PUTTING GEOSPATIAL INFORMATION INTO THE HANDS OF THE "REAL" NATURAL RESOURCE MANAGERS: LESSONS FROM THE NEMO PROJECT IN EDUCATING LOCAL LAND USE DECISION MAKERS

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ABSTRACT

Agencies and research institutions concerned with producing better geospatial data, information, and models often cite natural resource managers as the targeted user. However, the term "natural resource manager" usually translates to trained professionals with federal and state responsibilities, while much of the true natural resource management in America takes place at local levels of government (*i.e*., municipal and county).   Researchers and Extension Educators at The University of Connecticut have been working together since 1991 on projects that incorporate remote sensing, satellite derived land use and cover, and other geospatial data into educational efforts targeted toward this municipal audience. Significant barriers exist turning these data into information truly useable in the world of local land use planning; these barriers range from the technical (*e.g*., spatial resolution of remotely sensed data) to the logistical (*e.g*., attracting the attention of busy local officials). By focusing on educational applications, the Nonpoint Education for Municipal Officials (NEMO) Project has successfully assisted local officials in Connecticut to better protect natural resources as they develop their towns; nationally, NEMO is being emulated in a number of states. NEMO continues to improve its techniques and expand its information and educational offerings as new technologies such as 3-D and Internet-driven GIS become more capable and accessible.

INTRODUCTION

Technical breakthroughs in imaging, mapping, graphics display and other computer technologies provide exciting new opportunities to educate the public about natural resource issues. The question becomes: "who should be the target audience, and how exactly can these technologies be brought to bear to assist them?" Agencies and research institutions concerned with producing geospatial data, information, and models often focus on natural resource managers as the audience. However, "natural resource managers" usually means trained professionals with federal and state responsibilities, while much of the true management in America takes place at local levels of government.

Land use is decided primarily at the local level, often by municipal- and county-level volunteer officials (both elected and appointed) with little or no training in natural resource issues, and little professional assistance. If the goal is land use education with the intent to change policy, targeting these local officials provides the highest potential return. However, considerable challenges are inherent in making geospatial data useful and accessible to this audience.

BACKGROUND

There are 169 municipal units in Connecticut, each governed by a variety of local systems including selectmen, mayors, town councils, and volunteer commissions. There is no county government in the traditional sense. Regional Planning Organizations (RPOs) provide assistance to the towns within their jurisdiction, but the majority of land use decisions are made at the town level. While the larger towns have professional staff, most rely on volunteer commissions to make decisions on wetland enforcement, zoning, and planning. There is rapid turnover of commission members, and a large work load for the staff and volunteers. Reaching this changing and overburdened audience requires that an educational message be concise, informative, and interesting while providing tools and information they can effectively use.

Towards this goal, in 1991 a group of Extension Educators from the University of Connecticut recognized the educational value of a new statewide satellite derived land cover map created at the Laboratory for Earth Resource Information Systems (LERIS) (Civco, D.L. and J.D. Hurd 1991). The data were originally created to assist the federal/state Long Island Sound Study (a National Estuary Program) estimate nitrogen loadings to Long Island Sound. However, the Extension team was interested in the utility of land cover information for educating local land use decision makers about the land use/water quality connection in general, and nonpoint source pollution in particular.

Nonpoint source pollution, the number one water quality problem in the United States according to the Environmental Protection Agency, is generated when water washing over the land picks up an array of contaminants including oil and sand from roadways, agricultural chemicals from farmland, and nutrients and toxic materials from urban and suburban areas. This runoff finds its way into waterways, either directly or through storm drain systems.

The *Nonpoint Education for Municipal Officials* (NEMO) Project was formed in 1991, based on the relationships that water quality is a reflection of land use, land use is a local issue, and local issues are best addressed through education of key decision makers. NEMO is a joint effort of the UConn Cooperative Extension System (CES), LERIS of the University of Connecticut's Natural Resources Management and Engineering (NRME) department, and the Connecticut Sea Grant Program. The LERIS group provides the remote sensing and GIS expertise; the CES educators, working with a knowledge of the audience, organize the data for the public presentations. The team members have expertise in water quality, land use planning, GIS, remote sensing, and landscape architecture. Major funding is from the Water Quality Program of the USDA Cooperative Research, Education and Extension Service (CRSEES).

TECHNOLOGY, TOOLS, AND METHODS

The project's overall method is to create concise, easily understood presentations for town commission meetings, using localized maps and images of natural resources. The focus is on water quality education with two major target groups: individual towns – emphasizing issues specific to local decision makers from within their political jurisdiction; and, watershed systems -- working with multiple towns emphasizing cooperation across political boundaries. Digital information acquired through remote sensing research, state GIS data layers, and digitized local data provide the basis for the educational images.

The first project towns were coastal, favored because of their proximity to Long Island Sound. In addition, the towns were chosen based on their acceptance of new technology and the availability of digital data sets. Town meetings were scheduled and slides, maps, and other materials were created. The remote sensing information provided the broad overview of the towns, emphasizing their placement within the larger landscape. Additional GIS layers highlighting water systems, basins, road networks, political boundaries (parcels, zoning), and wetlands provide focus on critical areas within the towns (Arnold *et al*, 1993). It is important to note that our RS and GIS images are not used "as is" from the software packages -- they are simplified and tailored by importing them into a presentation software (figure 1).
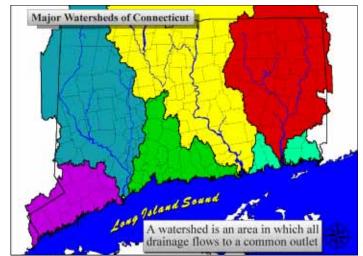
Figure 1. Educational image of major watersheds in Connecticut. The image is simplified, compared to a typical GIS screen.

NEMO is not solely focused on present conditions. One of the project's major objectives is to enable local officials to visualize the future impacts of their current land use policies and plans. For instance, NEMO makes use of a zoning-based "build-out" analysis, which contrasts current levels of impervious surface, known to be a reliable indicator of the potential for water quality degradation (Arnold, and Gibbons, 1996; Schueler, 1994) with future levels estimated from zoning regulations (figure 2). Although build-out analysis is a common planning technique, the ability to conduct a build-out based on land cover (rather than population or housing units), and the ability to show the results in a colorful and easily-understood form, are possible because of the use of RS and GIS technologies.
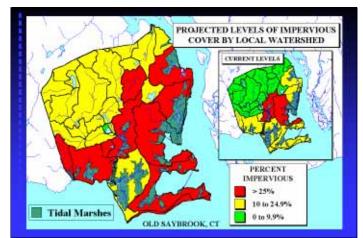

Figure 2. Impervious surface build out analysis for Old Saybrook, CT.

The project expanded statewide in 1997 with a state grant to conduct regional workshops, coupled with production of hard copy GIS maps to each of the 169 towns. Using *ArcView Avenue* scripts to automate the process, maps were created showing satellite derived land cover, basins, water resources, and political boundaries (figure 3). These maps were a simple yet effective way to highlight the relationship of water resources and land use. GIS was used not only for the maps and educational images, but to help select the locations for the nine regional workshops. The workshops were a great success, attracting land use officials from over two-thirds of the 169 towns, and stimulating requests for follow-up NEMO educational material and presentations.
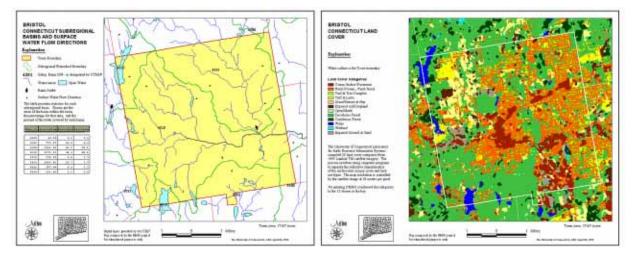
Figure 3. Town-level maps of hydrography and land cover were part of the map set created for each of the 169 Connecticut municipalities.

Beyond town level programs, NEMO is engaged in a number of multi-town watershed projects, particularly in the lower Connecticut River valley. The watershed programs are based on a partnership between a Resource Team of natural resource experts from Cooperative Extension and other organizations, and a Watershed Committee of representatives from the watershed towns (Arnold *et al.*, 1996). These programs expand the NEMO model to include additional GIS data layers such as parcel information, additional analyses such as forest fragmentation (figure 4), and visualization techniques like three-dimensional imagery.
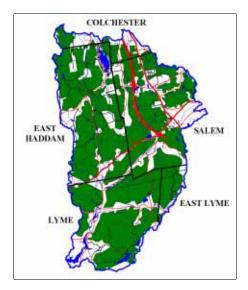

Figure 4. Forest fragmentation map of the Eightmile River watershed, showing large patches of unfragmented forest in green. Local knowledge was coupled with GIS analysis to make this map.

The philosophy of these projects is that watershed management is largely about land use management, and therefore must encompass data and issues that go beyond what would traditionally be thought of as central to a "water" program.   In addition to water resources, these projects focus on cultural, historical, and land resources. Each Watershed Committee is intimately involved in gathering data and analyzing results; for instance, the forest fragmentation analysis (figure 4) made use of Committee "judgement calls" as to the fragmenting nature of small local roads. Brochures, meetings, and mapping exercises help increase the level of cooperation among committee members and ultimately among watershed towns. The professional nature of the maps, brochures, and the unique images provided by remote sensing and GIS have, in many ways, convinced individuals who might otherwise be

skeptical of the watershed projects. The results have included signed compacts among towns, open space planning and acquisition, and changes to local land use plans and regulations.

The Use of Geospatial Technology to Address Local Land Use: Barriers and Potential

The use of geospatial technology for educational purposes is not without barriers. For example, existing Landsat Thematic Mapper (TM) satellite information has the limitation of pixel resolution. Since many of the towns in Connecticut are small, a magnified view will often push the resolution limits of the 30 meter data. To compensate, other higher resolution data sets are used whenever possible. The recent incorporation of scanned orthophotographs, at one meter resolution, has provided a tremendous tool for viewing and digitizing local features. The unaltered scans by themselves, as stand alone images, have been very effective as simple backdrops to the digital layers.

Digitizing on screen, over the orthophotographs, facilitates capturing detail but is a manually-intensive process; automating the separation of land cover features using the grayscale images is difficult. An alternative method used during the creation of a new 1996 statewide land cover database was a combination of 10 meter panchromatic SPOT and 30 meter TM spectral data (Hurd, J.D. and D.L. Civco, 1996). This provides high spatial detail while retaining the spectral information require to automate the land cover identification. Not surprisingly, even these data show resolution limits when overlaid with planimetric-level parcel data (figure 5). The landscape in New England is very heterogeneous, making the process of separating and categorizing land cover features difficult; for example, large-lot residential units are often masked by the surrounding forest cover. Until analytical methods and data resolution improve, land cover identification will remain a time-intensive part of the project.
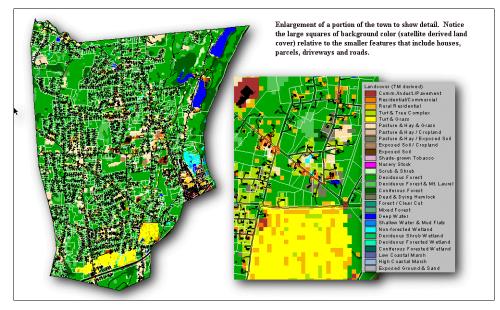

Figure 5. Planimetric parcel data, overlain on satellite-derived land use/land cover data. Continued advances in resolution are needed to ensure the use of RS data for local land use applications.

A new NASA Regional Earth Science Application Center (RESAC) at the University of Connecticut will be helping to facilitate these improvements. The Center, a collaboration of NEMO and LERIS, will focus on bringing geospatial technology to bear on the problem of urban/suburban sprawl. The Center will combine RS research, GIS and World Wide Web applications, and on-the-ground (NEMO) educational programs. The research agenda has several components: to create higher-resolution land cover data; to create methods to directly estimate the impervious component of land cover; and to create sprawl and forest fragmentation indices to characterize the impervious coverage. This information will then be used to drive Web-based (and possibly CD-based) GIS applications that focus on making the data truly accessible and useful to local land use officials.

As high resolution images become more common and costs are reduced, specific images targeted to individual towns or projects may be available. New land cover identification techniques will improve access to local information at a faster rate. Real time or near real time images would provide an ideal visual aid for municipal audiences. Graphically, three dimensional technology is steadily improving and has already provided an important visual element to our educational presentations. With the improvement in projection systems, the speed of graphics cards, and lower cost shutter-glass systems, true color 3-D images may someday be a common element at this local level.

INTERNET APPLICATIONS

World Wide Web (WWW) applications are already proving invaluable in improving accessibility of local officials to geospatial data. As with GIS, towns are just beginning to connect to the new technology. The current focus with the Internet is to reach individual commission member, planners, and others trying to duplicate the project methods. Having fact sheets, slides, and other material available over the Internet saves the time required to duplicate and distribute hardcopy materials. For instance, the NEMO WWW site offers both an electronic publication order form, and downloadable *Microsoft Powerpoint* presentations.

As software improves, active GIS applications are gradually being incorporated, increasing the usefulness to a broader audience. Our watershed projects include Web-based GIS data catalogues offering data, maps, and images. Going one step further, Internet map servers can allow town officials and the general public to view maps of their town and manipulate the layers through programs tailored to the educational message -- without any knowledge of GIS. A trial interactive map of the Eightmile River watershed is up and running on the NEMO Web site (figure 6).

The combination of Internet and geospatial technologies has almost unlimited potential for assisting local decision makers. It increases our ability to overcome two key barriers: accessibility, and "user-friendliness." The applications phase of our NASA Center will be focusing on creating Web-based "tutorials" for local officials that educate them while giving them access to maps and visualization techniques at the click of a mouse.
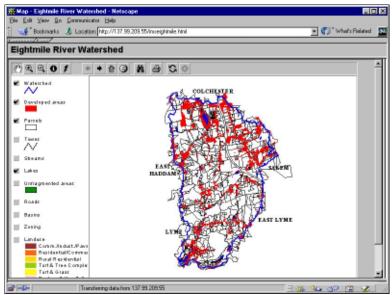

Figure 6. Interactive mapping over the Web allows access to information without knowledge of GIS.

A surprising impact of the Internet system is the global visibility for the program. Information requests and comments have come from over 14 foreign countries, each using the web site to access electronic fact sheets and other posted material. Another is the national market. Over the last year, information requests have been fielded from 42 states. Seventeen states are in some stage of adapting the NEMO educational approach (figure 7). Although the presentation is modified as required for local regions, the basic NEMO concepts are the same: land use as the central issue; education as the approach; and the use of geospatial and Internet technologies in the service of that education.
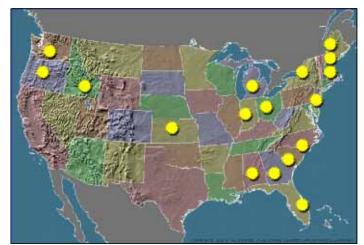
Figure 7. Currently, seventeen states are in some stage of adapting NEMO.

CONCLUSION

Has the program been successful at home? Without a doubt. Awareness has increased in the local communities and the town officials are communicating across political boundaries. Land use plans, policies and practices have been changed to better protect water (and other natural) resources. Some towns have become involved simply after hearing what others have done. There are continuous requests for materials and presentations from groups within the towns such as land trust organizations and environmental foundations. It can be difficult to "hand tailor" the data sets for every organization requesting a presentation -- the data simply doesn't exist for many of the towns. However, detailed examples from neighboring towns have proven very effective as educational tools.

The town and watershed projects are successful programs. The promotional material alone has increased recognition for the towns, in turn providing incentive for the local officials and the public to get involved. The local officials, even those with differing political and economic goals, are beginning to work together because they see the benefits from the program. Remote sensing and GIS images have proven invaluable, helping local officials to "step back" and take a broader view of the landscape -- one that doesn't stop at the town boundary. Some GIS procedures, such as combining zoning categories and parcel information across political boundaries, although difficult to create, prove very effective in demonstrating the values of GIS technology for the towns, enticing their interest.

The NEMO team continues to improve the techniques and expand the information and educational offerings as new technologies develop. However, our "bottom line" is always whether the end products will prove truly useful and effective in the crucible of a late-night local commission meeting. Balancing the use of technology without overwhelming the educational message is a constant challenge which the project team looks forward to meeting.

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