Environmental
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GIS for Environmental Management Solutions

# Algonquin Forestry Authority Uses GIS across the Forest

The Algonquin Forestry Authority (AFA) has been using geographic information systems (GIS) in its management practices for about 15 years. This Ontario Crown agency is responsible for sustainable forest management and the wood supply that goes from the forest to mills surrounding Algonquin Park. Recently, AFA upgraded its GIS by adding server GIS-enabled Web technology to better access forest management information and share that data with staff and other resource managers.

GIS is a computer-based tool that shows relationships between forest attributes on a map. A forester can access data from many sources, such as aerial imagery, other agencies' databases, Web service data, and scanned maps, and add it to the GIS project. ESRI's GIS organizes and stores information about the forest as a collection of thematic layers that can be linked to geography. It also integrates information in a way that helps people get a clear understanding of the nature of their forests and make sound forest management decisions.

AFA's GIS is composed of a full suite of ESRI software including ArcInfo, ArcView, ArcPad, and ArcGIS Server Standard Enterprise edition. This setup provides AFA with a fully integrated environment to best collect, view, analyze, and manage resource-related data. A Web portal, built on ArcGIS Server, enables the agency to better manage data sharing among its staff. Through the portal, employees can view and analyze the park's resources from any location at any time.

GIS is used mainly for forest management. It stores forest management historical information.

Algonquin Park comprises 763,000 hectares, with approximately 56 percent of the total park area available for forestry activities. This forest provides 45 percent of Crown wood to industry in the southern region of Ontario. The forest is a transition area between Canada's southern and northern tree species, with two distinct forest types in the park. On the west side is a hardwood forest made up of predominantly sugar maple, beech, yellow birch, and hemlock; on the east side are white pine, red pine, poplar, and white birch. The mixture of species in the forest

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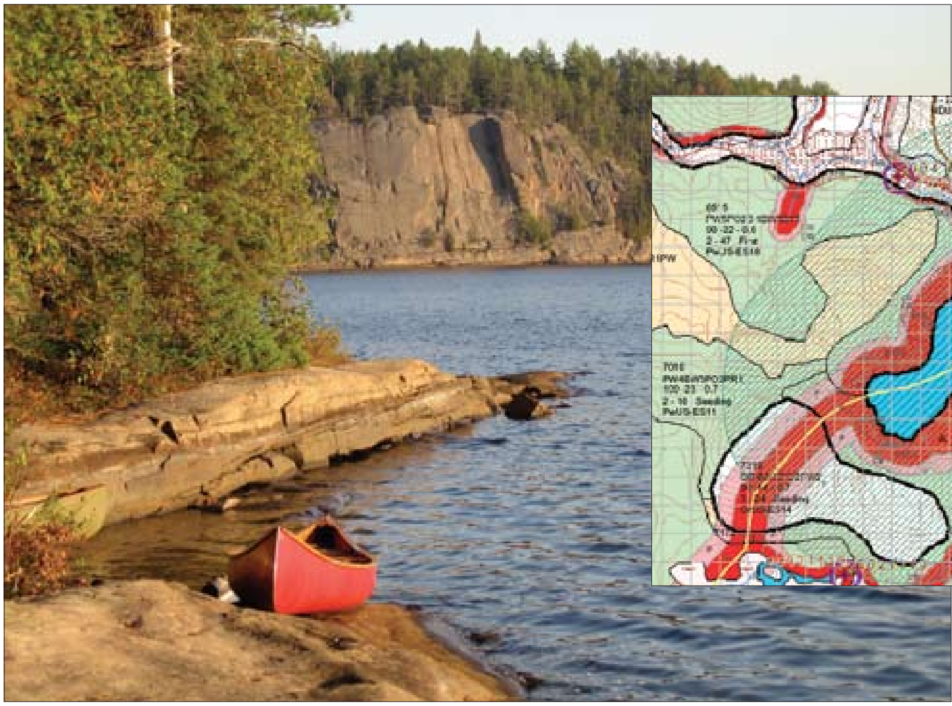
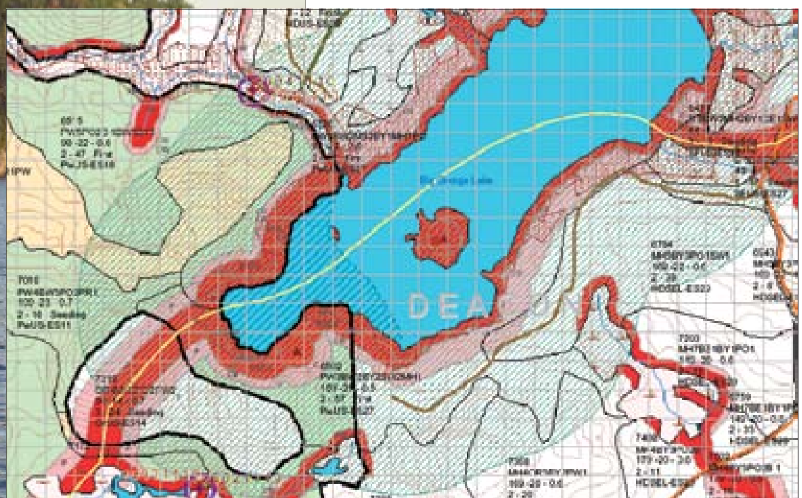
## In This Issue







Map of cutting activities based on the forestry management plan helps guide activities.

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## Algonquin Forestry Authority Uses GIS across the Forest

creates managerial challenges. GIS is used to plan forestry activities and create reports so the public can be assured that the park continues to be managed as a sustainable forest.

AFA is registered to both the ISO 14001 environmental standard and the Canadian Standards Association's Z809 sustainable forest management standard. It is therefore required to comply with mandates for reporting and management practices. GIS supports this regulatory compliance.

Algonquin Forest Authority's GIS team has been using ESRI's ArcGIS software to gather and track information and keep that information updated. By adding ArcGIS Server technology, the GIS team can now author maps and easily serve them along with various tools that other staff can use to interact with the data.

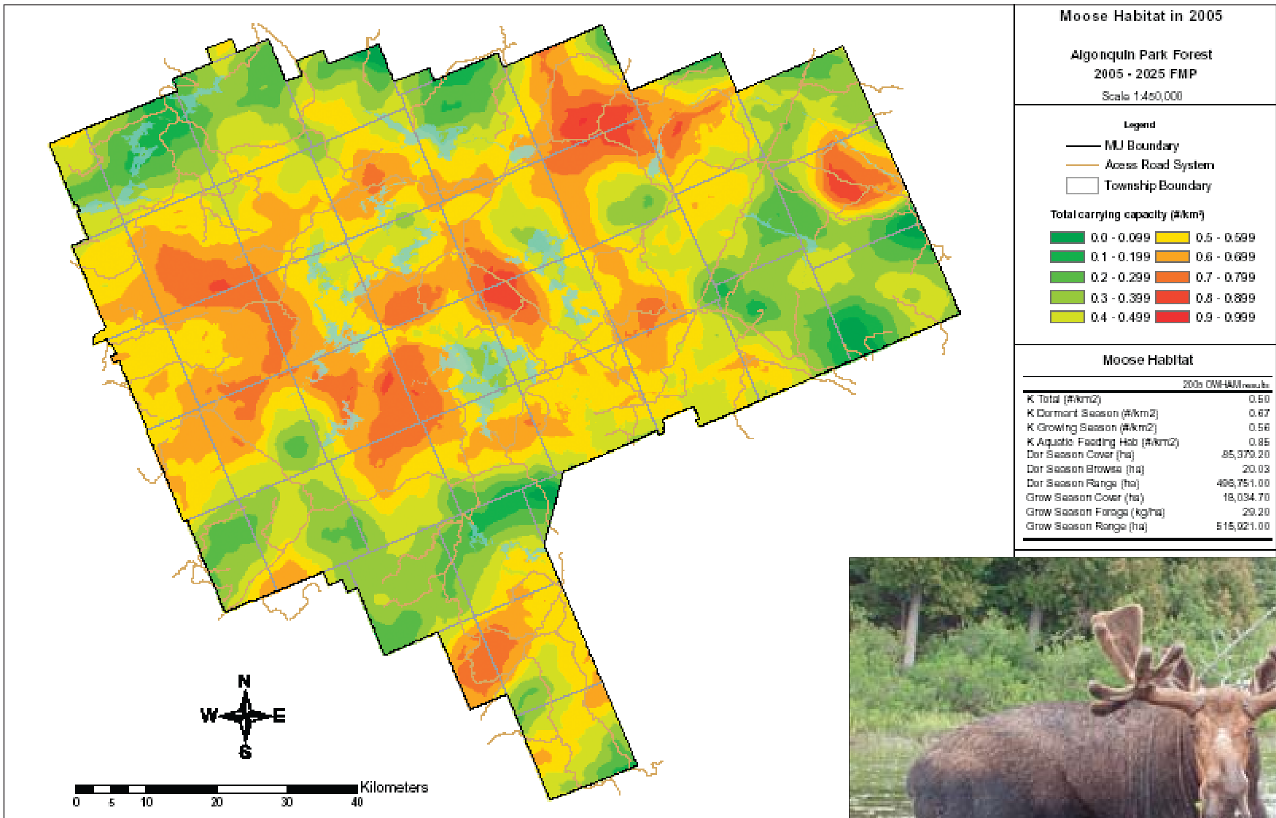
Algonquin Forestry Authority general manager Carl Corbett explains, "GIS has proven an essential component in our forest management methods. We are required to track how the forest is growing, regenerating, and responding to various treatments. GIS helps us document and plan our activities of responsible, sustainable management. The task is simply too complex to perform in a paper environment."

Protecting wildlife habitats is a component of AFA's environmental mandates. To do so, staff members use GIS to devise a management plan. They also use GIS to maintain park zoning established by the Algonquin Park Management Plan. These maps show different usage types such as wilderness and nature reserves, historic zones, and recreation areas.

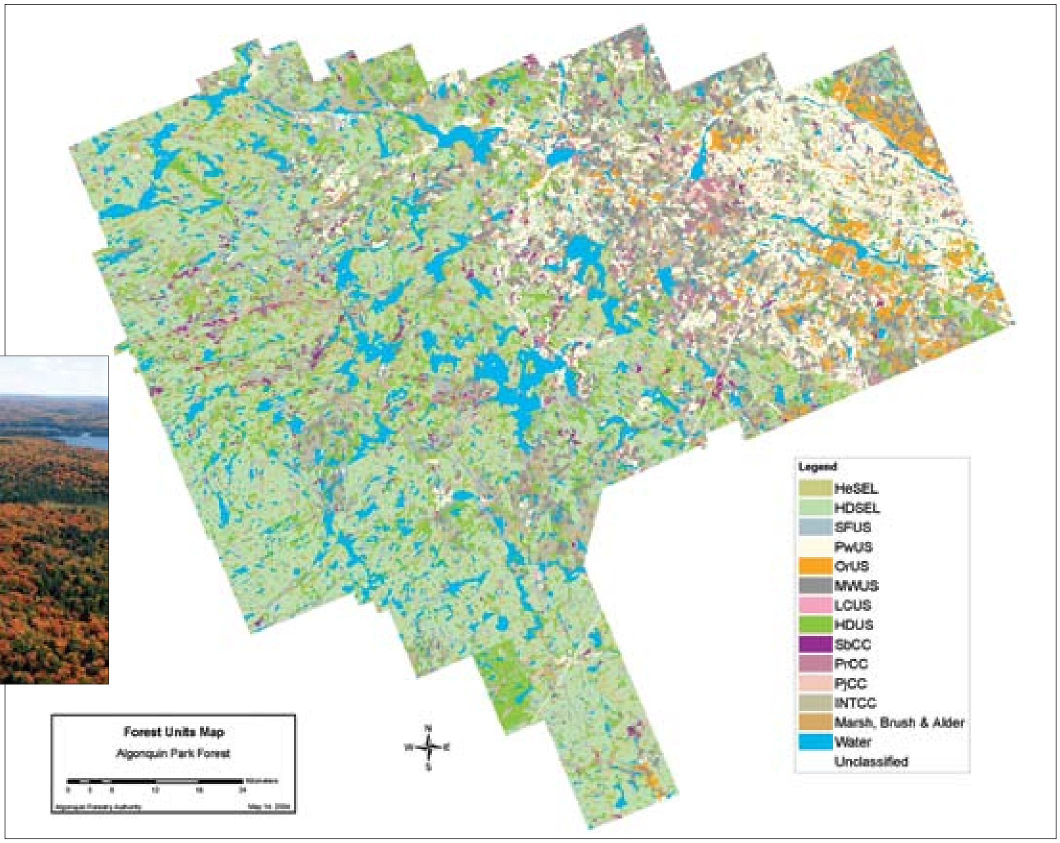
Continuing the advancement of its GIS configuration has improved AFA's workflows and opened up greater opportunities for staff to use forestry data. Moreover, government agencies use GIS in their everyday work processes. The Ontario Ministry of Natural Resources Forest Information Manual is the framework by which industry and government undertake their roles and responsibilities in providing and exchanging information for forest management planning or ensuring compliance with the Crown Forest Sustainability Act and its regulations. The standardized format is a conduit for easy forestry data exchange.

To meet the park's needs at the local level, AFA uses GIS for a host of applications including strategic and operational planning, stand management, access road planning, values mapping (e.g., cultural and recreational values), wildlife habitat protection, and scientific data gathering and reporting. AFA supervisor of technology Peter VanderKraan and GIS technician David Webster set up ArcGIS Server out of the box. They talked with various forestry associates to get advice about approaches and data model organization, then implemented the system on their own.

"We put together a variety of GIS applications




Moose habitat data is stored in the wildlife database and depicted on a map for wildlife habitat planning within forestry practice.




GIS depicts stand inventory data.

that improved staff work processes," explains VanderKraan. "For example, we fed data from the government's Strategic Forest Management Model into the GIS to identify areas eligible for treatment. GIS processes the data, which helps us plan harvest areas based on stand age, time since last treatment, and impact on wildlife habitat as well as identify areas by a designated period of time for various management activities."

"ArcGIS Server allows us to share data locally," continues VanderKraan. "Moreover, the GIS environment is a seamless fabric that is familiar to that of the whole Ontario government repository. Therefore, whether we are working locally or provincially, the flow of data is the same. ArcGIS software provides us with the type of scalability that allows an easy evolution of our technology."

A geodatabase of forest inventory contains information about stand species, age, stand classification, and other basic forestry information. The database also includes habitat and wildlife information. Based on this data, AFA develops a forest management plan of activities. The plan includes forest stand location and how much of each forest type is cut and during which season. The majority of harvesting is conducted using partial cutting systems where all trees are individually marked for either retention or cutting.

GIS helps foresters determine what areas have been cut in the past and helps them plan what is to be cut in the future. Variables in formulating this harvest plan include not only the tree species, cutting cycle, and location but also other relevant information such as road system by season (e.g., gravel vs. winter road) and proximity to recreational assets. Because AFA is required to make these plans available to the public, labeling, color coding, and legends are created in accordance with the Ontario map standard for easy interpretation.

GIS also generates allocation maps to guide the forestry contractors who perform the work. Algonquin Forest Authority supervisors access these maps via a GIS map catalog that allows them to view a digital map and print it if they need it. As part of the work process, once management activities are complete, data is entered into the GIS database to create weekly and monthly reports. The GIS technician puts this information into the system and maintains an updated inventory of the state of the forest.

Having a current forest database is an essential asset for people managing a sustainable forest. Whether caring for a stream or a raptor's nest, protection policies need to be implemented and recorded. Because GIS is connected to attribute tables, users can easily enter the data and create a new map that includes these changes. Users can select types of information from tables to include in their projects and produce a variety of maps to show species, age, and habitat as well as their relationships.

GIS interfaces with other types of software and data. This permits Algonquin Forestry Authority's GIS staff to create tools, adding functionality that can be brought into the work-

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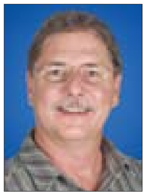
## ESRI on the Road

**2009 ESRI Federal User Conference**
February 18–20, 2009
Washington, D.C.
www.esri.com/feduc

**National Association of Environmental Professionals**
May 3–6, 2009
Scottsdale, Arizona
www.naep.org

**2009 ESRI International User Conference**
July 13–17, 2009
San Diego, California
www.esri.com/uc

## Robin Smith Joins ESRI Industry Solutions Team



ESRI's new environmental industry manager, Dr. Robin D. Smith, has much to offer the GIS community. Environmental managers and intelligent-technology users will benefit from his 25 years' experience conducting and managing more than 60 environmental investigations and modeling projects as well as subsequent ecological and human health risk assessments for corrective actions both national and international.

Smith holds a Ph.D. in toxicology and a bachelor of science degree in evolutionary ecology. Throughout his career, he has worked with representatives from industry, national and local governments, and nongovernmental organizations, providing him with useful experiences for his new position at ESRI.

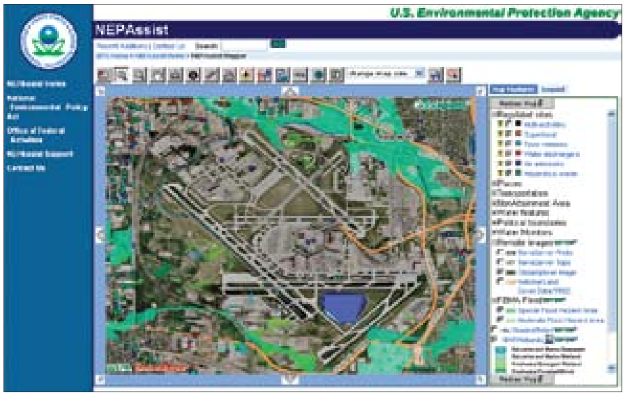
"We face increasingly complex environmental issues that demand we use the best technologies available to understand, communicate, and address these challenging situations," notes Smith. "GIS plays a pivotal role in our ability to analyze, manage, preserve, and sustain our environment. GIS is powerful because of its ability to rapidly bring together groups, organizations, and individuals in a way that facilitates environmental decision making on a shared or common problem. My goal is to bring this technology to all levels of society, industry, and government to support the stewardship of our environment."

## U.S. Environmental Protection Agency Renews ELA with ESRI

*Software Agreement Ensures GIS Expansion within Federal Agency*

Renewing its five-year enterprise license agreement (ELA) with ESRI, the U.S. Environmental Protection Agency (EPA) continues its use of GIS as a core technology across its nationwide service. The ability to deploy unlimited ArcGIS software allows EPA employees to extend the agency's existing applications and create new ones to support its mission of protecting human health and the environment.

Renewing the software agreement supports continued expansion of GIS within the EPA. Five years ago, the federal agency signed an ELA with ESRI that proved to be very successful. It facilitated the expansion of the EPA GIS user community. This, in turn, has widened the range of GIS applications for research, regulation, and reporting. Additionally, the agreement has effectively supported fast response to environmental events. For example, aftermath activities following hurricanes require easy access to GIS software to perform geospatial analysis necessary for issuing water well precautions and spill notifications and delivering other vital information. The license agreement has made it possible for responders to get the software essential to perform immediate assessments, publish vital information and reports, and create a basis for decision making. This is just one of EPA's many GIS successes that have prompted its renewal of the ESRI ELA.




EPA's NEPAssist application uses ESRI technology to help simplify the process of filing and reviewing Environmental Impact Statements and Environmental Assessments.

"The ELA helps ensure that EPA staff members have access to the geospatial technology they require to do their work," says EPA's geospatial information officer Jerry Johnston. "It enables us to centrally manage software licenses and deployment. More importantly, no one goes without the GIS tools they need for their work. GIS is deeply integrated into many parts of our agency's business, and its use continues to expand."

The license allows EPA staff to access a full range of ESRI products in the ArcGIS Server, ArcGIS Desktop, and ArcGIS Mobile suites. Because of easy software access, employees have found more uses for GIS such as emissions monitoring, hazardous waste assessment, and water discharge permits issuance. A broadened use of GIS has improved the EPA's analysis, science, regulation, and environmental decision making. It also supports EPA's efforts to keep the public informed about environmental conditions, news, and concerns.

Learn more about ELAs offered through the ESRI Federal GIS Program at www.esri.com/fgp.

# City of Davenport Uses 3D Visualization to Prepare for Flooding

*By Dave Cox, GIS Specialist, City of Davenport, Iowa*
*Kevin James, GIS Coordinator, City of Davenport, Iowa*

The city of Davenport, Iowa, has a long history of flooding. In the last 33 years, there have been eight major Mississippi River floods that have affected the city. In the early 1980s, Davenport decided to use passive flood protection instead of building permanent flood walls or levees to protect the downtown area. This passive protection plan consists of temporary earthen levees, sandbag walls, pumps, and a series of gates to close storm sewer pipes. To efficiently and effectively complete these tasks before floodwater reaches downtown areas, the city has developed a detailed flood plan consisting of written procedures and maps for various flood levels.

During the winter of 2007–2008, large amounts of snowfall threatened the city with potential flooding in the spring. This risk prompted the public works director to ask GIS personnel to create a demonstration for the city council of Davenport's current flood plan. GIS staff reviewed the maps in the plan and decided that a 3D model would be a more effective way to convey the different aspects of the plan. They used ArcGIS 3D Analyst extension's ArcScene application to create a 3D model that showed what parts of the city would be inundated at various flood stages. This model made it possible for the city staff and council to visualize data about how floodwater could affect specific areas of the city at any flood stage.

**Building the Model**

Prior to GIS, Davenport's approach to creating flood models took a long time to complete. Staff would print contour maps, then draw red lines on these maps to show where the predicted floodwater levels would reach. Multiple calculations were made to account for the slope of the Mississippi River. Now, GIS provides analysts with tools for building a 3D model based on information the city already had such as two-foot contour data, building footprints, storm utility data, street centerlines, and aerial photography.

Adding GIS to the workflow for modeling Mississippi River flooding supports a logical progression and produces insightful results. The first step is to create two surface triangulated irregular networks (TINs) using the 3D tool in ArcGIS Spatial Analyst. One TIN represents

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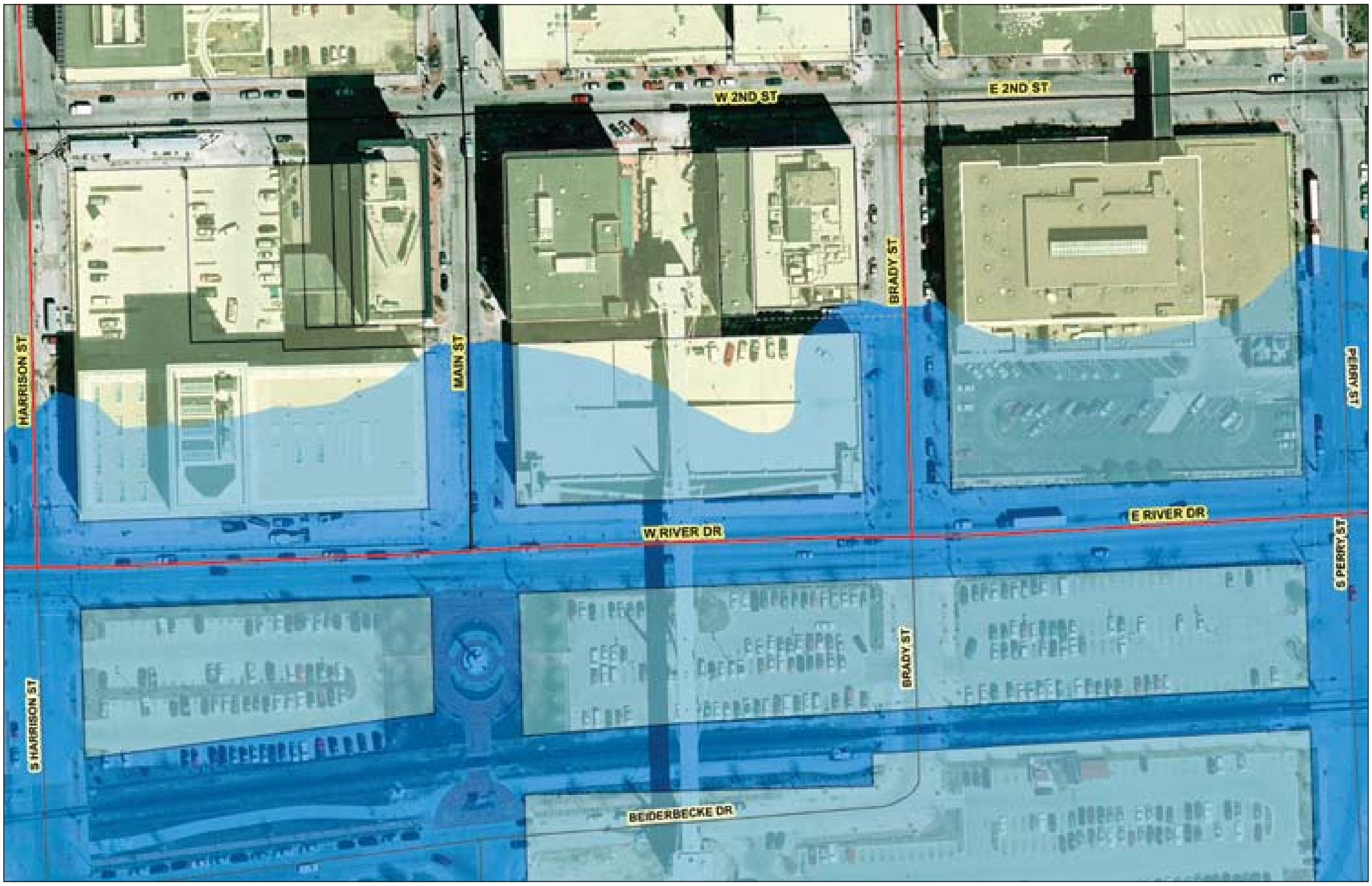



GIS flood model predicts how Mississippi River rise will impact Davenport's downtown area.

# Hurricane Proofing a Community

*By Barbara Shields, Geography Journalist*

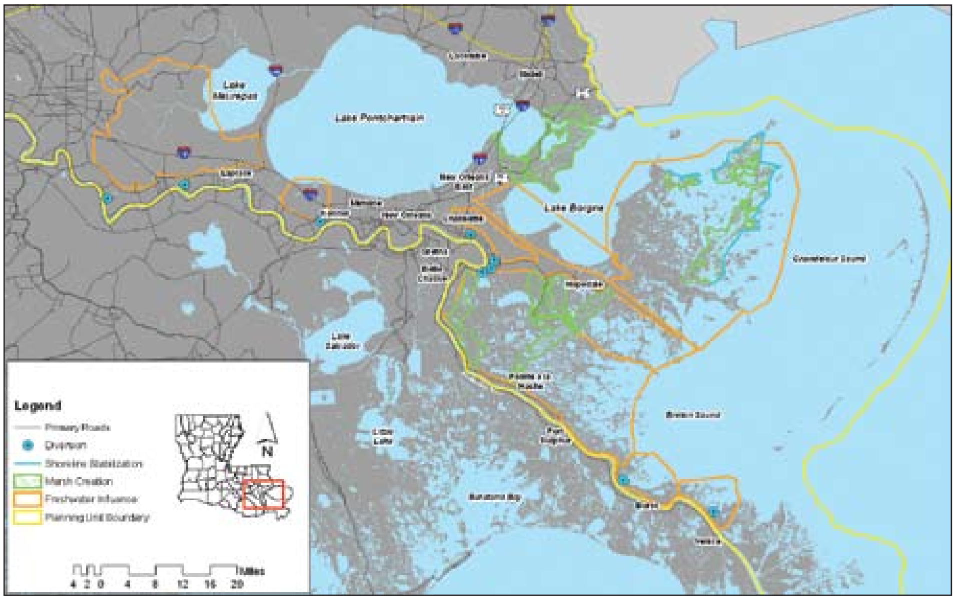
The onslaught of storms and surges that beleaguer Louisiana's gulf shore is not a momentary battle. Hurricanes will continue to blow throughout the next millennia, but iron-willed Louisianans have no intention of giving up—not now, not ever. Since technology is unable to halt a hurricane, the best strategy is defense. How does a civilization buttress its cities against an unrelenting assault of natural disaster?

Research scientists, engineers, and planners have collaborated to produce more than 100 alternatives for shoring up the state's coast with options that span from 100- to 1,000-year risk reduction. Led by the U.S. Army Corps of Engineers—New Orleans District, these professionals are using technology and science to assess the various alternatives for coping with the threat of rough weather, sea, and river conditions to fortify towns and restore the natural habitat.

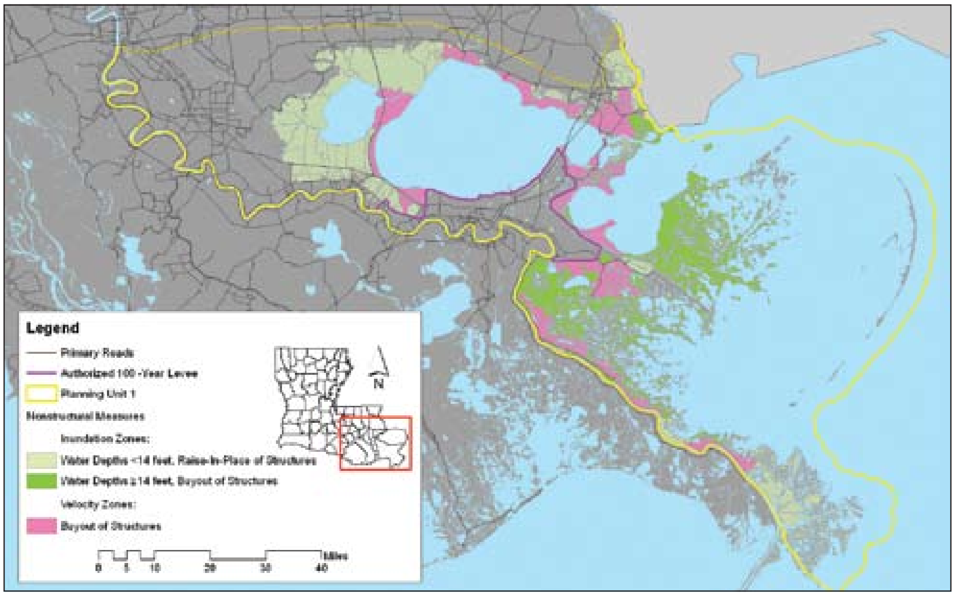
This effort is titled the Louisiana Coastal Protection and Restoration (LACPR) technical report, which the U.S. Army Corps of Engineers initiated in response to congressional and executive directives to conduct a complete analysis for category-5 hurricane protection. The goal is to save lives, property, the environment, and cultural heritage. Corps scientists determined potential surge and wave elevations for both frequent and infrequent events based on critical factors such as wind-speed relationships, central pressure, forward speed, and landfall location.

The technology that supports the methodology of this effort needed to be open and easily integrated to ensure a consistent, systematic approach to modeling storm events, data sharing, alternatives analysis, and lessons learned. For example, project data and modeling is being shared with the Mississippi Coastal Improvements Program and is also tied to the State of Louisiana's master plan for coastal restoration and hurricane protection.

An essential tool that planners are using is GIS software that enables them to see the problem and forecast scenarios based on weather severity, changes in population growth, engineering of levees and other infrastructure, effects on environmental habitats, and more. The Army Corps of Engineers has a geospatial facility within its Engineer Research Development Center located in Vicksburg, Mississippi. The lab uses ESRI's ArcGIS software for all its projects.



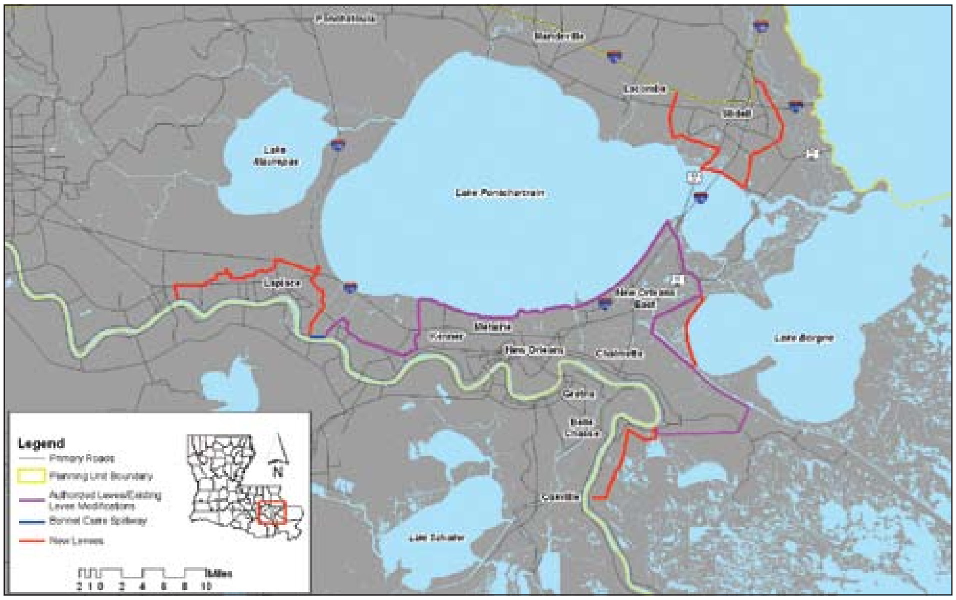

The coastal restoration plan shows reclamation of estuaries, such as the creation of marshlands (green), that offer natural defense against storm surges.




Map of nonstructural plan alternatives shows FEMA velocity zones where water surge levels are less and greater than 14 feet and suggests areas for buyout (pink) that restrict human habitation. The dark purple line is the location of a levee designed to the 100-year risk reduction level.

At the Engineer Research Development Center, GIS specialists work with research scientists to create databases, develop map layers, assess data relationships, and design predictive modeling methods. Data from contributing agencies' databases and remote data such as lidar are input into GIS, which completes calculations and creates data visualizations on an intelligent map. Data can also be run in models. For example, the team used GIS to visualize coastal circulation and storm surges. The Advance Circulation (ADCIRC) model output maps for analyzing hurricane surge and flooding events. Data from various sources, such as the National Hurricane Center, was downloaded to the model. Then GIS generated situation maps. Output reflected a variety of factors used to predict how often and how severely the region could expect to be inundated by water during future hurricanes.

The report's hurricane catastrophe defense options have been categorized into three groups. The first group is a set of nonstructural alternatives that either relocates people out of harm's way or elevates structures above the floodplain. It involves raising houses, buying out areas, restricting human habitation, and restoring the area to its natural condition such as reclaiming a neighborhood developed on marshland and returning it to its natural state. The second group is a set of structural alternatives that includes enhancing the existing levees by adding height to them; building new levees, floodwalls, pumps, gates, and weirs; and assessing the value of the floodgate system. The third group is a set of coastal restoration alternatives that targets coastal features as a first line of defense against hurricane surge and waves. GIS reveals how a degraded habitat loses its ability to absorb storm impact. Coastal restoration options that sustain the estuarine environment include development of additional marshland, diversion of rivers, and restoration of shorelines.



New Orleans' existing levees (purple) around Lake Pontchartrain and proposed levees (red) are structural alternatives for storm preparation.

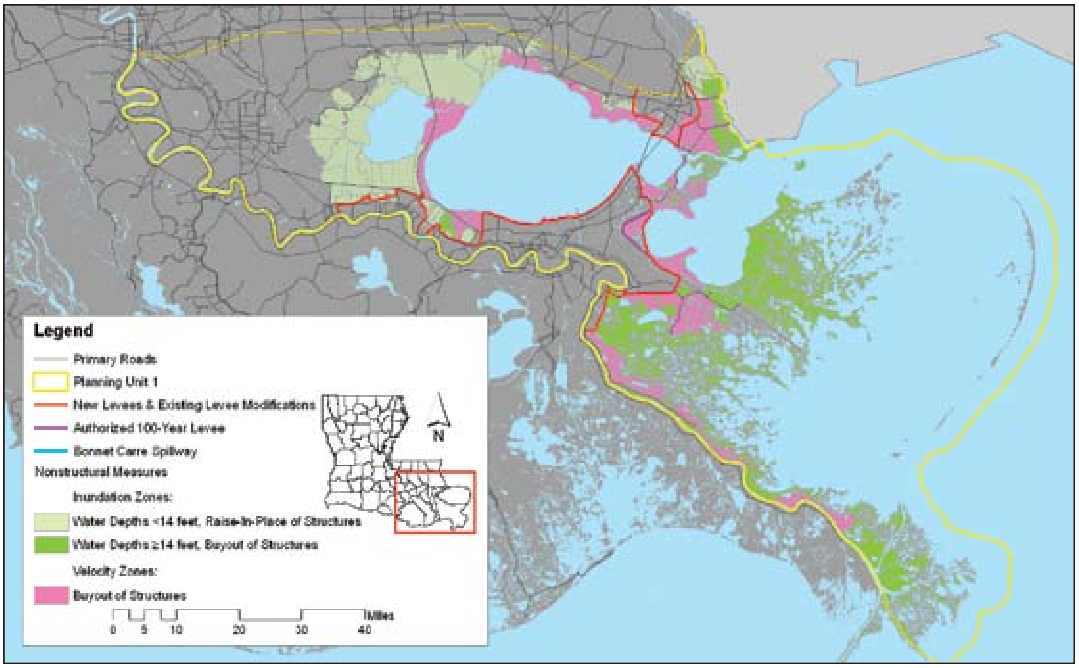
Planners are using GIS to model how these options could affect the landscape. Every one of the 100-plus alternatives in the report includes a map representation. GIS models both elevation and water surge levels to predict and demonstrate outcomes.

A draft of the LACPR technical report has been submitted to the National Academy of Sciences for peer review and professional feedback. The Army Corps of Engineers will soon revise and submit the report to Congress for consideration, planning, and response. The final report will offer Congress an array of alternatives for evaluation and comparison.

Planning decisions are complex. At this time, decisions have yet to be made by the government about a plan of action and funding of solutions; however, the efforts of planners, engineers, scientists, and researchers who contributed to the LACPR report and the use of GIS imagery offer a means for better understanding the challenges and solutions of the Louisiana coastline.

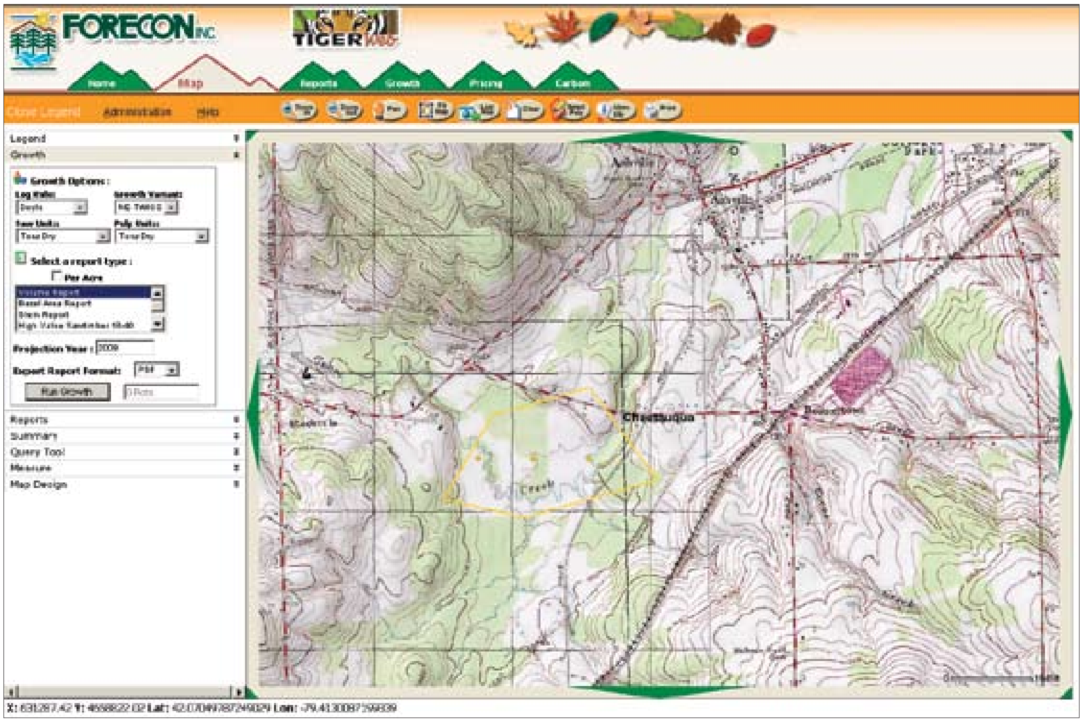
Special thanks go to Clint Padgett, GIS scientist for the Army Corps of Engineers, for the information in this article.

The complete LACPR plan formulation atlas and draft technical report are available online at www.lacpr.usace.army.mil.



New Orleans' comprehensive map of options shows floodplain water depths (green areas), suggested buyout areas (purple areas), an existing levee, (purple line), and proposed levees (red lines). It is composed of data from a variety of sources and is shared with a variety of stakeholders. Congress considers these maps for planning storm surge defense.

# Forestry Carbon Trading Opportunities Explored with GIS




FORECON's TIGER GIS tool generates a variety of reports, such as volume, basal area, and stem reports, that are accessible via the Web. The site visitor selects options for growth, a type of report, a projection year, and an export format, then clicks the Run Growth button, and GIS delivers the site-specific growth report requested.

Fossil fuel emissions lead to a host of degradations of our planet including global warming. Forest researchers are offering a means of monitoring and counterbalancing civilization's need for manufactured goods with nature's ability to cleanse the atmosphere of harmful emissions resulting from production. A key tool to measure these trade-offs and provide the basis for designing sustainable plans is the use of geographic technologies. GIS can combine many layers of data, model that data in many ways, and generate reports and maps that make it easy to comprehend a complex problem.

One of the problematic greenhouse gases thought to significantly contribute to global warming is carbon dioxide ($CO_2$), a compound made up of both carbon and oxygen. Nature works hard to offset this greenhouse gas by utilizing reservoirs, such as forests and oceans, that use photosynthesis to remove carbon from the atmosphere, subsequently reducing $CO_2$. For instance, growing trees convert, or sequester, $CO_2$ from the atmosphere and turn it into wood. Foresters are using GIS to analyze forests' carbon sequestration rates. This technology can also be implemented to reveal opportunities in carbon trading to gain economic advantages from sustainable forest management.

Forests in the United States sequester about 200 million metric tons of carbon each year. In its most recent U.S. Greenhouse Gas Inventory Report, the Environmental Protection Agency (EPA) notes that U.S. forests sequestered 10.5 percent of the carbon dioxide released in the United States by the combustion of fossil fuels. GIS can reliably measure, monitor, and verify carbon storage occurring within forests.

Traditionally, foresters have used GIS for basic timber inventory services. The emerging role of the Internet, coupled with evolving geographic technologies, is creating a compelling new business landscape for sustainable and profitable forest management.

FORECON, Inc., a multidisciplinary forestry and natural resources management consulting firm, is using ESRI's GIS software for developing forest management applications that deliver information, such as current forest inventories and forecasts of inventory growth, to the company's clientele. Using the geographic approach to forest analysis also leads foresters to a site-specific understanding about how carbon stocks associated with specific forests are changing. This, in turn, provides the information needed to develop sound and sustainable forest management plans.

Forest landowners, who are often pressured by costs such as property taxes, occasionally sell land for development and other nonforest purposes, which sometimes leads to the fracturing of the forest land base. But an alternative solution for meeting costs is the opportunity provided by the emerging carbon marketplace.

The Chicago Climate Exchange (CCX) is a prominent organization that has developed a successful market mechanism to allow the reduction of greenhouse gases through several options. As an example, manufacturing companies can join CCX by agreeing to reduce their carbon emissions footprints by a certain percentage within a specified time period. One means of doing this is through carbon offset credit trading. To meet emission reduction goals, CCX member businesses can purchase forest carbon sequestration credits to help offset their emission production levels. The revenue paid to the carbon offset credit provider goes toward compensating for the costs of sustainable forest management. Exchange allowances are issued to members in accordance with their emission baselines and other regulations.

GIS offers a scientific method of calculating carbon sequestration and the basis for credible certification. Impartial validation is essential for accreditation of forest carbon sequestration, and calculating these credits must be held to scientific standards. GIS not only houses and manages immense forestry databases but also runs forestry models and displays stand volume and carbon sequestration data via tables and maps. This information can also be delivered over the Internet along with tools that help clients easily interact with spatial and tabular data. Subscribers can get the exact information they need to prove their carbon sequestration projects are credible and transparent in the way they are being developed and reported.

A process has been developed that provides managers with robust information for both forest management and possible carbon market participation. The process starts in the field, where foresters gather timber inventory data. Using GPS technology while they are inventorying the forest, foresters reference geographic location coordinates to the stand attribute data. The field data collected includes tree species and diameter and, often, additional ecological information.

The georeferenced field data is downloaded into a geodatabase, and tree data is joined to other timber stand data tables located in a SQL Server geodatabase. The sample data points that represent a particular stand are run through a timber inventory program to produce timber volumes and stem counts by species and diameter class for a particular area designated by a geographic polygon on the map.

One customized GIS—the Timber, Inventory, Growth, Evaluation, and Reporting (TIGER) system—is integrated with the U.S. Forest Service's growth and yield model variants. The GIS processes the timber data collected and makes growth estimates for a variety of time intervals. It also provides a direct translation of the timber data into carbon units, essential to producing the information required for forest carbon market participation. This data is then made available to whomever the forest owner chooses including the forest manager and the CCX verifier, who must audit the process by which project owners are reporting their carbon credits.

Using a GIS-enabled Web site, foresters and investors can geographically view the report. The site provides clients with a forestcentric map interaction experience. The Web site includes applications for a wide range of forestry work processes and data management tasks. Built on GIS server technology, the Web site allows users to run customized and standardized growth models on stands, tracts, and management units as well as generate reports in various file formats.

Growth measurements taken in the field and entered into the stand inventory database can be processed with ESRI's GIS software to create predictive models and produce a growth map.

The Carbon tab on the Web site gives the contractor's clientele and certain CCX verifiers easy access to data and interactive tools. Site visitors can quickly and easily view growth rates and carbon sequestration conversion data needed to make sound investment decisions for both business and the environment. A mapping function graphically displays the specific forest's ownership, and users can drill down to the tract and forest-stand level. GIS allows users to link to various reports, including stand and stock tables by species and diameter class as well as the associated carbon stock equivalents, for that particular part of the forest's ownership.

The potentially significant consequences of climate change are causing companies to be more mindful of their impact on the environment. By participating in carbon trading, businesses not only are reducing their carbon impacts but also are to be applauded for their corporate social responsibility. These green marketing strategies provide a competitive advantage because they enhance brand perception by the emerging environmentally conscious consumer.

Forest industry carbon-trading participants include timber investment management organizations (TIMOs), industrial forest companies, nongovernmental organizations such as land trusts, pools of small private landowners, and tribal landholders.

After a rigorous analysis of their forest resource is made and a project proposal is accepted by CCX and verified by an independent verification entity, forest landowners may be able to register their carbon sequestration credits and sell them at the current market rate. The forest carbon offset project owners then commit to a period of 15 years of managing that forest sustainably to continue benefiting from carbon market participation.

To learn more about this GIS solution, contact Mike Darr of FORECON, Inc., by e-mailing him at mdarr@foreconinc.com.

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flow to improve efficiency. AFA has added a feature to a GIS routine so that an e-notification is distributed to inform supervisors and other relevant people that updated maps are available for their particular areas. In addition, securities were initiated so that people only receive information relevant to their own job processes. For example, the forester who approves change notices can access a specific map and forward required changes to the GIS technician. Once the changes are made, GIS sends an automatic notification to the AFA staff that the map in a map catalog has been updated.

An advantage to using GIS in a server environment is that it makes it possible for an increasing number of staff to use AFA data for more purposes. VanderKraan notes, "Using ArcGIS Server changes the way we store data. Rather than our people gathering data and putting it in a big vat where they don't see the results of that information, they can be a part of the map creation. This makes it more compelling for our staff to interact with the GIS and the data. This Web-accessible interaction affects the way our people approach data. It puts technology capabilities into the hands of people who have very little technical expertise. Furthermore, we can tailor our workflow to complement our current data structures or data communication flow in the park. We often work in a disconnected environment because we don't have cell tower or satellite access in the forest. But staff can download the information to their laptops/PDAs/UMPCs in the office at night and, in the morning, take the new data and updated maps on these devices in the field. We are moving out of a paper environment into a digital environment."

**"ArcGIS Server is making it possible for us to improve workflows and put current information into the hands of the people who need it."**

Carl Corbett, AFA General Manager

Forest inventory is one of the more common uses of GIS by foresters. But the technology can make use of an agency's databases in other ways. AFA also uses GIS to track the forest's road systems. The road system geodatabase includes active and decommissioned roads, water crossings, and seasonality factors. Primary road information is made available to the public via a Web site. Other road information is kept confidential to maintain and protect park values. These roads are closed to public travel and are available only to specified staff for management purposes.

Wildlife data is also stored in the GIS for study and research. The locations of species are plotted and their habitats protected. Because GIS works with tables, animal type and feature can easily be selected and added to the map along with identifying data. This can be worked into the sustainable plan of the forest. For instance, aquatic feeding areas for moose are

# Water Resource Perchlorate Data Analyzed with GIS

Perchlorate contamination of water resources is problematic in many parts of the country, particularly in the Southwest. Perchlorate, a chemical used by rocket fuel and fireworks manfacturers, is associated with thyroid disease and cancer. GIS helps environmental analysts assess levels of water contamination.

California State University, San Bernardino, used GIS in its study of the area's perchlorate contamination including groundwater, surface water, soil gas, and hydropunch.

Researchers used EarthSoft's EQuIS environmental data management extension to ESRI's ArcGIS Desktop software to analyze an extensive dataset with information from more than 2,000 samples in the San Bernardino area.

The GIS identified

- Probable extent of delineated contaminant plume in the study zone
- Locations of perchlorate "pockets"
- General groundwater movement trends
- Potential pathways to perchlorate encroachment

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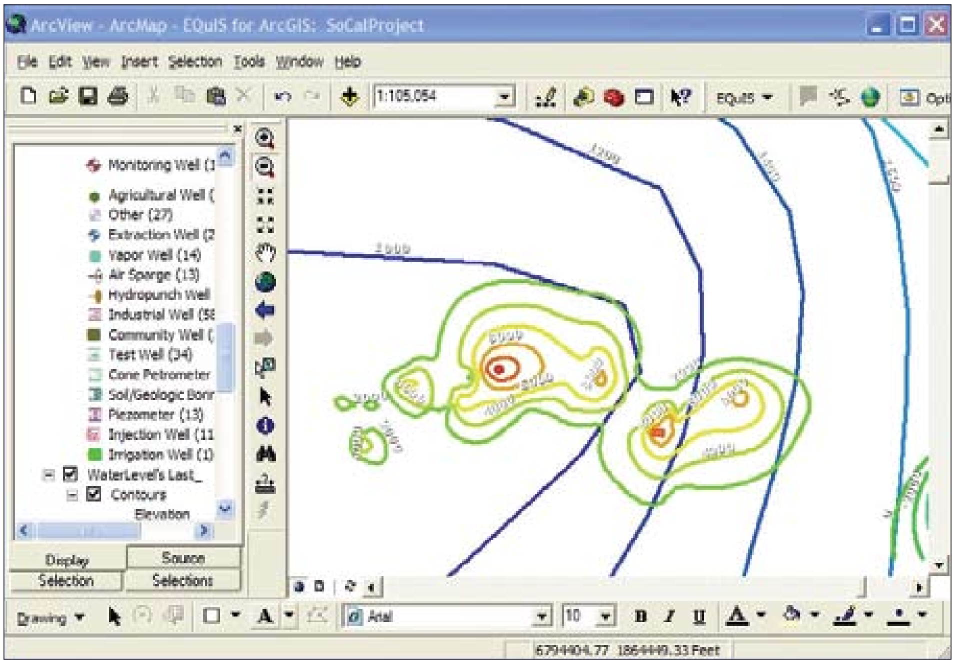


A pocket of perchlorate contamination is shown in red. Blue lines indicate water flow direction. The map author can query to show sensitive receptors such as private homes and wells that may be in the path of the groundwater carrying the contaminant load.


denoted, and forestry operations are restricted around those areas during the season moose are using them. "GIS data about species and habitat can be easily shared with scientists researching the many aspects of the forest. We work with various research and government agencies to develop GIS modeling processes that will enhance the development of future plans," says VanderKraan.

Cultural concerns can also be addressed with GIS. "Algonquin native values are noted in the GIS and maps," explains Corbett. "AFA works with the local Algonquin Tribe to identify areas of importance. For example, a white birch stand depicted on the map may be a good resource for bark needed to make canoes.

"GIS is used to successfully report the efforts for preserving and nurturing habitat while performing forestry practices," Corbett continues. "We have used it to develop a tactical plan and to identify and regenerate difficult pine management areas. By calculating variables such as cover types, soil information, slope, and moisture, we have been able to classify forest ecosystems.

"Inspectors, contractors, and government workers can all access our forest data catalogs and get the maps they need," concludes Corbett. "Not only does GIS help us move toward a paperless form of reporting and analysis, but ArcGIS Server is also making it possible for us to improve workflows and put current information into the hands of the people who need it."

*continued from page 5*

## City of Davenport Uses 3D Visualization to Prepare for Flooding

the actual ground level. It is created using the city's existing two-foot contour data. Another TIN represents the river rise calculated using river slope data from previous floods, which was collected by Davenport's engineering/survey division. In the second step, the river TIN's elevation is set to flood stage zero as a starting point for modeling. In the third step, using ArcScene, analysts offset the base height of the river TIN to various flood stages, then display areas of the city where flooding would or would not occur. The fourth step is to verify the GIS model's accuracy by comparing its outcomes with paper maps and written documentation from previous years. In the fifth step, analysts add the locations of levees, pumps, and gates to the model so areas that would be protected by this infrastructure are shown in the visualization.


Using 3D modeling adds dimensional visualization of predicted flood level's relationship to buildings such as this hotel.

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