GIS for Agribusiness

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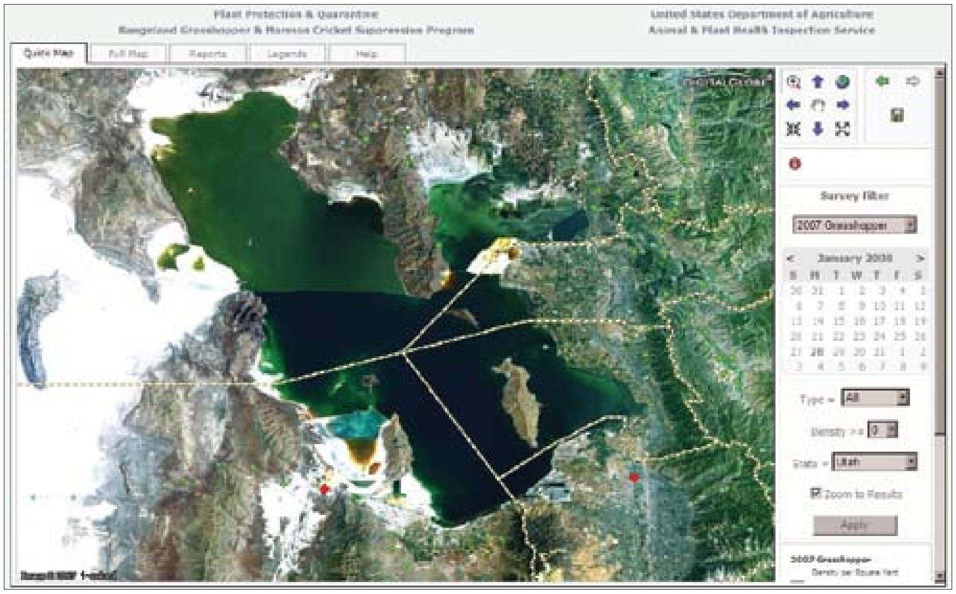
In This Issue

USDA APHIS Uses GIS Web Technology for Plant Protection Program

Protecting the nation's croplands from infestation has become a high-tech battle wherein government agencies are deploying spatial sciences to locate and monitor agricultural pests. An essential component in this campaign is geographic information system (GIS) technology, a computer-based geographic tool that can access a database and dynamically display its data in an interactive on-screen map. Recent advancements in Web technologies have made it possible for more people to input crop and infestation information into databases and, in turn, generate crop management maps from them.

The U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has been using GIS for years to map infested areas and plan treatment programs. The relationships between features on a map communicate necessary and strategic information. Because APHIS' charge is to safeguard agricultural and natural resources from the risk of animals, plant pests, and noxious weeds, it has a lot of data and a lot of geography to consider. APHIS managers and researchers working in the agency's Plant Protection and Quarantine (PPQ) program rely on GIS to monitor pest and weed activities. Four years ago, researchers used GIS to study the effects of the emerald ash borer on ash tree populations by layering data such as tree crown measurements, aerial images taken in different seasons, and water availability. The researchers could then determine what variables were increasing the risk of ash borer tree damage.



U.S. Department of Agriculture Animal and Plant Health Inspection Service uses GIS to show rangeland grasshopper and Mormon cricket trap activity and propose treatment plans.

Welcome to *GIS for Agribusiness*

Welcome to the first edition of ESRI's semiannual newsletter *GIS for Agribusiness*. We hope that you will enjoy these articles about how GIS is helping people working in the agriculture industry gain advantages from geospatial technologies. Learn more at www.esri.com/agriculture.

Barbara Shields, Editor

The next year, PPQ staff used GIS to manage the impact of the Asian longhorn beetle in New York. This time, a wider variety of data layers was accessed. Using geographic information layers such as tax maps and building footprints, researchers located properties within the Asian longhorn beetle quarantine areas and created maps for scheduling survey and chemical treatment operations.

These types of studies were performed with desktop GIS software, but soon USDA staff implemented GIS-enabled Web applications, making it possible for more PPQ staff to use the geographic approach to pest management. This created a change in the way the agency conducts its programs. Once it began using

continued on page 2

continued from page 1

USDA APHIS Uses GIS Web Technology for Plant Protection Program

ESRI's Internet mapping software, ArcIMS, APHIS was able to deliver data to more people. With the release of ArcGIS Server 9.1, APHIS came to another GIS milestone by introducing ArcGIS Server technology into its Rangeland Grasshopper and Mormon Cricket Suppression Program. Currently, APHIS manages 17 states affected by this infestation. The server technology opens a door for in-depth applications of geographic data.

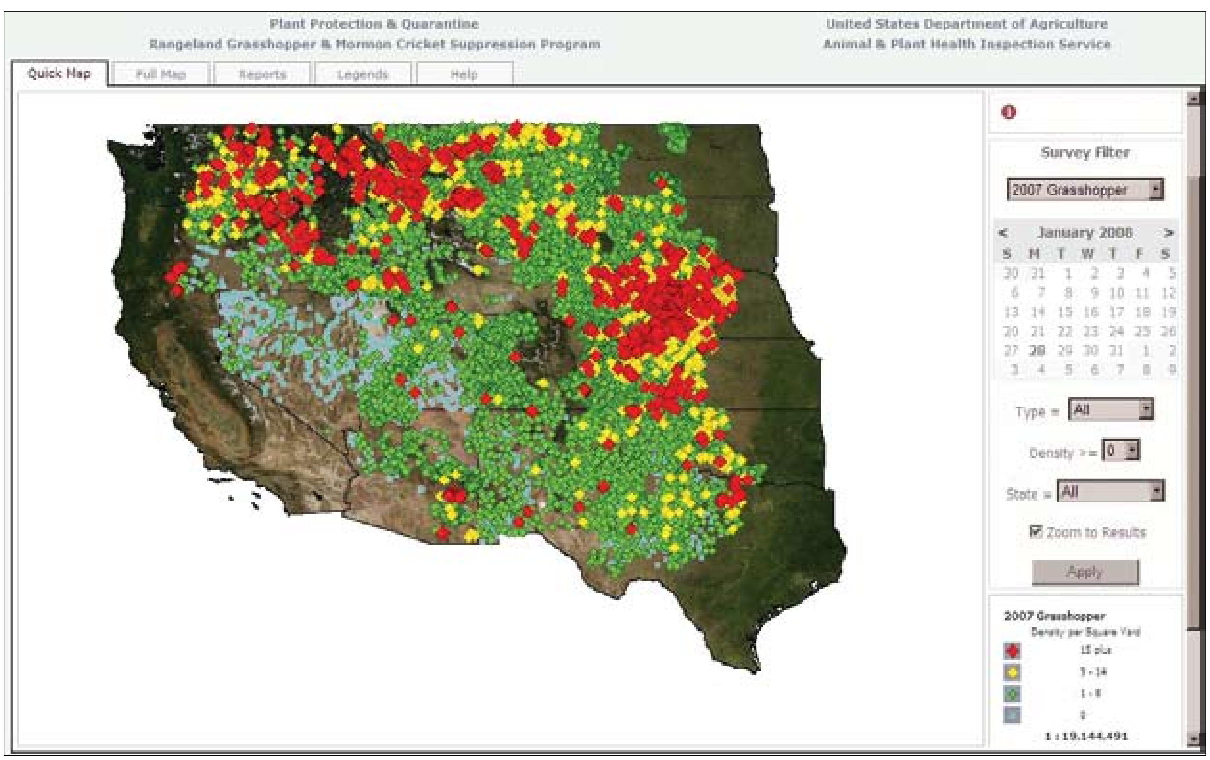
Botanists, entomologists, veterinarians, and a host of other professionals who have little knowledge of how GIS works can use such technology for research, management, policy making, and other USDA activities. These users can simply access APHIS data via their browsers to study attribute variables and geographic relationships. Furthermore, the software makes it fairly easy for APHIS' GIS developers to create dashboards and tools for online users to work with a variety of databases.

For the Rangeland Grasshopper and Mormon Cricket Suppression Program, PPQ field agents use mobile GIS tools for ground survey tasks. To study grasshoppers, field survey crews use handheld devices to record pest-related data and pest locations. PPQ devised a digital form that works on a mobile device integrated with a GPS. The field surveyor can capture x,y location data while inputting other pest surveillance data required by the PPQ Integrated Survey Information System.

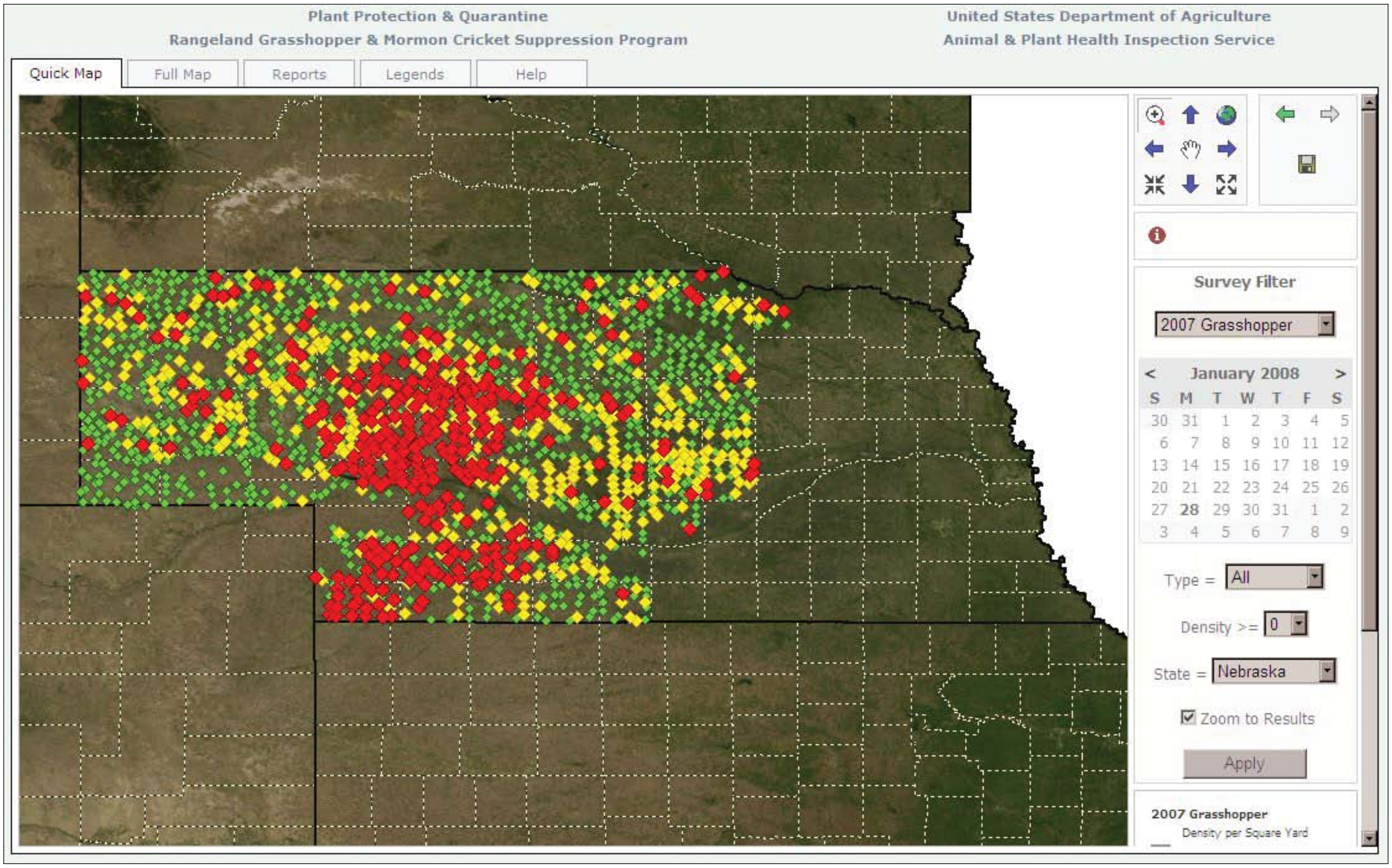
The mobile tool uses a synchronization service, which aids mobile technology by managing the input of field data into the Microsoft SQL Server database. In other words, this process makes it possible to synchronize data gathered in the field to the PPQ database over the APHIS network. More than 30,000 point locations are synced over the network during the season. Spatial Database Engine functionality within ArcGIS Server enables GIS to easily manage large amounts of the data and associated attributes and metadata. This allows program managers to easily get to the exact information they need for their management decision making and report outputs via the Web mapping application.

The national program director for the Rangeland Grasshopper and Mormon Cricket Suppression Program in the Washington, D.C., area uses GIS-generated maps to meet the demand of the U.S. Congress. The maps provide a cumulative view of infestation data by area. Data can be queried via a variety of filters including dates, pest density, location by state, and grasshopper life stage survey information. The national program director can easily create his own map products for USDA meetings and fill congressional requests. Having the mapping capabilities at his disposal, he regularly provides updates at the secretary of agriculture's Drought Task Force meetings. This task force is convened to inform the secretary of activities within USDA agencies that assist growers and ranchers in drought-stricken regions.

Grasshopper and Mormon cricket outbreaks can be exacerbated by drought conditions. Therefore, the task force meets twice monthly, and the APHIS Rangeland Grasshopper and Mormon Cricket Suppression Program provides updates about the current status of grasshopper populations and their potential for causing economic damage to ranchers. The survey maps are the most effective way to convey a large amount of information in a short period of time. In addition, the survey maps are provided to congressional staff members during the annual budgeting process. Rather than rely on lengthy text descriptions on the status and outbreak potential of the grasshopper populations, staff can review maps that convey this



This GIS-generated map shows grasshopper density per square yard (blue is 0 and red is 15 plus) and makes obvious those areas where Congress needs to direct treatment funding.



GIS maps are available on the Internet thanks to ArcGIS Server technology. On this Nebraska map, a defined area is displayed. The reader can choose to see specific pest data, such as insect type, date, density, and state, on the interactive map. Standard GIS reader features, such as pan and zoom, improve the view.

information, ensuring better-informed decisions regarding the need for funds to combat grasshopper outbreaks in the upcoming year.

Laura Stretch is the APHIS regional GIS manager for the PPQ Western Region. "The advantage of ArcGIS Server is that it is enabling our field specialists, managers, and researchers to access a larger variety of data on their own," says Stretch. "This makes it easier for them to extend their ability to manage PPQ programs. As we build on our GIS infrastructure, we can digitize and capture information about treatments and determine the most appropriate places to perform surveys. We are able to use ArcGIS Server to create tools for this. ESRI's GIS software has scalability, which means that as more people take a geographic approach to their work, the system grows to accommodate their demands. This leads to geographic data being leveraged in ever-widening fields of analysis, from biological to political and environmental projects. The capacity in technology that we've been waiting for since Internet mapping first started is now available through the ArcGIS Server environment."

"We are in the midst of evolutionary change, enabling field surveyors and managers to better perform their surveillance work," Stretch explains. "We do not want to encumber busy program and field personnel by requiring them to learn the many nuances of GIS. Fortunately, they won't have to, because this server platform will empower the field force and decision makers by giving them information and user-friendly tools that will help them make informed decisions."

This evolution is evidenced in the way PPQ professionals are now approaching their work. With new technologies at their fingertips and data becoming more readily available via a browser, the possibilities for improved program management and research are infinite. An important component to sharing data is open architecture, which is basically an open-arms technique that enables users to access geodata developed by others without having to go through a complex data conversion task.

GIS software developers and application developers are moving away from designing incompatible data models to those built on industry standards that support sharing. This is essential to Web data access. This open architecture approach will allow APHIS to work not only within its own agency but also with many government agencies in using GIS for cross-disciplinary purposes.

"Once our infrastructure is in place, using ArcGIS Server, we plan to continue designing tools and making them readily available to PPQ staff and other users," notes Stretch. "We can customize them for local events while maintaining the overall database. Furthermore, the templates and methods we design for studying one type of infestation, such as the Mormon cricket, can be adapted to manage other types of infestation such as the light brown apple moth. It can be adapted to any type of pest species. The flexibility of our GIS to scale and change with our current needs helps us respond by creating plans, developing goals, and opening up data for other scientists and decision makers to explore."

Send inquiries about GIS and the USDA APHIS project to Laura Stretch, laura_stretch@aphis.usda.gov.

ESRI on the Road

ESRI Europe, Middle East and Africa User Conference 2008
October 28–30, 2008
London, England
www.esriuk.com/emea2008

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

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

GIS for Agriculture Is on the Web

People working in the field of agribusiness are applying GIS to improve crop management, business strategies, and communications. Visit ESRI's GIS for Agriculture on the Web to read about solutions for production, agribusiness inputs and outputs, research, and government. View demos, read case studies, and keep up on the latest GIS news. Visit the Web site at www.esri.com/agriculture.

GIS for the United States Department of Agriculture

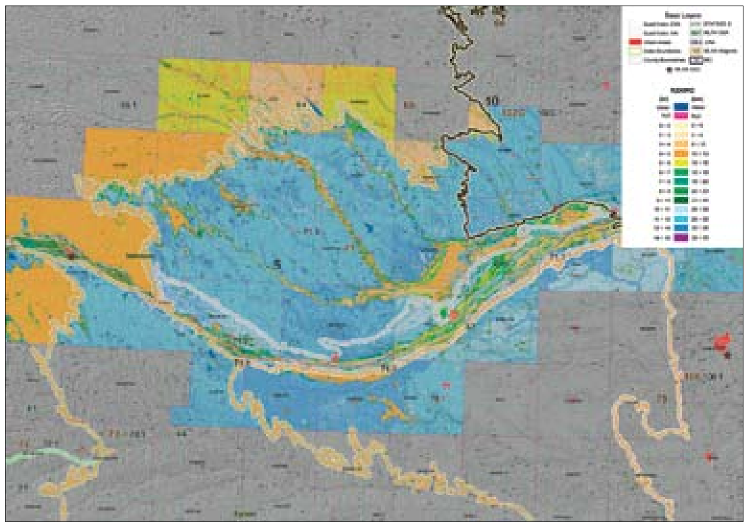
ESRI's Best Practices Series

This collection of articles related to GIS for the United States Department of Agriculture shows how a government agency uses GIS in many ways. This booklet provides government officials with examples of how to use GIS to manage large volumes of agricultural data for a variety of purposes, from assessing nationwide land use to site-specific concerns. Download the *U.S. Department of Agriculture* Best Practices booklet at www.esri.com/showcase/best-practices.

GIS Showcase: Soil Root Zone Available Water Capacity: Central Nebraska Loess Hills

This Root Zone Available Water Capacity (RZAWC) map of Central Nebraska Loess Hills is from a collection of interpretive maps illustrating the application of detailed soil survey information obtained from the Soil Survey Geographic Database (SSURGO) for natural resource planning.

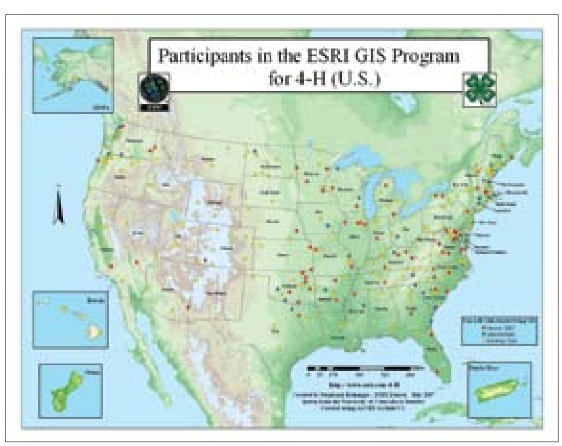
Available water in the surface layer is critical to establish plants, but the amount of available water stored throughout the root zone usually determines the most productive soils.



Courtesy of USDA Natural Resources Conservation Service–National Geospatial Development Center.

ESRI 4-H and Youth Community Mapping Program

ESRI is pleased to have offered a 2008 GIS grant for U.S. 4-H programs. More than seven million youths benefit from the national 4-H mission to empower young people to reach their full potential by participating in community engagement and service projects with caring adults. ESRI helped establish the GIS program for 4-H to bring GIS and other geospatial technologies to young people across the nation while fostering the 4-H goals of learning, mastering skills, and demonstrating generosity as well as encouraging independence and a sense of belonging in the community. The grant enables youth in more than 500 U.S. counties to use GIS in their community service projects. It was created and launched by the national 4-H headquarters; the Cooperative State Research, Education, and Extension Service; and the U.S. Department of Agriculture (USDA). To learn more about the grant and 4-H GIS projects, visit www.esri.com/industries/k-12/4-h.



The GIS program aids youth community service projects in more than 500 counties.

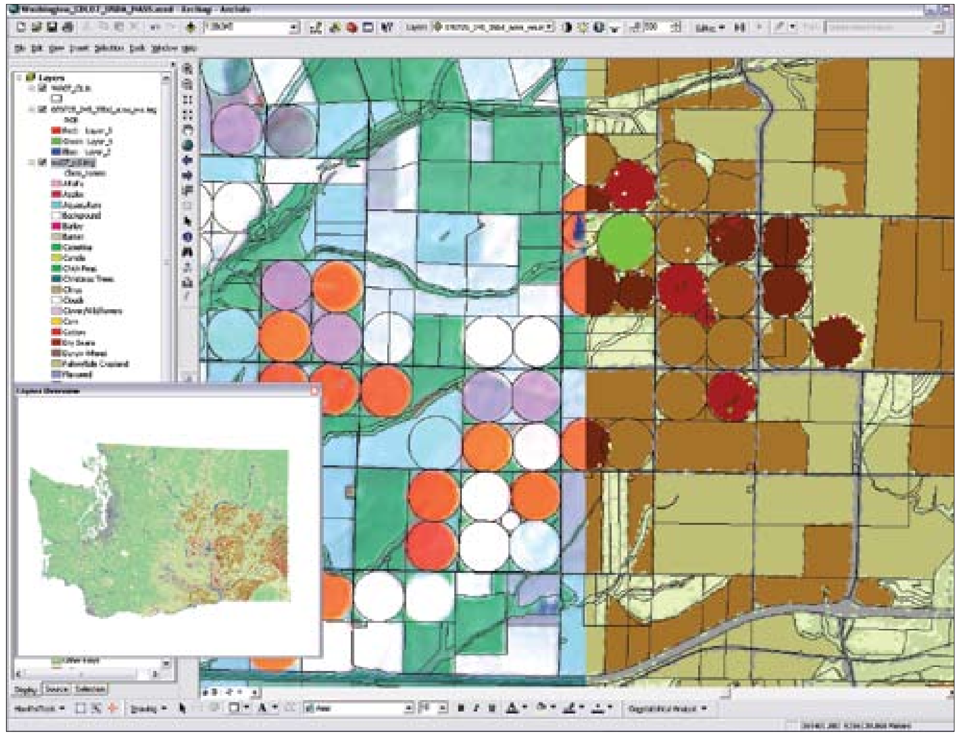
Agribusiness Grows with Crop-Specific Maps

U.S. Farmland Data Layer Available for Download

By Jessica Wyland, ESRI Writer

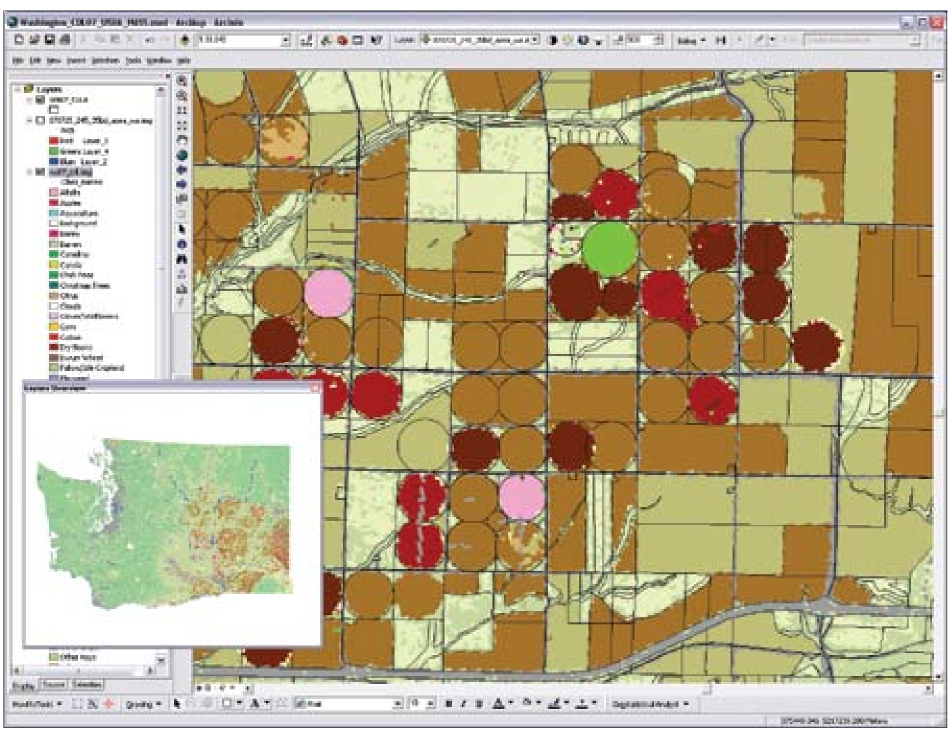
Crop-specific maps, created by combining survey data and satellite images, provide a literal lay of the land for farmers and agribusinesses such as seed and fertilizer companies. Crops grown in the U.S. Corn Belt and Mississippi River Delta areas are mapped extensively in the Cropland Data Layer (CDL), now available for download or on disc from the U.S. Department of Agriculture (USDA)/National Agricultural Statistics Service (NASS). Geographic information system software from ESRI is used to prepare and manage data and to build geospatial snapshots of cropland.

"The Cropland Data Layer has many possibilities inside and outside the farming community," said Rick Mueller, a GIS expert with NASS. "It can be leveraged in a GIS to perform spatial queries against other enterprise GIS data layers. It could be extracted and used as a mask so public or private entities could focus solely on their own interests by eliminating all cropland areas to assess urban sprawl, watershed analysis, or deforestation."



A combination of the Washington 2007 Cropland Data Layer with raw AWiFS data taken on July 25, 2007, is shown with a Common Land Unit overlay using the swipe function. The band combination displayed is 3,4,2.

Other uses for crop-specific maps include water quality assessments; monitoring of watersheds; agribusiness facility location; transportation, routing, and forecasting; studies of crop rotation patterns and migration trends; pesticide applications; wildlife habitat observations; and determination of crop stress or blight locations. Enhancing a GIS with land-cover data layers has proved helpful to farm growers' associations; crop insurance, seed and fertilizer, and farm chemical companies; libraries; universities; federal and state governments; and value-added remote sensing/GIS businesses.



A section of the state of Washington is shown in the NASS 2007 Cropland Data Layer with USDA/Farm Service Agency Common Land Unit data overlay.

For each state in the Corn Belt and Mississippi River Delta areas, the CDL provides the rasterized data, categorization accuracy statistics, and ancillary vector shapefile data layers. The CDL download or disc includes ESRI's ArcReader freeware and an ArcReader project that bundles the raster and vector datasets together for display in ArcReader.

"ArcGIS Desktop from ESRI makes it possible for us to create resourceful maps to identify the spatial extent and associated acreage of the crops grown in these specific states," said Mueller. "ArcReader freeware ensures that anyone can access the data."

continued on page 7

Study of Soil and Landscapes Improved with GIS Visualization

By Barbara Shields, ESRI Writer

Understanding how soils occur in the field and vary across landscapes is a critical skill for today's agronomists; therefore, it is an integral component of the curricula at Purdue University in Indiana. Students use geographic information systems in the classroom and in the field, which helps them better understand soils and the landscapes in which they occur and recognize geological features that indicate different soil types.

Soil Classification, Genesis, and Survey, a class taught by professors Darrell G. Schulze and Phillip R. Owens, incorporates the latest version of ESRI's ArcGIS software to study the relationships between soils, topography, land use, and geology. The teachers use GIS to share data with the students who, in turn, use it to observe different points in the landscape. At the beginning of the class, most students know little about geography and GIS; by the time they complete the course, they are able to access geographic data and view it with GIS tools.

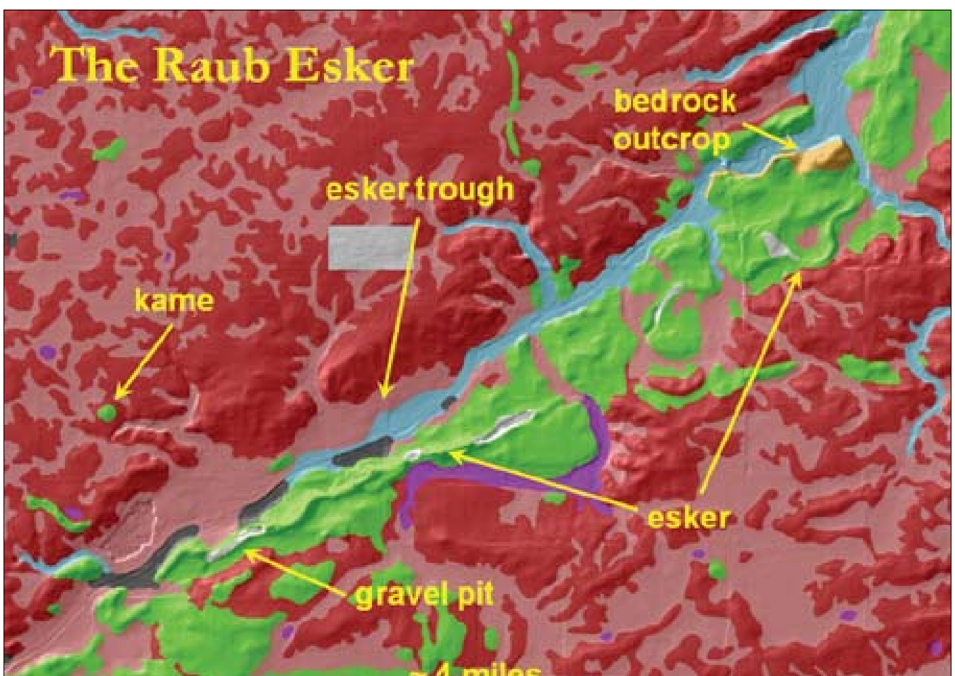
Schulze accessed the U.S. Department of Agriculture's (USDA) soil survey data as well as data from the Indiana Spatial Data Portal and the Indiana Geological Survey. "This data is robust," notes Schulze. "In 2007, the USDA completed digitization of soil data for Indiana. Now I can access soil data for any county in the state." Schulze took on the task of downloading this data along with high-quality aerial photography and high-resolution digital elevation models (DEM). Using GIS to aggregate the data in various ways that fit class objectives, he created multiple useful data files. For example, he created a dominant soil parent material model that groups polygons so that students could see relationships that are not readily apparent from traditional representations of soil survey data.

With GIS, students are able to visualize the geomorphology of their study area. Owens states, "Students easily relate to the features they can see while they are standing in a field; however, larger landscape features that occur over kilometers are much more difficult to immediately understand. Teaching soil geomorphology using Tablet PCs and GIS provides the students with tools to see relationships over large distances and has revolutionized our ability to teach spatial relationships." They can see, for instance, that Purdue is located in a part of the world that was glaciated 20,000 years ago and understand close correlations between the soil parent material and the surficial geology. The DEMs highlight relevant topographic variations. By comparing this information with soil data, students can make conjectures about how geological phenomena have affected soils. For example, the students can also see that soils formed on dense glacial till—which was smeared down and compacted by ice as a glacier moved along its path—are wet because water cannot move readily through dense till. Sandy and gravelly soils formed on the outwash deposited by rapidly running water from the melt are better drained and do not have a high water table in the winter like the soils on a glacial till do. GIS shows how the difference in the internal soil drainage class of those soils is influenced by the different parent soil materials.

By projecting the desktop PC display onto a screen, the teacher demonstrates GIS operations in the classroom. Students become familiar with using basic viewing features, such as zoom in and pan, and toggling layers on and off as they begin to review datasets and relationships. They also see how to access data with ESRI's ArcExplorer and import it into their map projects.

During the normal weekly three-hour lab periods, the class goes on field trips near campus. Students take along assigned ruggedized Tablet PCs, which are loaded with ArcGIS and integrated with GPS, as they drive to locations near campus. There, they examine soil pits to study soil types.

Later in the semester, the class goes on two all-day field trips. Students travel north by bus from Lafayette, Indiana, to Lake Michigan on the first trip, and as far south as Bloomington, Indiana, on the second trip. Class time is continued while traveling on the bus, and students are literally oriented as they follow their routes via the GPS and ArcGIS interface on their Tablet PCs. The bus has a monitor on which the teacher continues to teach soil-to-geology relationships.



The clear imagery of a GIS-created map highlights key data elements such as the characteristics of the esker.

Purdue students take GIS on the road to better understand the real world of soil assessment via digital data.

GIS loaded on a ruggedized Tablet PC allows users to view specific data in the field to determine soil characteristics and perform analysis.

Students can explore the lesson and make observations on their Tablet PCs. "While we are traveling to our destination, I use GIS to display the outcome on a monitor mounted in the bus. We can show them how to read the landscape," Schulze explains. "They learn that a slope or a particular shape of a hill was formed by a particular geomorphic process and can then deduce the material that is underneath. They learn to recognize, for instance, an esker, which is a long, skinny hill that has sand and gravel under it where there was once water flowing under the ice. Using their Tablet PCs, they can compare the virtual esker with the reality of the landscape. GPS indicates, in real time, where they are on the map, verifying their interpretation of what they are seeing. Using these tools in the field makes topics much clearer than trying to understand the material from a textbook, where these connections are more abstract."

Purdue is located in Tippecanoe County. In the western half of the county, a lot of the soils have been formed under prairie vegetation, giving them dark-colored surfaces. In the eastern half of the county, soils formed under forest vegetation and have a lighter color. The prairie soils tend to be slightly better for growing crops because they are higher in organic matter and, overall, the topsoil has better physical properties. Forested soils are more prone to crusting. This type of soil identification can help agronomists predict crop yield. These delineations are made obvious to students out in the field, who can then make map-to-reality comparisons.

Newly released data, map products, and models continue to advance with each new class. Schulze is currently working on an application with which students can click on a polygon to query the attribute table as well as click on a link that leads them to a schematic diagram of a soil profile illustrating what the soil looks like below the surface.

"Two approaches can be taken in using GIS for education," explains Schulze. "One is teaching about GIS and how it works, and the other is using GIS to teach agricultural concepts. In the latter, teachers design maps for students and put them into a format that works well for the specific class. The data is preassembled and put into a format that works easily for the student and helps the teacher focus precisely on the topic. Students' hands-on use of GIS-loaded Tablet PCs reinforces concepts from the lecture. GIS is helping us teach concepts in our class that would otherwise take students years of field experience to acquire."

Learn more about ESRI's solutions for agriculture at www.esri.com/agriculture.

continued from page 5

Agribusiness Grows with Crop-Specific Maps

Each year, the Cropland Data Layer Program focuses on corn, soybean, rice, and cotton agricultural regions to produce digital categorized, georeferenced output products. ESRI's ArcGIS Desktop is used to manage and edit ground data. The layers are built with imagery from the ResourceSat-1 Advanced Wide Field Sensor (AWiFS), owned by India. ESRI's ArcMap is used to build the maps.

The datasets were created as an offshoot of the Acreage Estimation Program, historically used for its statistical methodology and ability to produce acreage estimates in table/spreadsheet format. Since functionality was extended into the GIS world, users are able to export categorized images to commercial vendor formats for creating mosaics. Once the images are stitched together, the next step is to bundle the data and distribute it within the agency and to selected researchers in the GIS community.

The Agricultural Statistics Districts (ASD), county boundaries, major roads, railroads, hydrography, and the NASS Area Frame Land Use Stratification of any chosen state could be included in ESRI's shapefile format. All shapefiles except the Area Sampling Frame were accessed on the National Atlas Web site.

An ASD is defined as a contiguous group of counties having relatively similar agricultural characteristics. Distinctions used by NASS usually place each state into as many as nine agricultural statistic districts to simplify data comparison. Each district is more homogeneous with respect to agriculture than the state as a whole. The districts are usually numbered first from west to east, then from north to south. The ASD shapefile of the United States is available for download.

For more information or to download the Cropland Data Layer, visit www.nass.usda.gov/research/Cropland.

For more information on GIS for agriculture, visit www.esri.com/agriculture.

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