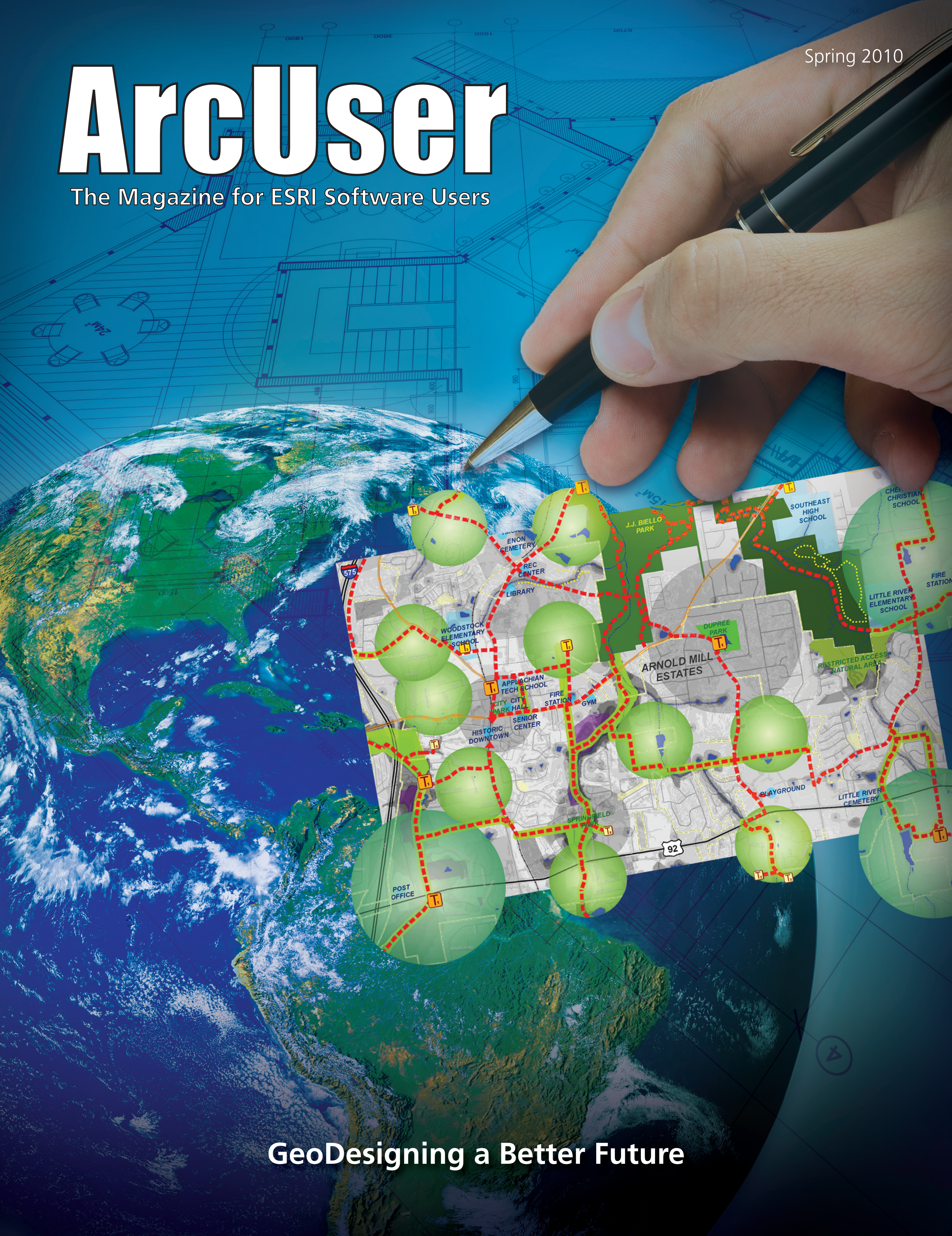
Spring 2010

ArcUser

The Magazine for ESRI Software Users



GeoDesigning a Better Future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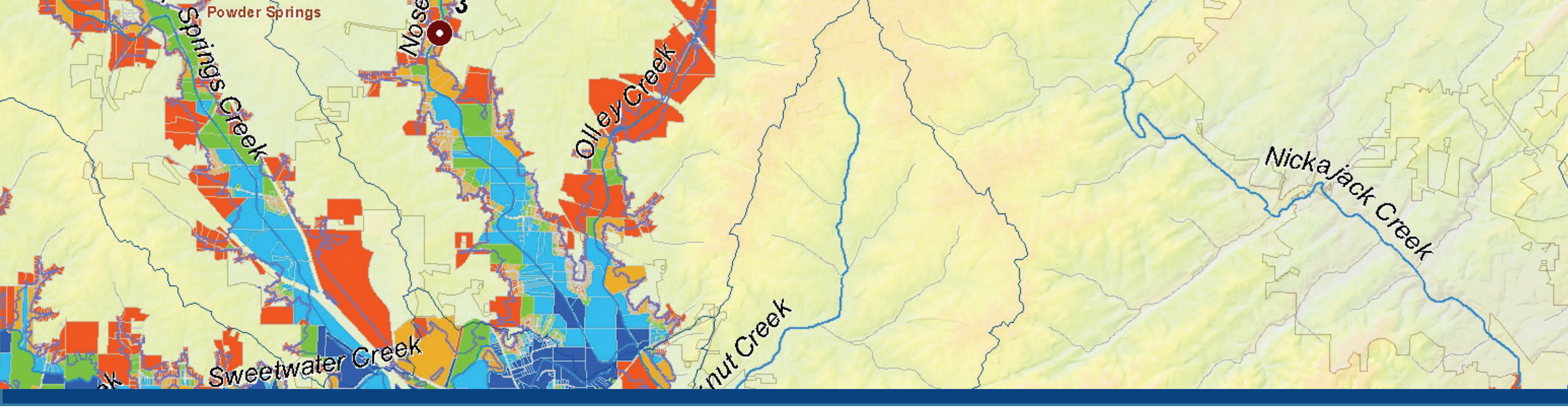

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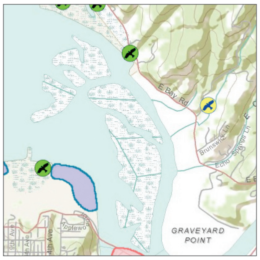
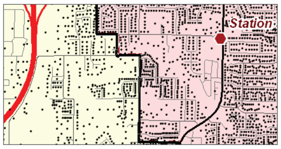
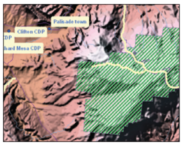
GeoDesigning a Better Future

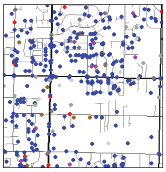
FEATURE

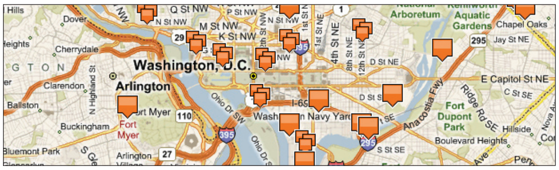
SPECIAL SECTION











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Collaboration
Is No Longer Optional

Although we cling to the romantic image of the lone scientific investigator uncovering some fundamental truth, the current model of scientific investigation is better represented by the Large Hadrain Collider (LHC). The world's largest and highest-energy particle accelerator, LHC will be used by more than 10,000 researchers in 85 countries to test predictions about the nature of high-energy physics when it goes back online. Michael Goodchild, in his address at the Space-Time Modeling and Analysis Workshop held in Redlands, California, in February 2010, reminded attendees of this reality and asserted the important work in science is being conducted by teams that are making discoveries about complex systems. Scientific teams making these discoveries require "powerful data acquisition systems and sophisticated tools, and when these systems are embedded in geographic space-time; they need GIS."

GIS has been instrumental in giving us a greater appreciation of the complexity and interdependency of many systems—ecological, geologic, and social—and the challenges facing those systems. It has been tremendously useful in managing and analyzing the myriad of measurements we've been collecting relating nearly every aspect of the planet.

The vision of a societal GIS has been around for more than a decade. However, recent developments have made that vision much closer to reality. Now Web, mobile, and the Cloud are viable platforms for accomplishing GIS work. But it is the advent of GeoDesign in combination with these platforms and the new GIS tools being developed that are making GIS a more powerful collaboration tool for GIS professionals and more accessible to nearly everyone. As Jack Dangermond has observed, GIS isn't touching just a few researchers, GIS professionals, or those who work with geographic information, "but it's infecting and affecting virtually everything that people do."

These developments will make GIS more effective in modeling outcomes and shaping human actions to take into account consequences. By making the results of science more comprehensible, GIS has the potential to engage science with policy and avoid that frustrating situation in which, as Goodchild said, "science ends when discoveries are in the pages of refereed journals." The new generation of GIS is coming full circle by supplying the tools and platforms that can fulfill the original vision of the role of GIS as a way to design a better future for the planet.

Monica Pratt

Monica Pratt
ArcUser Editor

editor's page

ArcUser
The Magazine for ESRI Software Users

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DEPARTMENTS

SOFTWARE AND DATA

MANAGER'S CORNER

HANDS ON

BOOKSHELF

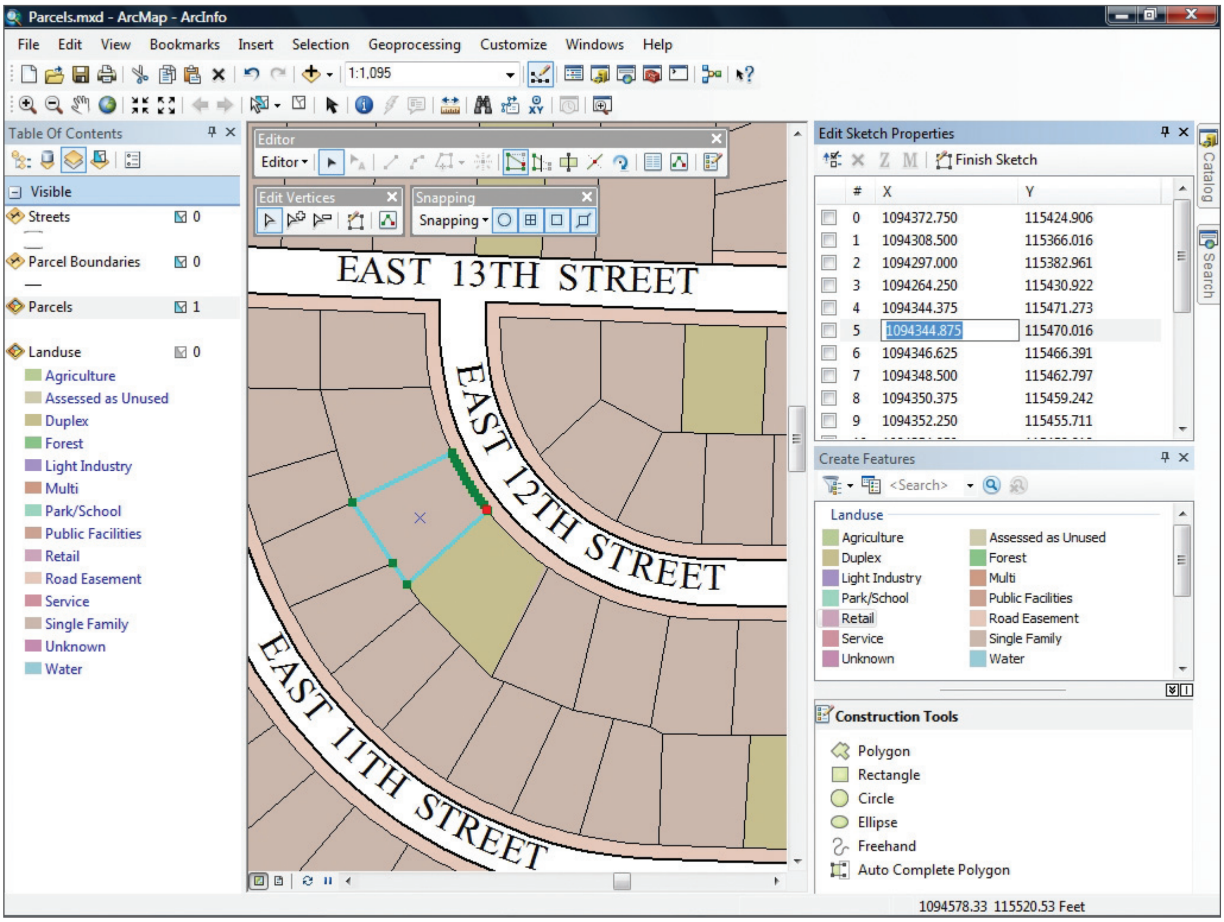
USER

EDUCATION

END NOTES

ArcGIS 10 Will Transf

A simple and pervasive system



The new editing environment in ArcGIS 10 lets users accomplish editing tasks in a more intuitive, task-based manner.

ArcGIS 10 implements a vision of GIS as a simple and pervasive system for using maps and geographic information.

This release was called ArcGIS 9.4 in the beta phase. However, feedback from more than 2,000 beta participants indicated this update—featuring hundreds of improvements—should be called ArcGIS 10.

ArcGIS 10 will make GIS easier, more accessible, and more collaborative. It employs a much simpler user interface—a map. This map-centric approach is used for interacting, querying, editing, sharing, analyzing, and combining data.

The focus in ArcGIS 10 is squarely on helping users get more done. ArcGIS 10 integrates productivity tools that support the workflows of GIS professionals. Best practices templates incorporate intelligence that helps users get started quickly without having to worry about configuring the geodatabase.

A new, enhanced editing experience lets users accomplish editing tasks in a more intuitive, task-based environment. Users spend less time searching for tools and less time learning how to use them.

Commonly used tools for editing have been moved to a new toolbar that follows the user from task to task so it is always handy. The new toolbar for snapping is map based, and a new, quick pop-up helps users choose the desired feature.

Some enhancements were developed specifically for parcel editing tasks. The Create Features panel gives a more graphic, sketch-based way of creating features. The ability to perform bulk map feature editing and automated changes in parcel ownership that retain parcel accuracy helps users spend less time accomplishing more.

At ArcGIS 10, users can search by keywords or data types to find data and maps. They can also use the search function to quickly and easily find symbols to use in their maps and tools for analysis.

Users can work faster because ArcGIS 10 is faster. The higher performance of ArcGIS 10 results from averaging local graphics cards on desktops and improving cache generation and management, as well as optimizing Web graphics. These caching and Web graphic improvements translate into more responsive drawing performance that includes smooth, continuous panning of data.

This upcoming release also introduces the notion of time in both visualization and analysis. The software is time aware at the data, interface, and tool level. ArcGIS 10 lets users create, manage, and visualize time-aware data. They can display and animate temporal datasets as well as publish and query temporal map services. The ability to see data over time opens opportunities for more in-depth analysis.

ArcGIS has always been the premier software for spatial analysis. With this release, ESRI advances geographic science with new

orm How People Use GIS

tools. Using Python, the capabilities of ArcGIS can be combined with other scientific programming to create powerful solutions and automate common tasks.

Analysis and visualization in 3D is also improved in ArcGIS 10. At this release, ArcGIS becomes a full 3D GIS, offering 3D data models, editing, analysis, and visualization. It is much easier and faster to perform 3D visualization and users can do virtually everything that they do in a 2D environment in a 3D environment.

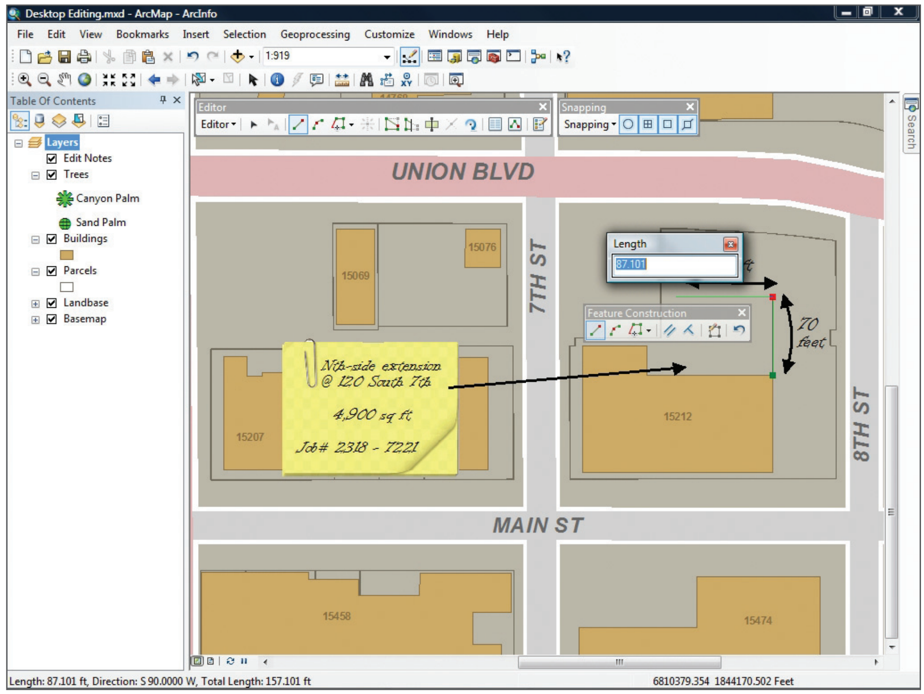
ArcGIS is expanding GIS to be more fully realized on mobile devices. Now users will be able to experience all the aspects of GIS on the mobile platform in the field and, often, in real time. This release makes GIS easier to use on Tablet PCs. Not only can users create custom applications but ArcGIS Mobile also has a customizable, out-of-the-box application that allows users to extend ArcGIS. ESRI is expanding this concept not only to Windows Mobile but also to the iPhone platform. ESRI is providing a software developer kit (SDK) so organizations can build their own focused iPhone applications. The mobile platform enables the use of GIS information throughout organizations.

The expansion of GIS use is improved with added support for cloud computing. ArcGIS at 9.3 is cloud ready. ArcGIS 10 will be even more tightly integrated with the ArcGIS Online search and share capabilities. This makes it easier for users to create and distribute projects that may include data, layers, maps, tools, scenes, globes, diagrams, and add-ins.

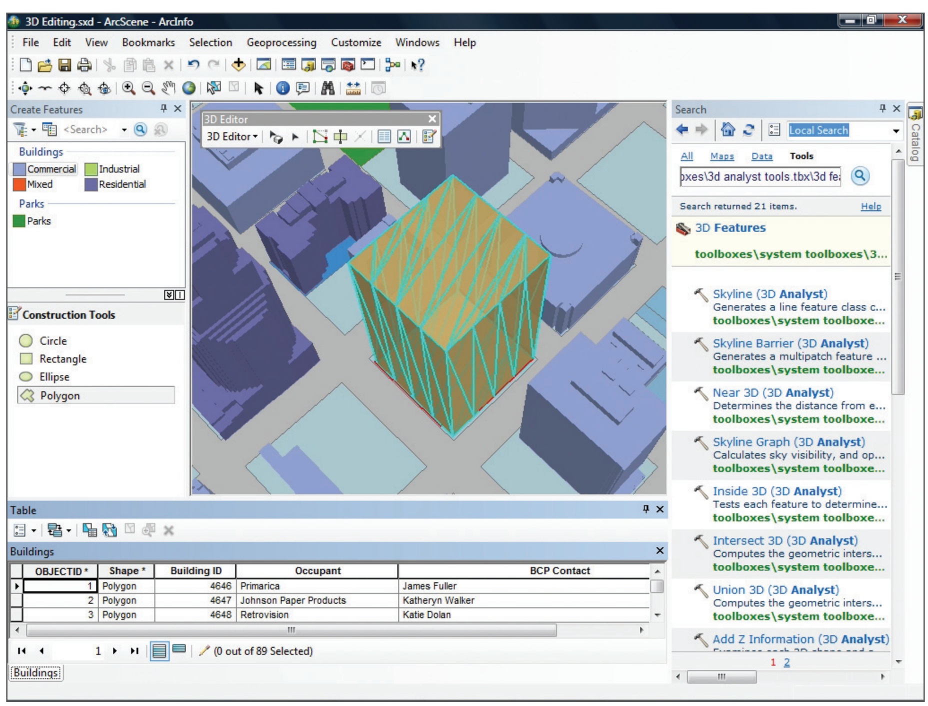
Also at version 10, ArcGIS will be extended to support enterprise clouds. Any client can access these server-based resources and integrate data through mashups and APIs. In addition, ESRI is collaborating with Amazon Web Services (AWS) and has joined the growing community of AWS Independent Software Vendors (ISVs) building services and solutions in the cloud computing environment.

Another area where ESRI has focused a great deal of energy over the last two years has been integrating imagery into the ArcGIS platform. With this release, ArcGIS is a strong platform for imagery. It dramatically improves display speed and builds on the notion of on-the-fly image analysis, now done on ArcGIS Server, but soon available on the desktop. The image processing tools on the desktop furnish display speed that is extraordinary.

ArcGIS 10 is expected to ship during the second quarter of 2010. Find the latest information on ArcGIS 10, including podcasts and videos, at www.esri.com/whatscoming.



Commonly used tools for editing have been moved to a new toolbar that follows the user from task to task. The new toolbar for snapping helps users quickly adjust tolerances for snapping.



ArcGIS 10 is a full 3D GIS with 3D data models, editing, analysis, and visualization.

Incorporating Expert Knowledge

New fuzzy logic tools in ArcGIS 10

By Gary L. Raines, Don L. Sawatzky, and Graeme F. Bonham-Carter

For many spatial modeling problems, experts can describe the decision-making process used to predict real-world phenomena: the favorability for locating mineral deposits or archaeological sites, the occurrence of hazards such as landslides or disease outbreaks, the habitat of specific animals or plants, or the optimal site for a business. For most interesting spatial problems, expert knowledge is often expressed in terms such as *nearness* to some feature or by statements involving *sometimes* or *maybe.* Such semantic descriptions are useful but imprecise.

Fuzzy logic is used extensively in poorly definable engineering applications such as the anti-lock braking system (ABS) that controls brakes in cars; the focusing and exposure controls on digital cameras; and the control of water intake, temperature, and other settings in high-end washing machines. Fuzzy logic provides an approach that allows expert semantic descriptions to be converted into a numerical spatial model to predict the location of something of interest.

In addition to Boolean logic and Weighted Overlay tools in ArcGIS 10, two new Overlay tools—Fuzzy Membership and Fuzzy Overlay—are available. Overlays using fuzzy logic provide more flexible weighting of evidence and combinations of evidence than traditional Boolean or Weighted Overlays. These new tools in ArcGIS are derived from the Spatial Data Modeller (SDM) toolbox developed by the U.S. Geological Survey and the Geological Survey of Canada. *[SDM is a collection of geoprocessing tools for spatial data modeling that is available from ArcScripts at http://arcscripts.esri.com/details.asp?dbid=15341.]* The Fuzzy Logic tool is just one of many methods available from the SDM toolbox that includes weights of evidence, logistic regression, expert systems, and model validation.

A Nonspatial Example

Table 1 illustrates a simple example of a nonspatial Boolean and fuzzy logic model through a chart on tallness. Boolean logic deals with

Table 1: A nonspatial example comparing Boolean logic with fuzzy logic. In Boolean logic, truth is "crisp," zero or one. In fuzzy logic, truth has degrees between zero and one. Fuzzy tallness and fuzzy oldness are the membership in the concepts tallness and oldness. Boolean tallness and Boolean oldness are binary memberships in these concepts. Thus in Boolean logic, a person is either tall or not; whereas in fuzzy logic, a person can be somewhat tall. The operators AND and OR are used for combining evidence in both methods.

Evidence						
Person	Height	Fuzzy Tallness	Boolean Tallness	Age	Fuzzy Oldness	Boolean Oldness
Fred	3′ 2″	0.00	0	27	0.21	0
Mike	5′ 5″	0.21	0	30	0.29	0
Sally	5′ 9″	0.28	0	32	0.33	0
Marge	5′ 10″	0.42	0	41	0.54	1
John	6′ 1″	0.54	1	45	0.64	1
Sue	7′ 2″	1.00	1	65	1.00	1

Nonspatial Models	
Boolean Logic	Fuzzy Logic
Truth (Marge is tall) = 0	Truth (Marge is tall) = 0.42
Truth (Fred is old) = 1	Truth (Fred is old) = 1
Truth (Sally is tall and old) = 0	Truth (Sally is tall and old) = 0.21
Truth (John is tall or old) = 1	Truth (John is tall or old) = 0.54

situations that can be true or false. Fuzzy logic allows degrees of truth (expressed as a membership function) in the range of zero to one. In this example, an expert uses fuzzy membership values to define the importance of two characteristics of people (tallness and oldness) to be used as predictive evidence (values between 0 and 1). The expert also defines how the evidence is combined, in this example using fuzzy AND and OR operators.

Probability is a special case of fuzzy membership. If the probability of truth is 0.8, then the probability of false is 0.2 (i.e., if the probability of an event occurring is x, then the probability of the event not occurring is always 1-x). This additive-inverse property of probability statements is not required in fuzzy logic. Fuzzy membership can be thought of as the "possibility" that the statement is true.

In a Boolean model, the height of Marge (listed in Table 1) is absolutely not tall or tallness is zero, whereas in a fuzzy logic model, Marge's height is somewhat short with a tallness of 0.42. Generally,

Fuzzy logic provides an approach that allows expert semantic descriptions to be converted into a numerical spatial model to predict the location of something of interest.

a membership of 0.5 indicates an ambiguous situation that is neither true nor false. An example of a membership function with semantic descriptors (e.g., possibly short, possibly tall) is shown graphically in Figure 1. Fuzzy membership thus provides sensitivity to the subtle aspects of the process being modeled. In addition, a variety of fuzzy combination operators are available that greatly extend the simple AND and OR operators used in Boolean logic and allow the flexibility and complexity incorporated in making many real-world decisions to be modeled.

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Incorporating Expert Knowledge

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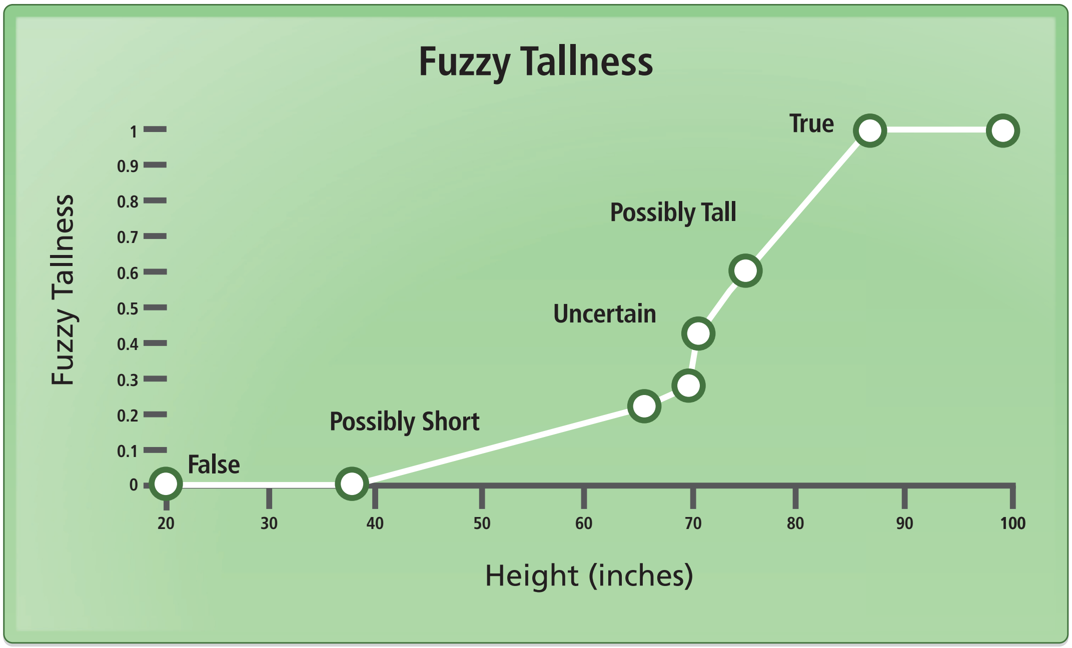

Figure 1: Graphic example of the membership function Tallness. The semantic statement might be, "a height of 82 inches is always considered tall," whereas "a height below 38 inches is never considered tall." A height of about 70 inches is ambiguous for tallness and given a membership value of 0.5.5.

A Spatial Example

In a fuzzy logic model in ArcGIS, evidence rasters are assigned membership values with the Fuzzy Membership tool. Table 2 (on page 12) defines the fuzzy membership functions available. Memberships are combined using the Fuzzy Overlay tool to select a fuzzy combination operator based on how the evidence interacts.

Table 3 defines five fuzzy operators. In a given model, different operators may be used. These operators provide greater flexibility than a weighted-sum or weighted-overlay model and let the expert incorporate greater sensitivity based on knowledge of how the evidence interacts. In practice, operators for combining evidence are relatively easy to select, but fuzzy membership may require some tuning of the membership parameters to represent expert knowledge.

Fuzzy OR	$\mu(x) = Max(\mu_i)$
Fuzzy AND	$\mu(x) = Min(\mu_i)$
Fuzzy Product	$\mu(x) = \pi_{i=1}^{n}\mu_i$
Fuzzy Sum	$\mu(x) = 1 - \pi_{i=1}^{n}(1-\mu_i)$
Gamma	$\mu(x) = (Fuzzy\ Sum)^{\gamma} - (Fuzzy\ Product)^{1-\gamma}$ $where\ \gamma\ is\ a\ user\ input$

Table 3: Summary of fuzzy combination operators implemented in the Fuzzy Overlay tool in ArcGIS 10. WHERE is the membership value for crisp measurement x, and I indicates each of the n evidence layers.

A Simple Expert Semantic Summary

Figure 3 is a simple example of a fuzzy logic spatial model. This geologic model for Carlin-type gold deposits uses datasets that are available with the Spatial Data Modeller tools (www.ige.unicamp.br/sdm/default_e.htm). *[Carlin-type gold deposits, with ore grades commonly between 1 and 5 grams per ton, are primarily mined from open pits in Nevada. They are named for the most prolific goldfield in the Northern Hemisphere, the Carlin Trend Field.]* From a semantic description of the criteria for finding Carlin-type gold deposits, a simplified expert semantic model might consist of the following statements:

- High values of antimony (*Sb*) or arsenic (*As*) are favorable for Carlin-type gold. Use stream-sediment geochemistry to define a mineralization geochemical factor.
- Host rocks of Carlin-type deposits are primarily Paleozoic and Mesozoic dirty carbonate rocks. Use a geologic map to define a lithologic factor.
- Dirty carbonate rocks are chemically low in potassium (*K*). Use stream-sediment geochemistry to make a lithologic adjustment to the mineralization geochemical factor. Elevated *K* differentiates Carlin-type gold deposits from volcanic-rock-hosted gold deposits, although both types are high in *Sb* or *As*.

From these semantic statements, a simple outline of the fuzzy logic model can be defined.

A Simple Fuzzy Logic Model

Frequently such models have submodels or factors that describe complex aspects of the spatial model. These submodels often represent factors defined by a single discipline; thus, "the Expert" for the entire model is—in practice—often a team of experts who bring knowledge from diverse fields when defining the decision process. A final model is derived by combining the factors. The following semantic statements describe the process for determining the geochemical, lithologic-adjusted geochemical, and lithologic factors in the model shown in Figure 3.

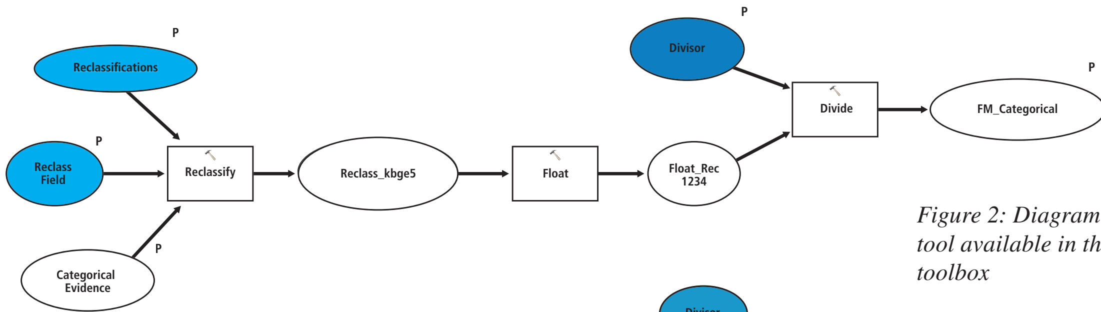

Figure 2: Diagram of the Categorical Weights tool available in the Spatial Data Modeller toolbox

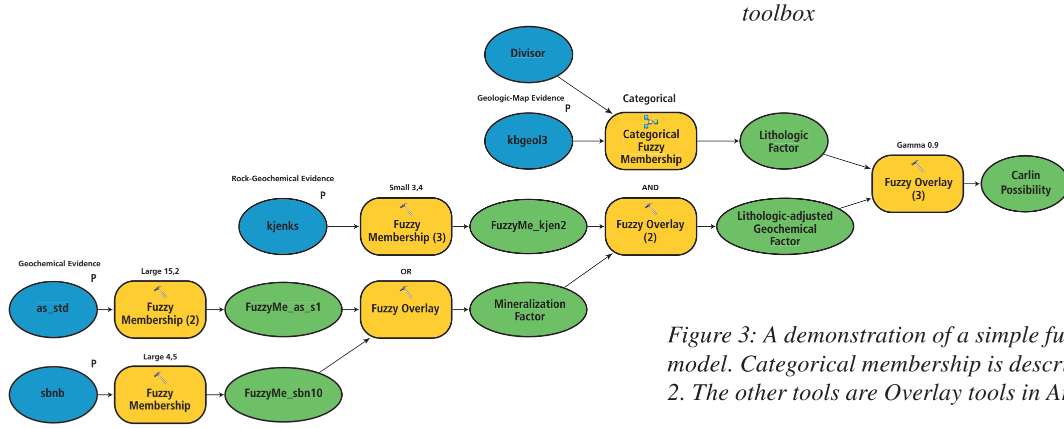

Figure 3: A demonstration of a simple fuzzy logic model. Categorical membership is described in Figure 2. The other tools are Overlay tools in ArcGIS 10.

Mineralization Geochemical Factor

Use the Large Fuzzy Membership tool for assigning fuzzy membership values to *Sb* and *As*. Tune the parameters for the Large Fuzzy Membership tool to produce fuzzy evidence maps acceptable to the expert.

Combine the *Sb* and *As* fuzzy maps with a Fuzzy OR operator. Use the Fuzzy Membership tool for *K,* again tuning the parameters for the Small Fuzzy Membership tool to make an acceptable map.

Lithologic-Adjusted Geochemical Factor

Use the Fuzzy AND operator to combine the mineralization geochemical factor with the *K* membership.

Lithologic Factor

Assign the fuzzy memberships to the various lithologies present on the geologic map following guidance from the expert and using the Categorical Fuzzy Membership tool in the Spatial Data Modeller toolbox and diagrammed in Figure 2.

Combine the lithologic-adjusted geochemical factor with the lithologic factor using the Gamma combination operator to produce the Carlin-type gold possibility map. Tune the gamma parameter value to produce an acceptable combination.

Once the model shown in Figure 3 is assembled, it will be necessary to adjust the fuzzy membership parameters to tune fuzzy memberships to represent properly the expert's concepts. This tuning can be done graphically in a spreadsheet or, more often, spatially by inspecting rasters. Using iteration methods in separate tuning models is useful for quickly computing a selection of rasters with a range of parameters. Experts will recognize the best representation of the spatial data. When disagreements occur about the optimal tuning of the fuzzy memberships, multiple models can be built quickly representing different opinions and tested during model validation. Figure 4 provides a comparison of the Boolean and fuzzy logic models. A weighted sum model would be more similar to—but not the same as—the fuzzy logic model.

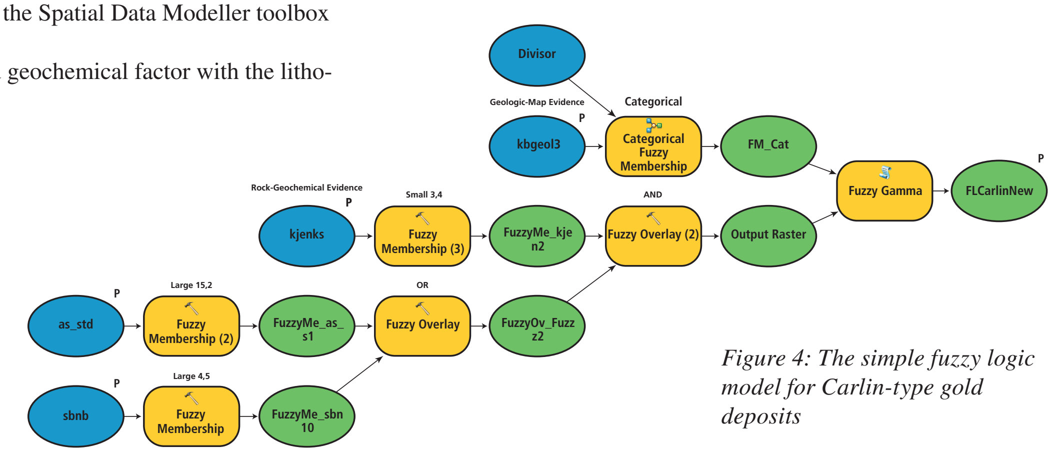

Figure 4: The simple fuzzy logic model for Carlin-type gold deposits

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Incorporating Expert Knowledge

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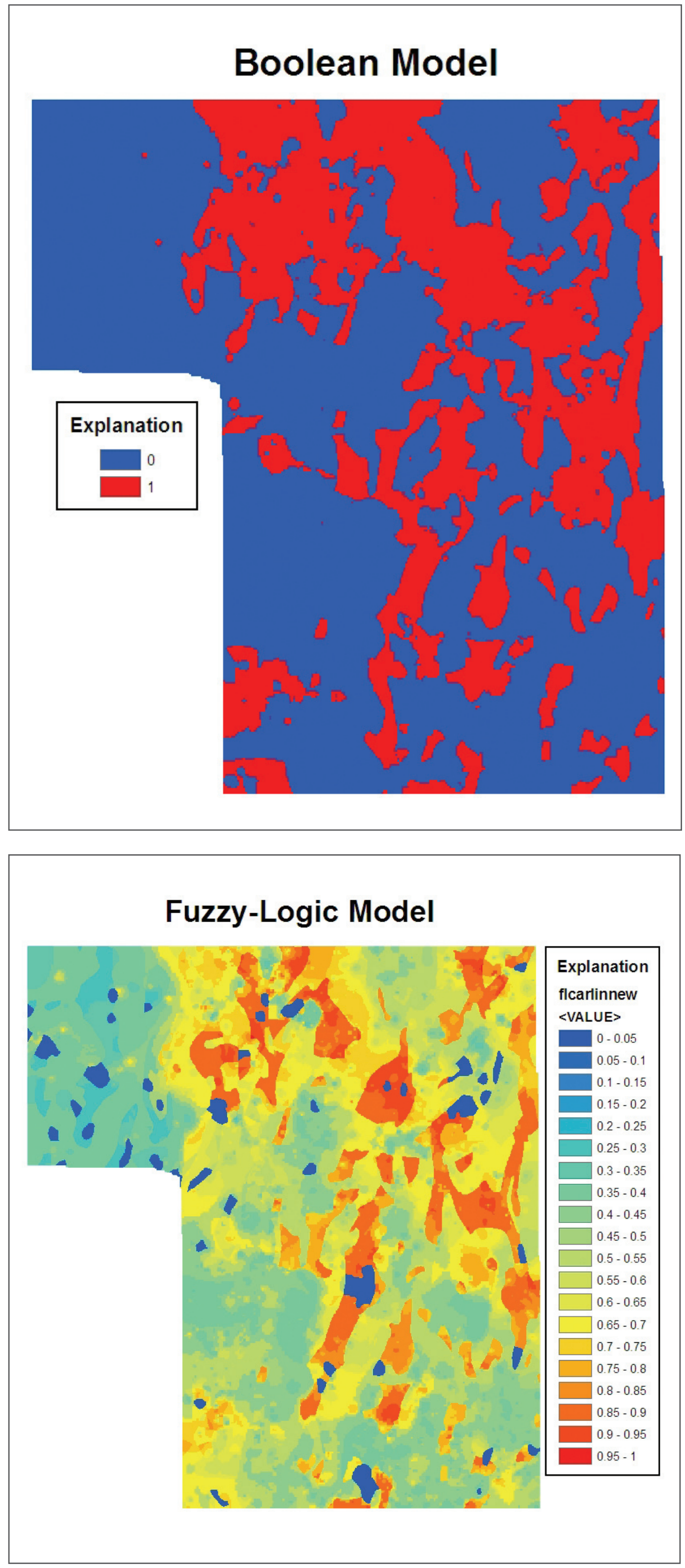
Membership Function	Description	Definition
Linear	A linear increasing or decreasing membership between two inputs. A linearized sigmoid shape.	$\mu(x) = 0 \; if \; x < min, \mu(x) = 1 \; if \; x > max,$ $otherwise \; \mu(x) = \frac{(x - min)}{(max - min)}$ where min and max are user inputs
Large	Sigmoid shape where large inputs have large membership	$\mu(x) = \frac{1}{1 + \frac{x}{f_2}^{-f_1}}$ $where \; user \; inputs \; f_1 \; is \; the \; spread \; and \; f_2 \; is \; the \; midpoint$
Small	Sigmoid shape where small inputs have large membership	$\mu(x) = \frac{1}{1 + \frac{x}{f_2}^{f_1}}$ $where \; user \; inputs \; f_1 \; is \; the \; spread \; and \; f_2 \; is \; the \; midpoint$
MS Large	Sigmoid shape defined by the mean and standard deviation where large inputs have large memberships.	$\mu(x) = 1 - \frac{bs}{x - am + bs} \; if \; x > am \; otherwise \; \mu(x) = 0$ where m = mean, s = standard deviation and *b* and *a* are multipliers provided by the user.
MS Small	Sigmoid shape defined by the mean and standard deviation, where small inputs have large memberships.	$\mu(x) = \frac{bs}{x - am + bs} \; if \; x > am \; otherwise \; \mu(x) = 1$ where m = mean, s = standard deviation, and *b* and *a* are multipliers provided by the user.
Near	A curved peak of membership over an intermediate value.	$\mu(x) = \frac{1}{1+f_1 * (x - f_2)^2}$ $where \; user \; inputs \; f_1 \; is \; the \; spread \; and \; f_2 \; is \; the \; midpoint$
Gaussian	A Gaussian peak of membership over an intermediate value.	$\mu(x) = e^{-f_1} * (x - f_2)^2$ $where \; user \; inputs \; f_1 \; is \; the \; spread \; and \; f_2 \; is \; the \; midpoint$
Table of Contents (TOC)	The experts can visualize the membership values displayed on the map.	Membership is defined based on the classes in the symbolization in the Map document table of contents.
Categorical	Each named class is assigned a membership value by the expert.	Membership is defined by entering the values times a multiplier into a reclassification table.
Somewhat	Applied to slightly adjust a membership function.	Square root of membership.
Very	Applied to slightly adjust a membership function.	Membership squared.

Table 2: Summary of fuzzy membership functions implemented in the Fuzzy Membership tool in ArcGIS 9.4. In addition, there are two hedges (Somewhat and Very) that qualify the membership. These functions have been found most useful in spatial modeling problems. The first five membership functions produce a sigmoid shape of the membership, which is used commonly in many fuzzy logic applications. Experience with these functions can be gained rapidly by implementing them in a spreadsheet and adjusting the parameters.

After completing the model or models, it is important to validate the results. If there are known examples of what is being modeled (i.e., known deposits, animal sightings), these can be used to test how well the model classifies known examples. The Area Frequency tool in the Spatial Data Modeller toolbox provides a measurement of the efficiency of prediction measure. Lacking known examples, the judgment of the experts and field testing are required to validate the model. For more information, contact Gary Raines at garyraines.earthlink.net.



Boolean and fuzzy logic models. The model uses Bitwise OR and AND in place of Fuzzy OR and AND. The fuzzy gamma is replaced by a Bitwise OR, which is most similar to a fuzzy gamma.

Further Reading

An, P., W. M. Moon, and A. N. Rencz, 1991. "Application of fuzzy set theory for integration of geological, geophysical and remote sensing data." *Canadian Journal of Exploration Geophysics,* V. 27, No. 1, pp. 1–11.

Bonham-Carter, G. F., 1994. *Geographic Information Systems for Geoscientists—Modelling with GIS.* New York: Elsevier Science, pp. 291–302.

Eddy, B. G., G. F. Bonham-Carter, and C. W. Jefferson, 2010. "Mineral potential analyzed and mapped at multiple scales—a modified fuzzy logic method using digital geology," Harris, J. R. (editor), in *GIS Applications in Earth Sciences: Special Publication.* Geological Association of Canada, Special Publication 44, pp. 143–162.

Nykanen, V., D. I. Groves, V. J. Ojala, P. Eilu, and S. J. Gardoll, 2008. "Reconnaissance-scale conceptual fuzzy-logic prospectivity modeling of iron oxide copper-gold deposits in the northern Fennoscandian Shield," *Australian Journal of Earth Science.* V. 55, pp. 25–38.

Raines, G. L., and G. F. Bonham-Carter. 2006. "Exploratory Spatial Modelling Demonstration for Carlin-type deposits, Central Nevada, USA, using Arc-SDM," Harris, J. R. (editor), in *GIS Applications in Earth Sciences: Special Publication.* Geological Association of Canada, Special Publication 44, pp. 23–52.

About the Authors

Gary L. Raines retired as a research geologist for the U.S. Geological Survey in Reno, Nevada. His research focused on the integration of geoscience information for predictive modeling in mineral resource and environmental applications. He now teaches classes in spatial modeling.

Don L. Sawatzky retired as a research geologist for the U.S. Geological Survey in Reno, Nevada. His research focused on computerized analyses in remote sensing, geophysics, and structural geology.

Graeme F. Bonham-Carter retired as a research geologist for the Geological Survey of Canada, Ottawa. He is interested in applications of GIS to mineral exploration and environmental problems. For 10 years, he was editor-in-chief of *Computers & Geosciences,* a journal devoted to all aspects of computing in the geosciences.

The Next Generation of GIS

Dealing with design and space-time

The rapidly changing nature and scale of problems such as global climate change and the widespread failure of the banking system threaten to overwhelm the resources of individual nations and defy the methods of traditional science. However, leading researchers and practitioners of geospatial technology believe a new generation of GIS is evolving that will help understand and address these problems far more effectively.

Many of these leaders were recently brought together for a pair of related meetings held at the ESRI headquarters in Redlands, California. The first event, the 2010 GeoDesign Summit, was sponsored by the University of California, Santa Barbara; the University of Redlands; and ESRI. It was held January 8–10. More than 170 academics and professionals met to discuss GeoDesign, a new GIS field that marries the original conceptualization of GIS by Ian McHarg as a tool for designing the human environment with the natural one with the more familiar applications of GIS for data collection, creation, and management; data analysis; and decision support.

As ESRI president Jack Dangermond noted when introducing keynote speaker Thomas Fisher, this new field is exciting because it creates a "continuum between measurement and design." Fisher, the dean of the College of Design, University of Minnesota, approached the topic from the design side rather than the GIS side. He emphasized that GeoDesign should fulfill the real mission of design, which is "making things work better in the world," particularly as related to sustainability and social justice issues rather than just making things look more attractive, the popular impression of what design does. He also recognized that GeoDesign has a strong temporal element because it brings together geography, which looks at the "way the world is and was," with design, which looks at the way the world might be, connecting the past, present, and future. Also, he noted, geography and design both are fundamentally spatial disciplines.

Fisher said that historically, society has been designing without a lot of information on consequences—consequences to the environment, other people distant in time or space, and other species. The focus has been almost exclusively on fulfilling present needs. As GeoDesign can bring data to bear on these decisions "it will profoundly change the way we live and the way we inhabit the planet." (For more information on the GeoDesign Summit, see "Designing GeoDesign: Summit on new field that couples GIS and design," on page 16 of this issue.)

Developing tools for dealing with large-scale, complex problems was also the impetus behind the Space-Time Modeling and Analysis Workshop. Thought leaders from seven countries, who work in academia, government, and industry, met February 22–23, 2010, to share current work being done on this aspect of geospatial technology and develop an agenda for defining research areas and designing spatiotemporal tools going forward.

This workshop, cosponsored by the Association of American Geographers (AAG), the University of Redlands, the University of Southern California, and ESRI, was the first Redlands GIS Week event. The workshop included keynote presentations, Lightning Talks, and breakout sessions that identified the most important challenges and immediate strategies for incorporating space-time into GIS processes.

In his Keynote Address, Michael F. Goodchild, professor of geography at the University of California, Santa Barbara, and director of spatial@ucsb, observed that while "we have been talking about spatiotemporal analysis modeling for a number of years, we are now at a bit of a tipping point where we can really start making progress."

Spatiotemporal tools are "a way for looking at spatial data that will help us deal more effectively with the complex problems we now face, like climate change and economic meltdowns and infectious disease, that don't allow for a leisurely, reflective approach to solving them."

The geospatial approach has become more valuable because the role of the scientist and science in society have changed. The era of the lone scientific investigator is over. Discoveries about complex systems require teams of researchers who need powerful data acquisition and management systems coupled with sophisticated tools for handling both space and time.

Goodchild also believes that science must have a more active role in society and engage with policy making. To do this, the scientific community must package the results of science for general consumption. GIS is well suited to the task of bringing all the pieces of scientific understanding together in a way that can be comprehended by the public to influence policy. Policy and public interest are driven by change. This means getting and holding the public's interest is difficult with static maps. Incorporating the time dimension in GIS will make it more captivating.

In addition, every major issue has an associated time scale. Climate change occurs over decades, climate tipping points over years, and economic meltdowns occur in a matter of months, while infectious diseases span weeks and disasters are framed in days. The analysis and response to events has to speed up and occur in near real time.

One approach Goodchild suggested for developing spatiotemporal tools in GIS was to consider space-time as a collection of "sandboxes" or domains based on the tools, data, and assumptions of the team working in that area. How many areas or sandboxes are there? He introduced seven sandboxes for examining application areas for space and time. His remarks served as a starting point for much of the discussion over the following two days.

Workshop presentations explored the wide-ranging work being done across many fields, particularly transportation and health. David Maidment, director of the Center for Research in Water Resources, University of Texas at Austin, described the ambitious work of the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) on space-time for hydrology. CUAHSI represents more than 100 universities that develop infrastructure and services that advance hydrologic science and promote education in this area.

Integrating GIS, which describes the water environment of watersheds, streams, gauges, and sampling points, with water resources observation data that describes the water itself and consists of measurements such as flow, water level, and concentrations, is made most challenging because this observation data is not standardized at all.

"Connecting GIS data with observational data is connecting space and time," said Maidment. The point water observations time series CUAHSI developed combines a point location in space with a series of values in time and uses WaterML invented by CUAHSI for transmitting water data on the Internet. Using Web services, the consortium has the world's largest water data catalog, which accesses 4.3 billion data values. This system lies over existing water data systems and allows them to be seen as a whole. CUAHSI built a hierarchy of concepts to reconcile the meaning of variables used in observational data so data can be located without requiring special knowledge of the naming conventions of each organization that might supply that observational data.

In closing, Maidment identified the complex challenges of space-time. He noted that time is subtle: although it's really continuous, the data collected about time is discrete. Time stamps play a key role, and time has dimensions (e.g., hour, day, month) that interact. Finally, time has two forms—Universal Time (UTC), which is like geographic coordinates, and local time, which is like projected coordinates. He concluded that space-time reference frames and tools for moving data between them were needed.

The GeoDesign and spatiotemporal tools being developed will magnify the impact of GIS on society's understanding of the world that can inform human behavior to act in a more sustainable manner. As Paul Torrens, an associate professor in the School of Geographical Sciences at Arizona State University and director of its Geosimulation Research Laboratory, has observed, "This is a wonderful time to be working with or developing geographic information technologies, at the cusp of some very exciting future developments that will bring GIS farther into the mainstream of information technology and will infuse geography and spatial thinking into a host of applications." The current integration of design and space-time into GIS processes and software represents a significant step in the ability of GIS to enable geographic knowledge.

Designing GeoDesign

Next Steps in GeoDesign

GeoDesign—as a discipline, a field of study, and a practice—continues to evolve. Several action items were identified by the end of the 2010 GeoDesign Summit to help further this evolution including

- Obtain a broader consensus. Everyone is invited to participate in this discussion at participatorygeodesign.ning.com/ and en.wikipedia.org/wiki/GeoDesign.
- Identify the new geospatial functionality, tools, and technologies needed to support broader adoption of GeoDesign.
- Hold a GeoDesign Challenge, with a cash prize, to encourage the development of real-world geodesign projects.
- Publish a book of GeoDesign case studies.
- Determine the optimal methods of teaching design principles to geospatial professionals and develop a GeoDesign curriculum.
- Hold another GeoDesign Summit in early 2011 to review the progress made.

More than 170 academics and professionals from fields such as geography, architecture, GIS, urban planning, engineering, conservation, and forestry attended the 2010 GeoDesign Summit held on the ESRI Conference Center in Redlands, California.

Summit on new field that couples GIS and design

By Carla Wheeler, ArcWatch *Editor*

Thomas Fisher, dean of the College of Design at the University of Minnesota, spoke passionately about the need for geodesign in his Keynote Address.

Although the word *GeoDesign* and its definition may be newly coined and evolving, ESRI president Jack Dangermond observed that the concept of incorporating geographic knowledge into design isn't new as he addressed attendees at the world's first GeoDesign Summit in January 2010.

"GeoDesign is going on. It has been going on for hundreds of years," he said, pointing to examples in farming, urban planning, and site selection for stores. For example, farmers have always taken geography into account when deciding what crops would be appropriate to grow on their land and where to locate their farms (e.g., near a water source for irrigation).

Dangermond and a group of thought leaders from academia and a variety of professions believe it's time to better integrate geospatial technologies such as GIS with design to deal with the planet's most pressing problems. To jump-start that process, the 2010 GeoDesign Summit, sponsored by the University of California, Santa Barbara; the University of Redlands; and ESRI, was held January 8–10 at ESRI's conference center in Redlands, California. More than 170 academics and professionals from fields such as geography, architecture, GIS, urban planning, engineering, conservation, and forestry attended the event. Besides listening to keynotes and Lightning Talks (i.e., presentations lasting only a few minutes) on GeoDesign and how it's being used, attendees participated in "idea labs" for creating agendas for topics such as GeoDesign theories, education, future technologies, 3D visualization, and analysis in design.

The Wikipedia entry they created to define GeoDesign reads, in part: "GeoDesign is a set of techniques and enabling technologies for planning built and natural environments in an integrated process, including project conceptualization, analysis, design specification, stakeholder participation and collaboration, design creation, simulation, and evaluation (among other stages)."

The entry continues with a quote from "GeoDesign: Fundamental Principles and Routes Forward," the presentation Michael Flaxman made at the summit: "GeoDesign is a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts."

"We are at the beginning of what many of us see as a new field," said Thomas Fisher, dean of the College of Design at the University of Minnesota, in his Keynote Address. With the world facing what he called "exponentially increasing stress on the systems we depend on" such as natural ecosystems and building infrastructure, there's a great need to use spatial data and technologies in planning and design to tackle problems such as those associated with global warming, threats to species, and poorly designed infrastructure.

Continued on page 18

Designing GeoDesign

Continued from page 17

"One of the powers of GeoDesign is it makes these problems visual," he said. "They are easier to ignore when they are abstractions. Because we have been designing the world without data-rich knowledge of consequences, we've created a situation where we've made ourselves vulnerable as a species, which to me gives urgency to GeoDesign. This is something we don't have a lot of time to develop."

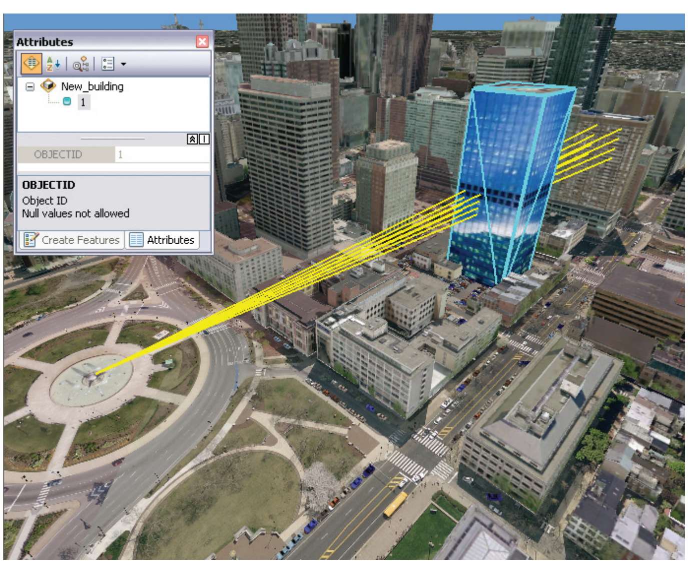
The purpose of the two and a half day summit was to

- Define and formalize the term *GeoDesign* and its methodology.
- Promote and advance GeoDesign research and education.
- Discuss how to go about creating better GeoDesign technologies and tools.
- Talk about how to more deeply couple design with GIS and other geospatial technologies.
- Prepare a set of use cases to show what GeoDesign can accomplish.

In his opening remarks, Dangermond spoke about the great potential for GeoDesign, which is described by some as a pairing of design and GIS. It unites the art and creativity of design with the power and science of geospatial technology. GeoDesign can produce more informed, data-based design options and decisions.

"The notion of integrating these two fields is very exciting to me. We have a kind of continuum from measurement to making decisions that integrates all of our ways of doing things into new processes," Dangermond told the gathering.

Dangermond said accelerating improvements in geospatial technologies will hasten advances in GeoDesign. New design-friendly capabilities and tools in the upcoming release of ArcGIS 10 will help professionals apply GeoDesign methodologies to problems and challenges related to anything from climate change to pandemic diseases, environmental protection to food production, and resource conservation to infrastructure improvements.



The virtual city template, available with the ArcGIS 3D Analyst extension at ArcGIS 10, provides a useful example of a well-defined 3D city. It was demonstrated during the summit.

"Geospatial technology is migrating to the Web and will be used by practically everyone in some way or other," Dangermond said. This new style of serving geography will affect virtually everything that people do—not just a few researchers, GIS professionals, or those who work with geographic information. Improvements in GIS, the explosion of location-based services (LBS), faster computers, more bandwidth and storage, the boom in mobile devices, and the emergence of cloud computing will also speed GeoDesign along, according to Dangermond.

While some people describe this as disruptive technology, for Dangermond, "it's just another step in the evolution in the enabling technology that allows us to bring these new ideas that will come out of this meeting to fruition. Organizations also are beginning to serve geographic knowledge, which is providing a new infrastructure to build on top of, hopefully, the design notions that come out of the summit." Dangermond continued, "Agencies will not be providing data files or maps. They will be providing services, and these services will be a new framework. Just like the Apple iPhone is providing a framework for all kinds of apps, these geospatial services—and the ability to build creative applications on top of them—will explode our field and the general interest in designing our future."

Designer-Friendly GIS Technology

Matthew Baker, Nathan Shephard, and Bern Szukalski from ESRI demonstrated currently available tools and services and soon-to-be-released technology that will assist designers in their work.

Baker's demonstration focused on the modeling, sketching, and feedback capabilities in ArcGIS Desktop 10, set for release in the second quarter of 2010. To find the best areas suitable for redevelopment in Detroit, Michigan, he created a model that used public GIS data and extracted block group parcels in the city that met criteria such as high poverty rates, vacant properties, and high unemployment. He used basemaps available from ArcGIS Online, an ESRI Web site that provides free maps and other resources for GIS applications.

The model's results pointed Baker to key redevelopment areas. Baker then began sketching a new neighborhood using standard land-use symbols for neighborhood design, which will be available in future templates in the ArcGIS 10 editing tools. He received instant feedback on the suitability of his designs in the form of pie and bar charts that were based on the features he sketched using an ArcGIS 10 add-in called the Dynamic Charting tool. Every time new features are added to the map, the Dynamic Charting tool provides updates.

Shephard demonstrated new design-friendly capabilities in the ArcGIS 3D Analyst extension to ArcGIS Desktop 10. These capabilities included template-based (sketch) editing in 3D; 3D vector analyses of line of sight; 3D object intersections and skylines; volumetric analysis of buildings, shadow impact, and visibility zones; and a template of a virtual city. The virtual city template provides a useful example of a well-defined 3D city. The four key elements of such a city are a topographic basemap, high-resolution imagery, an elevation surface, and 3D buildings. If the data is available, users can add other elements such as vegetation, streetlights, and park benches.

"These new capabilities allow you to quickly and accurately solve 3D GIS problems, such as assessing the impact of a proposed building on your city or identifying areas of concern based on 3D topography,"

> **"As GeoDesign can bring data to bear on those design decisions, it will profoundly change the way we live and inhabit the planet."**
>
> —Thomas Fisher, Dean of the College of Design at the University of Minnesota

said Shephard.

Szukalski showed the audience ArcGIS Online resources for GeoDesigners or Web mappers that serve as what he called an "excellent substrate" of content. "These new basemaps and others provide great maps you can use as is or to represent a great canvas for design or GIS work," said Szukalski. These resources include

- The updated World Imagery map, which compiles the best available imagery for the United States and many cities around the world including London, England, and Geneva, Switzerland
- Bing Maps for enterprise, aerial, hybrid, and roads
- The new World Street map, which includes building footprints for major cities around the world

Urgent Need for GeoDesign

The summit brought together thought leaders in GIS, architecture, design, conservation, and many other fields including Michael Goodchild, professor of geography at California State University, Santa Barbara; Carl Steinitz, research professor at the Graduate School of Design, Harvard University; Kim Tanzer, dean of the School of Architecture at the University of Virginia; and William B. Rogers, president and CEO of the Trust for Public Lands. They spoke on how GIS is being used in design today and on its great potential to integrate the creativity of design and the science of GIS.

Fisher from the University of Minnesota spoke passionately of the urgency of the situation. Citing ideas put forth by the Pulitzer Prize-winning author Thomas Friedman and professor of psychology David Barash at the University of Washington, Fisher argued that humans have created a giant Ponzi scheme with the planet over the last several hundred years, sucking resources and exploiting labor to maintain a certain way of life.

This has led to the creation of what Fisher described as "fracture-critical systems" like the one that led to the collapse of the Interstate 35W bridge in Minneapolis, Minnesota, in 2007. Other fracture-critical threats include the exponentially increasing atmospheric carbon accumulation and rapidly declining biodiversity.

"Even the recent financial crisis grew out of a fracture-critical system," Fisher said. "We designed financial products such that we increased the debt . . . where a few investment banks go down and they bring the entire global financial community down with *[them]*," Fisher said. "It's a classic collapse of a fracture-critical system. There is a spatial component to this. The banks do not know where the debt lies. Here, too, GeoDesign can help us understand the flows of money spatially across the planet."

Fisher called a fracture-critical system a metaphor for the world humans have designed for themselves. But he pointed out that innovations such as GeoDesign can help reverse the course. "A lot of what we have been designing—our cities, our buildings, our landscapes—have been designed without a lot of information about the consequences of our actions on other species, on distant populations, on future generations," he said. "As GeoDesign can bring data to bear on those design decisions, it will profoundly change the way we live and inhabit the planet. Through innovation, we can rethink the way in which we inhabit the planet, we can rethink the way we use resources, and we can prolong our ability to sustain ourselves. GeoDesign's time has come, and it's none too soon."

Dangermond concurred. "We need this right now," he said. "We need to not only understand what's occurring on the planet, but we also need to take more proactive involvement in designing what occurs. Then we have to promote those designs, those creations, those in our mind's eye expressions, to the rest of society. That's the challenge."

The Role of Volunteered Geographic Information in a Postmodern GIS World

A conversation with Michael Goodchild

The rising interest in compiling georeferenced data has manifested itself in the growth of volunteered geographic information (VGI) Web sites. This is an assertive method of collecting geospatial information as opposed to the authoritative method employed by government agencies and private industry. Wikimapia, a site that encourages participants to post comments about georeferenced locations, is a good example of VGI. On the Flickr Web site, users can upload photos related to specific locations, while OpenStreetMap is an international effort to create a free source of map data through the efforts of volunteers.

ESRI writer Jim Baumann recently interviewed Michael F. Goodchild. Goodchild is professor of geography and chair of the executive committee of the National Center for Geographic Information & Analysis (NCGIA) at the University of California, Santa Barbara (UCSB) and director of the Center for Spatially Integrated Social Science (CSISS), a research organization at the university, and associate director of the Alexandria Digital Library Project. He has been involved in the VGI movement and has written extensively on it.

Baumann: *Gazetteers have traditionally been essential in collecting and distributing geographic information. Now there is a groundswell of people participating in Web-based social networking sites and contributing volunteered geographic information. These sites can be viewed as asserted gazetteers in what might be described as the democratization of geographic data. Please discuss what the GIS community gains (and loses) from this phenomenon.*

Goodchild: Although gazetteers (the names layer) are important for many reasons, and increasingly so, they have never included more than the officially recognized names that appear on maps. Names that are not officially recognized, such as "downtown Santa Barbara," and names that are meaningful to local communities, such as "the Riviera" *[the hilly area of Santa Barbara north of downtown],* do not appear in any gazetteer. This limits many applications, for example, making it difficult to build GPS navigation systems that recognize the full range of place-names that people need to use. Moreover, the official mapping agencies are not likely to invest in adding such names to their gazetteers anytime soon. However, place-names are one of the most successful forms of volunteered geographic information, and people are clearly willing to spend time providing them to Web sites. Volunteered gazetteers can provide much richer descriptive information than before; allow features to have multiple names; and include names for the smallest, least significant features.

What do we lose by relying on volunteered place-names? I think one major problem is lack of accuracy, whether by accident or design. But a more significant problem concerns preservation. National mapping agencies can devote significant resources to preserving place-names, ensuring that future generations have access to today's data, but no such mechanisms exist for volunteered geographic information. Once the initial enthusiasm has worn off, who will undertake the tedious task of updating and preserving?

Baumann: *Do you see assertive and authoritative spatial data working together, in parallel, or in opposition to each other?*

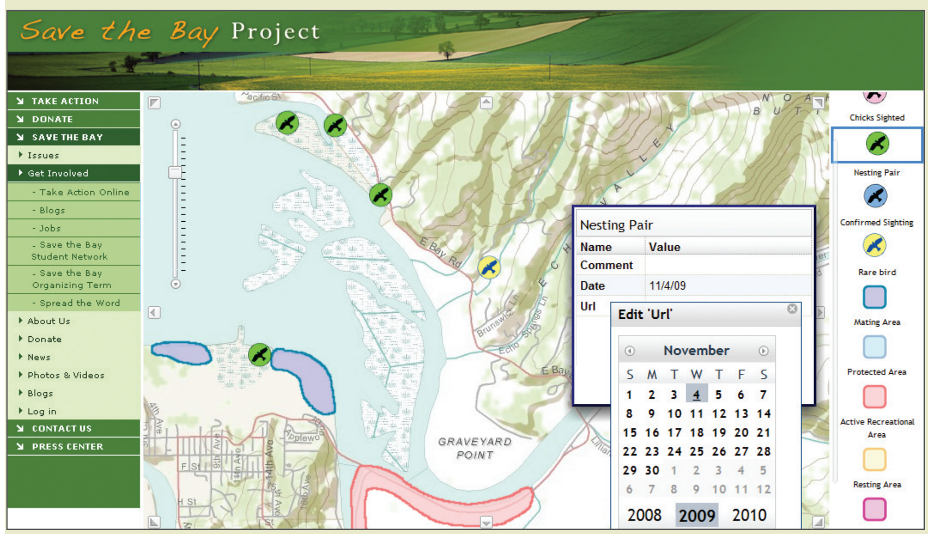
Goodchild: I think the best option is to make them complementary, and there are already signs that the traditional authorities are willing to work with citizens. In the UK *[United Kingdom],* for example, the Ordnance Survey has developed a program that encourages volunteers to provide geographic information about their local communities, and volunteers are playing an increasingly important role in ensuring that authoritative sources of geographic information are accurate and kept up-to-date.

Baumann: *What role does VGI play in societal GIS? How will it help shape the evolution of GIS?*

Goodchild: One of the criticisms leveled at GIS has been its insistence on a single point of view. VGI is, in a sense, postmodern GIS, in which individuals are able to assert their own views of their surroundings and play a part in local decision making. Another criticism was the tendency of GIS to empower those who could afford its high costs and marginalize those who could not. I think that by engaging citizens in the process of acquiring and using geographic information, VGI has the potential to alter this landscape significantly and soften some of these criticisms.

Baumann: *While Wikimapia has genuine potential, it seems to be populated with some information that is not particularly useful or interesting. However, I do think that it can be a valuable resource. For example, obscure yet relevant information that might otherwise be lost could be posted and contribute to our collective body of knowledge. You mentioned that you think the benefit of sites like Wikimapia will be in the compilation of local data. Please expand on this observation.*

Goodchild: Wikimapia demonstrates what is possible in a general sense, but I think the eventual value of sites like Wikimapia will be much more specialized. I'm thinking of local community groups and their need to acquire and share descriptions of their communities for specific purposes such as planning, networks for hobbyists who need to acquire and share highly specialized geographic information, or sites that might be developed by local communities to provide information for tourists.



Baumann: *Marshall McLuhan's view of the Global Village is often used to describe the World Wide Web. What is required to nurture a problem-solving geospatial initiative on the Web that would take a leading role in our virtual world community?*

Goodchild: Geospatial data and tools are essential in almost everything we do as humans, and over the past few years, they have become accessible to virtually all of us on the well-endowed side of the digital divide. We have seen volunteer initiatives, such as MapAction and the GISCorps, playing an important role in disaster response and other volunteer activities that are providing open sources of basic map information in communities that have never previously had access. I think the most significant new opportunity lies in the fact that a substantial fraction of the human population now has access to mobile phones and, hence, to electronic networks. I think mobile phones could be used to acquire and share damage assessments in the immediate aftermath of a disaster and to develop detailed databases for community planning. Project GLOBE has already shown the potential for empowering schoolchildren worldwide as environmental sensors; a new initiative, sponsored by a major foundation, could explore the potential of a much more powerful and comprehensive approach that would reach beyond the digital divide.

Baumann: *"The bad invariably pushes out the good" is an axiom that has been applied to various disciplines. How true do you think that is when it comes to data quality in VGI-based initiatives? What will happen if individuals or groups subvert, either consciously or simply through a lack of attention, VGI-based projects? For example, you have mentioned a nonexistent café that was geographically referenced to the park in front of the Santa Barbara mission.*

Goodchild: The experience of Wikimapia seems to be that accurate, large-scale information resources can be created from volunteer action. Wikimapia's accuracy varies and is most problematic for the more obscure entries that are not accessed very often. Similarly, I think VGI will be most accurate when it concerns the largest, most prominent, and most important features on the earth's surface. The message in my example of the nonexistent café is that such errors are particularly obvious when the information is geographic, because they conflict with the feature's spatial context. Wikimapia relies on volunteers with specialist knowledge to monitor information; a similar approach to geographic information that relied on local specialists could work very well to clean out errors.

Baumann: *You indicate that "computerization carries authority per se." This perceived authority has been ascribed to other forms of mass media including print and broadcast journalism. The Fourth Estate refers to the press and its ability to both function in the role of advocate and shape public opinion. Do you think VGI and other public mapping efforts play a similar role? When considering the pitfalls of these efforts, Google's controversial replacement of post-Katrina images of New Orleans with pre-Katrina views springs to mind.*

Goodchild: Yes, I think there is a tendency to believe what one discovers on the Web, whether the source is authority or assertion. Bad information can always be dressed up to look good. We usually think of metadata as the mechanism for resolving such problems, but asserted sources rarely carry any metadata. Somehow, we need to convince sources such as Google that providing simple metadata, such as the date of acquisition of imagery, would be in everyone's interests.

For more information on this topic, see Goodchild's 2007 paper on VGI, "Citizens as Sensors: The World of Volunteered Geography," which is available online at www.ncgia.ucsb.edu/projects/vgi/docs/position/Goodchild_VGI2007.pdf.

Geoenabling Federal Business Processes

Improving services to citizens through place-based approaches

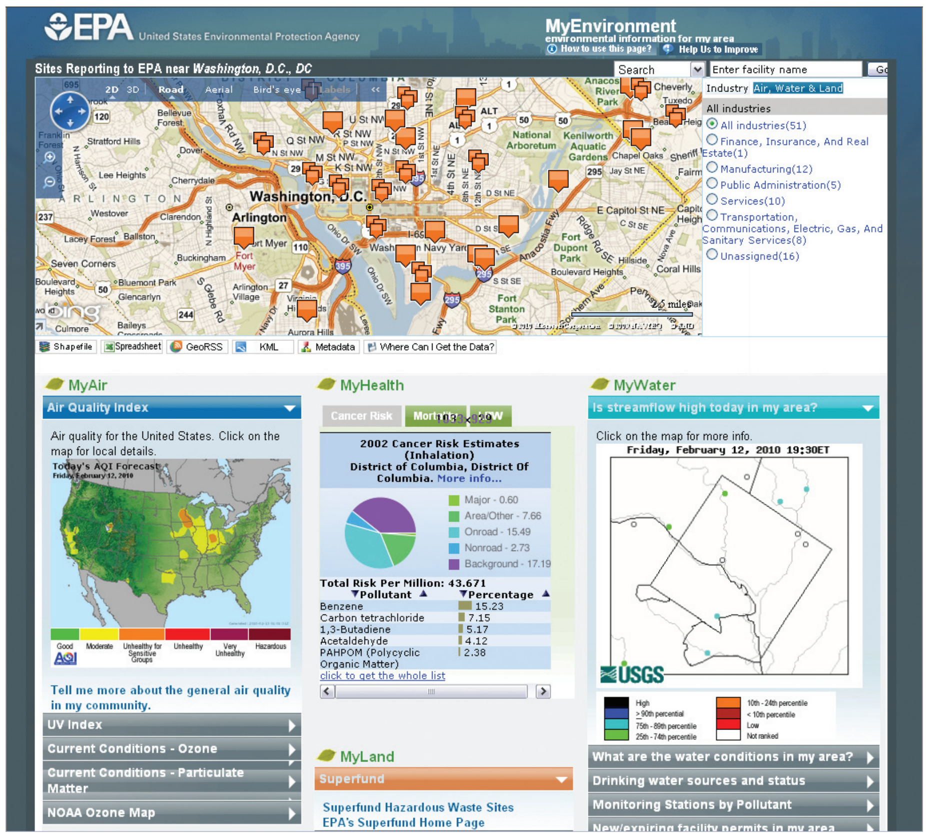
By Sarah Hammer, Jessica Zichichi, and the Geo-Enabled Business Work Group

Have you ever wondered about the quality of the air and water in your community or what types of toxins you may be exposed to? Have you wanted to learn if adverse environmental factors were present near a home you are considering purchasing?

While the answers to these questions would seem to require extensive research across numerous sources, Environmental Protection Agency (EPA) uses geospatial technology to deliver the environmental information that answers these and other questions using a single, easy-to-use online interface called MyEnvironment.

MyEnvironment is a Web-based mapping application that provides data on environmental conditions from numerous federal, state, local, and private sources. The site incorporates mapping technologies and georeferenced data to organize and display everything from Superfund sites and other facilities that report to the EPA to daily ultraviolet (UV) indexes and local water quality data. Users can find personalized information by searching by ZIP Code or address. MyEnvironment links directly to relevant data sources and presents the information in several formats, such as maps, reports, and charts.

MyEnvironment is just one example of how federal organizations are geospatially enabling their business operations. Many federal agencies are using geospatially driven approaches similar to the one used by the EPA for performing business processes and accomplishing mission goals. These agencies often face common challenges: coordinating across programs, combining numerous sources of information, and addressing reductions in budget and personnel. Geoenabled innovations throughout the federal government have helped agencies streamline mission-critical functions, saving resources and improving results while, at the same time, empowering individuals to learn about issues facing their communities. This article provides an overview of some geospatial projects implemented at federal agencies as a way to provide insights into the trends, challenges, solutions, and resources that could be leveraged by GIS users across the nation.



MyEnvironment links directly to relevant data sources and presents the information in several formats, such as maps, reports, or charts.

Raising Awareness

GIS analysts working outside the federal government may not be aware of the types of geospatial applications and data that are available and may not see how the work of government agencies relates to their daily lives or jobs. In particular, the work of cross-agency federal initiatives, such as the Geospatial Line of Business (Geospatial LoB), may not be visible to nonfederal GIS personnel because these efforts tend to focus on coordinating the activities of federal partners. However, initiatives such as the Geospatial LoB are focused on coordinating the production, maintenance, acquisition, information architecture, and use of geospatial data to reduce the cost of federal government programs; inform decision making; and, at the same time, improve services to citizens.

As key stakeholders in this endeavor, the public should be made aware of the Geospatial LoB efforts to maximize the value of geospatial investments. The Geo-Enabled Business (GEB) Work Group, an integral part of the Geospatial LoB, is composed of a number of federal agency representatives who volunteer their time to assist federal program managers and executives in identifying their geoenabled business needs, capabilities, and opportunities. The GEB Work Group meets regularly to identify new geoenabling opportunities and document existing examples that may provide a foundation for expanding knowledge about the capabilities, benefits, and applicability of geospatial technologies for addressing federal agency business functions.

The agency-specific stories and examples provided in this article, collected from Geospatial LoB partners, illustrate how

geospatial resources, approaches, materials, or products developed by federal agencies may be leveraged or reused by the public to meet different needs.

To determine how geospatial technologies and approaches are used within the federal government to carry out its business, Geospatial LoB team members assembled use cases profiling federal programs or projects that leverage geospatial technology successfully and productively meet internal needs or provide information to the public. Interviews were conducted with members of the U.S. EPA, the U.S. Department of Agriculture (USDA), the U.S. Department of Justice (DOJ), the Bureau of Land Management (BLM), the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Administration (NOAA).

Information collected from these groups was analyzed to identify common themes, approaches, and lessons learned. For more information on a particular example, contact the authors. The article concludes with an overview of where Geospatial LoB is headed.

Examples of Geospatial Enabling

A list of geoenabled use cases is summarized in Table 1. To highlight trends and application areas, use cases are organized into six categories: consolidating information, improving and streamlining operations, increased sharing and interagency coordination, automating and improving adherence to standards, providing GIS toolkits and suites of services, and including stakeholder outreach and input.

Consolidating Information

A key characteristic of GIS technology is its ability to bring data and information together. Many agencies leverage GIS to combine data from disparate sources to serve specific, mission-oriented goals. For example, NOAA created nowCOAST, a geoenabled Web site that provides access to real-time coastal data. This site brings together georeferenced information from numerous federal agencies, NOAA's internal resources, and 15,000 external sources. Providing timely information on coastal and climatic phenomena directly supports three NOAA mission goals: protecting national safety, serving society's needs for weather information, and supporting the nation's commerce. For NOAA, GIS created value by enabling an integrated, authoritative, Web-based source for information on coastal conditions that is easily accessible for the public, commercial purposes, and federal users.

A different type of information consolidation is the development of the Common Land Unit (CLU) dataset by the USDA Farm Service Agency (FSA). FSA created the CLU as a comprehensive digital dataset that includes millions of farmland boundaries obtained from paper maps in more than 2,300 offices. The CLU helps FSA carry out mission-critical functions, including compliance and conservation, by combining digital farm boundaries with business data. The consolidated data helps FSA meet its mission goals while saving the agency time and resources.

Improving and Streamlining Operations

The TERRA program, also created by the USDA FSA, combines 27 formerly independent calculations and pieces of information into one geoenabled application. TERRA helps FSA weigh the costs and benefits of renting land from farmers to stop soil erosion—a mission-critical function that is part of the Conservation Reserve Program. Both farmers and staff members use this database to quickly visualize areas of protected land and improve decision making. Calculations that may have taken days in the past now take only minutes.

Another example of streamlining processes is the National Institute of Justice (NIJ) Mapping and Analysis for Public Safety (MAPS) program at DOJ. Through the MAPS program, NIJ created a range of geospatial tools that focus on mapping incidents of crime to better inform police investigations and actions. These tools provide a number of functions ranging from hot spot analysis, journey to crime estimation, and near-repeat calculations. MAPS tools support DOJ's mission by improving the ability of law enforcement professionals to fight crime while simultaneously providing resources that support researchers studying law enforcement and crime.

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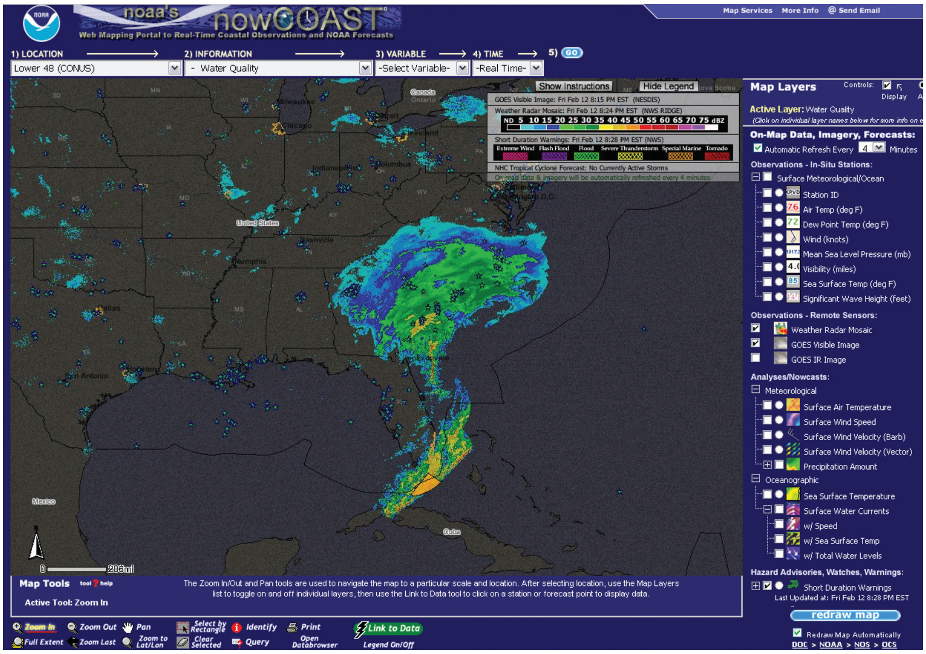


The nowCOAST Web site provides access to real-time coastal data from numerous federal agencies, NOAA's internal resources, and 15,000 external sources.

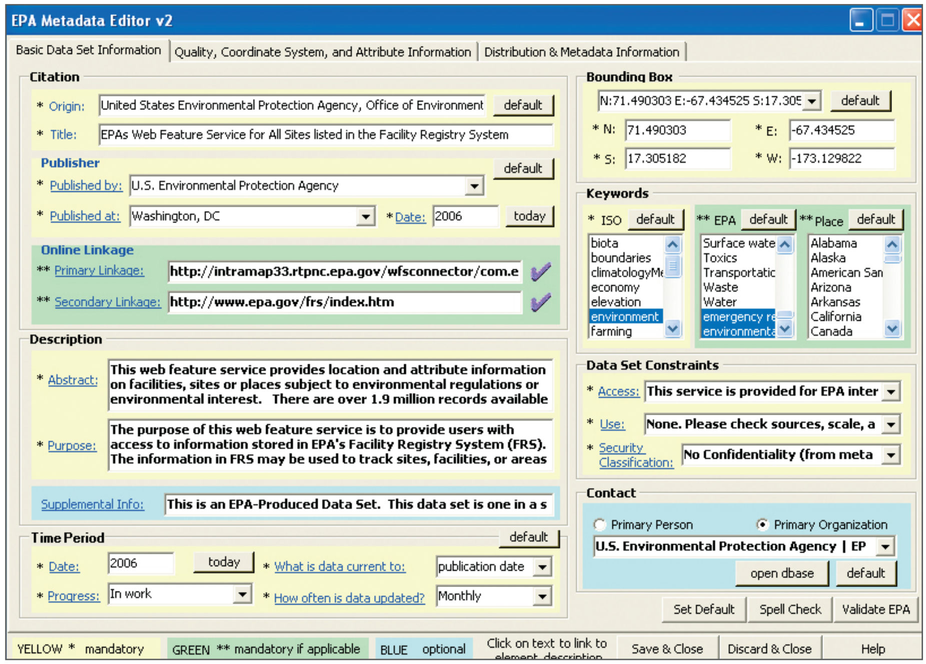
Geoenabling Federal Business Processes

Continued from page 23

Increased Sharing and Interagency Coordination

In addition to time and cost savings, many organizations use geospatial technology to facilitate inter- and intra-agency coordination. Enterprise Geospatial Services (EGS) facilitates spatial data sharing across FEMA by actively managing data collection, storage, and use. EGS facilitates data sharing between offices within FEMA and with other agencies, which curbs the tendency to create information silos within a branch or section.

BLM developed the National Integrated Land System (NILS) GeoCommunicator to coordinate geographic data from numerous groups (internal, federal, and state agencies and tribal and local entities). Information compiled in NILS furthers cooperation across offices and assists in making land-use decisions. Additionally, EPA Metadata Editor (EME) fosters increased sharing of geospatial resources through better-quality metadata. This freely available application encourages users both inside and outside the federal government to produce high-quality, reusable metadata that can be shared with others. *[For more information on EME, see "The EPA Metadata Editor" in the July–September 2007 issue of* ArcUser *magazine, which is available online at www.esri.com/arcuser.]* The coordination and sharing of information exemplified by these applications not only reduces redundancy but also provides decision makers with better access to higher-quality information and encourages agencies to coordinate their efforts to solve complex problems.



EPA Metadata Editor (EME) fosters increased sharing of geospatial resources through better-quality metadata.

The National Integrated Land System (NILS) GeoCommunicator, developed by the Bureau of Land Management (BLM), coordinates geographic data from internal, federal, and state agencies and tribal and local entities.

Automating and Improving Adherence to Standards

As agencies work together, providing data and services to one another, adhering to standards becomes increasingly important. One agency tackling standards related to address information is the Department of Housing and Urban Development (HUD). HUD uses geospatial data, especially address information, in its everyday operations and decision making. The agency's Geocode Service Center (GSC), a core part of its geospatial infrastructure, is a cost-effective solution that ensures the consistency and accuracy of address information for more than 17 data systems. GSC services are also used at HUD to validate addresses and match the same addresses within different datasets. GSC's high data standards have ensured data consistency across HUD programs and serves as a model for other agencies. The

Agency	GIS Application	Web Site
Bureau of Land Management	National Integrated Land System (NILS) GeoCommunicator	www.geocommunicator.gov
Department of Housing and Urban Development	Geocoding Service Center (GSC)	www.huduser.org/datasets/usps/USPS_Data_Dictionary.pdf
Department of Justice, National Institute of Justice	Mapping and Analysis for Public Safety (MAPS)	www.ojp.usdoj.gov/nij/maps/
Environmental Protection Agency	EPA Metadata Editor (EME)	www.epa.gov/geospatial/eme.html
Environmental Protection Agency	MyEnvironment	www.epa.gov/myenvironment/
Federal Emergency Management Agency	Enterprise Geospatial Services (EGS)	www.gismaps.fema.gov
National Oceanic and Atmospheric Administration	nowCOAST	nowcoast.noaa.gov/
U.S. Department of Agriculture	Common Land Unit (CLU) Dataset	www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prod&topic=clu
U.S. Department of Agriculture	Tool for Environmental Resource Results Assessments (TERRA)	www.fsa.usda.gov
U.S. Geological Survey	Geospatial Management Information System	www.usgs.gov/science_strategy/

Table 1: Federal geospatial innovations

EPA also uses EME to ensure high-quality data inside the agency. EME creates metadata that adheres to the FGDC Content Standard for Digital Geospatial Metadata.

Providing GIS Toolkits and Suites of Services

Many federal agencies provide value to their users by developing toolkits or suites of services. With these suites, users can access many geospatial tools easily. DOJ's MAPS, for example, provides law enforcement professionals and researchers with a complete desktop-based geospatial crime analysis kit. It contains two complete desktop geospatial systems, two profiling utilities, a crime analysis extension, a tactical crime analysis tool, linked charting programs, statistics programs, and a complete office program suite. In addition, NIJ provides Web-based crime tracking and prevention tools to augment the desktop software. FEMA also provides a variety of geospatial services to its users, including professional services such as geospatial project management, technical training, and systems engineering.

Including Stakeholder Outreach and Input

Many organizations recognize the crucial role that stakeholders have in creating and implementing a successful geospatial program or project. Numerous agencies reported utilizing stakeholders throughout the requirements gathering, application design, and development phases of application development. Several agencies continue to work actively with stakeholders to improve these geospatial applications. For example, while creating the CLU database, designers consulted FSA staff from offices around the country, key decision makers, and even farmers to create a tool that would assist in capturing CLU data and performing the functions FSA needed. NOAA, EPA, and U.S. Geological Survey have included stakeholders throughout collaborative design and implementation.

Conclusion and Next Steps

As these examples show, geospatial technology has become a core component of federal government mission operations. Expanding GIS technology in a way that realizes the best value for the government and the public is critical for creating a sustainable, geoenabled future. The Geospatial LoB will continue working with partners to identify existing and new areas where geospatial technology may be expanded, reused, consolidated, and leveraged. For more information on the Geospatial LoB and its structure, visit the FGDC.gov Web site and read the Geospatial Line of Business fact sheet (www.fgdc.gov/geospatial-lob/factsheets). To become involved or learn more about the Geospatial LoB, contact Lew Sanford at lsanford@usgs.gov.

About the Authors

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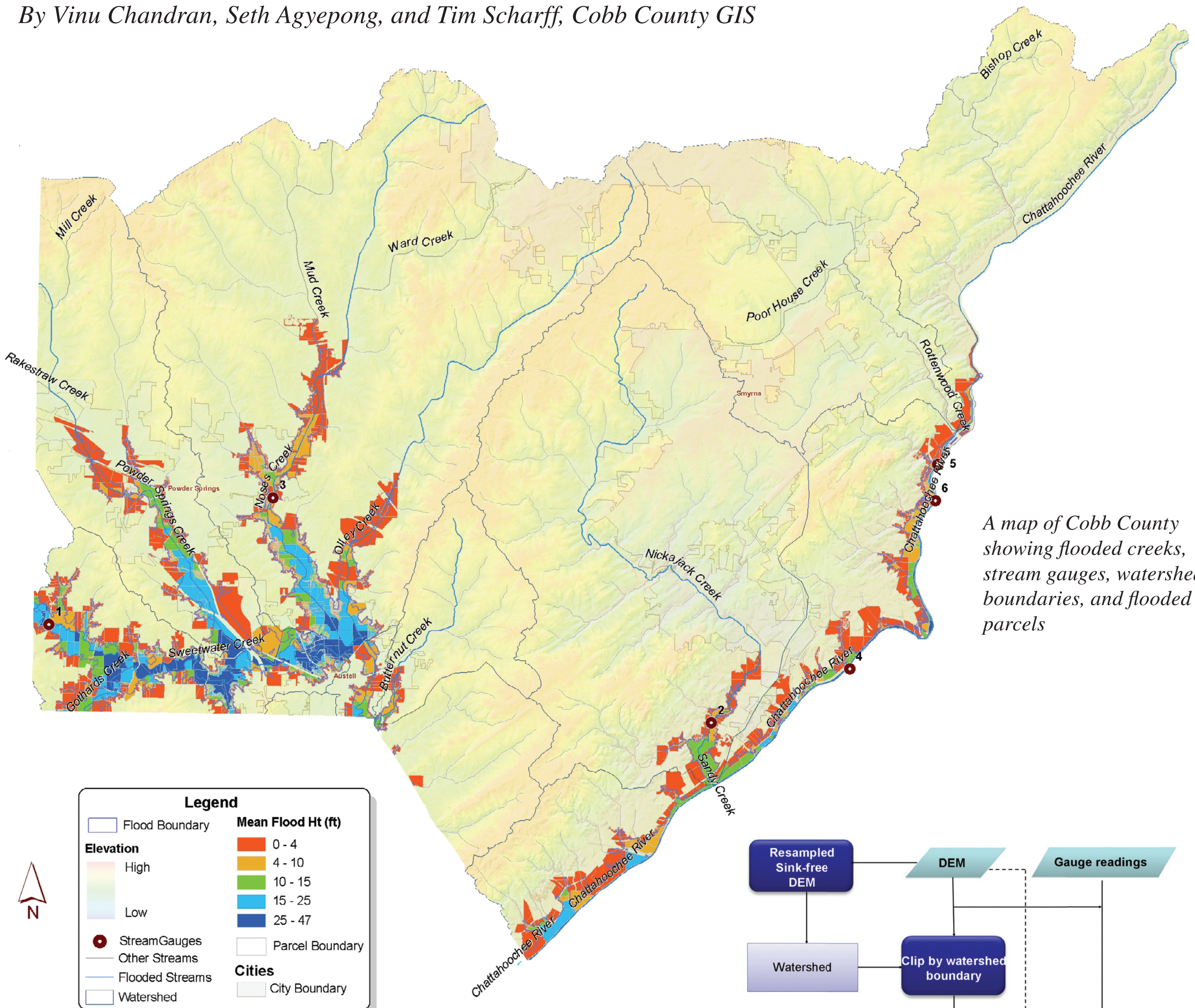
Getting Answers Quickly

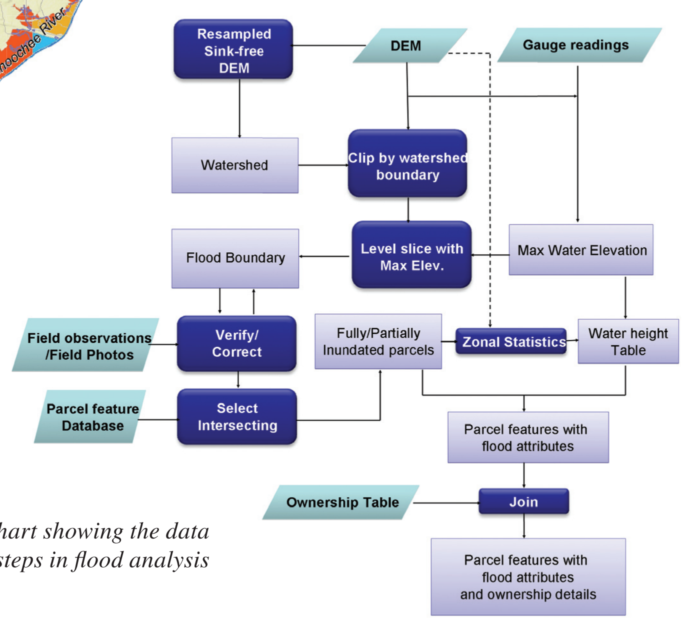
Hydrologic analysis and 3D GIS improve flood response

By Vinu Chandran, Seth Agyepong, and Tim Scharff, Cobb County GIS

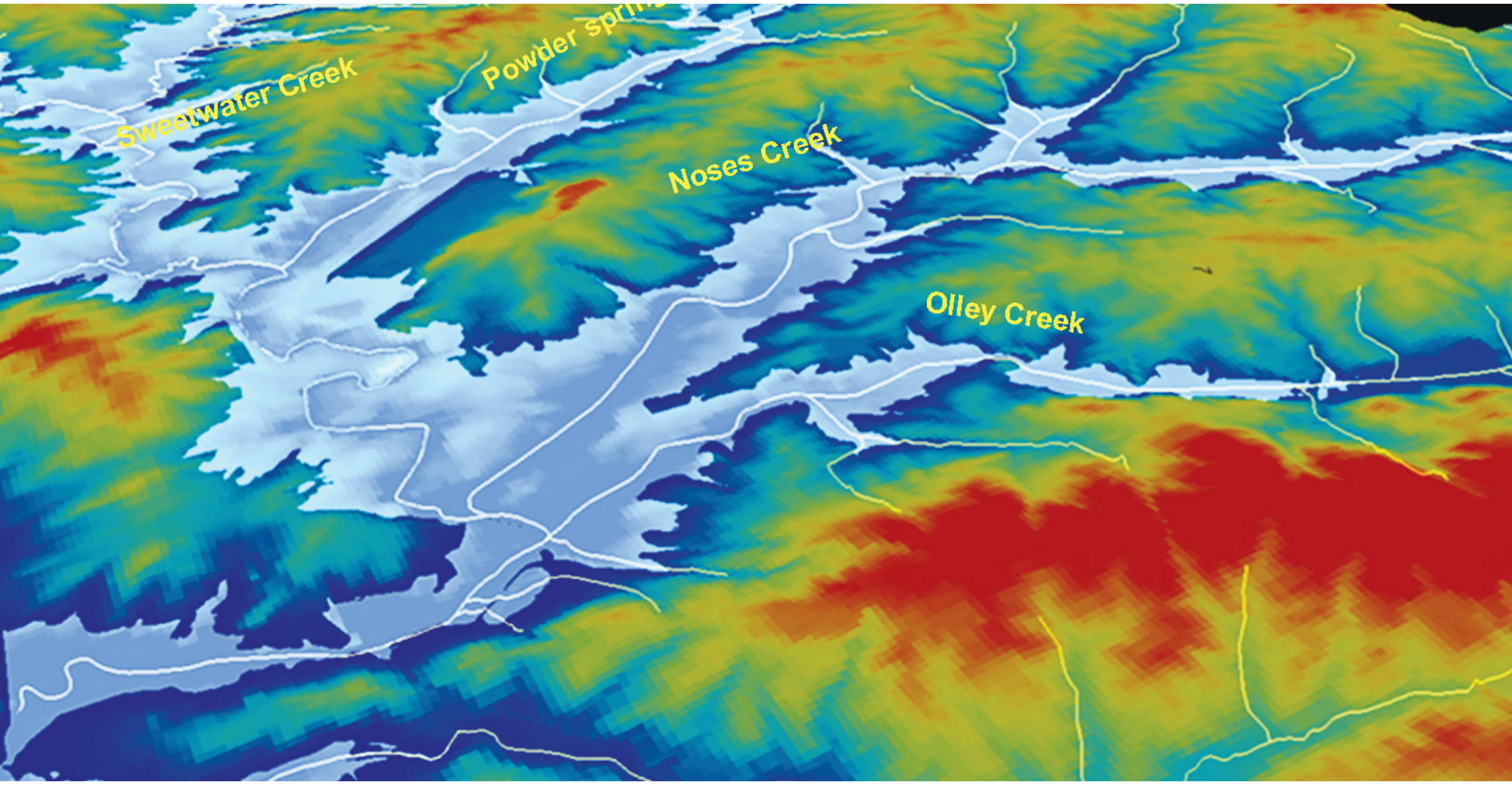


Location Map
Cobb County, GA

A map of Cobb County showing flooded creeks, stream gauges, watershed boundaries, and flooded parcels



A flowchart showing the data processing steps in flood analysis



A three-dimensional view of the flooded area showing stream centerlines and elevation

In September 2009, torrential rains in the northern portion of Georgia caused excessive runoff, triggering massive flooding in several areas. Flooding principally affected Cobb, Fulton, and Douglas counties and caused nine deaths and approximately $250 million in property damage.

Cobb County, in northern Georgia, with a population of approximately 700,000, experienced heavy flooding along the banks of Chattahoochee River and various major creeks. Hundreds of houses and families in southern and southeastern Cobb County were affected. County and federal governments and relief organizations played an important role in rehabilitating affected areas by providing emergency response, shelter, and postdisaster support.

Part of that support came in the form of geospatial modeling within an enterprise GIS environment. Established in 1999, Cobb County's enterprise GIS was an integral part of the county's Emergency Operations Center (EOC). At the EOC, GIS staff collected data from damage assessment teams and staff members supporting the center, created data layers, performed analyses, and produced maps in response to several requests for information.

Away from the EOC, GIS staff in different departments coordinated with the EOC to create data layers and produce maps, such as the road closure maps generated by Cobb County Department of Transportation. To focus immediate assistance where needed most, identification of the flood-affected properties was important. Flood analysis carried out by the GIS group and the tax assessor's office benefited different departments that were working to provide a fast and effective response and mitigation after the event. The flood inundation analysis was carried out with stream gauge measurements from the United States Geological Survey (USGS) and spatial data contained in the county's enterprise GIS.

The main objectives of the analysis were to identify the approximate extent of floodwater coverage; identify and locate the affected parcels; determine the minimum, maximum, and mean water heights in the parcels; and identify and document completely and partially flooded properties. The analysis used three data sources: maximum stream gauge readings at select locations, a high-resolution elevation surface derived from the county's digital terrain model (DTM), and the parcel database. All vector and raster data analyses were carried out in ArcGIS Desktop because it has the vector, raster, and three-dimensional capabilities needed to complete the analysis. Apart from the routine analysis, the hydrologic analysis tools helped in the faster delineation of watersheds, whereas the 3D capabilities helped in visualizing the output.

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Aerial photos of a subdivision in Cobb County before (top) and after (bottom) the flood

Determining the Flood Boundary

Deriving the flood boundary as fast as possible was the main goal of the EOC request. Necessary modifications were made to the flood boundary using the field observations. The corrected flood boundary was then used to identify inundated parcels.

Stream gauges served as the primary source of water level information during the flood event. Readings from seven gauges located on various streams/rivers were used to determine the elevation of floodwater at these locations. The crux of any terrain-based analysis is a three-dimensional representation of the terrain. Hence the accuracy of the output is highly dependent on the terrain model. A highly accurate digital elevation model (DEM) with a horizontal resolution of 8 feet, which was derived from the county's 2-foot contours and stored as a float double-formatted raster image, is available from the county's enterprise GIS data warehouse. To verify the flood boundary and make corrections during field verification, the original 2-foot contour data was used. A line feature class of the streams was used to identify the stream centerlines and names. Orthophotos and oblique aerial photography were used in conjunction with photographs taken from aircraft to verify the flood boundary and the floodwater heights at known locations.

The county maintains a parcel geodatabase in ArcSDE as well as tables in a CAMA (computer-assisted mass appraisal) system that contains ownership, property classification, and valuation information for more than 248,000 parcels. Each record in the parcel geodatabase and CAMA table is identified by a unique parcel number, which was used to link these tables to obtain the ownership and property class information.

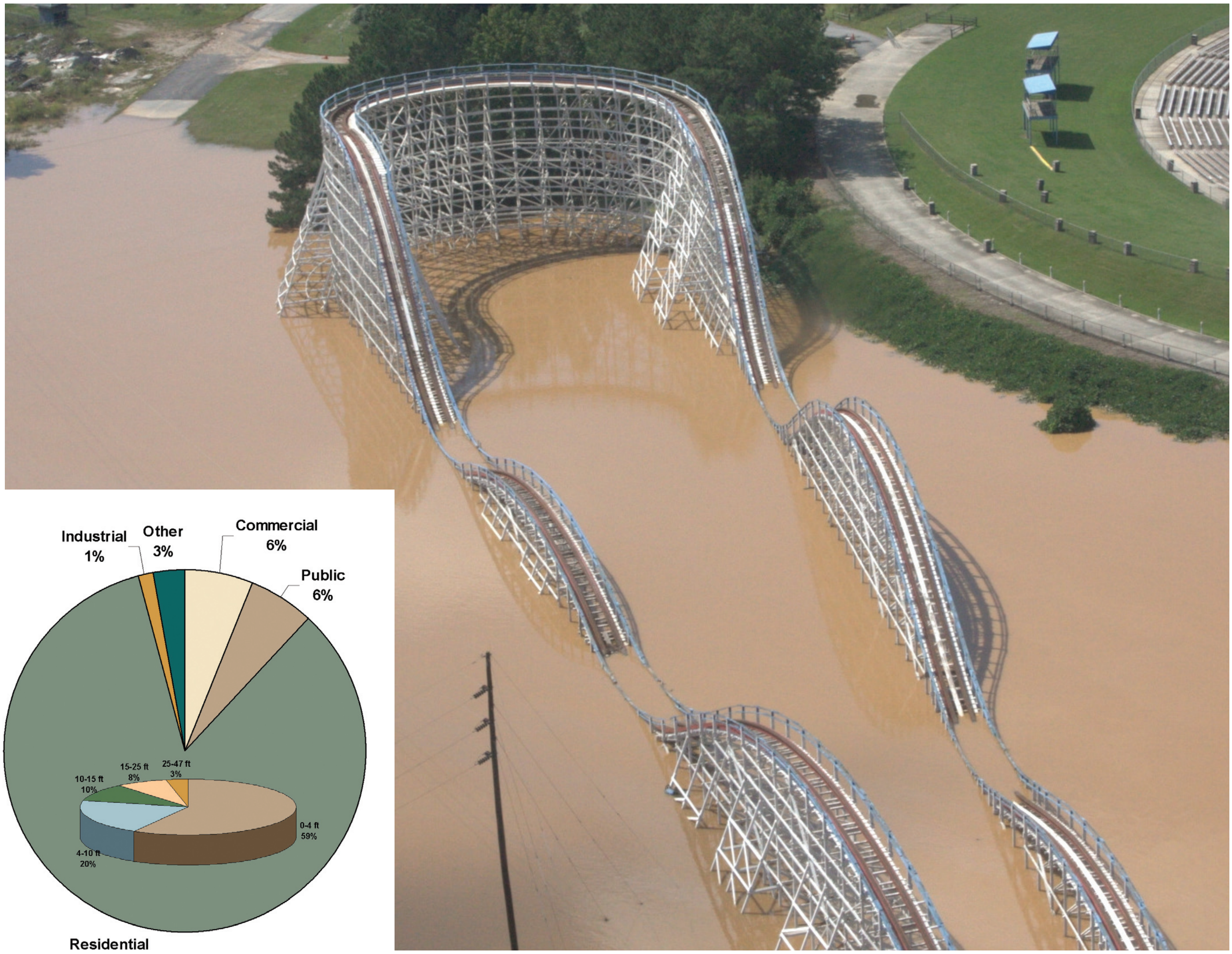
Calculating the Flood Extent

Runoff water from a hydrologic unit (watershed) is always drained to a particular stream. Thus, the stream floods the area within its watershed. The flooded areas in the county were divided into six watersheds for flood boundary calculation. Watershed boundaries were derived from a resampled (32-foot) sink-free DEM using the Hydrology tools in the ArcGIS Spatial Analyst extension. U.S. Geological Survey stream gauge sites were visually identified from the orthophotos. The ground elevation (m-values measured in feet) at these locations were obtained from the DEM. The flood boundary was calculated by determining the maximum flood elevation in feet (H) for a watershed, then identifying the areas in the DEM having values less than H. The maximum flood elevation is calculated as where SG is the maximum stream gauge reading in feet.

$$H = M + SG$$

Inundation areas were calculated separately for each watershed. The DEM grid (8-foot resolution) clipped by watershed boundary, was level sliced to identify the area below the maximum flood elevation. The flood cover raster was then converted to a polygon feature to obtain the flood boundary. For generating the preliminary flood boundary, slope of the streams was not taken into account. Modifications were made to the flood boundary using observations from the field. Flood boundaries from all the watersheds were then combined into a single polygon.

The flood-affected parcels were identified by intersecting the flood boundary with the parcel feature layer. Parcels completely falling within the flood boundary were classified as fully inundated. The minimum, mean, and maximum floodwater heights for each parcel were calculated by estimating the respective elevations from the DEM (using the zonal statistics tool), according to the following formulas on page 29.



The pie chart shows the percentage of the county's 3,794 properties that were affected by the flood. The chart inset shows the percentage of residential properties under different floodwater levels. The photograph shows a section of Six Flags theme park that flooded.

$$H_{min} = 0 \text{ or } H - M_{min} \ \textit{if} \ H > M_{min}$$

$$H_{mean} = 0 \text{ or } H - M_{mean} \ \textit{if} \ H > M_{mean}$$

$$H_{max} = 0 \text{ or } H - M_{max} \ \textit{if} \ H > M_{max}$$

Where H_{min}, H_{mean}, and H_{max} are the minimum, mean, and maximum water heights and M_{min}, M_{mean}, and M_{max} are the minimum, mean, and maximum ground elevation values, respectively.

The formulas above are used for calculating floodwater heights for each parcel.

The parcel feature table was then joined with the ownership table to obtain the parcel class (e.g., commercial, residential, public property). ArcScene was used to generate a three-dimensional visualization of the flooded area. The field inspectors were provided with situs addresses along with the flood height information for the parcels. This information helped them easily identify and determine the extent of damage for each property. The county has since established a river model in HEC-RAS to help ensure future flood inundation boundaries can be obtained with better accuracy. *[HEC-RAS, or the Hydrologic Engineering Center's River Analysis System, is a software program developed by the U.S. Army Corps of Engineers for performing one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modeling.]*

Information is the lifeline of any EOC, and GIS technology is a valuable tool when it comes to managing and analyzing data and ensuring its broad availability. Through the use of GIS, Cobb County was able to quickly determine the approximate extent of flooding; generate maps and reports that helped first responders, inspectors, and repair crews prioritize the areas to visit; and publish information to department managers and personnel via a Web mapping application.

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The Virtual Estuary

New GIS tool for exploration and analysis

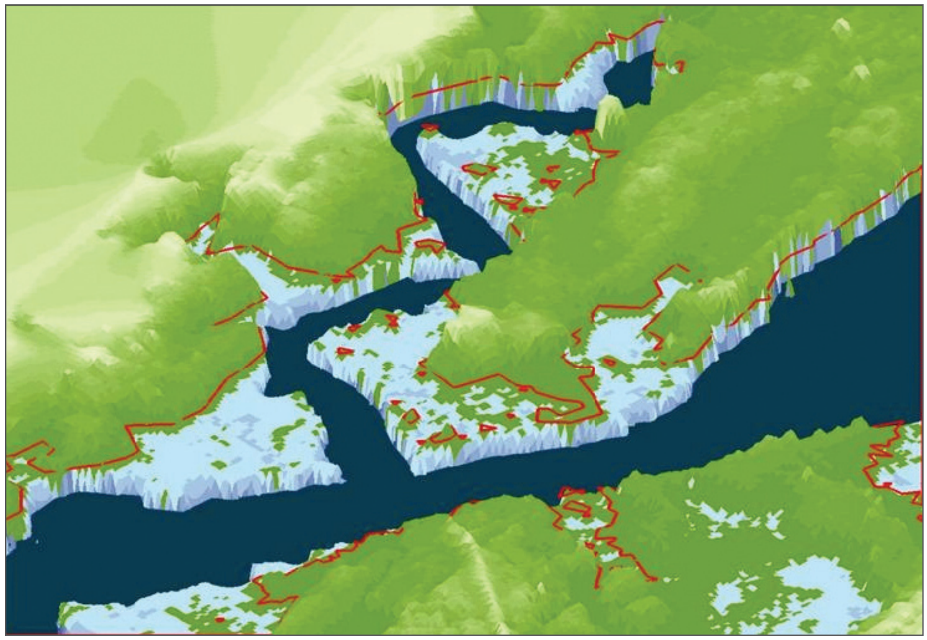
By Sandra Fox, St. Johns River Water Management District, and Stephen Bourne, PBS&J

A GIS tool developed by a team of experts is helping scientists more effectively study complex coastal and estuary systems.

Coastal flooding from extreme weather events threatens millions of lives and properties along U.S. coastlines every year. Especially hard hit are areas along the Atlantic Ocean and the Gulf of Mexico where over 60 percent of homes and businesses are within 500 feet of the shoreline. Yet, the ability to explore and study complex coastal environments with accuracy and speed has been limited, if not impossible. Affordable hydrologic models that work well on inland studies simply don't translate to coastal applications. However, more sophisticated supercomputer-based modeling techniques are cost prohibitive.

In a pioneering effort, the St. Johns River Water Management District (SJRWMD) led a team of experts from academia, government, and industry in the development of the Analytical Framework for Coastal and Estuarine Studies (ACES) GIS tool, one of the first comprehensive coastal and estuarine tools. Still under development, ACES is designed to help scientists accurately monitor and manage the health of a complex estuary from within the Arc Hydro hydrologic environment. *[Arc Hydro is a data model template for use with water resources applications that has been developed by ESRI in collaboration with key state, national, and international contributors.]*

This tool has been used to support estuarine and coastal studies for the Guana/Tolomato/Matanzas Estuary, also a National Estuary Research Reserve for SJRWMD, as well as water quality studies in the Gulf of Mexico. *[The National Estuarine Research Reserves are "living laboratories" that help researchers better understand coastal communities and find methods for dealing with the challenges these areas face.]*



In this portion of the estuary displayed in ArcScene, the high tide polygon (red line) and low tide polygon (solid dark blue) along with a digital elevation model (DEM) of the area

Cooperative Development

SJRWMD is responsible for regulating water use and protecting wetlands, waterways, and drinking water supplies along Florida's sensitive eastern coastline from Fernandina Beach to Vero Beach. The agency's Surface Water Quality Monitoring (SWQM) has used Arc Hydro to develop specialized hydrologic tools such as an automated pollution load screening model and a drainage area spatial data summary tool.

Yet, while greatly beneficial, these hydrologic tools were unable to account for tidal influences, which directly impact water quality in estuarine waters. This limited the agency's ability to accurately manage water quality throughout the region.

SJRWMD put together a technical team to develop ACES that included experts from SJRWMD, University of Florida, The Nature Conservancy, U.S. Geological Survey, and PBS&J, a consulting firm. The agency also put in place an expert review team that would be responsible for evaluating the end product developed by the technical team. The review team included the members from the Center for Research in Water Resources at the University of Texas, Austin; U.S. Army Corps of Engineers' Engineer Research and Development Center; and PBS&J.

The technical team's first task was to establish a master plan for the tool development from proof of concept to production. SJRWMD stipulated that the tool must be applicable to all SJRWMD estuaries and include existing GIS-based tools and enhanced Arc Hydro geodatabases developed by SWQM. Goal-driven brainstorming sessions helped keep the technical team on track throughout the development process. The initial brainstorming sessions and literature review focused on the nature of an estuary, estuarine hydrodynamics, estuarine classification, existing GIS-based modeling technologies for estuaries, and synthetic modeling of water quality in estuaries.

The team found that the first step in approaching the study of estuaries was the creation of a GIS-based workbench tool that could integrate multiple sources. Water in coastal areas frequently comes from multiple sources. These might include surface water flow, incoming tides, manmade waterways, and even in some cases groundwater. The tool had to allow for the creation of virtual estuaries and estimation of bulk parameters of the estuaries and facilitate development and integration of other models into the same framework.

Conceptual Controls

In the initial development phase of the ACES project, the technical team developed an estuary control volume conceptual model that connects features in the estuary physical model with elements contributing to the control volumes such as waters from coastal bases, oceanic constituents, riverines, and intracoastal waterways. Groundwater influence was not considered in this initial application since the influence is likely small as compared to the other elements.

The team relied on a simple multiple linear regression (MLR) tool for evaluating relationships between constituents emanating from drainage areas and the measured values of water quality in the control volume. A more robust estimate of contributing areas may be obtained by using an iterative process that compared predicted and measured values while modifying the drainage area contribution. Throughout the effort, the team communicated extensively regarding various topics ranging from the deceptively simple, such as the definition of an estuary, to the complex and controversial modeling approach.

Coastal Possibilities

The ACES prototype tool is composed of a GIS-based database of spatial and temporal data that describes the environment and an accompanying ArcMap-based toolset. Using ACES, scientists can essentially build a virtual model of the estuary they are interested in using topographic,

The St. Augustine Inlet to the Guana/Tolomato/Matanzas Estuary is a barrier that was accurately characterized with the ACES tool. The Matanzas Inlet is one of Florida's few remaining natural, unmanaged inlets.

bathymetric, and tidal datum data.

Within an Arc Hydro model, ACES can be used to determine estuarine bulk parameters (such as total area, high and low tide, volume, depth, and tidal flow) related to the shape of the estuary. With data related to flow rates into and out of the estuary, more complex parameters can be derived, such as residence time (the time water stays within a system) and flushing potential (an estuary's ability to flush a harmful substance).

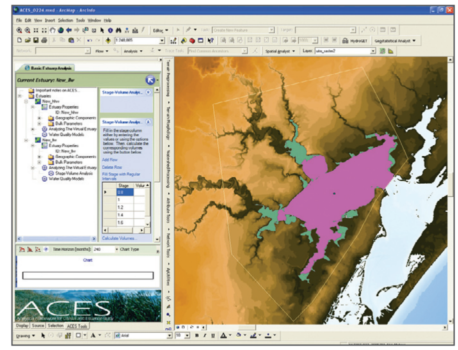
Using this information, the relative importance of tidal versus land-based flow on estuarine hydrodynamics can be assessed. Relationships between estuary water quality and flow rates can also be investigated. Using the ACES regression model capabilities, scientists can find the correlative relationships between the influential factors of upstream riverine drainage, coastal drainage, and estuarine non-point source pollution.

Prototype in Action

An ACES prototype was used to support estuarine and coastal studies for the Guana/Tolomato/Matanzas Estuary, which is also a National Estuary Research Reserve for SJRWMD. Guana/Tolomato/Matanzas encompasses approximately 73,000 acres of salt marsh and mangrove tidal wetlands, oyster bars, estuarine lagoons, upland habitat, and offshore seas in northeast Florida. Along the northern section of the reserve, the Tolomato and Guana rivers meet the waters of the Atlantic Ocean. The southern section follows the Matanzas River, which extends from Moses Creek south of Pellicer Creek.

The ACES tool was also used to support a water quality study of Copano Bay in south Texas, a project sponsored by the Texas Commission on Environmental Quality. A popular fishing and recreation site, Copano Bay is a large watershed with source waters from Aransas Bay and several rivers. Dr. Stephanie Johnson, then a doctoral student in the Center for Research in Water Resources at the University of Texas under Dr. David Maidment, wanted to develop an accurate water quality model for the bay. Johnson had already acquired estuary depth measurements, which she converted to volumes to model the processes within the bay.

"To complete this study, I needed basic information, such as the bay volume and symmetry, which I could have calculated by hand using available contour maps, though it would have been a tedious process," said Johnson. Working with the ACES development team, Johnson used the ACES program to automatically develop the necessary estuary volume versus depth curve for use when computing the total maximum daily load of pollutants. "Through the ACES program, I was also able to create highly visual images that I incorporated into my larger water quality model and used to communicate with various nontechnical stakeholders," added Johnson.



ACES was used to find the volume of Copano Bay in Texas at several tidal levels to estimate pollutant loadings in the bay. Each colored polygon shows the shoreline for a different water level.

In the near future, environmental scientists at SJRWMD will use ACES to explore the estuaries along the northeastern coast of Florida, including the mouth of the St. Johns River, the Indian River Lagoon, and the Nassau and St. Marys rivers. ACES presents a wealth of possibilities for the exploration and analysis of estuaries at universities and within water management districts. This tool will continue to evolve in functionality and application to help coastal experts more easily explore and understand complex coastal environments.

About the Authors

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Is ONE Route Good Enough?

Using ArcGIS Network Analyst in pipeline alignment optimization

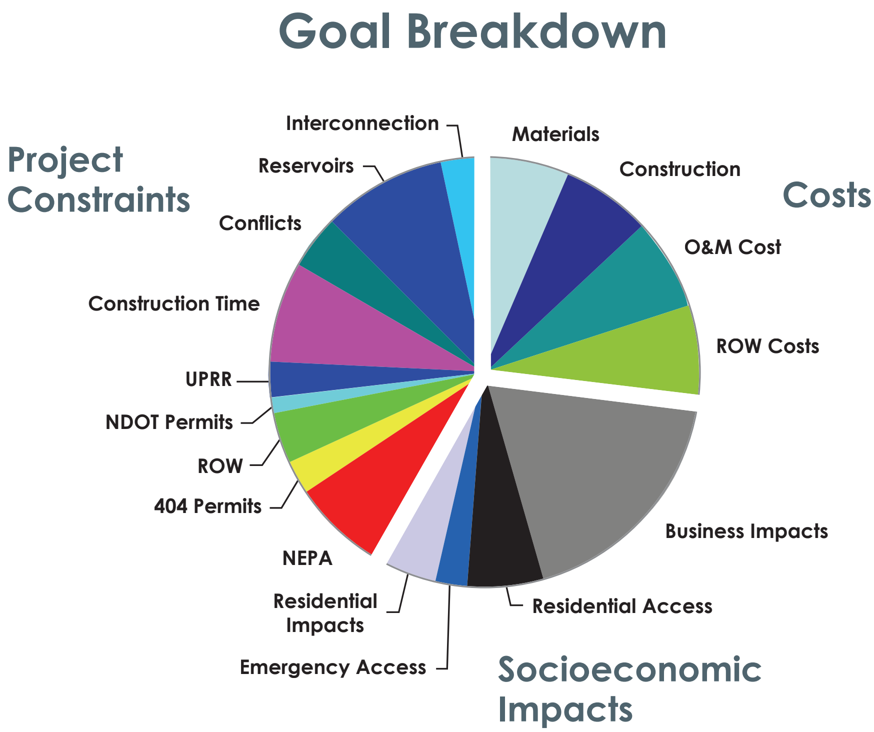
By Ahmad M. Salah, Ph.D., GISP, and Denis Atwood, P.E.

Pipelines are considered by some to be the most cost efficient and environmentally friendly method for transporting oil, gas, water, and other fluids. The continued growth of municipal areas is increasing the demand for pipelines. However, the high cost of building pipelines and the potential devastation that can be caused by pipeline failures require that these projects be thoroughly planned.

Most pipeline alignment tasks involve linking the conduit from an origin point to a destination point. In some applications, more than one origin and destination may be required for the same alignment. Between the origin and destination points, decision makers are always confronted with numerous and a sometimes seemingly infinite number of potential corridors from which to choose.

Pipeline alignments have been designed using many methods ranging from filling out simple and subjective forms to employing sophisticated GIS tools. The ArcGIS Network Analyst extension can be used for performing spatial analysis on linear networks. Node-to-node routing, one of the types of analysis that can be performed using Network Analyst, minimizes an objective function (i.e., define the shortest route).

Having said that, is producing one "best" route the most



The decision matrix breakdown

desirable result for all applications? Depending on the network, a significant number of potential routes may be possible. Depending on the specific network problem being considered, a single best solution may not be the most feasible or useful. For example, the third best route from a cost perspective may be the best when considered from a maintenance or environmental perspective. Decision makers often like to consider multiple options before coming to a final decision on the selected route, especially for significant and large diameter pipelines. For these reasons, modelers typically generate more than just the default "best" route. Selecting more than one default route using ArcGIS Network Analyst can be done both manually and programmatically.

This article summarizes the use of ArcObjects and Visual Basic for Applications (VBA) to develop a custom application for pipeline alignment optimization that can identify a number of potential routes and list and rank these routes for further analysis in an automated fashion. The application extracts project-specific information, including segment weights and costs from a Microsoft Excel spreadsheet, and imports them as attributes to a pipe network feature class composed of individual pipe segments. The application loops through the potential corridors to list a predetermined number of potential routes. A feature class listing these corridors is generated and displayed. The application then exports the output back to Microsoft Excel and ranks the corridors according to their total weight (summation of weights for the comprising segments) and costs and generates a graph illustrating all the generated corridors in a triaxial chart for quick analysis of the potential routes.

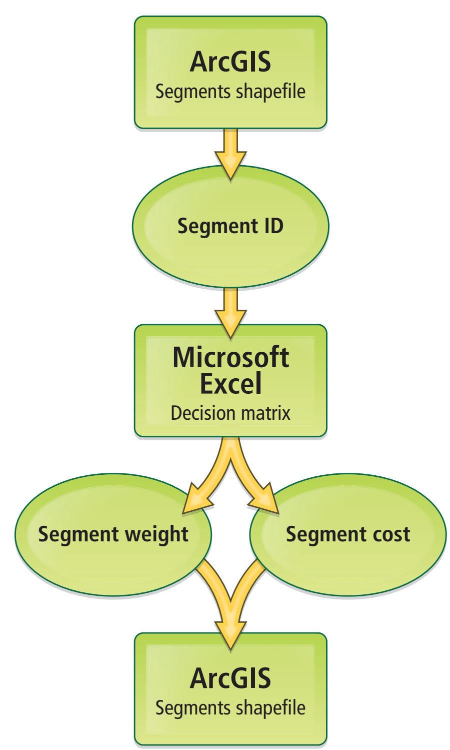
This application uses a pipe segments feature class in which the segment IDs are stored as integers in a field named SgID. It also uses a decision matrix, a two-dimensional table listing all segments available between origin and destination points and their scores for each criteria and subcriteria included in the analysis. The decision matrix is created in Microsoft Excel. Decision makers and stakeholders use Excel when developing project priorities, defining project design criteria, assigning relative weights to criterion, and assigning a score for each segment for each criterion. This is a preprocessing tool that aggregates all factors into two numbers—weight and cost. Weight combines all segment weighted scores on all criteria, while cost combines the associated costs for each segment.

Engineering, environmental, and socioeconomic factors are considered in the decision matrix. Each segment is given a score on each of these factors along with the relative weights between these criteria. The weighted score for both weight and cost is calculated for each segment. The lower the value assigned to the segment, the more desirable the segment would be for the pipeline corridor.

Engineering considerations include land uses, terrain, materials, constructability, right-of-way acquisition, crossings and conflicts, soils, geology, length, and operation and maintenance.

Environmental considerations include land use, visual and physical impacts, National Environmental Policy Act (NEPA), permits (for departments of transportation or local and regional agencies, or for Section 404 *[permits issued pursuant to Section 404 of the Clean Water Act, which regulates the discharge of dredged, excavated, or fill material in wetlands, streams, rivers, and other U.S. waters]*), and site conditions.

Socioeconomic considerations include business and residential impacts, agency consider-



The process for importing segment weights and costs

Continued on page 34

Is One Route Good Enough?

Continued from page 33

ations, and construction time.

Once the pipe network is identified and the decision matrix is populated with the relative scores and weights for all the segments and criteria, the application is ready for the analysis. The analysis process consists of three steps:

1. Import segment weights and costs into ArcGIS.
2. Identify potential corridors.
3. Export results back to Microsoft Excel.

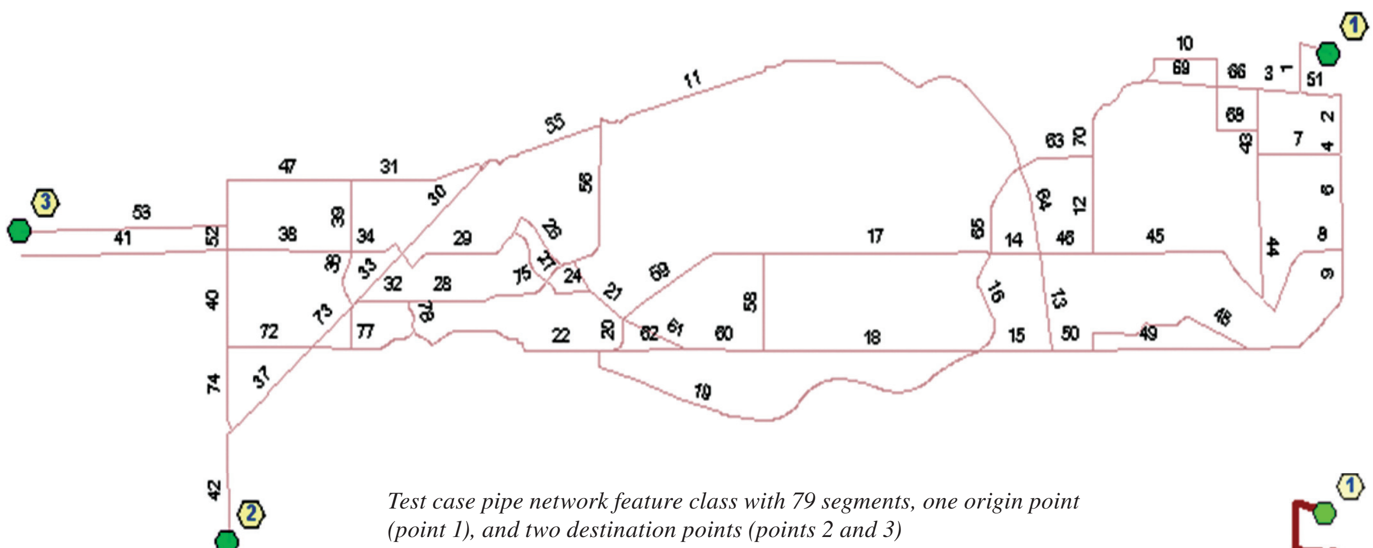
Optimizing a corridor from a nest of segments is similar to finding the directions through a network of roads—at least one attribute is required for the optimization process. Minimizing an objective function is the key to determining the best route. In this analysis, two attributes are used: total segment weight and cost.

Once the decision matrix is populated with criteria weights and segment costs and scores for all criteria, it is important to import the segment weight and cost into the Pipe Segments feature class in ArcGIS. From ArcGIS, the application lets users browse for the Microsoft Excel decision matrix. Once the file is opened, the application looks up the segment weights and costs for each segment based on segment ID in the segments feature class and reads the data from Microsoft Excel cells, which contain weight and cost. The application highlights each cell in the decision matrix to indicate is has been successfully read.

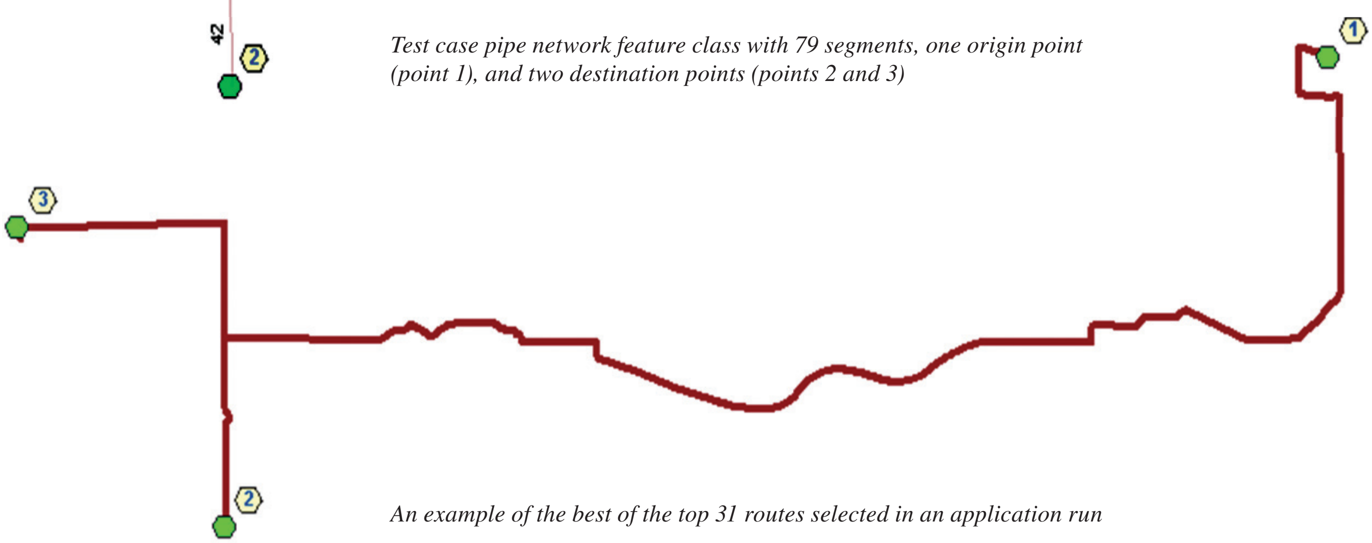
The application then appends three fields to the Pipe Segments attribute table. The SgLength field contains the length of each segment in map units, which is feet. The SgWeight field contains segment weights imported from the decision matrix. The SgCost field contains segment costs imported from the decision matrix. However, if these fields exist before the application runs, the values in these fields are just updated.

Once the individual segments', weights and costs are imported from the decision matrix, the application is ready to perform the Network Analyst process. The application loops through the segment feature class and identifies all potential routes from the start node to the end node(s). The algorithm for this command minimizes the total weight of the segments comprising the current corridor. It does not take the cost of each segment into consideration in selecting the corridor but does keep track of the cost and sums it for each potential corridor.

After successfully identifying routes, the application generates a new feature class and



Test case pipe network feature class with 79 segments, one origin point (point 1), and two destination points (points 2 and 3)



An example of the best of the top 31 routes selected in an application run

Corridor ID	A ranked list of corridors
Total weight	Sum of the weights of all the segments that comprise a corridor
Subtotal Costs	Sum of the costs of all the segments that comprise the corridor
Segments	An ordered list of all the segments comprising the corridor
Triaxial Summary Chart	Representation of the total weight as bars and subtotal costs as lines

Table 1: Fields exported to the Best Corridors worksheet

adds it to the active data frame in ArcGIS. The new date- and time-stamped feature class is saved in the application's Model Output folder. Each feature in this file is a potential pipeline route between origin and destination points. The number of potential routes is determined by the preset number of iterations.

In summary, successful corridor identification requires

- A polyline feature class for the pipe segments
- A segment feature class with three fields named SgLength, SgWeight, and SgCost
- ArcGIS Network Analyst extension loaded and an active ArcGIS Network Analyst window

Each route can be viewed in ArcGIS geographically and exported to CAD, if desired. Also, the application reads the values from the attribute table of the output feature class and exports it to Microsoft Excel. In Microsoft Excel, the file contains only one worksheet named Best Corridors and a chart. Both can be saved if desired. (See Table 1)

The application also generates a summary report for each run, if it's present in a dialog, and a Microsoft Word document that lists

- The date and time of the application run
- The spatial data path
- Feature class used
- Geodatabase used (with path)
- Shapefile projection
- Shapefile alias name
- The modeler ID
- Number of fields and records in the used shapefile
- Total number of features selected

While one "best route" may be sufficient in some cases, for most pipeline applications, a list of the top 20 routes will help decision makers arrive at a more well-informed choice. Because building transmission pipelines requires a large time investment and can have significant environmental and socioeconomic effects, determining pipeline routes deserves detailed analysis. This application can save time by automatically providing a list of potential routes.

For major pipelines, the involvement of the public and other stakeholders in the decision-making process is paramount. The decision matrix and the dynamic process described are very useful. Stakeholders, agencies, and the public can be involved in assigning weights and scores to segments. Once that is done, the application can be run and, within a short time, a chart can be generated that ranks the top potential routes. Once a good algorithm is defined, automated route generation saves a lot of modeling time.

By programmatically linking ArcGIS to Microsoft Excel/Word and/or CAD for further analysis and reporting, the application provides a user-friendly interface embedded into ArcGIS that lets users go through the optimization process. The linkage tool took about two weeks to program, test, and implement. The authors anticipate this tool will be used in future pipeline alignment projects.

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Illustrating the Value of GIS

ArcGIS Explorer as a marketing and decision-making tool

By Kevin Willis, Lake County GIS Director

The Lake County GIS Division wanted to better inform the public about how and where GIS technologies are contributing to the county in a positive manner. The division also wanted to encourage county departments to evaluate how GIS can add value in new areas. The division decided that ArcGIS Explorer is the tool for better educating others about the value of GIS.

Lake County, located in central Florida, northwest of Orlando, has 1,156 square miles of which 203 square miles, or 17.58 percent, is water. Historically a rural area, Lake County has experienced more than a 25 percent population growth rate from 2000 to 2006. According to U.S. Census Bureau estimates for

ArcGIS Explorer, which can be used to create mashups of map services and local data, was used in the creation of a video that demonstrates how Lake County uses GIS to benefit county operations.

2006, it was ranked as the 23rd fastest growing county in the United States with a population approaching 300,000. This growth has caused the county to struggle to maintain and expand its infrastructure.

This situation provided an opportunity for the county to explore ways for taking advantage of GIS. GIS technologies are not just leveling the playing field; they are leveraging it by adding value through identifying cost savings and allocating resources more efficiently. GIS is helping people make better decisions.

Lake County GIS uses a hybrid approach to data sharing and data custodianship. Using this approach, non-GIS staff are trained to use GIS technologies at a basic level within their departments. These users, or GIS liaisons, are mentored by the GIS Division staff. This model extends the county's use of GIS and allows the GIS staff to focus proactively on data analysis and modeling tasks. Over the past two years, the Lake County GIS enterprise environment has initiated many solutions that address real-world issues. GIS-enabled solutions enhance the level of service the county provides to citizens through cost savings, data analysis, and project modeling and visualization and can leverage county resources to provide risk management benefits.

Explaining what GIS is and its benefits to someone who lacks a technical background can make for a long conversation. Lake County GIS needed a way to demonstrate the value of GIS and educate others in understandable terms and avoid spiraling into a technical abyss of deep explanations. Because a picture is "worth a thousand words," a video presentation seemed the appropriate medium for broadening GIS awareness.

Lake County GIS decided ArcGIS Explorer could best communicate visually how GIS is adding value across county business functions because it can demonstrate through real-world examples how GIS technologies are providing exceptional benefit to the public. Both data providers and consumers of data could learn how GIS can better provide services to their customers.

Using ArcGIS Explorer, Lake County GIS has created a short video called *GIS Technologies: Leveraging the Playing Field* that highlights the county's local data holdings and applications and includes embedded video, graphics, and text. The audio narration describes how GIS is being implemented in the county to make better decisions. The video had its premier showing during the Lake County GIS Day event in November of 2009 and was placed on the Lake County GIS home Web page so visitors can better understand how GIS is used throughout the county.

This video is an excellent resource for marketing to stakeholders, fostering cooperation, and creating partnerships with local communities. ArcGIS Explorer is a superb marketing tool for Lake County GIS. Powerful and interactive ArcGIS Explorer presentations can communicate geographically, in a near real-time manner, what is occurring. The video has raised awareness of the new Economic Development Property Finder application, which was designed to attract new businesses and increase job opportunities within Lake County. The video also shows how GIS technologies contribute to local government business needs through applications such as the Proposed Future Land Use Interactive Map. Lake County also presented how GIS technologies assisted with grant application efforts for both mapping and data analysis.

In addition to its role in creating the video, ArcGIS Explorer helps citizens utilize county GIS data for their specific needs. Its easy-to-use and powerful interface, available at no cost, can display scenarios and promote informed decisions. ArcGIS Explorer integrates projects and programs effortlessly and provides decision makers with a dashboard perspective for quickly and clearly understanding information.

It is estimated that 80 percent of all databases can be displayed visually. GIS technology breathes life into Lake County's databases, which optimizes how and where county resources produce the greatest return on investment.

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View the video, visit the Lake County GIS home Web page at www.lakecountyfl.gov/departments/information_technology/geographic_information_services/

About the Author

Kevin Willis, GIS director, has an M.C.S.E. certification and an M.B.A. in information technology management.

Acknowledgments

Corey Mathis, GIS analyst, created and edited the GIS tasks in ArcGIS Explorer. Doug Woodyard, telecommunications manager, assisted with final video and audio adjustments; Mike Bowers, director of the Water Resources Management Division, did the video narration; and the Information Outreach Division assisted with embedding and formatting the video in the GIS home Web page.

Getting Started with Geoprocessing and ArcObjects in .NET

By Chad D. Cooper, GISP, Southwestern Energy Company

What's that? You say you want to do some geoprocessing and maybe even some ArcObjects programming using .NET, but just aren't sure where to begin? Visual Studio and the whole ".NET Framework" thing are somewhat intimidating, aren't they? If you are not a programmer by training, you sure can be. Namespaces, classes, assemblies, methods, references, solutions… it's enough to scare anyone not familiar with it. But have no fear. You—yes you—can be up and running with your very own .NET geoprocessing application in no time.

What You Will Need

- Notepad (or any text editor) and a command prompt.
- Microsoft .NET Framework 2.0 or higher (www.microsoft.com/net/).
- Microsoft Visual Studio 2005/2008 (Visual C# Express version available free at www.microsoft.com/express/download/).
- An ArcSDE connection, either enterprise or workgroup (optional).
- Exercise archive gpandnet.zip, downloaded from *ArcUser Online.* This archive contains the source code and the listings in a PDF for easy reference when reading this article and the file geodatabase with the sample data.

Why Use the .NET Framework for Geoprocessing?

At ArcGIS 9.2, ESRI introduced the Geoprocessor .NET assembly, which opened up the geoprocessing toolbox to .NET developers. There are several reasons you might want to use the .NET Framework for your geoprocessing tasks. Maybe your company's IT department is already a .NET shop. The .NET Framework is enterprise tested and accepted. If you have non-GIS .NET developers, they can be a valuable resource to you when learning the ins and outs of .NET programming. .NET solutions are also extremely scalable. The entire library of over 30,000 ArcObjects components is exposed to you (more on this later), providing you have low-level access to the very objects that the core geoprocessing tools and framework are built with. As we will soon see, communication with the geodatabase is well integrated. Last but not least, .NET applications are fast and efficient.

Getting Started

Before you proceed, you need to open the listing files in the exercise archive downloaded from *ArcUser Online* so you can refer to them. Next, verify that you have the Microsoft .NET Framework installed. To find out if you have .NET Framework version 2.0 or greater installed, go to C:\WINDOWS\Microsoft.NET\Framework. If you have a v2.xx folder there, you already have the .NET Framework 2.0 installed (you may have several folders here, ranging from versions 1.x up to 3.5).

If you do not have a licensed version of Visual Studio 2005/2008 Professional, Microsoft provides a lightweight but fully functional version for both the VB.NET and C# languages. To follow along with the examples in this article, download and install Visual C# 2008 Express Edition. Installing Visual Studio 2005 (any licensing level) will also install the .NET Framework 2.0, while installing Visual Studio 2008 (also any licensing level) will install the 3.x .NET Framework.

To make compiling at the command line a little easier, set up a

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User Environmental Variable on your user PATH to the .NET 2.xx directory. This will allow you to run the C# command line compiler from any directory with ease. Right-click My Computer, click the Advanced tab, click Environment Variables, find the PATH variable in the list of User variables, click edit, and add ;C:\WINDOWS\Microsoft.NET\Framework\v2.x.xxx to the end of the existing PATH variables list. Make sure you get the version correct, and don't forget the semicolon in the front to separate it from the previous environmental variable in the PATH list.

Hello World!

The .NET Framework supports both the Visual Basic and C# languages. For the purposes of this article, all code listings will be in C#. There are a number of ways to write and compile .NET applications. Writing your code in Notepad and compiling using the C# command line compiler is by far the simplest way of constructing a .NET application.

Start Notepad (or your plain text editor of choice) and type the code from Listing 1. This is a simple C# program that prints the classic "Hello world!" to standard output at the command prompt. Save this file as HelloWorld.cs, where .cs is the file extension for a C# file. In this example, I'm working in the directory I created at C:\testing\csharp.

Before we can run our code, we must compile it into an executable file. To compile this example, we will use the C# command line compiler. Assuming you have your PATH environmental variable set up, open a command prompt window (Start > Run > type cmd), and compile your code, as in Listing 2.

Typing csc calls the C# compiler, the /out: flag tells the compiler where to put the output executable file, and the final argument we pass in is our input C# file. Now, at the command prompt, navigate to your executable's directory and run it (as shown in Listing 3). Congratulations, you just wrote, compiled, and ran your first .NET program! Not so hard, eh?

Stepping Things Up a Notch

The next section will get an Integrated Development Environment (IDE) up and running. With the classic "Hello world!" under our belts, let's get down to business. Launch Visual Studio/Visual C# 2008 Express (which I will hereafter collectively refer to as just Visual Studio), go to File > New Project, and select Console Application. Give your project an appropriate name, click OK, and Visual Studio creates a new solution for you that includes references to assemblies we will be using and a C# file named Program.cs by default.

Before we can use any geoprocessing tools (or any ArcObjects components) in our program, we must add references to the proper ESRI assemblies to expose those functionalities. If the Solution Explorer pane is not visible in Visual Studio, go to the View menu and select Solution Explorer. In the Solution Explorer, expand your projects tree and expand the References tree. You should see references to several System assemblies that Visual Studio sets automatically for you when it builds your solution. Right-click References and select Add Reference.

The Add Reference window may take a few seconds to come up, and when it does, select the .NET tab, scroll down through it and examine the assemblies that are available to you, especially those that begin with ESRI, as those are all the ESRI assemblies that contain the geoprocessing and ArcObjects functionalities that we want to expose for our use in Visual Studio. Select ESRI.ArcGIS.Geoprocessor from the list and click OK. Notice that the assembly has been added to the References in your project. Now let's focus on Program.cs and writing some code.

Writing Geoprocessing Code

To access the Geoprocessor object's methods and properties, we still need to do one more thing: add a using directive to our code. The using directive has two uses: to permit the use of types and create an alias for a namespace or a type. Every variable and constant has a type, as does every expression that evaluates to a value in a namespace (i.e., a collection of different classes), so you don't have to qualify the entire namespace. This will soon make more sense. In Program.cs (which is where we will be typing from here on), on the line below the current last existing using directive, type the following:

```
using ESRI.ArcGIS.Geoprocessor;
```

Add the following line inside your Main function, and instantiate (create an instance of) a Geoprocessor object:

```
static void Main(string[] args)
{
    Geoprocessor gp = new Geoprocessor();
}
```

Note that as you started typing "geoprocessor", Intellisense kicked in and took you right to the Geoprocessor class in the drop-down list of items available to you. Now, comment out using ESRI.ArcGIS.Geoprocessor;. Do you notice that Geoprocessor loses its green color? Hover over it. Nothing, right? That's because you just removed its reference. Now add ESRI.ArcGIS.Geoprocessor. before Geoprocessor, so you have this:

```
static void Main(string[] args)
{
    ESRI.ArcGIS.Geoprocessor.Geoprocessor gp = new
       ESRI.ArcGIS.Geoprocessor.Geoprocessor();
}
```

You now have effectively fully qualified the entire namespace and told Visual Studio where to look for the Geoprocessor class. You can use whichever method you choose. However, the first method, employing the using directive, seems to be the preferred method and is the method I will employ in the examples here. Next, add a new line and type gp.;. You should get an AutoComplete list with all the Geoprocessor methods that are now available to you. Pretty nice, eh?

Now that we have a Geoprocessor object available to us, let's put it to use on a small, simple file geodatabase of Arkansas data that I assembled from Geostor (geostor.arkansas.gov) and the U.S. Geological Survey National Hydrography Dataset (nhd.usgs.gov). Listing 4 goes into every geodatabase in C:\Data and prints the feature class names to standard output. This is not very useful by itself, but getting access to datasets is crucial to virtually all geoprocessing tasks.

There are several different ways to execute your program. To run your program from within Visual Studio (also known as "debugging"), go to Debug > Step Into or press the F11 key. This will start your program in the Main() method. Once there, press F10 to step through your code. Notice that a command prompt window gets launched, and any Console.Writeline() statements get printed to this. Another way is to build your application (Ctrl + Shift + B or Build menu > Build Solution) to an executable file (.exe), open a command prompt window and navigate to the Debug directory where your compiled executable is stored by default. (My Debug directory is C:\VS\ArcUserArticle\Geoprocessing\GpExample\GpExample\bin\Debug)

Run the executable. Listing 5 shows how to run the executable (by navigating to the directory, typing the executable's name, then pressing Enter) and the results you will get. Compiling an executable and running it from the command line is a common method of running .NET console programs. You can easily schedule processes this way through Windows Scheduled Tasks or an enterprise scheduler.

Performing Basic Geoprocessing Tasks

Now that we have created a Geoprocessor object, set up a workspace

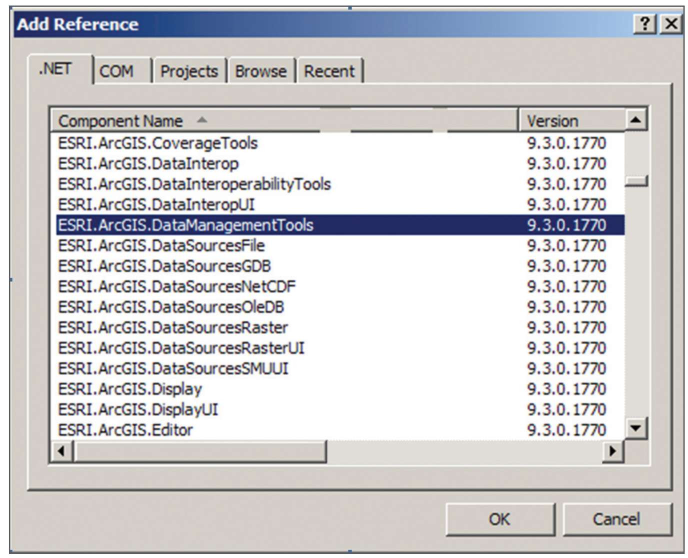

Figure 1: Adding assembly references to your project

on our file geodatabase, and iterated through the feature classes in the geodatabase, let's see how to set up and perform some basic geoprocessing tasks with ArcToolbox tools. First, it is important to note that any geoprocessing tool available to you in ArcToolbox is available to you programmatically through .NET—all you need to do to get access to a tool is add a reference to its assembly, or toolbox.

To do this, in the Solution Explorer in Visual Studio, right-click the References folder of your project and select Add Reference. Scroll down until you start seeing ESRI assemblies. What you get should resemble Figure 1. The assembly ESRI.ArcGIS.DataManagementTools is the assembly that houses all the tools available to us in the Data Management toolbox in ArcToolbox. To expose assemblies for use in your solution, you would add references to ESRI.ArcGIS.Geoprocessor, ESRI.ArcGIS.Geoprocessing, ESRI.ArcGIS.DataManagementTools, and ESRI.ArcGIS.AnalysisTools, then add them using directives for each assembly to your program file.

To illustrate how to programmatically set up tool inputs and outputs, let's perform some relatively simple geoprocessing tasks—selecting, clipping, buffering, and exporting—on our file geodatabase feature classes. Along the way, we'll also do some logging to a text file.

For more information on accessing the geoprocessor from C#, see the post "Overview of accessing geoprocessing functionality" at

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the ArcGIS Resource Center (resources.esri.com) and "Executing geoprocessing tools" (resources.esri.com/help/9.3/ArcGISEngine/dotnet/43d8cc77-5193-4ca8-9878-6027782e2bbb.htm), both available from the ArcGIS Resource Center for Geoprocessing.

Listing 6 is a program that performs basic geoprocessing tasks on feature classes in the ArkansasData file geodatabase. This listing is verbosely commented, so I won't go into the details. Essentially, we go into the streams polyline feature classes, select all the perennial streams that intersect the city limits polygons, clip those streams to the city limits, sum up the stream lengths for each new feature class, and write those results to a text file.

If you need to process every feature class in your geodatabase, you could employ the code in Listing 4 and use it to dynamically fetch the list of feature classes for iteration at run time instead of explicitly listing your inputs as is done in Listing 6 on lines 27–28.

Working with ArcSDE

So far we have worked with file geodatabases, but what about ArcSDE (both Enterprise and Workgroup)? Let's dig a little deeper into using ArcObjects in .NET by connecting to instances of Enterprise ArcSDE running on SQL Server (2005, in this case) and Workgroup ArcSDE running on SQL Server Express 2008. (Apologies to those working in Oracle shops: I don't have access to an Oracle ArcSDE instance to test against.) For more information on connecting to geodatabases (including Oracle ArcSDE), see the article "How to connect to a geodatabase" (resources.esri.com/help/9.3/ArcGISEngine/dotnet/c778d2bb-eb36-4793-9c89-20795811c5eb.htm) available at the ArcGIS Resource Center for Geoprocessing.

Connecting to ArcSDE generally entails setting up your connection properties, using those properties to open up a workspace within the geodatabase, then opening a feature dataset within that workspace. Listing 8 shows how to connect to Enterprise ArcSDE on SQL Server 2005 and Workgroup ArcSDE on SQL Server Express 2008. Note the similarities in the connection properties between Enterprise and Workgroup ArcSDE. Also note that opening up the database for either instance uses the same code—only different connection properties. If you are unsure of any of the connection properties you need, ask your database administrator.

Working with ArcGIS Server

The ESRI.ArcGIS.Server assembly exposes hundreds of methods we can use to interact with ArcGIS Server. Using ArcObjects, we can connect to ArcGIS Server and get a list of running services. Listing 9 is a simple example showing how to connect to an ArcGIS Server instance and return a list containing each service along with its status (as illustrated in Listing 10). Keep in mind that the account this process runs on must have the required privileges to access your ArcGIS Server instance.

A script written by Sam Berg of ESRI, called AGSSOM, is an excellent example of how to use ArcObjects to more fully interact with ArcGIS Server. AGSSOM can be found on the ESRI ArcScripts site (arcscripts.esri.com/details.asp?dbid=16293).

Documentation, Help, and Additional Resources

ESRI provides a wealth of information to help you build .NET applications. The ESRI Resource Center for Geoprocessing (resources.esri.com/geoprocessing) is your one-stop shop for searching for reference materials, forum postings, and sample code. The Developer Resources section will provide you with the ArcObjects API reference, the geoprocessing tool reference, and the Geoprocessing Object Model Diagram (OMD). Of course, the ArcGIS Engine Forums are always a good place to search for help and sample code. Lastly, the .NET Framework Developer Center on the Microsoft Developer Network (MSDN) (msdn.microsoft.com/en-us/library/aa139615.aspx) is a great place to find reference materials for anything related to general .NET development.

Conclusion

There is no denying that the .NET platform is complex and daunting when viewed by a beginning programmer. That said, I truly hope that the samples provided here have shown that creating simple geoprocessing programs with .NET is within your reach. No matter the data format used—from shapefiles to file geodatabases—and whether you are working with ArcSDE or ArcGIS Server, the ESRI geoprocessor and .NET are a powerful and well-tested combination that can automate both simple and incredibly complex processes. For more information, contact

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Chad Cooper, who has been working in GIS for seven years in technician and analyst positions, has worked with Southwestern Energy Company for the last five years. Cooper holds a bachelor's degree from Mississippi State University and a master's degree from the University of Arkansas, both in geology. He realized he could both have fun and earn a living in working with GIS. A huge fan of the Python programming language for several years, Cooper wrote his first .NET program two years ago. Cooper lives in Texas with his beautiful wife and two handsome, lively young boys. In his free time, he enjoys fishing with his boys, photography, and occasionally riding a bike.

CHOOSING A SCENIC BYWAY USING SPATIAL CRITERIA

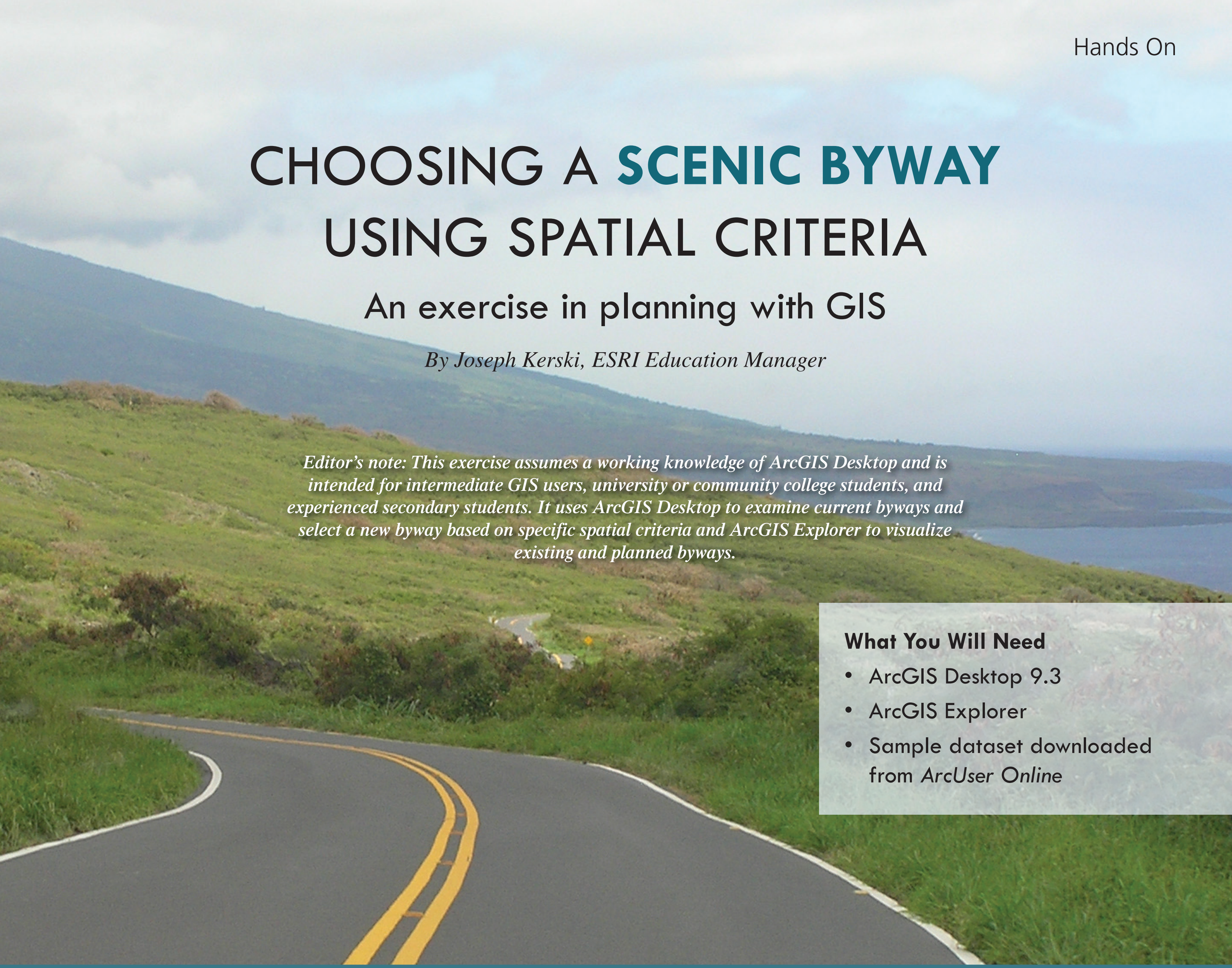
An exercise in planning with GIS

By Joseph Kerski, ESRI Education Manager

Editor's note: This exercise assumes a working knowledge of ArcGIS Desktop and is intended for intermediate GIS users, university or community college students, and experienced secondary students. It uses ArcGIS Desktop to examine current byways and select a new byway based on specific spatial criteria and ArcGIS Explorer to visualize existing and planned byways.

What You Will Need

- ArcGIS Desktop 9.3
- ArcGIS Explorer
- Sample dataset downloaded from *ArcUser Online*



One of the author's favorite byways. This road hugs the south side of Haleakala Volcano on the island of Maui.

All of us have probably enjoyed traveling on a scenic byway at one time in our lives. What makes this route especially memorable? Have you ever thought about the qualities that are used in determining the criteria to designate a state or national scenic byway?

Because these criteria are inherently geographic in nature, planning a scenic byway is routinely done with the help of GIS. These plans represent an interesting mix of objective and subjective considerations. Consequently, choosing scenic byways can make an excellent instructional activity using GIS because it combines inquiry, technology, and multiple disciplines in a decision-making environment.

A new lesson in the ArcLessons library, Planning a Scenic Byway in Colorado, places you in the role of the State Scenic Byways program coordinator (an actual job position). As the coordinator, you will consider the criteria used by the National Scenic Byways Nominations Guide. "Scenic" is only one of six criteria used by the guide; others consider natural, historic, cultural, archaeological, and recreational qualities. You must choose between four roadways. To do this, you will use a variety of data, including traffic patterns, terrain, rivers, and population centers along with a weighting system, to choose the roadway that best meets all the criteria. You will consider federal land and terrain; using ArcGIS Desktop and ArcGIS Explorer to view the area in 2D and 3D will help you make your decision. GIS skills developed in this lesson include spatial and attribute querying, weighting, symbolizing, layouts, and the use of GIS to make an informed decision.

In late 2009, the State of Colorado posted a job opening for a State Scenic Byways program coordinator at the Colorado Department of Transportation (CDOT) headquarters in Denver. Here is the position description:

This position serves as the statewide Staff Authority on the scenic and historic byways program. It directs the program by formulating policy for approval by the Governor's Scenic and Historic Byways Commission; serves as a resource to local agencies, communities, and byway organizations statewide; develops and implements planning and marketing strategies for the byway program; writes grant proposals for public and private funds; administers and supervises federal grant contracts; and interprets federal and state requirements. This position exists to work with CDOT staff; FHWA; and resource agencies such as the Colorado Department of Tourism, Bureau of Land Management, Colorado Historical Society, and others, to implement strategies for directing federal funding to Colorado.

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CHOOSING A SCENIC BYWAY USING SPATIAL CRITERIA

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After reading this description, what do you think would be the most challenging part of the job, and why? Let's say you decide to apply for this job position, and based on your experience with GIS, CDOT decides to offer you the job. Your first task on the job is to learn all you can about the existing state scenic byways. You do this by examining a Colorado scenic map supplied by MilebyMile.com (www.milebymile.com/maps/Colorado_road_map.pdf).

1. Go to the location where you downloaded and unzipped the data and lesson from the sample dataset archive.

2. Start ArcMap and open the scenic_byways_colorado.mxd map document. What do you notice about the pattern of scenic byways in Colorado? What types of federal lands seem to have the most scenic byways? Why?

3. Open up the attribute table of the scenic byways map layer and sort on Length. The values in the Length field are in meters. What is the total length of scenic byways in Colorado? Use the Statistics tool and give your answer in kilometers.

4. Describe the location of the five longest scenic byways in Colorado listing the towns along the route. Give the length of each byway in kilometers.

- How many of the five longest scenic byways in Colorado are on the Great Plains, or in the mountains?
- How many are along interstate, U.S., or state highways?
- Why do you think these differences exist?
- How many scenic byways are in urban centers, and how many cross the Continental Divide?

5. Choose three scenic byway segments in the attribute table. Find these three segments, or ones nearby, in the highways attribute table. Examine the Average Annual Daily Traffic (AADT), which is the average number of vehicles traveling on these roads each day.

- What is the AADT of your three chosen segments? Sort on AADT and choose the three most-traveled segments of highway in Colorado.
- What is the AADT of these segments? Zoom to each.
- Do the locations of these well-traveled roads make sense?
- What is the AADT on the least-trafficked road segment in Colorado, and where is it?

6. Symbolize the highway segments based on the AADT field values. Use thicker lines for more heavily traveled roads. Describe the pattern of highway use in Colorado. Interstate highways are the most major roadways, followed by U.S. highways, then state highways; these designations are in the field ROUTESIGN. Which type of highway experiences the most traffic in Colorado, and why?

7. Summarize AADT by ROUTESIGN and indicate the average AADT on each type in Table 2.

8. On the Colorado Scenic Byways site (www.coloradobyways.org/Main.cfm), choose your two favorite byways. Describe where they are located, and explain why they are your favorites. Save your map document in an appropriate location.

Proposing a New Scenic Byway

This year, the state and citizens of Colorado want you to propose one additional road as a scenic byway. Four road segments have been submitted for your consideration. To help you make your decision, you first examine the National Scenic Byways Nominations Guide, which has been included in the sample dataset you downloaded from *ArcUser Online*. This guide lists six intrinsic qualities as essential components used in designating a highway as a byway: scenic, natural, historic, cultural, archaeological, and recreational. For the purposes of the National Scenic Byways Program, these qualities are defined as shown in the sidebar entitled "Scenic Byways Qualities."

Weighing Qualities

Which of these six qualities seems most important to you? Least? Why?

1. Examine your scenic_byways_proposed map layer. The six qualities have been assessed and applied to four different road segments in Colorado that are contained in this layer: Proposed Byway 1 is in west central Colorado, along State Highway 139 between Loma and Rangely. Proposed Byway 2 is in north central Colorado, along State Highway 9, U.S. Highway 40, and State Highways 14 and 125 from Silverthorne to Kremmling, to Walden, and north to the Wyoming border. Proposed Byway 3 is in east central Colorado along U.S. Highway 36 from Byers east to the Kansas border. Proposed Byway 4 is in southeast Colorado along U.S. Highway 160 from Trinidad east to the Kansas border.

Description	Location	Towns Connected	Length (km)
1			
2			
3			
4			
5			

Table 1: Information on the five longest byways

Type of Highway	Average AADT
Interstate	
U.S.	
State	

Table 2: Average Annual Daily Traffic (AADT) for three selected segments

Byway No.	Scenic	Natural	Historic	Cultural	Archaeological	Recreational
Byway 1						
Byway 2						
Byway 3						
Byway 4						

Table 3: Quality assessments for proposed byways

SCENIC BYWAYS QUALITIES

Scenic—The heightened visual experience derived from the view of natural and man-made elements of the visual environment of the scenic byway corridor. All elements of the landscape contribute to the quality of the corridor's visual environment.

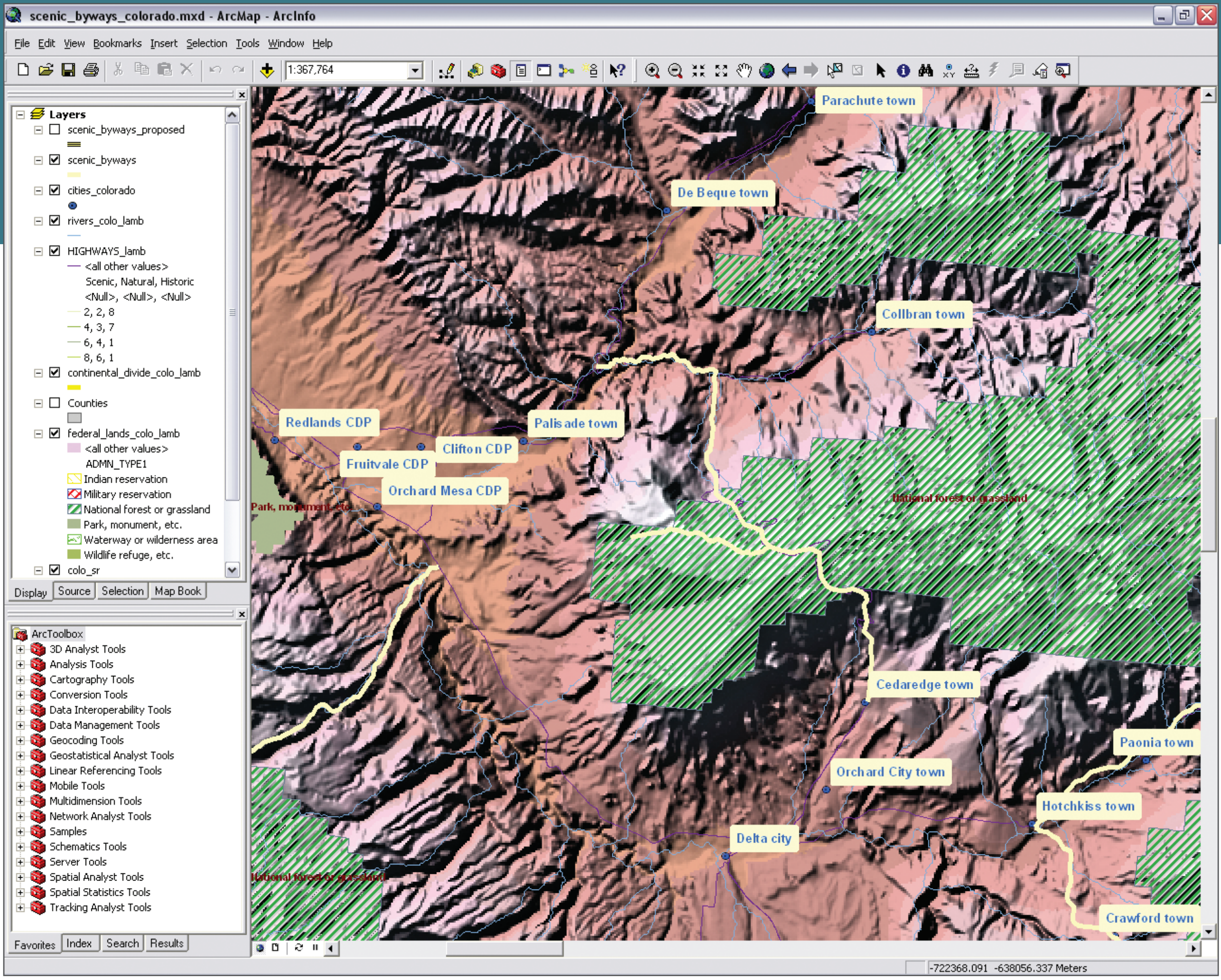
Natural—Applies to those features in the visual environment that are in a relatively undisturbed state. These features may include geologic formations, fossils, landform, water bodies, vegetation, and wildlife and are relatively undisturbed by humans.

Historic—Reflects the historic actions of people and may include buildings, settlement patterns, and other examples of human activity, and possess integrity of location, design, setting, material, workmanship, feeling, and association.

Cultural—Cultural features provide evidence of the customs or traditions of a distinct group of people including crafts, music, dance, rituals, festivals, speech, food, special events, and architecture and could highlight one or more significant communities and/or ethnic traditions.

Archaeological—Involves physical evidence of historic or prehistoric human life or activity that can be inventoried and interpreted. The ruins, artifacts, structural remains, and other physical evidence have scientific significance, educate the viewer, and evoke in the viewer an appreciation for the past.

Recreational—Involves outdoor recreational activities in association with and dependent on the natural and cultural elements of the corridor's landscape. They include skiing, rafting, boating, fishing, and hiking. Driving the road may qualify as a pleasurable recreational experience.



The ArcMap document in the sample dataset contains layers showing federal lands, political boundaries, cities, topography, and existing and proposed scenic byways.

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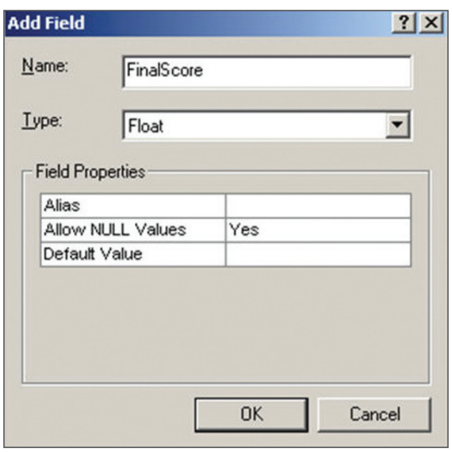
CHOOSING A SCENIC BYWAY USING SPATIAL CRITERIA

Continued from page 43

2. Fill in Table 3 to indicate how the six qualities were assessed for each proposed byway.

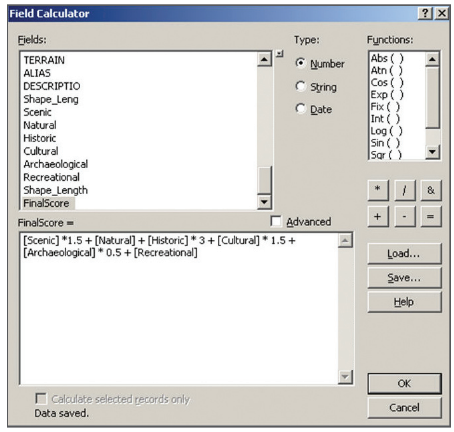
These quality assessment values are based on a 1–10 scale with 10 reflecting the highest quality so the byway with the highest score is the one you will select. For example, a byway with ratings of 7, 4, 3, 5, 9, and 1 would have a final score of 29. If you chose the byway based on the highest total score (with all qualities given equal weight), which byway would be chosen?

3. Conduct some research on these four routes. For example, Byway 4 traverses the Comanche National Grassland. This area covers over 435,000 acres of grassland that has a rich history. It has been home to dinosaurs, the Comanche Indian Tribe, cattle ranchers, and the U.S. Forest Service and encompasses the Cimarron Cutoff of the Santa Fe Trail and natural wonders including more than 257 species of birds, such as Say's phoebes, rock wrens, western meadowlarks, mourning doves, and redheaded woodpeckers. At Picketwire Canyonlands, more than 1,300 dinosaur tracks can be viewed. Prehistoric rock art, early homesteaders' rock huts, and limestone markers can also be seen. Write a paragraph about each of the four proposed byway routes, including as many of the six byway qualities as you can in each paragraph.



In the scenic byways attribute table, add a field named FinalScore and set its type to Float. Also set Allow NULL Values to Yes.

Based on your research, you feel that the byways should not be equally weighted but be weighted as shown in Table 4.



Calculate the new field using the weighting formula. Select all fields and operators using the mouse rather than typing in the formula box, or cut and paste the expression that has been saved as bywaysfinalscore.cal in the geodatabase.

To calculate a final score, use this formula: (Scenic * 1.5) + Natural + (Historic * 3) + (Cultural * 1.5) + (Archaeological * 0.5) + (Recreational * 1.0)

4. Open the attribute table for the scenic_byways_proposed layer and add a field. Name it FinalScore, set its type to Float, and set Allow NULL Values to Yes. Why should the FinalScore field be a floating point (i.e., with decimals) type rather than an integer type?

5. Go to Options > Clear Selection, then right-click the new FinalScore field > Field Calculator. Calculate the new field using the weighting formula. Select all fields and operators using the mouse rather than typing in the formula box. Alternatively, click the Load button on the Field Calculator and load bywaysfinalscore.cal, the expression that has been saved in the geodatabase. Click OK to populate the FinalScore field with calculated values.

Quality	Factor
Scenic	1.5
Historic	3.0
Cultural	1.5
Archaeological	0.5
Recreational	1.0

Table 4: Weighting factors for qualities

6. Which proposed byway received the highest final score, and where is it located? Symbolize the four byways using graduated symbology. Use the values in the FinalScore field to determine the thickness of the lines. What does this new map help you to do? Besides the six quality criteria, consider the amount of federal lands that the roads cross. Because the federal lands were set aside as national forests, grasslands, and national parks, the more federal lands that a proposed bypass crosses, the better candidate it will make.

7. To find out the amount of federal lands these roads cross, intersect the proposed bypasses with federal lands and save the output feature class in the geodatabase. Symbolize the proposed bypasses that intersect federal lands using a shade of blue. Which of the four proposed bypasses intersect federal lands?

8. To determine which bypasses intersect the most federal lands, access your attribute table for the new intersect layer. Select the segments with a final score of 41 (Bypass 2) using Select By Attribute or by highlighting them with the mouse in the table. Right-click the shape_length field and choose Statistics. Note the length, in meters, of the roadway. Do the same thing for each segment with a final score of 43.5 (Bypass 4) and note its length (also in meters). Fill out the table below and convert length to kilometers. Which bypass would you select based on the criteria of the length of roadway on federal lands?

9. Next, weight the less-trafficked bypasses more favorably, because you consider a large number of vehicles antithetical to the whole notion of a scenic byway. As you did earlier, select the four different byways by their FINALSCORE, one by one, summarizing on AADT, entering the mean AADT for each bypass in Table 6.

Based on these numbers and your preference, which bypass should be selected? Could

Bypass	Length, in kilometers, of bypass that intersects federal lands
Bypass 2	
Bypass 4	

Table 5: Bypasses that intersect the most federal lands

a busier roadway be considered more worthy of being designated a scenic byway? How? Following are a few analyses:

River Analysis

Turn on the rivers layer. Which of the four proposed bypasses seems to cross or follow the most rivers? What are the differences between rivers on eastern plains versus rivers in the mountains? How do rivers impact the scenery, and does considering rivers change the bypass that you most want to select? Why or why not?

Urban Areas Analysis

Turn on the cities layer. Which of the four proposed bypasses seems to be nearest cities? Symbolize the cities as graduated symbols based on the attribute Pop100. Which of the four proposed bypasses is nearest major cities? Does considering city locations and sizes change the bypass that you most want to select? Why or why not?

Terrain Analysis

Turn on the shaded relief layer. Which of the four bypasses traverses the most varied terrain and the flattest terrain? Does a consideration of the relief of the landscape as shown on the shaded relief layer change your judgment on which bypass should be selected? Why or why not?

Looking at Data in 2D and 3D

1. Start ArcGIS Explorer and add the feature classes for existing and proposed scenic bypasses from your geodatabase. Does the 3D capability of ArcGIS Explorer change your answer to the previous questions in terms of which bypass is on the steepest or flattest terrain? Do you consider steep or flat terrain to be more scenic? Does the 3D perspective change your mind in terms of the bypass you most favor? Why or why not?

2. In ArcMap, create a layout that contains a title, north arrow, name, scale bar, legend, the selected bypass in a different color than the other byways, and any other information that you feel is necessary. How did the weights that you assigned to each of the six quality criteria affect the final score?

3. Rerun the calculations with your own weights. How did you weight the criteria, and why?

4. Give a presentation about what you have learned about scenic byways, how byways are selected, and how the spatial perspective and GIS enhanced your decision-making process.

Conclusion

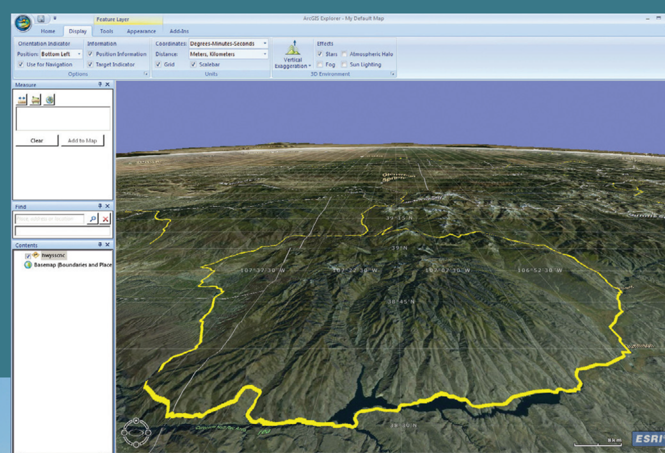
In this exercise, you used spatial analysis techniques and data from a variety of sources to consider several criteria, weight them, and make a better decision. For additional exercises and instructional materials, visit www.esri.com/arclessons.

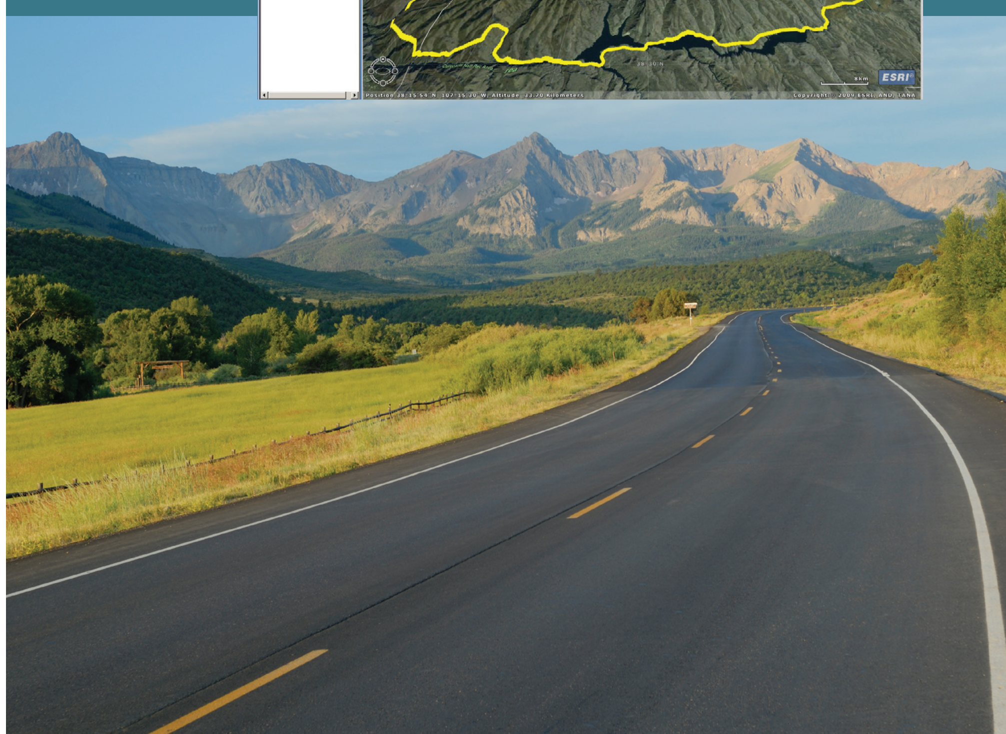
This lesson incorporates querying spatial and attribute data, weighting factors, and symbolizing the results of analysis so a more informed decision can be made.

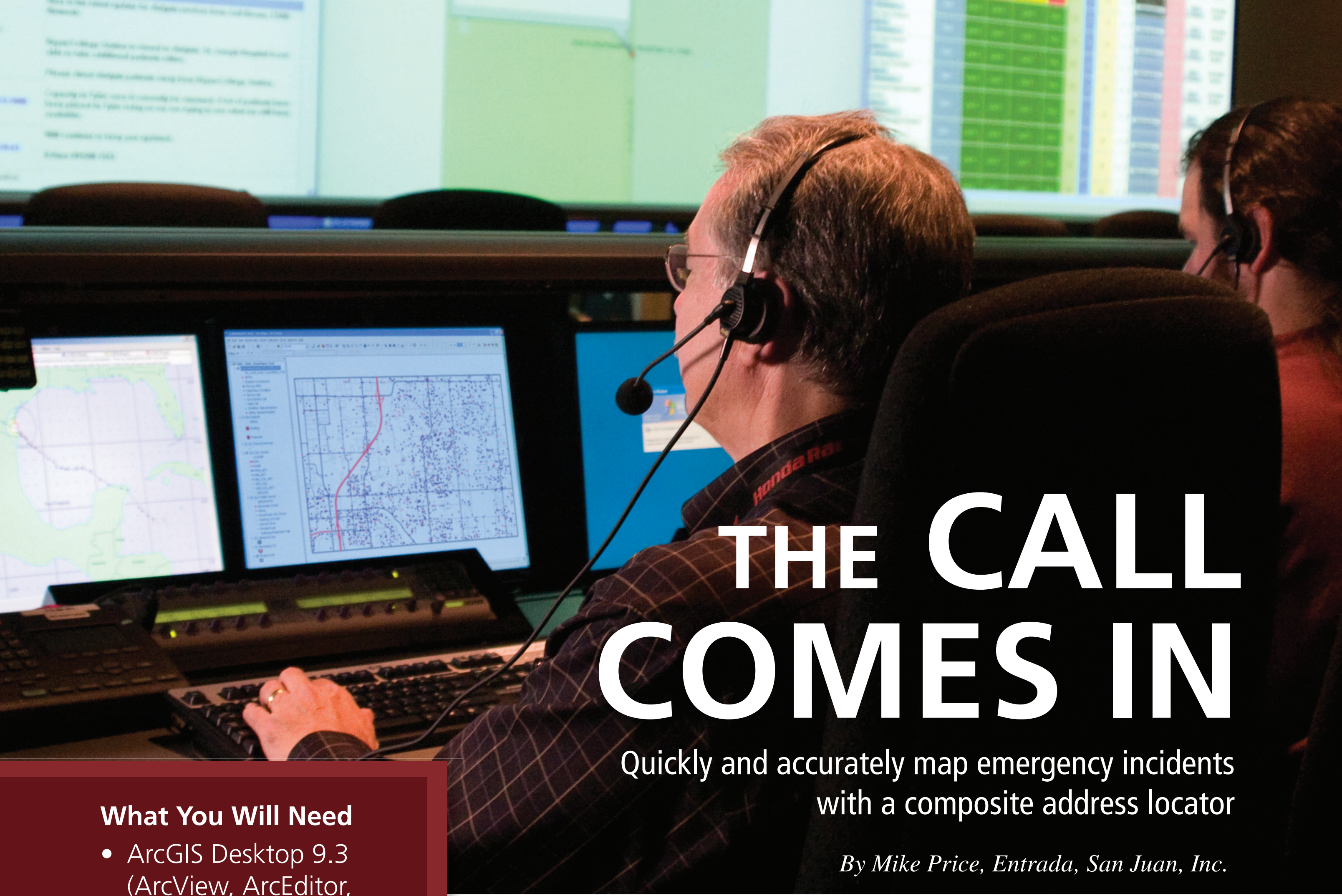
Bypass	Mean AADT
Bypass 1	
Bypass 2	
Bypass 3	
Bypass 4	

Table 6: Mean Average Annual Daily Traffic (AADT) for bypasses

Add the feature classes to ArcGIS Explorer to see if viewing the data in 3D changes your choice of byway.







THE CALL COMES IN

Quickly and accurately map emergency incidents with a composite address locator

By Mike Price, Entrada, San Juan, Inc.

What You Will Need

- ArcGIS Desktop 9.3 (ArcView, ArcEditor, or ArcInfo)
- Sample dataset downloaded from *ArcUser Online*

Address geocoding is an essential public safety skill. However, officers need to understand the benefits, limitations, and complexities of systematic address locators. To quickly and accurately map incident locations, a Public Safety Access Point (PSAP) relies on computer-aided dispatch (CAD) software and georeferencing datasets to match the caller's address to a point on the map. At the dispatch center, a trained operator must capture, interpret, record, and map as much incident information as possible.

After determining the incident's location, the operator identifies the needed and available resources and passes as much information as possible to responding units. These tasks must be accomplished as quickly as possible—typically 60 seconds or less. Once mapped, the CAD system matches the closest available emergency resources with the call type and sends out automated tones, coupled with digital information and voice instructions. Consistent, complete, and current addressing datasets are essential to this process.

This exercise shows how to produce addressing datasets by creating geocoding services or address locators for three datasets that will place a location on a map with a high degree of accuracy. Rather than geocoding a single incident, this exercise processes several thousand incident points captured during a single year in a major metropolitan area. Standardizing addresses and using a progressive composite address locator will achieve an extremely high success rate on the very first pass. This exercise applies the same sequential logic that is used by response centers around the world.

The data for this exercise was created for a textbook and tutorial series on performing emergency services mapping. It is based on data from actual jurisdictions and represents field conditions but has been modified to protect sensitive information.

The exercise is organized into five tasks.

Task 1: Understanding Addressing Data
Obtain and analyze geocoding reference data. Review incident data format(s).

Task 2: Creating Individual Address Locators
Design and build stand-alone address locators for each reference dataset.

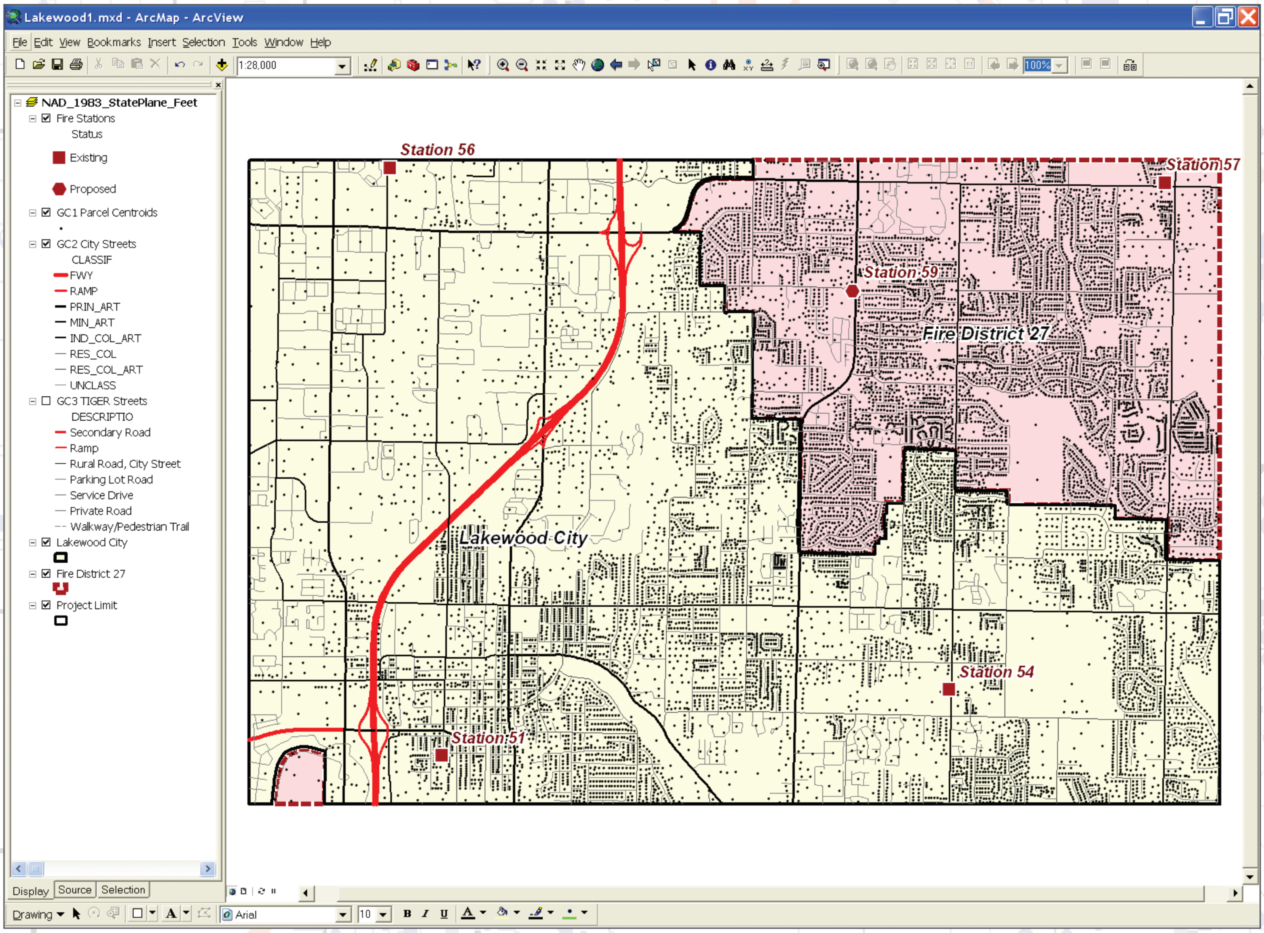
Task 3: Building a Composite Address Locator
Combine all address locators in hierarchical order in a composite address locator.

Task 4: Geocoding Incidents
In ArcMap, geocode nearly 7,000 emergency incidents, updating unmatched addresses and resolving ties.

Task 5: Adding Detailed Information about Incidents
Join incident date and type information to all geocoded points to display fires and explosions, Hazmat incidents, emergency medical services (EMS) responses, and service calls.

Getting Started

To get started, go to the *ArcUser Online* and download Lakewood.zip. Store this file near a root directory and extract the data, respecting directory structure. Start ArcMap, navigate to the new Lakewood folder, and open Lakewood1. Right-click in an open toolbar area and select the Geocoding toolbar. Move it next to the other open toolbars and inspect its buttons. The Address Locator Manager and Geocode Addresses buttons are active. Two other tools, Location Inspector and Review/Rematch Addresses, are inactive.



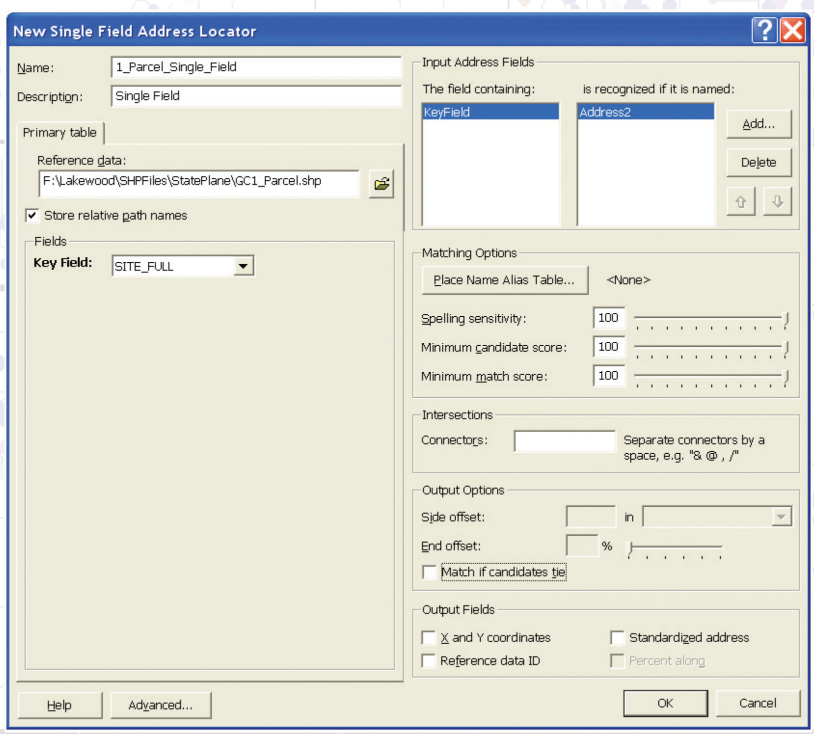
The exercise data is based on data from actual jurisdictions and represents field conditions but has been modified to protect sensitive information.

Task 1: Understanding Addressing Data

A typical PSAP will use several address datasets to place an incident on a map. A geocoding sequence starts with the most reliable, accurate, and current dataset available to identify a single point location on a map. To increase the success rate of the geocoding process, the service will standardize incoming addresses to match the reference data schema. Place-name alias tables also increase geocoding reliability.

1. Open the attribute table for GC1 Parcel Centroids and inspect its fields. Study the SITE_FULL field and sort it. Notice that each address includes one standardized string, possibly including an address numeric; a direction prefix, a street name, a street type, and a direction suffix. These address points provide a certain address match against standardized input data with a high degree of reliability.

2. Open the attribute table for GC2 City Streets and inspect its fields. This dataset, developed and maintained by the Lakewood Public Works Department, is current and complete. This polyline dataset separates addressing into left and right and to and from numerics, and includes separate fields for name direction and type. GC2 City Streets is the second geocoding data source. It supports a U.S. Streets Lo-



Create a Single Field Address Locator that references the GC1_Parcel shapefile.

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Name:	Description:	Reference data:	Store relative path names	Fields	The field containing:	Is recognized if it is named:	Place Name Alias Table
1_Parcel_Single_Field	Single Field	\GC1_Parcel.shp	Checked	Key Field – SITE_FULL	KeyField	Address2	<None>
2_City_US_Streets	US Streets	\GC2_City_Street.shp	Checked	See Table 2	Street	Address2	<None>
3_TIGER_US_Street	US Streets	\GC3_TIGER_ Street.shp	Checked	See Table 2	Street	Address2	<None>

Table 1: Parameters for creating individual address locators

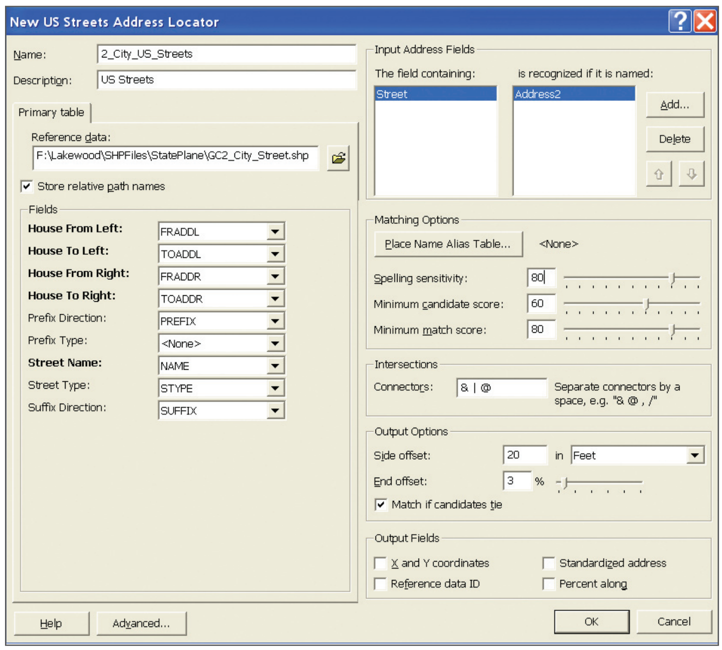
cator. Unfortunately, CAD data often does not include sufficient information to apply a U.S. Streets with Zone Locator. Typically this data lacks municipality or ZIP Code information. Each agency must decide how to clip streets to include unique names or process addresses in different communities that share similar street names.

3. Next, open the attribute table for the GC3 TIGER Street shapefile and inspect its fields. This dataset is adapted from 2009 Census TIGER street data, now in development by the U.S. Census Bureau. It includes a schema similar to the Lakewood Public Works data. Notice that field names and placement are different. This is the third addressing dataset, and it captures many road intersection addresses and the locations of incidents that might occur outside the extent of the Public Works dataset. The TIGER 2010 data, not yet released, will be different from TIGER 2000 data.

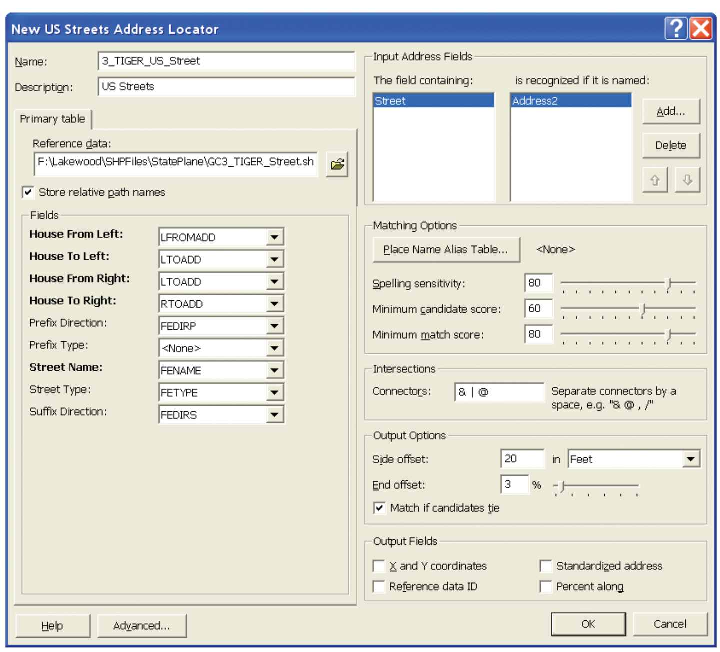
4. Now click the Add Data button, navigate to \Lakewood\DBFFiles and locate Inc_2008_Address, and load this table containing incident data. Open this table and inspect it. This dataset contains nearly 7,000 incident records and has only a few fields. It has an index field (INDEX), an incident number field stored as an alpha string (INC_NO), and a standardized address field named (ADDRESS2). Notice that there is no field in this dataset to identify a geocoding zone.

5. Sort ADDRESS2 and notice it contains both numeric and street intersection addresses. These addresses were generated and posted using CAD software, then edited by the local jurisdiction to correct inconsistencies. This data is clean and contains only incident addresses. Other information will be joined to these geocoded points later using the INC_NO field.

To review: In this task, the three reference datasets in the map document were reviewed, and one file containing incident data was added to the map document.



The second geocoding data source, GC2 City Streets, supports a U.S. Streets Locator. It is maintained by the Lakewood Public Works Department and is current and complete. It will be used to build the 2_City_US_Streets address locator.



The data source for the third address locator, the GC3 TIGER Street shapefile, was adapted from 2009 Census TIGER street data, now in development by the U.S. Census Bureau.

Spelling sensitivity	Minimum candidate score	Minimum match score	Connectors	Side offset:	End offset:	Match if candidates tie	Output Fields
100	100	100	<Blank>	<Blank>	<Blank>	Unchecked!	Optional
80	60	80	& I @	20 Feet	3	Checked	Optional
80	60	80	& I @	20 Feet	3	Checked	Optional

Task 2: Creating Individual Address Locators

Address locators will be created for each reference dataset in this task.

1. Save the ArcMap document, close ArcMap, and start ArcCatalog. Navigate to \Lakewood\SHPFiles\StatePlane and preview the tables and geography for the shapefiles. The file name for each reference file begins with the letters *GC* and a numeric code that indicates that file's geocoding sequence.

2. In the ArcCatalog tree, right-click the \Lakewood\SHPFiles\StatePlane folder and select New > Address Locator. Specify Single Field as the Address Locator Style and click OK.

3. In the New Single Field Address Locator dialog box, enter 1_Parcel_Single_Field as the Address Locator name. On the Primary table tab, set Reference data to \GC1_Parcel.shp and set SITE_FULL as the Key Field. In the Input Address Fields area, delete Name from the field under is Recognized if it is named and add Address2. Set all scores and sensitivities to 100.

4. ***Under Output options, uncheck the box next to Match if candidates tie.*** It is essential to uncheck this box because all ties (based on duplicate addresses) will be bumped to the City Streets locator. Click OK to build the 1_Parcel_Single_Field locator.

5. Build the 2_City_US_Streets geocoding service by right-clicking the \Lakewood\SHPFiles\StatePlane folder and creating a second address locator. Use Tables 1 and 2 as guides when creating this locator. Name this address locator 2_City_US_Streets. Set \GC2_City_Street.shp as the reference set, and define reference fields using the same parameters as 1_Parcel_Single_Field locator. This time, using the information in Table 1, specify fields for numerics, direction, and type. Although many addresses will automatically match, don't forget to make sure STYPE is chosen for the Street Type field. If a required field is accidentally omitted when creating a locator, delete the locator and rebuild it. Set only Address2 as the recognized field and set spelling and scores to 80, 60, and 80. Accept the Connectors defaults and leave other choices unchanged. Click OK to build this locator.

6. Next, build the 3_TIGER_US_Street geocoding service using parameters in Tables 1 and 2. This locator is similar to the 2_City_US_Streets locator. Because the new TIGER codes are not consistent with earlier systems, the field names will not assign automatically, so carefully assign fields as shown in Table 2.

Address Locator	2_City_US Streets	3_TIGER_US Streets
House From Left:	FRADDL	LFROMADD
House From Right:	TOADDL	LTOADD
House To Left:	FRADDR	RFROMADD
House To Right:	TOADDR	RTOADD
Prefix Direction:	PREFIX	FEDIRP
Prefix Type:	<None>	<None>
Street Name:	NAME	FENAME
Street Type:	STYPE	FETYPE
Suffix Direction:	SUFFIX	FEDIRS

Table 2: Fields for U.S. Streets Address Locators

Task 3: Building a Composite Address Locator

The three individual address locators just created are now linked together in a composite address locator. A composite locator links two or more other address locators together in a hierarchical order

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Name	Address Locator	Selection Criteria:	Input Mappings	The field containing:	Is recognized if it is named:	Output Fields	Output Spatial Reference	Store relative path names
Checked	1_Parcel_Single_Field	Blank	KeyField Address	Address	Address2	Optional	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	Checked
Checked	2_City_US_Streets	Blank	Street or Intersection Address	Address	Address2	Optional	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	Checked
Checked	3_TIGER_US_Street	Blank	Street or Intersection Address	Address	Address2	Optional	NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet	Checked

Table 3: Parameters for composite address locator

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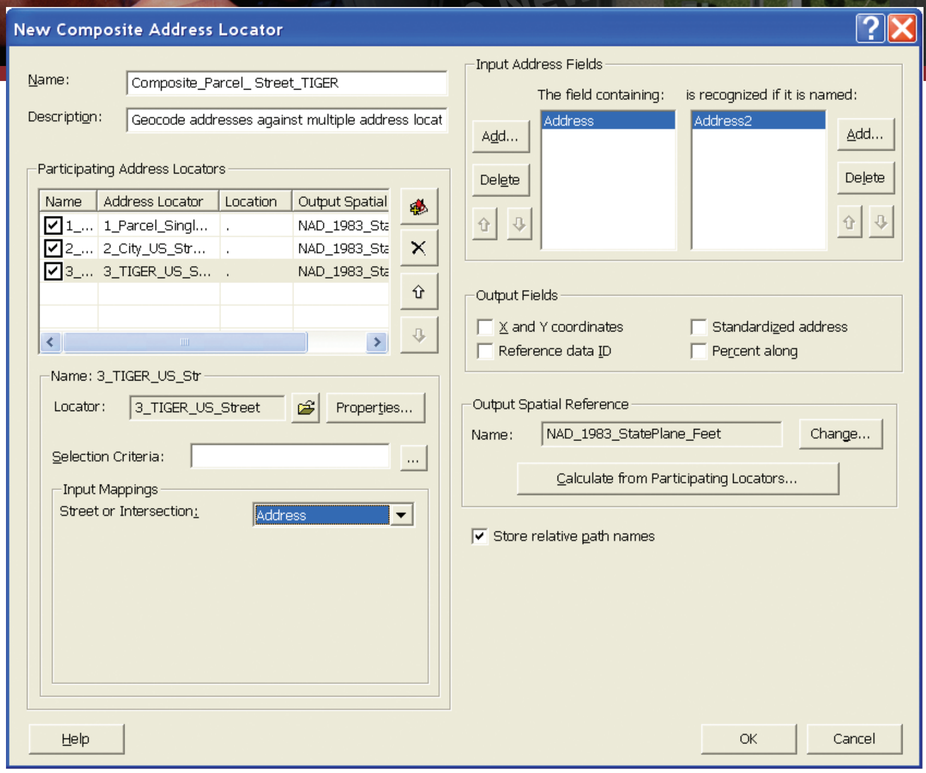
and passes unmatched addresses from each locator to the next. This composite address locator will geocode using Parcel Centroids first, then City Streets, and finally TIGER Streets.

1. Right-click the \Lakewood\SHPFiles\StatePlane folder and specify Composite Address Locator.

2. Using Table 3, name this locator Composite_Parcel_ Street_TIGER and add participating locators in order: 1_, 2_, and 3_. These numeric name prefixes will be useful soon.

3. Once all three are loaded, perform the next step. It is a performance tip. On the right side of the New Composite Address Locator wizard, find the Input Address Fields area. Next to The field containing window, click the Add button and specify Address as the primary field. Set its recognized name to only Address2. By specifying only Address2, the composite address locator will target only standardized data and ignore other Address fields. Typically reference datasets can also contain a primitive Address field.



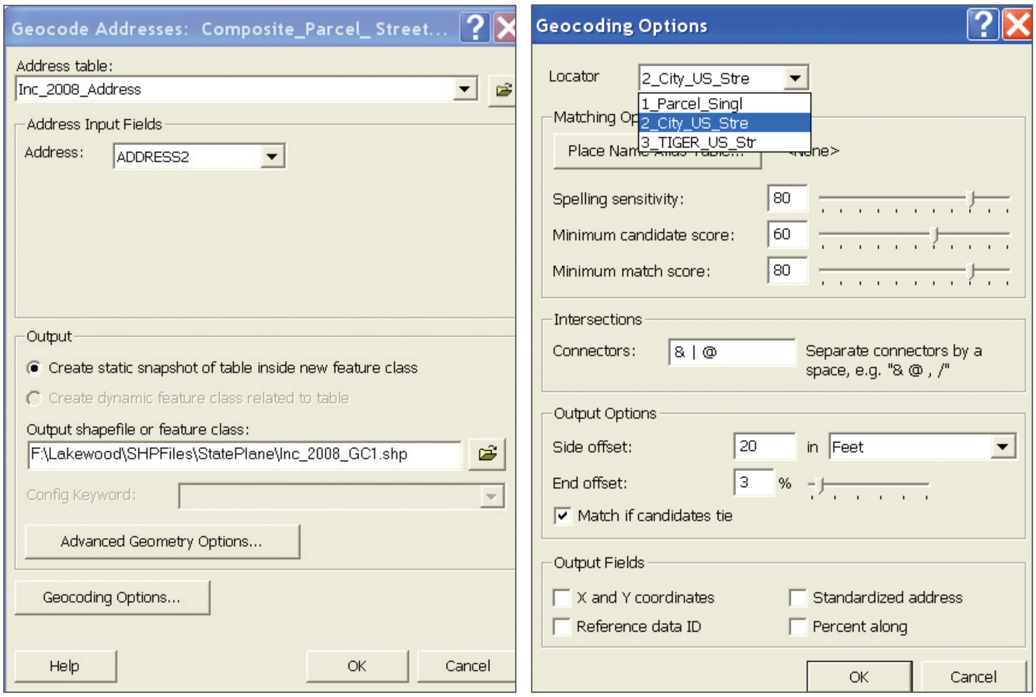
Use the three individual address locators to create a composite address locator.

4. Keep all Participating Address Locators checked; select each one and individually set its Input Mappings field to Address. Use any individual address locator to calculate the output spatial reference. After setting the spatial reference and all three Input Mappings, the OK button should become active. If it does not, review the setting. Click OK to build the composite address locator. Now it is time to geocode all 6,976 incidents. Close ArcCatalog and reopen the Lakewood map document in ArcMap.

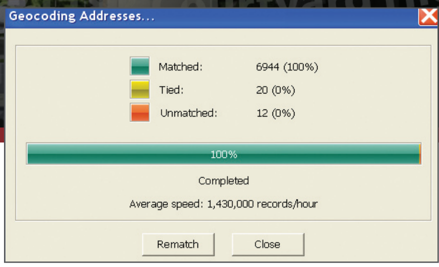
Task 4: Geocoding Incidents

Now, after setting some parameters for the composite address locator, it will automatically geocode all the incidents.

1. In ArcMap, load the Geocoding toolbar, if necessary, and click the Address Locator Manager button. Navi-



Keep all Participating Address Locators checked and select each one and individually set its Input Mappings field to ADDRESS2.



The composite address locator should generate 20 ties and 12 unmatched addresses.

gate to \Lakewood\SHPFiles\StatePlane and load only Composite_Parcel_Street_TIGER. Close the Locator Manager window.

2. Open the TOC Source tab, right-click the Inc_2008_Address table, and select Geocode Addresses.

3. Set the output file location and name to \Lakewood\SHPFiles\StatePlane\Inc_2008_GC1. Using a numeric counter in the file name will make it easier to rerun the model or test it with differing parameters. Click the Geocoding Options button to verify that all three individual locators participate in the composite address locator. Update or adjust properties, such as spelling sensitivities and threshold scores, at the same time if necessary. Click OK to continue and watch the geocoding process.

4. If the three address locators were built according to the specifications given, they should generate a high percentage of matches. Only about 20 ties and 12 unmatched addresses should be left from the set of 6,976 incidents.

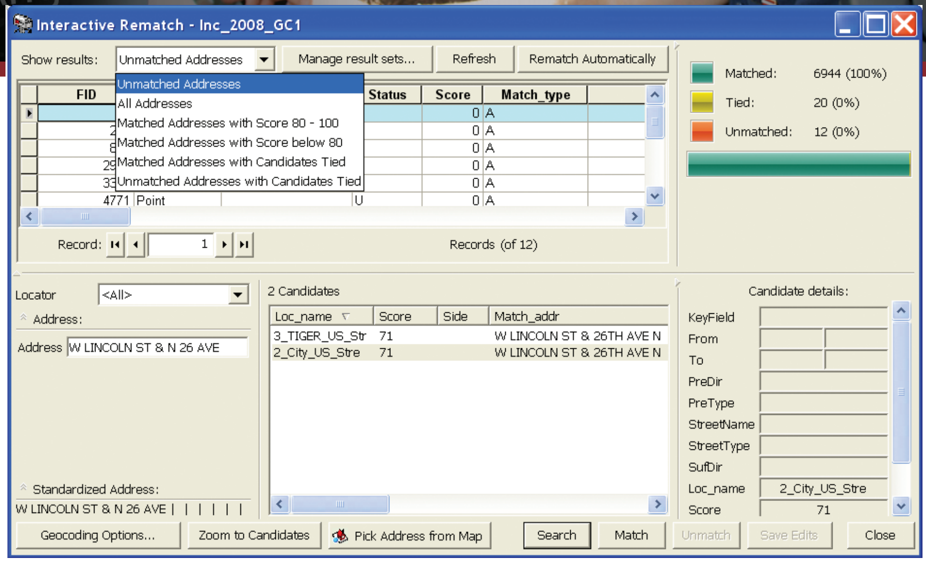
5. The sample dataset includes a Microsoft Excel spreadsheet containing suggested fixes for known addressing errors. Navigate to \Lakewood\Utility and load the Database worksheet, Fixes1.xls. Review its contents. In the real world, records management at a fire station is never perfect, and this spreadsheet contains fixes for several nongeocoded records.

6. To update these unmatched or tied records, click the Rematch button. Let's repair unmatched addresses. Under Interactive Rematch, look at the Show results area and select Unmatched Addresses. In the results window, locate an improperly geocoded address and find its corresponding entry in the Fixes1 table. Copy the ADDRESS2_F string into the text box next to Address on the left side of the Interactive Rematch dialog box. Click the address in the Candidates list and select the record with the highest percentage (which will likely be the one with the highest order, e.g., 1_, 2_, or 3_) and click Match. The score will change from U to M, and the Loc_name field now lists reference data, providing the best fit. Continue down the list, making repairs, selecting the best reference data and building matches. When finished, all records should match.

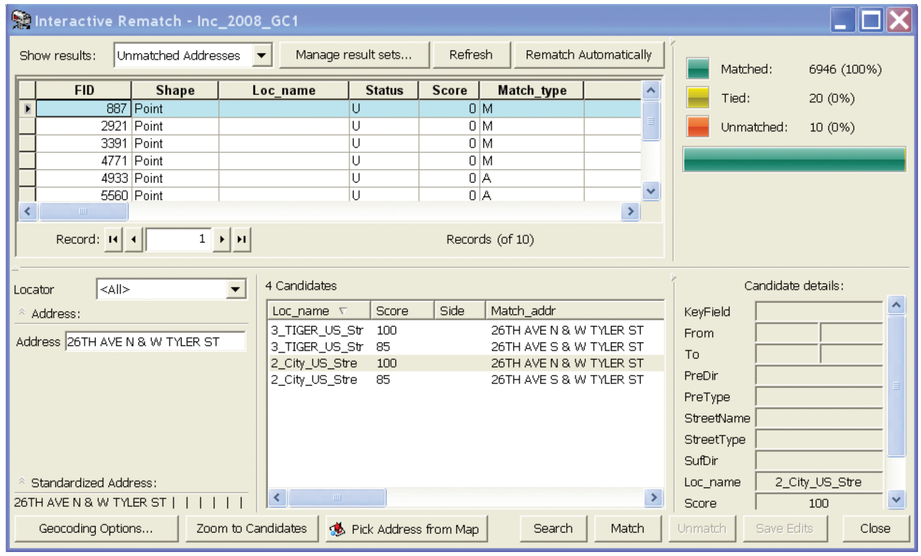
7. Review tied records next. In Show results, select Matched Addresses with Candidates Tied. Locate the ADDRESS2 window and sort its contents so identical tied addresses are grouped. Ties often occur in clusters, so fixing one will often fix others.

8. Click one of the candidates in the window. The selected record is displayed as a larger yellow dot on the map. Below the Candidates window, click the Zoom to Candidates button. If you could access the actual incident records, you could select the appropriate point. However, that is not the case in this exercise, so select the westernmost or northernmost point (as long as these points are in close proximity—

Continued on page 52



Click the Rematch button and under Interactive Rematch, select Unmatched Addresses.



Use the Fixes1 table to fix unmatched addresses by copying the ADDRESS2_F string into the text box next to Address on the left side of the Interactive Rematch dialog box.

THE CALL COMES IN

Continued from page 51

say, 1,000 feet or less). Click the Pick Address from Map button and use the crosshair tool to choose the best candidate, then click Match. Also check the Fixes1 spreadsheet to see if any ties show up there.

After matching the last tied records, all tied records should show a 100 percent score. While matching ties, look for the reasons they occurred. Some are readily fixed by editing street address ranges, which will require that you rebuild the affected address locators before continuing. Other errors, such as those caused by looped streets and offset intersections, are hard to avoid.

Finally, consider matched addresses that score less than 100. Show results for matched addresses and sort the Score field in ascending order. Only a few records will have scores less than 100. See if you can boost those scores to 100 by using observations, intuition, and the Fixes1 spreadsheet. After fixing all records, close the Interactive Rematch dialog box and save the map document.

Task 5: Adding Detailed Information about Incidents

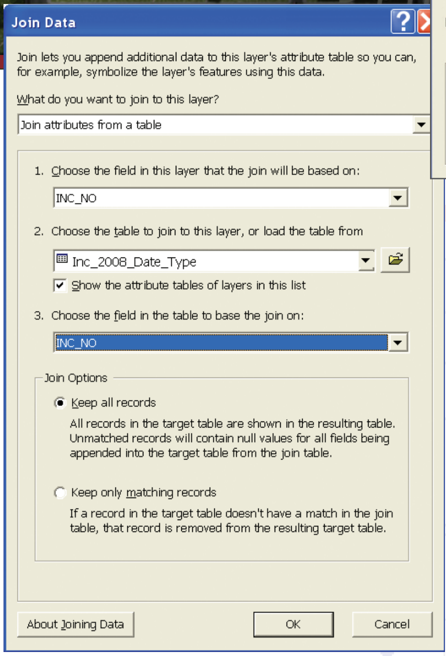
The input data contains only incident numbers and addresses. With all these points properly placed on a map, joining or relating data from other tables will add more information on the incidents such as date and type of incident. The last step will symbolize incidents using a graduated color scheme that identifies incidents by type.

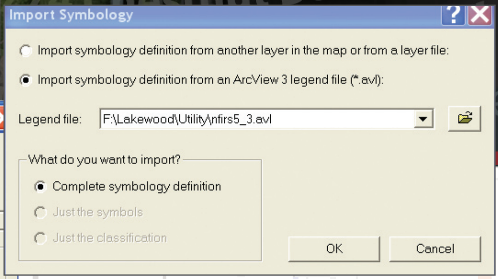
1. Navigate to \Lakewood\DBFFiles and add Inc_2008_Date_Type.dbf to the map document. Open Inc_2008_Date_Type and compare it to the attribute table for Geocoding Results: Inc_2008_GC1. Note that these tables share a common field, INC_NO, so there may be a one-to-one relationship between the tables.

2. Right-click Geocoding Results: Inc_2008_GC1 and choose Join. Create this join to Inc_2008_Date_Type.dbf using INC_NO as the common field. Inspect the results and verify that all records have joined.

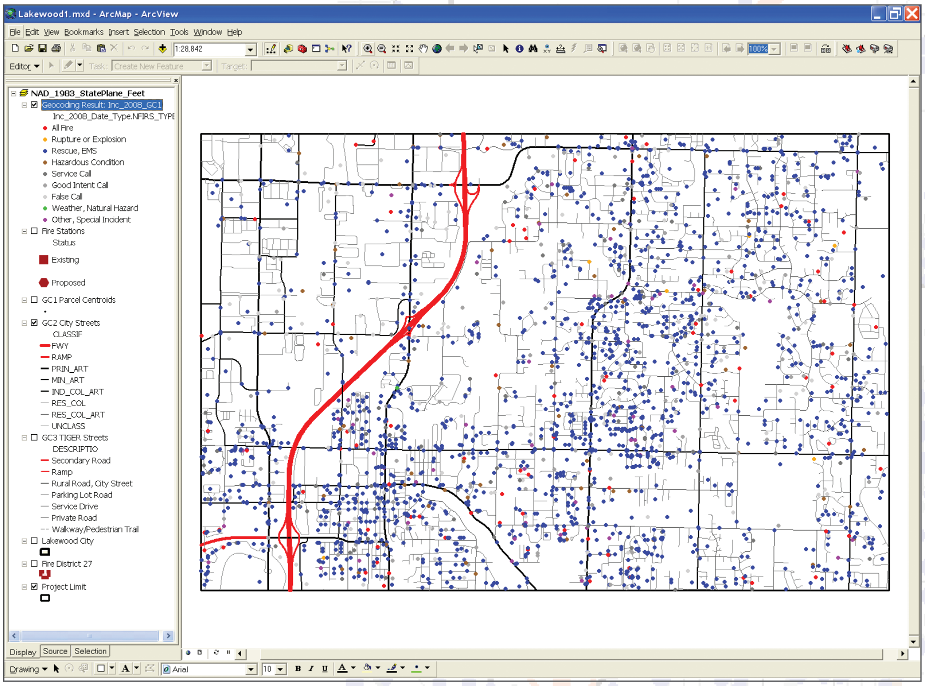
3. The next step symbolizes incident points using a graduated color legend that corresponds to the National Fire Incident Reporting System (NFIRS). Open the Layer Properties dialog box for the incident layer (Geocoding Results: Inc_2008_GC1) and click the Symbology tab. Click the Import button and choose ArcView 3 (*.avl) file and navigate to the \Lakewood\Utility folder. Select nfirs5_3.avl and set the Value field to NFIRS_TYPE. Click OK several times to apply the legend.

4. Save the finished project. Once the color scheme is applied, check the symbology properties to learn more about NFIRS incident types. Incidents are coded thus: 100 series points are fire related; 200 series points are explosions or ruptures; 300 series points are rescues and EMS calls; 40 series points are hazardous conditions; and all points over 499 are service calls, false alarms, and special calls.





Join the table Inc_2008_Date_Type to Geocoding Results: Inc_2008_GC1 to symbolize the incidents. Load the ArcView 3.x legend to use the NFIRS color scheme.



Once the incidents are symbolized, check the symbology properties to learn more about the incidents.

Acknowledgments

The author thanks all the people who helped provide mapping data and other information that was used in this tutorial. Because this data has been synthesized, those providers might not recognize their own data. Thanks also go to the author's advanced GIS students at Bellingham Technical College in Washington who helped identify and resolve real-world training issues.

Boosting Geoprocessing Productivity

Why and how to organize geoprocessing projects

By Barbara Bicking, ESRI Product Engineer, Geoprocessing Team

Editor's note: *ModelBuilder and the geoprocessing tools in ArcToolbox are designed to make users more productive. The author of this article introduces a simple workflow that helps make geoprocessing work easier and faster—even fun—and will make it more easily shared. Consistently using her methodology for setting up and documenting projects will eliminate questions such as*

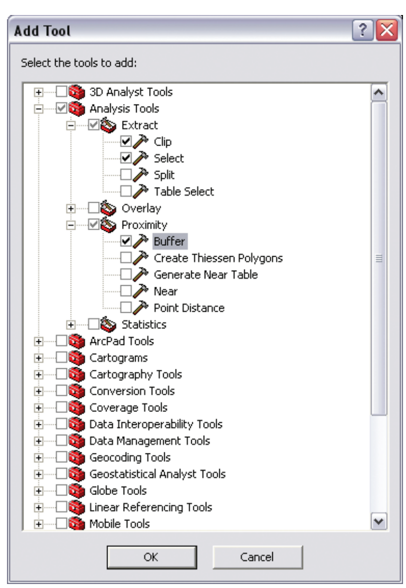
Where was that tool again?

Where did I stick that model?

How did I do that?

This exercise steps the reader through a fictional project. The workflow described is based on using ArcGIS 9.3.1 ArcCatalog with ArcToolbox, but the process is the same in ArcMap. It consists of five tasks.

1. **Customize the ArcToolbox window.**
2. **Create a project toolbox with the system and custom tools needed for the project.**
3. **Create a folder structure for holding output from processes, documentation, and other project materials automatically using a model.**
4. **Set the project environment parameters.**
5. **Document the project.**



Select system tools and place them in the SystemTools toolset.

Getting Started

The fictional project in this exercise is based on creating buffers around selected wells in a study area.

1. The first step is creating a project folder. Use Windows to create a folder, and name it BufferSelectedWellsInStudyArea. Use descriptive names for project folders, toolboxes, models, and script tools and use the same name for everything that pertains to a project. Documenting projects by using descriptive names is critical to productivity. Adding the date to file names(e.g.,BufferSelectedWellsInStudyArea_12Oct09) is also a good practice.

2. Start ArcCatalog and make the ArcToolbox window visible. Before changing the ArcToolbox window settings, save the default setting to a file.

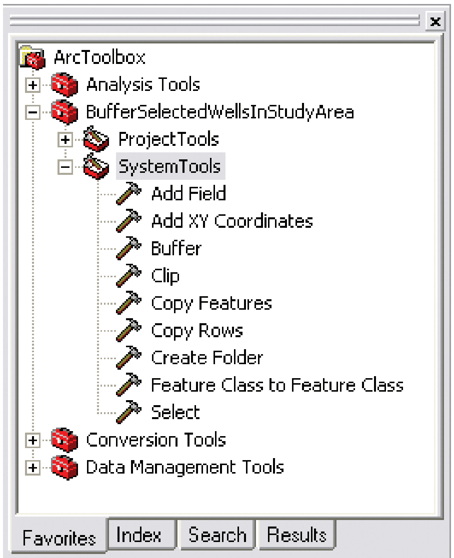
Continued on page 54

Project Setup Checklist

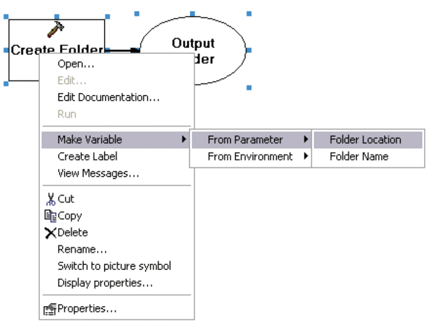
- ☐ Create a project folder. Give it a descriptive name and date.
- ☐ Create a project toolbox. Give it a descriptive name.
- ☐ Create a System Tools toolset inside the project toolbox.
- ☐ Populate the System Tools toolset with the needed system tools.
- ☐ Create a Project Tools toolset inside the project toolbox for custom tools.
- ☐ Create the Project Folder Structure model in the ProjectTools toolset.
- ☐ Set the Folder Location in the Project Folder Structure model to the project folder and run the model to create folders.
- ☐ Set the Current Workspace to the indata folder and Scratch Workspace to the outdata folder.
- ☐ Export all models to a graphic and save the graphic in the docs&pics folder inside your project folder.
- ☐ Export all models to a Python script in the scripts folder inside your project folder.
- ☐ Create a model report for all models and save the graphic in the docs&pics folder inside your project folder.

Boosting Geoprocessing Productivity

Continued from page 53



All the system tools that should be collected in the SystemTools toolset are shown.



Drag the Create Folder tool onto the model. Right-click the tool and choose Make Variable > From Parameter > Folder Location.

Right-click in the ArcToolbox window and choose Save Settings > To File to C:\ and name the file defaultATBwindowSettings.

[Note: In ArcCatalog, it is necessary to save the settings, whether default or custom, to preserve them. In ArcMap, each new map document is created with the default settings. Changes are saved with the map document (.mxd). Settings changed in ArcCatalog can be saved as an .xml file. This file can be loaded into ArcMap where the settings become part of the map document or can be shared with others.]

Task 1: Customize the ArcToolbox Window

Now customize the ArcToolbox window. This project uses only a few toolboxes. Removing unneeded toolboxes will make it easier to find the ones that will be used. Removing toolboxes from the ArcToolbox window does not delete them from the program. All tools in toolboxes covered by the license level remain available and can be loaded back into ArcToolbox. To add a toolbox back into the ArcToolbox window, just right-click in the ArcToolbox window and select Add Toolbox. Navigate to the Toolboxes folder (typically C:\Program Files\arcgis\ArcToolbox\) and select the desired toolbox.

1. Start removing the toolboxes not needed for this project by right-clicking 3D Analyst Tools and selecting Remove. Toolboxes are removed one by one, but once the process is done, it's done.

2. Repeat this for all toolboxes except Analysis Tools, Conversion Tools, and Data Management Tools.

3. Save these settings by right-clicking in the ArcToolbox window and choosing Save Setting > To File. Name the file BufferSelectedWellsInStudyArea and save it to the project folder with the same name.

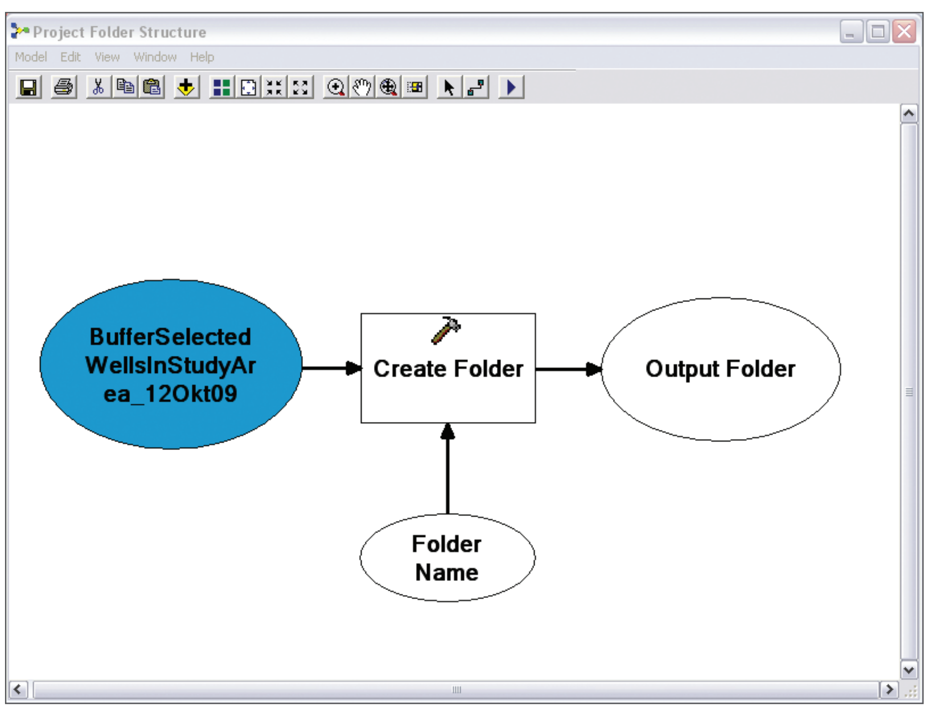
Task 2: Create a Project Toolbox

A project toolbox will be created in the BufferSelectedWellsInStudyArea project folder so geoprocessing work can be performed without having the ArcToolbox window open.

1. To change the default location of toolboxes and models in ArcCatalog (or ArcMap), Select Tools > Options, click the Geoprocessing tab, and navigate to the BufferSelectedWells InStudyArea_12Octk09 folder, click Apply and click OK. *[To reinstate the default location for storing toolboxes, go to this dialog box again and click the Reset button.]*

2. Right-click in the ArcToolbox window, choose New Toolbox, and name the new toolbox BufferSelectedWellsInStudyArea.

3. The project uses two types of tools: System tools that come with ArcGIS and Project tools that will be created. Creating two toolsets will keep these types of tools separate. Create the first toolset by selecting the BufferSelectedWellsInStudyArea toolbox, right-clicking it, and choosing New > Toolset. Name the new toolset SystemTools. *[Note: Two toolsets may be generated—this is a known issue. Simply go to ArcCatalog and choose View > Refresh to remove the extra toolset from the display.]*



Open the Model Properties dialog box, click the Iteration tab, select Get the iteration count from this variable, and select Folder Name from the drop-down menu.

4. Populate the SystemTools toolset by selecting it, right-clicking, and choosing Add > Tool. In the Add Tool dialog box, expand Analysis Tools, expand the Extract Toolset, and check the Clip and Select tools. Still in Analysis Tools, expand the Proximity toolset and check the Buffer tool.

5. Expand the Conversion Tools, expand the Geodatabase toolset, and check the Feature Class To Feature Class tool.

6. Expand Data Management Tools, expand the Features toolset, and check the Add XY Coordinates and Copy Features tools. Still in Data Management Tools, expand the Fields toolset and check the Add Field tool, then expand the General toolset and check the Copy, Delete, and Rename tools. Expand the Table toolset and check the Copy Rows tool. Finally, expand the Workspace toolset and check the Create Folder tool.

7. Click OK. The tools will be added to the SystemTools toolset.

8. Next create a second toolset and name it ProjectTools. Although both toolsets were created in the ArcToolbox window, they are stored in the project toolbox, which was created in the BufferSelectedWellsInStudyArea project folder. The ArcToolbox window merely points to, rather than stores, resources.

9. Close the ArcToolbox window.

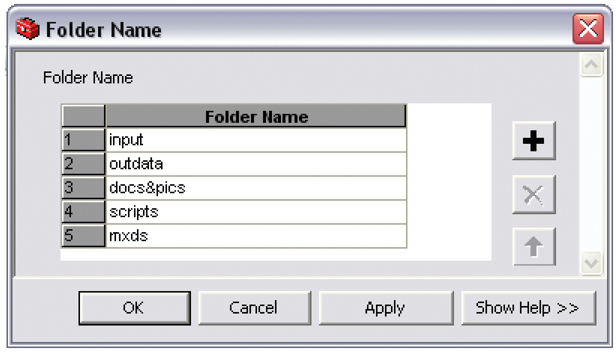
Task 3: Create the Project Folder Structure with a Model

The next task will be to build a model in the project folder that will automatically generate five folders (indata, outdata, doc&pics, scripts, and mxds) that will keep the materials for the project organized.

1. Create a new model in the ProjectTools toolset by right-clicking it and choosing New > Model.

2. Access the Model Properties dialog box by either using the Model menu and choosing Model Properties or by right-clicking the model canvas and choosing Model Properties.

3. In the Model Properties dialog box, name the model projectFolderStructure. For the label, enter "Project Folder Structure," and for the description, enter "Setting up project folder structure". Check the box next to "Store relative path names so paths" will reflect the toolbox's location in the project folder.



Double-click the Folder Name node to open the variable dialog box and add four more rows by clicking the Add Data button. Click on each row and enter the folder names: indata, outdata, docs&pics, scripts, and mxds.

4. Click the Environments tab. Expand General Settings and check Current Workspace and Scratch Workspace. Click the Values button. Expand General Settings in the new dialog box and set the Current Workspace location to C:\ and the Scratch Workspace to C:\temp. Click OK.

5. In the Model window, save the model. The model name now appears in the ArcToolbox window.

6. Now to build the model. Expand the SysTemTools toolset. Drag and drop the Create Folder tool onto the model. Right-click the tool and choose Make Variable > From Parameter > Folder Location. Double-click the Folder Location variable node to open its dialog box. Set it to the BufferSelectedWellsInStudyArea_12Oct09 project folder. Because the workspace is set to C:\, the path will automatically be appended. Click OK. The model nodes are now colored.

7. To create the five project folders (indata, outdata, docs&pics, scripts, and mxds) in BufferSelectedWellsInStudyArea_12Oct09 will require exposing the Folder Name parameter. Right-click the Create Folder tool and choose Make Variable > From Parameter > Folder Name.

8. The Folder Name node appears on top of BufferSelectedWellsInStudyArea_12Oct09 so use the Select tool to move it to its own spot in the model. The Folder Name needs to be set to series so it will create five folders with five names. Right-click the Folder Name node and choose Properties. On the General tab of the dialog box, select A series of values and click OK. *[Note that the Folder Name node in the model is now stacked, which indicates that there is more than one input.]* Double-click the Folder Name node to open the variable dialog box. Add four more rows by clicking the Add Data button four times to create a total of five rows. Click each row and enter the folder names: indata, outdata, docs&pics, scripts, and mxds. Press the Tab key to move from row to row. Click OK when done.

9. From the Model menu, choose Model > Validate Entire Model. The model elements are colored, which seems to indicate it is ready to run. However, some additional modifications are needed. Save the model.

10. Model iteration needs to be set so the model will use the five values for the folders. Reopen the Model Properties dialog box and click the Iteration tab. Select Get the iteration count from this variable. From the drop-down menu, select Folder Name. Click OK and save the model.

11. To make it easy to identify what this model does, label the Folder Name parameter by selecting it, right-clicking, and choosing Create label. The word *Label* appears on the Folder Name node. Moving the label off the node is a little tricky. Click in a white area of the model to deselect everything, then click the word *Label* and drag it away from the node. Right-click Label and choose Display Properties. In the Name field, type "Series of 5 folder names used in model iteration to set up the project folder structure". Create another label for the entire model by clicking in the white space of the ModelBuilder window and choosing Create label, then type "Creating folders to set up the project folder structure" in the Name field.

12. Validate the model and save it. Click the Run button. The model should create the five folders for the project.

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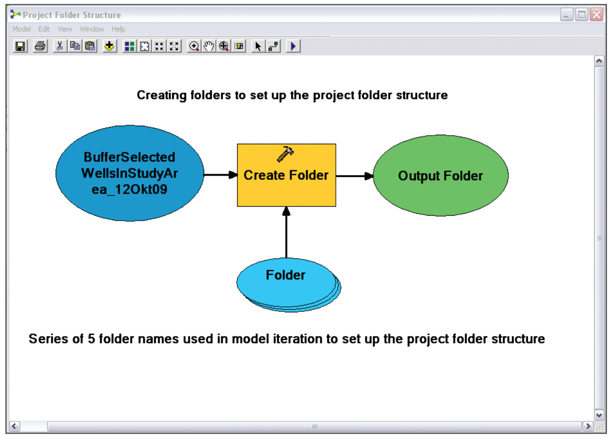
Boosting Geoprocessing Productivity

Continued from page 55

Task 4: Set Project Environments

Now that the project folders have been created, the Current Workspace and the Scratch Workspace environment variables can be set. This is done at the application level (i.e., in ArcCatalog). In ArcCatalog, choose Tools > Options. In the Options dialog box, click the Geoprocessing tab and click the Environments button. Expand General Settings and set the Current Workspace to the indata folder in the BufferSelectedWells InStudyArea_12Okt09 project folder. Set the Scratch Workspace to the outdata folder, also in the project folder. If a project requires that the output coordinate system is consistent or a fixed extent, this is also where those parameters are set.



Add labels to identify the purpose of the model.

Task 5: Document the Project

Documenting the project is both important and easy. This process will also preserve the project. Everything needed to do this is built into ModelBuilder.

1. First, export the model as a graphic by choosing Model > Export > To Graphic. Save it as BufferSelectedWellsInStudyArea.jpg in the docs&pics folder.

2. Next, export the model as a Python script by choosing Model > Export > To Script > Python and save it using the project name in the scripts folder.

[Note that the script created from the model does not contain the model iteration that was set using the Folder Name series variable. Setting iteration for the script requires just a few changes in the exported script, and those changes are shown in Listing 1.]

3. The last thing to do to document the project is to create a model report. Choose Model > Report and save it in the docs&pics folder.

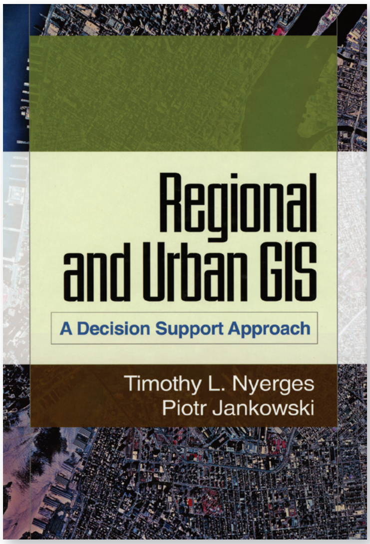
Conclusion

The true beauty of this process is that it can be reused with every project from now on. Simply follow the steps outlined in the Project Checklist that accompanies this article for projects that will be well organized, documented, and reusable.

```
# ---------------------------------------------------------------------------
# BufferSelectedWellsInStudyArea.py
# Created on: Thu Sep 03 2009 01:37:54
#   (generated by ArcGIS/ModelBuilder)
# Description:
# Setting up project folder structure
# ---------------------------------------------------------------------------

# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Load required toolboxes...
gp.AddToolbox("C:/workspace/EnvironmentsDemo/EnvironmentsDemo.tbx")

# Set the Geoprocessing environment...
gp.scratchWorkspace = "C:\\Temp"
gp.workspace = "C:\\workspace"



# Local variables...
Output_Folder = "C:\\workspace\\EnvironmentsDemo\\indata"
EnvironmentsDemo = "C:\\workspace\\EnvironmentsDemo\\outdata"
Folder_Name_List = "indata;outdata;docs&pics;scripts;mxds

##using a tbx ALIAS, such as envDemo, makes the #gp.toolbox location superfluous
#gp.toolbox = "C:/workspace/EnvironmentsDemo?Environments

# Process: Create Folder...
for Folder_Name in Folder_Name_List.split(';'):
       ##it is a good practice to qualify a tool by its tbx ALIAS name
       ##as shown here by using envDemo.
       gp.CreateFolder_envDemo(EnvironmentsDemo, Folder_Name)
```

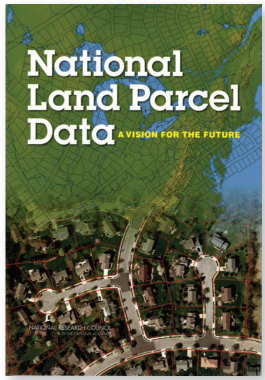
Listing 1: Exported python script

gis Bookshelf



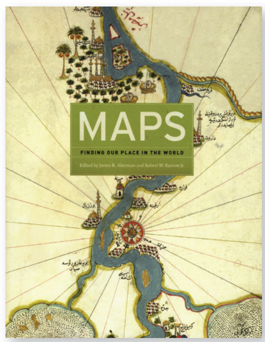
Regional and Urban GIS: A Decision Support Approach
By Timothy L. Nyerges and Piotr Jankowski

Regional and Urban GIS: A Decision Support Approach combines the theory and implementation of GIS for decision support, specifically in the areas of land, transportation, and water resources management. The motivation for writing this textbook came from the need to answer questions about "the research, development, and practice of sustainability" and use GIS to help move from individual sustainable projects to methods and practices that institutionalize sustainability. The target audience for this book includes both professionals and students. It cites real-world case studies and information on the use of multicriteria evaluation (MCE), which extends basic GIS-based analysis by increasing the interactivity of decision analysis activities. The Guilford Press, 2009, 299 pp., ISBN:160623336X



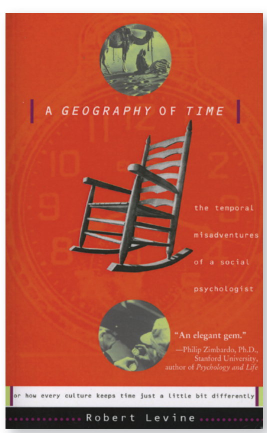
National Land Parcel Data: A Vision for the Future
By the Mapping Science Committee of the National Research Council

As the authors of this report state in the opening pages, "Private ownership of land is the foundation of financial, legal, and real estate systems" in the United States. Parcel data is also needed for analyzing the impact of natural disasters, transportation needs, and other issues. Consequently the creation and maintenance of landownership records is a vital concern for individuals and governments at all levels. This report provides a systematic assessment of the current state of parcel data in the United States and makes recommendations on coordinating the work of local, state, federal, and private organizations in the creation of nationwide parcel data. *(Note: This book may be read online at no charge by visiting the National Academy of Sciences Web site.)* National Academies Press, 2007, 172 pp., ISBN-10: 0-309-11030-0



Maps: Finding Our Place in the World
Edited by James R. Akerman and Robert W. Karrow Jr.

Maps: Finding Our Place in the World was written as a companion to the ambitious museum exhibit of the same name in Chicago, Illinois, mounted between November 2007 and January 2008 by the Field Museum and the Newberry Library. However, this book is far more than a slick catalog. It provides the reader with a broad view of the role of maps in civilization, organized by the reason these maps were created. It contains chapters on wayfaring maps, cosmological maps, maps of local geography, maps that tell the stories of American history, maps that describe phenomena such as William Smith's revolutionary map of the geology of England and Wales, and maps of the imaginary landscapes such as the landscape of the online game World of Warcraft. The maps selected for each chapter and the essays written to acccompany them are entertaining as well as informative. University of Chicago Press, 2007, 336 pp., ISBN: 0226010759



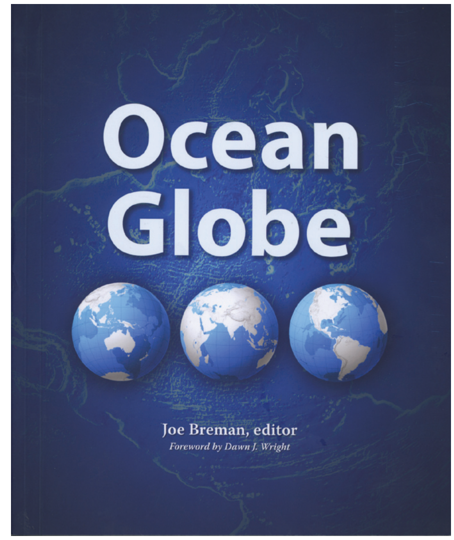
A Geography of Time: The Temporal Misadventures of a Social Psychologist
By Robert Levine

As time is becoming more tightly incorporated in GIS software implementation, it is interesting to explore how geographic location affects the perception of time. Human perception of time is also becoming a more relevant topic today because so many spatio-temporal applications revolve around decision support. *A Geography of Time: The Temporal Misadventures of a Social Psychologist* examines different concepts of time, how time has been measured, and how different cultural norms relating to the tempo and duration of time affect social interaction and the quality of life. In the course of his yearlong travel to 20 countries, author Robert V. Levine observed many of these differences firsthand. In addition to anecdotal evidence, Levine, a psychology professor at California State University, Fresno, cites research he conducted with his students comparing the pace of life in 31 countries based on average walking speed, the time required to purchase stamps, and the accuracy of bank clocks as well as the observations and studies of others. In the end, Levine hopes this survey helps readers examine their own perspectives on time and arrive at a middle time that balances event time of less time-driven places with clock time that is a prominent feature of life in the United States. Basic Books, 1998, 288 pp., ISBN: 0465026427

Capturing the Digital Ocean Floor

How GIS is used for mapping the undersea landscape

Although oceans dominate the earth's surface, the undersea world is far from fully explored. As Dawn J. Wright notes in the foreward to *Ocean Globe,* "95 percent of the global ocean floor remains either unmapped or mapped at a resolution that pales in comparison to the topographic maps that we have of Mars, Venus, and the dark side of the moon." The researchers who contributed chapters to this new ESRI Press book are working to improve our knowledge of the seafloor using GIS to manage, model, and map data to create a truly digital earth—one that includes the oceans that cover 70 percent of the earth's surface.



Contributors to this book come to seafloor mapping from very different perspectives: from researchers concerned with tsunami modeling and forecasting to biologists studying sea turtles to scientists trying to determine sites for sustainable aquaculture. Each chapter describes a different aspect of marine research that relies on seafloor mapping and uses GIS to meet that need. An appendix by Albert E. Theberge Jr. provides a brief history of seafloor mapping.

The first chapter, "Bathymetry—the art and science of seafloor modeling for modern applications," coauthored by Timothy A. Kearns and Joe Breman, describes modern data capture techniques, methods of GIS data representation, and applications of bathymetric data and is of special interest to the general GIS practitioner as well as those specializing in marine GIS.

Breman, also the editor of this volume, served as the editor for *Marine Geography* and a coauthor of *Arc Marine: GIS for a Blue Planet,* both published by ESRI Press. Breman is the founder of International Underwater Explorations in Maui, Hawaii. He is a GIS architect with IT consulting firm Akimeka, LLC. He is also a professor of oceanography, guest lecturer for the National Oceanic and Atmospheric Administration (NOAA) Marine Sanctuary, and scuba diving instructor. Breman holds a master's degree in marine sciences from the University of Haifa, Israel, and a bachelor's degree from the University of California, Santa Cruz.

Although the target audience for *Ocean Globe* is college and graduate students, it's accessible to anyone interested in gaining a better understanding of seafloor mapping. ESRI Press, 2010, 294 pp.

Why Attend?

the ESRI User Conference

This conference is for all GIS users regardless of experience or industry. Attendees can access more than 70 hours of learning and training and discuss hot topics such as geodesign, cloud computing, Web 2.0, and green government. They can connect with like-minded peers, industry thought leaders, and ESRI staff and business partners.

- **40** Tracks
- **100** Special interest, regional, and user group meetings
- **275** Technical workshops
- **300** Exhibitors
- **600** User presentations, map posters, and special displays

Register Now

The registration **deadline** is **May 21, 2010.** Some complimentary conference registrations are often available with an organization's ArcGIS software maintenance plan. A customizable letter of justification for attending the conference can be downloaded from www.esri.com/uc.

Special rate hotel rooms can also be booked online at www.esri.com/uc. Staying in downtown San Diego at a participating conference hotel offers the best value and convenience when it comes to travel, amenities, networking, and attending events at the Convention Center. (Special rates are not guaranteed after June 10.)

Everything GIS
at the ESRI International User Conference

For one week, in one place, ESRI software users from around the globe will have everything related to GIS technology at their fingertips. The ESRI International User Conference is open to all ESRI GIS users.

That week will be July 12–16, 2010, when thousands of people interested in geospatial technology will gather for the ESRI UC at the San Diego Convention Center in California.

"Our users are inspired people doing important work with GIS," says ESRI president Jack Dangermond. "They continue to astound us each year with the quantifiable, meaningful, and powerful differences they're making in the world. The User Conference should be invaluable, a conference you can't help but get something out of, whether it's help with a project or recognition for the work you do. It's a forum where creativity and new ideas are appreciated and shared."

It's also where ESRI software users will learn about ArcGIS 10, due for release soon. "This is a very big release," says Dangermond, adding that it will be "cloud ready." ESRI has a new relationship with Amazon Web Services to host ArcGIS in its cloud.

ArcGIS 10 will be demonstrated at the Plenary Session on Monday, July 12, and will be the focus of many other discussions, demos, and workshops. Improvements will include easier data creation and management, the integration of space and time for temporal spatial support, 3D models and visualization tools, mapmaking time-savers, enhanced editing and sharing capabilities, and new ways to perform analysis and modeling.

"ArcGIS 10 simplifies working with a GIS. It puts the map up front," Dangermond says. Enhanced by cloud computing and Web services, "this is an easier, more accessible, and collaborative GIS."

Dangermond also will share his vision of GIS during the plenary and talk about how many different industries use the technology to plan and make better decisions. Interesting and noteworthy guest speakers will give keynote talks that highlight the importance of geospatial information and technology.

A Full Schedule

The ESRI UC offers a broad slate of events and activities that revolve around the latest geospatial technology developments and applications such as specialized tracks; user presentations; technical workshops; special interest, regional, and user group meetings and exhibits; map posters; and special displays.

The Map Gallery opening will follow the plenary. Visitors will be able to browse through the collection of maps that illustrate how GIS is used by a wide variety of organizations in more than 100 countries. Groups such as the National Geographic Society and the Smithsonian also will present colorful map displays. The Exhibit Pavilion will house a variety of technology vendors. Attendees can watch GIS demonstrations; speak to ESRI staff about technical support; and see how geospatial technology is used in business, public safety, defense, utilities, and other sectors, in the ESRI Showcase.

Unique Highlights

Midweek, ESRI will honor the winners of the Special Achievement in GIS (SAG) awards at a ceremony. Organizations are lauded for their extraordinary use of GIS. Winners demonstrate vision and leadership in applying the technology to better serve society, such as enabling faster 911 response and creating information-rich public Web sites.

GIS Kids Camp will provide school-age children with a way to explore GIS. And the popular Thursday Night Celebration always boasts a new theme.

Another draw is the Spatial Outlet and bookstore, which sells books about GIS including titles from ESRI Press. Authors also will be on hand, signing books.

Play a Part

Attendees make the conference a success and worthwhile for their peers. Here's how to participate:

- Give a Lightning Talk—a clear, quick, and informal presentation that's completed in five minutes or less. The deadline to submit the presentation is April 30.
- Have your videos, screen captures, and images featured in the plenary. The submission deadline is May 28.
- Share your paper and digital maps that illustrate the power of GIS. The submission deadline is June 14.

Submission details will soon be available at www.esri.com/uc.

The Geographic Approach for the Nation

★ ★ ★ ★ ★ ★ ★ Highlights from FedUC ★ ★ ★ ★ ★ ★ ★ ★ ★

"GIS is changing things; it is changing—actually—everything," asserted ESRI president Jack Dangermond in his address to the more than 3,000 attendees of the ESRI Federal User Conference (FedUC), held February 17–19, 2010 in Washington, D.C.

The first FedUC was held 15 years ago. FedUC attendees represent a diverse group that forms one community drawn from civilian GIS users across many disciplines and interests as well as users in the military and intelligence communities.

The conference theme this year, The Geographic Approach for the Nation, underlined the message that a national GIS is emerging. This distributed network of systems and services supports national policies and priorities. A geography-based approach enables transparency and accountability in government processes, allows better performance measurement and place-based approaches to governance; and encourages citizen engagement.

"The first step in open government is showing where you're putting money," Dangermond said. "The second way GIS can help is overlaying maps of where there are problems. That's where you start to get into an information-driven government."

In a new era of open government, GIS is enabling transparency and accountability by making projects' status and expenditures more easily known. During the Plenary Session, ESRI staff demonstrated GIS applications that are making government more accessible and decisions more information driven. Recovery.com has been a tremendously popular site that uses maps linked to charts that allow visitors to drill into information to discover which funds are being spent where. Another example shown was the U.S. Department of Transportation stimulus spending site which addresses accountability by answering why money was spent on particular projects. ESRI has developed Web templates that streamline the process of building Web sites for tracking stimulus spending and projects. These templates are being used by many federal and state agencies.

ChesapeakeStat was cited as an example of how GIS is aiding performance management. This site provides far greater access to program information and interactive capabilities that complement existing paper processes.

GIS is quite naturally supporting the development of place-based policies so government can more easily target priority places, coordinate projects and programs, and support integrated decision making.

The enhanced mobile capabilities of GIS are also leading to increased citizen engagement with government. Through the use of Web and mobile technologies, volunteered geographic information (VGI) is emerging. VGI makes it possible for every citizen to be a "sensor." GIS could be used not only for gathering the observations of millions of people but also integrating them. Now citizens can help build a national GIS.

Another conference theme was Gov 2.0—an approach that views government as a platform for getting things done by bringing the advantages of Web 2.0 to government. GIS helps government make its data and information available to other organizations so they can more effectively do their jobs. The conference keynote speaker, Dr. John Holdren, noted that good decisions can't be made without good data. "That's why the Obama administration has placed such a priority on putting high-quality data in the center of the executive branch." Not just good data but the ability to visualize that data is crucial for decision makers in the government and the public. Data visualization is one of the strengths of GIS. Holdren is President Obama's science and technology advisor and the director of the White House Office of Science and Technology Policy.

As Dangermond noted during the Plenary Session, GIS professionals are building authoritative data, high-quality maps, performing analysis, and developing models and applications that make information available in a much more timely manner. He contrasted the months it took to integrate and analyze data associated with the response to Hurricane Katrina in 2005 with the minutes it took to acquire the same kind of common operational picture (COP) for the Los Angeles fires in 2009.

Many presentations at FedUC provided more information on the impending release of ArcGIS 10. This release focuses on GIS development on the Web.With ArcGIS 10, GIS is easier, accessible, and collaborative and uses cloud architecture, Web services, information integration, crowd sourcing, and open data sharing.

ESRI also announced during the conference that it is collaborating with Amazon Web Services (AWS) and has joined the growing community of AWS Independent Software Vendors (ISVs) building services and solutions in the cloud computing environment.

Developments in organizational cooperation coupled with increased GIS software capabilities and pervasive data collection is building a body of knowledge that is quite extraordinary and will further enable the use of geography and GIS as an organizing principle for governance and society.

In accepting the Making a Difference award, Tim Trainor, chief of the Geography Division of the United States Census Bureau, noted, “We are at a very good time. It’s at a convergence of lots of technology, lots of very rich software, rich datasets, and a highly skilled professional body that can actually use that data. This is our time.”

Transforming GIS

2009 ESRI Middle East and North Africa User Conference

More than 450 professionals from executives and managers to GIS and IT end users gathered in Manama, Bahrain, for the 2009 ESRI Middle East and North Africa User Conference (MEAUC).

This event for ESRI users in the Middle East and North Africa was held November 10–12 at the Diplomat Radisson Blu Hotel. MEAUC is a forum for learning about the newest developments in GIS and building relationships with other members of the international ESRI user community.

The conference was held under the patronage of His Excellency Sheikh Mohammed bin Mubarak Al Khalifa, Deputy Prime Minister for the Government of Bahrain. Khalifa deputized His Excellency Sheikh Ahmed Ateyatalla Al Khalifa, Minister of Cabinet Affairs for the Kingdom of Bahrain, to attend the conference in his stead.

“GIS is slowly transforming into a pervasive technology,” said Dr. Ghulum Bakiri from MicroCenter, the ESRI distributor in Bahrain. “And many countries in the region are embarking on a national NSDI *[National Spatial Data Infrastructure]* initiative to act as the platform of choice for integrating diverse islands of information that exist in various departments and government organizations. This conference gave GIS professionals and decision makers an outstanding opportunity to share their experiences and gain valuable insight into essential best practices in this challenging undertaking.”

Attendees heard from ESRI president Jack Dangermond during the Plenary Session. He discussed his vision for GIS, its impact on the world, and explained that now GIS is not only about providing maps and information but is also an indispensable tool for analysis and decision making for developing environmental policies and urban plans.

At conference sessions, users had questions answered and learned how to obtain results in their organizations and communities through using GIS. They saw the latest GIS tools and applications, heard about time-saving tips and tricks, and met with ESRI staff and business partners. Technical workshops, led by ESRI product managers and paper sessions on successful GIS applications showed attendees new ways to get solutions to technical issues and cost-saving ideas for specific markets.

For the region’s next gathering, users in the Middle East and North Africa are invited to attend a combination European User Conference (EUC) October 26–28, 2010, in Rome, Italy. See the annoucement in the accompanying article, “Upcoming Conferences” on this page.

Upcoming Conferences

2010 EMEA Conference

The 2010 ESRI Europe, Middle East, and North Africa User Conference (EMEA) will take place October 26–28 in Rome, Italy, at the Ergife Palace Hotel. The EMEA is being hosted by ESRI Italia, the ESRI distributor in Italy. This union of the European User Conference (EUC) and Middle East and North Africa User Conference (MEAUC) gives users throughout these regions the chance to connect with an even larger ESRI community. More information is available at www.esri.com/meauc.

ESRI Latin America User Conference

The ESRI Latin America User Conference (LAUC), in its 17th year, will be held September 22–24, 2010, in Mexico City, Mexico. The event, hosted by the ESRI distributor in Mexico, SIGSA, will be held at the Sheraton Maria Isabel Hotel & Towers on the Paseo de la Reforma. The LAUC is the premier event for GIS users throughout Latin America and between 800 and 1,000 attendees are expected. Participants can form valuable relationships with peers and meet with key contacts—from ESRI staff and business partners to the region’s industry leaders. Attendess can find out how to launch and grow successful GIS projects and share geographic knowledge. Learn more, register, and see how to participate at www.sigsa.info/lauc2010.

For a complete listing of ESRI events worldwide, visit www.esri.com/events.

A Decade of Success

Combining geospatial technology and problem-solving skills

By Michael Winston, Shelly School District

A program developed by an Idaho school district encourages students to use GIS skills to solve real-world problems. Teachers in the Shelley School District have been using GIS technology for a decade. The Solutions program developed by the district exposes students to new technologies and skills that are valuable in the problem-solving process.

Shelley School District is located about 20 miles from the Idaho National Laboratory (INL), a national science laboratory. The district's teachers were first introduced to GIS technology at INL, and GIS was a natural fit for the Solutions program. Some of the GIS projects students have worked on over the years include using current census data to redistrict the school board zones, creating maps for the City of Shelley showing fire hydrant locations, and mapping noxious weeds for county and state weed agencies.

Teachers like to involve students in both short-term projects and longer-term projects. Short-term projects help students gain an initial sense of accomplishment, which instills the confidence that will be required for longer-term projects. Long-term projects generally require higher skill levels but can be rewarding for students who persevere.

As successful as these GIS projects have been, teachers were concerned that too many students were passing up opportunities to work with GIS projects, and many students involved in GIS projects were learning advanced computer skills but lacked basic map-reading skills. As a result, the program was restructured. Students are now introduced to mapmaking/map-reading skills at a younger age. For example, students learn how to make simple compasses, how to make maps, how to read topographic maps, and how to use GPS technology in geocaching activities. This introduction exposes more students to GIS and helps them pick up basic skills.

One project, Holding the Line, is a capstone effort that exemplifies the aspirations teachers have for effectively incorporating GIS in the classroom. This project addressed the slow spread of noxious weeds toward Yellowstone National Park. Current weed control measures had not been effective in preventing the spread of one weed in particular: leafy spurge *(Euphorbia esula)*. A consortium of government agencies, weed control entities, watershed organizations, and interested citizens banded together to stop the spread of leafy spurge to Yellowstone Park.

Rebecca Schneiderhan, who has since graduated and has her own GIS consulting business, was contracted to oversee the distribution of four million beetles as part of a biological control effort started more than 10 years ago. The beetles are effective in controlling leafy spurge but harmless to native flora and fauna. They are released at marked sites that have been studied for years to determine how effective the beetles are in controlling spurge. Schneiderhan was tasked with collecting two million beetles from previous release sites, purchasing two million additional beetles, then releasing all four million beetles in areas adjacent to the Yellowstone Park boundaries. The beetles were successfully collected, and released at target sites, and those sites were mapped.

Much of the beetle collecting and mapping was done using the services of Paul Muirbrook, an individual who established a business that hires high school students and high school graduates to perform various GIS/GPS tasks for local government agencies. Schneiderhan was also assisted by a second grade student who helped collect beetles and map the sites. These sites will be monitored for the next five years to determine the effectiveness of the effort in preventing the spread of leafy spurge.

This project is considered a capstone project for Shelley District's GIS efforts because it provides opportunities to help solve real-world problems and helps students of all ages develop multiple skills. For example, students involved in this project learned about plants (weeds), insects, Yellowstone Park, government agency interactions, and how GPS and GIS technologies can be used. It also provided employment opportunities for both entrepreneurs and summer hires and helped build partnerships between government agencies and schools.

In summary, Shelley School District's efforts to expose students to GIS/GPS technologies have evolved over the years. The district's teachers now attempt to introduce students to mapmaking fundamentals at an early age and seek projects that involve solving real-world problems, encouraging students to use their skills in the solutions of those problems.

New ESRI Authorized Instructors

The Authorized Training Program (ATP) is pleased to acknowledge the newest class of ESRI Authorized Instructors. These candidates have passed all ATP requirements and have been granted authorization to teach the specified ESRI courses within the United States and United States Territories, excluding Puerto Rico. These instructors join a network of over 250 Authorized Instructors. To locate an Authorized Instructor in your area, visit www.esri.com/atp, contact ATP by e-mail at atp@esri.com, or call 909-793-2853, extension 1-2111.

Abbreviations for each course authorization are listed in the accompanying table. The course authorizations shown with each instructor listed indicate only the most recent authorization(s) received by that instructor. Visit the ATP Web site for complete information on all authorizations held by an instructor.

Course Abbreviations

AG1	Introduction to ArcGIS I (for ArcGIS 9)
AG2	Introduction to ArcGIS II (for ArcGIS 9)
AGD1	ArcGIS Desktop I
AGD2	ArcGIS Desktop II
AGD3	ArcGIS Desktop III
AGSA	Working with ArcGIS Spatial Analyst
BGDB	Building Geodatabases
IAGS	Introduction to ArcGIS Server
LGAD	Learning GIS Using ArcGIS Desktop
MGDB	Introduction to the Multiuser Geodatabase
PAO	Introduction to Programming ArcObjects with VBA
PAOJ	Introduction to Programming ArcObjects Using the Java Platform
PAON	Introduction to Programming ArcObjects Using the Microsoft .NET Framework
PYTH	Introduction to Geoprocessing Scripts Using Python

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Many Mobile GIS Training Resources

ESRI courses for staff implementing these solutions

BlackBerrys, iPhones, smartphones, and other mobile devices provide instant access to information—no matter where we are. Mobile GIS is one of the technologies enabling this trend. Many organizations, including utilities, public works, and public safety agencies, use mobile GIS to collect field data, ensure the currentness of their GIS database, and maintain situational awareness. ESRI provides training options for staff who are responsible for implementing and maintaining the mobile GIS solutions.

The *Authoring and Serving ArcGIS Mobile Projects* instructor-led course teaches a recommended workflow for creating and deploying an out-of-the-box ArcGIS Mobile project. The course emphasizes the unique requirements of a mobile project and uses a realistic mobile GIS scenario to present concepts and the decision-making process needed to successfully implement a mobile GIS project. Course exercises immerse students in the project planning phase and each step in the mobile workflow all the way through to project deployment.

Throughout the course, students learn how to adapt existing data, maps, and GIS workflows to the mobile environment. Students create a geodatabase and choose a data transaction model for a mobile project, design a mobile map, and create optimized mobile map services for use in the field. Security considerations and techniques for maintaining a mobile project over time are covered. Group discussions and activities provide students with ample opportunity to strategize and share ideas for using the course project as a road map for other mobile GIS projects.

The course is designed for GIS analysts and experienced ArcGIS users who want to deploy mobile GIS projects using out-of-the-box ArcGIS Mobile functionality. Developers who want to understand core ArcGIS Mobile functionality will also benefit from attending.

Building Applications Using the ArcGIS Mobile SDK—This is another instructor-led course that introduces the ArcGIS Mobile SDK (software development kit) for the Microsoft .NET Framework and teaches how to design and build custom mobile applications that enable situational awareness and real-time geographic data collection in the field. Students will learn recommended practices for integrating mobile controls and multiple data sources in mobile applications deployed in the Windows 32 (Tablet PC) and Windows Mobile (smartphone and Pocket PC) environments.

In addition to the instructor-led courses, ESRI has created a series of free Web training seminars. These one-hour training seminars provide information on how other organizations are using mobile GIS and what ESRI mobile GIS solutions are available.

Creating a Common Operational Picture with ArcGIS—Agencies responding to emergencies such as wildfires, chemical spills, or homeland security threats rely on a common operational picture (COP) to monitor, respond to, and manage the situation. By combining GIS basemap data with changing, real-time event data from cameras, a COP creates broad situational awareness by sensors and other means of communication. This seminar examines how a COP system can be created using ESRI's ArcGIS Server technology.

Introduction to ArcLogistics Navigator—ArcLogistics Navigator, a new product within the ArcLogistics solution, extends the efficiencies gained with optimization in ArcLogistics to the vehicle with turn-by-turn guidance. This seminar covers ArcLogistics and ArcLogistics Service Pack 1, setting up navigation and sending and receiving routes from ArcLogistics to a mobile device.

Introduction to ESRI Mobile GIS Solutions—Mobile GIS is currently used by government, utility companies, public safety agencies, and commercial organizations to streamline business processes and collect up-to-date information about assets, infrastructure, and conditions in the field. This seminar helps organizations evaluate ESRI mobile

GIS solutions. It will assist organizations in identifying their mobile technology needs and determine the mobile GIS solution that best meets those needs. The presenter examines each solution's unique purpose, use cases, and deployment options.

Maximizing GPS Accuracy in GIS Data Collection—The application of GPS in civilian markets has evolved from high-value surveying and timing industries, where accurate location was critical, to more recent widespread adoption in location-aware applications on consumer handsets. GPS plays a critical role in enterprise field service and work automation systems where mobile GIS tools leverage GPS to help workers locate themselves, navigate to their work, and accurately collect new geographic information. This presentation examines techniques for maximizing accuracy of GPS in mobile GIS data collection.

For more information and to register for these and other courses, visit www.esri.com/training.

More Training Courses

ESRI constantly develops new courses that teach the skills and knowledge you need to succeed in the rapidly changing field of geospatial technology. You can upgrade your skills, investigate a new career path, or stay current with the industry. Learn how to make the best use of data sources, perform analyses, disseminate information effectively, and develop applications.

Instructor-led courses are offered in several formats: instructor-led courses taught in a traditional classroom setting; instructor-led, virtual classroom courses that include lectures and hands-on exercises in an interactive, online classroom; and instructor-led courses taught by ESRI Professional Services, which cover specific industry solutions or products.

Self-paced, multiple module Virtual Campus Web courses are available as well as Virtual Campus free, one-hour training seminars. Instructional podcasts are free, short audio recordings.

Desktop GIS

Using Lidar Data in ArcGIS—This Web course is designed for data managers and GIS analysts and teaches how to transform large lidar datasets and prepare them for three-dimensional visualization, modeling, and analysis in the ArcGIS Desktop environment. Learn how to derive terrains, digital elevation models (DEMs), and intensity imagery from lidar data, then use this data for advanced 3D modeling and analysis.

Creating and Publishing Maps with ArcGIS—This instructor-led course teaches how to employ the elements of good cartography as part of a standard process that you can apply each time you make a map. You learn to create maps that are easy to interpret and properly designed for their audience and delivery medium.

Performing Analysis with ArcGIS Desktop—Learn strategies for planning an analysis project and techniques for solving a variety of spatial problems in this instructor-led course. This course teaches a proven process that can be applied to all types of spatial analysis projects.

Working with CAD Data in ArcGIS Desktop—This course teaches fundamental concepts of CAD data integration within ArcGIS. This instructor-led, virtual classroom course provides best practices for working with native CAD data in ArcGIS, converting CAD data to GIS data, and options for converting GIS data to CAD formats.

Server GIS

Building Web Maps Using the ArcGIS API for JavaScript—Learn how to create high-performing Web maps that share GIS content on the Web in this instructor-led course. This course teaches how to create Web maps that are attractive, fast, and easily used by their intended audience. Learn how to build lightweight, focused Web maps that utilize internal and external ArcGIS Server Web services.

Extending ArcGIS Explorer for Developers—In one hour, learn how you can rapidly develop a user-friendly front end for GIS data or ArcGIS Server services in this free Web training seminar.

For More Information	
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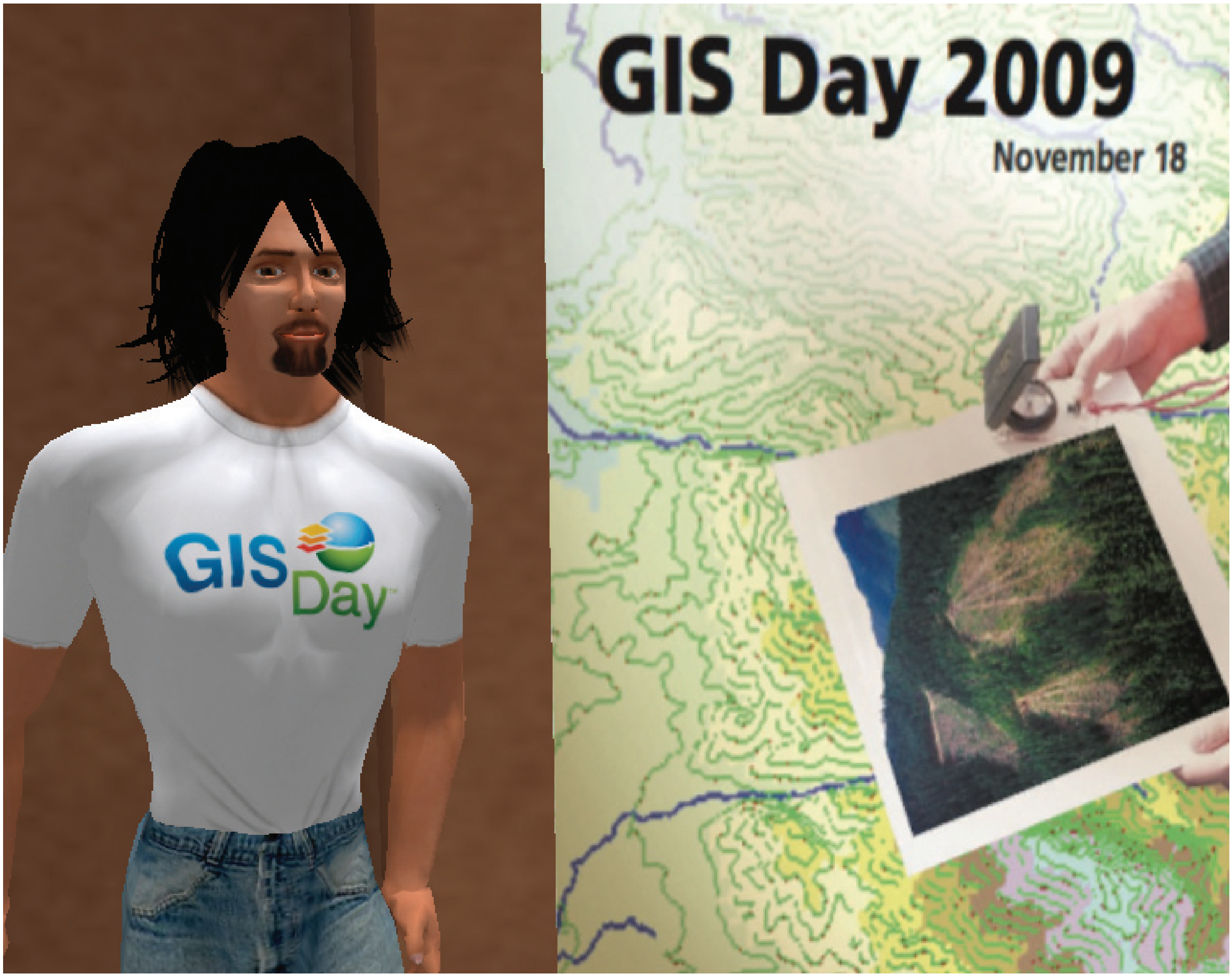


The author, shown as his avatar Gadget Loon, and his GIS class students hosted a GIS Day event in Second Life.

GIS Day Goes Virtual

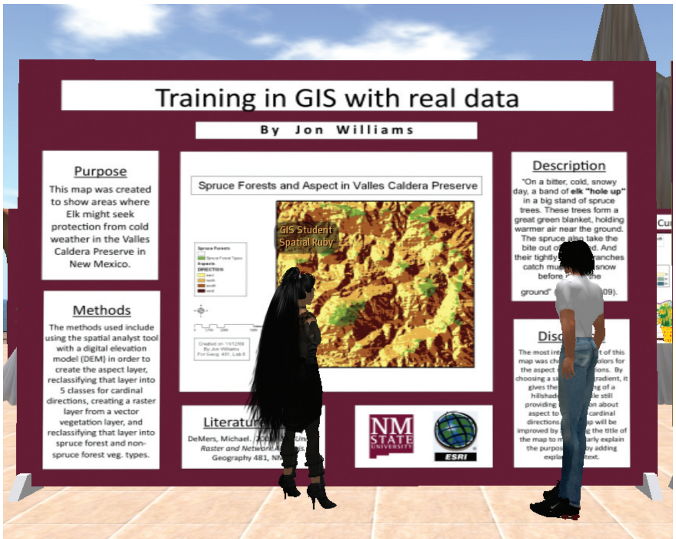
A less expensive, transportable, and interactive event in the metaverse

By Michael N. DeMers, New Mexico State University

At New Mexico State University (NMSU), the 2009 GIS Day celebration took on quite a different look from previous years. Attendees donned avatar shapes and digital costumes to view student posters and projects inside a virtual display area in a portion of a multiuser virtual environment called Second Life.

Aggie Island, as this virtual environment is known, is owned and maintained by the university's College of Extended Learning and Information and Communications Technologies. As part of the author's *Geography 481* class, which teaches the fundamentals of GIS, 15 students voluntarily created virtual posters that demonstrated their GIS accomplishments. These students received official ESRI Certificates of Participation that are displayed on the backs of their posters. The display opened on GIS Day (November 18, 2009) and has been kept up to encourage GIS education and the use of virtual worlds, such as Second Life, for learning, exposition, and collaboration.

The event, staged in the center of Aggie Island, resembled a scaled-down, virtual version of a poster session at the ESRI International User Conference. As with real-world poster sessions, there was food (all digital and calorie free), beverages (including virtual champagne), free goodies (such as virtual GIS Day ball caps and T-shirts), and lots of information about GIS and how it is used. A small movie theater showed a YouTube video that introduced GIS to visitors who were



As part of the virtual GIS Day, students created virtual posters that demonstrated their GIS accomplishments.

Like real-world poster sessions, the virtual version had food, beverages, and swag. The food and drink were digital and calorie free, and the free goodies included virtual ball caps and T-shirts.

new to the topic. Student volunteer avatars provided attendees with directions and encouragement. These avatar students also staffed an information desk that provided materials about the GIS courses available from NMSU as well as information about the National Geography Awareness Week event that was taking place on campus concurrently with the GIS Day events in Second Life.

Since it opened, the virtual GIS Day display on Aggie Island has received nearly 100 avatar visitors from different parts of the United States and abroad—many more attendees than could be expected from a one-day, real-world event held in a small venue. However, the advantages of having such an event in a virtual world go beyond just the number of attendees.

First, a virtual event minimizes cost. Printing an average poster costs between $30 and $100. If the current poster display was created in the real world, it would cost at least $450 and possibly as much as $1,500. Posters and certificates for the event cost the author a grand total of $300—in Linden dollars, the currency of Second Life. At the current U.S.-Linden dollar exchange rate, the cost was approximately $1.25.

Second, setting up a real poster display typically involves renting display boards and space, physically moving the displays and tables around, and setting up the posters themselves. Besides the hours involved, the cost is sometimes prohibitive if there are many attendees.

Perhaps the most important advantage of a virtual GIS Day event is that the entire display—including the structures—is portable. It can all be moved to a different location, such as a traveling display. The Aggie Island display will be part of an ESRI-sponsored event at the March Microcomputers in Education Conference in Tempe, Arizona. This is similar to the high school lyceums that were popular years ago, but without the expense. This would be an effective and inexpensive way to get the word out to more potential GIS users. In fact, Linden Laboratories, the owners of Second Life, also have a Teen Grid that allows secondary teachers to have GIS poster sessions for their classes. The possibilities, to steal words from ESRI president Jack Dangermond, ". . . are limited only by your imagination."

For the immediate future, the NMSU GIS Day poster display can be accessed in Second Life using the following landmark: AggieLand Public, NMSU Aggie Island (133, 76, 26). For more information, contact the author's avatar, Gadget Loon, in Second Life through instant messaging or directly (in the nonvirtual world) at

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DeMers is the author of another article on this topic, "Inside the Metaverse: A 'Second Life' for GIS Education," which appears in the Winter 2009 issue of *ArcUser*.

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