LANDSCAPE ASSESSMENT WITH SMALL SCALE DATA, KLAMATH BASIN, CALIFORNIA-OREGON

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Abstract

The Klamath Basin Virtual GIS Data Facility ("GIS Facility") has been established at Humboldt State University in support of the Klamath Basin Ecosystem Restoration Office's (KBERO) mission of holistic resource management for the FEMAT "Klamath Province" (10.6 million acres) and the congressionally-defined Klamath Economic Zone (19.7 million acres). Both areas of interest cross the California-Oregon state boundary. The KBERO mission requires integrated, co-registered, and seamless GIS data layers covering political and administrative boundaries; lithospheric, hydrographic and atmospheric elements; plant and animal community characteristics, socioeconomic components, and descriptive landscape statistics including temporal dimensions. The initial challenge of the GIS Facility was to create a small-scale set of base frame information that could be used specifically to prioritize restoration efforts in the Province and more generally, to model broad ecosystem characteristics at the landscape level. Vector data at 1:100,000 nominal scale and a raster vegetation classification derived from 1994 Thematic Mapper imagery were combined in a database as input to modeling efforts. Graphic, boolean, and mathematical models have been produced that have energized the planning process and have provided important products to facilitate dialogue among the stakeholders in the region.

INTRODUCTION

The Klamath Basin Virtual GIS Data Facility ("GIS Facility") has been in operation at Humboldt State University since June of 1995. This represents the implementation of a *Strategic Plan* completed by Carlson and Fox (1994) which outlined an ambitious digital data development and modeling program in support of the Klamath Basin Ecosystem Restoration Office's mission of holistic resource management for the Klamath hydrobasin proper (Cooperrider and Garrett 1995). As envisioned, the initial role of the GIS Facility was to produce and make available to all cooperators, regional, "seamless" geographic information at small scales (1:100000 or 1:250000) that would then be used to produce generalized models of ecosystem dynamics for this very large region. This paper documents these early efforts and describes the data compilation difficulties as well as some of the early models derived from the small scale data. The information is being compiled in electronic map form as GIS data layers.

GEOGRAPHIC DOMAIN

The primary area of interest for this project began as the Forest Ecosystem Management Assessment Team's (FEMAT's) Klamath Province comprised of the Klamath-Trinity-Smith River watersheds covering 10.5 million acres of northern California and southern Oregon as shown in Figure 1 (Carlson et. al. 1994). Subsequently the area has expanded to the entire

19.7 million acre Klamath Economic Zone (Figure 2) as defined by the Klamath River Act of 1985. This expanded area adds all of the watersheds from the Rogue-Chetco rivers in Oregon to the Russian-Gualala rivers in California.

The study areas have a rich mix of ownership and management responsibilities with two-thirds

Figure 1: Regional Setting

Figure 2: Klamath Economic Zone

in federal ownerships. Most of the federal land is in Forest Service units though the Bureau of Land Management, U.S. Fish and Wildlife Service, and National Park Service are well-represented. The majority of the non-federal lands are in private ownerships ranging from small acreage/lots to large corporate holdings. Indian Reservations cover over 150,000 acres. State lands form a small percentage of the total acreage though they tend to be ecologically sensitive units.

The Economic Zone includes terrain in eight counties of California and five counties of Oregon. The Province is the only FEMAT region to cross state boundaries. The towns and communities are distinctly rural in character, tend to be relatively small and scattered, and have economies closely tied to the local resource base--forestry, fisheries, agriculture, recreation and mining.

The biophysical diversity mirrors the administrative diversity in complexity. Elevation ranges from sea level at the mouth of the Klamath to nearly 9000 ft at Crater Lake and over 8000 ft in the Trinity Alps. Near the coast, cool, moist redwood and Douglas fir forests dominate the moderate hills and marine terraces but they yield to drier oak and pine mountains and dry grasslands of the seasonally hot interior valleys.

DEVELOPING SMALL-SCALE DATA

While the long-term objective for the project is to develop large-scale data layers for ecosystem modeling, the short-term need was for small-scale layers that could be quickly assembled from existing data and used to develop some preliminary landscape-level assessments of ecosystem characteristics. This was essential to help in the allocation of annual restoration monies appropriated by Congress and allocated by KBERO, the Klamath River Task Force, and others.

Reliance on existing data is not without significant difficulties. Problems were compounded by the large area of coverage and the involvement of two states. Our efforts have highlighted classic problems with data consistency and completeness (esp. misadvertising), lack of metadata and lineage information, and conflicting versions of data themes independently used and "improved" from original sources. The following discussion highlights our experiences with a variety of data layers.

<u>DEMS (1:250,000)</u>. The digital elevation models for the Klamath Economic Zone were downloaded from a USGS public web site (http://info.er.usgs.gov). Complete coverage of the study area required all or portions of 22 files averaging almost 9 MBs per file. There did not appear to be any problems with the files themselves as they imported into our ARC/INFO and ERDAS software easily. Subsequently, a physiographic model was constructed for the entire Economic Zone. Several sub-basin watershed models have also been produced for cooperators and, in several cases, vector data has been overlaid on the diagrams. As of this writing, these files have only been used for graphical purposes, so any actual data errors may not have been discovered yet. Due to data irregularities in the DEM grid, the state boundary does show up as a "line" in the merged files.

We will be using the DEM coverage to create slope, aspect, and TIN layers that will be used in an attempt to apply the revised Universal Soil Loss Equation (RUSLE) over the entire Economic Zone.

<u>Hydrography</u>. The 1:100000 California hydrography files (EPA RF3) came from the GIS Technology Center at Teale Data Center (see http://www.gislab.teale.ca.gov) which is the

spatial data repository for the state of California. The Oregon hydrography files were difficult to locate and have been changing over the last year. Our current data was accessed by FTP in November 1995 from a USGS public site in Oregon (http://wwworegon.wr.usgs.gov/index.html). The files are available by hydrologic unit code as Pacific Northwest Reach Files (EPA RF2), but this is a different version from California's RF3s. Significant data inconsistencies have been found along the state boundary. In most places the streams line up across the border but many are missing on the Oregon side. In some cases it appears as if contour lines were digitized instead of the stream arcs. Many lines exist that do not appear on the most recent USGS maps.

In order to merge the data sets, the attribute tables had to be made consistent. This resulted in including some attribute items that appear on only one side of the border or the other, but the fields are only completed for the one side. In the California data, the attribute to link to the DS2 file (EPA Stream Reach Table) has been maintained though the file has yet to be acquired. This additional stream data does not appear to be available for the Oregon side.

Soils. The soils layer is derived from the 1:250,000 STATSGO soils data developed by the Natural Resources Conservation Service (NRCS). The California data was provided by the state NRCS office in Sacramento and the Oregon data was provided by the Oregon Department of Fish and Wildlife. The attribute information for the spatial data is provided in 15 relational tables utilizing many-to-many constructs. INFO and/or SQL programming is required to extract information for analysis.

The data layers imported easily, the map unit polygons edge-matched perfectly at the state border, and the attribute table structure was identical between the states. The major problem we encountered was trying to understand the attribute table constructs and the complexities of extracting information from the many-to-many relationships. Mike Whiting at the California NRCS office was a willing and frequent tutor. A map showing the weighted distribution of K- and KF-factors (soil detachability coefficients) independent of slope has been constructed. At present we are working on an RUSLE model to provide some indication of erosion potential and sediment yield by sub-watersheds.

Roads. The 1:100,000 roads coverage for Oregon was downloaded from the Oregon State Service Center (http://www.sscgis.state.or.us) but the coverage did not include highways. To complete the roads layer for Oregon, a separate highways coverage was downloaded from the Service Center and spliced into the roads coverage. The California roads layer was obtained from the Teale Data Center. The layer contained several classes of transportation features including roads, trails, highways, and interstates. There were a number of missing arcs in the California roads layer. The coverage was completed by adding arcs from a 1:24,000 roads layer obtained from the California Department of Forestry via the USFS Remote Sensing Laboratory in Sacramento.

The Oregon roads layer contained roads and trails without attributes while the Oregon highways layer did contain attributes. To combine the mixed Oregon roads layer with the California roads layer, items in the Oregon attribute tables had to be changed to match the items in the California attribute tables. Finally, the attribute types were made consistent between the layers though many fields are still blank since the information was missing. Once this was done, there were no problems encountered when joining the Oregon roads with the California roads.

Land Administration (Ownership). The California ownership data came from the Teale Data Center. Polygon label errors were abundant and there were many contiguous polygons with common ownership that needed to be dissolved into a single polygon. Even more evident were problems between "competing" California data sets. The California Department of Fish and Game ownership coverage, for example, extends farther north than the entire Teale coverage for California.

The Oregon data was provided by Lori Kleifgen at the Defenders of Wildlife through their Oregon Biodiversity Project. However, the coverage was last updated by the U.S. Forest Service Regional Office in Portland. This coverage had latitude parallels built into the coverage topology and many of the polygons at the section level were slightly offset and open at the corners. The coverage had to be cleaned by hand because a dissolve would collapse the patchwork structure of ownership. The biggest problem was reconciling the state boundary. The southernmost Oregon data and the northernmost California data overlapped in many places--to one half mile in places. Attribute data was not consistent either in types or categories. For example, California showed "state parks" while Oregon simply listed "state lands". The attributes were manipulated to match on both sides of the state boundary in preparation for joining the coverages.

Watershed/subwatershed Boundaries. The watershed and subwatershed boundary coverage was generated using the EPA's Hydrologic Unit Code (HUC) data sets. The greatest problem was finding the data sets which are tiled by major HUC codes. Once found, there were no problems combining the sets into a seamless coverage.

Image Processing and Vegetation Classification. Nine Landsat TM images were provided by NASA as part of the Mission to Planet Earth program. This imagery is being used to classify the vegetation for most of northern California and southern Oregon (well beyond the borders of our defined study areas) in cooperation with the Rocky Mountain Elk Foundation, the California Department of Fish and Game (CDFG), the California Department of Forestry (CDF), and the U.S. Forest Service.

The dates of the imagery range from late June to early August 1994, and represent the best available dates with a high sun angle. The imagery was terrain corrected and rectified by Hammon, Jensen, Wallen and Associates (HJW) in Oakland. While the image team was waiting for post-processing (radiometric and geometric correction) of the images, we developed our own corrected images and distributed preliminary unsupervised classifications to our cooperating ground teams. Once the corrected images were delivered and ground truth information began to arrive, work began on developing signature files. Ground data in the form of GPS points and plots which were to have been converted to ARC/INFO coverages have not yet been delivered. It is my understanding that the CDFG technicians working towards this conversion have encountered considerable difficulty. Most of our ancillary data, however, is sufficient for initial spectral signature development.

There have been no problems with the image data itself nor with the registration that was performed by HJW under contract from the USFS Region 5 Remote Sensing Lab. The actual positional error has not been determined, but is believed to be within one pixel (30 meters). Edge matching between images is excellent, which has allowed the creation of regional thematic maps spanning several scenes.

The biggest challenge presented by this imagery is the large file sizes. Each scene represents 350 megabytes of information, and some map compositions have involved portions of three scenes. Radiometric balance problems have been handled rather easily with our ERDAS IMAGINE software.

Other Layers. Additional layers which have been created for this project include 1) various boundary files--study areas, states, and counties, 2) cities and urbanized areas, 3) long-lat and quad index grids, 4) mine site locations, and 5) past restoration project locations.

SUMMARY

The development of seamless, small-scale data layers in preparation for landscape level ecosystem assessment has been challenging and not necessarily straight forward. Several simple models have already been produced which have been extremely helpful to decision-makers. For example, one output was to show the relationship between the watersheds/streams and the underlying political/administrative boundaries. On another, the locations of nearly 4000 mine sites were displayed with the watershed/stream coverages. More recently, we have been producing subwatershed maps showing the physiography, stream, ownership, and road patterns and we have completed a soil detachment potential map for the entire economic zone. Even the simple display of single, seamless thematic layers has been of great benefit to decision-makers since they have never had a landscape-level picture of thematic patterns.

In the coming months additional modeling is planned: 1) RUSLE model, 2) habitat models and T&E species distributions, 3) stream habitat change model, 4) vegetation change detection model(s), and others.

In the longer term, the primary tasks of the GIS Facility will be to move to 1:24000 scale seamless layers. The GIS Facility will develop a hierarchical earth registration network, register additional existing GIS data layers into that network, produce missing GIS data layers, and integrate both existing data and new data into seamless GIS products needed to conduct more detailed holistic resource management and research. The processing of remotely sensed imagery will continue to play a large role in fleshing out GIS data layers.

Overall, the work plan for the GIS Facility falls in three areas: 1) dissemination of spatial analysis products, 2) research on ecosystem assessment methodology, and 3) education & training of agency personnel and graduate students. The GIS layers will be made available on INTERNET to all cooperating organizations.

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