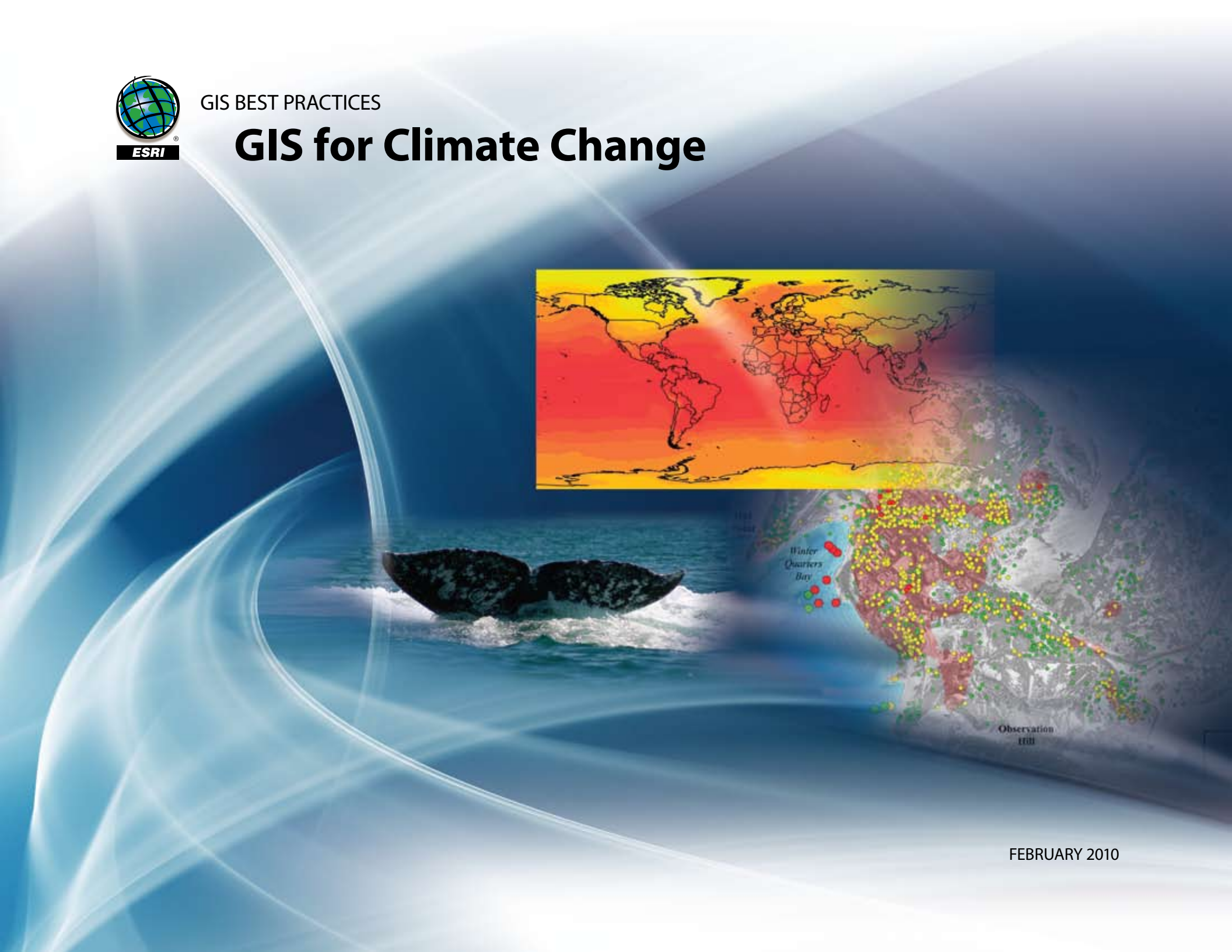
GIS BEST PRACTICES

GIS for Climate Change



FEBRUARY 2010

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Climate Change Is a Geographic Problem

By Jack Dangermond and Dr. James Baker

Reducing the risks caused by climate change is an immense challenge. Scientists, policy makers, developers, engineers, and many others have used geographic information system (GIS) technology to better understand a complex situation and offer some tangible solutions. Technology offers a means to assess, plan, and implement sustainable programs that can affect us 10, 20, and 100 years into the future.

A GIS-based framework helps us gain a scientific understanding of earth systems at a truly global scale and leads to more thoughtful, informed decision making:

- Deforestation analysis spurs successful reforestation programs and sustainable management.
- Study of potential sea level rise leads to adaptive engineering projects.
- Emissions assessment brings about research into alternative energy sources such as wind turbine siting and residential solar rooftop programs.

Climate change is a geographic problem, and we believe solving it takes a geographic solution. GIS users represent a vast reservoir of knowledge, expertise, and best practices in applying this cornerstone technology to the science of climate change and understanding its impact on natural and human systems.

—Jack Dangermond

Stopping deforestation and growing new forests, particularly in the tropics, are the easiest and fastest ways for society to reduce carbon dioxide in the atmosphere and mitigate global warming. GIS is one of the key elements of the forest carbon monitoring systems needed by tropical developing countries to manage their forests. The William J. Clinton Foundation, in partnership with ESRI, is helping selected countries build compliance-grade monitoring systems for mapping carbon information and providing decision-support tools for these countries to meet international regulations. Once these GIS systems are in place for forest monitoring, they can also be used to

establish and maintain property rights and land tenure, key elements of economic development. Therefore, just as forestry monitoring is the entry point for dealing with climate change, the systems we use for forestry monitoring are the entry point for development in general.

—Dr. James Baker

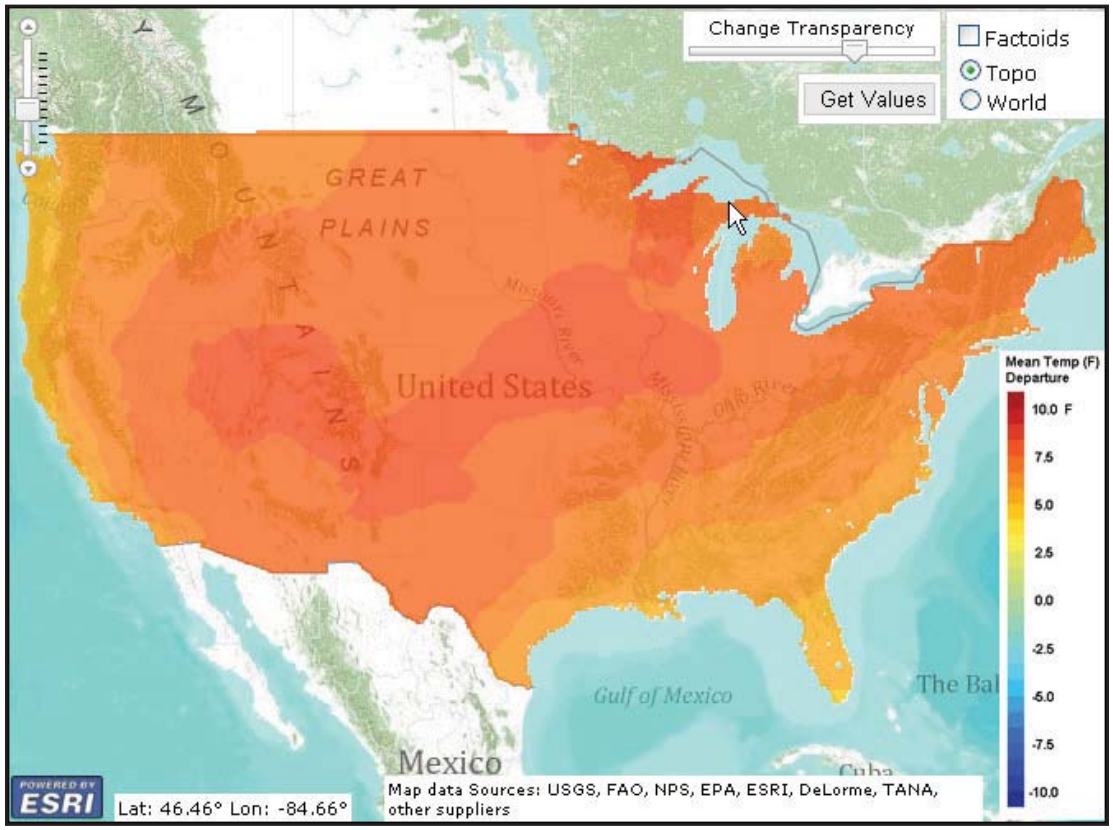
Jack Dangermond founded ESRI with a vision that computer-based mapping and analysis could make significant contributions in the areas of geographic planning and environmental science. The recipient of 10 honorary doctorate degrees, he has served on advisory committees for the National Aeronautics and Space Administration, the Environmental Protection Agency, the National Academy of Sciences, and the National Science Foundation.

Dr. James Baker is currently the director of the Global Carbon Measurement Program of the William J. Clinton Foundation, working with forestry programs to reduce carbon dioxide emissions and alleviate poverty in developing countries.

The Nature Conservancy Deploys ESRI Technology for Climate Trend Analysis

Climate Wizard Delivers Climate Change Data and Models

The Nature Conservancy Climate Wizard, powered by ESRI, displays free maps of historic climate change and future projected change. Climate Wizard offers scientists, planners, environmentalists, and public users an intuitive means to understand and compare climate change models useful to decision making.



Use Climate Wizard to analyze climate trends globally and locally.

ESRI has had a longtime commitment to environmental sciences and is working with many organizations dedicated to meeting the challenges of climate change (www.esri.com/climate). For many years, ESRI has supported Nature Conservancy efforts to protect our planet by providing environmental expertise and geographic information system (GIS) technology.

The new ESRI-powered version of Climate Wizard was first demonstrated at the 2009 United Nations Climate Change Conference (COP-15) in Denmark. It allows anyone to click a map location and get up-to-date data of climate change trends. A user can also choose between different climate change models to predict impacts on that location.

Climate Wizard uses 16 models from the Coupled Model Intercomparison Program (CMIP 3) published for the United Nations Environment Programme and the World Meteorological Organization Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. The user selects a model or ensemble of models from a menu and displays them on a GIS map interface.

These new displays replace previous static climate map images with live Web mapping services. An important new capability available due to this improvement enables users to query the 16 different climate change projections for three carbon emissions scenarios at specific locations. They can see the range of future climate projections in graph and tabular formats and view and analyze dynamic data using GIS functionality to see highly specific details relevant to their unique projects. They can also download the climate change data in GIS format.

An extension of Climate Wizard—a future climate model comparison application—allows users to directly compare different model outputs for a chosen area.

The Nature Conservancy launched Climate Wizard in January 2009, with the intent of making climate change a place-based issue so that people would consider how changes in the earth's climate affect them. The original objective was to build a state-of-the-art framework that could easily accept new data as it is coming from modeling agencies and put this information into the hands of researchers quickly and easily. The addition of ArcGIS Server technology to the tool in December 2009 has made a big step toward achieving this objective by providing live Web mapping services and maps that can be queried on the fly, as well as improved Web application mashup capabilities. The Climate Wizard project is a collaborative effort of the University of Washington, The Nature Conservancy, the University of Southern Mississippi, and ESRI.

"ArcGIS Server has made it possible for our vision of Climate Wizard to come into fruition," says Evan Girvetz, senior scientist with the Conservancy Global Climate Change Program. "We feel this tool is now on the cutting edge of GIS technology. The framework is there, and users can get the maps and information they need to better plan for future climate in specific places."

Chris Zganjar, information specialist for the Conservancy Global Climate Change Program, has been dedicated to the project since its inception. "GIS brings sophistication to the Climate Wizard. We can now serve vital climate change data to the practitioner with an easy-to-use tool," notes Zganjar. "Real data that virtually scales down to a person's backyard brings the issue into personal space."

In its development of the GIS framework for Climate Wizard, ESRI Applications Prototype Lab used the beta version of the next release of ArcGIS Server.

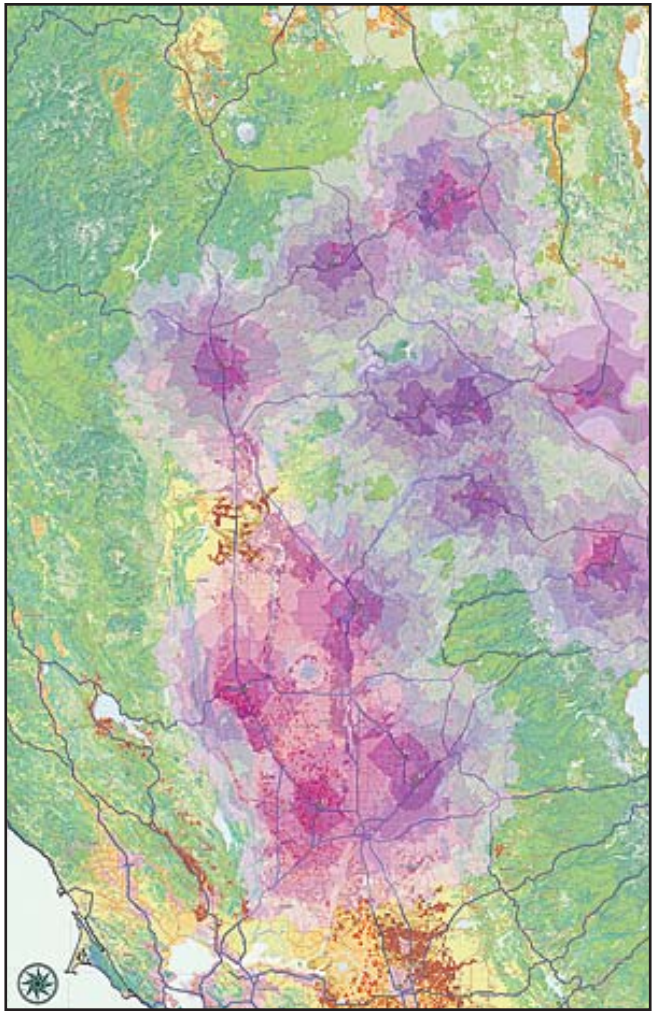
(ESRI press release, February 2, 2010)

Assessing Economic Biomass Resources in California with GIS

California has a large and diverse biomass resource base that could potentially provide the state with renewable energy, according to research from the California Biomass Collaborative. Feedstock for biomass energy production in California comes from forestry and forest products; agriculture; and urban sources, such as municipal wastes. Biomass may also emerge in the form of new crops as the state moves to reduce consumption of fossil fuels and petrochemical feedstock and use more sustainable and renewable resources for energy and products.

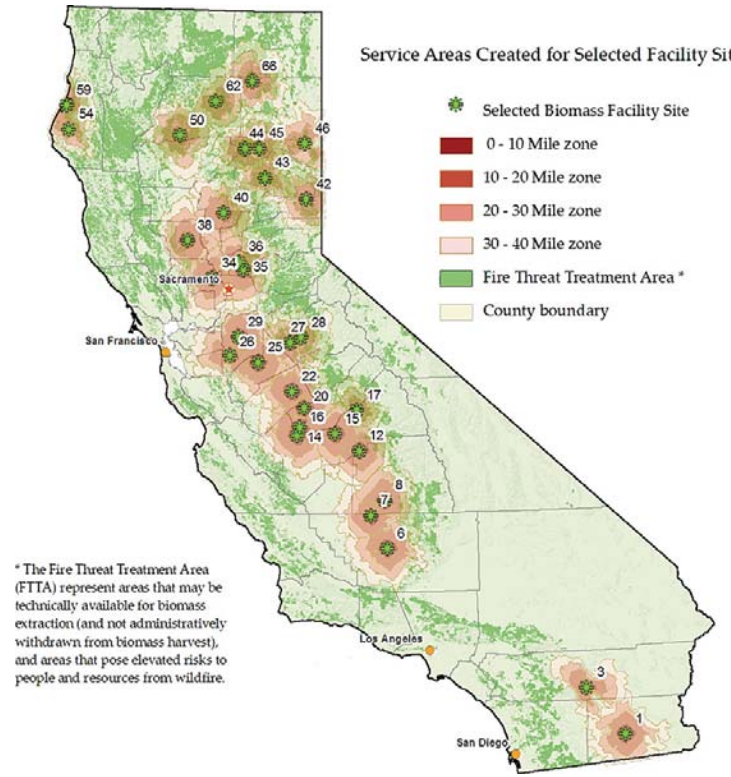
In a recent report, the California Energy Commission asserted that dedicated biomass crops for energy, fuels, chemicals, and other bioproducts may develop given sufficient market incentives or in association with new agronomic practices.

The California Biomass Collaborative used ArcGIS Desktop software to examine the economic feasibility of biomass supply for different types of manufacturing facilities of future bioenergy, biofuel, and bio-based products. The collaborative is made up of researchers from the California Energy Commission and the University of California (UC), Davis. The data used for the study was provided by the California Biomass Collaborative, California Department of Forestry and Fire Protection, California Department of Water Resources, California Energy Commission, UC Davis, and ESRI and included previously assessed data about gross and technically feasible feedstock supplies.



This project examines the economically feasible biomass supply for different types of future bioenergy, biofuel, and bio-based product manufacturing facilities sited across the landscape. This assessment extends that work by identifying supply curves (cost of supply by quantity delivered) (courtesy of California Biomass Collaborative).

Using the ArcGIS Network Analyst extension, researchers identified feedstock supply zones within fixed distances of each facility site. The actual distance along the road network was determined, as contrasted with simpler analyses employing a fixed radius and tortuosity factor. Researchers accumulated area in acres for each resource polygon to yield the total area within the supply region based on transportation distance. By adding cost information per road and feedstock type, the team was able to determine total delivered feedstock cost.



The team identified supply curves—the cost of supply by quantity delivered—and added cost information by road class and feedstock type. The resulting data allows optimization of facility scale or size by satisfying different requirements such as the minimization of delivery cost and the maximization of facility profit.

Facility size optimization was evaluated by combining feedstock delivered costs with economies of scale for capital and operating costs. Using the ArcGIS Spatial Analyst extension, the team was able to provide future developers with a map of supply overlap to assess potential competition for feedstock among facilities.

The GIS work of the California Biomass Collaborative may support statewide efforts to attract developers and include biomass as a viable renewable resource to meet state energy demands.

(Reprinted from the Fall 2009 issue of *ArcNews* magazine)

Carbon Nation

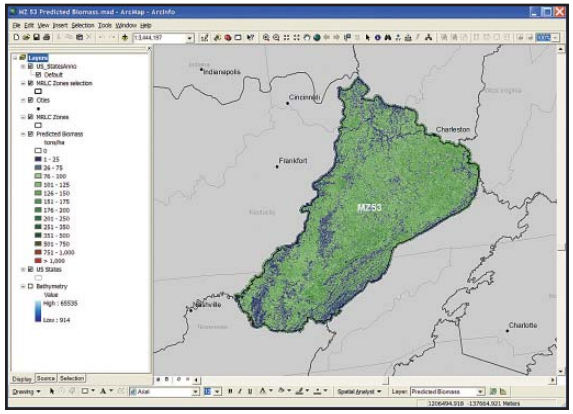
Automated GIS Process Is Creating a Snapshot of Biomass and Carbon in U.S. Forests

By Gregory J. Fiske, Woods Hole Research Center, Falmouth, Massachusetts

Summary

Scientists at the Woods Hole Research Center are using Python to automate processes for use in preparing the National Biomass and Carbon Dataset.

Carbon is a hot topic these days. People everywhere are increasingly aware that carbon in the form of carbon dioxide (CO_2) is one of the greatest contributors to the global climate change problem. Even school-aged children now know about fossil fuels and how our excessive use of them contributes to the accumulation of greenhouse gases in the atmosphere. At the same time, researchers around the world are working to understand where carbon is being stored, how much is being stored over time, and how this information can be used to better understand the global carbon budget. But while coal-fired power plants and SUVs have become icons of carbon imbalance, we tend to overlook another leading contributor to human-induced carbon emissions: land-cover change.



Modeling and prediction activities for NBCD2000 are being carried out using ecoregional zones developed by the Multi-Resolution Land Characteristics Consortium.

The connection between the carbon cycle and land cover is complex. Understanding the role of land-cover change, such as the conversion of forest to pasture or prairie to pavement, is a chief objective of scientists at the Woods Hole Research Center (WHRC), an environmental science, education, and policy institution on Cape Cod in Massachusetts. The center's staff have been pursuing answers to this question for many years, employing tools such as GIS and remote sensing to aid them in determining how much carbon exists, where it is located, and why it matters.

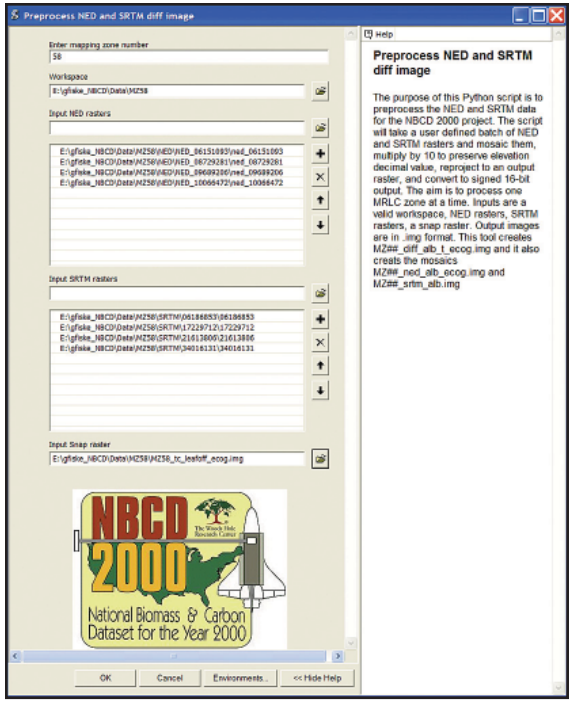
Looking at Biomass and Carbon

A team at WHRC has undertaken an ambitious project to quantify the amount of biomass and, in turn, the amount of carbon that blankets the 48 conterminous United States. Dr. Josef Kellndorfer, an associate scientist at WHRC, and his team are generating the National Biomass and Carbon Dataset for the year 2000 (NBCD2000). This project makes use of high-resolution (30 meter) National Aeronautics and Space Administration (NASA) satellite datasets, topographic survey data, national land-use/land-cover data, and extensive forest inventory data collected by the United States Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) Program.

With this large collection of data layers at a nationwide scale, the challenge is managing data systematically and automating processing tasks wherever possible. Modeling and prediction activities are being carried out using polygons describing the 67 ecoregional zones that were developed by the Multi-Resolution Land Characteristics Consortium (MRLC) as a basis for mapping. *[MRLC (www.mrlc.gov) is a group of federal agencies that joined together to purchase Landset 7 imagery and coordinate production of the National Land Cover Database.]*

Automating Data Preparation

Use of this data required that each of the dozens of GIS procedures employed in data preparation and analyses be repeated 67 or more times. Additional processing resulted from model updates, data modifications, or error fixes. Many data preparation tasks—such as reprojecting, clipping, raster-based math, and associated analyses—were conducted in the desktop environment. To automate these tasks in ArcGIS Desktop 9.2 (ArcInfo), the NBCD2000 team turned to Python scripting. For each task, a Python script was written and linked to a toolbox GUI in ArcToolbox. The collection of scripts was gathered into a single NBCD toolbox and shared with each WHRC team member via a local server running ArcGIS Server 9.2. Kellndorfer felt the development of an automated strategy was crucial for maintaining workflow and continuity from zone to zone because data preparation tasks were divided among the team members.



New NBCD2000 project team members can quickly be productive because the tools in the NBCD toolbox have been completely documented.

The actual statistical modeling of biomass is accomplished using a Linux-based high-performance computing cluster with multiple processing nodes. Both commercial and open-source image processing software was also used for a variety of analysis tasks. The team made every effort to ensure that all software packages worked together smoothly. For ease of integration in subsequent processing steps, Python scripts were written to generate files with the appropriate format and data type.

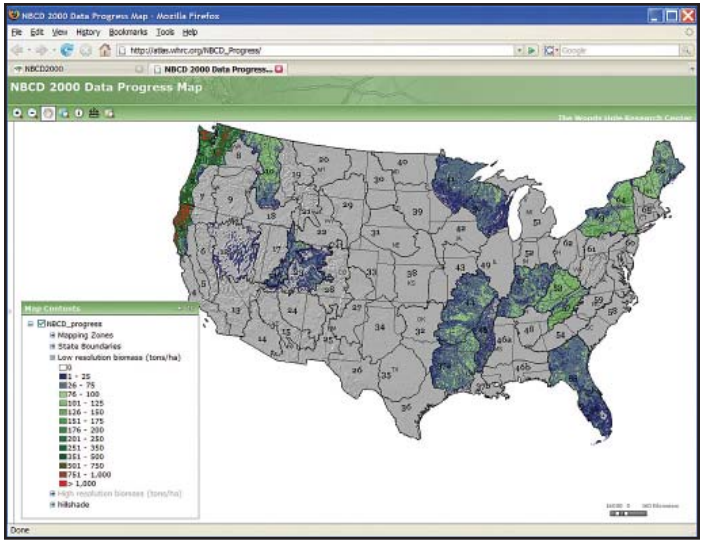
The core data layers for estimating carbon are two nationwide estimates of elevation: the 2000 Shuttle Radar Topography Mission (SRTM) digital surface model and the National Elevation Dataset (NED) digital terrain model. Essentially, these datasets are "differenced" to produce an estimate of vegetation canopy height that is used in subsequent biomass prediction.

The key tool in the ArcGIS NBCD toolbox generates this difference layer for each mapping zone. The necessary SRTM and NED tiles, acquired from the United States Geological Survey (USGS) seamless server (seamless.usgs.gov), are mosaicked. The NED surface is subtracted from the SRTM surface using raster math. In the final operation, the raster is clipped to the mapping zone boundary and converted to the proper bit depth required by the statistical modeling routine.

The tool performs a series of multistep, often time-consuming, GIS tasks within minutes. Previously, these tasks could require nearly an hour of setup time but now they are fully automated. Automating these tasks using Python scripting has greatly increased processing efficiency and saved hundreds of hours. Because help for the toolbox GUIs has been completely documented, new NBCD2000 team members can quickly become familiar with each tool and perform data processing with greater ease and confidence.

Providing Invaluable Information

The NBCD2000 dataset will be an invaluable information source for carbon stock assessment and flux modeling in the United States. Once completed for the conterminous United States, it will provide a baseline for comparing data products from the next generation of advanced earth-observing remote-sensing platforms. Funded by NASA's Terrestrial Ecology Program with support from the USGS Landfire Initiative, the NBCD2000 project directly supports the North American Carbon Program, a major component of the U.S. Climate Change Research Program. Clearly, a dataset of this scale could not be generated without a sizable team effort and the great benefits in efficiency, accuracy, and scalability afforded by the range of automated tools available through the desktop GIS environment.



Using an ArcGIS Server 9.2 map service, completed height and biomass data has been posted on the WHRC Web site.

About the Author

Gregory J. Fiske, a research associate with WHRC, is a geographer and an aspiring Python programmer.

(Reprinted from the Summer 2008 issue of *ArcUser Online*)

Building an Oasis in the Desert

GIS Helps Ensure that Masdar City Meets Its Carbon-Neutral, Zero-Waste Goals

Highlights

- Every facet of designing and building the city will be analyzed with ArcGIS.
- Asset management using ArcGIS means all systems can be visualized, maintained, and tracked efficiently.
- An enterprise geodatabase will be used throughout the city's life cycle.

Many of us are interested in decreasing our carbon footprint, whether one individual, one family, or one organization at a time. Imagine living in an entire city specifically designed to meet the ambitious goals of zero waste; sustainable living; and, ultimately, carbon neutrality. This is the vision of Masdar City, which is being designed and constructed in Abu Dhabi, the capital of the United Arab Emirates (UAE), by Masdar, Abu Dhabi's multifaceted initiative advancing the development, commercialization, and deployment of renewable and alternative energy technologies and solutions. *Masdar,* which means "the source" in Arabic, integrates the full technology life cycle—from research to commercial deployment. The Masdar company aims to create renewable energy solutions.

Masdar City is a prime example of how GIS can be used to design our future. This shimmering oasis of 6 square kilometers, located 30 kilometers from Abu Dhabi city, is committed to sustainable living. To reach its carbon-neutral ambitions, Masdar City will use only renewable energy sources. A photovoltaic power plant will generate most of the electricity, while the city's cooling will be provided via concentrated solar power. The zero-waste targets of Masdar City will be achieved through a combination of recycling, reuse, and some breakthrough waste-to-energy technologies. Landscaping within the city and crops grown outside will be irrigated with gray water and treated wastewater produced by the city's water treatment plant.

This artist's conception shows an aerial view of Masdar City as it will look when completed.

Through this innovative design, residents in Masdar City will consume far less energy. Peak demand at Masdar City is currently predicted to be only 200 megawatts instead of the

800 megawatts normally required by a conventional city of the same size and climate zone. Desalinated water consumption will drop from 20,000 cubic meters per day to only 8,000. And Masdar City will eliminate the need for millions of square meters of landfill.

The first residents of Masdar City will be the students and faculty of the Masdar Institute of Science and Technology (MI). MI is a graduate-level university specializing in alternative energy and environmental technologies and is a collaboration between Masdar and the Massachusetts Institute of Technology. MI will ensure a ready supply of highly skilled graduates to meet the growing demand within the clean technology and sustainable energy sectors.

Shifting from Oil to Renewable Energy

UAE is a federation of seven emirates, or federal states, located in the southeast Arabian Peninsula. Abu Dhabi, the capital of UAE, has a rapidly growing economy, due largely to the emirate's vast oil reserves: Abu Dhabi is estimated to hold approximately 9 percent of the world's crude oil reserves.

Despite its vast hydrocarbon resources, Abu Dhabi has adopted a progressive approach to its economic growth. The emirate is committed to diversifying its economy away from oil, ensuring the long-term development and prosperity of the country. As a worldwide leader in the energy markets, the emirate believes it is well placed to invest its knowledge and financial resources in the world's future energy markets—renewable energy. So in April 2006, the Abu Dhabi government established Masdar. Through its portfolio of projects that includes carbon monetization, clean technology investments, and renewable utilities projects—both in Abu Dhabi and abroad—the company is contributing to the global effort of mitigating climate change. In this way, Masdar plays a key role in the development of Abu Dhabi's renewable energy sector, driving continual innovation and commercialization of clean and sustainable energy technologies.

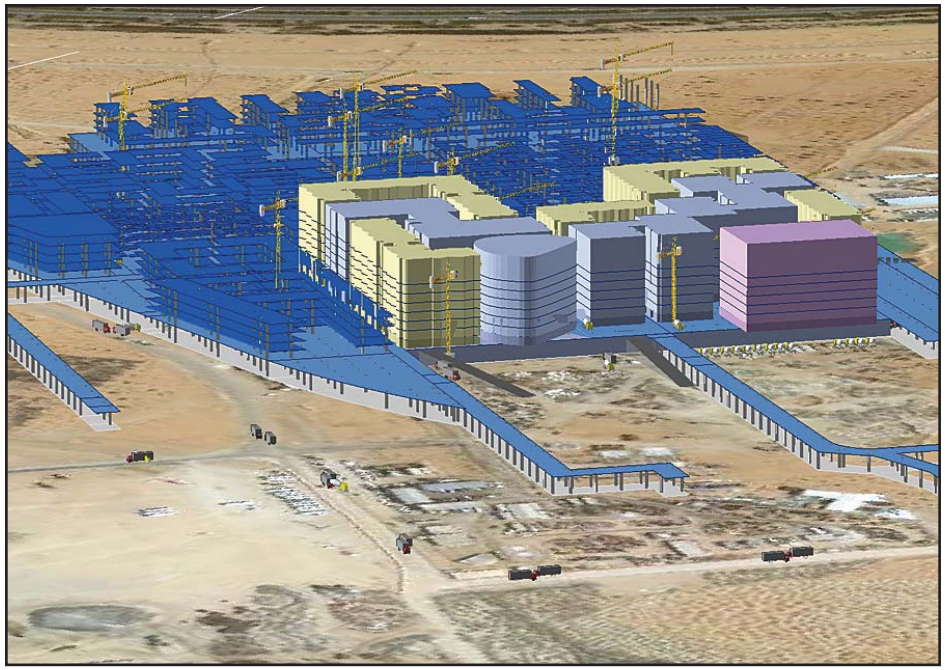
Masdar's progress since its development has been significant. The company has established partnerships and large-scale renewable energy programs around the world. And as a further sign of Abu Dhabi's advancement in the alternative energy space, UAE was recently successful in its bid to host the headquarters of the International Renewable Energy Association, against strong European competition, in Masdar City.

CH2M HILL, an ESRI Business Partner and a leader in full-service engineering and consulting based in Colorado, was chosen as a leading partner for the Masdar City design/build project.

CH2M HILL had used ESRI technology on many projects in the past and knew ArcGIS was the solution necessary to manage and analyze information throughout the city's life cycle.

Lean, Green City Planning

"GIS is imperative in managing the overall spatial information necessary for designing, building, and operating Masdar City," says Derek Gliddon, GIS manager, Property Development Unit, Masdar.



Staff members at the City of Masdar use GIS to model building information throughout the life cycle of the project.

For the city to meet its challenging goals, CH2M HILL carefully considered the geography of the area: sun angles, wind patterns, street widths, and building density and height. The orientation of buildings on a diagonal grid to provide maximum natural shading was modeled in ArcGIS. To understand all the variables and communicate effectively during the project, the company used

a geodatabase that enforces use of a single, shared coordinate system across the project. A common basemap was created to support planning, design, and construction of the city, with the foresight that the city would also be maintained and operated using the same data.

"Building a city like this has never been done before. And GIS is proving to be an absolutely critical tool," says Shannon McElvaney, information solutions consultant, CH2M HILL.

Data layers contained in the geodatabase include information such as transportation, vegetation, drainage, structures, boundaries, elevation, biodiversity, buildings, and utilities, as well as terrain elevation, bathymetric data, and remotely sensed imagery. Information from tabular databases is incorporated into the map layers, as well as GPS coordinates and georeferenced photographs. All the construction-related information, including cost, schedule, and carbon tracking data, is tied together by location, making it more accurate and efficient to use.

The resulting information is available company-wide. ArcGIS Server was recently deployed and will enable the more than 100 organizations involved in developing Masdar City to access maps, data, and analytic services, thus reducing problems of multiple data versions in circulation. A sophisticated Web browser-based virtual city visualization and navigation tool uses master plan data from the geodatabase and links to the program scheduling software. This tool is used to visualize the construction of the city over time. Construction managers can navigate anywhere in the city; "play" the project timeline; and identify spatiotemporal clashes, accessibility problems, and other logistical issues. On a fast-paced, high-density development, these issues are very important. Information can be searched using spatial criteria and viewed on easily readable thematic maps. Using GIS to visualize the massive amounts of data makes communicating about the project easier.

Optimized Facility Placement

ArcGIS introduced the spatial analysis and modeling necessary for the most efficient placement of facilities at the city. Water and sewage treatment plants, recycling centers, a solar farm, geothermal wells, and plantations of various tree species were placed using traditional planning principles modeled with ArcGIS. Questions—Is there enough physical space available? How much are the buildings shading each other? How much space is needed between a facility and the residents?—are modeled and the best answer chosen through GIS.

McElvaney cites a problem that was quickly resolved when line work from one building was off by 30 centimeters from the previous line work. Having access to all the data and visualizing it with GIS allowed catching the mistake: "A mistake like that could be very time and cost intensive

to fix during the construction stage. GIS is extremely helpful in preventing that kind of thing from happening."

From Models to Real Life

GIS has ensured that the carbon-neutral status of the city translates from a concept to design. CH2M HILL used ArcGIS to even choose where to place construction materials during the building phase. Alternative scenarios for where to place building materials could be modeled so that, in the end, the company could choose the most efficient location for reducing transportation-related carbon emissions.

GIS was able to model water and power usage over a period of 10 years, plotting monthly resource demand across the city like a geographic histogram. The variables appear as different heights, allowing planners to see any issues rapidly. "This exercise immediately revealed a couple of problems with the logic that had not been easy to spot in a massive spreadsheet format," says McElvaney.

Changes happening during construction were tracked and recorded to monitor the effect on carbon neutrality. Masdar City has a team that keeps track of all fuel and material use and reuse during building. This team is also responsible for logging any environmental infractions. Team members found that using a GPS-enabled camera to take photos and transfer them to the GIS to document the location of an infraction allowed them to see what happened where and whether there were underlying trends, all of which contribute to managing the sustainability of the build.

Innovative Transportation

Masdar City will utilize breakthrough transportation technologies that revolutionize and redefine urban transport. A Personal Rapid Transit (PRT) system running on solar-charged batteries will transport residents around the city. There will be 3,000 PRT vehicles, generating 130,000 trips each day across 85 stations. A Freight Rapid Transit system will make up to 5,000 trips per day to transport the city's goods. ArcGIS was instrumental in visualizing all routes for the PRT network and testing predicted walk times between PRT stations. Transportation planners also used ArcGIS to find optimal locations for perimeter parking garages, along with effective road and rail transport routes into the city. Real estate plots were valued using routing GIS.

Beyond Construction

Conventional cities of similar size create approximately 1.1 million tons of CO2 per year—80 percent from buildings and energy creation, 13 percent from waste, and 7 percent from transportation. Masdar City expects to eliminate the emissions by producing zero carbons. ArcGIS will continue to be used and integrated with a computerized maintenance management

system that will include the location of all infrastructure assets; gas pipes; smart grid infrastructure; clean, gray, and black water networks; and the transportation network. Moving forward, GIS will make facilities maintenance easier and enable the tracking of resource use and reuse and the overall carbon balance of the operational city. GIS will be used in city governance, where it will form part of the city's sustainability performance feedback service, which will inform residents about their personal contribution toward overall city performance.

(Reprinted from the Fall 2009 issue of *ArcNews* magazine)

Conserving Bolivia's Critical Resources

GIS Helps Gauge Land Change Effects on the Nation's Endemic Biodiversity

By James Toledano, J. Ronald Eastman, and Florencia Sangermano, Clark Labs, Clark University; and Tim Killeen, Conservation International

Highlights

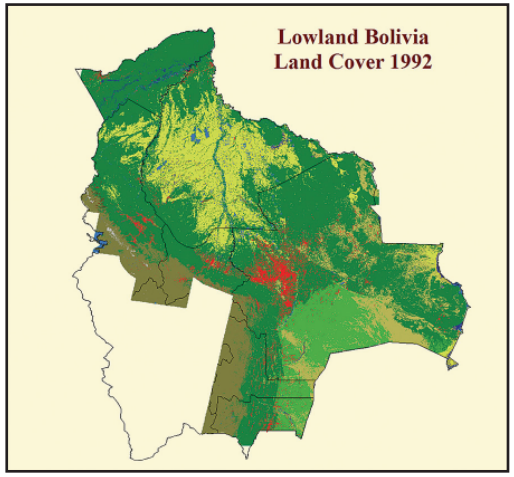
- Land Change Modeler is now an extension for ArcGIS software.
- GIS contributes to the accuracy of mapping the potential of land-cover classes.
- Software provides a means to combat threats, such as economic development.

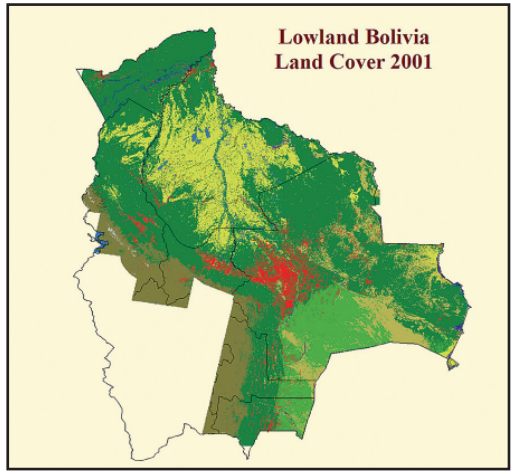
Due in part to a tremendous amount of economic growth in recent decades, the Bolivian lowlands saw forest loss of almost 3 million hectares between the years of 1992 and 2004, with almost half of this loss coming between 2001 and 2004 alone. This land change is expected to be the major contributor to biodiversity loss (even more important than climate change) and contributes to habitat degradation, fragmentation, and destruction. Indeed, the rate of deforestation is second only to that of Brazil. With forests dominating more than 65 percent of the land cover in lowland Bolivia, it is essential that this land-change dynamic be appropriately analyzed, particularly as we now know tropical forests are a critical component for maintaining climate system function and that they also represent the habitat for a wide range of species.

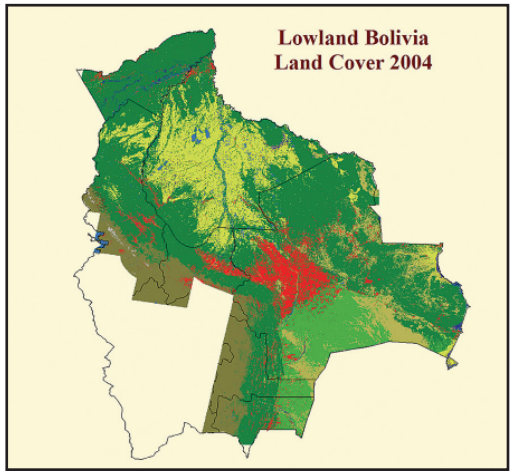
Conservation International, based in Arlington, Virginia, is an organization at the forefront of preserving natural systems in a sustainable manner. It has focused much attention on land-cover change in the Amazon, particularly in Bolivia, and it has relied more in recent years on the scientific application of GIS for insights into managing habitat loss and predicting future scenarios of change. To better implement this effort, Conservation International has prioritized the oversight of the development of essential integrated tools for identifying hot spots and conserving habitat and biodiversity—tools to better manage, monitor, and prioritize the risks to the environment associated with economic development.

Clark Labs (an ESRI Business Partner located in Worcester, Massachusetts, and based within the Graduate School of Geography at Clark University) partnered with Conservation International over several years to develop a land-change modeling software environment to analyze land-cover change and assess the potential impacts of these scenarios on biodiversity.

The result of this collaboration was the development of the Land Change Modeler (LCM), implemented within Clark's IDRISI GIS and image processing software and recently as an extension for ArcGIS software.







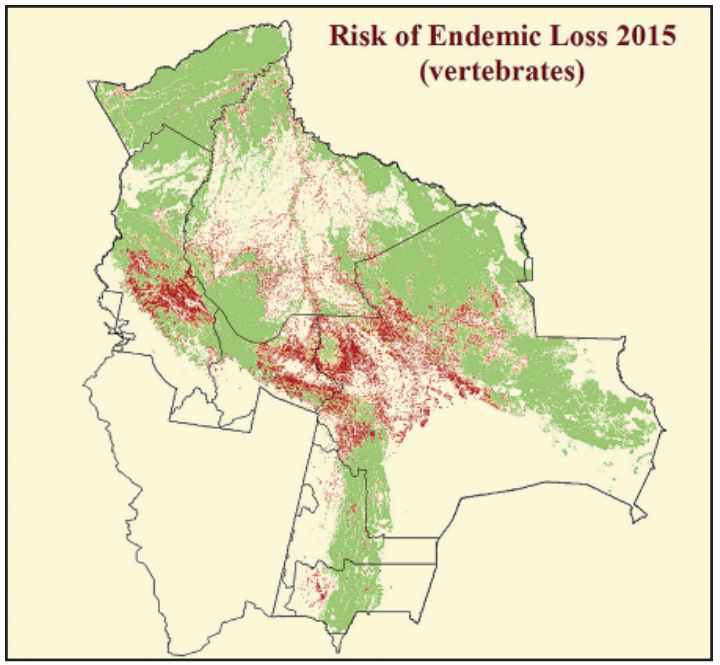
These land-cover maps depict dramatic lowland deforestation (red) over time between 1992, 2001, and 2004 (data: the Geography Department at Bolivia's Noel Kempff Mercado Natural History Museum).

Bolivian Land-Change Dynamics and Implications on Biodiversity

For a recent showcasing of LCM, Clark used land-cover maps depicting dramatic deforestation over time that were developed by the Geography Department at Bolivia's Noel Kempff Mercado Natural History Museum for that nation's lowlands. These maps showed forest change that occurred between 1992 and 2001. A set of 28 static and dynamic driver variables that may have impacted this change, such as proximity to infrastructure, slope, and soil type, were also included. Information on known road improvements for Bolivia as part of the planned intervention input to the prediction phase further refined the model. For this project, a multilayer perceptron neural network was used to create a predictive model, relating the observation of deforestation with the driver variables. Clark chose this method because of its high accuracy for mapping the transition potential of land-cover classes. To assess the quality of the model, a prediction was made to 2004 and the output was validated against known conditions in 2004.

Once the model was calibrated, additional future scenarios were then produced. One such scenario included both a soft and hard prediction of land change in the Bolivian Lowlands for the year 2015. The hard prediction yielded one possible scenario of the locations of change, while the soft prediction gave an indication of the deforestation vulnerability in 2015. Results from this scenario were then combined with biodiversity data to uncover the potential impact on biodiversity.

Using collections of species range polygons, initially supplied by NatureServe and subsequently recalibrated in Land Change Modeler for ArcGIS, a species richness map was developed for all birds, mammals, and amphibians. A total of 73 species endemic to Bolivia were identified, including 36 amphibians, 16 mammals, and 21 birds. This map was combined with the 2015 soft prediction (deforestation vulnerability map) to derive a risk of biodiversity, or endemic loss.



A species richness map was developed, then combined with the 2015 soft prediction to derive a risk of biodiversity, or endemic loss.

Habitats Already Lost

The results are alarming. Assuming business as usual, the potential forest loss could be devastating to biodiversity in Bolivia. For example, one of the endemic species, the masked antpitta (*Hylopezus auricularis*), an already threatened species, is projected to lose one-third of its habitat by 2015. Indeed, for the base time period of this study, 2001–2004, 4 percent of the current endemic mammal habitat has already been lost. The implications of land change on biodiversity are occurring now.

Land Change Modeler for ArcGIS provides a means to combat threats, such as economic development, and to assist those engaged in important conservation practices to prioritize threatened environments. Clark Labs, in conjunction with Conservation International, is currently conducting training in the use of these important tools for land-use planning and sustainable development in countries undergoing high biodiversity loss to further prioritize their planning interventions.

About the Authors

James Toledano is executive director of Clark Labs, Clark University. Ron Eastman is the director and founder of Clark Labs. Florencia Sangermano is a research associate at Clark Labs. Tim Killeen is a senior research scientist at the Center for Applied Biodiversity Science, Conservation International.

More Information

For more information on Conservation International, visit www.conservation.org. For more information on Land Change Modeler for ArcGIS, contact Clark Labs (www.clarklabs.org). Noel Kempff Mercado Natural History Museum is a recipient of GIS software from ESRI's conservation programs and has received additional support from the Bolivian government, Conservation International, The Nature Conservancy, and the World Wildlife Fund.

(Reprinted from the Spring 2008 issue of *ArcNews* magazine)

Mapping the Solar Potential of Rooftops

Germany's SUN-AREA Research Project Uses GIS

Highlights

- Using ArcGIS Desktop tools, researchers identified all necessary rooftop data.
- ArcGIS Desktop ModelBuilder was used to determine the solar potential of all roof areas.
- The ModelBuilder application gave the team an intuitive interface.

The solar age has dawned in Germany. About 20 percent of the country's rooftops are suitable for solar power production, according to recent results from the SUN-AREA Research Project. The project aims to determine how solar energy resources can be optimized by placing photovoltaic panels on rooftops around the country.

The SUN-AREA project is sponsored by the University of Osnabrück and the TOPSCAN topographical information company. It is led by geomatics engineer Martina Klärle and researchers Dorothea Ludwig and Sandra Lanig.

Preliminary findings of the SUN-AREA project estimate that, at full potential, solar power could meet the entire energy needs of homes throughout Germany. The team began its work with an examination of the northern German city of Osnabrück.

"We have proven that 70 percent of the city's total demand for electricity can be covered using only the roofs that are already present in Osnabrück," Klärle says. "In other words, if all the roofs that are especially suitable were now fitted with photovoltaic devices, we could meet 70 percent of the electricity needs of all of Osnabrück."

Germany is very well suited to generate electricity using photovoltaic systems. The majority of the population is not concentrated in urban centers, but spread out over rural areas. That means more space per person, and more roof area.

SUN-AREA researchers used ArcGIS Desktop applications to calculate the possible solar yield per building for the city of Osnabrück.

"My vision is to use all suitable roof surfaces to make solar electricity," Klärle says.

Now Klärle is trying to turn the SUN-AREA vision into reality. She gave city officials a solar power potential map of Osnabrück with an exact catalog of all suitable rooftops. The data has been made public and has already received positive response. The city is stepping up efforts to equip public buildings with solar collectors. Osnabrück has doubled its solar energy installations in the past year alone.

"We're at the point where we can't afford to get our electricity from coal-fired power plants, and we don't want to get it from nuclear power plants," she says. "I just won't accept that we have all this potential on our roofs, and we don't use it."

The SUN-AREA Method

SUN-AREA researchers set out to develop solar power potential maps of each roof area, each city, and each county or district in Germany.

The team started by gathering data, then devised a digital analysis method for identifying high-potential areas. Rooftop data was collected with aerial laser scanners. Klärle spent time flying through the skies over Germany, seeing to the effectiveness of the scanning technology.

Using ArcGIS Desktop tools, including ArcGIS Spatial Analyst, the researchers identified all necessary rooftop data, such as outer form, inclination, orientation, and clouding. The team used an algorithm sequence, created with the ArcGIS Desktop ModelBuilder application, to determine the solar potential of all roof areas. Important data included the angle and alignment of the roof, the sun's path across the sky, shadows cast by a chimney or another rooftop over the course of the day, and the seasonal change in hours of sunlight. The SUN-AREA project also calculated solar suitability, potential power output, CO2 reduction, and investment volume for each subarea of a roof.

The ModelBuilder application gave the team an intuitive interface to implement necessary data and tools to model solar power. The system detects optimal locations for producing solar power based on laser scanner data and plain view data.

The results from the Osnabrück pilot region are available to the public via an interactive online map created with ESRI's Web GIS technology (www.osnabrueck.de/sun-area).

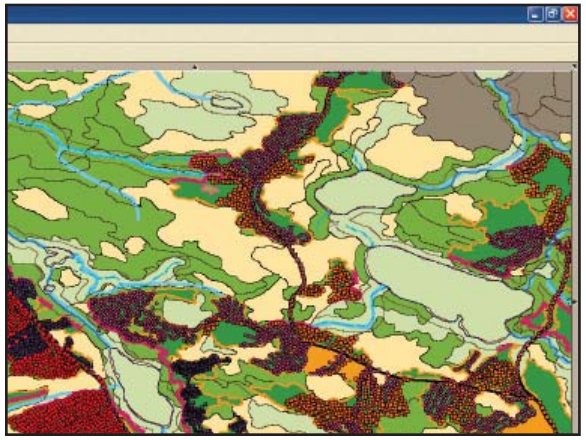
(Reprinted from the Fall 2009 issue of *ArcNews* magazine)

Harvesting Efficiently Using Mobile GIS

Kruger Publication Papers

Corner Brook Pulp and Paper (CBPP), a division of Kruger Publication Papers, has been using GIS since 1987 when they had a direct link to the Newfoundland Forest Service GIS located at Herald Towers, in Corner Brook. Today, they use ArcPad for pre-harvest planning field work by capturing the necessary terrain and tree stand attributes required for inventory analysis and operations planning. They also use ArcPad to help navigate harvesters in the woods and record harvesting activity.

Each harvester is equipped with a GPS recorder that tracks location and activity.



Harvest boundaries are defined as digital shapefiles and downloaded to the computers on the harvesters. This enables them to see where they need to cut and track where they have already been.

CBPP currently employs approximately 400 people for their harvesting and silviculture programs and another 500 in their newsprint mill and Deer Lake Power operations. Their operations typically run 24 hours a day, five days a week and naturally must work within seasonal time constraints.

Pre-harvest planning is an intensive and rigorous activity that requires collecting accurate block boundaries for harvest digitally to reproduce operational maps. CBPP uses ESRI's ArcPad

software, running on Thales and Trimble GPS units, to create and manipulate shapefiles of harvest blocks in the field, then adds this data to the company's corporate GIS. This data is used to create an accurate representation of a harvest block, an accurate volume determination, and the minimum road requirements for passage along with other valuable attributes affecting navigation such as slope and hydrology.

To further improve harvesting operations, CBPP installed simple electronic service recorders (Multidats) on five harvesters in September 2006. Each Multidat is equipped with an internal GPS unit and exterior antennae mounted on the roof of each machine. Once an operator has entered his three digit code into the Multidat, the system senses the machine's motion and begins to record activity data and GPS coordinates. When a machine is sitting idle for longer than five minutes the operator is prompted to enter a stop code which explains the reason the machine is not working.

They also equipped the harvesters with a Tablet PC running ArcPad. A customized application was built to show the information captured from the GPS Multidat system in ArcPad so that the operators could visualize their current location along with other information previously downloaded from the corporate databases. With the track logs turned on the operator can see the areas they have harvested in order to most efficiently navigate to new harvest locations within their defined block. Prior to using ArcPad for navigation, a foreman would tie ribbons around trees, marking the boundaries for harvest to guide machine operators. The foreman's job has changed significantly now that he can show the operators on a screen where he expects them to harvest so that and they can navigate directly to these locations. Today, before each harvester begins work, the computer in each harvester machine is loaded with a shapefile of the harvest boundary.

All harvesting activity is tracked, logged, and uploaded to the company's central database at the end of each day. These data logs are then sent to a download station in the foreman's vehicle through a short range RF modem connection. The download station then connects to the Internet via a cell phone modem when the foreman's truck is within range of a cell tower, and the shapefiles are uploaded to the company's FTP site. From there the data is incorporated into the company's GIS and displayed through the use of an ArcGIS Server system so field supervisors back in the office can visualize the track logs of their harvesting equipment over the operating area.

Since installing a navigation and tracking system in each harvester, CBPP has realized the following benefits:

- Increased productivity through targeted direction to identified stands for harvesting
- Reduced environmental incidents as operators now see the buffer zones and streams on the maps in the cab
- The technology helps attract and retain employees (the tools are not only interesting for the operators to work with, but also provide increased safety and personal satisfaction through productivity gains)
- Easier to communicate with contractors who have navigation systems
- Better monitoring tools help create the most economically efficient harvest plans

"We have been successfully using the navigation portion of this system since May 2007 and we are in the process of automating the upload and display of the shapefiles in our ArcGIS Server application," said Deon Hamlyn, Operations Superintendent, Corner Brook Pulp and Paper. "My hope is to automate the entire process. I also envision transferring harvest tracking data between machines, so that forwarders know where harvesters have cut. We have realized fantastic productivity gains by digitally capturing and displaying our operations. It seems clear, the greater our field communication becomes, the greater the economic return."

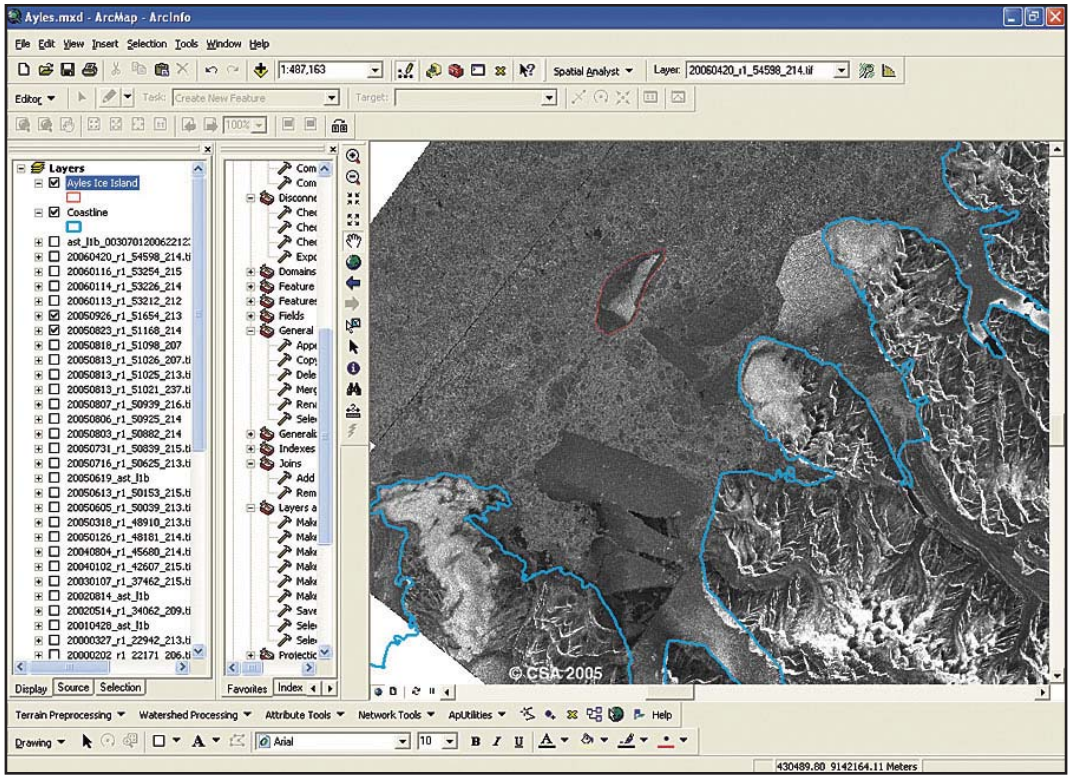
"We have realized fantastic productivity gains by digitally capturing and displaying our operations."
Deon Hamlyn,
Operations Superintendent,
Corner Brook Pulp and Paper

(Reprinted from the Vol. 11 No. 1, 2008 issue of *ArcNorth News* magazine)

Mapping the Ayles Ice Shelf Break

GIS Tracks 33-Square-Mile Ice Island in the Arctic

It was the Arctic ice shelf collapse heard around the world: this past New Year's weekend, the BBC, the Canadian Broadcasting Corporation, CNN, the *New York Times*, and other media organizations broke the story that the ancient Ayles Ice Shelf in Canada had cracked from its mooring in an Ellesmere Island fjord and floated into the Arctic Ocean.



Ayles ice island, delineated by a red polygon, broke from Ellesmere Island (outlined in blue) on August 13, 2005. The RADARSAT background images were processed by the Alaska Satellite Facility at the University of Alaska in Fairbanks.

The ice shelf calving was discovered by Laurie Weir of the Canadian Ice Service in September 2005 while she was comparing satellite images of the ice shelves. She contacted Luke Copland from the Laboratory for Cryospheric Research at the University of Ottawa in Canada, who launched a scientific investigation into what occurred. Though the news spread in some scientific circles and was reported at a conference, journalists did not catch word of the story for 15 months.

With the possible culprit being global warming, all eyes turned north, where the newly formed ice island sits safely—so far—in sea ice about 10 miles off Ellesmere. "Right now it's frozen in off the coast," says Derek Mueller, a geographer and postdoctoral researcher at the Geophysical Institute University of Alaska Fairbanks, who helped to investigate and write a paper about what happened to the 33-square-mile Ayles Ice Shelf.

Though the ice island has only traveled a short way since the August 13, 2005, incident and there's no obvious current danger to ships or oil drilling platforms, the chance of trouble ahead exists, Mueller says. "It could break away at any time and float further down to the south, and it would likely start breaking up as it floats," he states. "These ice islands will be tracked by the Canadian Ice Service so that ships will be warned," adding that the possibility exists, though slim near term, that the ice island could drift down toward the coast of Alaska with the Beaufort Gyre current and into shipping lanes and toward oil drilling operations. "Worst-case scenario, if it did hit one of the oil drilling platforms, it could cause a lot of damage," Mueller adds.

Though not enough evidence exists to blame global warming for the collapse of the Ayles Ice Shelf, Mueller says that what occurred is consistent with other signs of climate change in the Arctic. "Taken together, all of these signs are worrisome," he says.

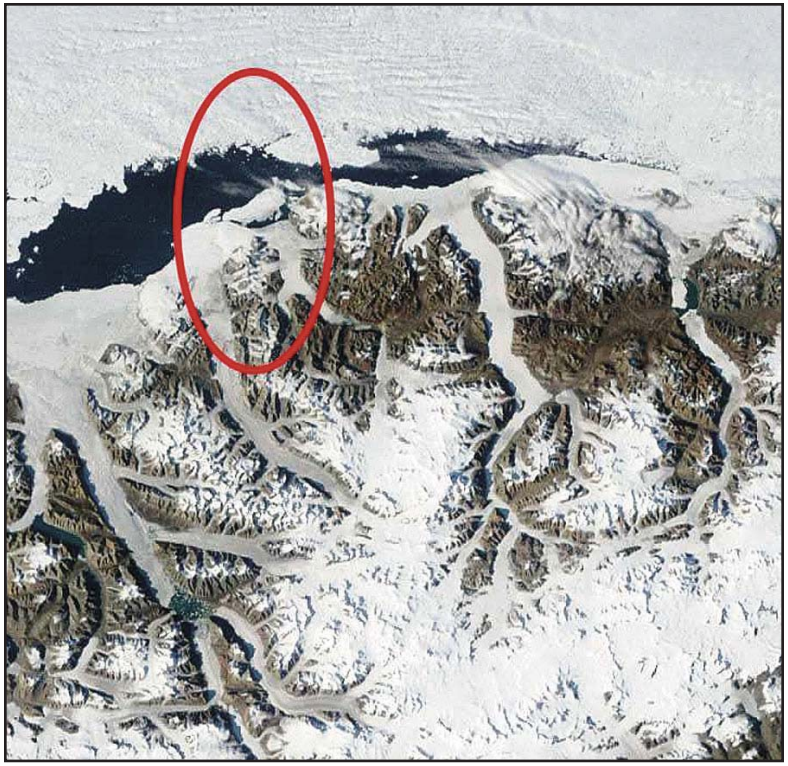
Sizing Up the Ayles Ice Shelf

Having studied the ecosystems on the Ellesmere Island ice shelves as part of his Ph.D. research in biology, Mueller was invited to help investigate the Ayles Ice Shelf breakup and contribute to a paper the researchers were writing about the calving. In his work, through the university's ESRI campuswide site license, Mueller used ArcInfo software to create a map that helped researchers visualize the chain of events and learn how much ice was lost from the fjord on the north end of Ellesmere Island.

Eric Bottos from McGill University, Derek Mueller from the Geophysical Institute at the University of Alaska, and Alexandra Pontefract from McMaster University sample microbial mats on the Markham Ice Shelf (August 2005). (Photo courtesy of Denis Serrazin).

"The break was visible, but what we wanted to know was, What was the size of the ice island when it broke away?" Mueller says, adding that mapping and analysis showed it shrank from about 41 square miles to 33 square miles. "Aside from the loss of the Ayles Ice Shelf, 20 percent of the nearby Petersen ice shelf was also lost just after August 13, 2005. And some multiyear landfast sea ice (MLSI) that had been there since the 1940s was lost from Yelverton Bay to the west of Ayles Fjord."

After georeferencing and projecting RADARSAT images (provided to the Alaska Satellite Facility by the Canadian Space Agency and its private partners) before and after the ice shelf breakup, Mueller imported the geographic TIFF (GeoTIFF) format into ArcInfo. With vector layers, such as coastline contour lines, from the Canadian government laid down, he traced polygons over the top of the RADARSAT images of the ice shelf taken at different times.



A Moderate Resolution Imaging Spectroradiometer (MODIS) image of the Ayles Ice Shelf breaking away from Ellesmere Island (August 13, 2005, at 20:45 Coordinated Universal Time (UTC). (Image courtesy of NASA.)

"Using GIS, I put down several images that I could flick back and forth showing where the ice was before any of the activity, calculated the square kilometers—the area of that polygon—then looked again and saw where ice wasn't located," he says. "Then we could essentially calculate the ice loss," which was about 54 square miles, according to Mueller.

"GIS also helps interpret satellite images," Mueller states. "What is good about that method is you can keep those polygons and flick the image to another time. Sort of like a time machine, you can flick backward in time and forward in time and watch for changes. And if you have a polygon or a vector overlay in ArcInfo, then you can look for your border underneath and, if it alters over time, you know you've got a change."

In studying the Ayles Ice Shelf breakup, the researchers found that factors in addition to possible long-term climate changes likely contributed to the calving.

In addition to higher-than-usual temperatures that summer, Ellesmere Island was struck by strong winds, according to Mueller. "A lot of the multiyear landfast sea ice broke away from the shore—from the front of the Ayles Ice Shelf—and a lot of the sea ice was pushed away as well," he says. "That was caused by very strong winds pushing offshore and alongshore. Those winds pushed away the sea ice, and that allowed the ice shelf itself the freedom to move away."

Though the new ice island stayed put in the summer of 2006, Mueller says it's not stuck permanently. "It may last another year. It may last another few months. It's not necessarily stable ice."

Even in winter, the humongous chunk of ice could begin moving again. "It's fairly exposed to all the currents that are churning around in that area," Mueller says.

Mapping Ice Types

Mueller also used ArcInfo several years ago when he mapped ice types while studying microbial mats on the ice shelves. Microbial mats, often present in extreme environments, are this planet's oldest known ecosystems.

"I was interested in looking at cold-tolerant organisms in ecosystems that are ice dependent, he says, adding that "microbial mats composed of algae, microinvertebrates, and bacteria are commonly found on the surface of Arctic ice shelves. The ice shelves are a unique habitat for microbial mats, which can perhaps provide some clues as to what types of life existed when the planet was younger and how that life evolved."

In ArcInfo, he mapped the ice types, such as the marine "basement" ice and the meteoric or atmospheric iced firn, and also noted the sites where he took samples of microbial mats. Mueller will use that map to refer to as he continues studying the changes in the Arctic ice shelves in the years ahead.

"I'm looking for baseline information on the cryosphere—the cold parts of the earth—to look for changes due to climate warming." He adds. "Ice shelves may be a valuable indicator of climate change. When the ice shelves disintegrate, it represents a loss of habitat." He is concerned that the ice shelves may completely break up within his lifetime based on predicted warming of the Arctic.

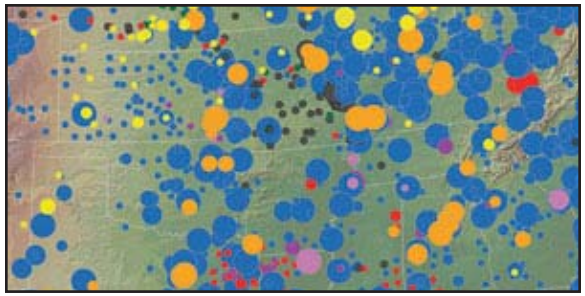
"Working to preserve habitats and biodiversity is important," Mueller concludes. "These ice shelves may harbor some cold-adapted organisms that could be interesting for biotechnology. Or you might simply value the habitats that we are losing from our landscape."

(Reprinted from the Spring 2007 issue of *ArcNews* magazine)

National Carbon Sequestration (NatCarb)

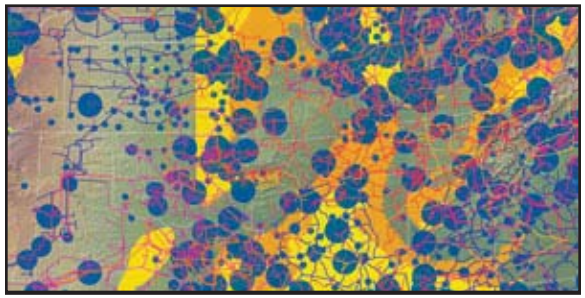
Kansas Geological Survey Data Access and Support Center

By Nicholas Callaghan

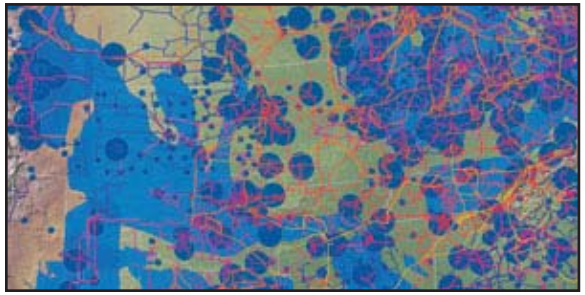


North American CO_2 Sources.

North American Saline Basins.



North American Power Grid with Coal Basins.



North American Power Grid with Saline Aquifers.

The U.S. Department of Energy's Regional Carbon Sequestration Partnerships (RCSPs) generated data for the layers displayed in the Carbon Sequestration Atlas of the United States and Canada. Geospatial data such as carbon sources, potential storage sites, transportation, and land use are required for efficient implementation of carbon sequestration on a broad scale. National Carbon Sequestration (NatCarb) is a relational database and GIS that integrates carbon storage data from the RCSPs and various other sources.

The purpose of NatCarb is to provide a national view of the carbon capture and storage potential in the United States and Canada. This digital spatial database allows users to estimate the amount of CO_2 emitted by sources (such as power plants, refineries, and other fossil fuel-consuming industries) in relation to geologic formations that can provide safe, secure sequestration sites over long periods of time. NatCarb provides access to the necessary information regarding the costs, economic potential, and societal issues of CO_2 capture and storage, including public perception and regulatory aspects.

Courtesy of Kansas Geological Survey at the University of Kansas.

(Reprinted from the *ESRI Map Book Gallery,* Volume 23)

Renewable Energy—No Longer the Impossible Dream!

GIS and the Science Behind Tapping Wind Power Offer Insight on the Resource's Feasibility

Highlights

- ArcGIS improves the quality and accessibility of data to maximize the efficiency of decision making.
- Nearly all the wind power facility layouts can be done with GIS.
- Locating the right site can be done quickly and accurately with publicly available data and GIS technology.

Just then they came in sight of thirty or forty windmills that rise from that plain. And no sooner did Don Quixote see them that he said to his squire, "Fortune is guiding our affairs better than we ourselves could have wished. Do you see over yonder, friend Sancho, thirty or forty hulking giants? I intend to do battle with them . . . With their spoils we shall begin to be rich . . ."

When Miguel de Cervantes wrote of the impetuous and noble hero Don Quixote 400 years ago, he could not have imagined that one day environmental scientists and energy analysts would "dream the impossible dream" of stocking the electric grid with the power of the wind. Nor could he have envisioned the hulking giants that now line many a horizon, the 400-foot-tall wind turbines each wielding three 130-foot steel blades and weighing 8.5 tons. When he talked of tilting at windmills, the Spanish literary master would not have guessed that public utilities, private companies, and investors would someday look to the wind to "beat the unbeatable foes" of waning fossil fuel supply and deleterious carbon emissions.

Wind energy now accounts for 1 percent of the United States' power supply, and forecasts from the U.S. Department of Energy say that figure could reach 20 percent by 2030. While wind farms crop up across the country's windiest terrain, critics point to the need for new transmission lines and the variability of the wind. Many citizens support the idea as long as it's "not in my backyard."

The Maple Ridge Wind Farm is a 321-megawatt project spanning the New York towns of Martinsburg, Lowville, Watson, and Harrisburg, about 75 miles northeast of Syracuse. The project produces enough electricity to power up to 160,000 average New York homes. Maple Ridge has increased the amount of wind power in New York by 600 percent. New York is a state with a 25 percent Renewable Portfolio Standard, designed to be in full effect by 2013.

Despite criticism, wind power is touted as one of the cleanest, most reliable renewable resources dreamed up so far. But is harnessing wind power on a wide scale as quixotic as dreaming the impossible dream?

In 2008, the United States surpassed Germany as the world's biggest generator by volume of wind energy. The amount of wind power the United States generates has doubled in the last two years, according to the American Wind Energy Association (AWEA), a trade group for wind power developers and equipment manufacturers. An investigation into the solid science of wind power facility development clarifies the potential and reliability of this blustery resource.

Twenty-eight U.S. states have set renewable energy mandates and are determined to woo wind developers. A Nebraska utility brochure boasts, "Nebraska has wind. In fact, the state ranks sixth in America for wind development." An energy company in Minnesota is announcing

plans to buy an interstate transmission line and develop wind energy to replace coal-generated electricity. One county in Montana is distributing a wind map book compilation of all necessary data to entice investors.

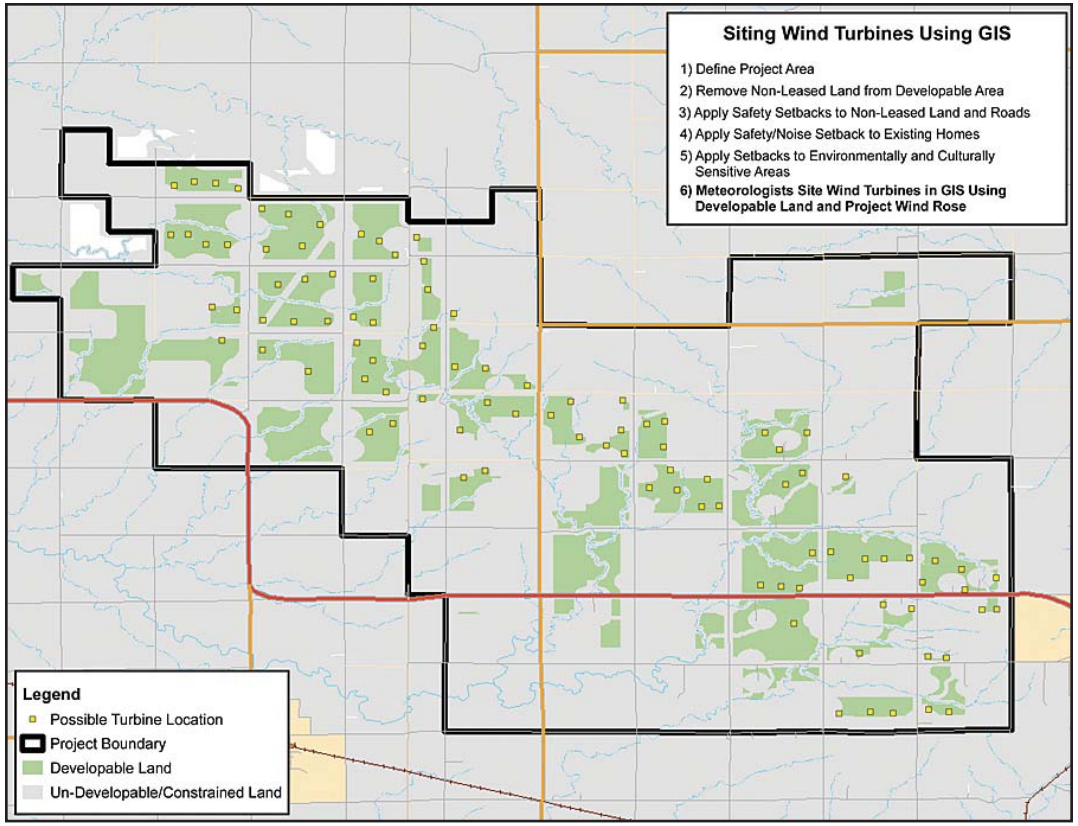
Harnessing the Wind

Wind turbines convert the kinetic energy in moving air into rotational energy, which in turn is converted to electricity. Humans have used wind power for centuries to move boats, grind grain, and pump water. Timeless and simple as it may seem, development of a wind power facility is much more complex than staking a pinwheel in the breeze.

Iberdrola Renewables is the largest developer of wind power in the world. It has a flurry of wind power projects in the works as utilities aim to reduce dependence on nonrenewable energy. Modeling the feasibility of these projects requires studying location, wind speed, environmental concerns, and other variables.

There was a time not long ago when the company's development teams of meteorologists, engineers, environmental permitting staff, and land agents only had paper maps to work from. These paper maps didn't show property ownership, wetlands, county- or state-required safety setbacks, rights-of-way, or environmental and cultural resource sites.

Knowing that there had to be a better way, Iberdrola investigated available technologies that would help it organize and analyze complex data and decided that GIS from ESRI, which was a familiar platform for engineers in the electric and gas industry, would dramatically improve the quality and accessibility of its data and maximize the efficiency of decision making. ArcGIS Desktop and ArcGIS Server became fundamental to the business model of the company.



This example of siting wind turbines with GIS shows six layers of data.

Smart Layers for Smart Maps

The life of a wind farm project starts with a look at potential plots of land. Most developers require land within a prescribed distance of a transmission line to tie in power to the grid. If the wind is strong and steady, developers may decide to build their own transmission line. By loading utility data into the GIS, researchers can quickly see existing transmission routes and estimate the benefits of accessing existing electric lines.

Another important consideration for developers is landownership. State and county land-use data in the GIS identifies areas under development restrictions from the Bureau of Land Management and those requiring right-of-way grants. If land is privately owned, developers will have to obtain consent from individual landowners.

A layer of constraints is added, marking areas that are environmentally protected for migratory flight paths or other animal activity. Other site restrictions are military bases and airports where developers must consider radar interference and Federal Aviation Administration regulations.

Wind data is equally crucial to researchers, who add a resource layer to ArcGIS detailing wind speed and reliability. Meteorological data is continuously collected during a one- to five-year period using tower-based anemometers and vanes mounted at several height levels up to 60 meters aboveground. Wind power can be classified into wind power density classes ranging from one (poor) to seven (excellent). For example, a wind power class of four has an average wind speed of 15.7 to 16.8 mph at a height of 50 meters aboveground. In addition to site research, meteorologists use wind data stored in ArcGIS Server to help design the layout of a wind farm by identifying wind direction, strength, and location.

Site Scouting Field Trip

"Almost all the wind power facility layouts can be done in the GIS, with maybe one or two visits to the field," says Tyler Hoffbuhr, GIS analyst and manager with Iberdrola Renewables. "Now we can stock the GIS with U.S. Geological Survey maps, property lines, aerial photography, and detailed topography data to see how the buildable area matches up with the wind data."

When development teams visit a proposed location, they collect site-based data to compare with digital information and maps within the GIS. Using a mobile device equipped with GPS and GIS, the team is able to update data from the site and make any necessary adjustments to the facility layout.

"GIS enables us to reach our goal of finding the best wind areas while causing as little impact as possible to wildlife and the environment," says Hoffbuhr. "Locating the right site can be done quickly and accurately with publicly available data and GIS technology."

In total, wind power facility development is about a four-year process that involves the site research and data collection, as well as procurement of government permits, landowner permission, funding, and the physical resources. When the plans are ready, developers hand over the project to the construction team.

"Once all the initial research is done, construction of the wind power complex happens quickly, sometimes in four to six months," says Laurie Jodziewicz, manager of siting policy, AWEA. "Projects under construction right now will be online and delivering energy within a year or less."

Once a wind farm is up and running, operators continue to use GIS to help gather inspection and operational data. Since wind energy is variable, utility companies have to figure out what

to do when the wind does not blow. With ArcGIS technology, operators can model and predict how well the wind will perform in the next few hours or days and accurately match energy production with demand.

But Will It Work?

Healthy government incentives are driving much of the wind power development in the country. A report led by the Department of Energy's National Renewable Technology Laboratory in Golden, Colorado, reiterated predictions that wind energy will claim a 20 percent share of electricity production in the next 10 years. The report called the forecast "ambitious," but "feasible."

The energy industry is already on board with more than 9,000 new wind farms under construction in the United States and nearly 20,000 existing.

"With sophisticated site development technology and incredible wind resources, wind energy is becoming increasingly valuable," said ESRI's utility industry expert Bill Meehan. "We are now seeing utilities integrate wind power into the electric system to supplement fossil fuels. Wind is a cost-effective, nonpolluting energy source that will continue to be one answer to international energy concerns."

The Elk River Wind Project is a 150-megawatt wind energy project located in Butler County, Kansas

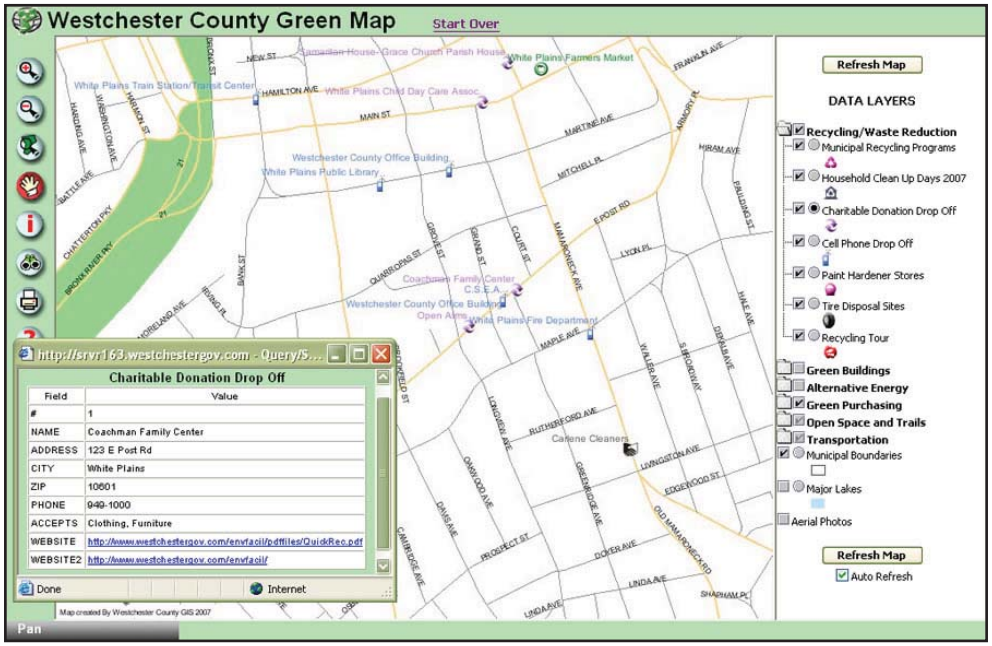
(Reprinted from the Fall 2009 issue of *ArcNews* magazine)

Westchester County's Green Map Aids County Global Warming Task Force Plans

By Maggie Jones, ESRI Writer

Environmentally conscious staff members of Westchester County GIS in New York State have found a way to raise awareness about global warming in their community. They have created an online Green Map (http://greenmap.westchestergov.com/) that allows residents to see resources that support green practices such as recycling centers, tire disposal sites, and farmers' markets.

The map service utilizes ESRI's ArcIMS software along with technology from Green Map System, Inc. (GMS), an organization devoted to developing sustainable communities with mapmaking tools that increase awareness of local conservation opportunities.



Users can query the features using the Identify tool. Links to relevant Web sites can be accessed for more information.

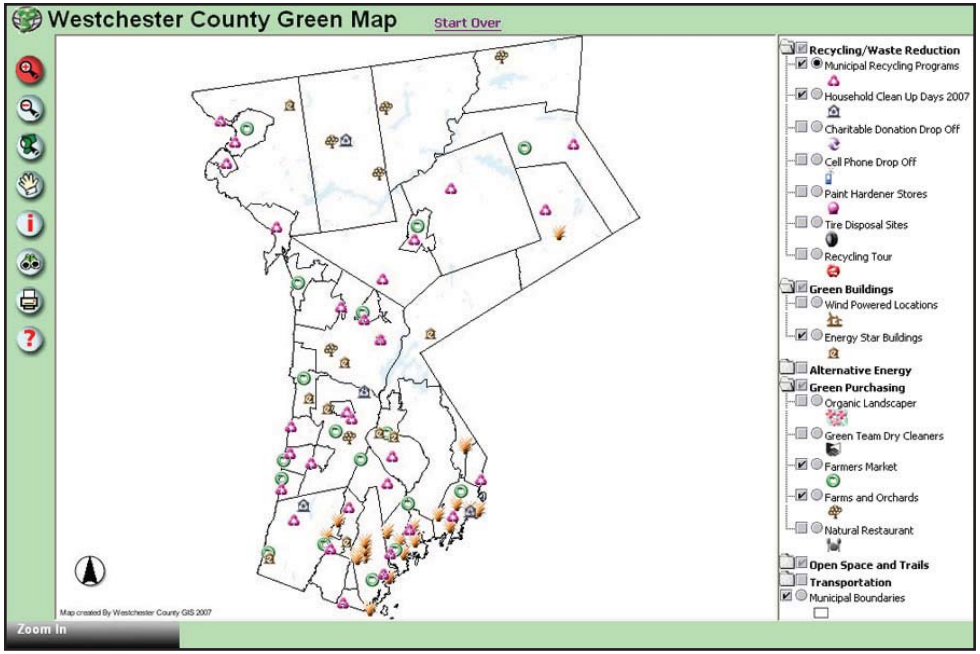
More than 900,000 people live in Westchester County, which borders New York City. As a densely populated county, it finds following environmentally friendly practices necessary for sustainable living. The county's interactive Green Map was launched as part of county executive Andy Spano's Global Warming Task Force, whose mission is to create a countywide action plan to reduce greenhouse emissions and promote sustainable development through awareness and education.

The Green Map helps residents find environmentally friendly and green resources that are available in their own community. Viewers can select the category they want, such as bus stops, tire disposal sites, farmers' markets, or green buildings, and find the nearest and most accessible locations.

Users also have the option of viewing aerial imagery on the map.

Designed for easy navigation, the map lets users simply select the resources they wish to see labeled, find the most convenient location, and zoom in until they can see the exact place (e.g., intersection or street name). Users can display or hide features on the map, as well as find out more about anything that interests them, by clicking a link to source Web sites. Residents frequently visit the site to find the closest farmers' markets, cell phone recycling locations, or hazardous household chemical disposal sites. If county residents would like to spend time outdoors, they can also use the Green Map to search for local parks and nature reserves.

The Web site supplies community members with downloadable datasets for each of the categories represented on the map. The site provides detailed information about the dates and locations for household cleanup days and other green activities, which are also displayed on the map. The ArcIMS software-based application enables users to browse, query, and print their maps. In contrast to traditional Green Map publications that usually appear in either hard-copy format and/or Adobe Acrobat PDF, the online map gives users a more accessible, intuitive, and interactive look at the county and its local resources. Additionally, Westchester County's GIS specialists can easily add or update features as needed and are able to display any amount of data without crowding the map or simplifying the data, which often occurs with printed maps.



Westchester County's Green Map application highlights facilities, programs, and services that encourage greener living within the county. Here, the pink triangles represent municipal recycling programs, the green circles are farmers' markets, the trees are farms and orchards, the houses represent locations for household cleanup-day events, and the orange flora represents the locations of the county's aquatic restoration sites.

"It is a resource for anyone who wants to find out how to make their household and community more environmentally friendly places to live, work, and play," said Cynthia Louie, GIS specialist for Westchester County, adding that public involvement in conservation practices has increased since its implementation. By taking climate change issues into its own hands, Westchester County is leading the way for other local and regional governments that want to find a way to develop more sustainable practices.

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