Spring 2012

ArcUser

The Magazine for Esri Software Users

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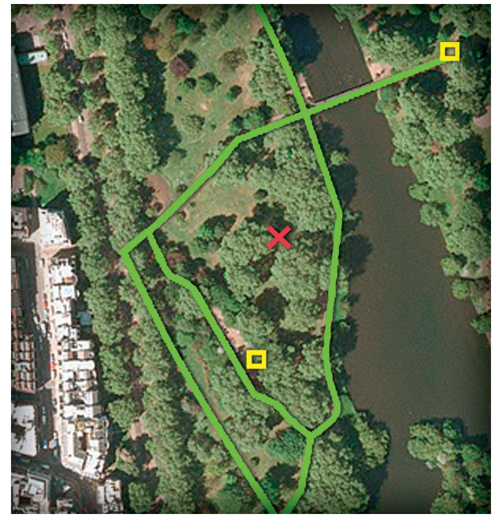

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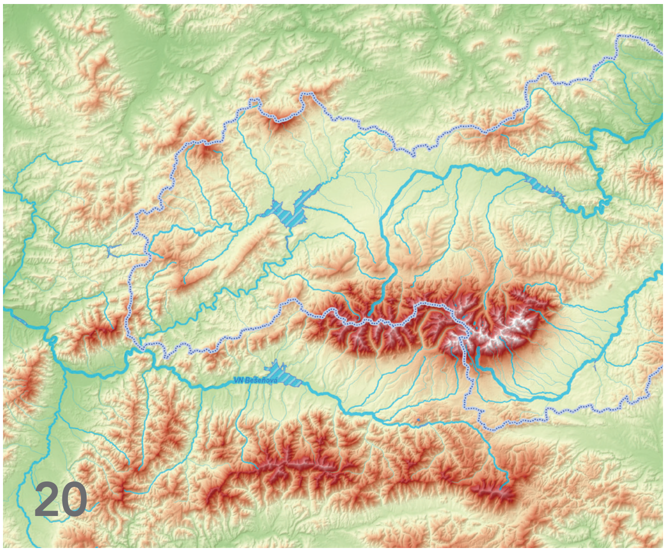
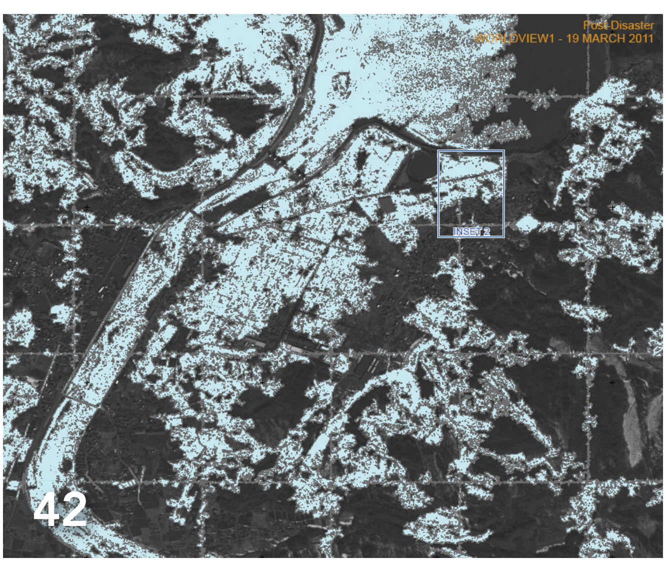


Focus

Features



Special Section

Visionary Technology

As articles in this issue demonstrate, GIS is extending our vision of the world. It lets geologists in Illinois see the terrain below, modeling subsurface geology in three dimensions. GIS is also giving archaeologists a better understanding of a Latin city from the first millennium by viewing photogrammetric models of finds in context with each other and the surrounding area. Through an application developed in ArcGIS Explorer, GIS is helping younger members of the Hopi Tribe see their intimate relationship with the landscape of their ancestors.

GIS is also helping us see a better, more sustainable future engendered by a deeper understanding of earth systems. Because GIS is highly scalable, it is being applied to challenges on community, national, regional, and global scales. "Improving Landscape-Level Environmental Impact Evaluations" describes how two countries are working together to intelligently manage the water resources they share. On a much smaller scale, GIS-based apps on smart devices are assisting local governments in enlisting the direct support of citizens to improve communities. Citizens use these apps for activities such as reporting problems, gathering information, and volunteering their time.

Whether on a transnational or neighborhood scale, GIS fosters collaborative effort and shared responsibility for outcomes.

Another article in this issue, on the 2012 GeoDesign Summit, highlights a new way in which GIS is sharpening our vision of the world we would like to have. Geodesign combines the science-based methods of GIS with concepts from value-driven design to arrive at creative solutions within a geographic context. One of the defining characteristics of this new approach is the use of GIS-based tools that provide immediate feedback on the consequences and costs of design alternatives. Using geodesign, we can develop local solutions that consider global impacts.

Monica Pratt
ArcUser Editor

editor's page

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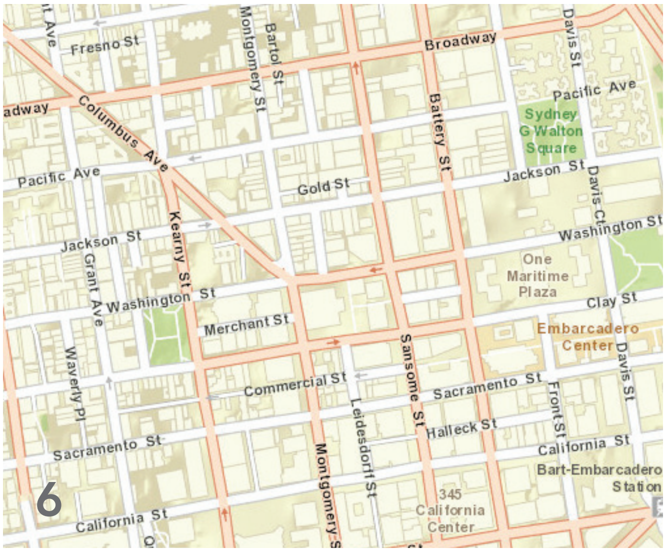
Departments



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Integrated
ArcGIS Platform

ArcGIS 10.1 provides high performance, promotes collaboration

ArcGIS 10.1 will change the way geographic information is managed by GIS professionals and accessed by their organizations. This complete GIS further integrates desktops, servers, mobile, and web applications and provides additional tools and infrastructure for extending the reach of existing GIS implementations. With ArcGIS 10.1, organizations can transition to next-generation GIS platforms without jeopardizing current GIS investments.

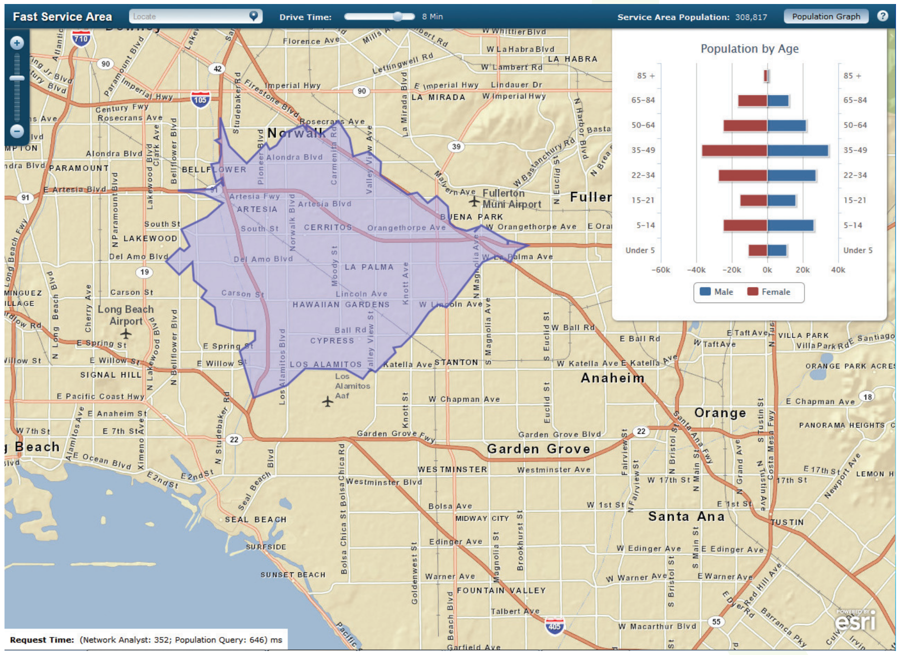
ArcGIS Online is now a fully integrated portal used by thousands of GIS users around the world to store and manage maps, data, and other geospatial information as well as access thousands of free maps, datasets, services, and tools. Esri continuously updates ArcGIS Online with new maps, imagery, and task services so users get the most current and accurate basemaps and GIS products available on the web.

ArcGIS Online for Organizations, a new subscription for ArcGIS Online, is a customizable, web-based system designed for managing an organization's geospatial content using cloud tools and infrastructure. It allows administrative control over data creation and access while making geographic information easily available both inside and outside the organization, enabling collaborative efforts.

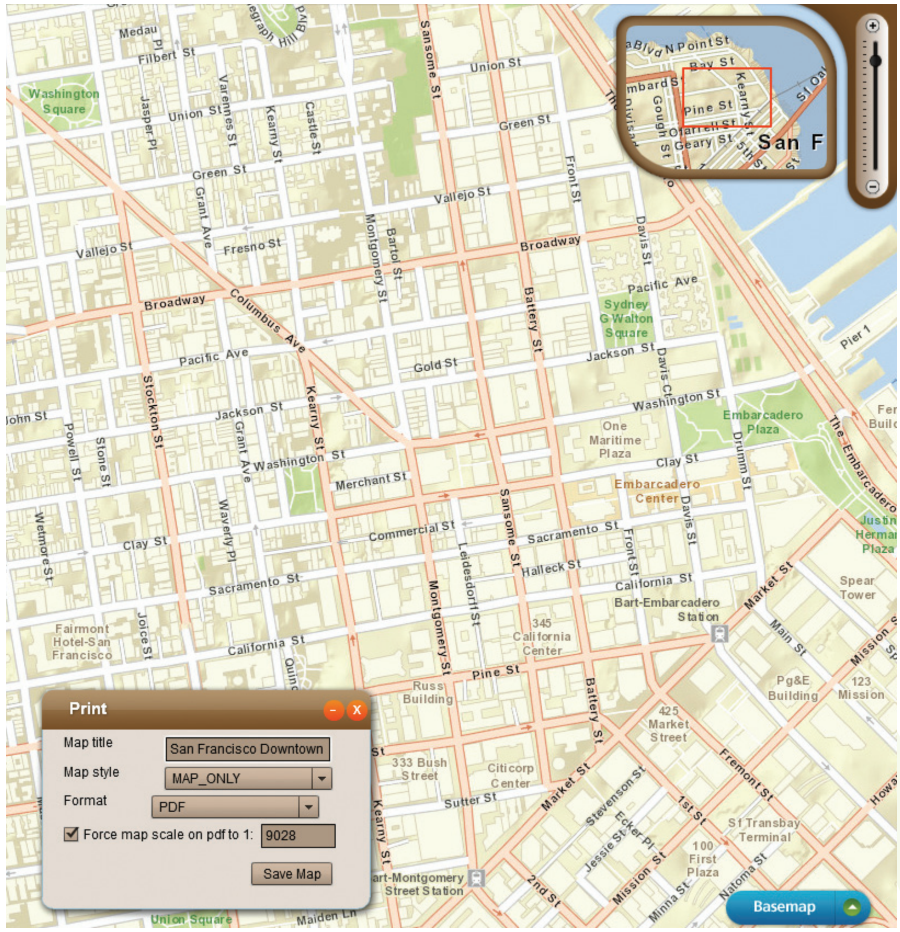
At 10.1, ArcGIS for Server has a new, simplified, and high-availability architecture referred to as a *site*. An ArcGIS 10.1 for Server site includes a web server, web gateway, and GIS server for processing requests. With the web gateway, the site can be accessed through one common URL even though it may be composed of multiple machines. Running natively on 64-bit Windows and Linux operating systems, ArcGIS for Server provides users with high-performance web editing, map caching, on-the-fly analyses, and imagery exploitation capabilities.

Users have additional choices for deployment. ArcGIS for Server is fully certified on VMware and VCE's Vblock platform and can be deployed on Amazon Elastic Compute Cloud (EC2) on both Windows and Linux. Multiple GIS servers can be configured for the site and organized into groups called clusters. Each cluster can be configured

Learn more about what's new in ArcGIS 10.1 at esri.com/whatscoming.



↓ Esri continuously updates ArcGIS Online with new maps, imagery, and task services so users get the most current and accurate basemaps and GIS products available on the web.



to run a dedicated subset of services. For example, a cluster of servers with more processing power can be exclusively committed to running computationally intensive processes such as geoprocessing.

Once ArcGIS for Server is installed, services are immediately available through HTTP, eliminating the need for an existing web server and allowing users to get up and running quickly. The ArcGIS for Server site can also be integrated with an organization's web server using ArcGIS Web Adaptor. GIS servers can communicate with each other so workflows—such as asynchronous geoprocessing or map caching—can be distributed across servers to be more easily accomplished. Multiple GIS servers can be administered with minimum disruption to the site.

The new ArcGIS 10.1 for Server architecture is cloud-friendly. ArcGIS Server Cloud Builder for Amazon Web Services, a new Windows-only desktop application, lets administrators build and maintain ArcGIS for Server sites on Amazon EC2, create templates (e.g., custom sites), back up sites, or delete sites without logging into the Amazon-hosted machine. GIS servers can still be administered via Amazon Web Services Management Console for more fine-grained control over the site.

↑ ArcGIS for Server includes new services, including a print service that allows users to produce high-quality, large-format PDF maps directly from web maps.

ArcGIS for Server includes new services, including a print service that allows users to produce high-quality, large-format PDF maps directly from web maps. Along with the ability to generate sophisticated GIS and mapping services with Standard and Advanced editions, all editions of ArcGIS for Server will provide simple mapping capabilities from a spatially enabled database.

GIS professionals will find this release of ArcGIS for Desktop to be the most empowering GIS authoring environment to date. Any GIS resource—including maps, imagery, geodata, and tools—can be delivered as a web service on both ArcGIS for Server and ArcGIS Online. Desktop users can easily package maps and layers and make that content available to staff, stakeholders, partners, or the public via online groups while maintaining complete control and ownership of this content.

At 10.1, developers gain even greater access to the ArcGIS system via improved APIs and software development kits (SDKs) for web and mobile applications, configurable viewers, and the new ArcGIS Runtime. With ArcGIS Runtime, developers can create and deploy focused, fast, stand-alone GIS applications for desktop users. The runtime is a small, lightweight deployment designed for both desktop and cloud development that does not require installation and can be run directly from a CD. In terms of its capabilities, ArcGIS Runtime fits between ArcGIS Engine and ArcGIS Web Mapping APIs.

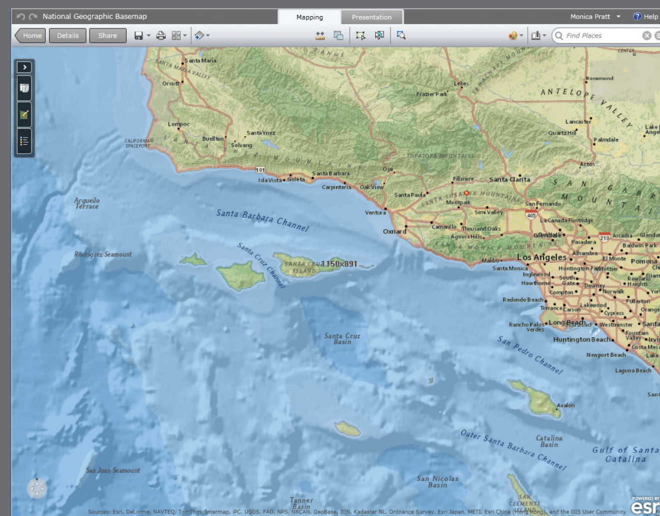
Mobile developers can also create custom business applications using ArcGIS Runtime SDKs for iOS, Android, and Windows Phone devices. These apps can use the powerful mapping and geocoding capabilities available from ArcGIS for Server and ArcGIS Online. Apps can be deployed to the enterprise or the public via the App Store and Marketplace. A free ArcGIS application, available for download on all major mobile platforms, lets users explore map content, collect and edit GIS features, and use sophisticated geoprocessing tasks.

National Geographic Basemap

Multiscale reference map of the world on ArcGIS Online

The National Geographic World Basemap, a general reference map for informational and educational purposes, is available from ArcGIS Online. This new Internet-based map service combines a century-old cartographic tradition with GIS technology. Created by the National Geographic Society in cooperation with Esri, it provides a basemap for users who want to display minimal data against a vibrant, detailed background when creating web maps and web mapping applications.

This reference map includes physical and natural features, administrative boundaries, cities, transportation infrastructure, landmarks, protected areas, ocean floors, and other layers. Shaded relief and land-cover imagery supply added context. Global coverage is available to 1:144,000 scale, and more detailed coverage, down to 1:9,000, is available in urban areas in North America. The map uses data from a variety of leading data providers including DeLorme, NAVTEQ, UNEP-WCMC, NASA, ESA, and USGS.



Better Web Editing

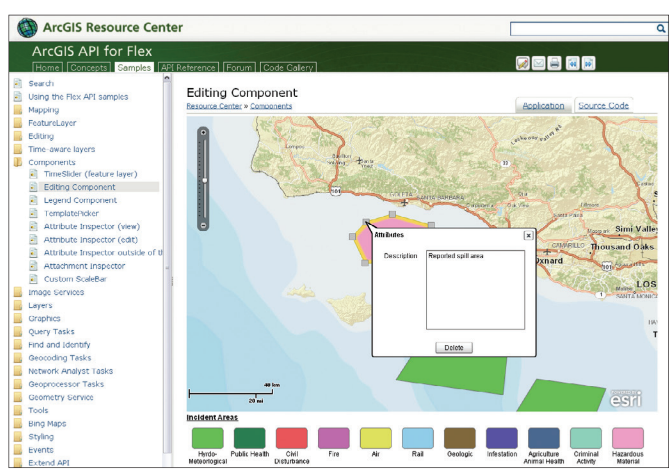
And other enhancements in ArcGIS API for Flex 2.5

ArcGIS API for Flex 2.5 provides an improved editing user experience and includes support for Web Map Tile Service (WMTS) layers and enhanced support for KML and for ArcGIS.com web maps. Based on Flex 4 and Flash Builder 4, ArcGIS API for Flex 2.5 works well with the Adobe Flex 4.6 software development kit (SDK) (as well as Adobe Flex SDKs for 4.1, 4.5, and 4.5.1.) and ArcGIS Server 9.3 and above.

As with previous releases of ArcGIS API for Flex, you can use this API to create interactive and expressive web applications that leverage ArcGIS for Server resources. These applications support all map projections and dynamic and cached map services from ArcGIS for Server. You can incorporate graphics that allow users to draw on a map or click on pop-up windows for additional information. The API includes classes and methods for GIS tasks such as querying, locating addresses, finding attributes, identifying features, routing and other network analysis operations, and performing geoprocessing operations. Use Flex components, such as Editor, InfoWindow, AttributeInspector, TemplatePicker, and TimeSlider, for rapid application development.

You can use ArcGIS API for Flex without installing ArcGIS for Server on your machine if you have access to ArcGIS for Server via a uniform resource locator (URL). Esri offers numerous samples and several sample servers to use when getting started creating with ArcGIS API for Flex. Each sample (help.arcgis.com/en/webapi/flex/samples/index.html) is a live demo accompanied by the complete source code. Download the Flex API Library to get the source code for all samples.

Learn more about developing web applications with ArcGIS API for Flex at the ArcGIS Resource Center (links.esri.com/flex).



↑ Use the Editing component to let users edit geographic features over the web. This sample, on the Editing samples on the ArcGIS Resource Center, demonstrates how you can build a feature sketching application using ArcGIS API for Flex.

Ready-to-Deploy Viewers for Flex and Silverlight

Esri provides GIS web client mapping applications for ArcGIS for Server built using Adobe Flex and Microsoft Silverlight technologies. Both are designed to meet the business needs of organizations for easily configurable web mapping apps that require no programming skills to deploy. The ArcGIS Resource Center supplies extensive support for both viewers: explanations of concepts, samples, forums, API reference, and code gallery.

ArcGIS Viewer for Flex

Along with ArcGIS Viewer for Flex 2.5., Esri also released ArcGIS Viewer for Flex. It is available in uncompiled and compiled packages. The uncompiled package is targeted at developers who intend to create custom widgets and/or extend the core viewer application. The compiled version is for users who intend to create custom web mapping applications by configuring the viewer's XML configuration files. The 2.5 release also includes an application builder that employs a three-stage process that helps novice users learn about the viewer's configuration properities while creating and deploying a new application.

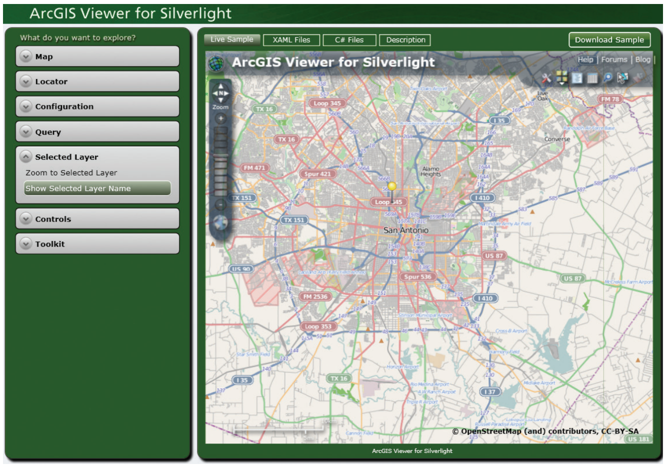
↑ ArcGIS Viewer for Flex sample integrating a GeoRSS with the map

Viewer functionality is defined by widgets. Many core widgets are included, and new functionality can be defined with custom widgets developed using ArcGIS API for Flex. ArcGIS Viewer for Flex 2.5 can be downloaded from the ArcGIS Resource enter (links.esri.com/flexviewer).

ArcGIS Viewer for Silverlight

ArcGIS Viewer for Silverlight 1.0 includes a configurable viewer, an application builder, and an extensibility kit. The viewer is a ready-to-deploy configurable rich Internet application (RIA) built on ArcGIS API for Silverlight. This web client works with ArcGIS for Server services and data content from ArcGIS Online. Configuring the viewer with the application builder is easy and does not require either editing configuration files or programming. The extensibility kit lets developers extend the core viewer framework using add-ins that leverage Silverlight libraries including ArcGIS API for Silverlight and the native Silverlight API.

This release includes an updated Application Builder user interface; more intuitive editing workflows; default enabled on-click pop-up windows; the ability to use web maps from ArcGIS Online and support for accessing an organization's web maps maintained in ArcGIS Online; and localization for Arabic, Italian, Portuguese (Brazilian), and Russian. The viewer can also show the results of geoprocessing operations using the map service (when applicable).



↑ ArcGIS Viewer for Silverlight sample with the OpenStreetMap basemap

Make Custom Apps with Detailed Population Data

With Community Analyst API, developers can create customized applications that assess the population characteristics of an area.

Esri Community Analyst is Software as a Service (SaaS) that provides analysis and mapping of thousands of demographic, health, economic, education, and business data variables. This demographic data is also available as an add-in for ArcGIS for Desktop.

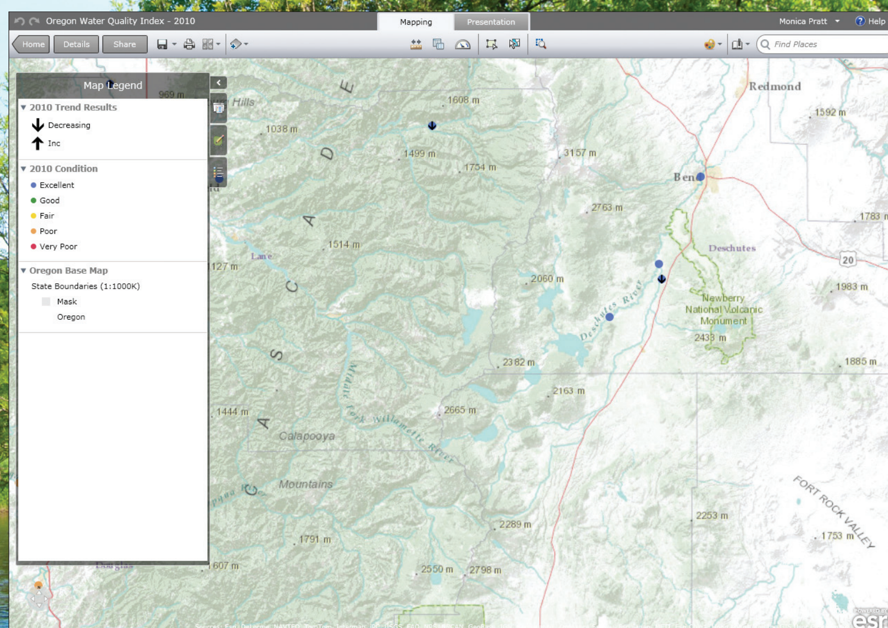
With Community Analyst API, developers can create custom web, mobile, and desktop applications that produce detailed reports using thousands of data variables, including demographic, health, and crime. The API also gives developers more control over what data and specific geographies they want users to view, publicly or internally. Data can be aggregated and summarized at 10 levels of geography or specified by polygon, drive time, or distance. Community Analyst automatically aggregates and accurately summarizes the data regardless of the size or shape of the area being analyzed. Information is provided as presentation-ready PDFs, Microsoft Excel spreadsheets, or XML streams, allowing maximum flexibility in creating custom applications.

The API is available in Flex, REST, Silverlight, and SOAP formats. Resources available to make developers productive include code samples and blogs. Visit the Community Analyst website (esri.com/ca) to try Community Analyst API free for 30 days.

Seeing Beyond the Data

Developing understanding

As Esri president Jack Dangermond has observed, "Understanding our world isn't just an 'environmental' issue." Our stewardship of the earth and its resources profoundly affects nearly every aspect of our lives and will affect the lives of future generations. Understanding the earth's systems and its current condition is the foundation for science-based decisions that maximize positive effects and minimize negative ones.



↑ This map, shared on ArcGIS Online, was created by Lesley Merrick of the Department of Environmental Quality to show the status and trends for 131 water quality monitoring stations in Oregon based on a 10-year period from 10/1/1990 to 9/30/2010.

Although individual government agencies and research groups have been gathering data on environmental systems for decades, this data was most often gathered for specific purposes and managed separately to meet organizational needs for regulation and reporting rather than the broader goal of gaining an overall understanding of complex systems.

With the coevolution of measurement technologies and the Internet, the volume of data collected about the natural world has increased exponentially. What was once a data stream has been transformed into a tidal wave of sensor, tabular, satellite, crowdsourced, model, and digitized historic record data. With such a wealth of data, more readily obtainable because of the Internet, it would seem that the understanding of these systems would have increased commensurately.

However, that has not necessarily been the case. Understanding requires more than amassing data. Beyond just obtaining data, understanding demands the organization and synthesis of that data, producing information from which conclusions and predictions can be derived. This understanding provides a scientific basis for taking action or modifying behavior.

GIS aids in understanding earth systems by providing a platform for evaluating, managing, and integrating data in a geographic framework. The coevolution of GIS with other IT technologies has extended its reach from the desktop to the server, mobile devices, and the Cloud.

Always able to incorporate a broad spectrum of data types and formats, GIS data integration capabilities have continually expanded, so much so that GIS is the enabling platform for managing, using, and visualizing the outputs from other types of analysis software.

ArcGIS has also become a comprehensive platform for managing imagery and raster format data and making the wealth of information contained in that data format more immediately and widely accessible. Users can interact with imagery directly, through dynamic services, or through static (cached) services. These capabilities are especially valuable for natural resources applications. Historically, imagery has played an important role in environmental studies owing to the scale and frequency at which it is collected.

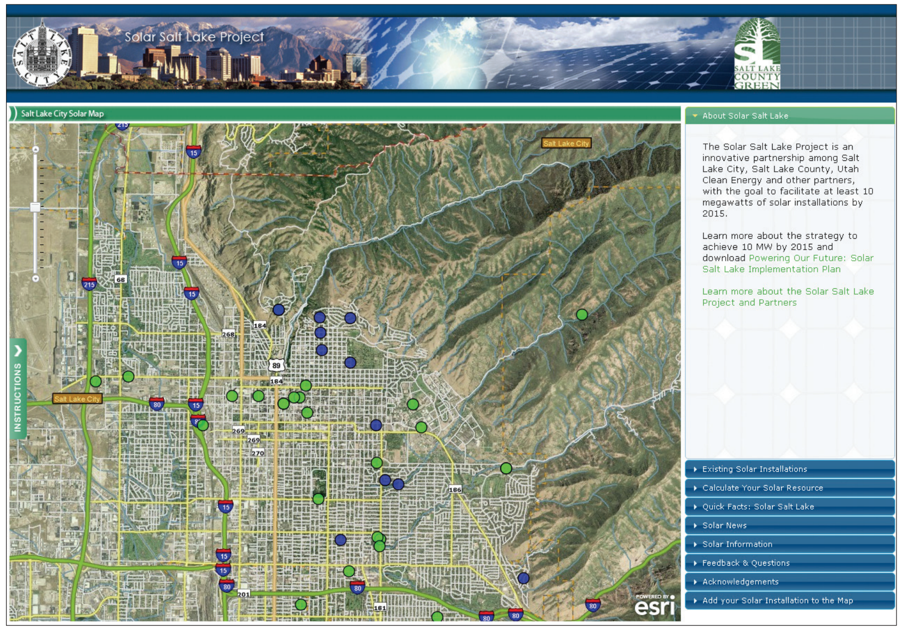
Hundreds of geoprocessing tools are available in ArcGIS for integrating, analyzing, and managing expansive datasets of all types. Custom geoprocessing tools can also be created using the popular scripting language Python. Geoprocessing tools are available on the desktop or can be accessed through web clients as services that run on ArcGIS for Server.

ModelBuilder, a graphic modeling framework for designing and implementing geoprocessing models that incorporate tools, scripts, and data, can automate workflows that would be prohibitively time-consuming to execute manually. Models also make processes repeatable and documented.

Intelligent web maps incorporate the results of data integration and analysis and are an efficient mechanism for sharing information. Using ArcGIS Online, Esri's cloud-based, collaborative content management system for maps, apps, data, and other services, information in maps and apps can be made available to a group of collaborators or the public. ArcGIS Online makes thousands of maps, including topographic, imagery, terrain, street, and ocean basemaps, available to anyone at no charge. These maps can be viewed and new maps created using an online map viewer or ArcGIS Explorer Online.

The articles in the Focus section of this issue demonstrate how geoprocessing tools, models, maps, and web apps have been applied to better understand the natural environment and the effects of human activities on it and manage and safeguard natural resources.

Regional management of natural resources can be especially challenging because the effects of human activities don't stop neatly at political boundaries. The Regional Water Management Board in Poland and the Slovak Water Management Enterprise in Slovakia built a GIS that provides a common database and platform for managing surface and groundwater in a 2,600-square-mile transboundary area shared by both countries. This ambitious system furnishes tools and data to



↑ The Solar Salt Lake Project, a joint effort of Salt Lake City, Salt Lake County, Utah Clean Energy, and other partners, has developed this interactive mapping app for assessing solar potential of sites to help reach the goal of producing at least 10 megawatts from solar installations by 2015.

three classes of users: government entities in both countries that make water policy; institutions, local governments, and other major water users; and businesses, other nongovernmental groups, and the public.

Although solar and other renewable methods of energy generation are desirable, their implementation can have adverse effects on plant and animal life. Improvements in GIS tools and the availability of spatial data on a regional scale enabled scientists at the Argonne National Laboratory to assess the impacts of commercial utility-scale solar energy development on Bureau of Land Management-administered land in six southwestern states covering approximately 677,000 acres. Employing ModelBuilder and custom Python scripts, 1,000 habitat models were processed without additional user input. If these analyses were run manually, processing just 425 of these raster models would have taken 32 man-hours, but using a script, it was accomplished in just 15 minutes on a typical Windows machine.

In some cases, the challenge is not the scope of a project but the need to convince individuals to modify their activities. By analyzing existing datasets collected by various state and federal agencies in the United States, researchers were able to identify areas in South Carolina where farmers' agricultural practices were causing watershed degradation. Based on these analyses, Research Planning, Inc., working under a grant from the South Carolina Department of Health and Environmental Control, conducted outreach programs that resulted in remediation of slightly less than 2,000 acres of watershed.

In each instance, GIS has enabled greater understanding of natural systems by abstracting aspects of the world into knowledge objects—data, imagery, models, and maps—that form a systematic framework for a collective understanding that is the basis for intelligent action. This is the understanding necessary to more wisely use natural resources and protect the earth systems on which the well-being of seven billion people depend.

Improving Landscape-Level Environmental Impact Evaluations

By Leroy J. Walston, Kirk E. LaGory, William Vinikour, Robert Van Lonkhuyzen, and Brian Cantwell of the Argonne National Laboratory

New spatial data and advancements in GIS tools allow much more comprehensive and quantitative analyses of the large datasets required when making programmatic evaluations of the ecological effects of proposed activities that cover a large area or region.

Understanding the environmental impacts of proposed human developments is critical to making appropriate siting decisions and designing mitigation strategies to reduce impacts on important resources. Impact analyses conducted under the National Environmental Policy Act (NEPA) in Environmental Impact Statements (EISs) or Environmental Assessments (EAs) are intended to determine the resource-specific impacts of proposed activities of federal agencies and their alternatives using the best available information.

Impacts to ecological resources are often a primary focus of these analyses. Information used in NEPA analyses include some measure of the known or probable presence of plants and wildlife in the project area, with special emphasis placed on threatened, endangered, and other special-status species.

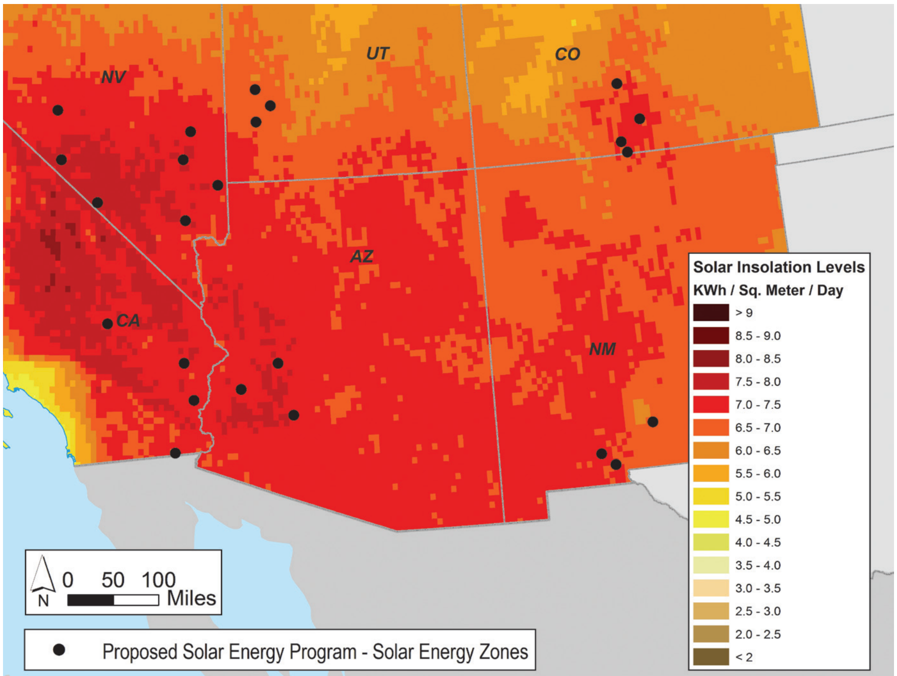
Site-specific information pertaining to ecological resources is usually easier to obtain for small-scale activities such as a local facility, road, or transmission upgrade project, where the ability to conduct fieldwork is more often feasible. However, site-specific data is more difficult—and sometimes impossible—to obtain for proposed activities that could affect a large area or region. These types of analyses often are considered in programmatic NEPA documents, in which a federal agency evaluates the implementation of a broad program or plan.

Under these programmatic evaluations, the exact location and size of developments are often not known. Because obtaining quantitative information for ecological resources at such large spatial scales is difficult, programmatic impact evaluations typically rely on sketchy or partial information such as recorded species occurrences, species ranges, and general habitat descriptions. However, new spatial data and improved GIS tools allow much more comprehensive and quantitative analyses using large, readily available datasets.

Draft Solar PEIS

This article examines a recent programmatic evaluation presented in the Bureau of Land Management's (BLM) and Department of Energy's (DOE) *Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States* (hereafter referred to as Draft Solar PEIS). This Draft Solar PEIS evaluates the implementation of commercial utility-scale (10-megawatt capacity or higher) solar energy developments on BLM-administered lands in the states of Arizona, California, Colorado, Nevada, New Mexico, and Utah. The agencies identified 24 proposed Solar Energy Zones (SEZs) in the six states, comprising approximately 677,000 acres, as areas best suited for utility-scale production of solar energy.

Argonne National Laboratory supported BLM and DOE in conducting impact analyses for ecological resources using publicly



↑ Solar Direct Normal Insolation Levels in the Southwestern United States and the 24 Proposed Solar Energy Zones (SEZs) Analyzed in the Draft Solar PEIS. The Solar Insolation Values are indicative of resource potential for utility-scale solar energy projects. Solar Insolation Data Source: National Renewable Energy Laboratory (www.nrel.gov/solar).

available spatial data, ArcGIS for Desktop tools, and custom Python scripts developed to conduct quantitative spatial analyses of impacts on ecological resources. *[Argonne is managed for the US Department of Energy by UChicago Argonne, LLC.]*

Given the large geographic scale of the proposed solar program, it was not feasible to conduct site-specific field surveys for all ecological resources present in and around each SEZ. To facilitate the impact analysis in the Draft Solar PEIS, the authors developed a systematic approach that relied on geospatial data collected and maintained by state and federal natural resource agencies. Rasterized regional land-cover data and species distribution models developed from state and regional gap analysis programs (GAP) were the primary geospatial data used in the ecological impact evaluation.

Data Sources

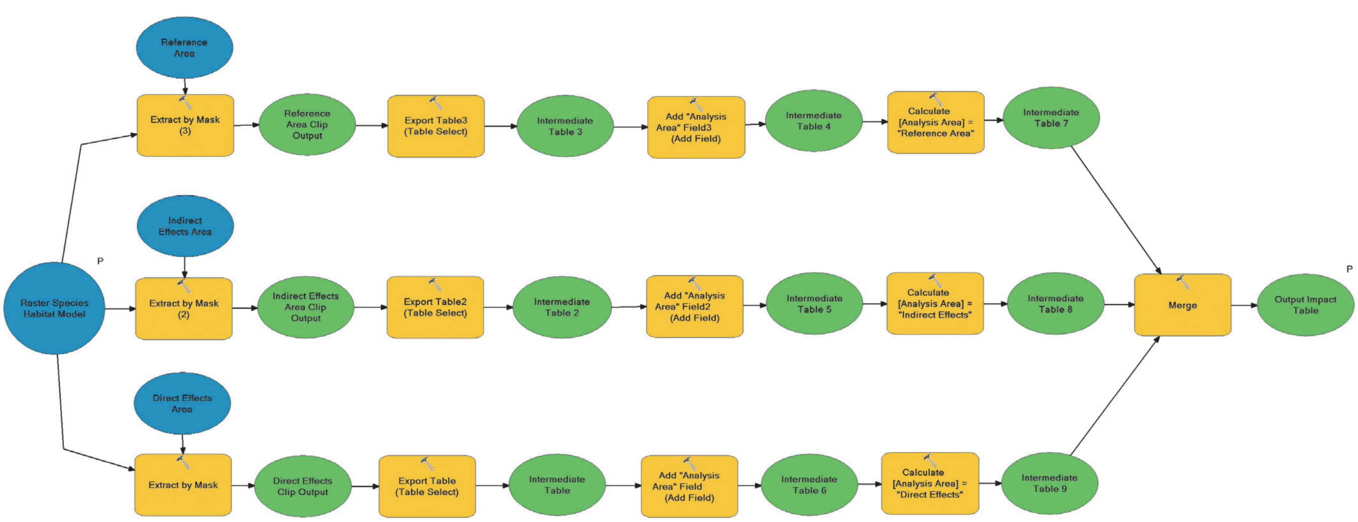
Regional land-cover data for Arizona, California, Colorado, Nevada, New Mexico, and Utah in Esri Grid format came from the USGS Gap Analysis Program, (gapanalysis.usgs.gov/data/land-cover-data/). Land cover was represented by 30-meter cells that described vegetation communities interpreted from remote sensing. For plants and some animal species that lacked individual habitat models, associated land-cover types were extracted and used as proxies for suitable habitat.

Potentially suitable habitat for animal species in California came from the California Gap Analysis Project (www.biogeog.ucsb.edu/projects/gap/gap_rep.html). Four hundred and fifty-five wildlife species have been modeled in the California Gap Analysis Project. California habitat suitability models had a 90-meter cell resolution and were in Esri Grid format.

A raster image of potentially suitable habitat for southwestern animal species (except for California species) was obtained from the Southwest Regional Gap Analysis Project (SWReGAP) (fws-nmcfwru.nmsu.edu/swregap/HabitatModels/default.htm), which has created habitat suitability models for more than 800 animal species. SWReGAP habitat suitability models had a 240-meter cell resolution.

Assessing Ecological Impacts

GAP habitat suitability models for more than 1,000 species of plants and animals →



↑ ModelBuilder diagram illustrating the conceptual workflow process for quantifying the intersection of rasterized habitat models in each analysis area

```
#Abstract: clip all raster datasets in a specified folder to
a specified polygon mask

#Import the module (s)
import arcgisscripting, arcpy, sys, string, os

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


gp.OverWriteOutput = 1
arcpy.OverWriteOutput = 1
gp.CheckOutExtension ("Spatial")

#Set the input workspace
gp.workspace = "I:\\Data\\InRaster"

#Set the output workspace and suffix
out = "I:\\Data\\OutRaster"

#Identify the mask shapefile (polygon)
mask = "I:\\Data\\PolyMask.shp"

#Loop the extract by mask geoprocess to clip all rasters in a
single folder
#Rename the output rasters

-try:
    #List rasters and reset the enumeration to make sure the
    first object is returned
    rasters = gp.ListRasters ("*")
    rasters.reset ( )
    raster = rasters.next ( )


-   while raster:
        Print ("Clipping Raster: "+ raster) #print the
        progress
        InRaster = raster
        InMask = mask
        suffix = "DE" # "DE" for Direct Effects, "IE" for
        indirect effects area
        FileType = InRaster [-4:] #output raster file type
        Print FileType
        OutRaster1 = InRaster.replace ('-',' ')
        OutRaster2 = out + "\\" + OutRaster1 [0:-4] + suffix
        + FileType
        #Extract by mask procedure
        gp.ExtractByMask (InRaster, InMask, OutRaster2)
        raster = rasters.next ( ) #set 'raster' to the next
        raster dataset name

-except:
    #If an error occurred, print the messages
    print "Error: Check Code"
    print gp.GetMessages ( )

print "Rasters clipped successfully"
```

↑ An excerpt of the Python script, written for conducting spatial analysis by looping through all raster species, predicted suitable habitat models for each analysis area.

in all 24 SEZs were evaluated in the Draft Solar PEIS. Ecological impact analyses were not discretely limited to the SEZ footprints. Rather, ecological impacts were assumed to occur as direct or indirect effects. Direct effects could result from surface disturbances associated with ground clearing, vegetation removal, and habitat loss within the SEZ. Indirect effects might extend beyond the SEZ boundary and be the result of factors such as runoff, water depletion, dust deposition, noise, degradation of water quality, and visual impacts. Indirect impacts were deemed possible within five miles of the SEZ boundary. For these reasons, the ecological impact analysis included three analysis areas—the area of direct effects, the area of indirect effects, and the reference area—that were either created or processed in ArcGIS 10.

An area of direct effects is located within the boundary of each of the SEZs and included any assumed access roads needed to serve development within the SEZ. An area of indirect effects was an area within five miles of the SEZ where ground-disturbing activities would not occur but the impacts from surface runoff, dust, and other factors from project activities could occur. The reference area, used to determine regional habitat availability, encompasses an area within a 50-mile radius from the center of the SEZ.

Quantifying the amount of potentially suitable habitat in these three analysis areas allowed a better understanding of the possible impacts in a landscape context. Direct and indirect impacts were evaluated relative to the amount of habitat available in the reference area.

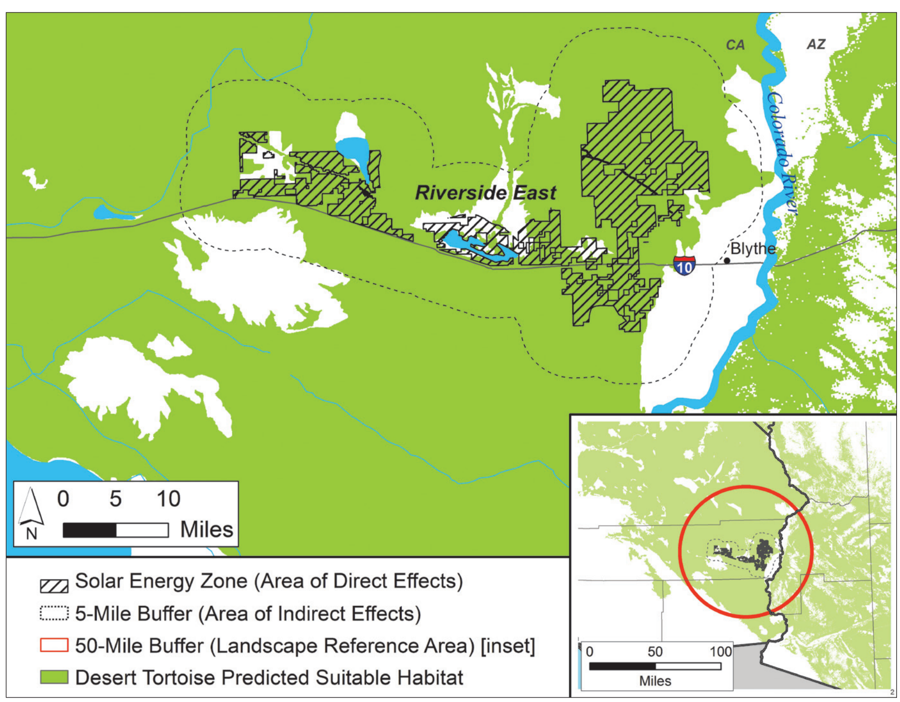
The analysis of habitat models for each area began with with the extraction of the habitat model cells that intersected that analysis area using the Extract By Mask tool in the Spatial Analyst extension toolset in ArcGIS 10. Next, an output table summarizing the number of intersecting cells was created. A text field was added to the table and populated to distinguish the results of each geoprocess operation when the tables were merged. Finally, all individual output tables were merged into one database (.dbf) table.

Saving Time and Money

However, one significant challenge remained: the individual geoprocessing tasks required for each habitat suitability model for each analysis area were time-consuming and prohibitively expensive. Processing time for geoprocessing operations can be reduced using ModelBuilder in ArcGIS *[a framework with graphic interface for automating geoprocessing tasks]* in batch mode. However, this approach lacks the computational advantage of using looped procedures.

To rectify this situation and facilitate iterations of these geoprocessing operations, a Python script was developed to loop through all habitat models. First, all rasterized habitat models were stored in a common directory. The script looped through all models in the directory, extracting intersecting cells within each analysis area and outputting a summary table merged across all habitat models.

The Python script employed the arcpy.mapping and arcgisscripting modules and used the Spatial Analyst extension via gp.CheckOutExtension ("Spatial"). Although the approach was similar to that used in ModelBuilder, the main difference was that, by identifying dynamic variables and using Python script through ArcToolbox, the necessary geoprocesses were looped through the entire directory,



↑ A proposed SEZ in Southern California illustrating habitat distribution models for the desert tortoise that was generated from gap analysis programs. Also shown: the area of direct effects, area of indirect effects, the landscape reference, and the three analysis areas used in the ecological impact evaluation.

which contained more than 1,000 habitat models, analyzing at once without additional user input, resulting in significant time savings. Running the script through a folder containing 425 raster habitat models was completed in approximately 15 minutes on a computer using a Windows 7 operating system with an Intel i7 2.93 GHz processor and 8 GB of RAM. These same geoprocesses and table edits would have taken more than 32 man-hours to complete manually. The script also reduces the risk of human error.

The resultant merged output table summarized areas of potentially suitable habitat intersected by the analysis areas. It was then used to make impact evaluations for each species. These evaluations were based on the amount of potentially suitable habitat in the areas of direct and indirect effects relative to the amount of habitat available in the landscape (i.e., reference area).

↑ Desert tortoise (Photo courtesy of Bureau of Land Management/California)

Conclusion

The availability of large-scale regional data such as GAP land-cover models or species habitat suitability models, combined with more robust spatial analysis procedures available through ArcGIS for Desktop software, allowed the analysis of multiple datasets at large spatial scales.

This enabled researchers to surpass previous qualitative evaluations by developing a more accurate and quantitative approach for determining the environmental impacts of human activities at larger spatial scales. These approaches, combined with the utility of ModelBuilder and operability of Python scripts in ArcGIS, allow a more timely and cost-effective synthesis of available spatial data for programmatic evaluations and add a quantitative basis to environmental decision making.

For more information, contact Leroy J. Walston at lwalston@anl.gov or 630-252-3270.

About the Authors

Leroy J. Walston (main author) is an assistant ecologist at Argonne National Laboratory with more than 10 years of experience in working with GIS applications to ecological systems. His work includes spatial approaches to evaluations of energy development impacts to aquatic and terrestrial ecosystems, communities, and sensitive species. He holds a master's degree in biology from Eastern Illinois University with special emphasis on landscape ecology.

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Brian Cantwell is a senior GIS programmer/analyst at Argonne National Laboratory with 28 years of experience in cartography and GIS. His work includes geospatial data management and analysis, development of land-use alternatives, and dissemination of data in support of major programmatic environmental impact statements. He holds a bachelor's degree in forestry from Southern Illinois University.

Turning Analysis into Action

Targeting likely sources of watershed impairment

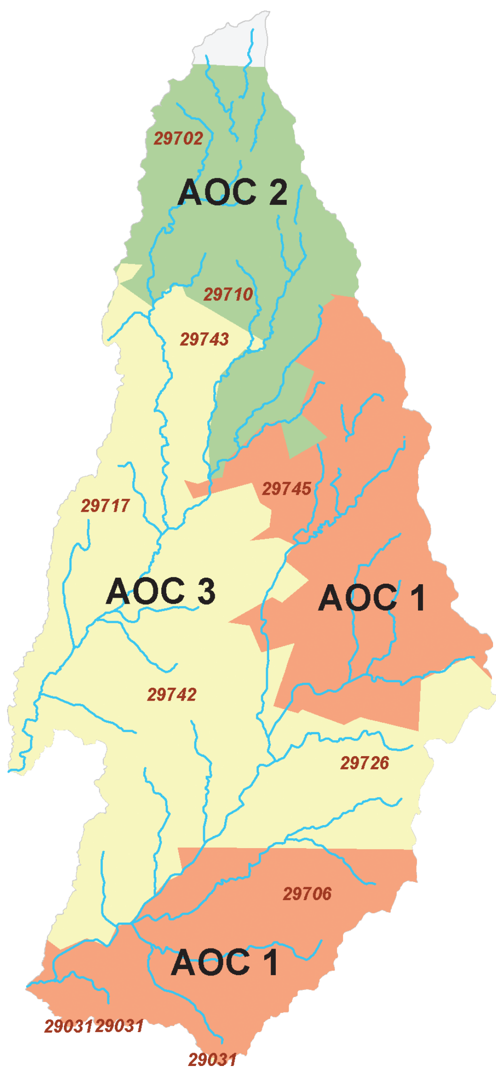
By Katy R. Beckham, Christine Boring, and Mark White, Research Planning, Inc.

A science-technology consulting firm in South Carolina used spatial analysis to identify landowners whose land-use practices might be contributing to the impairment of water bodies in the Catawba River Basin. Once these landowners were identified, an outreach program would encourage participation in a cost share program that helps install environmentally sound wells, waterlines, creek exclusion fencing, and other facilities.

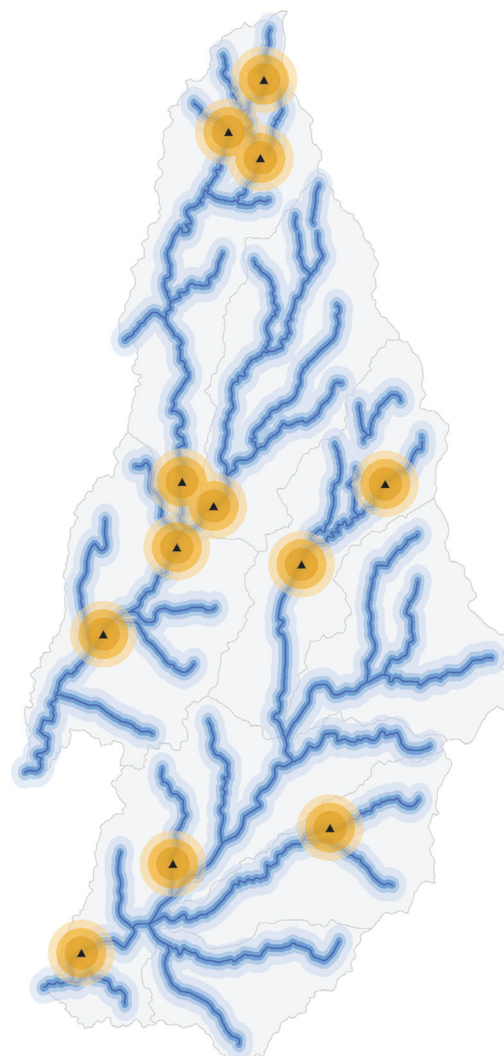
Protecting Water Quality

The South Carolina Department of Health and Environmental Control (SCDHEC) Bureau of Water, Division of Water Quality, in consultation with the US Environmental Protection Agency (EPA), administers grants for Nonpoint Source (NPS) Control Projects on impaired water bodies in South Carolina. Water bodies that do not meet water quality standards pursuant to section 303(d) of the Federal Clean Water Act are considered impaired.

EPA provides monies for these projects to SCDHEC under the Clean Water Act, section 319(h). Goals of the SCDHEC 319 program



↑ Areas of concern defined by ZIP Code



↑ Water quality monitoring station and hydro buffers include reducing nonpoint source contributions to South Carolina's watersheds and implementing Total Maximum Daily Loads (TMDLs). Most TMDL implementation projects in South Carolina focus on implementing best management practices on livestock farms and mitigating failing septic systems. *[Nonpoint sources are sources of pollution that lack a single point of origin or specific outlet to a stream and are generally carried off the land by storm water. According to the EPA, a TMDL "is the amount of a single pollutant (such as bacteria, nutrients, metals) that can enter a waterbody on a daily basis and still meet water quality standards set forth by the State."]*

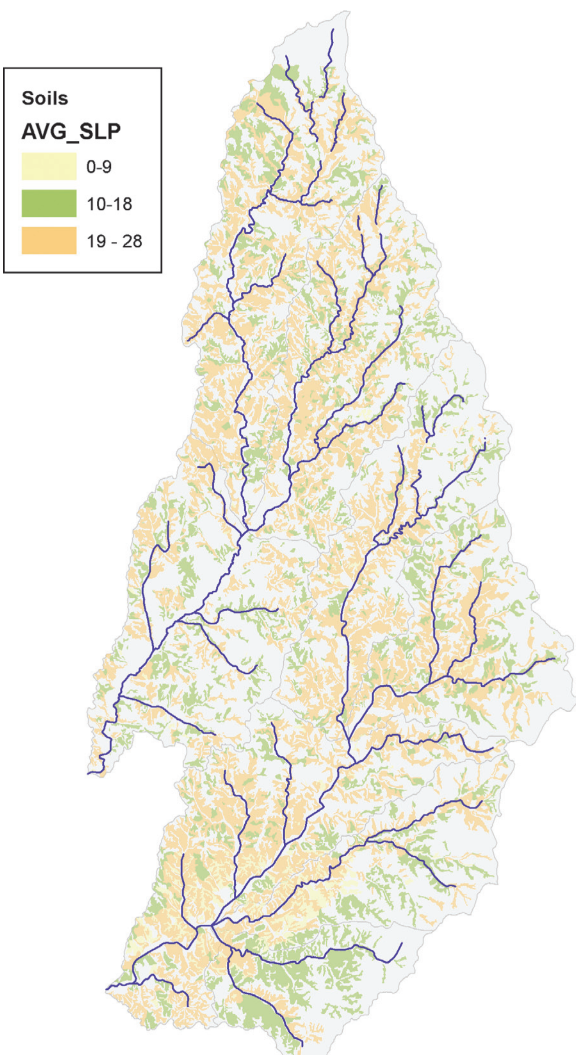
Targeted Approach to Watershed Health

SCDHEC awarded a grant to Research Planning, Inc. (RPI), to implement a TMDL for fecal coliform bacteria in the Bullock and Turkey Creek Watersheds in the Catawba River Basin. RPI's responsibilities under this grant included identifying landowners (farmers and septic system owners) whose current land-use practices may be contributing to impairment of the water bodies; implementing environmentally sound watering structures, wells, waterlines, creek exclusion fencing, and other BMPs on agricultural lands; and repairing failing septic systems.

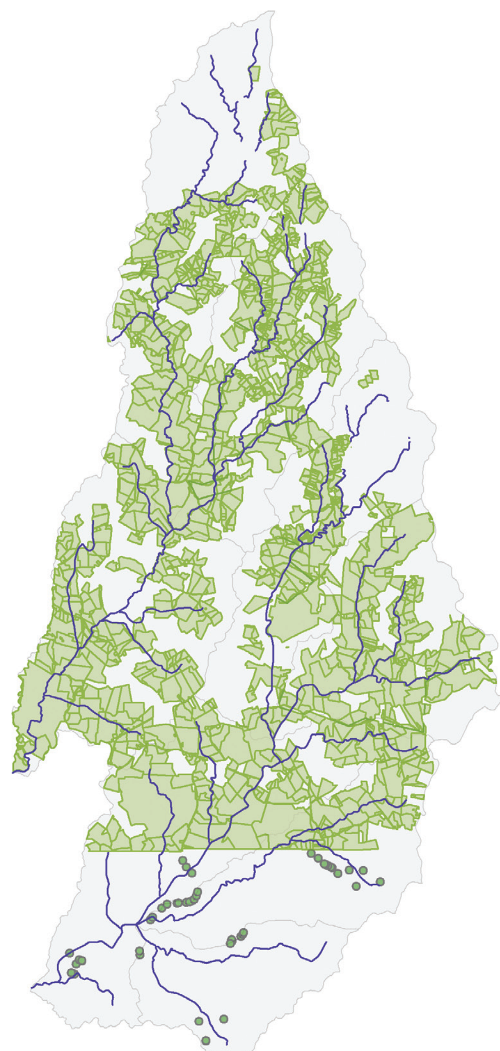
RPI would also perform community outreach to solicit additional participation either through grant monies, other federal programs, or on a volunteer basis to improve farm practices in the local watershed and beyond. SCDHEC requires detailed quarterly updates from all grantees to assess progress on the projects they manage as part of the 319 program.

Under past grants that SCDHEC had awarded to RPI, any improvement in watershed health was considered a success. However, during a kickoff meeting for the Turkey/Bullock Creek project, SCDHEC suggested that a more targeted approach for identifying potential participants (e.g., farmers) was the most attractive path forward.

Past efforts for identifying participant landowners were focused on community meetings and word of mouth. Restoring the full use of a water body is the goal of both the SCDHEC and EPA. Therefore, targeting improvements on lands most likely to impact water quality upstream of the sampling stations was desirable.



↑ Slope analysis



↑ Hot spot parcels to target for participation in the cost-share program

As an initial phase in the project and in an attempt to satisfy the need for a targeted approach, RPI suggested geospatial analysis as a method for identifying those agricultural lands that had the most impact on water quality within the watershed. The goal was to solicit participation in the 319 program by landowners whose lands greatly impact the area's hydrology. The 319 program offers two types of cost-share programs: programs for capital improvement for livestock producers that promote conservation and programs that help repair failing septic systems. Although RPI's analysis was twofold, this article focuses on programs for livestock producers.

Once a landowner is part of the program, monies are set aside to pay a percentage of the cost for implementing environmentally sound farm improvements that positively impact water quality in the watershed.

↑ Cattle standing in stream before the cost-share program was implemented

RPI initially reviewed previous studies of watershed impairment. Based on this review, RPI made a list of GIS layers that could be useful in this analysis and identified how they could be obtained. Hot spots of concern would be identified and used to focus cost-share efforts. These areas of concern (AOCs) were identified by creating a buffer and performing slope and parcel size analyses.

Establishing Areas of Concern

The AOCs were selected based on beef cattle production reported in the United States Department of Agriculture (USDA) 2002 Census of Agriculture, the most recent dataset available at the time of the analysis. This flat file, available at no charge, contains data on the number of beef farms, number of cattle, and other farm statistics. A spatial component was created based on ZIP Code data in the file. To obtain current estimates of beef cattle per ZIP Code within the study area, census data was joined to Esri's ZIP Code shapefile. Using the number of beef cattle, RPI ranked ZIP Codes within the watershed, with AOC 1 being an area with the highest number of beef cattle—areas that would show the most impact within the study area.

Buffers were created around both hydrological features and water quality monitoring stations (WQMS). Hydrological datasets obtained from Esri as part of the standard ArcGIS data package included streams of third order and higher. Hydrological datasets from local and state governments and other sources were considered, but they included smaller order streams that covered too much area, negating the desired targeted approach. Also, some of these datasets contained ephemeral and intermittent water bodies. A trial-and-error approach was used to determine the buffer sizes that best fit the analysis. Buffer sizes chosen for the analysis (given in miles) were 0.125, 0.25, and 0.50.

WQMS data, obtained from the SCDHEC website at no charge, included only point features. Larger buffers were created for these points than for the hydrological features. Buffers chosen were 0.50, 0.75, and 1 mile.

Slope Analysis

The slope analysis was conducted on a merged soils dataset for the study area. This dataset was created from datasets obtained at no cost from the South Carolina Department of Natural Resources (SCDNR). To capture the entire study area, these datasets were merged together from multiple quadrangles and clipped to the study area. The dataset contained not only soils information but also slope data for each soil type. To highlight areas where runoff was more likely to occur, only areas with significant slope were needed for analysis. This was determined by calculating an average of the slopes in the area. Any slope number greater than that average was considered significant for purposes of this analysis.

Parcel Size Analysis

The parcel size analysis was conducted to select larger parcels that were more likely to be used for agricultural purposes. This was but one method in a multilayered analysis designed to identify tracts of land that could be impacting the watershed's hydrology. This analysis used a parcel dataset acquired from York County's GIS department and made available for free to government agencies. Also obtained from the same source were land-use and subdivision data.

The parcel dataset contained the owner name, owner address, parcel address, parcel size, and other attributes. The future land-use dataset was used in conjunction with the parcel size dataset because it is constantly being updated by the county government's GIS department to reflect zoning changes, as land use in this particular county trends toward nonagricultural functions. A dataset containing subdivisions was also used in the analysis.

Initially, parcel selections were made to remove subdivisions and nonagricultural parcels. Parcels having a centroid in a subdivision were removed to eliminate "minifarms" or houses with more acreage than typical for a subdivision. Using the Select By Location command in the subdivision and parcel datasets, analysts selected features that were exported to a new shapefile.

The future land-use dataset was queried to retrieve agricultural land-use parcels and exported to a new layer. This new parcel dataset, excluding subdivisions, was used to clip the new agricultural shapefile to yield only agricultural parcels and create a dataset showing parcels currently in agricultural land use that are not in subdivisions.

To ensure that analysis was limited to areas with potential large farm operations that are most likely to impact water quality, RPI determined (based on its experience working with these types of cost-share programs) that a large parcel is one of 250 acres or more.

Hot Spot Selection

After all analyses were complete, the final datasets were layered to determine where the study hot spots were located. The hot spot analysis was designed to return only the areas in highest demand for cost-share participation with theoretically the most impact to the watershed.

Hot spot parcels were those that met at least one of the following criteria:

Parcels located within the hydrological features (0.5 mile) and/or water quality monitoring stations buffers (1 mile)

or

Parcels containing soils with a slope greater than 10 percent (i.e., greater than average in this area)

or

Parcels located in at least one buffer (either hydrological features or water quality monitoring stations) with a parcel size greater than 250 acres

All selections were exported to new shapefiles that were merged, dissolved by tax map ID number (to eliminate duplication of parcels that met more than one of the criteria), and attributed to reflect all the conditions. The parcel attribute information was joined back to the final parcel shapefiles to add information for soliciting participation in the program.

↑ Cattle excluded from the water body through funding from the program

Results of Outreach

Direct mailings were made to landowners in hot spot areas identified using the parcel attribute information. Large wall maps were made showing hot spot areas and taken to local cattlemen meetings where farmers from the study area would be in attendance. Using this analysis, farms in hot spots were actively pursued. As of this writing, RPI has worked with nine agricultural landowners in the watershed to help remediate slightly less than 2,000 acres by installing approximately 12,000 feet of waterline, more than 20,000 feet of fencing, and seven wells. For more information, contact Katy R. Beckham at kbeckham@researchplanning.com.

About the Authors

Katy R. Beckham is a GIS analyst and biologist for Research Planning, Inc. She focuses on GIS mapping for oil spill response, water quality improvement/watershed management, and other ecological projects. Beckham holds a bachelor's degree in aquaculture, fisheries, and wildlife biology and a master's degree in forestry and natural resources, both from Clemson University in Clemson, South Carolina.

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Mark White is the GIS manager and senior analyst for Research Planning, Inc. He focuses on project and personnel management for natural resource mapping projects, emergency response data management, and damage assessment. White specializes in geospatial analysis, database design and management, remote sensing, and new project development. He holds a bachelor's degree in geography from the University of South Carolina in Columbia, and a GIS professional (GISP) certification from the GIS Certification Institute (GISCI).

Resources

United States Department of Agriculture (USDA) Census of Agriculture dataset
www.agcensus.usda.gov

SCDHEC Water Quality Monitoring Stations data
www.scdhec.gov/environment/water/surface.htm

South Carolina Department of Natural Resources soils data
www.dnr.sc.gov/gis.html

Making a Big SPLASH in Transboundary Water Resources Management

By Rafał Kokoszka, the Regional Water Management Board in Krakow, and Emil Żyszkowski, GISPartner

↑ The PLUSK project is located along the border of Poland and Slovakia. Seventy percent of the project area is located in the Vistula River basin, and the remaining 30 percent is in the Danube River basin.

As pressures on the natural environment from urbanization and economic development increase, we must take responsibility for earth's resources. Because globalization is pervasive and affects almost all aspects of our lives, the effects of our actions are not limited to one country. However, taking effective and coordinated action in transboundary areas that cover more than one country is even more complicated.

In recent years, water resources have become the subject of special concern by citizens and local governments. These concerns have been reflected in European Union (EU) directives. The natural level of geography for monitoring and protecting water resources is the river catchment. *[A river catchment is all the land drained by a single river and its tributaries.]* EU directives require water resources protection and management at this level.

To this end, Poland and Slovakia built a GIS named PLUSK (or SPLASH) that is designed to serve as a common platform for information exchange, analysis, and surface water and groundwater resources management. The project name comes from combining the international country name abbreviations for Poland (PL) and Slovakia (SK).

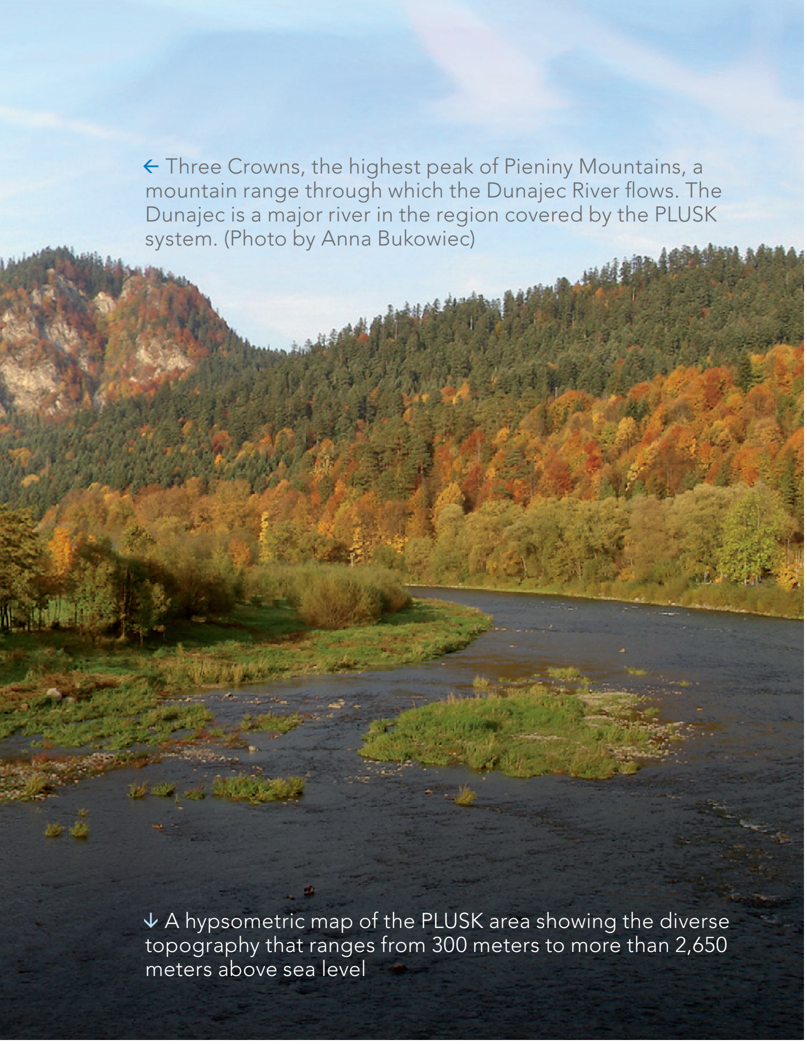
The system covers part of the Dunajec, Poprad, and Orawa river basins, an area of more than 6,700 square kilometers (km^2), or about 2,600 square miles, located in a transboundary area between Poland and Slovakia.

The Regional Water Management Board (RZGW) in Krakow, Poland, along with Slovak Water Management Enterprise, State Enterprise (SVP), in Banska Štiavnica, Slovakia, have implemented a project titled Evaluation of Information System PLUSK for Common, Polish-Slovak Border Waters, for the Purpose of Water Framework Directive and Floods Directive Implementation. This project was cofinanced by EU under the Cross-border Cooperation Program, Poland-Slovak Republic 2007–2013.

Serving Poland and Slovakia

The PLUSK system serves users in both countries. Three groups of users are recognized and have varying levels of access to PLUSK data and tools:

- Government units responsible for conducting water policy (who are the most advanced-level users)
- Institutions, local government units, and major water users (who are intermediate-level users)
- Nongovernmental organizations, people in business with water issues, and of course the public (the basic-level users)



← Three Crowns, the highest peak of Pieniny Mountains, a mountain range through which the Dunajec River flows. The Dunajec is a major river in the region covered by the PLUSK system. (Photo by Anna Bukowiec)

The goals for the system could not be accomplished unless a common database was created for the whole area. This required gathering specific information and harmonizing both the spatial and attribute aspects of the data.

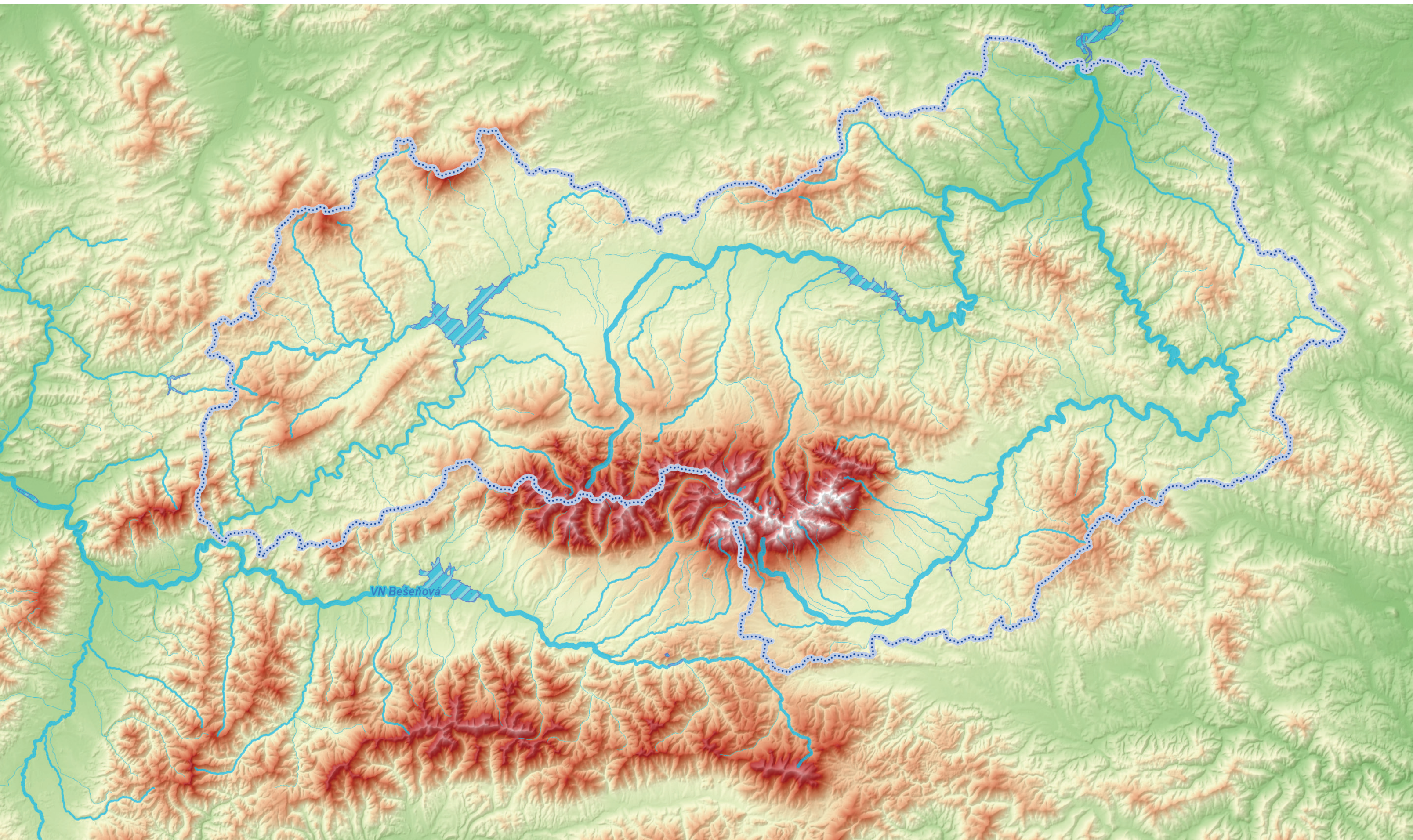
One of the most important goals of PLUSK was implementing tools for elaborating quantitative and qualitative water management balance. These tools support implementing a River Basin Management Plan and help shape water use according to sustainable development rules. These rules will help mitigate the adverse use of ground and surface water.

PLUSK is designed to enhance the process of issuing water use permits by improving coordination and cooperation between Polish and Slovak agencies. A pilot program is planned for implementing the procedures required for coordinating the administrative actions related to issuing water use permits.

Each water use application is subjected to a two-phase analysis, conducted using system tools, that evaluates the impact of a new water use on water resources. Users access the system via a web map application. The portal publishes data as a map composition containing editing mechanisms for points of water removal or sewage discharge and tools for balancing water resources. The results of analysis are visualized on maps in a web app.

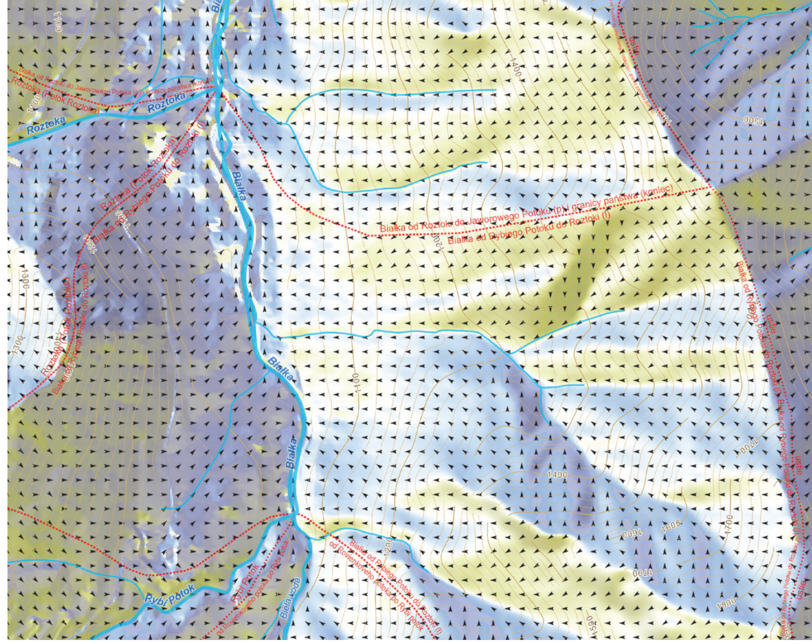
PLUSK System

Building such a complex and specialized GIS involved specialists from different fields: water management and water resources balance experts, GIS specialists, database architects, analysts, and IT architects. The system was implemented by a consortium



↓ A hypsometric map of the PLUSK area showing the diverse topography that ranges from 300 meters to more than 2,650 meters above sea level

↑ Land-use information is important in supporting analysis of water resources. Data from European Environment Agency (EEA)–CORINE Land Cover (CLC) was used.



↑ The catchment area is the perfect level of reference data. Here the surface aspect is marked with the flow directions for surface water.

of GISPartner, Pectore-Eco, Innovation Technology Group, and Centrum Informatyki ZETO between November 2010 and September 2011. RZGW and SVP provided substantial support for this effort.

The result was a system built using the most modern solutions and software provided by Esri and GISPartner. It was composed of an Oracle/SDE database, ArcGIS for Desktop applications, and a web map portal created with ArcGIS for Server.

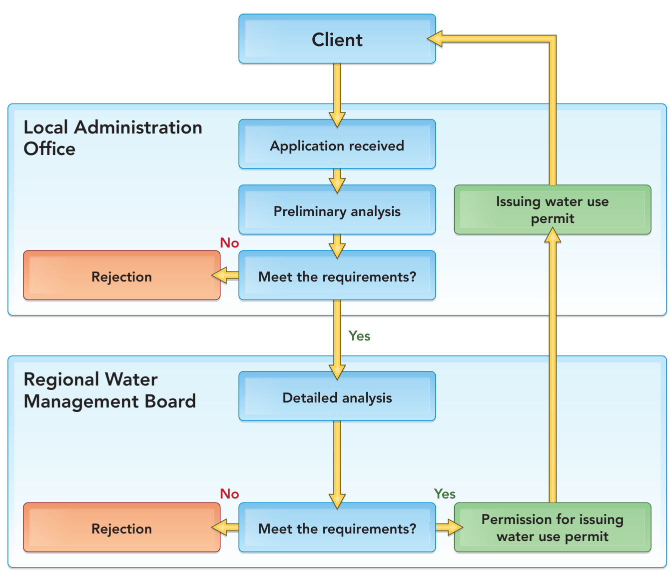
The PLUSK database, based on Oracle Standard Edition 11*g*, is the repository for reference data such as scanned topographic maps; orthophotos; administrative division layers; and key water management data such as hydrographic network, catchment division, quantitative and qualitative monitoring networks, localization of water removal and sewage discharge points, digital terrain models, and land use. All data required for conducting balance analysis is contained in this database. Spatial and attribute data from both countries has been harmonized into a coherent database that covers the whole area. Most operations related to populating the database, data update, verification, and harmonization were conducted in ArcGIS 10 for Desktop. Some data can also be updated using web app tools.

The PLUSK web map portal, a central component of the system, is based on a web mapping app called iMap 4.0 that was designed by GISPartner. The portal is displayed in two languages—Polish and Slovak—and provides access to data gathered in the system database.

The portal is divided into thematic modules. Each module is represented by a specific map that presents data for the chosen subject and a set of tools and actions for searching for and analyzing data along with creating reports. There are also editing tools specific to each module for editing attribute data for points of water removal and sewage discharge. The data and tools made available by the application are based on the user's authorization level. Water resources balance, surface waters, groundwaters, protected areas, catchment morphometry, and soils are the main PLUSK modules. The server portion of the portal, especially map and geoprocessing tools publishing, is based on ArcGIS 10 for Server Enterprise Advanced.

The key component of PLUSK is a set of functions for conducting the calculations and simulations needed for water resources balancing. These tools, in the form of geoprocessing services, are launched from iMap. Access to analytic functions is restricted based on membership in an authorized user group. For example, water resources analysts from RZGW have access to all functionality, while local government workers have access only to the resources necessary for preliminary verification of an application for issuing a water use permit.

Analysis results, presented as maps, graphs, and quantities, are accessed using dedicated web app tools. The results of a current balance calculation, based on water users who already have water use permits, are visible to everyone using the portal. The system can also be used to conduct variant analysis, which allows analysis of future water resources demand by changing the values of removals and discharges for existing water users or adding potential new users.



↑ Diagram illustrating successive steps of the administrative procedure proposed for issuing water use permit

Tools for Balancing Water Resources

Balancing water resources makes use of a set of calculations and analytic procedures that cover the quantitative and qualitative comparison of groundwater and surface water resources with needs of current water users (or those applying for permission to use water). Balancing these needs takes into consideration the influence of water structures (i.e., retention reservoirs) and the requirements for protecting the natural environment. It is also the framework for expanding the concept of water resources management. Calculations are made for a specific area, usually a catchment or a portion of a catchment.

In PLUSK, tools for balancing water resources are crucial. This innovative approach is based on the full integration of the model with spatial information. Input data, such as localization of removal/discharge points, hydrographic network, catchment division, and water gauge localization, which are necessary for valid functioning of a model, along with streamflow measurement results, water structures, and localization of balance nodes used in the calculations, are taken and stored in database layers and tables.

Results are published as maps, graphs (i.e., profiles), and numeric values that can be accessed using the Identification tool. Previously, models developed in Poland using a spatial component had not been implemented as fully functioning, closed user applications. PLUSK is the first solution that integrates water resources balancing with a spatial component that has been implemented in the RZGW Krakow area. It is also the first system of this kind in Poland based on an Esri server solution.

This new approach to balancing water resources gives users many options. Water use permit issuance can be linked with model balancing. The system dynamically takes new points of removal/discharge into consideration as soon as a water use permit is issued. The solution for balancing water resources is presented as an interactive map service, which enhances and speeds up the analysis of the impact of a new removal or discharge on water resources. Consequently, water use permits can be issued more rapidly but still be based on reliable data.

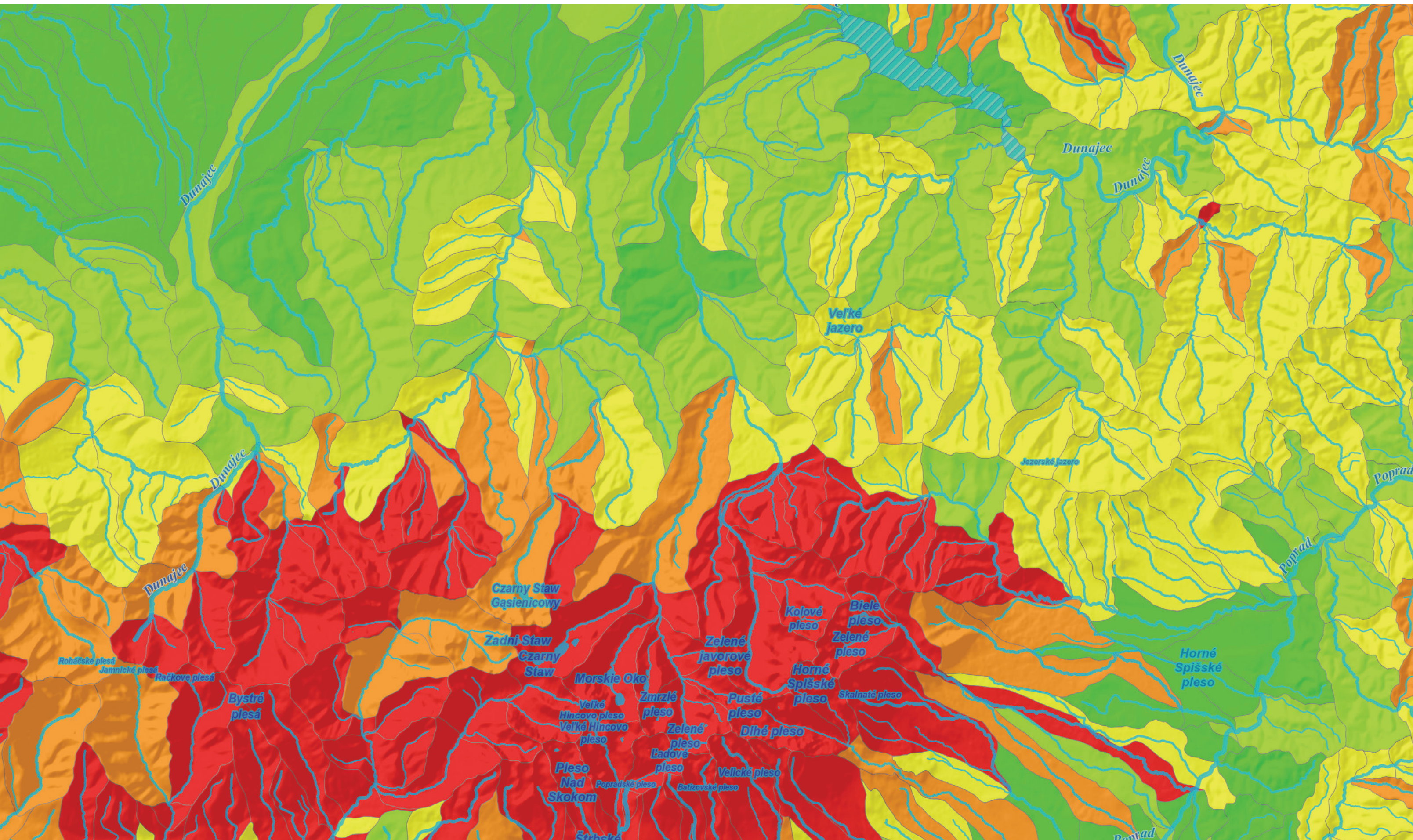
Verifying New Water Users

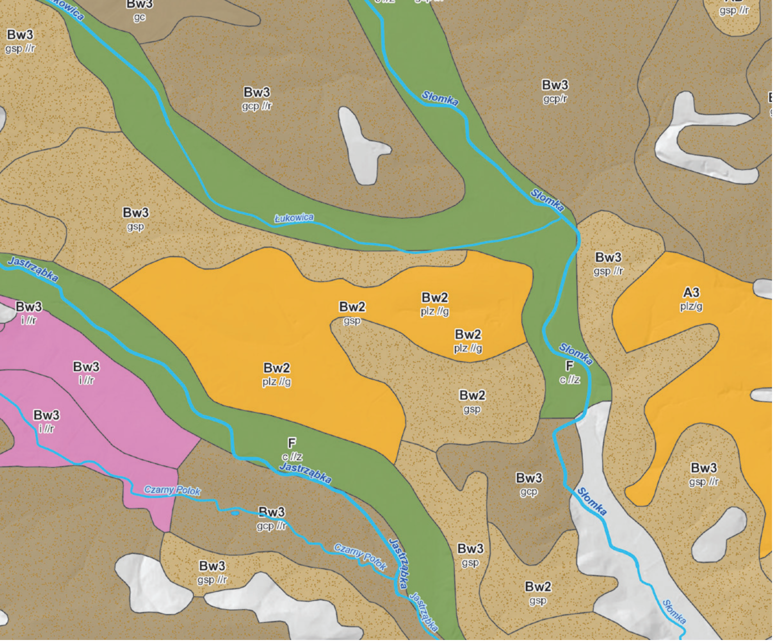
Reliable outcomes can be obtained only by using current data on existing water removals and sewage discharges. It was natural to integrate the process of receiving applications for water use permits with the tools for calculating water resources balance. PLUSK was implemented at several levels and involved different administration units.

Applications are registered in a local administration office and entered by a clerk into the system, including the location of the water removal or sewage discharge point, using a web app. A preliminary evaluation is made of the application using tools for calculating water resources balance. This evaluation identifies only cases in which inferred water removal or sewage discharge goes drastically beyond the available water resources.

The application is sent to specialists in RZGW Krakow for further analysis. The RZGW analyst, using the same tools, makes

↓ This map shows the average slope of fragmentary catchments. The wide range of data gathered in PLUSK allows users to prepare different types of analytic maps.





↑ Because of substantial differences in soil marking methodology between Poland and Slovakia, harmonization of this data was one of the biggest challenges of the project.

another analysis taking two aspects—quantitative and qualitative—into consideration. The quantitative analysis determines the quantity of water used by the applicant.

These results are illustrated on a map showing the returnable water withdrawal in relation to instream flow in a particular river section. Results are also graphed to show the guaranteed returnable water withdrawal with a specific probability of occurrence. This graph is a profile measured parallel to water course sections.

The results of a qualitative balance address loads, absorptivity, and the concentrations of biochemical oxygen demand, nitrogen, and phosphorus and are published as maps showing current concentrations in relation to threshold level and graphs of the hydrochemical profiles of rivers. After approval, the application goes back to the local government office, where a water use permit is issued. The entire process, including paperwork, is carried out in the PLUSK map portal.

Alternative Scenarios Analysis

Besides linking balance analysis to the issuing of water use permits, RZGW analysts conduct situational analysis (what-if scenarios) using the PLUSK system. The system models possible changes in water removal and sewage discharge values for existing users and can model additional hypothetical users so the effects of increased demand can be evaluated. Separate simulations can be conducted simultaneously by several analysts. These simulations have no impact on the current water resources balance.

Conclusion

The PLUSK project was designed to integrate water policy for international river basin districts and created an information exchange system for processing and publishing spatial information about the environment from a common database for the Polish–Slovak transboundary catchments. The system is based on Esri software and GISPartner solutions and is a very innovative approach to balancing demands on water resources. This unique approach was possible thanks to GIS.

The PLUSK implementation on the transboundary area will surely increase the effectiveness of the water resources evaluation process and will provide substantial organizational support for issuing water use permits. The system can be extended in its functionality and in the area administered without requiring modification to the web map application or water resources analysis tools. System expansion will require only adding spatial data to existing datasets.

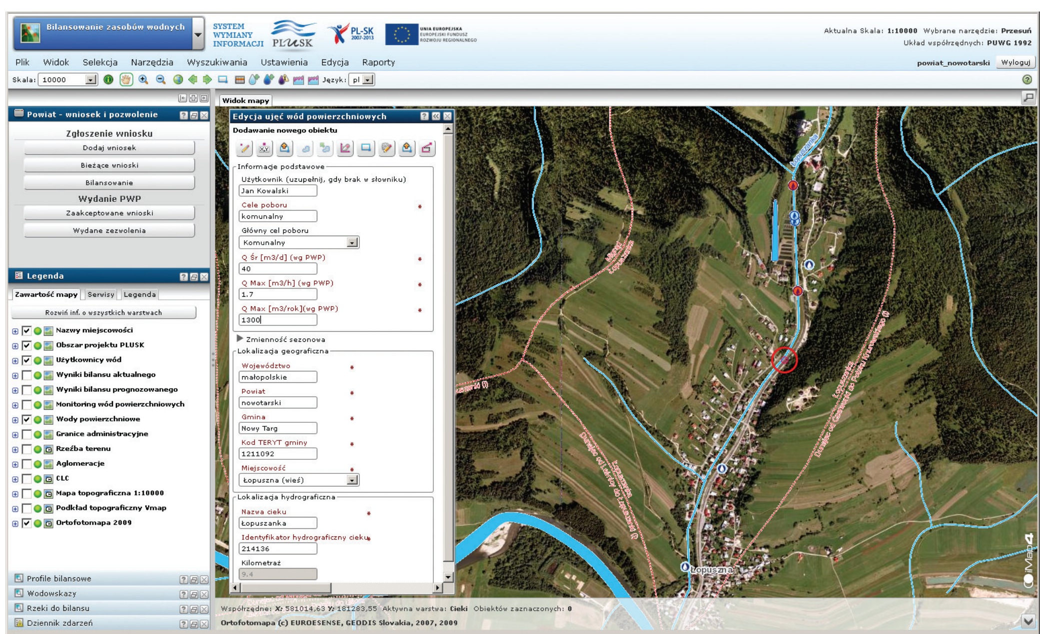
If this pilot program for implementing cooperative procedures between the administration offices in two countries responsible for issuing water use permits and conducting water policy is successful, efforts may be made to extend it to other areas and possibly sanction it in law.

For more information, contact Rafał Kokoszka (rkokoszka@krakow.rzgw.gov.pl) at the Regional Water Management Board (www.krakow.rzgw.gov.pl) or Emil Żyszkowski (ezyszkowski@gispartner.pl) at GISPartner (www.gispartner.pl).

About the Authors

Rafał Kokoszka, PhD, has been an employee of RZGW in Krakow since 2001. He majored in environmental engineering and land surveying at the University of Agriculture in Krakow and received his doctorate in 2008. He uses GIS tools in his work every day.

Emil Żyszkowski is the manager of the GIS department at GISPartner. He obtained a master's degree in physical geography at Wroclaw University in 1995. Since 1994, he has been involved in GIS and has worked for GISPartner since its founding in 2003.



↑ Data for a new water removal or sewage discharge point is processed online via the PLUSK portal.

ArcGIS API for Android App Streamlines Field Inspections

By Jozef Kaslikowski, Tri-County Electric Membership Corporation

An electric cooperative developed an app with ArcGIS API for Android that moved its field equipment inspection process from a paper-based one to a streamlined one using GPS-enabled tablets.

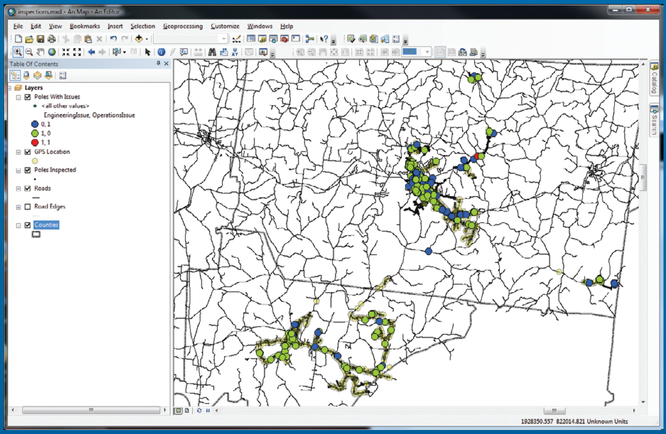
Tri-County Electric Membership Corporation (TCEMC) serves more than 53,000 members in central Tennessee and southern Kentucky. For several years, TCEMC has been moving GIS into more and more areas of the cooperative's operation. One of the last untouched processes was inspections of field equipment.

Everything regarding inspections was being tracked on paper and often in multiple ways, from lists of poles beginning at the substation to the more recent printouts of circuits. The process was inefficient and frustrating to both operations personnel and engineering staff members who had to interpret the field notes. Follow-up trips were often needed to correctly identify facilities with issues. This delayed corrective actions. The large amount of data collected on paper made reporting and tracking impractical.

The paper process had endured for one reason: ease of use. Until recently, mobile devices and software were awkward and cumbersome to use. Training users who might not be familiar with computers was difficult, and equipment was expensive (not to mention problems with battery life and data synchronization). The new iPad and Android tablets were cheaper than laptops and provided a new platform for building easy-to-use solutions that can be operated with two fingers. With ArcGIS API for Android, TCEMC's entire basemap and data on all equipment to be inspected could be placed on an Android tablet and taken into the field. Each tablet has GPS capabilites so it can show the user's current location and a camera that can be used to document problem areas.

ArcGIS for Desktop is used to create a basemap, convert it to a tiled map cache by ArcGIS for Server, and automatically downloaded to each tablet each day along with pending inspection requests. Inspections are overlaid onto the basemap using the touchable graphics in the inspection app. The user simply touches the piece of equipment he would like to inspect, and the appropriate form for recording the inspection is displayed. The inspector's name is logged for each inspection, as well as the last good GPS coordinate, the time the form was submitted, the current known attributes of the equipment, and any issues identified during the inspection. At the end of the day, network connectivity is restored, and the completed inspections are automatically uploaded to the GIS database.

System administration is minimal, because every effort was made to automate tasks. Pending inspections are identified by comparing GIS data to the list of inspections that have been recently completed.



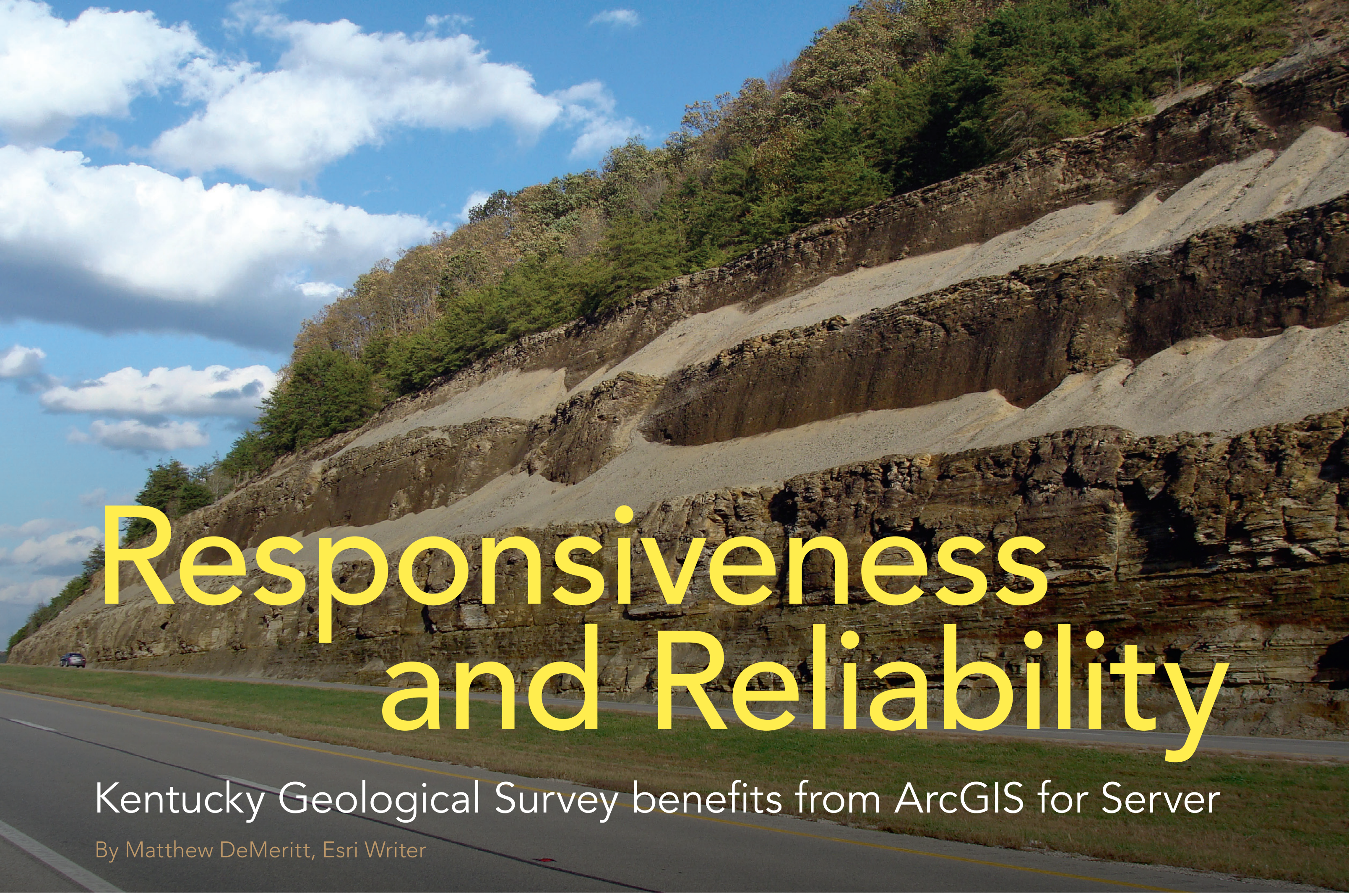
↑ Completed pole inspections with issues identified by department

Identified problems are automatically routed to the appropriate department.

A web-based application was created to manage the resultant corrective actions for the departments as well as incorporating the information into the engineering staking package. Engineering staff can be assigned individual tasks, or tasks can be assigned in bulk based on territories. Operations supervisors can manage their corrective actions based on service areas. Correction tickets can be printed with an included map provided by the same ArcGIS for Server service that the tablets use. Each assignment is tracked, and additional notes can be added at any point. Finally, each department can separately resolve its own issues without affecting the other.

The completed inspections are stored in a Microsoft SQL Server database that is used for reporting and analysis. Since all information is time stamped, the progress of the inspection cycle can be observed using the new query layer and time-aware layer features of ArcGIS 10. By storing the equipment attributes at the time of inspection, changes in equipment between inspection cycles can be tracked.

TCEMC has taken advantage of newly available hardware and Esri APIs to provide an easy-to-use yet powerful inspection tracking system. By building on common consumer-based equipment, TCEMC can choose from among many vendors and different price points. This solution also benefits from custom app deployment and a standard Windows PC development environment.



Responsiveness and Reliability

Kentucky Geological Survey benefits from ArcGIS for Server

By Matthew DeMeritt, Esri Writer

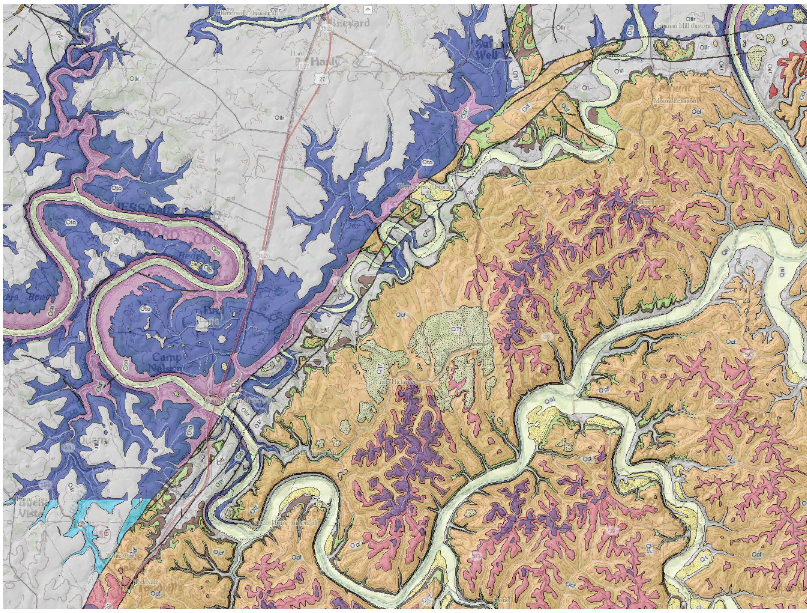
↑ The Devonian Ohio Shale, exposed along Interstate 64 in northeastern Kentucky's Rowan County. This shale is the source of most of the natural gas production across Kentucky. Its high organic matter content, commonly 5 to 10 percent, gives the shale its nickname, black shale. (Courtesy Cortland Eble, Kentucky Geological Survey)

↓ KGS detailed geologic map of the state, including formations (colored polygons), faults (dark lines) of an area in central Kentucky, and a customized legend of map units

Geological surveys aren't just for geologists. Whether at the national or state level, geological surveys collect and archive land information and serve it to many different constituencies.

In Kentucky, practically every sector from petroleum to transportation needs information about land and location. They obtain that critical data from a website created and managed by the Kentucky Geological Survey (KGS).

Last year, KGS completed the migration of its KGS Geologic Map Information Service from ArcIMS to ArcGIS for Server, greatly improving rendering performance, expanding access to off-site information, and refining its development and maintenance processes.



Paper to Digital

When Esri introduced ArcIMS in 2000, it delivered digital maps online, replacing many paper map requests. Soon after, KGS adopted ArcIMS to serve its customers' mapping needs and reduce its paper map workflow.

ArcIMS gave KGS the opportunity to demonstrate geospatial technology to its constituents and reveal the benefits of digital maps over physical maps—something only GIS professionals had understood until then. Within a simple web browser, ArcIMS emulated the experience of overlaying plastic sheets onto physical basemaps.

"Our constituents quickly realized how much easier it is to click a check box to populate a basemap with data rather than fumble with large plastic sheets to get the same result," said Doug Curl, GIS programmer at KGS. "It didn't take long for them to accept the new browser-based method, which naturally resulted in requests for paper maps dropping significantly." Esri's first Internet map server provided the transitional technology KGS needed to acclimate its users to a more efficient digital workflow.

In 2004, KGS completed a project to digitize every 1:24,000 geologic alquadrangle in Kentucky to make one of the most detailed state geological maps available. KGS wanted to ensure its constituents could use all the information included in the map down to the smallest scale.

"That map is our core service," said Curl. "We captured pretty much everything that was on a 1:24,000 quadrangle *[including all faults and geologic features and descriptive information about the geologic units]* and put it into a database." All tabular data can be searched and displayed at small scales on a digital map. This is helpful, for example, when natural resources personnel need to present information on water wells or drill points in a small area.

Cut Down on Slowdown

As more of KGS's constituents learned about the site, traffic steadily increased. Each new wave of visitors jammed bandwidth and progressively added minutes to simple map display.

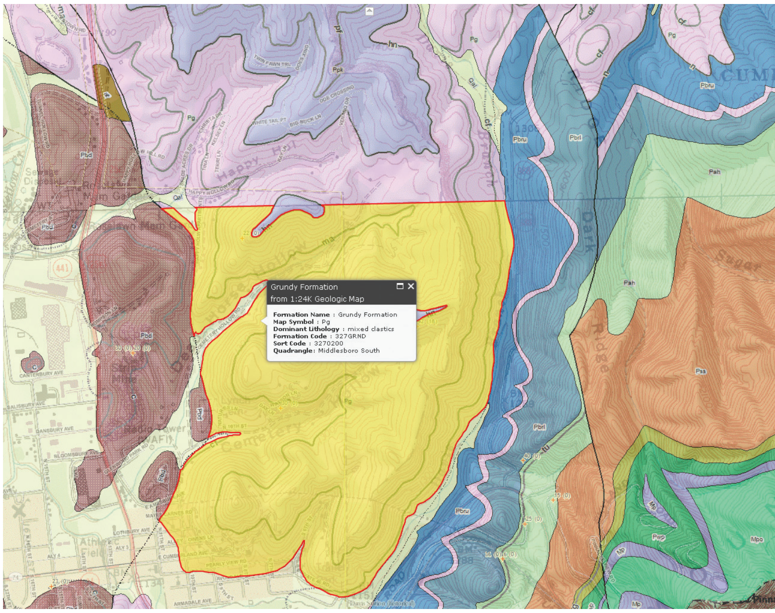
"Initially, few users complained about slow map refreshing because it was still considered new during those years," said Curl. "But as user expectations rose—mainly due to fast consumer mapping applications that users had become accustomed to—we began to get requests for speedier rendering."

Maintenance also became a double-edged sword. As Curl's team added new functionality to optimize its system, it had to frequently reboot ArcIMS, increasing server downtime and further hampering site performance. Fortunately, KGS anticipated its customers' wish list and had been planning a transition to higher technology. "We not only wanted to deliver speedier access to our core map and external services, but we also wanted to reduce our development and maintenance time and increase stability," said Curl.

Access to External Services

The KGS geologic map site is data intensive. It includes high-resolution vector geologic maps that depict the locations of hundreds of thousands of wells and other natural features. In addition, KGS relies on other state agencies for many layers of statewide basemap data.

When using ArcIMS, KGS had to acquire, maintain, and update its own copies of these basemaps whenever a state agency acquired



↑ Map showing coal thickness measurements of the Middlesboro and Cumberland Gap area in southeastern Kentucky

new data. This required transferring terabytes of data between agencies and importing this data into ArcSDE. By using streaming map services in ArcGIS for Server, KGS now can provide various basemap data via other Kentucky agencies' external published services and not have to worry about the design and maintenance of those layers, and it always has the most current version of the basemap without having to acquire and maintain the data. This allows KGS to focus on its own data.

Code Reduction

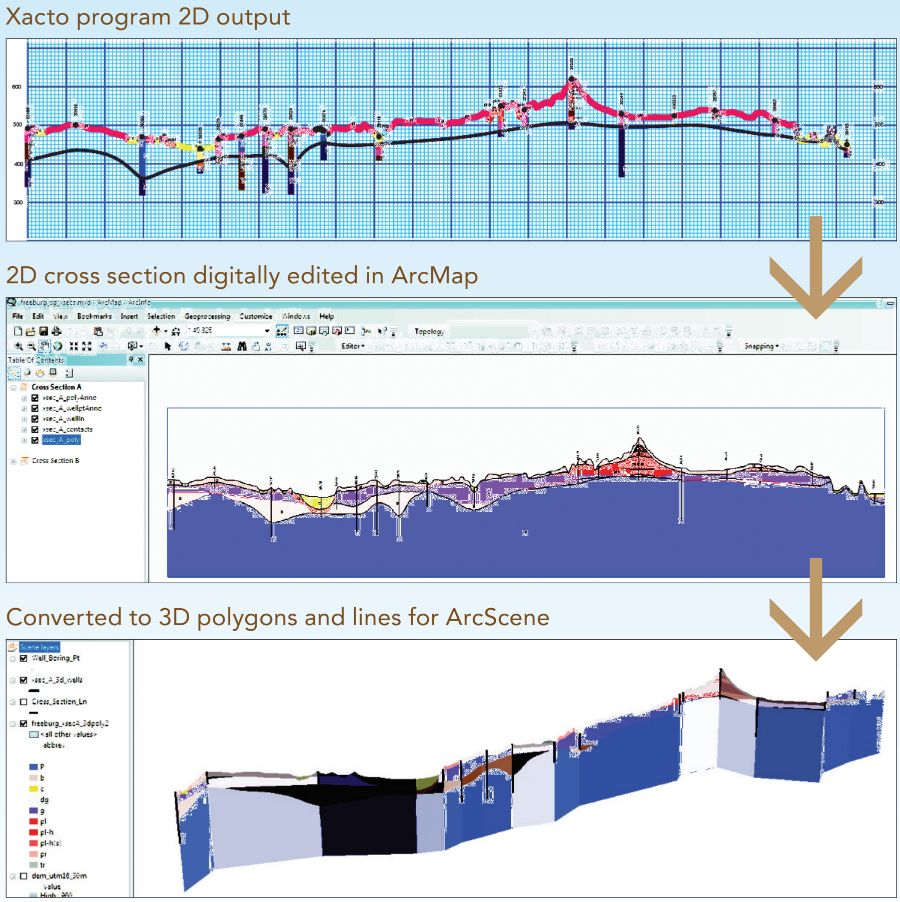
ArcGIS for Server out-of-the-box functionality eliminated much of the time Curl had spent coding functionality in the system. With ArcIMS, operations had to be programmed as separate tools. Curl also received user requests for other functionality, which he had to create from scratch.

"Since map navigation and other tools are programmed into ArcGIS for Server, my coding work has dropped significantly and freed time for me to address other priorities," said Curl. "The expanded capabilities included in ArcGIS for Server also sufficiently meet our constituents' needs, which has resulted in fewer user requests for new functionality."

Since migrating all its components over to ArcGIS for Server last year, KGS users experience quick drill downs into maps no matter how high the site traffic. Its on-site map service performs with exceptional speed and smoothness and streams external services with the same quick performance. KGS also saw a dramatic reduction in downtime, as user requests could be done on the fly and without the need to reboot the system after each change.

"The site since the migration far exceeds what we were able to do with ArcIMS," said Curl. "Providing the ability to click a data service within our site and have it instantly render on a map within the same browser—that's important for the user. Having less coding to deal with eased the development process and made our lives easier in turn."

MODELING THE TERRAIN BELOW



↑ The process of creating geologic cross sections in ArcGIS from 2D in ArcMap to 3D in ArcScene using Xacto program output

Creating dynamic subsurface perspectives in ArcScene

By Matthew DeMeritt, Esri Writer

A GIS and graphics specialist for the Illinois State Geological Survey (ISGS) developed GIS tools that help visualize subsurface geology.

Since William Smith's first modern geology map in 1815, geologists have portrayed 3D data on 2D maps using cross section diagrams. These diagrams show the strata of the earth's crust like a slice of layer cake viewed edgewise, giving geologists a valuable perspective of the earth's subsurface. Today, cross sectioning remains an important intermediate step in visualizing what is beneath the ground in true 3D.

Before the widespread use of computers, creating dynamic 3D views of the ground below was practically impossible. Today, earth scientists have more information about the subsurface than ever and sophisticated software systems to analyze and manage it. This has opened up new possibilities for generating 3D perspectives of the underground world.

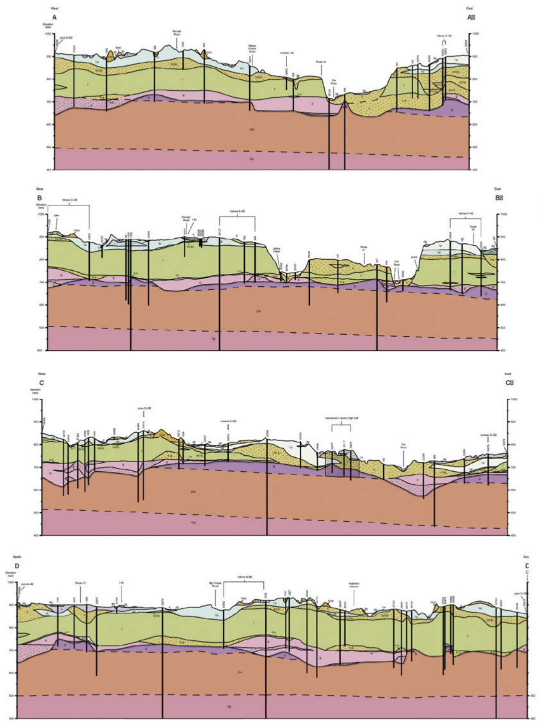
The Perils of Manual Cross Sectioning

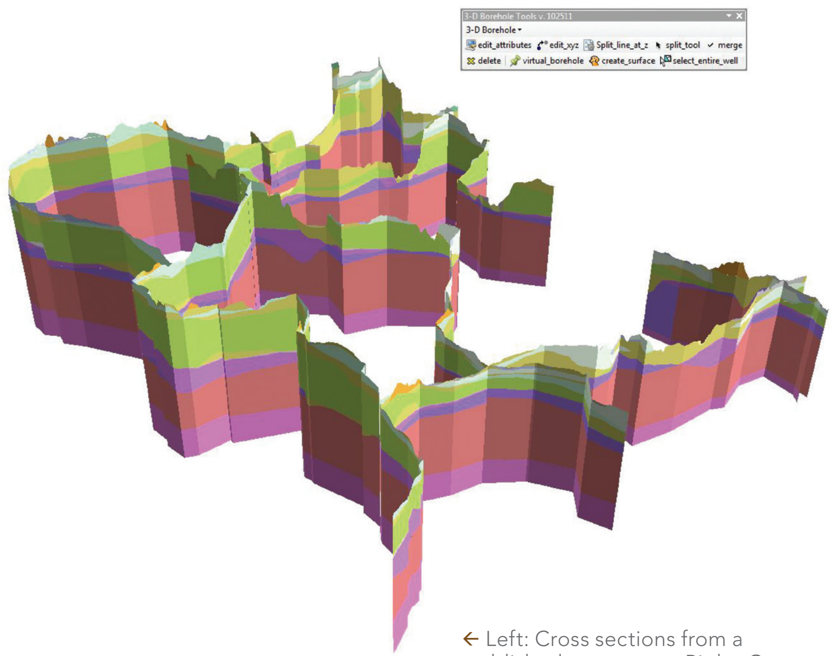
In 2007, Jennifer Carrell, GIS and graphics specialist for ISGS, Prairie Research Institute, University of Illinois at Urbana-Champaign, recognized the need for improving the process for making the cross sections shown on ISGS maps. At that time, most of the geologists still drew cross sections by hand and gave them to Carrell to digitize in ArcGIS. This hand-drawn method often included mistakes that were time-consuming to correct.

"Each inaccuracy in a cross section propagates throughout the map and can usually be traced back to some step in the manual process," said Carrell. "For example, if the location of one geological contact on a cross section is off by 50 feet, the contacts farther down the line of the section will likely also be off by at least 50 feet. The ideal solution would be to feed the data into ArcGIS and let it automatically create the framework for cross sections." Carrell saw a need for a solution that used the combined capabilities of native tools in ArcGIS to generate both 2D and 3D viewable cross sections much faster than ISGS had been producing them.

Xacto Section

Using Visual Basic, Carrell created a tool that generates a 2D cross section profile as a collection of polyline and point shapefiles that can be digitally edited in ArcMap ➔

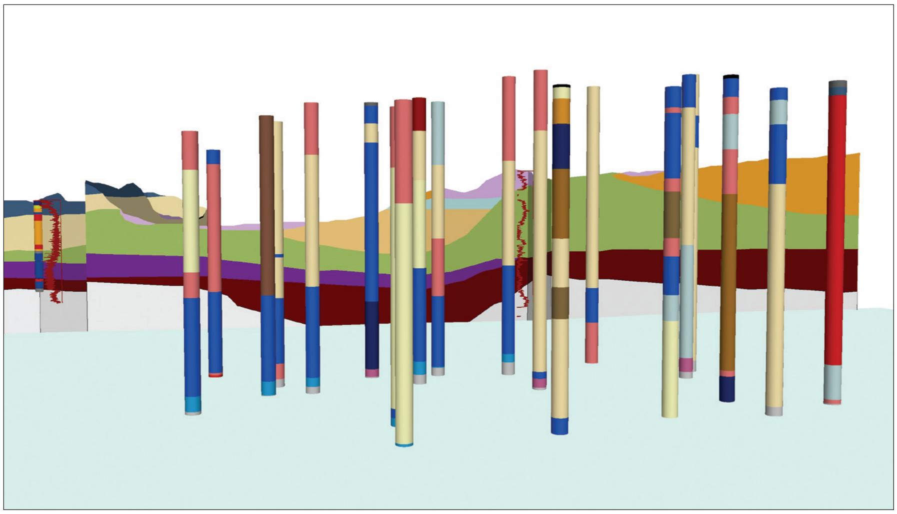




← Left: Cross sections from a published paper map. Right: Cross sections viewed in 3D in ArcScene.

and/or exported to Adobe Illustrator for finishing. "Sensor data, such as that acquired with lidar, can give us a very accurate profile of the land surface, while ground-based geophysical techniques, such as natural gamma radiation logging, can help us estimate the thickness of each layer below the surface with reasonable precision." Completed cross sections can be exported as 3D vector features for viewing and editing in ArcScene. Carrell dubbed her tool Xacto Section for its ability to virtually slice into the earth and compute a more exact profile of the subsurface.

Carrell researched other software programs that help automate the drawing of cross sections but found them either too expensive or too cumbersome to fit into the existing map production workflow.

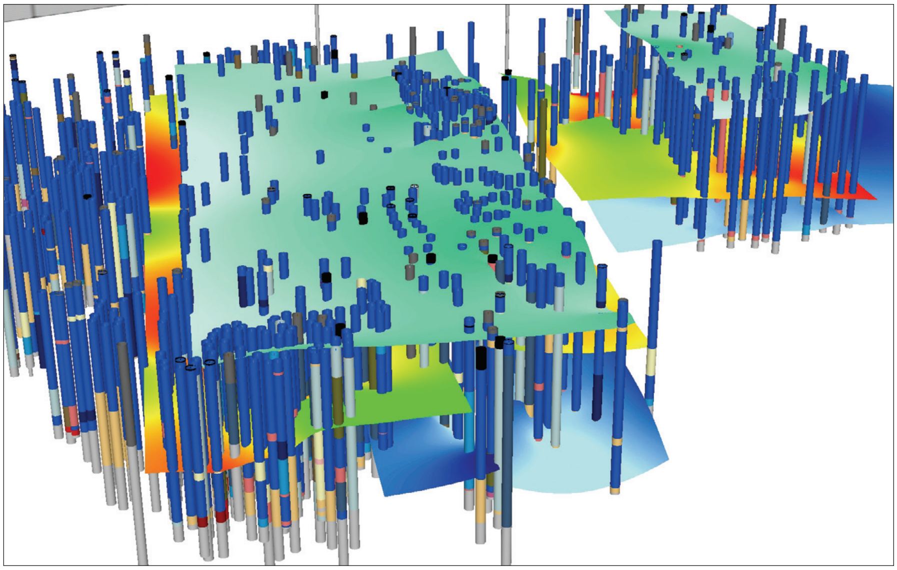


↑ 3D boreholes can be combined with cross sections in ArcScene.

Borehole Forest

Mapping subsurface geology is akin to trying to solve a jigsaw puzzle with 90 percent of the pieces missing. A significant portion of geologic data comes from boreholes drilled for engineering purposes or for water, coal, oil, gas, or mineral exploration. With enough of a sampling, distinct geologic layers can be identified based on their composition.

Encouraged by the results of Xacto Section, Carrell set out to create similar tools for graphically displaying borehole data that could take advantage of the 3D visualization capabilities of ArcScene. With 3D Borehole tools, geologists working in ArcScene can visualize boreholes together as a 3D "forest" of vertical cylinders or tubes, instead of boreholes being symbolized as lines on a 2D diagram.



↑ Boreholes and surfaces interpolated from borehole selections

"The 3D Borehole tools in ArcGIS allow the geologist to take tabular borehole data in the x,y,z attribute form and visualize them as 3D tubes in ArcScene," said Carrell. Using 3D Borehole tools in ArcScene, geologists can easily manipulate borehole log descriptions and geophysical data, which are then classified and interpreted by the geologist as mapping units. From there, they interpolate surfaces from point data and begin constructing a working conceptual model of geologic layers in a given area.

Initially, Carrell created the cross section tool mainly for 2D cartographic purposes. As ISGS accumulated GIS files for its cross sections, Carrell began to convert them into 3D and display them together with the 3D boreholes in ArcScene. In this way,

Key to borehole sediments

Fill and Unknown
Organic material and Soil
Boulders
Clay
Soft clay
Hard clay
Silty clay
Sandy clay
Clay and silt
Clay and sand
Clay and gravel
Silt
Sand and clay
Sand and silt
Sand
Sand, file
Sand, coarse
Sand and gravel
Sand and gravel, coarse
Gravel and clay
Gravel
Gravel, coarse
Gravel and boulders
Bedrock

they become not just a static cartographic product but valuable input data that can be used to map the geology of nearby areas. "Making the leap from 2D to 3D visualization has been really exciting for geologists at the ISGS because it provides a sense of depth required to understand complicated sequences of sediment," said Carrell.

In Use

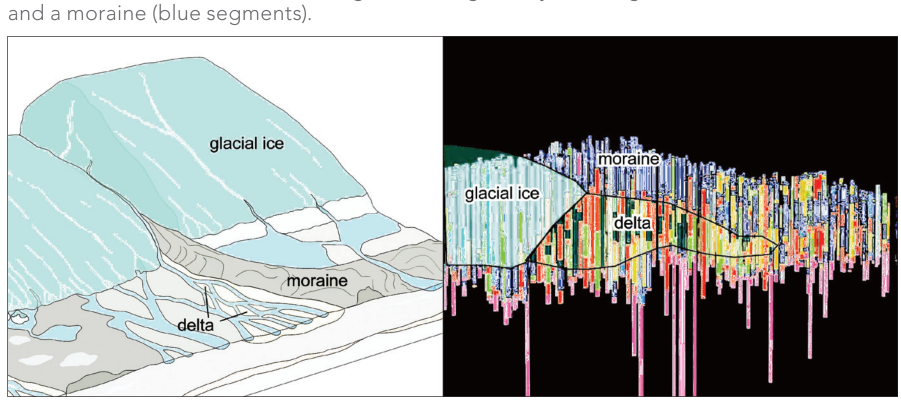
At ISGS, geologists use the tools to construct 3D models of subsurface geology at the county or regional scale. These models help governments and water utilities create water supply plans, especially in the fast-growing counties around Chicago. Being able to visualize the geologic materials in 3D has been invaluable to geologists in mapping the sand and gravel deposits that are potential sources of groundwater for drinking, agriculture, and industry.

As the geologic record revealed in boreholes shows a record of climatic change in the past, visualizing that data three-dimensionally similarly benefits climate research. Carrell currently works with members of ISGS studying the glacial geology of Illinois. "Being able to view borehole data together in 3D, they can more easily discern the shapes of glacial landforms such as fans, deltas, lakes, and channels," said Carrell. "This helps them piece together a more detailed story of how glaciers advanced and retreated across the landscape over the past two million years."

In addition to benefiting hydrology and climate research, Carrell's tools also inform civic planners and policy makers. Having more dynamic perspectives of the extent of aquifers or the location of potential house-swallowing sinkholes ultimately improves investigation and lessens risk. "Communicating our results in 3D makes a huge difference in terms of audience impact," said Carrell. "As a geological survey, anything we can do to make our scientific interpretations more precise and accessible benefits the public."

Since posting the tools on ArcScripts, Carrell's mapping tools for ArcMap and ArcScene have been downloaded nearly two thousand times. She has received feedback from individual geologists and agencies in Italy, Germany, the Netherlands, Argentina, and Canada, just to name a few countries. "Cross sections are used in many disciplines within earth science and planning," said Carrell. "It's gratifying to see that the tools I created meet the needs of those communities."

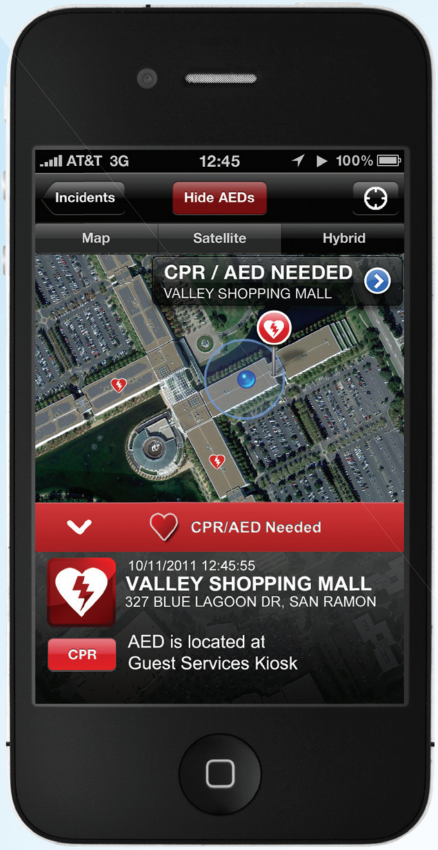
↓ Left: Diagram of a continental glacier and some associated landforms. Right: A sidelong view of boreholes reveals sand and gravel (orange and yellow segments) of a former delta and a moraine (blue segments).



Improving Citizen Engagement

GIS fosters participation

By Monica Pratt, *ArcUser* Editor



↑ When a call for CPR comes into the San Ramon Valley Fire Protection District, the Lifesaving App, available for Android and iPhone smartphones, notifies the nearest available volunteer to come to the rescue.

GIS-based civic engagement apps are improving the performance and image of government by helping citizens actively participate in government on their terms.

In recent years, citizens' expectations of government have changed radically. In response to perceived shortcomings of government, they have become impatient. These shortcomings can be categorized broadly as unresponsiveness, inefficiency, and lack of accountability and transparency. At the same time that citizens need and want more from government on all levels, governments are operating with fewer resources and dealing with systemic issues such as failing infrastructure.

Citizens' impatience with government is also a by-product of the profound transformation in their interactions with businesses, family, and friends. Thanks to smartphones and tablet devices and ubiquitous access to the Internet, these interactions have become on demand and customized. Impulse is quickly connected to action. People have become accustomed to buying anything from a jar of skin cream to a major appliance with just one click. Through social media, they just as quickly and effortlessly stay in nearly constant contact with friends and relatives—no matter where they live.

Thanks to the prevalence of these devices, concerns about the digital divide that were the centerpiece of discussions about putting government information on the Internet a dozen years ago are largely moot. Privacy concerns also seem to be a nonissue for younger generations who are comfortable sharing almost any information.

In contrast, traditional ways of interacting with government—writing letters, attending town meetings, participating in focus groups—seem cumbersome at best and exclusionary at worst and don't provide timely feedback. In addition, current methods used by government for communicating with citizens are unidirectional. This reinforces the impression that government isn't listening. In this era of social media, communication between government and governed should be a conversation.

Consequently, just pushing back-office applications out to the public-facing web will not meet the needs of citizens. The defining characteristic of a civic engagement app is its bidirectional nature. No matter the purpose, apps should incorporate a feedback mechanism that communicates not only citizen concerns but also government response.

Creating these apps requires understanding what citizens need and want and supplying it quickly. Instead of building monolithic apps designed to last, a more successful strategy is to make disposable apps that are rapidly created, used for a time, and discarded.

Two types of apps are emerging. The first type complements existing government services and makes them more accessible. The second, more intriguing type encourages people to work closely with government to do things no one had thought of doing before, like rounding up volunteers to clean beaches after a holiday weekend.

Other entities, with a variety of agendas, have also begun producing civic engagement apps. These entities can be startup companies, social-minded organizations, not-for-profits, and traditional GIS partners. Some companies seem dedicated to →

Civic engagement apps fall into seven categories:

Public information

Maps are being used with greater frequency to communicate complex information that would not be quickly grasped in another format. These apps are effective at addressing transparency concerns, provide a channel for feedback, and communicate both where and why government money is being spent. Recovery.com, mapping the American Recovery and Reinvestment Act economic stimulus spending, is a good example of this type of app.

Public reporting

The Federal Communications Commission (FCC) tapped into the power of crowd-sourced information through the FCC Speed Test, an iPhone app that measures the quality and speed of a consumer's broadband connection. During the first six months it was available from the App Store, 1.2 million people downloaded the app and reported back information that helped the agency plan infrastructure expansion and determine policy. The captured data is visualized as a mapped surface that can be explored.

Solicited comments

Apps don't have to be forever. When the Regional Transportation Commission of Washoe County, Nevada, wanted citizen comment on the Reno Sparks Bicycle and Pedestrian Master Plan, it worked with Esri partner CitySourced to develop an app that would let residents identify the locations for needed improvements, such as a crosswalk or a bike lane, simply by taking a photo of the location with a smartphone and writing comments in a form. These comments were captured and displayed on a web map. The app went up in summer 2010 and was taken down in early 2011.

Unsolicited comments

Governments can learn about public opinion on issues and the effects of events through apps that gather constituents' posts on social media sites such as Twitter and Flickr. Social media maps on events such as the Gulf of Mexico oil spill aggregated and shared comments, photos, and videos that greatly enhanced the information available on conditions.

Citizen as sensor

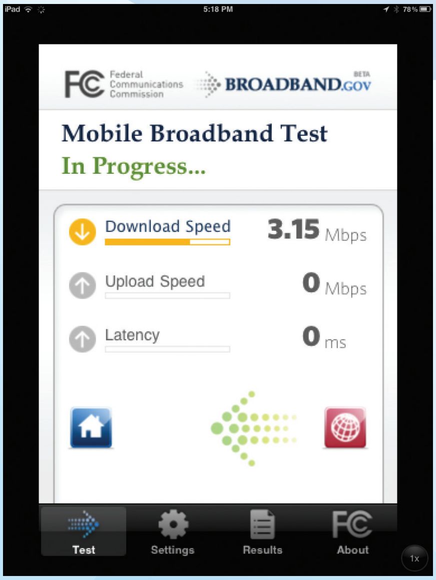
The Crime Tips app, from Esri partners The Omega Group and CitySourced, gives police many more eyes on the street. The iPhone/iPod/iPad app lets the user learn which crimes are happening nearby as well as anonymously report crime tips that will be forwarded to authorities.

Volunteerism

The Lifesaving App for the Android and iPhone, developed for the San Ramon Valley Fire Protection District by the nonprofit PulsePoint Foundation, crowd-sources Good Samaritans. In instances of cardiac arrest, time is vital. The Lifesaving App lets smartphone users volunteer to be notified if someone nearby needs CPR. When a 911 call is received, the nearest CPR volunteer, who is in the best position to respond in timely fashion, receives information on the incident.

Citizen as scientist

Individuals can contribute to collective knowledge with these apps. The free Mojave Desert Tortoise app lets users take a photo, find out more about this endangered species, and note location and other information about an individual tortoise.



↑ The FCC Speed Test, an iPhone app that citizens download, measures the quality and speed of a consumer broadband connection and sends that information to the Federal Communications Commission.

↑ Reports sent using the Citizen Connect app for iPhone and Android smartphones are automatically fed into the City of Boston's work order system. Residents can use the assigned tracking number to check on a request's status.

disrupting government, while others develop civic engagement apps to gain a competitive edge. In most cases, the apps are not integrated with government workflows. To the citizen, these apps appear to work, but because they don't furnish information in a way government systems can easily use, the information they provide is not easily acted on by government.

Embracing civic engagement apps brings new challenges and opportunities for GIS managers in local government. A compelling argument for taking ownership of civic engagement apps is to avoid problems stemming from poor integration with back-office processes and take advantage of new sources of geospatial information.

With these apps, usability is of paramount importance. Conventions of a typical GIS interface design may need to be abandoned in favor of ones that use interactions citizens will be familiar with. Another challenge associated with civic engagement apps is the design of workflows that take advantage of new sources of geospatial information and are integrated with business processes.

Rather than replacing the work of traditional GIS, these apps make the maps and data produced by GIS departments more useful and accessible to more people both inside and outside government. These apps also elevate the value of the authoritative data produced by government GIS departments as people become dependent on obtaining current, accurate data.

Beyond these general patterns of app development previously cited, civic engagement apps fall into seven categories (page 34) based on the type of interaction they encourage: public information, public reporting, solicited comments, unsolicited comments, citizen as sensor, volunteerism, and citizen as scientist.

Civic engagements apps have the potential to enlist new segments of the population—people who had not previously participated in government—and bring their concerns, insight, energy, and commitment to reinvigorate government. This is an exciting prospect.

5 Reasons to Use ArcGIS for SharePoint

By Derek Law, Esri Product Management

Two quick questions for GIS managers reading this article:

1. Does your organization have Microsoft SharePoint as part of its information technology (IT) solution?
2. Are your SharePoint users aware of the benefits of visualizing their business data in a spatial context?

If you answered yes to the first question and no or maybe to the second question, Esri has developed a way you can easily add GIS mapping functionality onto SharePoint pages and empower your SharePoint users with geographic information.

What Is ArcGIS for SharePoint?

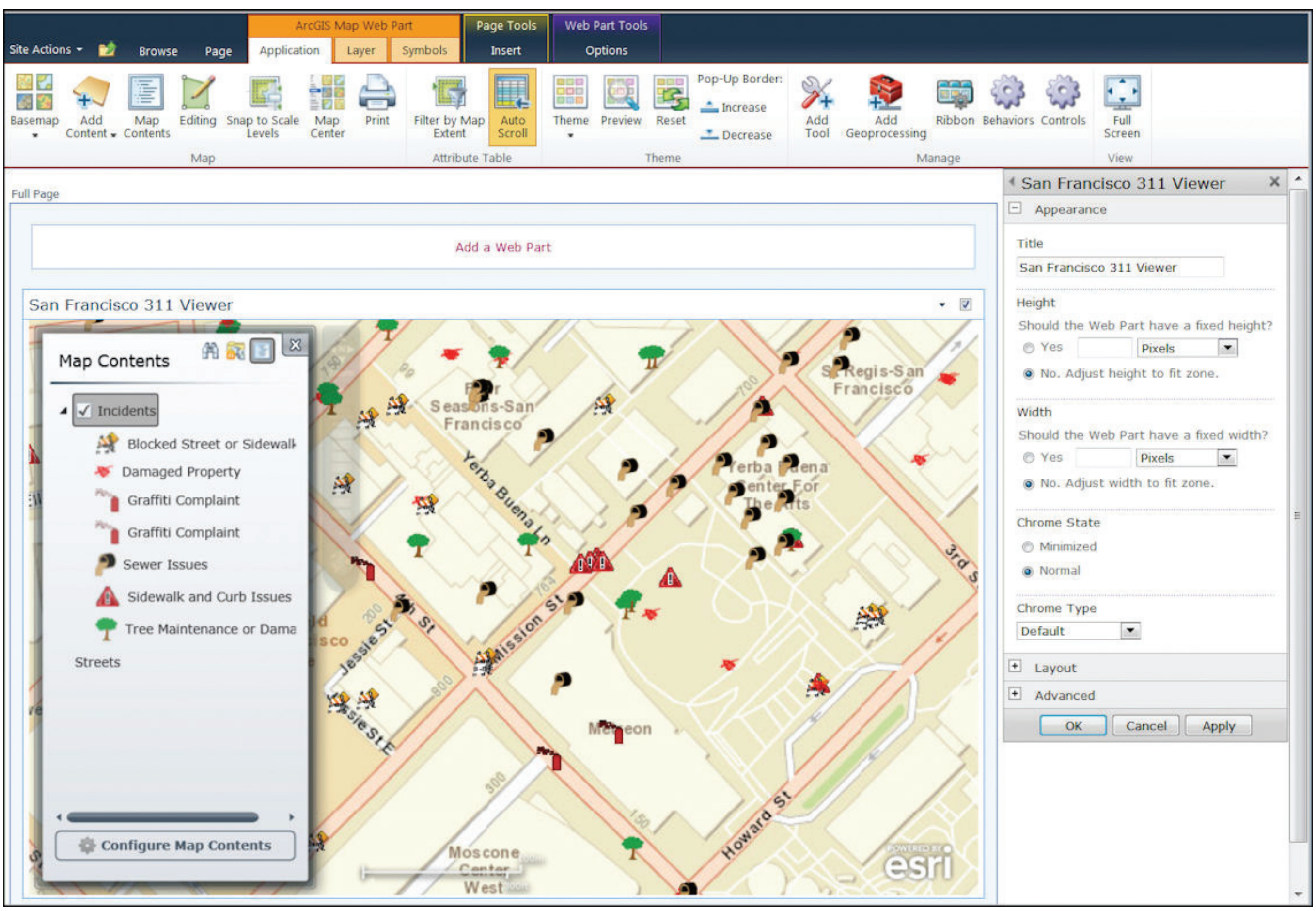
ArcGIS for SharePoint is a set of components built on the award-winning ArcGIS API for Silverlight and enables you to quickly and easily incorporate GIS functionality into SharePoint sites. ArcGIS for SharePoint recently won the 2011 *Visual Studio Magazine* Reader's Merit Award in the SharePoint Tools and Components category.

By installing ArcGIS for SharePoint onto a SharePoint farm, you enable the SharePoint platform to become a client application that can work with ArcGIS for Server web services and ArcGIS Online web maps. It also enables SharePoint lists containing spatial data to be displayed in a geospatial context. In effect, ArcGIS for SharePoint provides a geospatial dimension for SharePoint site content.

ArcGIS for SharePoint consists of three components: the Map Web Part, the Geocoding workflow, and the Location field.

The Map Web Part is an interactive map that enables the display of ArcGIS for Server and ArcGIS Online services, web maps, and SharePoint lists with spatial data. The web part is configurable and includes many core GIS mapping functionalities such as data display, map navigation, query and search, printing, and data editing.

The Geocoding workflow enables SharePoint lists containing spatial data (e.g., addresses or x,y coordinates) to be easily displayed in a spatial context. The workflow can be set up as part of a business workflow. For example, when the SharePoint list is updated, the corresponding displayed spatial data could be automatically updated.



↑ ArcGIS for SharePoint has an interactive Map Web Part.

The Location field is a custom data type used in SharePoint lists that enables records containing spatial data to be shown in a geographic context. It is typically used with the geocoding workflow. When a workflow is applied to a SharePoint list, the workflow adds a location field to the list, which displays the data on a map.

ArcGIS for SharePoint supports the latest capabilities offered by ArcGIS for Server and can be installed on Microsoft SharePoint Server 2010 or Microsoft SharePoint Foundation 2010. The Microsoft Silverlight plug-in needs to be installed in the web browser that is used to access your SharePoint pages.

Why You Should Use ArcGIS for SharePoint

Now that you know what ArcGIS for SharePoint is, here are five very good reasons you should consider using it.

Reason 1: It provides GIS and interactive mapping functionality in SharePoint sites.

ArcGIS for SharePoint adds a geospatial dimension to both working with and collaborating on SharePoint site content. It highlights the value of visualizing data spatially, something SharePoint users may not be aware of. SharePoint lists containing spatial data can be easily displayed in a spatial context and used with web services from ArcGIS for Server and ArcGIS Online for further GIS analysis. ArcGIS for SharePoint can use GIS functionality, such as buffering, overlay analysis, and network routing, by accessing geoprocessing services from ArcGIS for Server.

SharePoint analysts typically work with large amounts of tabular data and use key performance indicators (KPIs) to identify and assess patterns and trends. The Map Web Part provides an interactive map display with many GIS mapping capabilities included out of the box. This significantly different reporting approach enables SharePoint analysts to visualize and analyze their business data in a more revealing format—a map. ArcGIS for SharePoint can be easily integrated into an organization’s larger business intelligence solution built on the SharePoint platform.

Reason 2: It's easily configurable to meet business-specific needs.

Both the Map Web Part and the Geocoding workflow in ArcGIS for SharePoint have been designed to support users who are already familiar with configuring SharePoint parts and workflows. Both have an intuitive GUI point-and-click user experience. The Map Web Part offers both a design-time and run-time view of its interface, while the Geocoding workflow can be set up by following a simple wizard.

This means that SharePoint users who are not GIS analysts can learn how to work with and leverage the ArcGIS for SharePoint components in a short time frame. No programming or configuration file editing is required to work with these components. Users can quickly customize the components to meet their business requirements.

Reason 3: It helps GIS departments sell the value of GIS to an organization.

Organizations with GIS departments that already use ArcGIS for Server and ArcGIS Online can leverage ArcGIS for SharePoint to help promote and distribute their own work (and the value they bring to the organization) to other departments. ArcGIS for SharePoint can help elevate the use of GIS inside an organization.

ArcGIS for SharePoint helps extend the reach and usage of GIS services within an organization because it brings GIS to parts of an organization that may not directly use GIS but do use SharePoint. Some parts of an organization may not yet recognize the value of visualizing data spatially, and ArcGIS for SharePoint helps promote this paradigm. This is especially relevant as the usage of SharePoint continues to grow as an internal content management and collaboration system within many medium to large organizations.

Reason 4: It's extensible.

ArcGIS for SharePoint is built on ArcGIS API for Silverlight. Its Map Web Part can be extended via its lightweight and flexible extensibility API. For developers, the API provides access to the map component and its selected layers, which offer several points of interaction for customization.

In addition, you can include an extension to the Map Web Part that is open-ended and provides additional custom functionality. Within an extension, you may leverage any Silverlight library, including ArcGIS API for Silverlight and the native Silverlight API. You can manipulate the map and layers, display any Silverlight UI, make your components configurable, interact with other Silverlight or JavaScript components on the page, make calls to web services such as those provided by SharePoint or ArcGIS for Server, and much more.

Reason 5: It's available at no extra cost.

ArcGIS for SharePoint is available as a free download for existing ArcGIS for Server users. This set of components for SharePoint is provided at no extra cost. If your organization has ArcGIS for Server and SharePoint, why not leverage ArcGIS for SharePoint as part of your IT solution? ArcGIS for SharePoint, frequently updated to support the latest ArcGIS for Server capabilities, is fully supported by Esri. Users can call Esri Support for technical assistance if needed.

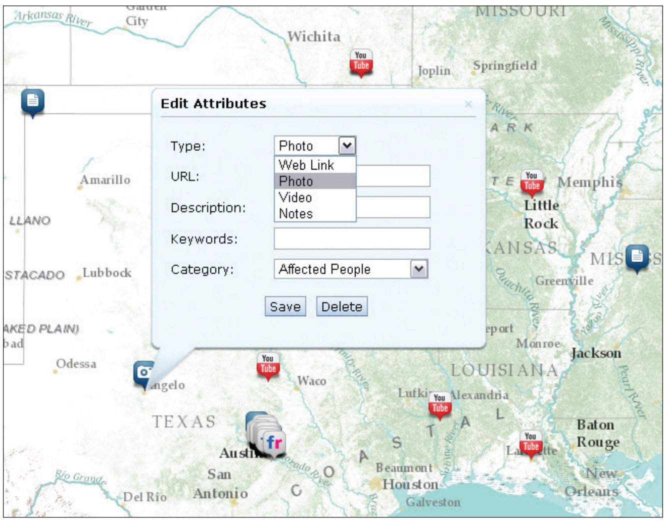
Resources

More ArcGIS for SharePoint product information is available on the Esri product pages. The ArcGIS for SharePoint Resource Center (help.arcgis.com/en/webapps/sharepoint/) is your main source of additional information about ArcGIS for SharePoint. It contains links to the download package, help and developer documentation, code samples, and support forum—all the resources needed to start working with ArcGIS for SharePoint.

Dealing with High Demand

Building high-capacity mapping applications

By Keith Mann, Esri Writer



↑ The Public Information Map template can be configured to allow the user to add features to the map.

Is your mapping application ready for the big time? Maybe a better way to ask this question is, how well will the computing infrastructure that supports your mapping application stand up to a huge spike in demand?

Wildfires raging in Colorado in 2010 precipitated a real-life test for Esri. In response to the fires, Esri published a public information map (PIM) for wildfires. The wildfire app ran beautifully on a single server machine and seemed to be handling the daily traffic with no problem until a major news organization provided a link to the map in one of its stories. Immediately, demand went through the roof, and the server exceeded its load capacity. It shut down, and the wildfire app went dark.

The application was quickly reborn, but not on the single server machine. This time, it was set up to run in the cloud. The second incarnation of the wildfire app used cloud services to distribute demand across multiple servers. Additionally, the base structure for this type of system was established and configured so that server machines could be added or removed as needed.

In other words, a scalable system for supporting high-capacity mapping applications was created. This system is now used for all Esri disaster response and current events maps (esri.com/news/maps/index.html).

This article provides a brief, high-level view of the thought process used in building the infrastructure for a high-capacity mapping application. Although it's certainly not the only way to do this, it is a tried-and-true method that allows incremental system design while maintaining manual control over scalability.

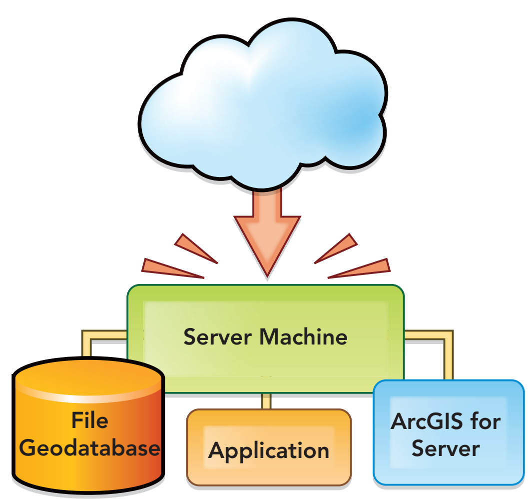
A Review of Amazon EC2

The strategy for adding capacity to the wildfire app uses Amazon Web Services (AWS)—specifically, Amazon Elastic Compute Cloud (EC2) (aws.amazon.com/ec2). Amazon describes EC2 as "a web service that provides resizable compute capacity in the cloud." Essentially, various components of Amazon's compute infrastructure can be rented to rapidly build a high-capacity support system.

The strategy also uses ArcGIS for Server to create and manage the GIS services for the application. Esri provides ArcGIS for Server as an Amazon Machine Image (AMI) running on Amazon EC2. The ArcGIS for Server on Amazon EC2 AMI includes 100 gigabytes of storage. These AMIs can be licensed in the same fashion that ArcGIS for Server is licensed on a local machine.

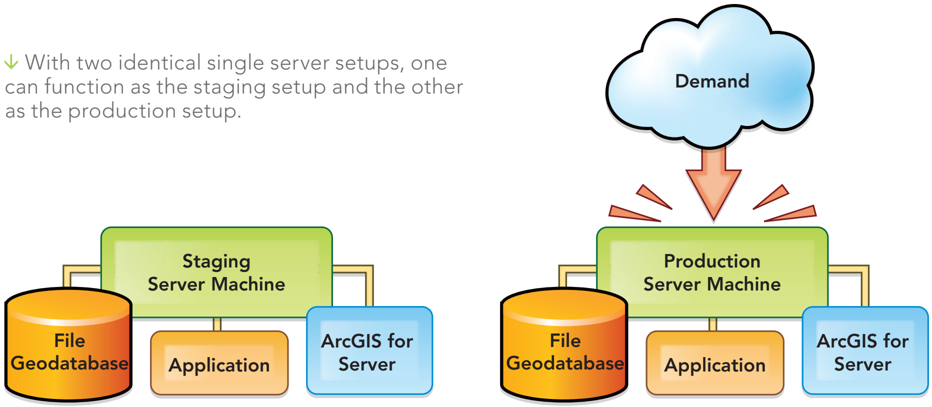
When you start an instance of ArcGIS for Server on Amazon EC2, you choose the ArcGIS for Server AMI, the size and type of machine it will run on, and other services and features such as Elastic Load Balancing and Auto Scaling.

You can upload your data and application to the instance's storage area and configure them with the ArcGIS for Server instance so that you can publish services and add them to the mapping application. Detailed resources for accomplishing these tasks are listed in the online version of this article.



↑ Spikes in demand from the Internet can quickly overload a single server machine setup.

↓ With two identical single server setups, one can function as the staging setup and the other as the production setup.



The Single Server Setup

A common method for deploying a mapping application is to put everything—the mapping application, the GIS server, and the data—on one machine.

This method is often used for internal applications because machine usage is either known or can be safely predicted. However, when the application is exposed to the Internet, it is more difficult to predict the maximum load on the server.

Sudden spikes in demand can quickly overload the processing capability of the server machine and cause it to crash. During the resultant downtime, your customers lose access to the application, and you end up spending hours getting the server up and running, only to have it crash again as soon as users discover its availability.

One way to combat spikes in demand is to use a server machine with more processing power. The problem with this solution is that you end up paying for a server that is underutilized most of the time. This scenario is true whether you're deploying your application on local infrastructure or in the cloud.

The Staging Server and Production Server Setup

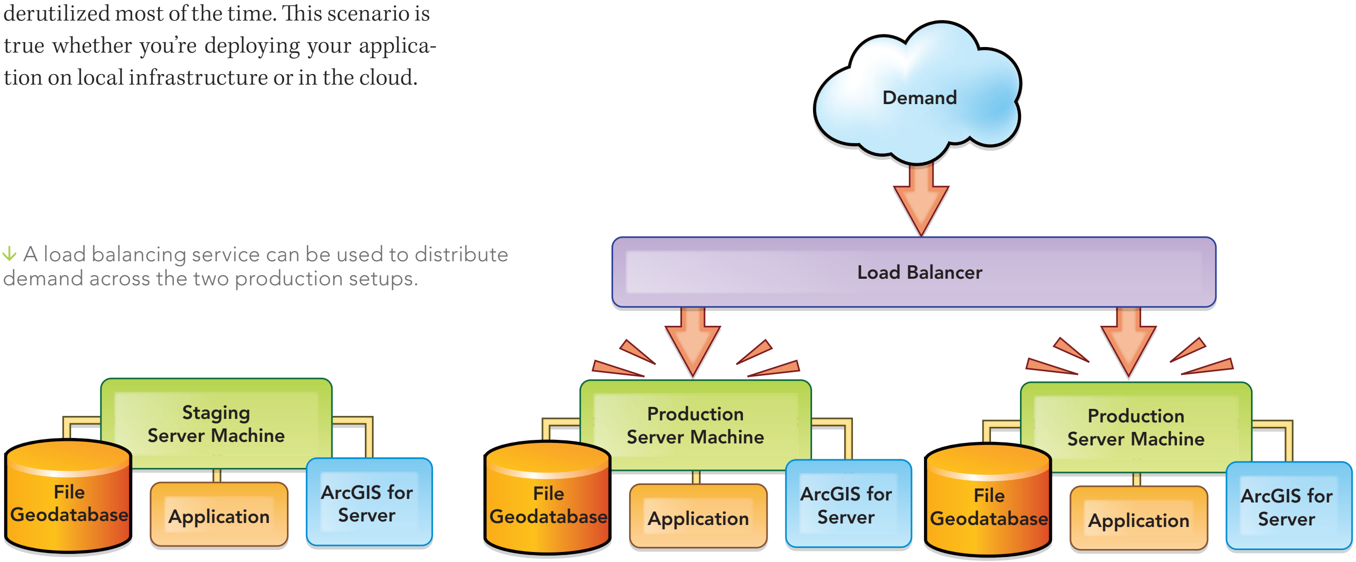
Another way to prepare for server overload situations is to make it easier and faster to spin up a new instance of your mapping application if it goes down. To accomplish this, first create a single server setup. Conceptually, you can think of this as your staging setup. Next, make a copy of your staging setup and *use the copy* as your production setup. End users only access the resources of the production setup. If demand overloads your production server, you make a new copy from the staging setup and use it to replace the crashed production setup.

On Amazon EC2, making a copy simply means starting a new instance from a custom AMI. To create the custom AMI, complete the staging setup and save it as an AMI. The custom AMI encapsulates your entire setup—the application, the data, and the GIS server. Creating a custom AMI can take 20 minutes to an hour. Once it's created, you can generate new instances from the custom AMI very quickly—in approximately 15 to 20 minutes.

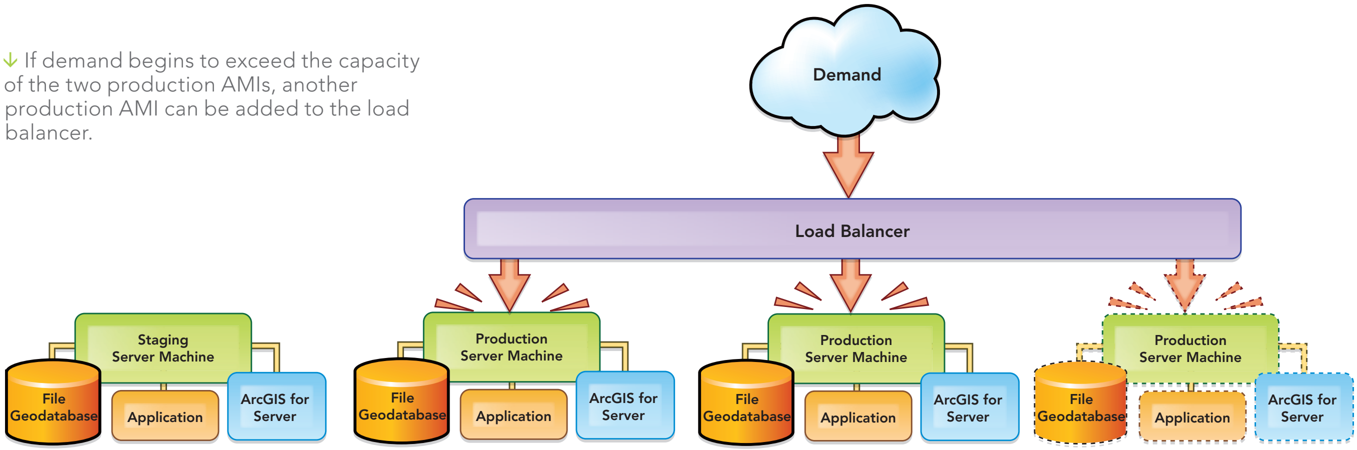
Having a staging setup lets you test your application and make edits before you deploy the production setup. If you want to add functionality to the application or make changes to the data and services, you can do this without disturbing the end users who are using the production setup. When you're ready to deploy the new setup, just kill off the production instance and replace it with the updated production instance.

However, this framework doesn't help you achieve the capacity needed to support large spikes in demand. To do that, you'll need two load-balanced production instances.

↓ A load balancing service can be used to distribute demand across the two production setups.



↓ If demand begins to exceed the capacity of the two production AMIs, another production AMI can be added to the load balancer.



Setting Up the Staging Server and Load-Balanced, Multiple Production Servers

In this scenario, you use the custom AMI created from the staging setup to generate two identical production instances. Next, you employ a load balancing service (called Elastic Load Balancing on Amazon EC2) that will distribute demand across the production instances.

If something goes wrong with one of the production instances, the application continues to work through the remaining production instance. This gives you time to start a new instance of the production instance and configure it with the load balancer.

You can also add additional machines to the load balancing service. If demand increases to a critical threshold—say, 80 percent on both production servers—you can start a new production instance from the custom AMI and add it to the load balancer. When demand subsides to normal levels, you can kill off the third production instance.

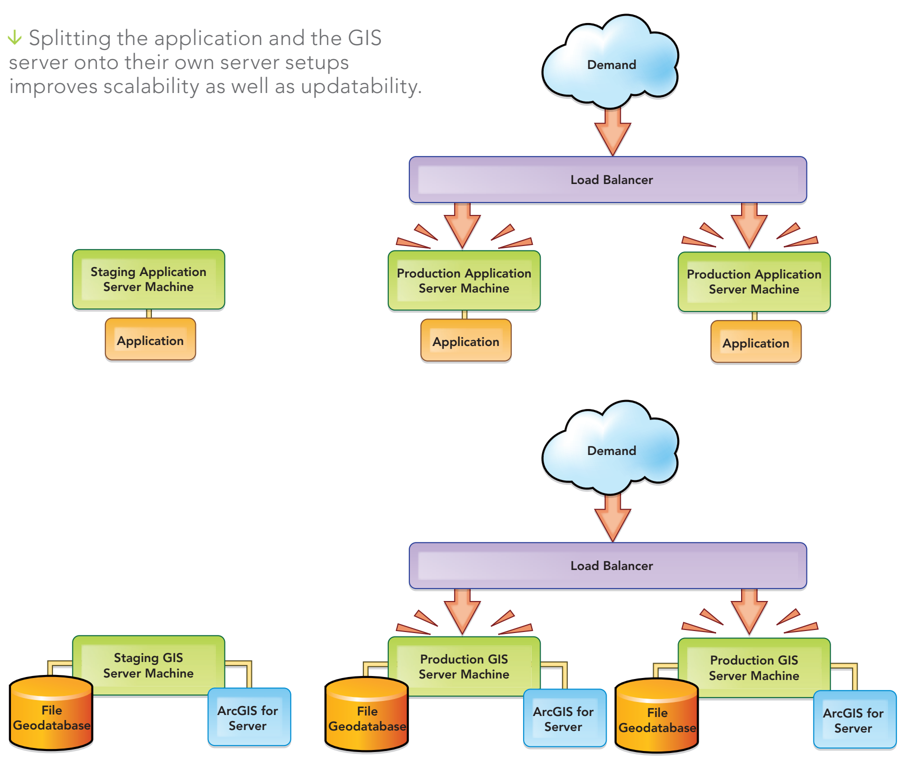
In this scenario, you are achieving a level of scalability that allows you to manually respond to spikes in demand that may affect the performance or viability of your mapping application. While the load balancer can be used to monitor whether the application is responding properly, it cannot check the fine-grained functionality of ArcGIS services. To more closely monitor your services, use ServiceMonitor, a script provided by Esri that checks each service periodically and makes sure it is responding. You can download the ServiceMonitor script at arcscripts.esri.com/details.asp?dbid=15335.

Multiple Staging Servers and Load-Balanced, Multiple Production Servers Setup

With most mapping applications, you'll want to make improvements, add functionality, or change the look and feel of the app on a regular basis. Changes to data and services usually occur much less frequently. You can take advantage of this phenomenon and make your high-capacity system more efficient if you put the application on a different server from the GIS server and data.

In this case, you make custom AMIs of the application server setup and the GIS server setup, create two new instances of each, and load balance the two production application AMIs and the two GIS server AMIs. This scenario provides scalability to your application as well as your GIS server and allows you to work on either while reducing the impact on your end users. Both the application and the GIS server setups can be scaled up and down depending on where the loads are greatest.

↓ Splitting the application and the GIS server onto their own server setups improves scalability as well as updatability.



Including an Enterprise Geodatabase Server for Feature Editing

Some mapping applications allow the end user to perform feature editing such as adding a point, line, or polygon to the map. To have consistency on the production servers running in the load balancer, editing must be done in an ArcSDE database. The ArcSDE database should reside on a separate instance from the production instances. These features are stored in an enterprise geodatabase.

Esri also provides an enterprise geodatabase AMI. Data for editable feature services, is stored in an instance created from this AMI. After putting the data in the enterprise geodatabase, creating the feature service, and configuring the service with the application, you make a custom AMI of the staging data server setup and launch new production instances.

In this example, one staging data server and only one production data server are used to support the application. If possible, use two production data servers, each with a mirrored enterprise geodatabase for redundancy. However, currently, this is not a simple, out-of-the-box solution provided with the Esri enterprise geodatabase AMI—it requires a strong understanding of enterprise database management.

Where to Go from Here

Amazon offers an Auto Scaling service that you can configure with the load balancing service to automatically spin up new production instances when load thresholds reach a specified level. However, you may find that maintaining manual control over scaling of your production instances is preferable.

Amazon's cloud infrastructure and data centers are available in a number of regions around the world. Each region has multiple Availability Zones, designed to protect your instances from failure. Instances can be spread across Availability Zones within a Region so that if one data center goes down, the other instances will continue to function. The Amazon EC2 Service Level Agreement commitment is to provide 99.95 percent availability for each Amazon EC2 Region. As long as you create production instances in different zones within the same region, you can have them all behind the same load balancer.

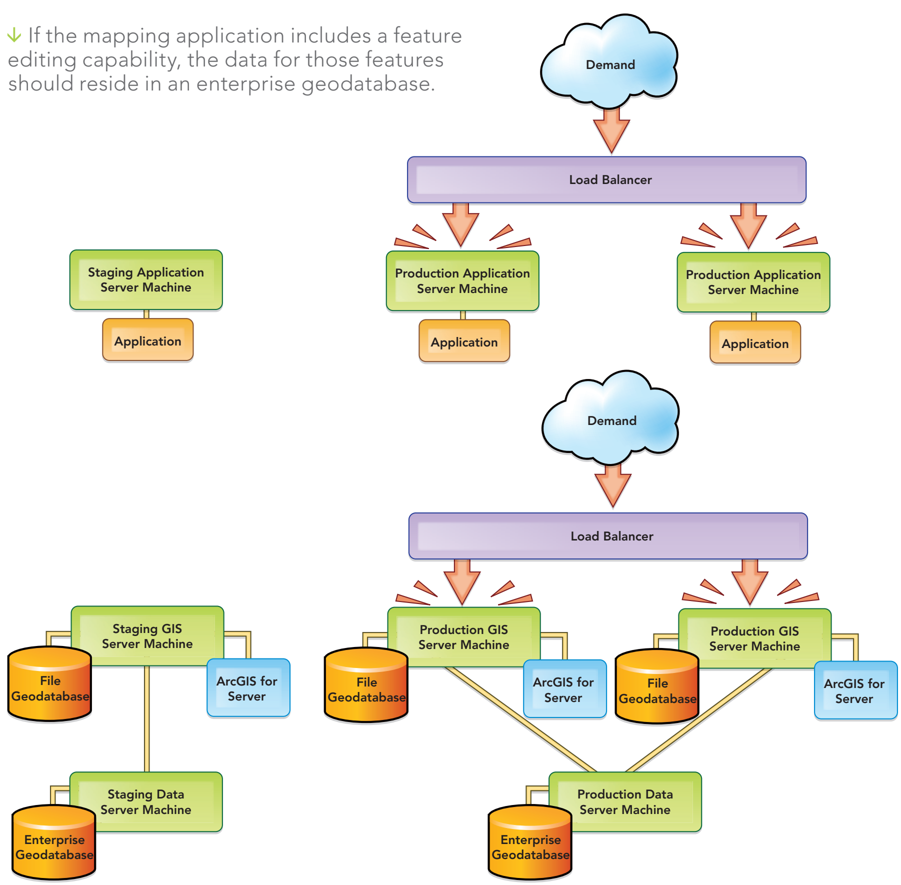
Conclusion

To support a high-capacity mapping application, you will need a scalable system of identical setups, each with a GIS server; an application; and, possibly, data server machines. If you want to maintain your system in a manner that minimally impacts your end users, consider creating a staging AMI that you can work on while the production AMIs serve your end users. Ideally, there should be two load-balanced production instances in the base structure of the system so that if one fails, the application remains viable. If demand on both production instances exceeds tolerances, another production instance can be manually or automatically added to the load balancer.

If you anticipate frequent changes to the application, you may find it useful to put the application server and GIS server on separate tiers of the system. Likewise, if your application includes the ability to add or edit map features, you should put the required enterprise geodatabase instance on a separate tier.

These concepts and suggestions are not the only way to use Amazon EC2 to bring high capacity to your mapping application, but you may find that this model is a practical approach to maintaining fine-grained control over how and when your system scales.

↓ If the mapping application includes a feature editing capability, the data for those features should reside in an enterprise geodatabase.



Looking Up for Answers on the Ground

Providing first responder maps for the 2011 Japanese earthquake and tsunami

By Karen Richardson, Esri Writer

A professor of anthropology used his remote-sensing expertise, developed exploring ancient cultures, to aid emergency response to the Tōhoku earthquake and tsunami.

Dr. Terance L. Winemiller, GISP, associate professor of anthropology and geography at Auburn University, Montgomery (AUM), in Alabama, took his first GIS course while in graduate school. His interest in geospatial technology led him to become a specialist in remote sensing. He found GIS was the perfect tool for interpreting ancient cultures by constructing maps of archaeological sites that had never been mapped before. Employing total stations and GPS collectors, he gathers data he uses to construct maps in ArcGIS in both two and three dimensions.

His interest in mapping led him to develop a GIS program at AUM in 2004—the first at the university. Today the program includes as many as eight courses for bachelor and master programs. A site license provides students with access to Esri software.

A Call to Action

On March 11, 2011, a powerful 9.0-magnitude earthquake hit Japan, unleashing a massive tsunami that crashed into Japan's northeastern coast, resulting in widespread damage and destruction. Japanese officials soon realized that they needed to understand the extent of the damage in order to help their citizens. Satellite sensors provide global coverage so the damage caused by natural disasters can be assessed using current and historical imagery. The worldwide remote-sensing community was asked to help.

When a major disaster strikes, the International Charter on Space and Major Disasters takes effect. This charter, first initiated by the European Space Agency, provides space satellite data to relief organizations responding to these events. The US Geological Survey

← An aerial view of tsunami damage in an area north of Sendai, Japan, taken from a US Navy helicopter rendering humanitarian assistance and disaster relief following the earthquake and tsunami (Mass Communication Specialist 3rd Class Dylan McCord/Released; courtesy of Official Navy Photos, used under Attribution Common License)

(USGS) was as part of the US team of signatories to this charter. USGS, working through GISCorps, an organization composed of GIS professional volunteers, requested help processing and analyzing imagery from Japan. Winemiller, along with Christopher Blair and Sissy Speirs, two student assistants who gave up other plans for their spring break, volunteered, and AUM became one of four universities in the United States that helped process and analyze imagery related to the disaster.

Efficient Workflow When Every Second Counts

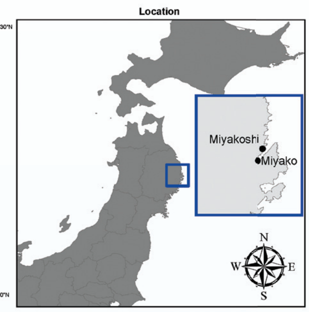
Winemiller was given access to more than 1,200 different imagery datasets. Less than two days after the disaster, the team began working on the project. They searched for imagery on the USGS Earth Resources Observation and Science (EROS) Hazards Data Distribution System (HDDS) public and restricted databases and public sites for coverage of the three areas in Japan they were assigned: Miyagi-Kamaishi, Iwate-Miyako, and Iwate-Miyakoshi.

"We were looking for images of both pre- and postdisaster to understand the changes that occurred and the amount of damage that was done," said Winemiller. "We studied the geology of the areas we were assigned to assess earthquake damage and, of course, damage from the tsunami, which was the easiest to identify."

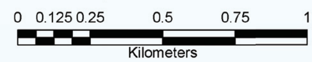
Time mattered. Winemiller's team had to sift through and process vast amounts of data from a variety of sensors and platforms. They needed to easily process and analyze this imagery and produce detailed maps. They chose ENVI image analysis software for image processing and image analysis and ArcGIS for GIS analysis and mapping production.

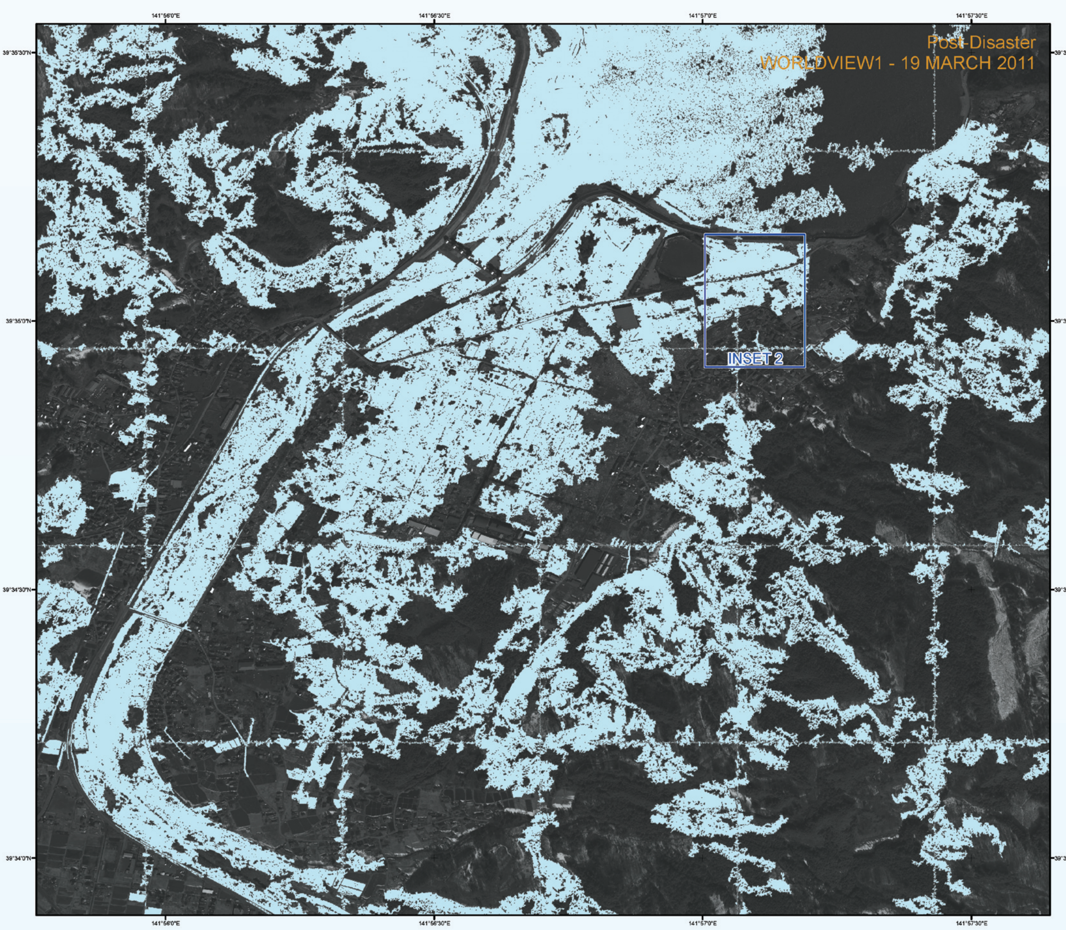
The automated image preprocessing tools in ENVI were used to prepare the imagery for viewing and additional analysis within

Tsunami Affected Areas - Miyako, Japan



Local Projection:
Geographic Coordinate System
Datum: WGS 1984
Scale: 1:8,000





Map Produced 20 March 2011
Cartography and GIS Laboratory
Auburn University at Montgomery

This map was produced in response to urgent need for geo-spatial information and interpretation. Geographic information contained herein is limited by the presence of clouds, resolution, scale, and limited time frame for change detection. Imagery analysis of the Miyako area revealed evidence of damage incurred by earthquake activity as well as tsunami. Releases will be monitored and revisions submitted as additional data are available.

← Winemiller's team processed vast amounts of data from a variety of sensors and platforms. Imagery analysis of the Miyako area revealed evidence of damage incurred from earthquake activity as well as tsunami.

↑ US Naval helicopters deliver food, donated by the city of Ebina, Japan, to survivors of the earthquake and tsunami. (Photo courtesy of the US Navy/Released Official Navy Photos, used under Attribution Common License)

ArcGIS. Imagery was resampled to create a uniform pixel count and pixel size so different images could be registered and fused together. Subsetting cropped images to focus them on areas of interest. Georeferencing established the correct position of an image relative to other images or on a map. Building a mosaic combined multiple images together into one larger scene.

After enhancement in ENVI, the images were pulled into ArcGIS to create before and after insets from the layouts of the same locations. From these insets, they created maps. The maps were uploaded to USGS, which provided them to first responders on a secure server.

"Some of the locations in Japan had little or no communication after the disaster, so the responders had no idea what was going on there," said Winemiller. "We found the layout capabilities of ArcGIS 10 to be the perfect tool because it was user-friendly, making it easy to pull in imagery. I don't think we could have done this with any other solution."

Many Imagery Sources

Imagery for this project came from sensors aboard IKONOS, SPOT, WorldView-1 and -2, QuickBird, Landsat, and many other satellites. First, the team looked through the imagery to determine coverage and see if the imagery could be used for this mission. They opened files in ENVI, which supports panchromatic, multispectral, hyperspectral, radar, thermal, and lidar imagery types. Winemiller and his students soon realized that a large percentage of the imagery required enhancement to improve clarity. They matched up images from different sources pixel for pixel and linked them together to create rasters that accurately mapped areas for damage assessment.

The need to get imagery to responders on the ground as quickly as possible limited opportunities for performing detailed image analyses. Initially, visual comparisons of the processed before and after scenes were performed to identify the areas with the most damage. Later, Winemiller used the feature extraction tool in ENVI on pre- and postearthquake imagery to identify grids, building footprints, and other items to more accurately compare images.

After the images were processed in ENVI, the team output the images as GeoTIFFs and imported them as datasets into ArcGIS, where the detailed maps were created using the enhanced and processed imagery. ENVI's advanced image analysis tools are also available directly from the ArcGIS environment for users who wish to access them through either a desktop or server environment. "The workflow between ENVI and ArcGIS was a piece of cake," said Winemiller.

Getting Maps to Responders Quickly

Satellite imagery has become a major component of postdisaster relief efforts like the one in Japan. The global coverage of satellite sensors makes them ideal for providing the imagery required when time is at a premium after a disaster.

Within 36 hours after the first request, Winemiller and his team of students had useful maps showing accurate pre- and postevent information so damage could be assessed. "Using satellite imagery with this solution enabled us to create up-to-date maps providing emergency responders in Japan with the critical situational awareness they need to understand which areas were affected, what the damage extent was, and what resources were needed," said Winemiller. "We were happy to help our global neighbors and provide our students with a terrific learning opportunity involving a real-world situation."

For more information, contact Dr. Terance L. Winemiller, PhD, GISP, at 334-244-3945 or twinemi1@aum.edu.

Photogrammetric Modeling + GIS

Better methods for working with mesh data

By Rachel Opitz, University of Arkansas, and Jessica Nowlin, Brown University

The authors describe how to bring photogrammetrically derived meshes into a GIS so that the 3D relationships between features can be easily understood, descriptive data can be integrated, and spatial analysis tools in GIS can support analysis and interpretation after the field project has ended.

Photogrammetric Survey in Archaeology

Close-range photogrammetric survey is increasingly popular as a recording method in archaeology. Photogrammetric survey uses a series of photographs of an object to deduce and accurately model its geometry.

This technique is commonly used to document features with complex geometries or large numbers of inclusions, including walls, pavements, rubble collapse, and architectural elements. These types of features can be quite time-consuming to document thoroughly by hand or using conventional surveying in the field.

The use of photogrammetric recording can greatly benefit projects by saving time and creating a visually rich final product. Photogrammetric models might be used in excavation to record a complex sequence of walls or a tomb or on a survey to document the environment around a rock art panel.

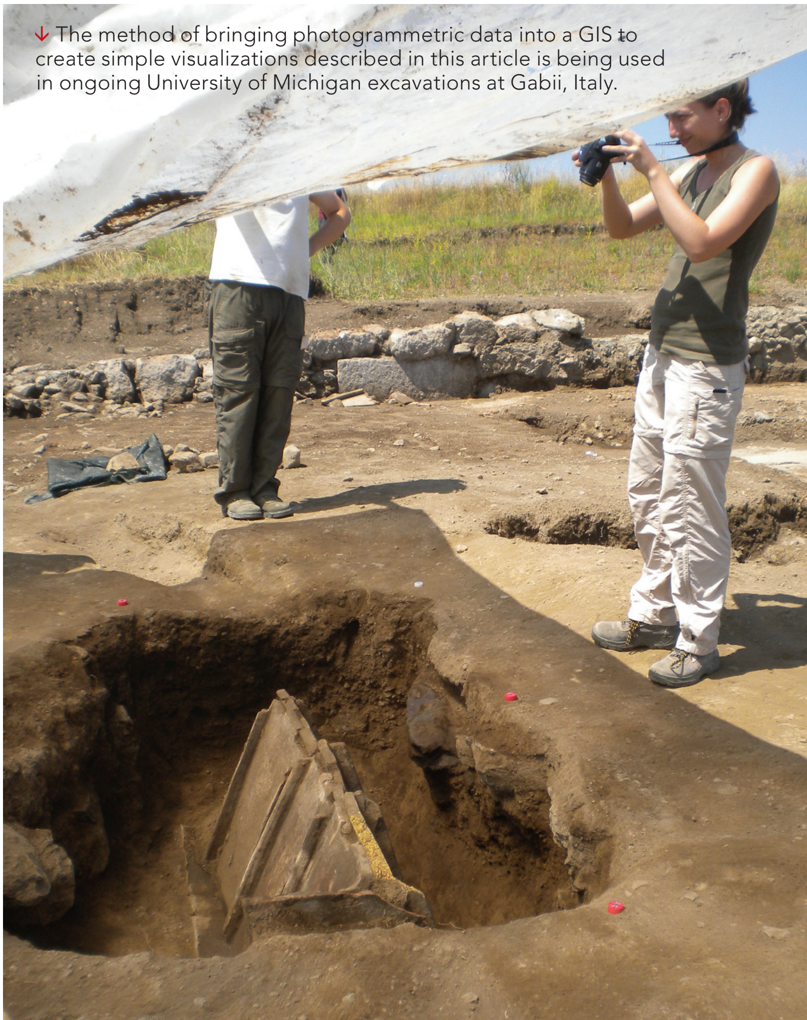
Photogrammetric models are typically assembled and processed in specialized software including PhotoModeler Scanner (www.photomodeler.com), Autodesk's 123D Catch (www.123dapp.com/catch), and Agisoft's PhotoScan (www.agisoft.ru/products/photoscan). Information on photogrammetric modeling is available from these companies.

A typical final product from a photogrammetry project is a textured polygonal mesh combining color and geometry data. In archaeology, the geometry of the features recorded is often complex, and both the position and shape of these features are important, so keeping the data in a mesh format—designed to handle complex geometries— is desirable rather than converting to a simpler geometry type or a voxel model. *[Voxel models use elements that represent a value on a regular grid in three-dimensional space.]*

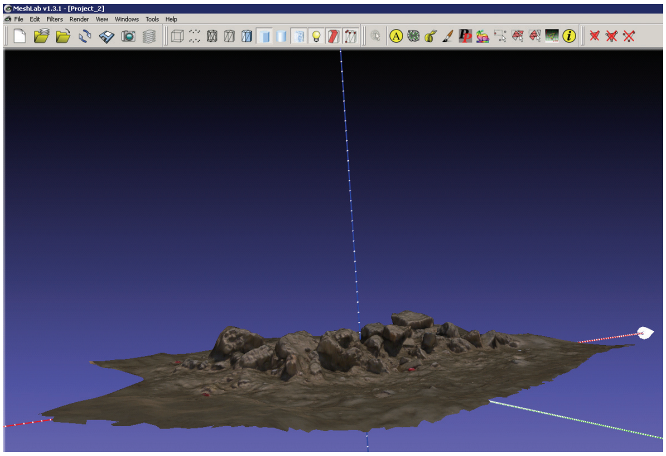
Looking at these models on their own can be useful, but to really exploit their potential, they should be viewed in context along with other data, such as survey data, photos, descriptions, and models of adjacent features that are collected in the course of a project.

Why Manage Photogrammetric Models in ArcGIS?

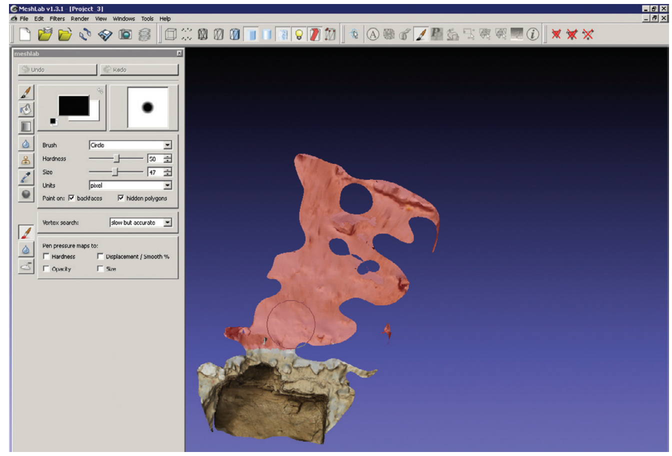
Many excavations already use ArcGIS to manage their spatial data and maintain links with other relational databases containing information such as stratigraphy, environmental data, ceramics, and osteology. Managing the results of photogrammetric surveys within an existing GIS environment is a practical solution to the problems of organizing, visualizing, and creating documentation from the 3D models. Bringing the models into a GIS facilitates the integration of photogrammetric and conventional survey data, making it easy to place the photogrammetric models in their proper locations. Finally, storing the models in ArcGIS allows archaeologists and managers to continue to work in a familiar software environment.



↓ The method of bringing photogrammetric data into a GIS to create simple visualizations described in this article is being used in ongoing University of Michigan excavations at Gabii, Italy.



↑ A textured mesh of a typical archaeological feature, a pile of rubble, viewed in Meshlab



↑ Working in Meshlab, unwanted polygon faces are selected and deleted.

The Basic Process

Much of the work required to bring photogrammetrically derived meshes into a GIS involves the production of a clean mesh. Once this is achieved, importing the mesh into the GIS is straightforward using the tools provided through the ArcGIS 3D Analyst extension. The creation of related information (making polygonal models of individual features, adding written descriptions, associating finds or sample data) can take advantage of GIS functionality for connecting to relational databases and managing attribute data.

The process of bringing photogrammetric data into a GIS and using it to create some simple visualizations is outlined here using an example from the ongoing University of Michigan excavations at Gabii, Italy. There are three phases for the ingestion of each model: the creation and cleaning of the mesh; proper formatting for import into the GIS; and geolocation of the mesh, along with the creation or linking of related information and metadata.

The Initial Mesh

The mesh produced by photogrammetric modeling software will be (substantially) internally consistent but without real-world coordinates or a sense of orientation. ArcGIS does not support editing individual nodes or faces of a multipatch, so it's essential that you clean the mesh data before importing it. Closing holes, removing any areas of extraneous data, and despiking are all done at this stage. There are a number of commercial and open source software packages designed for mesh editing. Meshlab (meshlab.sourceforge.net), a popular open source product for mesh creation and editing, is being used for the Gabii Project.

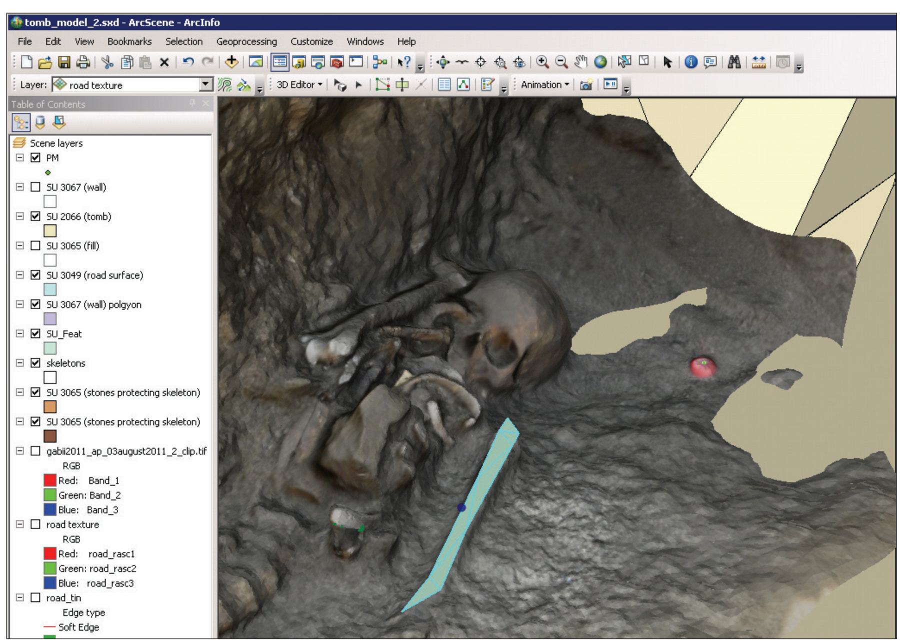
Export from Modeling Software

ArcGIS imports both VRML and COLLADA format files. Most photogrammetric and mesh editing software packages export to these formats. To minimize file sizes and improve performance, export files without color or normal data appended, as ArcGIS only uses the texture files.

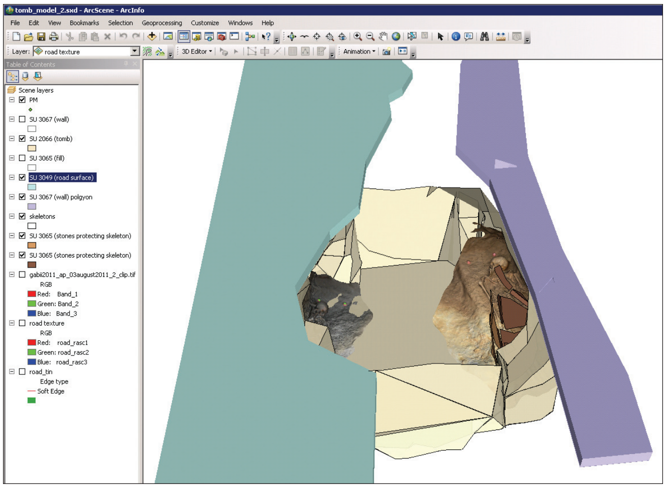
Creating good texture data is an important part of making models look right. Large, high-quality textures will look good but likely cause navigation to be slow and jumpy. Producing optimized textures, including enough detail to support interpretation but without slowing navigation on-screen, is therefore an important step. Using optimized textures where possible can make a big difference in the performance of the final model.

Import and Transformation: 3D Pseudoreferencing

Mesh data needs to be aligned with surveyed data to get the



↑ Top-up digitizing tasks, like producing a georeferenced sketch of a skeleton, are done using the photogrammetric model, snapping the polygons to the mesh while outlining individual bones.

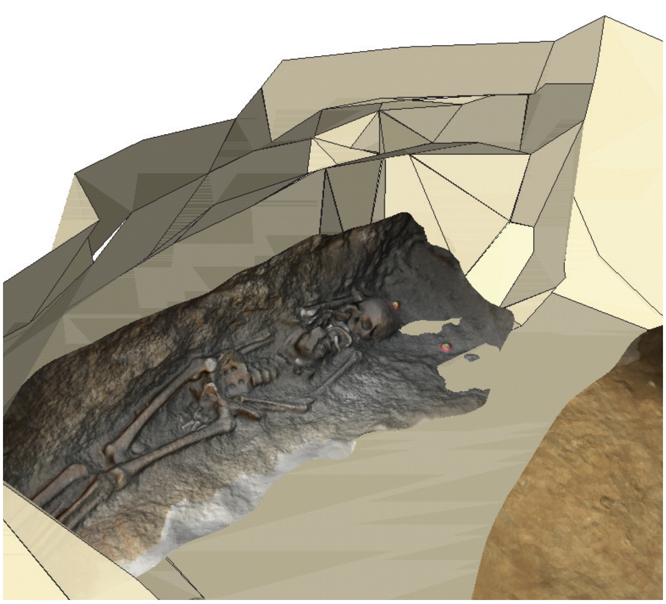


↑ The relationships between features are easily communicated through visually rich models.

models into their real-world locations. One approach is to survey in points on targets that appear in the photogrammetric model. Another approach is to survey in key components or a simplified outline of the feature in question, to which natural features in the model can be aligned. For good results, at least three reference features distributed across the model are needed.

Related Data: Creating Features on the Mesh

Using the 3D editing tools in ArcScene, polygons, polylines, and points representing individual features like a bone, pot, or stone can be digitized directly onto the model. These digitized features can then be used for simplified representations of the model, in the creation of 2D plans, or for spatial analyses in the GIS. Alternatively, this characterization could be carried out in the modeling software and imported and transformed in parallel with the model. Relationships between the models, digitized features, and descriptive attributes are maintained within the geodatabase.



Working with Mesh Data in a GIS Environment

Importing the models created through photogrammetric survey into a GIS makes it easy to understand at a glance the 3D relationships between features. Integrating these visually rich models with descriptive data and providing easy access to spatial analysis tools through the GIS supports analysis and interpretation after the field project has ended or when working in the lab. And, of course, 3D models make for compelling visualizations for use in teaching and publication, helping students, researchers, and the public explore and understand the archaeology.

For more information, contact Rachel Opitz, Center for Advanced Spatial Technologies (CAST), University of Arkansas, at ropitz@cast.uark.edu.

Detailed workflows for bringing mesh data into ArcGIS can be found at the CAST GeoMetaVerse (gmv.cast.uark.edu).

More information about the Gabii Project can be found at sitemaker.umich.edu/gabiiproject/home. The Gabii Project is supported by a grant from the US National Endowment for the Humanities.

Acknowledgments

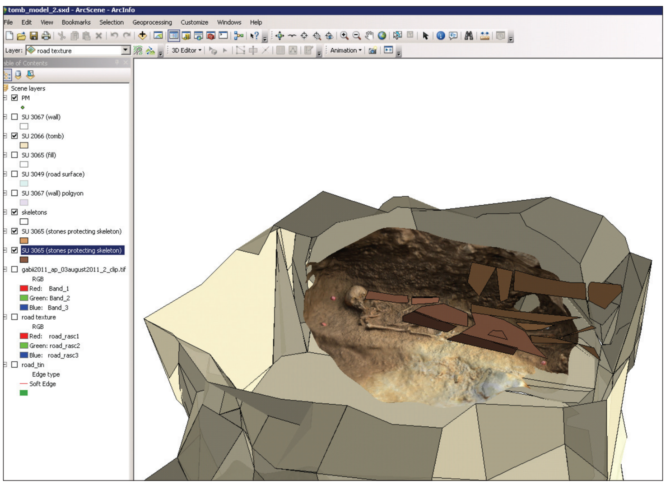
Special thanks to Soprintendenza Speciale per i Beni Archeologici di Roma (Dr. Anna Maria Moretti and Dr. Stefano Musco) for their ongoing support of the Gabii Project.

↓ (Left and below) The imported mesh is aligned with surveyed reference targets (green points and red bottle caps), and its alignment with surrounding features is checked.

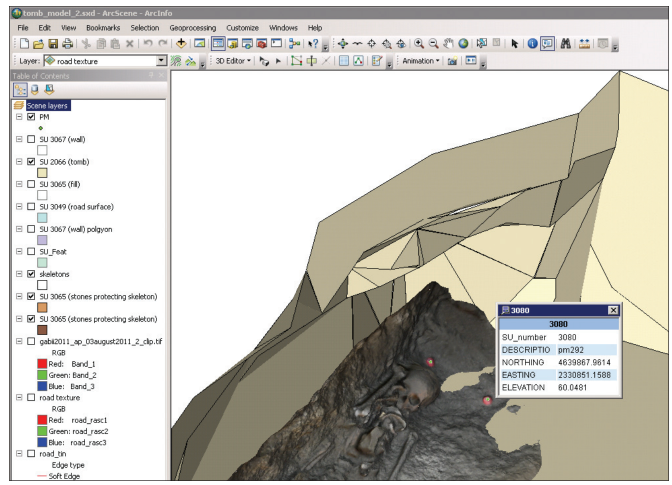
About the Authors

Rachel Opitz received a doctorate in archaeology from the University of Cambridge in 2009. She works for the Center for Advanced Spatial Technologies at the University of Arkansas and leads the GIS and Survey team for the University of Michigan excavations at Gabii, Italy. Her research interests include landscape archaeology, GIS, and laser scanning.

Jessica Nowlin is a doctoral candidate at the Joukowsky Institute for Archaeology and the Ancient World at Brown University. Her research interests include landscape archaeology, the application of GIS and remote sensing, economy and trade, road networks and boundaries, public archaeology, and archaeological ethics. She leads the photogrammetric survey for the University of Michigan excavations at Gabii, Italy.



↑ Mesh data can be viewed in combination with surveyed features. The skeleton, modeled using photogrammetric survey, can be seen with the slabs placed over it at the time of burial, modeled from survey data.

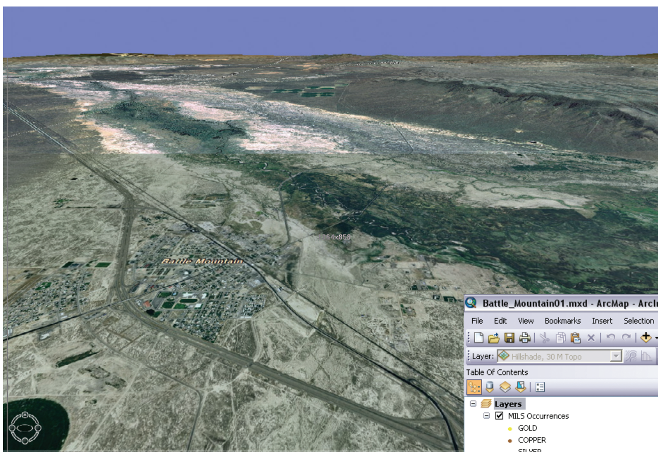


↑ Metadata, like the model number and stratigraphic unit number, can be stored in related point and polygon feature classes.

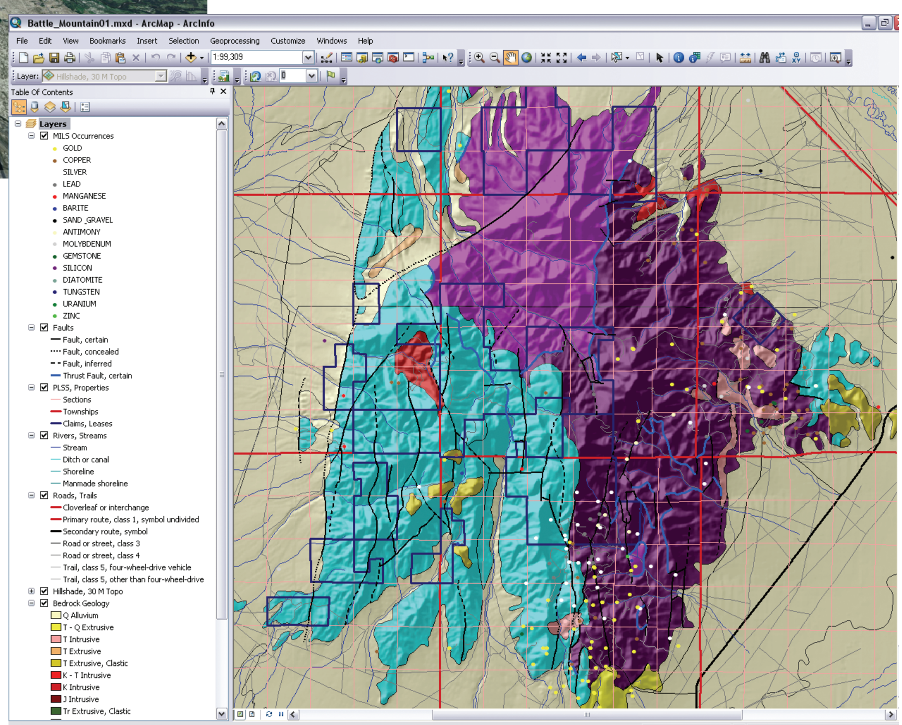
Importing Data from Excel Spreadsheets

Dos, don'ts, and updated procedures for ArcGIS 10

By Mike Price, Entrada/San Juan, Inc.



← This exercise models data from a well-known gold and base metals mining area in northern Nevada located near the town of Battle Mountain.



↓ Although the sample data is synthetic, it is true to the underlying geology of Battle Mountain, Nevada.

Many organizations keep valuable data in Microsoft Excel and comma-separated values (CSV) files. Learn a methodology for importing data kept in Excel and CSV files into ArcGIS that has been updated for ArcGIS 10 and Microsoft Office 2007/2010.

Excel spreadsheets have been used since the release of ArcGIS 8 to prepare and import tabular data into a GIS. Previous *ArcUser* articles described the benefits and limitations of spreadsheets in the version of ArcGIS current at that time. In early 2004, *ArcUser* editor Monica Pratt wrote "Working with Excel in ArcGIS" (esri.com/news/arcuser/0104/files/excel.pdf). In 2007, the author wrote another article on the same topic, "Mapping and Modeling Groundwater Geochemistry" (esri.com/news/arcuser/0207/files/groundwater.pdf).

Since these articles were published, Microsoft has released two new versions, Excel 2007 and Excel 2010. With each release, spreadsheet capabilities have improved and the processes for importing data into ArcGIS have changed. This article updates and refines rules and procedures for importing Excel 2003 files into ArcGIS 9.x.

This exercise reexamines the Excel spreadsheet as a data import tool, focusing on ArcGIS 10 and Excel 2007/2010. The tutorial uses spreadsheets to create and enhance geologic data. Field samples include Hydrogeochemical Stream Sediment Reconnaissance (HSSR) points plus custom soil and rock data. In this exercise, we will model a well-known gold and base metals mining area in northern Nevada, located near the town of Battle Mountain. The custom samples are typical of data that might come from the field, assayed by a modern analytic laboratory.

What You Will Need

- ArcGIS 10 for Desktop
- Microsoft Excel 2010/2007 or 2003 or the 2007 Office System Driver
- Sample dataset from the *ArcUser* website

A Word about Microsoft Excel Versions

If you have installed Office 2007, you can read .xls and .xlsx files. If you have Office 2003 or 2010 installed, you can read .xls files, but you will need to install the 2007 Office System Driver to read .xlsx files.

If you do not have Microsoft Excel installed, you must install the 2007 driver before you can use either .xls or .xlsx files. The 2007 Office System Driver can be downloaded from the Microsoft Download Center at links.esri.com/office_07_sysdriver. Carefully follow the installation instructions before you restart ArcGIS.

Also, if you have previously specified on the File Types tab of the Customize > ArcCatalog Options dialog box that ArcCatalog show you .xls files, you'll need to remove this file type to be able to access Excel files directly.

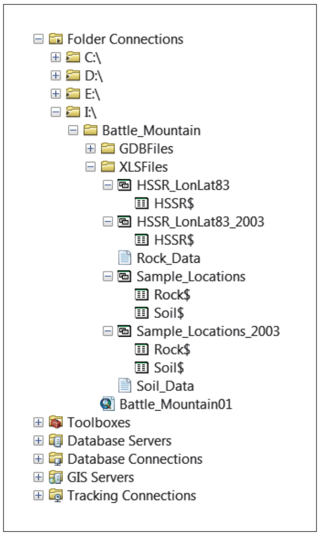
Before beginning to work the exercise, read the accompanying article, "Best Practices When Using Excel Files with ArcGIS," for valuable tips on working with Excel data.

Getting Started: Examining Files in ArcCatalog

To begin this exercise, go to the *ArcUser* website and download the training data, excelmagic.zip. Unzip the excelmagic.zip data into a project area on your local machine and start ArcCatalog.

Navigate to the Battle_Mountain folder and locate the XLSFiles folder. When ArcCatalog displays an Excel file, it adds a dollar sign ($) to each worksheet name. Inside this folder, expand all files. Locate Sample_Locations.xlsx and preview Rock$. This Excel 2010 spreadsheet contains two worksheets named Rock$ and Soil$. Rock$ and Soil$ contain sample numbers, universal transverse Mercator (UTM) coordinates, and field information that allow this data to be posted on a map. Next, preview HSSR_LonLat83.xlsx and study its only worksheet, HSSR$.

Next, locate and preview two CSV files, Rock_Data and Soil_Data. These files



↑ Preview the sample data in ArcCatalog.

Best Practices When Using Excel Files with ArcGIS

How many times have you imported spreadsheet data into ArcGIS only to find some cells empty or formatted with an unwanted field type? To avoid these and other problems, follow these practices when creating and maintaining data in Excel you will use in ArcGIS.

1. When creating spreadsheets, make sure fields are fewer than 255 characters.

ArcGIS reads the first 255 field characters. Fields with more than 255 characters are converted to BLOB fields and are not readable. Abbreviate, manually truncate, or split any fields longer than 255 characters.

2. Check the numeric field type before and after importing Excel data.

ArcGIS typically converts spreadsheet numeric fields to double precision (Double), which may not meet your needs. If necessary, create new fields of the desired type and calculate values into them.

3. Check the format for date fields.

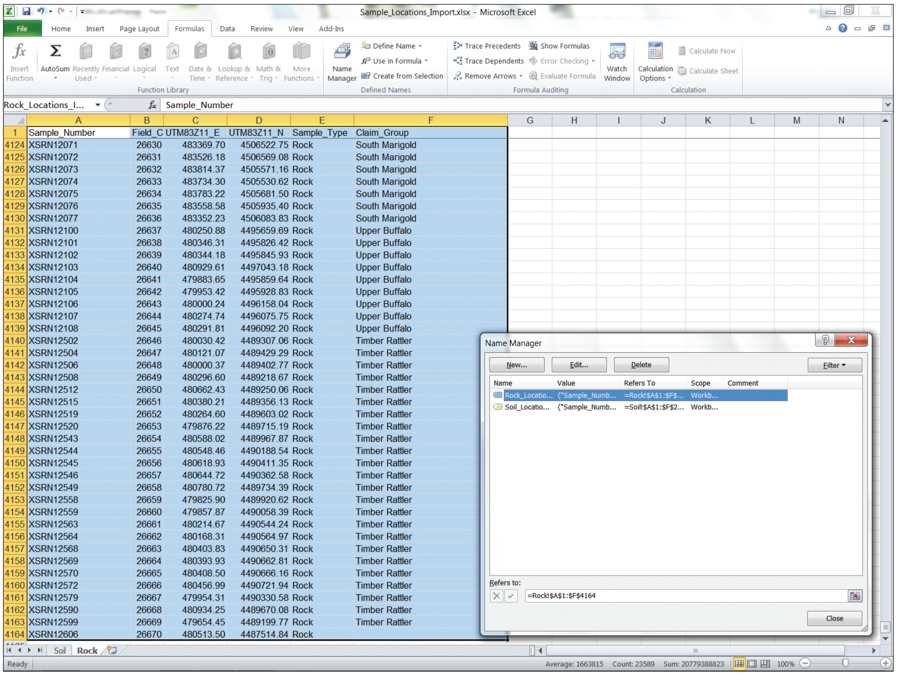
ArcGIS 10 uses the Lotus date/time format. In this format, the calendar date is represented by a whole number value that represents the number of days since January 1, 1900, plus one day (due to a bug in Lotus 123 and carried over to Excel). Time is represented as the decimal portion of a 24-hour day. If date/time data is important, format the input spreadsheet using a standard Excel date/time format.

4. Follow ArcGIS field naming rules when creating Excel column names.

The first row of an Excel worksheet sets the name for each column. Column names become field names when an Excel worksheet is imported into ArcGIS. Always follow these naming rules:

- Column/Field names must begin with a letter.
- Column/Field names must contain only letters, numbers, and the underscore character.
- Column/Field names must be no more than 64 characters. If a name is longer than 64 characters, ArcGIS retains the first 63 characters.
- Column/Field names may not consist solely of reserved words. Do not use these words in field names. See support.microsoft.com/kb/286335 for the list of reserved words. ArcGIS typically adds a trailing underscore to reserved word field names added by copying and pasting from other sources.
- Column/Field naming rules also apply to named ranges imported from Excel.

For more information, search ArcGIS 10.0 web help for *Excel worksheet*.



↑ After field names have been corrected, create a named range in Excel called Rock_Locations_Import_R.

contain companion analytic data for the Rock$ and Soil$ worksheets. The [SAMPLENO] field in both CSV files will support a one-to-one tabular join with the same field in the Soil$ and Rock$ worksheets.

Closely inspect the alignment of data in Soil_Data columns. Notice that [SAMPLENO] and [SB_PPM] are aligned on the left side of the column while [AU_PPB], [AG_PPM], [AS_PPM], and [HG_PPB] are aligned on the right. Scroll down through the table and observe that many fields in the right-aligned columns are empty. In the source CSV file, many of the fields contain nonnumeric strings that do not display properly.

Notice that [SB_PPM], a left-aligned field, contains many fields that begin with a less than (<) character. When a geochemical lab is unable to measure the presence of an element, the analytic posting will include a less than character, followed by the detection limit value. In [SB_PPM], the detection limit for antimony is five parts per million, and many samples contain less than this threshold value.

When ArcGIS reads an Excel worksheet table, it uses the first eight rows to define the field format. If those first eight rows contain mixed data types in a single field, that field will be converted to a string field, and the values contained in that field will be converted to strings. When ArcGIS reads a CSV file, the very first record defines the field type. Consequently, some rather detailed data preparation will be necessary before you can use these files. The next step will be to prepare the spreadsheet and CSV data for import into ArcGIS. Close ArcCatalog.

Preparing Excel Data for Importation

These detailed instructions are specifically for Excel 2007 and Excel 2010. If you want to try this exercise using Excel 2003, open Sample_Locations_2003.xls instead.

1. Start Excel 2007 or 2010 and open \Battle_Mountain\XLSFiles\Sample_Locations.xlsx. Open the Soil worksheet and inspect the data. This location table contains 20,096 soil sample points, posted in UTM North American Datum 1983 (NAD83) Zone 11 Meters. Coordinates are posted and displayed using a precision of 0.01 meters. Many samples are coded by Claim Group.
2. Save this spreadsheet as a new file so you can retain the original data as an archive. Name the new file Sample_Locations_Import.xls.
3. Click the Soil$ worksheet and look at the first row of data. Many text strings in this row contain spaces. Change these spaces to underscores. (Hint: Select only the first row and use Find and Replace.)
4. Next, clarify the coordinate system columns. Change Easting to UTM83Z11_E and Northing to UTM83Z11_N.
5. Now define a named range. Move to cell A1. Notice that the titles are locked, so tap the F8 key to begin to extend a cell range. Hold down the Ctrl key and tap End to stretch the range (highlighted in cyan) to the lowest rightmost cell. Make sure the header fields are included in the highlighted area.
6. In the Excel ribbon, select Formulas, click Name Manager, and click the New button. Name the new range Soil_Locations_Import_R. Click OK and close the Name Manager.
7. Press the Ctrl and Home keys to return to the upper left live cell. Click the Name Box drop-down, located just above cell A1, to select and verify your range name. Save the spreadsheet file.
8. Switch to the Rock$ worksheet and review this data. Make the same types of modifications to this worksheet to enforce correct field naming conventions. Make sure you have appropriate field names in the first row. (Hint: The tabular structure for the Soil$ and Rock$ worksheets is the same, so you can use the same procedure you used on Soil$.) Create a new range name called Rock_Locations_Import. Verify the new range and save the file.

Prepare a Composite Spreadsheet

HSSR_LonLat83.xlsx contains 96 sample sites collected as part of the HSSR back in the 1970s and 1980s. This data is often used as part of a regional reconnaissance program. Prepare the HSSR data for import.

1. In Excel, open HSSR_LonLat83.xlsx. Save a copy to work with and name it HSSR_LonLat83_Import.xlsx. Inspect this data and fix any field headers that don't follow the rules. Make sure to check for spaces in field header names.
2. The major fix will be to change the percent (%) symbol to the letters PCT. Use Replace by selecting the first row and pressing Ctrl + R to perform that task quickly.
3. Create a named range called HSSR_Import_R and make sure it includes those header fields. Save this file.

Managing CSV Files in a Text Editor

Now to prepare the Rock and Soil analytic data for proper import—a much more difficult task. First, you will use a text editor to prepare Soil_Data.csv.

1. Using Windows Explorer (or another file manager), navigate to \Battle_Mountain\XLSFiles and open Soil_Data.csv in WordPad. (Note: If CSV files are opened in Excel by default on your machine, right-click the file, choose Open With, and select WordPad.)
2. Immediately save this file as Soil_Data_Import.csv.
3. Notice that field names are properly constructed and that much of the analytic data is numeric. However, there are many records that contain < characters before a numeric value.

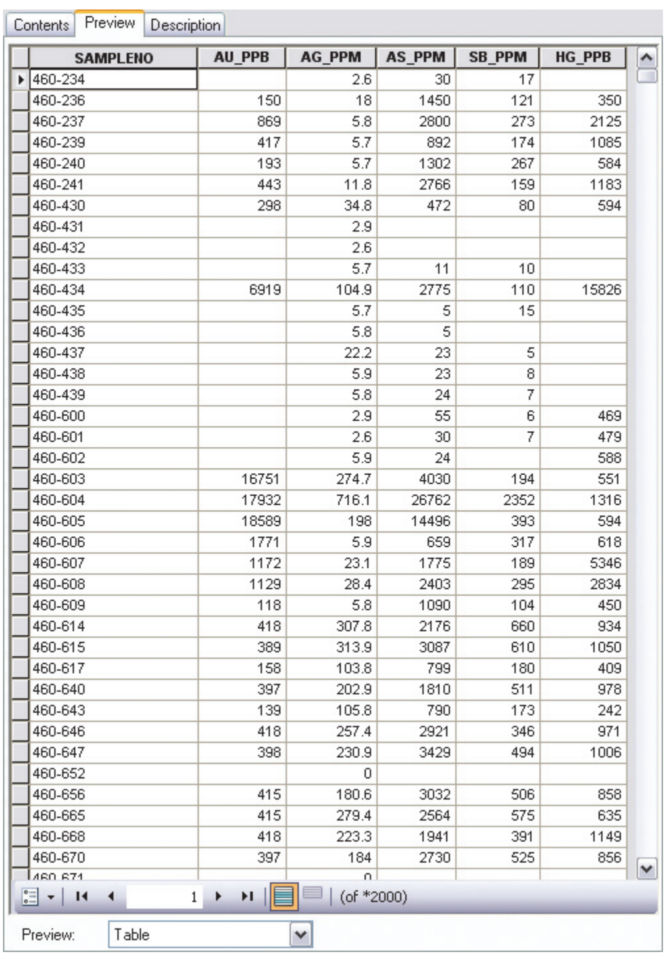
These records each contain less than the minimum detectable amount of a specific element. Sometimes, a sample contains more than a maximum detectable amount. These samples are usually coded with a greater than (>) symbol (e.g., >10,000 for gold). Fortunately, the over-limit samples in this dataset have already been resolved, so only the less than values need fixing.

Since it is statistically meaningful to recognize that some small amount of each element exists in all samples, it is not appropriate to change all < values to zero. Instead, change them to a smaller absolute value, typically 20 to 50 percent of the detection limit. Take a more conservative approach and use 20 percent. Table 1 lists the current value and smaller absolute value for elements below the minimum detection limit.

Element	Abbr.	Unit	Detection Limit	Change From	Change To
Antimony	Sb	PPM	5.0 ppm	<5	1
Arsenic	As	PPM	5.0 ppm	<5	1
Gold	Au	PPB	5.0 ppb	<5	1
Mercury	Hg	PPB	10.0 ppb	<10	2
Silver	Ag	PPM	0.5 ppm	<0.5	0.1

↑ Table 1: Elements below detection limit in sample data

4. In WordPad, move to the top of the document and begin by replacing the values for antimony. Select Replace (shortcut: press and hold the Ctrl and H keys) and (based on the values shown in Table 1) set Find to < 0.5 and Replace All to 0.1. Use Find and Replace All to change all values below the detection limit for arsenic, gold, mercury, and silver with the values shown in Table 1. When finished with the last element, perform one more Find for both < and > symbols to confirm that all the above and below limit values were found. You will see that the one sample below the minimum level for silver (Ag) was listed as <0.2 rather than <0.5. Change it to 0.1. Save and close the file.



SAMPLENO	AU_PPB	AG_PPM	AS_PPM	SB_PPM	HG_PPB
460-234		2.6	30	17	
460-236	150	18	1450	121	350
460-237	869	5.8	2800	273	2125
460-239	417	5.7	892	174	1085
460-240	193	5.7	1302	267	584
460-241	443	11.8	2766	159	1183
460-430	298	34.8	472	80	594
460-431		2.9			
460-432		2.6			
460-433		5.7	11	10	
460-434	6919	104.9	2775	110	15826
460-435		5.7	5	15	
460-436		5.8	5		
460-437		22.2	23	5	
460-438		5.9	23	8	
460-439		5.8	24	7	
460-600		2.9	55	6	469
460-601		2.6	30	7	479
460-602		5.9	24		588
460-603	16751	274.7	4030	194	551
460-604	17932	716.1	26762	2352	1316
460-605	18589	198	14496	393	594
460-606	1771	5.9	659	317	618
460-607	1172	23.1	1775	189	5346
460-608	1129	28.4	2403	295	2834
460-609	118	5.8	1090	104	450
460-614	418	307.8	2176	660	934
460-615	389	313.9	3087	610	1050
460-617	158	103.8	799	180	409
460-640	397	202.9	1810	511	978
460-643	139	105.8	790	173	242
460-646	418	257.4	2921	346	971
460-647	398	230.9	3429	494	1006
460-652		0			
460-656	415	180.6	3032	506	858
460-665	415	279.4	2564	575	635
460-668	418	223.3	1941	391	1149
460-670	397	184	2730	525	856
460-671		0			

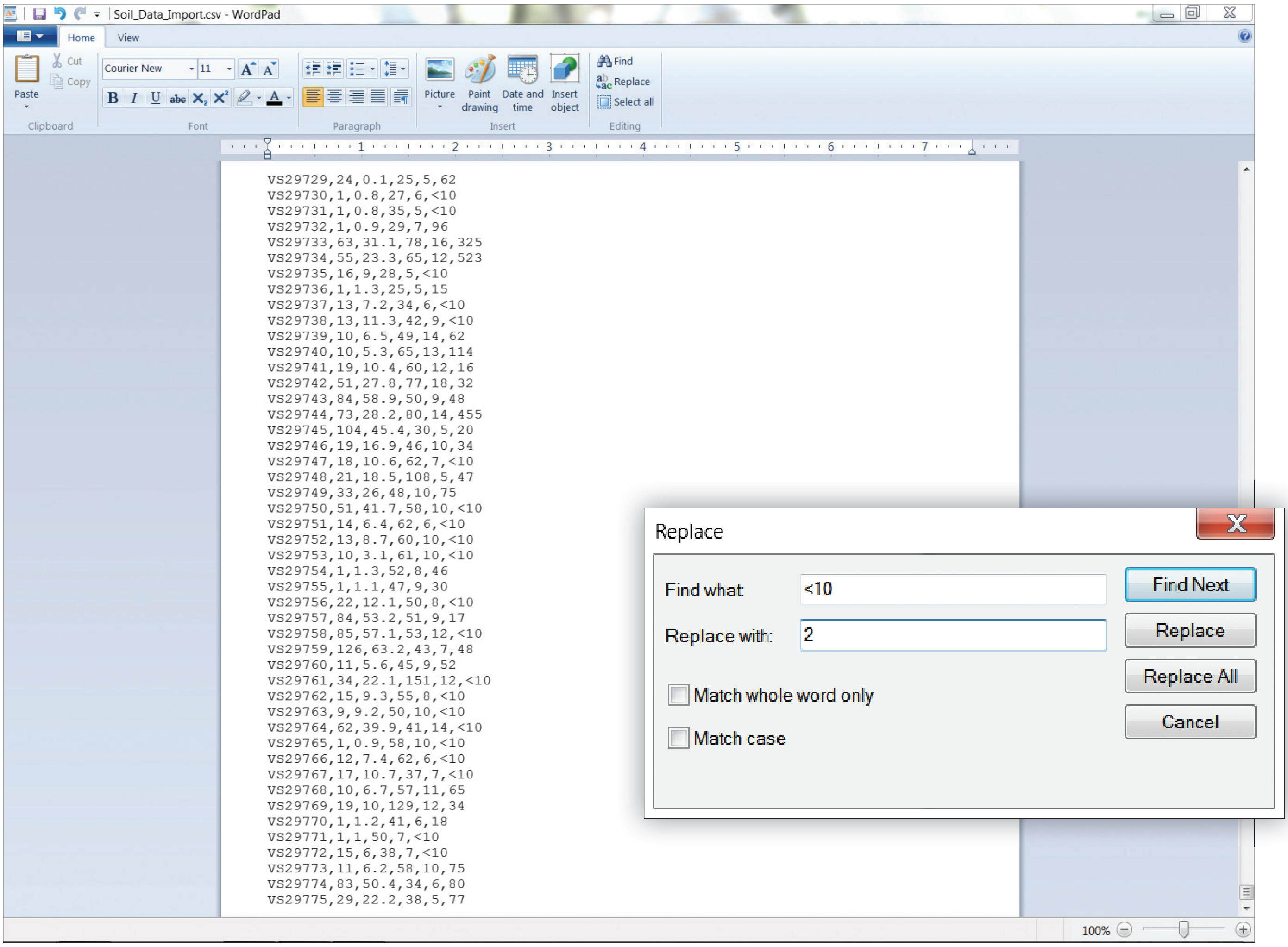
↑ When CSV files are viewed in ArcCatalog, many records have blank fields.

Managing CSV Files in Excel

Now, try a similar approach with Rock_Data.csv, using Excel to replace undesirable values. This approach is much more powerful, but also dangerous.

The danger with using Excel to edit and format analytic data lies in how it uses leading zeros to manage alphanumeric strings when all other characters are numeric. Excel tends to convert leading zero strings to numeric values, which forever changes the data. This can be especially dangerous when working with datasets such as tax parcels and lab samples. However, if the file is saved from Excel back into a CSV file, the leading zeros are gone forever and there are no problems.

1. In Windows Explorer, find Rock_Data.csv and open it in Excel. Immediately save the file as Rock_Data_Import.xls so you have the original CSV file and this copy in Excel.
2. Inspect the file and look for improper field names and inappropriate data formats. Note that numeric data aligns on the right side of a cell, while alphanumeric data aligns on the left. Note that alphanumeric data that did not show up in most fields when previewed in ArcCatalog is now visible in Excel.
3. Repeat the same Find and Replace All steps performed on Soil_Data_Import.csv in WordPad using the replacement values in Table 1. Note that the numeric values align on the right.
4. Search for the < and > characters to confirm that all the above and below limit values have been found. Another sample below ➔



↑ When the same file is viewed in WordPad, blank fields contain values preceded by a < or > symbol. These indicate values below the detection limits and will be replaced using values in Table 1.

the minimum level for silver (Ag) was listed as <0.2 rather than <0.5. Edit the cell manually to change the value to 0.1. Save the file.

5. Next, manually format columns to reinforce numeric data formats. Select Column A by right-clicking its header, select Format Cells, and choose Text. Right-click columns B, D, E, and F and format as Number with no (0) decimal places. Right-click Column C and format as Number with one decimal place.
6. Save the file as a CSV file, then reopen it in Excel and save it as an XLS file.
7. In the last step in preparing the Rock_Data_Import.xls, create a named range containing all the cells and name it Rock_Data_Import. Now the data can be imported into an ArcGIS geodatabase. Save the file and close Excel.

Building the Geodatabase (Finally)

As the final step in this exercise, you will create a geochemistry geodatabase and import the Excel named ranges and CSV files.

1. Open ArcCatalog and navigate to \Battle_Mountain\GDBFiles. Preview the Battle_Mountain.mxd file and review the layer files and the geodatabase layers in the Battle_Mountain file geodatabase.
2. Right-click the Battle_Mountain\GDBFiles folder, select New > File Geodatabase, and name it Geochemistry.
3. First, test a single table import of an Excel named range by right-clicking the new Geochemistry geodatabase and selecting Import > Table (single).
4. In the Table to Table wizard, set Input Rows by browsing to \Battle_Mountain\XLSFiles and opening Sample_Location_Import.xls. In the Input Rows dialog box, select Rock_Locations_Import_R.xls, the named range created previously. Name the output table Rock_Locations_Import, accept all other defaults, and click OK. The rock sample locations are added as a geodatabase table.
5. Open the table and verify that the import was successful. Pay special attention to field names and formats to make sure they were imported correctly. If not, check that you imported the correct file and that the named range included the field names. Make any corrections and reimport the file.
6. Continue populating the geodatabase by adding the rest of the tables. Right-click the Geochemistry geodatabase and select Import > Table (multiple).
7. In the Table to Geodatabase (multiple) wizard, load all remaining

tables, including three tables created from Excel tables located in \Battle_Mountain\XLSFiles:

- \Sample_Locations_Import.xls\Soil_Locations_Import_R
- \HSSR_LonLat83.xls\HSSR_Import_R
- \Rock_Data_Import.xlsx\Rock_Data_Import_R

and one CSV file:
\Soil_Data_Import.csv.

8. Click OK and watch as the four files are imported.

Because you carefully defined these import datasets, the ArcGIS data geoprocessing function readily uses the assigned names.

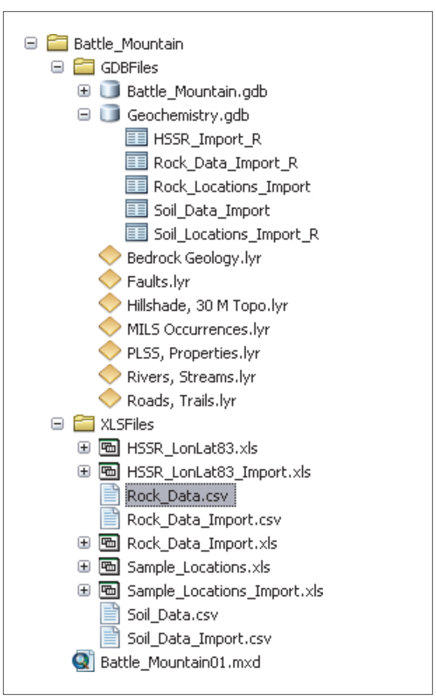
Finally, open each table in ArcCatalog and verify field names, formats, and record counts. You successfully outmaneuvered those tricky % characters. Finally, remove the _Import from each geodatabase table name and take a break.

Conclusion

If you preview the Battle Mountain geologic map or open the Battle Mountain MXD, you will see the bedrock geology, geologic structure, and mineral occurrences in the study area. Wouldn't it be interesting to place all these rock, soil, and stream sediment samples in this model and go prospecting? This model is designed to do just that. The geochemical data can be used to analyze favorable ratios between multiple elements, define spatial relationships between rock units and faulting, and compare your data to current mines and past producers.

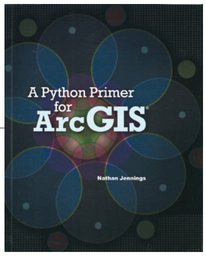
Acknowledgments

The data used in this exercise was originally developed as part of an ArcView GIS 3 mining training program. While the sample data is synthetic, it is true to the underlying geology. While landownership is imaginary, it reflects exploration trends around Battle Mountain, Nevada, in the early 1990s. Bedrock geology was derived from the Nevada Bureau of Mines and Geology County mapping series. HSSR data was developed through the US Department of Energy National Uranium Resource Evaluation (NURE) program. All data has been transformed from UTM North American Datum 1927 (NAD27) into the current NAD83 datum.



↑ Once all tables have been carefully prepared, they are imported into a new file geodatabase called Geochemistry.

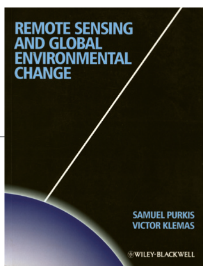
GIS Bookshelf



A Python Primer for ArcGIS

By Nathan Jennings

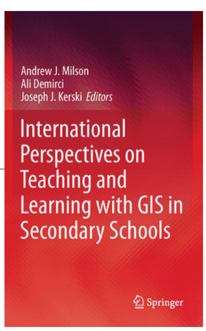
This workbook was written with the GIS user in mind. Rather than a text on the Python language, it is an introduction to using Python for ArcGIS geoprocesses. Written for ArcGIS 10, it teaches how to develop stand-alone Python scripts that accomplish geoprocessing tasks and can be run both inside and outside ArcGIS. It provides a systematic method for learning the elements of Python programming used in ArcGIS. The author, Nathan Jennings, is a full-time GIS professional with the City of Sacramento, California, who teaches courses in GIS programming, remote sensing, web map application development, GPS, and GIS software at American River and Sacramento City Colleges. CreateSpace, 2011, 458 pp., ISBN: 978-1466274594



Remote Sensing and Global Environmental Change

By Sam J. Purkis and Victor V. Klemas

Rather than providing extensive information on sensor specifications and operation, this book presents the fundamentals of remote-sensing technology and concentrates on the application of this technology in assessing the health of atmosphere, cryosphere, oceans, coastal areas, freshwater systems, and land cover and devotes a chapter to each. The target audience for this book is advanced undergraduate and graduate students in earth science, environmental science, or physical geography. However, it is a valuable reference for GIS professionals who use remote-sensing data for monitoring and mapping environmental change at regional and global scales. Wiley-Blackwell, 2011, 384 pp., ISBN: 978-1405182256

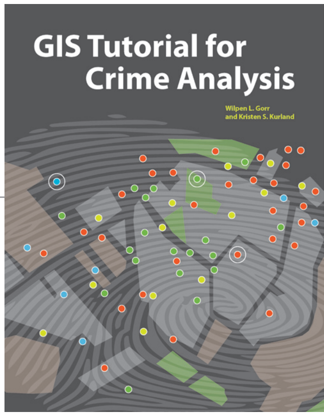


International Perspectives on Teaching and Learning with GIS in Secondary Schools

Edited by Andrew J. Milson, Ali Demirci, and Joseph Kerski

This book is the first publication to provide an international perspective on the pedagogical value of GIS technology in classrooms and offer a range of views on the subject. This book provides a truly global perspective: authors from 33 countries contributed, and countries from six continents are represented. GIS has revolutionized the way people explore and understand the world around them, and its effects are felt in the classroom. Instructors are using this technology in secondary-school classrooms worldwide to teach social and scientific concepts and processes, broaden students' technical skills, and sharpen problem-solving skills. Each country chapter includes a summary of the country's educational context, a case study illustrating how GIS is used in secondary schooling, and an assessment of the opportunities and challenges in teaching and learning with GIS now and in the future. The book ends with some reflections on the progress made in teaching and learning with GIS over the past 20 years, key trends for the remainder of this decade, and recommendations for meeting the goal of engaging all students in thinking spatially. Springer, 2012, 353 pp., ISBN: 978-9400721197

GIS Tutorial for Crime Analysis



By Wilpen L. Gorr and Kristen S. Kurland

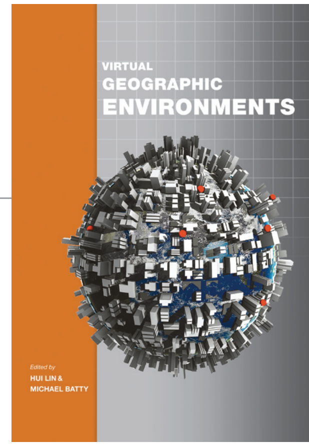
While the goal of this GIS workbook—to teach crime mapping and analysis skills using ArcGIS 10 software—is narrowly defined, the target audience is broad. Working GIS professionals, as well as people new to GIS and crime analysis, can benefit from the exercises in this book. The authors, Wilpen L. Gorr and Kristen S. Kurland, focus not just on crime mapping but also on creating and maintaining an information system that meets the needs of officers, investigators, and police executives for geoinformation products for management, analysis, public information, and media relations.

The book takes a learning by doing approach. Exercises use real crime data from the Pittsburgh Police Bureau and Allegheny County 911 Center in Pennsylvania that has been altered slightly to protect the privacy of individuals. Although exercises build on each other, each chapter is self-contained, so more advanced users can skip early chapters and move to areas of special interest such as hot spot analysis or making animations. Chapters move from basic GIS skills and the use of finished maps to designing and building those maps, performing crime analysis operations, preparing and managing data and updating maps, and automating processes using ModelBuilder. Each chapter includes Your Turn exercises, which reinforce the concepts and methods taught, and a challenging end of chapter assignment.

The authors have extensive experience teaching GIS to students at a variety of levels ranging from high school to graduate school as well as GIS professionals. Gorr is a professor of public policy and management information systems at the School of Public Policy and Management, H. John Heinz III College, Carnegie Mellon University, where he teaches and researches GIS applications. He is also chairman of the school's Master of Science in Public Policy and Management degree program. Kurland is a teaching professor of architecture, information systems, and public policy at the H. John Heinz III College and School of Architecture, Carnegie Mellon University, where she teaches GIS, building information modeling, computer-aided drafting, 3D visualization, and infrastructure management.

This book includes a 180-day trial version of ArcGIS 10 for Desktop software and exercise data. An instructor resource DVD is available on request. Esri Press, 2011, 296 pp., ISBN: 978-1589482142

Virtual Geographic Environments



Edited by Hui Lin and Michael Batty

Virtual Geographic Environments is a collection of papers by leading members of the geospatial community that discusses the development, value, and future of virtual geographic environments (VGEs). As editors Hui Lin and Michael Batty observe, moving GIS to the web has changed the way people interact with GIS and has led to a more decentralized and experimental approach to the use of GIS for problem solving. VGEs extend GIS by creating an environment in which users are immersed. The book's essays are organized into five sections. The first discusses the changes in technology that led to the development of VGEs. The second section serves as a primer on VGE virtual cities and landscapes. The third section covers interface design and public participation. Essays in the fourth section discuss the challenges associated with constructing mobile and networked VGEs. The final section addresses the challenges of combining mobility with VGEs. Lin, professor and director of the Institute of Space and Earth Information Science at the Chinese University of Hong Kong, is also the founding president of the International Association of Chinese Professionals in Geographic Information Science and the chief editor of the journal *Annals of GIS*. Batty is the Bartlett Professor of Planning at University College London, where he directs the Centre for Advanced Spatial Analysis. Esri Press, 2011, 364 pp., ISBN: 978-1589483187

Sketching the World's Futures

2012 GeoDesign Summit

By Monica Pratt, *ArcUser* Editor

What kind of world do you want?

During his Keynote Address, Braden Allenby challenged the audience at the 2012 GeoDesign Summit with that simple question.

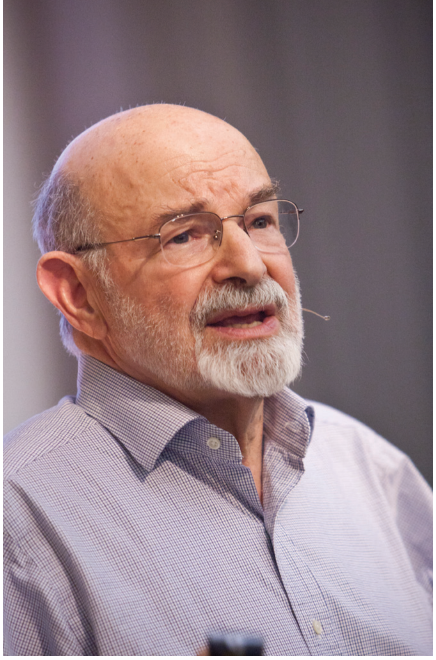
Allenby's question went directly to the conference's theme, GeoDesign: Creating Our Future. The event, held January 5–6 at Esri headquarters in Redlands, California, drew 160 attendees from diverse fields—landscape architects, architects, researchers, urban planners, environmental planners, civil engineers, developers, and academics—who share a common interest in creating a better world through geodesign. Allenby, along with other leaders in this emerging field, shared their opinions and insights during two intense days packed with presentations and discussions.

The conference agenda covered not only geodesign concepts and technology requirements but also implementation considerations and curriculum development. Now in its third year, the event's focus has evolved from defining geodesign as a field of study to applying geodesign concepts and methods to projects and identifying the methods, tools, and workflows that can enable more widespread use of geodesign.

An Evolutionary Step for Humans

During the Plenary Session, Esri president Jack Dangermond noted that geodesign is going to be regarded as "an evolutionary step for humans. It's going to be 'the ah, finally we connected the dots moment' when we realize the consequences of our human actions."

Geodesign combines the value-driven design process with science-based geospatial technologies. It is an old concept that has been empowered by recent technological advances. Digitized information and the web have enabled a high level of collaboration. As Thomas Fisher, dean of the College of Design at the University of Minnesota, noted during the conference, "Science is good at answers, but it is not so good at values. Geodesign closes the fact-value gap."



↑ Carl Steinitz

Two relatively recent developments in GIS technology have greatly enabled geodesign. The first is the creation of new tools that provide immediate quantitative feedback, which makes rapid, iterative, meaningful designs possible. By combining geographic analysis with the design process, the impacts of designs can be vetted using data describing physical and social factors with the goal of incorporating both values and facts in a holistic decision-making process.

The second development is the advent of intelligent web maps. Dangermond sees these geoinformation products as the foundation for how information will be delivered. They are a new platform for designers to sketch, share, and make results available on many devices in a timely manner. However, Dangermond noted that the effectiveness of many web maps is hampered by their poor design. To be effective tools for geodesign, these maps must be the product of good design as well as good technology.

Dangermond stressed that none of these technological advances will matter if geodesign isn't applied to real projects. "Doing real projects...isn't that what geodesign is all about?" said Dangermond. "All this knowledge needs to be linked with the design process and tools and methods that help create sustainable designs that are implemented." The bulk of the conference was devoted to demonstrating just that—how geodesign can and is being applied to challenging issues such as global climate change and preserving biodiversity.

Real Projects

The next few hours were devoted to presentations about real projects that are using geodesign. Douglas Olson, president of O2 Planning + Design, described how geodesign techniques have been applied to urban watershed management in Alberta, Canada.

Nine Lightning Talks followed. The eight-minute presentations gave the audience snapshots of geodesign applications in conservation, land-use planning, and city modeling and remodeling challenges.

Abby Jones, a recent graduate of Cal Poly Pomona, provided one of these snapshots. She gave an overview of Red Fields to Green Fields—Los Angeles. This was a final project in the master of landscape architecture program completed by her student team. Its goal was to "jump-start LA's economy" by transforming vacant, foreclosed, and underutilized properties into parks, open space, and areas for community gardens. The project identified capable and suitable areas in three communities and created site designs incorporating recreation, community, and ecological benefits. These designs underscored a key feature of geodesign—the quantification of design impacts.

Following lunch, a dozen paper presentations addressing geodesign in relation to academic programs, applications, software development, and future directions for geodesign were given at four locations across the Esri campus.

"How the Hell Do We Design?"

Later in the afternoon, attendees reassembled in the main auditorium to hear Carl Steinitz, the Alexander and Victoria Wiley Professor of Landscape Architecture and Planning Emeritus, Graduate School of Design, Harvard University, and a leader in the field of geodesign.

Steinitz opened his presentation with this question: "What if it was more true than false that we don't know what we are doing?" Over decades of project work in this area, he has come to believe that, owing to the "uniqueness among all projects," a certain amount of guesswork is inherent in the process. "Somehow or other, matching from thousands of

> "Complexity is the world you already have and where thinking about GIS becomes very interesting."

methods to relatively efficiently attack any one problem is not a science, it's not an art, it's somewhere in between. It's not fixed, and the amount of guesswork is really high. We (mostly) don't know what we are doing."

He posited that either lots of experience or lots of experimentation was necessary to improve this situation. One such experiment was carried out right in Redlands, California. It grew directly out of the first GeoDesign Summit. At that event, Steinitz had suggested universities work together on practical experiments. When no one responded to that suggestion, Dangermond asked, "Why don't we try it in Redlands?"

The result was the Redlands Workshop. The four-and-a-half-day event, cosponsored by the University of Redlands, the City of Redlands, and Esri and involving residents, was a practical exercise in geodesign. Participants were assigned to one of nine teams. Each team used one of the strategies for proposing change.

This year, Steinitz reported back to the group what workshop participants did and their "very, very tentative conclusions." He characterized the workshop as an interesting first experiment that proved nothing but was an important step toward geodesign. However, he noted that the fundamental question remains: "How the hell do we design?"

Taking Responsibility

Following Steinitz's discussion of how we design, the focus shifted to why geodesign is critical, the subject of Allenby's Keynote Address, Managing a Terraformed Planet: Earth Systems Engineering. An environmental scientist, environmental attorney, professor of civil and environmental engineering, and professor of law at Arizona State University, Allenby noted that global is a scale often omitted from geodesign discussions.

However, Allenby emphasized, we are living in an age of human impact on global systems and a world that is already being designed whether we want to admit it or not. "We are avoiding responsibility for a design that we have been implementing for at least two hundred years," he asserted. Consequently, the real question is not Should we be doing geodesign but Who gets to do it, and how should it be done?

When considering what we do about this situation, he asserted that a lot depends on how we define things like global climate change. If it is defined as a problem, then it has solutions. But if it is defined as a condition, "a condition of seven billion people that is coupled to changes in virtually every other earth system," then all the simple solutions fail. "The future is a whole lot more unpredictable than we think it is," said Allenby. "Complexity is the world you already have and where thinking about GIS becomes very interesting."

Geodesign can become a powerful tool for improving the world's existing design, but it will require a better understanding of this anthropogenic planet, acknowledgment of the challenges currently faced, agreement on design objectives, and determination of real design constraints.

Allenby made a compelling argument for the necessity of geodesign. "The way we think about the world is profoundly broken, and it's broken just at the time we need to be using all the imagination and all the skill that we have to try to break out of the obsolete barriers to thought that inhabit every one of us."

Geodesign in the Real World

The second day of the conference was devoted to presentations on innovative applications of geodesign principles by Paul Zwick

↑ Braden Allenby

of the University of Florida; Chris Drew of Smith + Gordon Gill Architecture; and Keith Besserud of Skidmore, Owings & Merrill as well as another round of Lightning Talks. These talks addressed the realities of dealing with multiple special interest groups and the challenges of communicating contested ideas, obtaining funding, and designing with existing systems.

Looking at the Future

The last two agenda items on the second day both addressed where the discipline and the practice of geodesign are headed. In his introduction to GeoDesign Education: Where We Are and Where We Are Going, a panel discussion by academic leaders in the field, Fisher reported about how geodesign is becoming pervasive at the University of Minnesota. It is being used in education, agriculture, and other departments. Geodesign is driving the challenge-oriented restructuring of education in which students major in a discipline and minor in a challenge such as biodiversity.

It is also changing the way universities are being run. The U-Spatial project at the University of Minnesota, the subject of Fisher's Lightning Talk in 2011, has had a profound effect on the university. U-Spatial networks data, equipment, and expertise across the university's three campuses to benefit all researchers working with spatial science and systems.

In the final presentation, Stephen Ervin of Harvard Graduate School of Design shared his provocative, wide-ranging, and often entertaining musings in GeoDesign Futures. He presented the audience with possible, probable, preferable, and wildcard futures.

An Interesting Community

While most summit attendees were from North America, geodesign is drawing attention across the globe. Five staff members from the multidisciplinary urban regional planning, architectural, and engineering consulting firm Khatib & Alami (K&A) traveled from Lebanon to attend the summit. K&A, which has offered GIS services since 1988, found the summit a valuable opportunity to observe how colleagues and researchers in various disciplines are addressing challenging issues or revising preconceived design or planning concepts and processes. The K&A team believes flexible strategies are needed to address urgent social, economic, and environmental issues such as desertification, social disparities, informal settlements, and diminishing water resources.

The concept—and more importantly the practice—of geodesign is gaining traction. The Saudi Planning and Geodesign Workshops 2011 concluded scarcely more than a month before this year's GeoDesign Summit. Books, newsletters, and articles on the subject have been published. (See the Additional Resources section.) Geodesign has been incorporated into university curricula, and several institutions have started master's programs in geodesign.

In summarizing the 2012 summit, Dangermond noted that "an interesting community is starting to emerge of friends and colleagues around the world that know something about geodesign." The event was capped with an open discussion of the requirements for pushing geodesign forward and a commitment to return to Redlands next year for the 2013 GeoDesign Summit on January 24–25.

Additional Resources

To learn more about this developing field, visit esri.com/technology-topics/geodesign. There you can download the e-book *Changing Geography by Design: Selected Readings in GeoDesign*, watch Dangermond's talk on geodesign at TED2010, and peruse other resources. Locate ArcGIS tools for geodesign at Arcgis.com by searching on *Geodesign with ArcGIS*. Also see "On Scale and Complexity and the Need for Spatial Analysis" by Carl Steinitz in the spring 2011 issue of *ArcNews*.

A Business Plan for the Planet

By Rachel Kyte, World Bank

The World Bank, a cooperative of 187 member countries, provides financial and technical assistance to developing countries around the world to help reduce poverty.

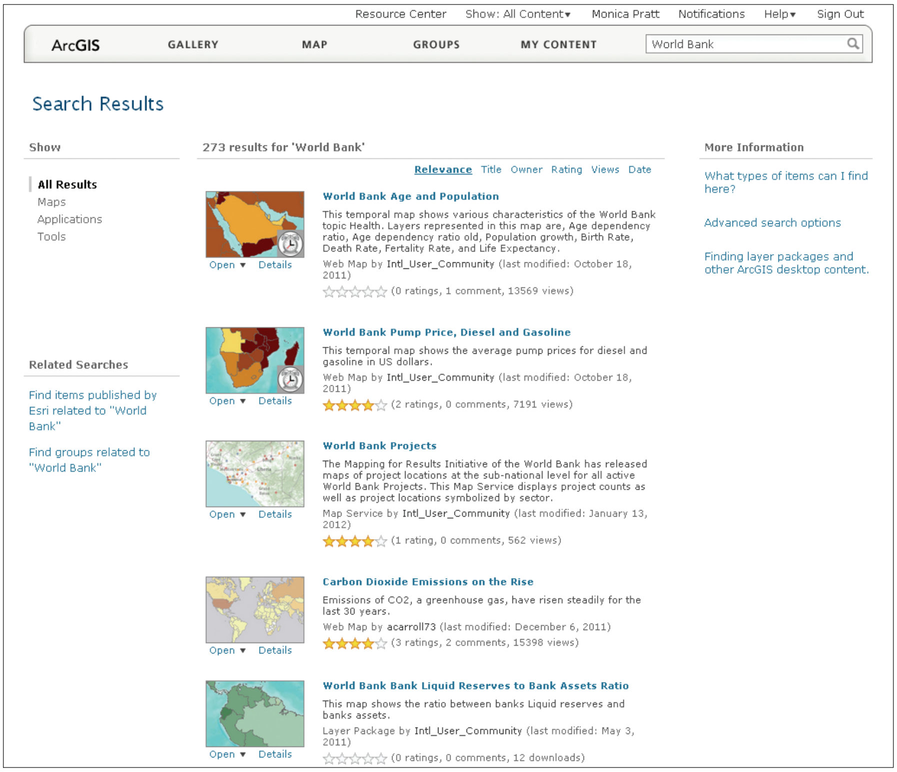
Conventional governance methods can't cope with the speed and scale of the technological, social, and environmental changes sweeping the world. Governments and international development organizations have to adopt a more holistic approach to the challenge—in essence, to draw up a "business plan for the planet."

Such a plan would require a comprehensive redesign of economic policies, broadening the way we calculate national products and services. It would include a more comprehensive form of wealth accounting that puts quantifiable values on natural capital and ecosystem services. The least developed countries need investment flows to speed up green and inclusive growth, while middle-income countries need to shift the pattern of their growth with resource efficiency and inclusivity at the fore. The developed world needs to play its part by shrinking the footprint caused by inequity and resource inefficiency. It's a global business plan for a multispeed world.

This can only be achieved with better data and, more important, the better application and use of that data. Data without purpose is clutter. We have learned over 65 years of serving our clients that, to be effective, development programs must be based on firm evidence and driven by reliable data.

Since the first Earth Summit in Rio de Janeiro 20 years ago, the debate on sustainable development has shifted focus to the sustainability of growth. Growth is essential for poverty eradication, but for growth to be sustainable, it needs to be greener and more inclusive.

Climate change threatens to undo much of what we've accomplished for the poorest and most vulnerable in developing countries and sharpens the need for integrated solutions across the economy. We calculate that climate change is already costing Africa 5 percent of its gross domestic product (GDP) growth per year. The need to find solutions that improve food security, provide energy access, balance water supply and demand, can cope with rapid urbanization, and bring climate adaptation to the fore demand lateral thinking and planning.

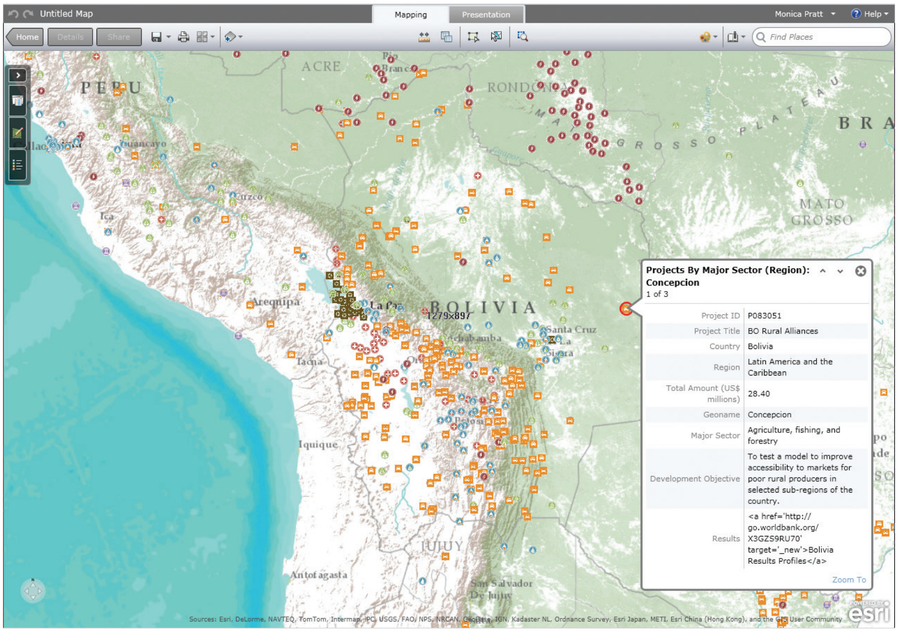


↑ World Bank makes its extensive data holdings readily available through maps on ArcGIS Online.

With these challenges, no country can afford the luxury of not empowering its most significant market and productive sector: women. In some countries in Africa, women compose the majority of small farmers and business owners, but access only about 5 percent of the bank credit. Underinvesting makes no sense.

The good news is that technology exists to enable more evidence-based, data-driven development. Technology is evolving rapidly, and data is becoming more accessible. Technology can become a source of empowerment that improves and strengthens growth programs through popular engagement.

We at the World Bank value open, accessible data and believe in its effectiveness. We have seen that it can help reduce poverty, restore ecosystems, and generate growth. Of key importance, though, is how data is collected; who keeps, analyzes, and shares it; and how this is done. At the bank, one of the most important tools for collecting, applying, and sharing data is GIS.



↑ The World Bank launched the interactive Mapping for Results (M4R) platform in October 2010 which visualizes the location of World Bank projects to better monitor projects and their impact on people, enhance transparency and social accountability, and enable citizens and other stakeholders to provide direct feedback. View this map on ArcGIS Online.

We have used GIS operationally since the early 1980s. Many teams are using and developing GIS tools and maps for a wide range of applications including assessing the viablity of current development projects or the location of planned ones. A map might show human settlement densities in a country relative to its clinics, hospitals, and schools to indicate areas of greatest need. A map could also be used to ascertain that there are sufficient service roads in the right places. Or a map could help determine how many people are at risk from flooding or earthquakes.

Projects benefiting from such spatial analyses include the bank's Climate Change Knowledge portal. In addition, the bank's spatial development infrastructure team has set up a high-priority rapid-mapping service for its natural disaster risk management situation room. A series of 49 interactive, country profile maps shows climate change priorities. The bank also performs urban growth analysis for more than 100 cities worldwide using remote sensing.

The World Bank Institute's Innovation Team has geocoded and mapped more than 30,000 geographic locations for more than 2,500 bank-financed projects worldwide under its Mapping for Results initiative. All new World Bank projects are now georeferenced to ensure that development planners can track and deliver resources more efficiently and effectively and avoid work duplication. Since the data is publicly accessible, it also empowers citizens to follow the progress of projects and service delivery in their countries.

The bank's Development Research Group uses GIS methods extensively to carry out policy research and provide support to bank operations. As part of its environmental policy research, the bank uses overlay mapping techniques to track the spatial distribution of potential environmental impacts and calculate the probable effects of climate change.

In our Global Facility for Disaster Reduction and Recovery (GFDRR), geospatial risk assessments are central to the World Bank's disaster reduction strategy. The bank does not engage directly in disaster response but focuses on risk reduction. In the event of a disaster, we do assist humanitarian agencies and postdisaster reconstruction (as in Haiti after the January 2010 earthquake). GFDRR has identified 31 priority countries deemed most at risk of disasters. The GFDRR lab has magnified its impact by inviting specialists in GIS and related fields to help map risk profiles in these countries under the Open Data for Resilience program.

Meanwhile, many countries are turning to GIS for planning and service delivery. Ghana is using GIS to map its extractive industries and assess their economic value. Jamaica has embraced the technology for similar reasons. Mali is using GIS to help adapt to the challenges of climate change. GIS has also helped revitalize Rwanda's coffee-growing industry. The value of GIS in poverty reduction was thoroughly explored in the World Development Report 2009 entitled *Reshaping Economic Geography.*

Cost was a major inhibitor in the early use of GIS. But, as the technology has become more affordable and commercially available, its use has expanded exponentially. Many proprietary technologies that used to be prohibitively expensive are now open source. The World Bank itself has opened many of its data banks to public access. It is crucial for the sustainability of GIS that its data is not lost but becomes permanently incorporated into national and international operations as spatial data infrastructure.

To an increasing degree, governments, aid agencies, and commercial enterprises are joining forces around GIS technology, particularly on issues, such as climate change, that are too big and complex for any one institution to handle. The World Bank recently entered into a partnership with the European Space Agency to incorporate satellite data—under the rubric Earth Observation for Development—into the bank's lending operations in sustainable development.

Collaborations such as these are bound to grow as more organizations tap into the power of GIS. This will bring the data necessary for a business plan for the planet one step closer to reality.

About the Author

Rachel Kyte is the vice president for sustainable development at the World Bank.

Smartphone App Aids District's Facilities Maintenance

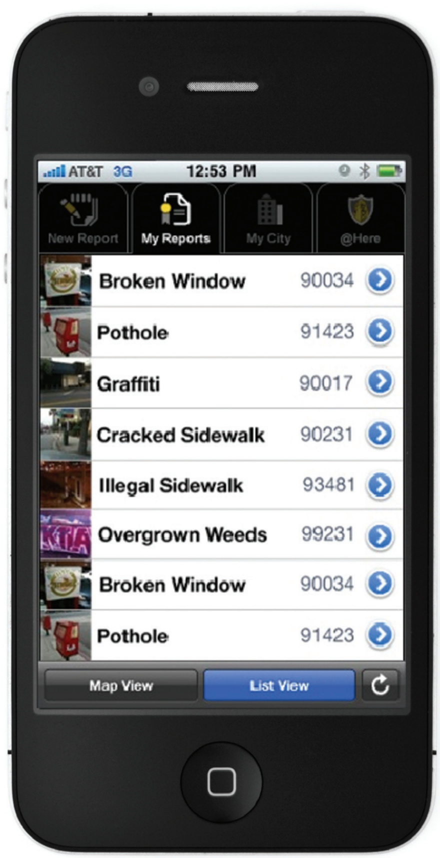
By Jim Baumann, Esri Writer

Students and faculty in the Los Angeles Unified School District (LAUSD) can report graffiti, broken benches, or other repair issues using a smartphone application that is integrated with the district's GIS.

LAUSD is responsible for educating more than 675,000 K–12 students annually and is the second-largest public school district in the United States. The district manages facilities that include 1,065 K–12 schools; more than 200 education centers, adult schools, and occupational skill and learning centers; and dozens of warehouses and storage yards within the district's 710 square miles.

The district has used Esri's GIS software since 1990 for administrative tasks including student enrollment forecasting and analysis, school boundary maintenance, student safety, disaster planning, and facilities operations and management. As additional applications were added, the GIS gradually evolved into an enterprise system.

↑ A smartphone app integrated with the Los Angeles Unified School District GIS lets students and faculty members report graffiti or other repair issues.



↑ A user reporting an incident is prompted through a series of steps to specify the incident details and supply a photo.

"GIS has played a big role on the administrative side of our operations," said Danny Lu, business analyst for LAUSD. "As we continued to expand our use of the technology, we realized that there were some commercial applications that could be easily integrated with ArcGIS and would fit into our existing workflow."

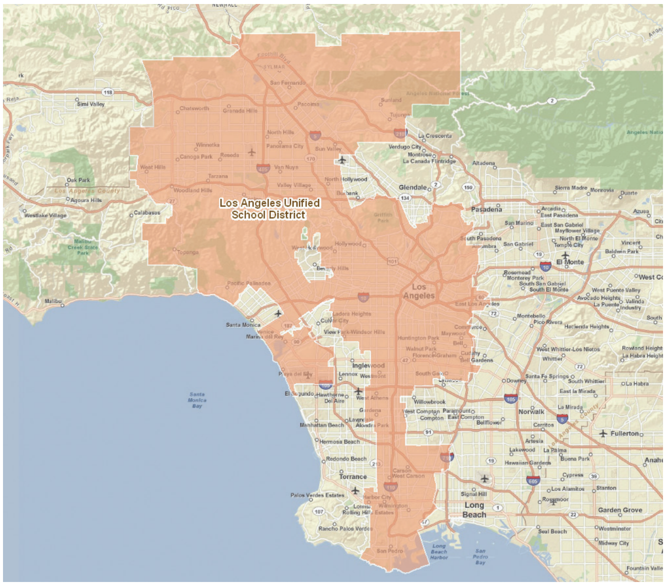
Upkeep of the numerous LAUSD facilities requires an army of administrative, maintenance, and technical staff members who are continually evaluating and processing the many service requests submitted each day. The district implemented a data collection system that allows campus staff to easily report nonemergency issues. This relieves the operations department from some inspection and reporting responsibilities and lets it concentrate on the repair and maintenance of the school district's assets.

In 2010, the district contracted with Esri partner CitySourced to implement LAUSD Service Calls, a smartphone application permitting LAUSD students and faculty to report issues related to the repair and maintenance of school facilities, such as graffiti, broken benches, or damaged sprinkler systems.

"We wanted to take advantage of today's technology and provide our community with an intuitive tool that allows them to easily document maintenance issues and send those reports directly to us so that we can resolve them," said Lu. "As an added benefit, by using the application, students and faculty members of LAUSD are provided with a sense of ownership while building community pride."

CitySourced uses Esri's ArcGIS application programming interface (API) for smartphones in the LAUSD Service Calls application so that the school district can integrate the volunteered data from the incident reports with its authoritative ArcGIS database. This helps the school district keep the GIS database up-to-date for its IBM Maximo asset management system.

Kurt Daradics, director of business development at CitySourced, said, "The LAUSD Service Calls implementation at LAUSD is an end-to-end solution. Incidents are recorded on the mobile devices and sent to the CitySourced servers hosted by



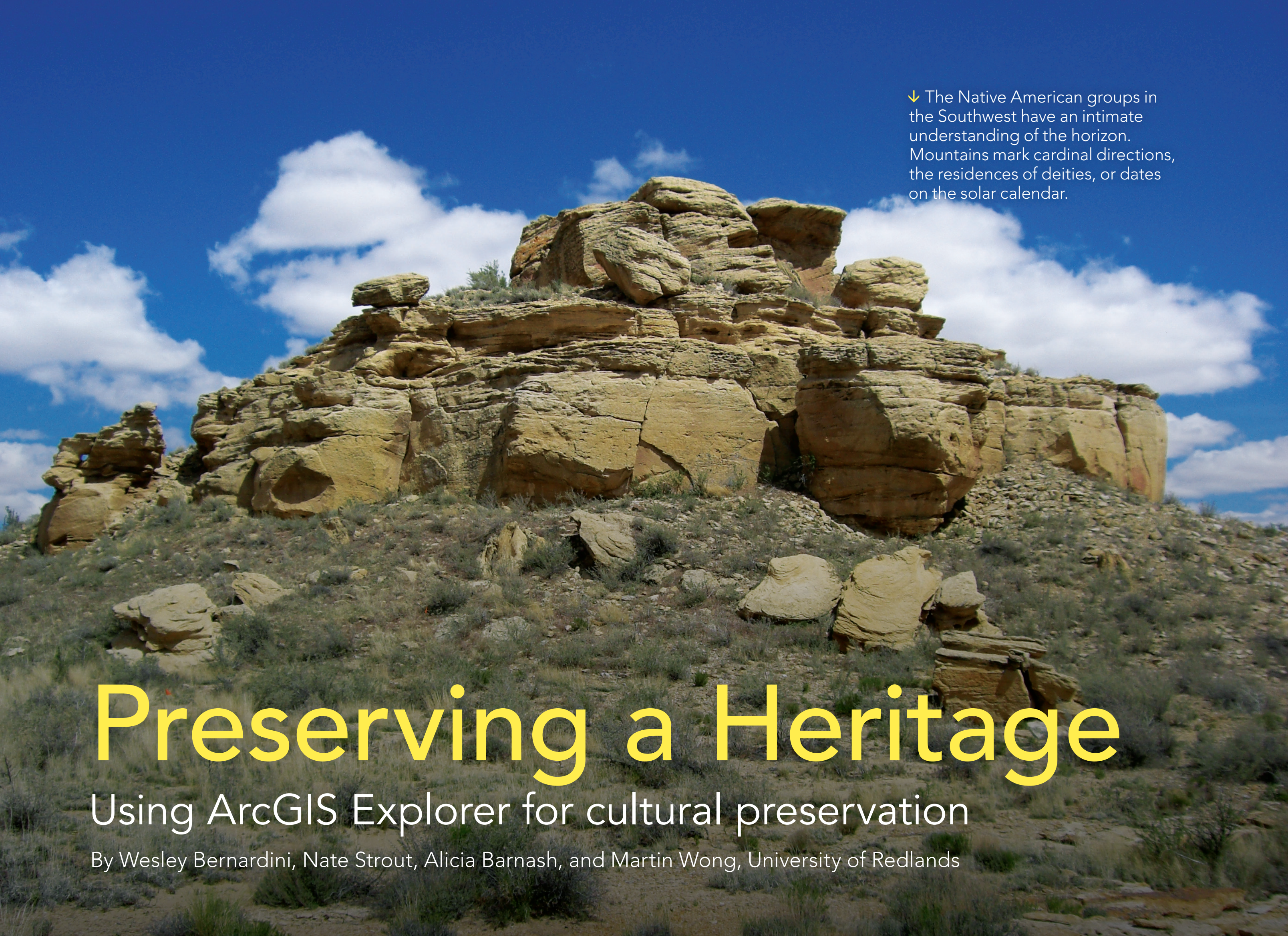
↑ LAUSD, the second-largest public school district in the United States, covers 710 square miles.

Microsoft Azure. Our servers route the issues directly into LAUSD's IBM Maximo asset management system as service requests, where they are reviewed and subsequently resolved by the district's maintenance department."

Daradics indicated that the LAUSD Service Calls application will eventually be able to automatically query the operational asset layers in the ArcGIS database so that the asset ID can be determined. The ID will then be attached to the asset specified in the incident report submitted by the LAUSD community member. This will allow all information related to the asset (maintenance history, age, and replacement costs) in the GIS database to be automatically retrieved so the school district can use its GIS to better manage and maintain its assets.

The LAUSD Service Calls application can be downloaded for free to the user's smartphone. When reporting an incident, the user is prompted through a series of drop-down lists to specify the incident location, type, required maintenance, and description. This report and accompanying photograph is sent to LAUSD's asset management system, where it is reviewed by a moderator to determine the required course of action. If maintenance is required, a work order will be generated, prioritized, and routed to the appropriate department for action.

According to Lu, the system also provides feedback to the person or persons reporting the complaint. When a work order is generated as a result of a service call, the asset management system automatically sends a response to the sender, indicating the incident report has been received and assigned. Students and faculty can use the CitySourced application to search for the calls they have placed. Under My Reports, they can view the status of an incident. This feedback loop demonstrates to the community that LAUSD is aware of and is working to resolve their concerns.



The Native American groups in the Southwest have an intimate understanding of the horizon. Mountains mark cardinal directions, the residences of deities, or dates on the solar calendar.

Preserving a Heritage

Using ArcGIS Explorer for cultural preservation

By Wesley Bernardini, Nate Strout, Alicia Barnash, and Martin Wong, University of Redlands

A team of archaeologists and GIS programmers at the University of Redlands in California created an add-in for ArcGIS Explorer that delivers archaeological content in an engaging manner and encourages hands-on exploration of the Hopi past by members of the Tribe, especially Hopi youth. Wesley Bernardini, associate professor of sociology and anthropology at the University of Redlands, leads the Spatial Archaeological Research Group (SARG), which includes Nate Strout, Alicia Barnash, and Martin Wong. Bernardini has been collaborating with the Hopi Tribe for 12 years to document and preserve ancestral Hopi sites.

The history of the Hopi Tribe, stretching back centuries before European contact, has been passed on through oral accounts. But when members of the Hopi Cultural Preservation Office noticed that some Hopi youth were more interested in video games than traditional cultural history, they wondered if they might be able to use digital technology to help communicate Hopi history to the next generation. The Tribe asked if SARG could help. Building on University of Redlands expertise in GIS and working closely with the Tribe, the team developed the Hopi Landscape Portal, an ArcGIS Explorer tool that allows Hopi High School students and others to explore Hopi history in a virtual 3D environment.

Analyzing the Southwestern Landscape

The Hopi Landscape Portal provides interactive access to data about ancestral Hopi villages and prominent places on the landscape that were visible from those villages. This digital interface helps students appreciate how ancestral Hopi groups were distributed across the landscape, how they migrated over time to form the Hopi Tribe, and how these movements affected their visual relationship to the landscape.

The Native American groups that call the Southwest home have an intimate understanding of the horizon. Mountains mark cardinal directions, the residences of deities, or dates on the solar calendar. Consequently, underlying the Hopi Landscape Portal Add-in is a large-scale line-of-sight analysis that enables the team to reconstruct spatial and visual relationships among culturally significant places.

The Tribe emphasized that it did not want the Landscape Portal to take the place of traditional cultural history, which is passed on orally through stories and in conversations with relatives. So the team designed the Landscape Portal to make it easy for students to discover new or unfamiliar ancestral places, but the portal does not provide encyclopedic information about those locations. Instead, the Landscape Portal helps students discover spatial relationships between modern and ancient places. Once they have discovered a relationship, Hopi teachers encourage students to seek more information about these places from culturally appropriate sources in their communities.

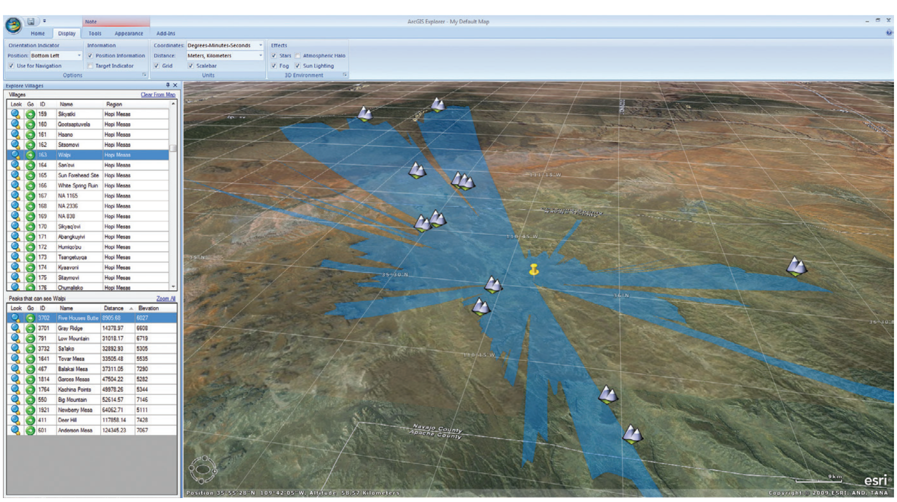
The portal covers Arizona, Colorado, and New Mexico—the primary area occupied by Puebloan populations, the ancestors of modern Pueblo Tribes. While Hopi ancestors lived and migrated over a larger region, the study area covers the region where most of this activity occurred over the past 900 years.

Choosing a Platform

The team chose ArcGIS Explorer because it is free to download and requires no licensing, so it is easily installed on tribal high school computers. Additional functionality is easily added through Python scripts. Its simple interface with intuitive zooming and panning navigation tools makes it appropriate for classroom situations in which students and instructors may lack previous exposure to GIS software.

For each ancestral Hopi village, the team ran the Skyline tool to generate a polygon defining the edge of the visible world around the village—the horizon. *[This analysis was conducted using ArcGIS 10 for Desktop with the 3D Analyst extension.]* To identify the specific peaks that make up the horizon, the team first used the Select By Location function to select from a list of US Geological Survey (USGS) peaks within a 1-kilometer buffer zone of the horizon boundary. Next, the Line Of Sight tool was used to assess whether these selected peaks are visible from the village (taking into account the earth's curvature and refraction). Finally, the team used a custom Python script to tabulate statistics for the distance to the peak, the azimuth, and the elevation difference between the summit and the village.

↑ A 3D model of extruded polygons representing the layout of an ancient Southwestern village



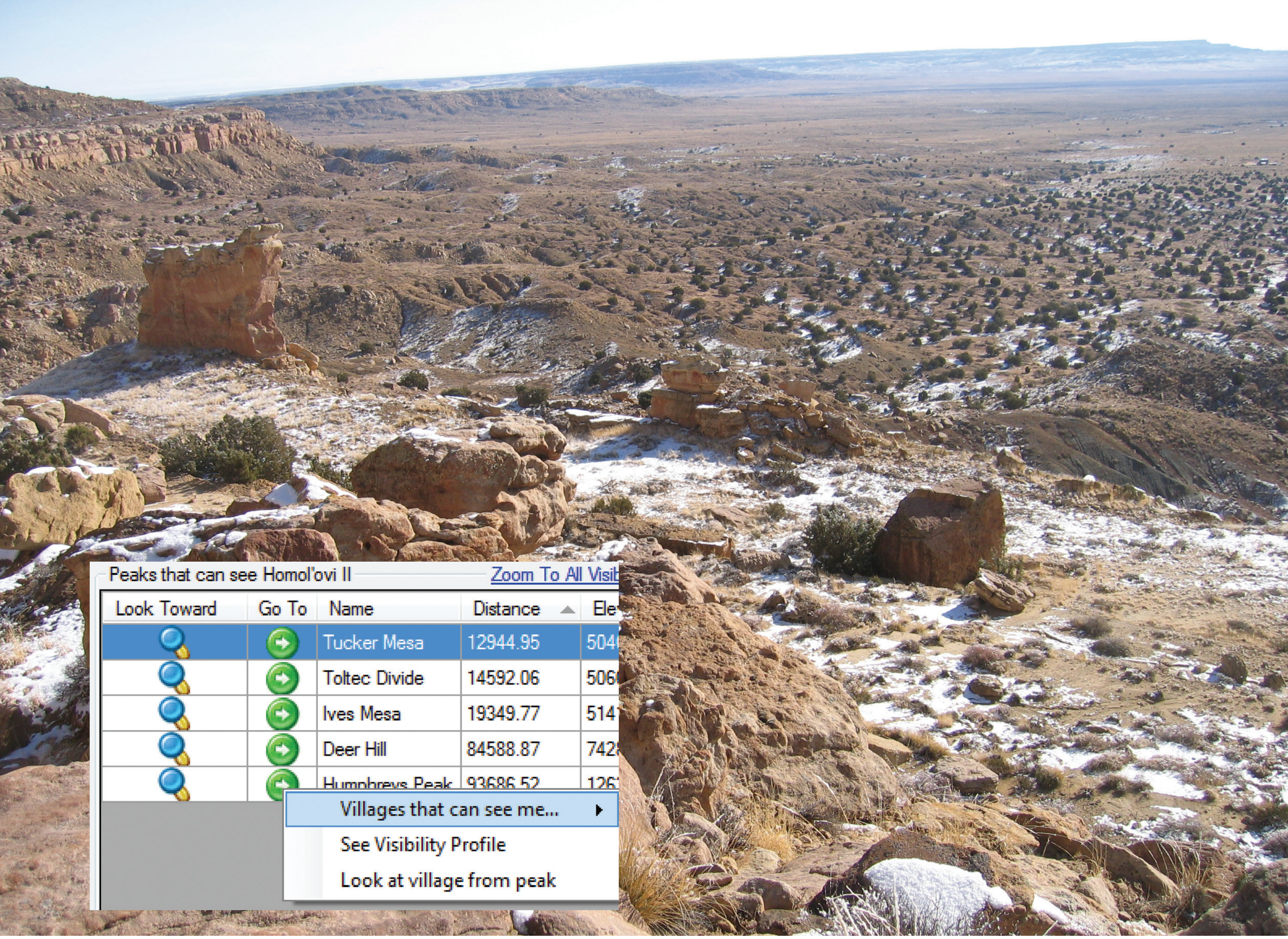
↑ A horizon polygon draped on the landscape

Using the Portal

The Hopi Landscape Portal Add-in opens with a searchable table of 72 publicly accessible ancestral Hopi villages in Arizona, Colorado, and New Mexico. This village table features a Go To button, which zooms to an oblique view of the site, and a Look Toward button, which rotates the view to face the selected location. Users browse an alphabetical list of villages sorted by name or region or choose villages from a particular region by selecting from a drop-down. Villages can also be sorted by the starting or ending date of occupation, a date range (e.g., occupations starting after AD 1250 and ending before AD 1500), or by the number of rooms they contain (a measure of population size).

After users choose a village location with the Go To button, they will see a 3D model of extruded polygons representing the layout of the village at its peak occupation. These models were created in ArcMap by digitizing scanned archaeological maps of wall foundations (or, for modern Hopi villages, digitizing polygons over an imagery basemap) and extruding the room polygons in ArcGIS Explorer. When the portal was demonstrated at the Hopi High School, students typically started at their current village, often hunting for their own house in the 3D model.

Once zoomed in to a village, users can right-click the village name to choose Look in a cardinal direction (north, south, east, west) or Add Horizon. The Add Horizon option adds a tinted polygon draped over the landscape representing the edge of the visible world from that point. Once the polygon



↑ Query results returning a list of all villages that can see the selected peak.

is turned on, a second right-click of the village name will open Zoom to Horizon, zooming out to an overhead view of the horizon polygon.

Along the edges of the Horizon polygon are mountain icons representing named peaks. Clicking a peak opens a pop-up window with the elevation of the peak, a wireframe sketch of the peak and its neighbors as viewed from the village, and photographs of the peak (if available). Although the database contains more than 20,000 peaks and 1,200 archaeological sites, the locations of most of these sites must be protected to prevent looters from gaining access to them. Consequently, the final version of the portal contains the locations of the pueblos that are in the public domain.

When the user zooms to a village, a second table interface opens a table listing all the peaks on the horizon of the selected village. This list is generated on the fly from a master table of line-of-sight visibility underlying the add-in. The peaks table includes the same Go To and Look Toward buttons and allows the user to zoom to or look in the direction of a selected peak. These horizon peaks can be sorted by distance from the village, azimuth, elevation above sea level, or the difference in elevation between the summit and the village itself. This table also includes a button that zooms to all visible peaks by providing an aerial view encompassing all the horizon peaks for the village.

From the peaks table, users can right-click a peak's name to open several additional functions. The Look at village from peak function spins the view to face the selected village. The See Visibility Profile function opens a pop-up window with a wireframe profile of the topography between the village and the selected peak. (This profile was generated using the www.heywhatsthat.com website.) Finally, a dynamic search window can be opened by right-clicking a peak to open the Villages that can see me function.

The Villages that can see me function opens a new window listing all the villages with line-of-sight visibility to the selected peak and can be sorted by name, region, date of occupation, distance, and number of rooms. Users can explore village-to-peak visual connections along many different axes. For example, users can search for contemporary villages that share a view to a culturally significant peak or 500-year-old villages that shared the same view or the largest (or most distant) village with a common view.

With this step, students—who began exploring the landscape with their own village—begin discovering unfamiliar cultural places. The relationship between the familiar and unfamiliar places is built on tangible, sensory data ("I can see that from my house!") so the discovery process is intuitive and exciting.

Beyond the Classroom

Because ArcGIS Explorer makes it easy to link images, text, and audio and video files to a point, the Hopi Landscape Portal Add-in can also serve as a common workspace for student assignments. In one lesson plan under development, students would be assigned the task of collecting information about a place in the Landscape Portal. They could do this by visiting and photographing the site or recording an interview with a community member on tablet computers that can be checked out from the classroom and then linking that information to a point on the map.

Students could compile and store cultural information about the landscape. Information collected by students could eventually be added to information about which Hopi clans lived in each ancestral Hopi village. Clan identity is an important part of Hopi life. Hopi history is told primarily through the migrations of particular clans, so it would be useful to query the portal to identify sites affiliated with specific clans. The Hopi Cultural Preservation Office is also considering the Landscape Portal as a way of digitally curating valuable cultural information in a format that promotes easy retrieval and editing.

GIS for Tribal Applications

Many tribes are embracing GIS as a tool for collecting, storing, and analyzing information about traditional cultural places. GIS can also function as an educational tool for interactive exploration of spatial data if the interface is user-friendly and has a shallow learning curve. The team wanted students and instructors to focus their energies on exploring the spatial data rather than learning how to use software. As this example illustrates, ArcGIS Explorer provides a perfect vehicle for designing and delivering interactive educational tools for classroom use.

For more information, contact Dr. Wesley Bernardini, associate professor, department of sociology and anthropology, University of Redlands, at Wesley_bernardini@redlands.edu.

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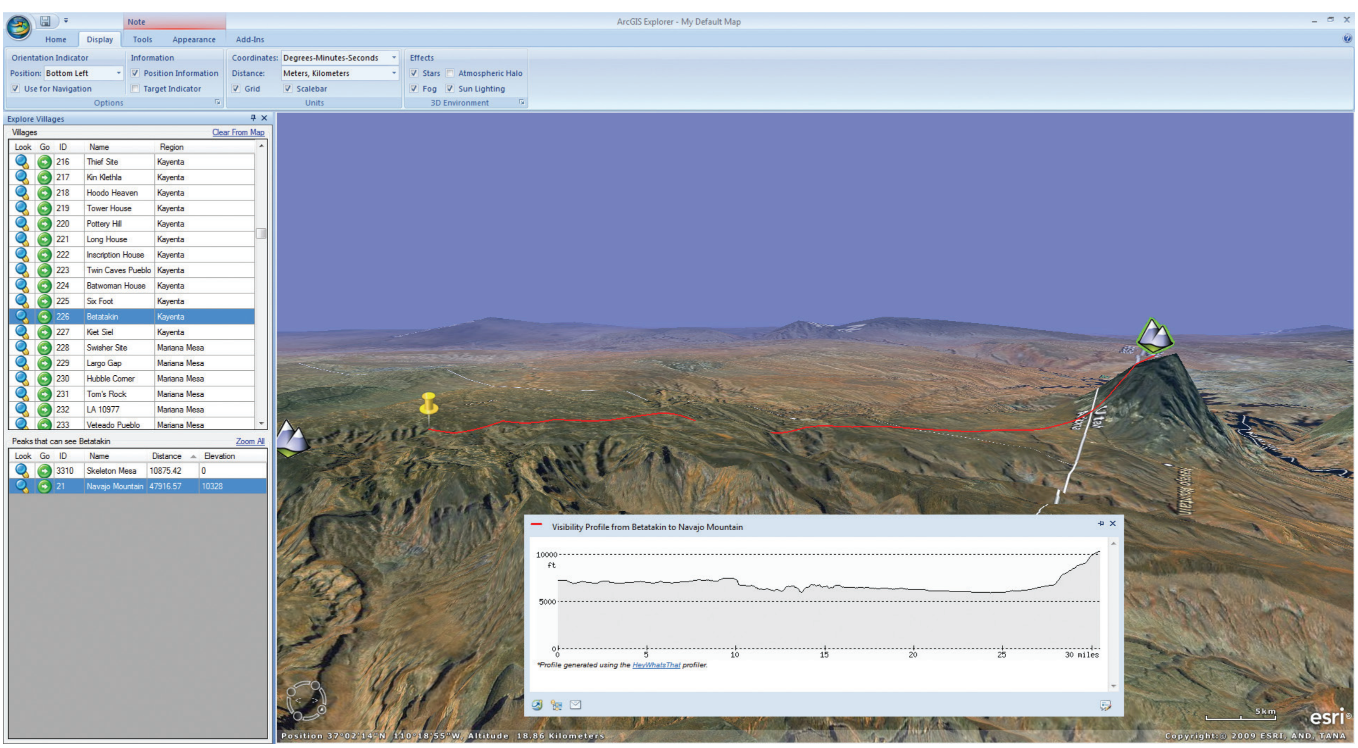

↑ Wireframe topographic profile between the selected village and peak

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