GIS Best Practices

GIS for the Conservation of Woodlands and Wetlands

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What Is GIS?

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. For example, a social analyst might use the basemap of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth.
GIS for Conservation of Woodlands and Wetlands

GIS is an indispensable tool that can be used to prevent damage to the valuable resources and habitats of our woodlands and wetlands. Deforestation, loss of biodiversity, and resource depletion due to global climate change, CO$_2$ emissions, logging, forest fires, and other human disruptions are threats to the earth's forested and marshy areas. GIS allows the user to manage geospatial information for monitoring change in woodland and wetland areas. Modeling change with GIS permits conservationists to make well-informed decisions about protection, policies and future land-use practices that will most benefit the conservation of forests, biodiversity, wildlife, and resources.

The temporal and spatial aspects of GIS technology enable users to make maps that help people easily see critical environmental concerns. This visual aspect of GIS technology makes it a key ingredient in raising public awareness about conservation issues. The ability to manage, analyze, and delineate a variety of geospatial data makes GIS essential for targeting areas in need and communicating ways for resources, biodiversity, and animal habitats to be sustained, protected, and conserved.
Preserving Biodiversity in Russia's Meshora Lowland

Using GIS for Image Analysis and Land Cover Classification

A small portion of the Pra River Watershed is shown classified into 10 classes. As is illustrated by the legend, extensive fieldwork will be necessary to differentiate the forest and agricultural categories.

The Russian Federation is an enormously large country with an equally large and extensive natural resource base. Its biological diversity is impressive. For the most part, the federation’s 145 million inhabitants are confined to the Russian Plain west of the Ural Mountains. Therefore,
the human impact on the environment tends to be somewhat less severe in those vast Siberian expanses east of the Urals but much more pronounced in the west. While a number of nationally protected environments are in jeopardy in the Russian Federation, one area of great concern to Russian and non-Russian scientists is the Meshora Lowland.

The Meshora Lowland, although largely unprotected, contains two national parks (Meshora and Meshchorskiy) and a strictly protected reserve (Okskiy Zapovednik), all three of which were created in an attempt to protect and preserve hundreds of species of rare and endangered flora and fauna.

The problem is that the lowland, including the parks and the reserve, is located adjacent to nearly 15 million people, the majority of whom live in the cities of Moscow, Vladimir, and Ryazan'. Thousands of other persons, however, live in hundreds of small agricultural villages and a few larger towns. All of these people, their juxtaposition to the lowland, and their ability to access and utilize the resources of the lowland potentially will have a long-term, damaging impact on it unless comprehensive, rather than merely local, policies regarding use are developed. Additionally, the lowland is located within the political jurisdiction of three separate political entities.

It is vital, therefore, for scientists to carefully study the Meshora Lowland so its unique biodiversity may be sufficiently managed, protected, and preserved for the enjoyment of future generations. It is also vital that all political entities work together in that process.

Since 1999, Dr. Brooks Green, associate professor of geography at the University of Central Arkansas, and his Russian colleagues (Dr. Elena V. Biryukova and Dr. Alexander Pribylov) at Ryazan' State Pedagogical University have been studying the Pra River Watershed, a significant drainage basin in the central portion of the lowland. The Pra River Watershed is a 180- by 48-kilometer, north-to-south trending system of small streams, shallow rivers and lakes, extensive marshes, vast meadows, and a dense Southern Taiga forest. Gentle gouging that occurred during the most recent glacial period essentially shaped the watershed's relief and drainage pattern. The watershed also contains rather large areas cleared and drained for a variety of agricultural, lumbering, peat extraction, and industrial purposes.
The purpose of this research, utilizing state-of-the-art GIS tools and image processing techniques, is to clearly identify the land use/land cover and the cultural resources (archaeological sites, historic structures, etc.) of the watershed. This analysis, when completed, will ultimately enable those individuals in the Decision Support System (DSS)—federal, regional, and local government officials, land use managers, park directors, and park/reserve scientists—to better develop and implement management and use policies for the preservation and protection of the delicate watershed resources.
Advances in remote sensing and GIS techniques enabled the entry point in this research project. The project is initially focused on the natural resources of the watershed. With funding from the University of Central Arkansas Research Council, Green obtained two Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images of the eastern portion of the lowland—the area that contains the Pra River Watershed. The Landsat 7 ETM+ images contained bands 1, 2, 3, 4, 5, 6h, 6i, 7, and 8 (the panchromatic band). A Hewlett-Packard CPU with a Pentium 4 processor on a Windows XP platform was used to apply the appropriate image processing and GIS analytical techniques.

Because of the large size of the two merged satellite images (12,741 rows by 9,761 columns), Green and his colleagues used the Analysis Mask option in ArcGIS (ArcView, ArcEditor) to delimit and extract the watershed. That process enabled subsequent operations to be completed more quickly and efficiently.

Once the watershed had been masked and extracted from the larger image set, they completed a land use/land cover classification utilizing the ArcGIS Classified option in the Layer Properties dialog box. Because members had good knowledge of the watershed, they completed a supervised manual classification with known training sites. (A supervised classification is one where the person classifying the image is familiar with the area and can choose sites—called training sites—that are known. An unsupervised classification is one where the person classifying the image is not familiar with the area and simply permits the program to identify similar pixels of the image.) That manual classification process enabled the researchers to carefully isolate and highlight specific ranges of data to select specific land use/land cover types.

Although the resulting land use/land cover classification map appeared to be very good, it was determined, for comparative purposes, that an unsupervised classification would be conducted. In this case, 10 classes were selected.

The unsupervised classification analysis utilized the ArcGIS Classified option in the Layout Properties dialog box. The results of this analysis were found to be superior to the manual classification technique. The research team concluded that the 10 classes more accurately portrayed the land use/land cover found in the Pra River Watershed, although they were unsure of specific differences in forest types and agricultural classifications.

The first stage, that is the classification stage, is now successfully completed.
The Next Stages

The next stage will be ground truthing (conducting fieldwork at the site) the classification. To guide the research team in its collection of field data on the various land use/land cover classifications in the watershed, it will use the unsupervised classification map created in ArcGIS. Following ground truthing, the classification will be corrected where needed so that actual land use/land cover in the classified image matches what is really on the ground (the actual land use/land cover). At this juncture, cultural features will be added for analysis and policy management and development. The final stage will be to test the impact of changes in land use and land cover.

DSS will be given the updated maps and data sets so its members can begin to make sound adjustments in management policies and more informed and improved decisions regarding activities that are now occurring within the watershed or will occur in the future.

(Reprinted from the Fall 2004 issue of ArcNews magazine)
GIS Hero Susan Minnemeyer Works for Frontier Forest Conservation

This article is part of an ongoing series honoring individuals who have made a difference in the world by applying a GIS solution to challenges or needs within conservation or their communities. Since these unique individuals have been selected for their innovations or special achievements in a particular field, the series is appropriately named GIS Heroes. ESRI recognizes Susan Minnemeyer as a GIS hero. Minnemeyer is the GIS laboratory manager for Global Forest Watch, an initiative of the World Resources Institute (WRI). Since joining WRI in 1999, Minnemeyer has coordinated and worked on GIS projects that have served to promote the protection and conservation of forests around the planet.

Frontier forests are the world’s remaining large intact natural forest ecosystems—undisturbed and large enough to maintain all of their biodiversity. Created by the World Resources Institute (WRI), Global Forest Watch (GFW) has a mission to ensure these forests are sustainably managed. GFW geographic data has come into great demand because of its ability to support understanding and proactive conservation lobbying.
A graduate of Duke University School of Environmental Studies, Susan Minnemeyer came to GFW with expertise in conservation biology and landscape ecology. Her conservation projects inevitably led her to use geospatial technologies, so she added GIS technology, remote sensing, environmental monitoring with satellite imagery, and building local mapping capacity to her abilities. Says Minnemeyer, "I am interested in big picture global environment issues. I am, however, also interested in practical applications. GIS allows people to communicate scientific information and results in an arresting way."

Minnemeyer's earliest projects with GFW focused on logging operations in Africa's Cameroon, a country that has had a history of illegal logging.

When Minnemeyer began working in Cameroon, most logging concession data was not shared and certainly not intended for public use. To further impede data collection, the various organizations working on environmental issues in the area lacked a sense of openness and trust among themselves. The goal of the data project was to move logging information into the public domain. This makes it more difficult for logging companies to carry out illegal logging or shady business practices.

GFW's goal was to produce an interactive atlas to share all types of information on the management of Cameroon's forests, such as logging concessions, protected areas, forest reserves, and quantity of timber production. Moving all types of information about forests into the public domain increases transparency and accountability, giving governments and conservation groups evidence of illicit operations.

To get the needed data, GFW developed relationships with local nongovernmental organizations (NGOs). Minnemeyer and her team worked with the Limbé Botanical and Zoological Gardens to develop the technology to digitize logging roads from Landsat satellite imagery. They created a database of logging roads for the forested zone of the country, including data for 40,000 kilometers of logging roads and satellite imagery, to track road development over time. The NGO Cameroon Environmental Watch worked with GFW to create digitized national topographic maps, which are used to define the boundaries of logging concessions and other managed forest areas. Using GIS, the team identified many cases where roads had been built in what appeared to be illegal areas. This information was made publicly available through the distribution of the data on 2,000 CD-ROMs.

Getting organizations to work together requires building bridges of common vision and good communication. Trust is built on solutions that work. The ultimate goal for GFW is to create a
solid foundation so that the technology and the ability to maintain the databases will continue whether or not GFW remains working in that area.

Minnemeyer has twice led GIS training sessions in Yaoundé for Cameroon Environmental Watch. She relates her first teaching experience: "We went to Cameroon in 2000 to give an ArcView training class. We specifically told the organization that we would train 2 to 4 people on how to use ArcView. When we arrived, 10 people had signed up to take the course. The organization had arranged a party, complete with speeches, painted banners, and video taping to celebrate the opening of our GIS training. Group photos were taken, and a graduation was given when the training was finished. The enthusiasm completely took me aback. I used the instructor-led training course and adapted it by using local logging concession datasets to give examples of polygons. Everything was based on Cameroonian data. People stayed to practice until 10 and 11 o’clock every night."

Eventually, GFW assigned a Cameroon-based GIS trainer, Lawrence Nsoyuni. He supports a local network of GIS users and was able to get GIS software for local NGO partners through an
An upswing in the project came when GFW assigned a project manager to Cameroon, Jacqueline Van de Pol, who became instrumental in providing an ongoing presence and creating links with the local community. She worked directly with the government, logging companies, and local NGOs and was able to obtain multistakeholder input into the data.

People who work on global issues find that projects located thousands of miles apart somehow manage to converge. While the Cameroon project was evolving, Minnemeyer had begun working with partners on a forestry atlas for Russia. The process for creating an atlas for Russia had been developed by working on an atlas for Canada.

Minnemeyer took these processes back to Cameroon to help Van de Pol plan an atlas for Cameroon. Together they built draft data as a basis for pitching the idea. Van de Pol was able to show the draft data to various groups and obtain their buy-in. She also was able to obtain the government's authorization, which gave the data official legal status. Their research helped define boundaries that became government-recognized boundaries.

"When you work with GIS, you learn so much from working with other people," Minnemeyer notes. "This atlas for Cameroon could not have happened without this project in Canada for which our Russian partners provided help. In Cameroon, we are using methods and tools we originally learned from working in Russia. Those efforts led us to begin working on atlases for the Democratic Republic of Congo, Gabon, and the Republic of Congo."

Because of the amount and types of geographic data demanded, Minnemeyer and a crew of project managers developed an interactive geographic data portal, which went live in 2004. The one-stop-shop portal is a project developed in partnership with the University of Missouri, which provides technological support and servers. The portal is built on ArcGIS architecture and includes ArcSDE to manage and access the data and ArcIMS software. The portal provides the links and Internet map server architecture, which allow users to interact with the data.

Partners post their databases on the GFW Web site (www.globalforestwatch.org) Data Explorer section. Data Explorer offers nine datasets for Cameroon, and the full data CD also includes published maps and ArcGIS projects. GFW will make updates available as they become publishable with the first update expected in July 2006.
In partnership with the Brazilian NGO Imazon (the Amazon Institute of People and the Environment), GFW published the report *Human Pressure on the Brazilian Amazon Forests*. The report, released in March 2006, is available on CD-ROM and via the GFW portal. It provides a starting point for tracking the speed at which human pressure is spreading in the Brazilian Amazon.

Minnemeyer is tireless in her efforts to describe the state of the forests and to provide information on logging and the companies operating in these regions. Her passion for conservation issues, accomplishments in getting communities to work together, and skill in applying GIS technology to a central need make her an important GIS Hero.

**More Information**

For more information, visit the Global Forest Watch Web site at www.globalforestwatch.org.

(Reprinted from the Spring 2006 issue of *ArcNews* magazine)
Restoring America's Everglades With GIS

By Frank S. Razem, South Florida Water Management District, and Michael Rose, GeoAnalytics, Inc.

Accela GIS Viewer depicts CERP projects, district lands, and developmental pressure on the Everglades.
America’s Everglades is a treasured national and international resource. Designated as a World Heritage Site, a Wetland of International Significance, and an International Biosphere Reserve, it is home to 68 threatened or endangered species, three national parks, 12 wildlife refuges, and a marine sanctuary. It includes Everglades National Park, one of the most biologically diverse ecosystems in all of North America, and Florida Bay, which has the only living coral reef on the continent. The Everglades was once a vibrant, free-flowing river of grass that provided clean water from Lake Okeechobee to Florida Bay and a haven for storks, alligators, panthers, and other wildlife.

Human intervention began to change all of that in the late 1800s, when primitive canals were dug to drain south Florida. Changes continued throughout the 20th century as more than 1,700 miles of canals and levees drastically changed the landscape, interrupting the Everglades’ natural sheet flow and sending valuable freshwater to sea.

An ecosystem in peril, the Everglades is currently besieged with a number of problems—50 percent of its historic wetlands have been lost, its water quality has deteriorated and water flows have been disrupted, and vast quantities of fresh water have been lost to the system.

The South Florida Water Management District (SFWMD) and the United States Army Corps of Engineers (USACE) have embarked on what has been termed "the largest restoration project in world history." The Comprehensive Everglades Restoration Plan (CERP) was approved by Congress and signed into law by presidential executive order in December 2000.

It is a $7.8 billion, 30-year plan to rescue the Everglades ecosystem through a series of specific ecological and water system improvements. During the next 30 years, the district; USACE; federal, state, and local agencies; tribal authorities; and private sponsoring partners will restore water quality, quantity, timing, and distribution. As part of this rescue plan, the South Florida Water Management District must purchase more than 400,000 acres of land at an estimated cost expected to top $2.2 billion.
The Everglades, once a vibrant, free-flowing river of grass that provided clean water from Lake Okeechobee to Florida Bay, now faces a variety of threats.

Legacy Systems

In 1987, the district's Land Acquisition Department internally developed the Advanced Technology Land Acquisition System (ATLAS) to manage its real estate business information. This legacy system consisted of two related data stores—an Oracle database (ATLAS) and a GIS database.

The ATLAS Oracle database was originally developed simply to hold the landowner's name, address, and district-assigned tract number. In the words of Dennis Meierer, senior supervising geographer, "ATLAS is no more than a glorified Rolodex." As the years went by, more than 168 related tables with thousands of fields were added to track the extensive land acquisition business process and ancillary information such as parcel numbers; county location; and section, township, and range data.

The GIS database contained approximately 90 separate GIS data layers that represented project boundaries and were composed of 25,000 polygons. These GIS data layers were maintained as ESRI coverages and edited in ArclInfo Workstation using ArcEdit and ArcPlot. The ArcView mapping tools were employed for map production.

Unfortunately, the GIS data layers replicated data stored in the ATLAS Oracle database. Maintaining redundant information in these separate databases had obvious drawbacks.
Beyond problems with inefficiencies caused by redundancy and inconsistency, much of this data was fundamental to the district's major projects and programs. Gathering and storing this data in databases and systems that were relatively isolated from one another meant that related mission critical information could not be easily or quickly accessed, shared, processed, or analyzed.

Like other early GIS systems, these isolated data stores evolved as the result of differing mandates, business systems, and technologies. This situation had developed as a result of incompatibilities between hardware and software and was the inevitable consequence of formal and informal processes established over the years for gathering and storing information for use by individuals, divisions, and departments.

In the course of implementing policy directives and completing mandated projects to protect the water resources of more than six million people in the region, information processing solutions were often developed in isolation to quickly meet immediate and specific needs. Furthermore, adequate solutions that could integrate disparate technologies did not exist until recently. These legacy systems were inadequate to fulfill the needs of the mandate set forth in the Comprehensive Everglades Restoration Plan.

Many of the district's most important projects are dependent on the broad and seamless use of GIS, the Web, and database systems. The Information Technology Convergence (ITC) initiative is the district's vision for making sure these technologies work together to help staff and the public analyze, store, and distribute critical data and information. Integrating this information will make many types of information widely accessible and enable more effective analysis and decision making. Integrated data will be easier to maintain and use, which will increase staff productivity and efficiency while reducing redundant efforts and significantly improving quality control and data integrity. Given these benefits, data integration was recognized as a prudent investment for the district's Land Acquisition Department.

The Land Acquisition Department implemented the Integrated Real Estate Information System (IRIS), an information technology convergence system for storing, maintaining, and accessing both spatial and tabular data. For GIS data management purposes, the two main GIS technology components are the Tract Editor GIS application and the IRIS geodatabase. For tabular data management activities, the IRIS Tabular database and an Automation application from Accela, Inc., have been implemented. The Accela GIS Viewer application provides the integration bridge between the spatial and tabular data using ArcIMS.
Tract Editor GIS Application—The SFWMD IRIS Tract Editor GIS application was developed using ArcObjects. The Tract Editor contains a task bar that enables the user to perform application functions as a step-by-step work flow process. Only tools relevant to the current task are enabled, and unrelated tools are temporarily disabled. This approach lets the application keep track of all edits the user performs throughout a session. At the end of an editing session, the GIS editor checks in the multiversioned edited personal geodatabase for the QA/QC manager, who approves and posts all the edits done back to an ArcSDE geodatabase. The process of posting the edits to ArcSDE utilizes the disconnected editing technology available from ESRI.

The Florida panther, an endangered species, is at home in the Everglades.

IRIS GIS Geodatabase—The SFWMD IRIS GIS Tract Editor application provides a toolset for maintaining the IRIS GIS data layers in a versioned, multiuser ArcSDE/Oracle geodatabase. The ArcSDE database is maintained on a server in the GIS Services section of the Information Technology Department which is located at the district in West Palm Beach, Florida.

Spatial data stored in the IRIS geodatabase consists of one feature dataset containing four related feature classes and one or more standalone feature classes. SFWMD_LANDS, the primary feature dataset in the geodatabase, serves as a container for logically related feature classes and tables. This feature dataset contains three feature classes—the TRACTS, EASEMENTS, and HISTORY layers.
The TRACTS layer is composed of tract polygons that indicate contiguous areas of ownership that were created by dissolving adjacent parcel boundaries with the same owner. Tracts are the geographic units of land management that underlay all district land acquisition activities. Tracts are lands owned by the district and its partners, land being considered for acquisition, or easements granted to the district.

The EASEMENTS layer, representing easements granted by the district over district-owned lands to other entities, is represented by polygons in the EASEMENTS layer within the SFWMD_LANDS feature dataset.

The HISTORY layer contains time-stamped copies of all edited tract polygons and a feature-linked annotation class. Whenever a tract polygon is edited, whether for merging, splitting, deleting, or modifying, the original polygon is copied to the HISTORY feature class. This allows the appearance of the tract layer to be reconstructed at any point in time based on the copy of the polygon and a time stamp.

Polygons in the history layer retain their original IDs, which are also recorded in the tract genealogy table. This table, combined with the series of changes to geometry stored in the history layer, allows users to reconstruct the chain of ownership in space as well as time. The feature-linked annotation is the district's tract number derived from the ACQ_ID field, a unique identifier used to track the acquisition business process.

Resolving these inconsistencies required varying degrees of effort. In some cases, it was easy to identify which database held the correct information. In other cases, it took hours of research because many records hadn't been updated for decades. This process was repeated for each of the 25,000 records. Once the data validation was completed, the data was migrated into the versioned, multiuser ArcSDE/Oracle geodatabase at the district.

The IRIS Tabular Database

The tabular data, stored in an Oracle database on a server hosted by Accela at the Qwest Communications Center in California, is served over the Internet with Accela Automation and Accela GIS. Macromedia ColdFusion and ArcIMS technology operating on a series of Web application servers provide this data using a Web browser. This information is currently available to all district offices, field stations, and service centers spread throughout the 16-county jurisdiction.

By the summer of 2004, the district will integrate the ArcSDE/Oracle geodatabase and the IRIS Oracle database between Florida and California. This integration effort will allow the GIS
editors in the department to access and modify the IRIS Oracle database in California and the geodatabase in Florida simultaneously using the Tract Editor application communications module.

As a truly integrated enterprise system, IRIS has a solid foundation and the ability to evolve as new GIS, Web, and database systems emerge. It will aid efforts to restore America’s Everglades for many years to come. For more information regarding restoring America’s Everglades, visit www.evergladesplan.org. For information on the South Florida Water Management District, visit www.sfwmd.gov.

(Reprinted from the July–September 2004 issue of ArcUser magazine)
Safeguarding Coastal Wetlands Through Exotic Species Control

Critters are gnawing away at Louisiana’s already disappearing coastal wetlands. Native to South America, a nutria looks like a cross between a beaver and a rat and can consume 25 percent of its weight in aquatic plants each day.

The yellow polygons are harvested areas, and the red polygons are leases with no hunting activity.

The Louisiana Department of Wildlife and Fisheries needs to identify areas of known nutria damage with little or no hunting activity.
Nutria were originally valued for their pelts. From the early 1960s through the mid-1980s, more than one million nutria were harvested annually, mostly for the European fur industry. With the collapse of the fur market, there is currently no significant demand for nutria. This has allowed the population to grow unchecked. Now considered a nuisance species, approximately 80,000 acres of coastal wetlands are impacted by nutria at any given time according to Louisiana Department of Wildlife and Fisheries (LDWF) estimates.

Over the past 50 years, Louisiana has lost land at an average rate of 34 square miles per year. This loss is due to natural processes that include shoreline erosion, subsidence, saltwater intrusion, and faulting as well as human activities such as levee construction. Because nutria tend to overgraze an area, they not only remove surface plants but they also often destroy plant roots and expose fragile organic soils to erosion. Damaged areas may deteriorate and become open water, which exacerbates the land loss problem.

The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) provides funding for many coastal restoration activities including the Louisiana Coastwide Nutria Control Program. The primary objective of the program is to significantly reduce marsh damage from nutria by removing 400,000 nutria per year. This is accomplished by paying registered trappers and hunters an incentive payment of $4.00 for each animal harvested. In 2002, the $13 million multiyear program was approved and the first nutria hunting season ran from November 20, 2002, to March 31, 2003.

LDWF is responsible for overall program management using funding obtained from the Louisiana Department of Natural Resources and the Natural Resources Conservation Service. Coastal Environments, Inc. (CEI), an ESRI business partner in Louisiana, was chosen to administer the program. CEI manages the nutria harvest and pays participants. The company also developed and maintains the program database and a mapping system for analyzing participants’ hunting activities and nutria damage assessments.

Recently, LDWF has documented and mapped nutria damage areas along the coast by conducting aerial surveys of established transects using ArcView. (Transects are study boundaries along which samples are collected.) Identifying nutria harvest locations and determining if these areas are in or adjacent to documented damage areas are two of LDWF's primary requirements. To address these requirements and other reporting and mapping needs, a Microsoft SQL Server 2000 database was developed to maintain participant and landowner information and a geodatabase was implemented with ArcSDE for maintaining the associated
Spatial data. ArcInfo was used for all mapping activities, and a Microsoft Access front end was developed for easy field data entry.

Harvest data can be summarized by township and range so harvests for different seasons can be compared. This example displays the changes in harvest distribution between the first and second seasons. Red indicates a decrease, and green indicates an increase in harvest activity for the second season.

As part of the application process, potential program participants must include maps and legal descriptions of their hunting leases. A participant may have multiple leases, and a landowner
may have multiple participants hunting on the same lease. Once an applicant has been approved by LDWF, participant information is entered into the SQL database and the related leases are incorporated into the nutria geodatabase Lease feature class. For the 2003–2004 season, 428 leases covering 1,820,105 acres were mapped.

The area of a lease may vary dramatically from less than 100 acres to thousands of acres. Consequently, mapping a participant's nutria harvest at the lease level is not sufficiently detailed. The initial contract required mapping and tracking of nutria harvest by township and range. However, a finer level of detail—the actual area hunted by each participant on each lease by township and range—was needed.

A custom script that programmatically created individual lease maps by participant was developed. More than 500 maps were produced for the 2003–2004 season and were used at the nutria collection stations where participants turned in harvests. Using a field laptop with a copy of the database, the collection manager entered the harvest total for each participant. The lease, township and range, and methods of harvest and carcass disposal were also entered. Each participant is required to identify harvest locations on lease maps. Because a participant may turn in multiple harvests throughout a season, this process was repeated every time a participant submitted a harvest.

The field database and lease maps were returned to CEI's main office each week. The field database was uploaded to the program database, and the areas hunted were digitized from the hard-copy lease maps and added to the Take feature class in the nutria geodatabase. The Take feature class documents the transaction number, participant, lease, program week, township and range, and harvest amount. The field laptop was returned to the collection manager with any updates from the program database. Harvest maps were produced by both week and month and delivered to LDWF so the department could track the hunting activities of program participants. During the 2003–2004 season, 1,039 harvest areas, covering 780,948 acres, were mapped.

LDWF also used ESRI software during annual aerial transect surveys. When vegetation damage was identified, the location was captured using differential GPS. An ArcView extension, GPS View, was used with ArcView on a laptop. Each damage site was recorded by logging polygons using stream mode digitizing with GPS equipment. The damaged sites were then analyzed in relation to the season's hunted areas.
Adopting the geodatabase has benefited the program’s mapping activities. CEI did not use ArcSDE or the geodatabase model during the first season. Migrating to ArcSDE during the second season made integrating the program database easy and simplified the reporting process. With its topology, relationship classes, and more robust editing tools, the geodatabase model has proved more efficient than using coverages and shapefiles. Improvements in mapping and data development continue to be made each year. Plans for next season include improvements to the geodatabase structure, additional topology rules, and new scripts for improving mapping efficiency.

LDWF estimates that it will take three to four seasons of sustained harvesting to noticeably reduce nutria damage. Findings from the 2002–2003 season show an increase in the number of damaged areas that are recovering and fewer areas that have converted to open water. During the first season 308,687 nutria were removed. Program participants in the 2003–2004 season removed 332,596 nutria. However, aerial survey results for this season were not complete when this article was written. For more information, visit www.nutria.com.

(Reprinted from the October–December 2004 issue of *ArcUser* magazine)
Virginia Department of Forestry Uses Internet GIS to Reach Landowners

Virginia ForestRIM allows users to add graphic annotations to maps, including text, points, lines, and polygons. ForestRIM automatically calculates acreages for polygon features and optionally adds that acreage as a label to the polygon.

Look at a recent land cover map of the mid-Atlantic area of the United States, and you'll undoubtedly notice that Virginia has a lot of forestland. What is less obvious are the threats to
this resource and the tremendous challenge the Virginia Department of Forestry (VDOF) faces in trying to reach the private landowners who ultimately determine the fate of this resource.

Historically, outreach was simpler when rural forest landowners owned large blocks of land. But over time these large blocks of land have been divided into smaller and smaller pieces as people moved into rural areas. Since 1992, Virginia has lost more than 180,000 forested acres, and today private individuals own about 66 percent (10.1 million acres) of what remains. Unfortunately, these smaller forest landowners do not typically think about the trees on their property as being forestland. They are unaware of the importance of their forests and the need for good management, protection, and conservation to ensure the health of the resource as a whole. VDOF’s mission to protect and develop healthy and sustainable forest resources in Virginia means the agency must teach, advise, and support all the landowners who can affect the future of Virginia’s forests.

As part of a plan to reach landowners, VDOF developed a two-phase approach: first, put spatial information and tools into the hands of its field employees, and second, provide that information and those tools to the public. Implementing the first phase was initially hampered because VDOF field offices, located throughout the state, are equipped with desktop computers that are not networked and use only 56K modems to reach the Internet. Despite these obstacles, VDOF wanted to use the ubiquity of the Internet to deploy a GIS that could be managed centrally and that would be easy for users to learn. Following a successful implementation for employees, VDOF would then provide spatial information and tools to its customers, such as landowners, planning commissions, forestry consultants, fire departments, and industry and conservation groups. These are users whose Internet connectivity and computer proficiency can vary widely.

Insofar as the agency had already developed a robust GIS program using ArcInfo, ArcView, and ArcView Spatial Analyst, VDOF then selected ESRI’s ArcIMS as the backbone to develop its Forest Resource Information Mapper (ForestRIM) application. ArcIMS allowed the agency to deliver GIS data and tools via the Web, customize the functionality and user interface, and focus on users’ needs. VDOF approached Terralogic, Inc., of Staunton, Virginia, which possessed substantial experience developing ArcIMS applications and was willing to push the technology to its outer limits. This was important given the significant customization VDOF desired for its application. Together, VDOF and Terralogic designed and built the application with one version for internal users and one for general public access.

ArcIMS made it possible for the agency to meet one of its key goals: to efficiently share information so that agency employees and the public at large can make better informed
decisions about Virginia's forest resources. For example, visitors to the ForestRIM Web site (www.forestrim.org) can easily zoom to their location of interest, such as a single property, county, or watershed. Users choose from more than 100 map layers collected from federal, state, local, and private organizations as well as VDOF's GIS layers. The dynamic map features of ArcIMS mean that users have access to numerous map tools for navigating, identifying, measuring, and querying features. And to address the slower connection speeds, VDOF integrated AirZip Accelerator from AirZip (Cupertino, California) into the application so that users can control map speed enhancements when they need to.

Users can query features from the map layers, then perform a "secondary search" based on the first query results.
One unique feature of ForestRIM of benefit to Virginia employees and citizens is its Map Annotation function that gives users the ability to add their text, points, lines, and polygons over the map layers they choose from the Layers List. Acreage is automatically calculated and displayed by default when a user draws a polygon, making it an especially useful tool for VDOF’s customers. Map annotations are saved for later use, for editing, or until the user deletes them. After composing a map, users can save it so at the next login the map is available for ease of renavigation or further editing, regardless from which computer they log in. For output, print formats are available in PDF, JPG, and PNG with both portrait and landscape layouts at the users’ disposal.

“Our mapping application has an array of functionality that helps our citizens understand the importance of Virginia’s forest resource," explains Mindia Brown, GIS manager for VDOF. "Users can choose from a list of layers, including recent aerial photography, topographic maps, forest cover, wildfire risk assessment, woodland home communities, gypsy moth defoliation, and more.”

User feedback has been very positive. VDOF employees working one-on-one with landowners have reported that an aerial photo map of a property with recommended management activities digitized on top can help make a more convincing case to landowners.

The public version of the application, released in February 2004, has also received enthusiastic responses from users. Landowners, forestry consultants, conservation groups, planning commissions, and others have logged on.

For more information, visit www.forestrim.org.

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