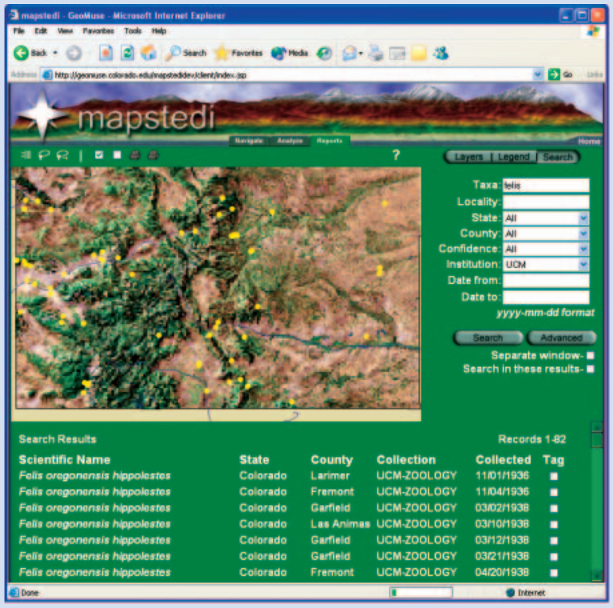

FIGURE 3 Current interface for MaPSTeDI beta client, showing mapped points returned for a search on mountain lions (*Felis concolor*) from the joint collections data. (Screen capture provided by R.G.)

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