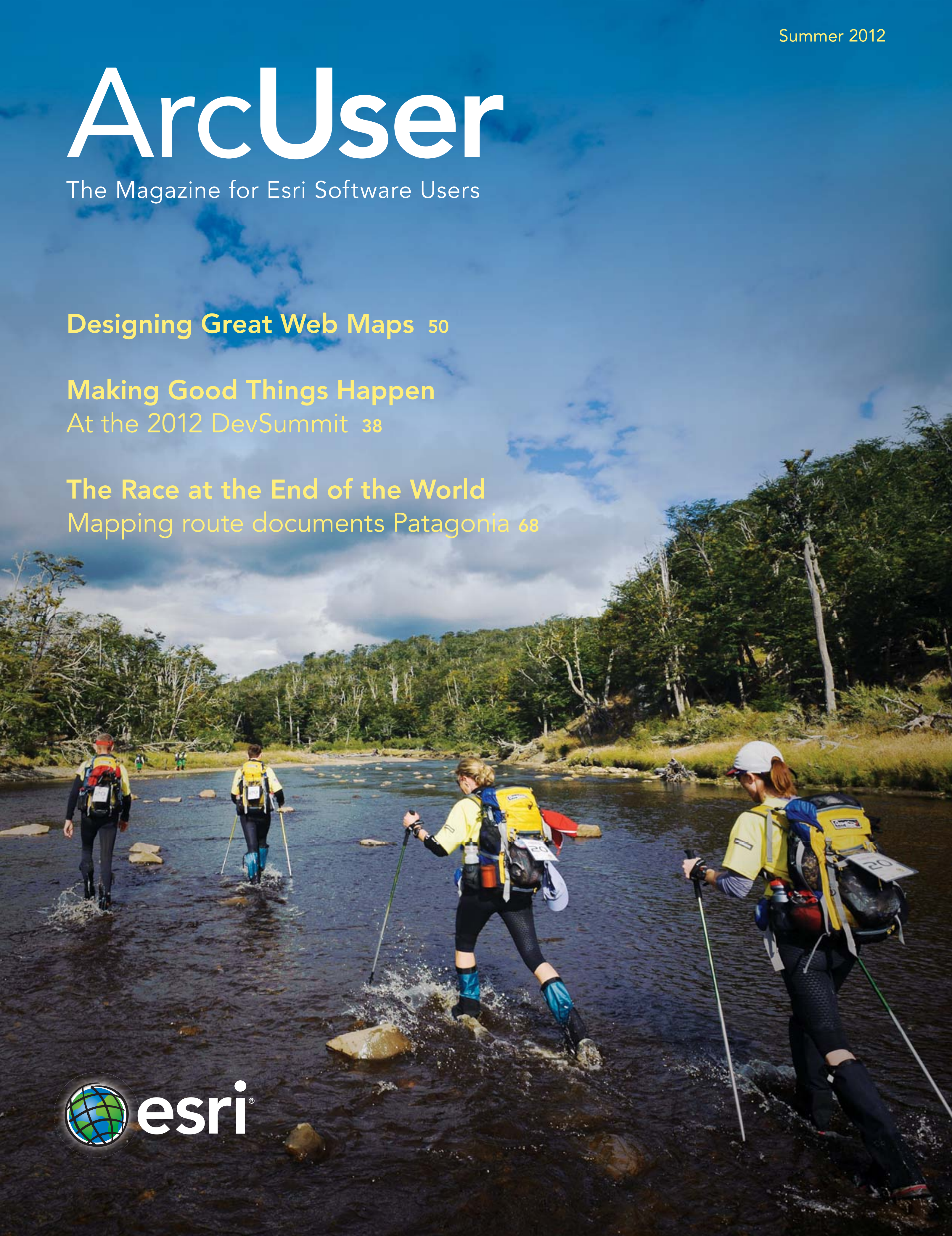
Summer 2012

ArcUser

The Magazine for Esri Software Users



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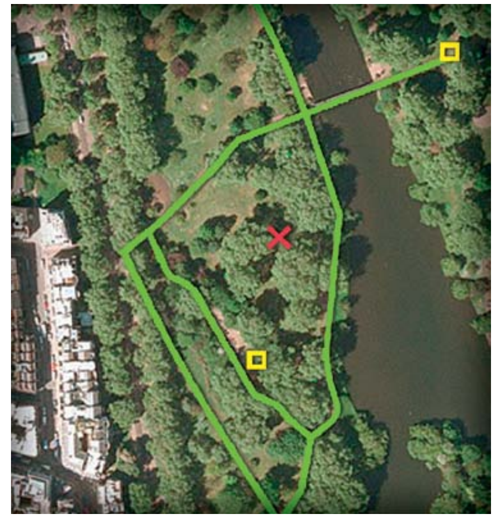

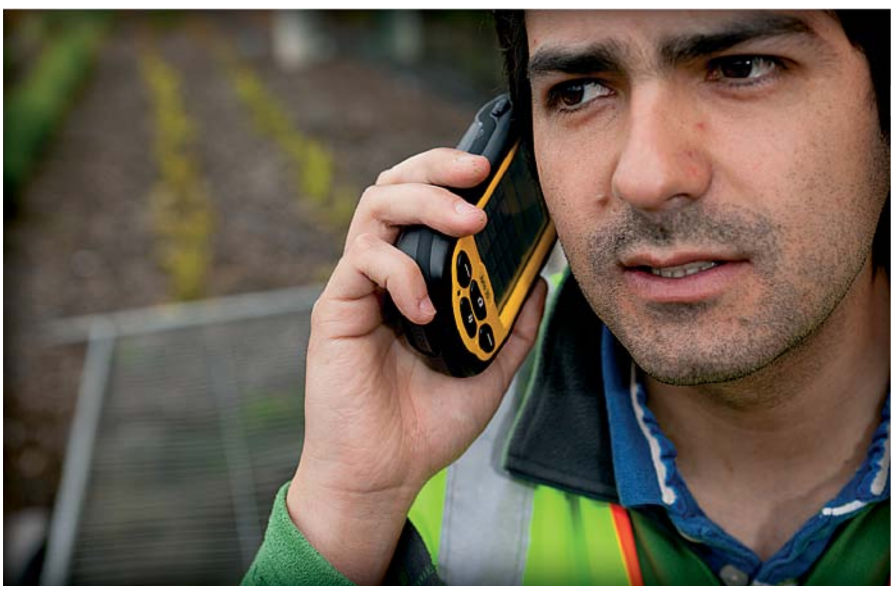


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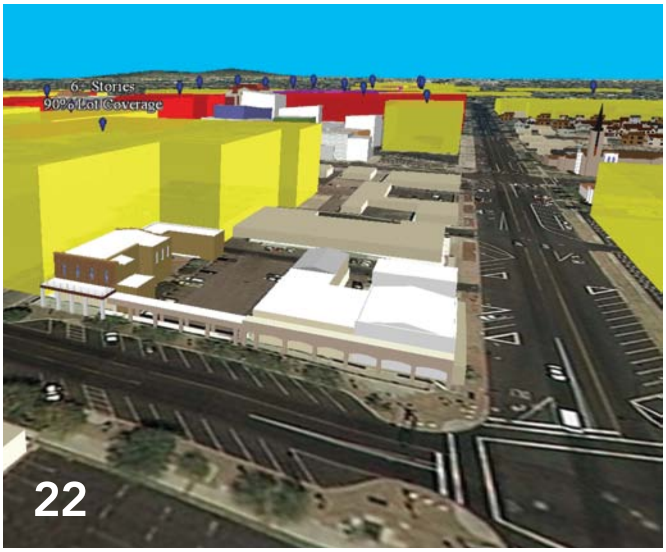

Focus: Transportation

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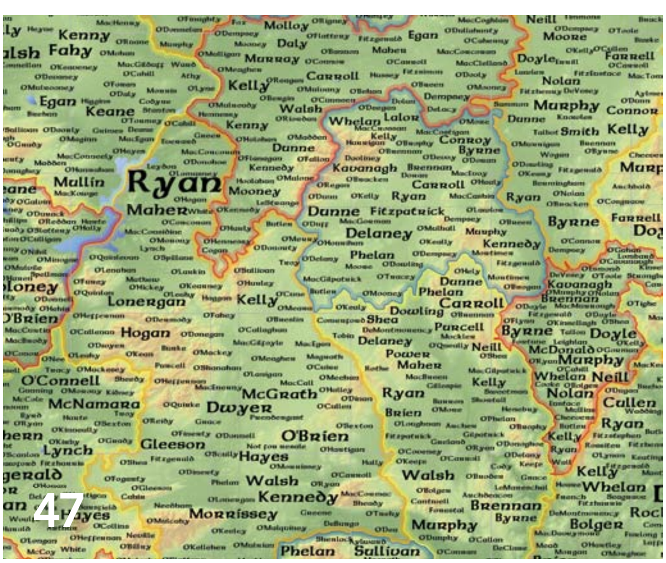

Special Section: Web Maps

Cover Image: The course of Patagonian Expedition Race, set in the remote wilderness of southern Chile, did not follow trails for much of the race. Teams used large-scale maps created using ArcGIS to determine the best route. (Photo Alexandre Buisse)

It's All About Perspective

Where we stand influences how we see things. Since 1972, we have had a viewpoint more than 400 miles above the earth, thanks to Landsat, which celebrates its 40th anniversary this year.

Through these images, we can see the growing dominance of the human presence as forests shrink, road networks grow, and more lights illuminate the landscape at night. In its decades-long mission, Landsat has amassed a portrait of the earth that is unmatched and has proved invaluable to science, business, and government.

As Richard Saul Wurman, the original information architect and past Esri User Conference keynote speaker, has famously observed, "Understanding precedes action." With GIS technology, tremendous data sources like Landsat can be analyzed and combined with other sources to provide a depth of understanding of effects and processes that was not previously possible. The ability to see the world at different times and different scales has greatly expanded our understanding of the world we live in.

ArcGIS, an open platform that makes mapping and information derived from spatial analysis accessible, is expanding this understanding of the world and enhancing the perspectives not only of researchers and specialists, but also decision makers and the public. It is helping address problems on scales from the global to the local.

"Climate Change & Africa: Understanding how to bolster the security of vulnerable populations," an article in this issue, describes how the Climate Changes and African Polical Stability (CCAPS) program is helping policy makers, journalists, and citizens understand aid activities and decision making processes on national, regional, and global scales. Working with the nonprofit Development Gateway, CCAPS has created an interactive application, developed with Esri technology, that lets anyone contribute and share comments, images and information on projects.

A new suite of tools being adopted by the United States Department of Housing and Urban Development (HUD) makes a wealth of information on areas of need and available programs accessible on the local level. HUD is replacing the costly, time-intensive paper-based process previously required of communities applying for federal aid with the eCon Planning Suite. The CDP Maps tool, part of the suite, empowers residents by giving them access to information on both needs and investments in their neighborhood and the ability to provide feedback to government. By enabling place-based decision making, HUD will save communities thousands of hours and dollars and target aid to areas of greatest need at a time when there are fewer dollars available and bigger problems to tackle.

As we reach this inflection point in the trajectory of our life on this planet, the need for an enlightened perspective has never been greater: one that encourages collaboration and fosters the collective will to adopt more effective strategies for balancing our needs and those of the earth.

Monica Pratt

ArcUser Editor

editor's page

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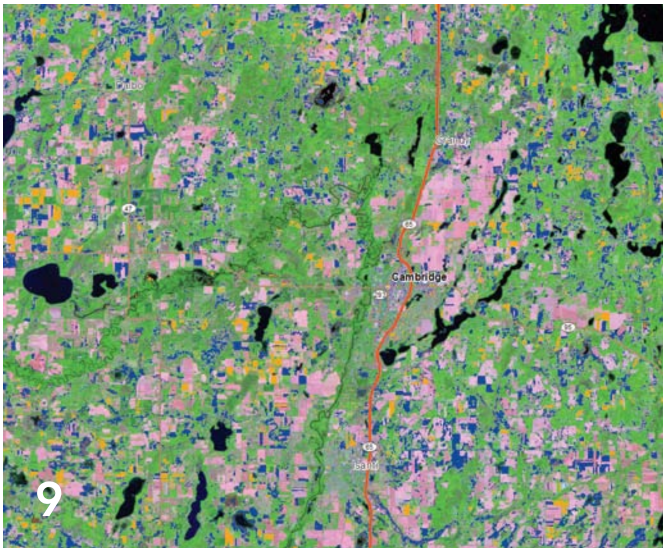

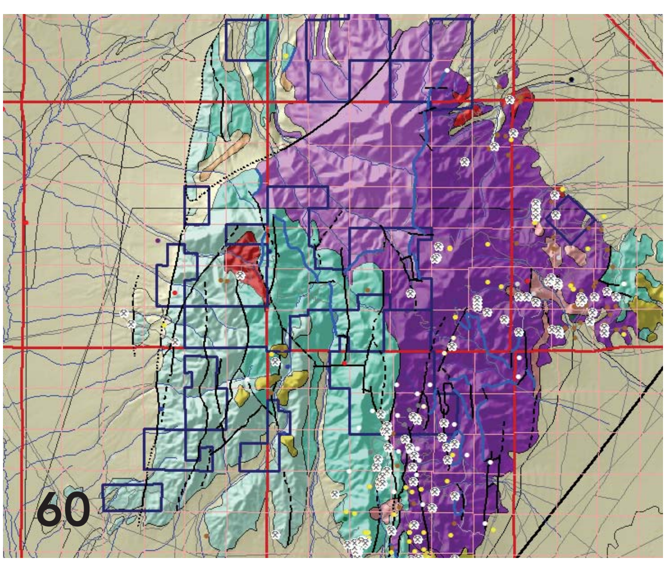

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Imagery: Past, Present, Future

By Karen Richardson, Esri Writer

Esri writer Karen Richardson recently sat down with Peter Becker, Esri's manager of imagery products, to understand where the industry is and where it is going. Becker was the technical manager for MAPS Geosystems in the United Arab Emirates for 15 years before joining Esri. At Esri, he worked on the development of image server technology. For the past 4 years, he has served as the product manager for imagery. He graduated with a bachelor's degree in engineering with honors in control engineering from the University of Sheffield in the United Kingdom.

Richardson: Over the past several years you have been working with imagery, you have seen a lot of changes. Is there one significant change that you've seen that stands out more than others?

Becker: It is not one but many. First, I'd have to say the move to digital sensors from the traditional scanned aerial film was a significant change. The volume, speed, and clarity of imagery that digital cameras collect is astounding. Plus, with no scratches or dust on the film to degrade the quality of the images, the processing possibilities and analysis are so much better.

Being able to acquire such a great number of images required a significant change in how imagery should be managed. Instead of viewing and working with a single image at a time, techniques were developed to make it possible to work with very large numbers of images. Naturally, the significant increase in computing power and optimization of algorithms has meant that it's now possible to nearly instantaneously process imagery into multiple products.

Richardson: You talked about imagery data management changing. In what ways has it improved?

Becker: Traditional desktop image processing software was designed primarily to work with a single or a few images at a time and could never scale to a large number of images. The integration of GIS techniques for handling large numbers of vectors, such as image footprints, databases of metadata, and process modeling techniques, enabled image management to be scaled by many magnitudes in terms of number of images as well as efficiency. Databases are used to manage the large number of parameters that define not only the properties of the imagery but the processing to be applied to it. The pixels in the images, in most cases, do not change. It is the parameters that define how to process the images that change.

The processing of imagery has also changed from a push-based model, in which each input image is transformed through a set of processes with intermediate outputs, to a pull-based model, in which the output is defined and the system selects and processes only the required pixels through a concatenated collection of image processing functions. This substantially reduces the data volumes accessed and removes the intermediate products that create bottlenecks when scaling. These new transactional image data management techniques enable image products to be created on the fly directly from the input imagery as soon as the image is available and has the highest value. Processing parameters can then be refined to create a graded product where accuracy and quality of the output improves as additional processing parameters—such as better orientation, terrain models, or color correction parameters—are obtained.

Using a GIS to produce imagery on the fly, together with the ability to manage very large volumes of data, means we do not have to wait for all the data to process to use what we need. We can view many images, zoom in to any location, and visualize the information that is there. This also allows us to quality check our work more quickly, so projects, such as an orthophoto project, that used to take months to create, now can produce images immediately. Going from the traditional input-output model to a transactional mode in which all the data is in a database and quickly accessed has changed the very manner in which large projects are done.

Richardson: Image services are one way of serving up data—what is an image service and how is it different from accessing imagery locally?

Becker: I'll use Esri's ArcGIS to give you an idea of what an image service is and split it into two parts. ArcGIS handles very large volumes of imagery in a data model called a mosaic dataset. This is a database model optimized for image data management. A mosaic dataset allows the user to ingest metadata about images into a structured database and then define processing to be applied. This processing can be as simple as cropping imagery and stretching but can also model more complex processes such as pan sharpening, orthorectification, color correction, or seam line creation. The actual processing is only applied on the fly as ArcGIS accesses the imagery and converts the base pixels into different products. The processing parameters can be changed and refined at any point in time. This is very different than the traditional way of managing imagery.

The mosaic dataset can be used directly on the desktop for simple access in small workgroups. The same mosaic datast can also be published to ArcGIS for Server, making that imagery accessible to a larger number of users. The server performs the required processing and returns only the required pixels to client applications. These services are dynamic and enable users to also change various parameters to control the processing and display order of the imagery, exposing the full information content in the imagery.

Image services also act as a catalog. Any area you query, the system not only shows you appropriate imagery but also all the metadata about each of the images, enabling users to refine what imagery is displayed based on metadata such as dates, sensor type, or properties such as viewing angle.

While dynamic image services provide access to rich imagery content, there is also a standard requirement for users to simply and quickly access the best imagery to use as a background in mapping applications. The optimum way to serve such imagery is as a map cache. This consists of large collections of small preprocessed image tiles that can be very efficiently distributed through the web. This is how most imagery that is displayed in Google Maps, Microsoft Bing, and ArcGIS Online is published. Mosaic datasets can be used to define these map caches, and then the server can generate and serve these tiles efficiently. Because they are optimized for cloud environments, there is not much load on the servers.

Richardson: Speaking of cloud environments, we hear a lot about the cloud these days. Is this affecting how people work with imagery?

Becker: From a user perspective, definitely. What most people are familiar with as background imagery in a web application are map caches that are stored and shared from multiple clouds. Pushing cached tiles to cloud storage and distribution is a simple example of using the cloud.

From a dynamic image services perspective, using public clouds is more challenging. Geospatial imagery is typically referred to by IT as "big data," and it creates a challenge for the cloud. A cloud pattern that has emerged for working with big data brings the computational power—the CPU—to the data, not the data to the CPU.

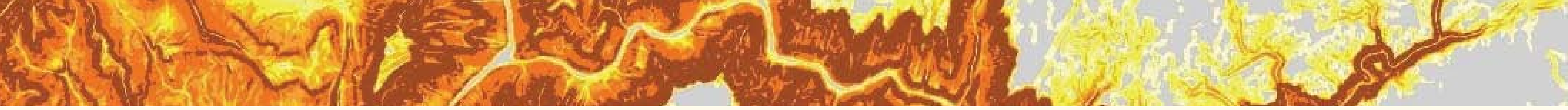
Traditional image processing patterns involve moving the imagery to processing centers. With the vast quantities of imagery, this is not practical. Now, with high processing capacity and software such as ArcGIS for Server, it is much more efficient to bring computing power to the data. The challenge is determining where and how best to store the imagery in the cloud. This will soon be resolved by multiple vendors offering optimized storage and processing options for imagery as well as the use of hybrid clouds. In hybrid clouds, much of the storage and image processing will remain on more dedicated infrastructures internal to organizations but also interface with public clouds. This will provide higher availability of cached maps in public clouds (like ArcGIS Online) created from a server running community clouds specialized for processing but accessible to the public.

Richardson: Last year, Esri provided access to the Landsat GLS *[Global Land Survey]* dataset as image services. This is Landsat's 40th anniversary. Are you planning anything to celebrate?

Becker: Certainly. The Landsat imagery provides phenomenal value through its ability to provide both temporal and multispectral data. Later this year, Esri will be releasing an updated version of the World Landsat services that provide simple access to the Landsat GLS dataset using image services. We will continue to improve the services by refining the parameters used to process the imagery to return better radiance values as well as color corrections and on-the-fly scan line removal. We will include the GLS 2010 data.

All these changes will further improve the ability for organizations to use Landsat imagery to compare images from different time periods to see how the world has changed. Landsat imagery allows us to view agriculture, encroachment, and the effects of natural disasters, to name a few examples. We are excited to work with USGS *[US Geological Survey]* to provide access to these important archives now and into the future.

↓ Using a GIS to produce imagery on the fly, together with the ability to manage very large volumes of data, means images can be produced immediately.



Richardson: There has been talk about access to global elevation data. Can you share some information on that?

Becker: This is a project that brings together publicly available elevation data including SRTM *[Shuttle Radar Topography Mission]*, USGS, NED *[National Elevation Dataset]*, and GMTED *[Global Multi-resolution Terrain Elevation Data]* as well as samples of commercial datasets, bathymetry, and high-resolution lidar data. This is all combined into a mosaic dataset and provided as an image service from the Amazon Cloud.

Using these services, users can quickly and easily zoom to any location on the earth's surface and immediately use the best publicly available elevation data for their projects. Multiple derived products, such as rendered versions of hillshades, slope, and aspect, are directly accessible. Users can access the actual data values for further processing and, when appropriate, analyses.

The services include terrain and surface models as well as topobathy models that combine different sources in multiple ways. This will be of great interest to a number of GIS users—many of whom use elevation in some form—as well as application developers. We will be extending this service in the future with greater analysis capabilities. We will also provide subscription access to elevation from commercial vendors who have valuable elevation datasets.

These services provide a template and best practice for organizations wishing to implement similar systems with their own data. Organizations can get copies of these services as templates that they can then replicate and pour their own data into. This gives them access to the information content of elevation data without taking a lot of time or worrying about how to manage all the data.

Richardson: Is lidar important?

Becker: Lidar is huge both internationally and in the United States, and for a good reason. It has a number of advantages over aerial imagery. Lidar can be collected at any time of the day or night in any season and does not have the limitations of traditional imagery.

Like lidar, 3D points are being used more and more to create surfaces. Both digital cameras and lidar create massive amounts of data, so the challenges are similar. Many of the techniques for dealing with point clouds are the same as with mosaic datasets of imagery—make them accessible by providing dynamic on-the-fly processing capabilities so they can be used to create many different, useful products quickly.

Richardson: Esri has a new release of its software coming out in the next few months. Are there any exciting enhancements included in that release for imagery?

Becker: ArcGIS 10.1 is our latest release, and it has a lot of improvements for working with imagery including simplifying workflows. There are new capabilities available when working with mosaic datasets, including automated image-to-image registration, color correction, and seam line generation, that will make the management of imagery even easier. Additional capabilities, such as mensuration (for the measurement of heights from satellite, aerial, and oblique imagery), will provide more information content. Support for radar and full-motion video will increase the available data sources. ArcGIS 10.1 will also be able to directly bring in lidar LAS files as points, TINs, and rasters for visualization, editing, and analysis. This release will also include the ability to serve lidar as elevation data to desktop and web applications.

The big message is that ArcGIS provides true seamless integration of vector and imagery data, and there is no reason to continue using imagery only as a beautiful background.

Richardson: You've talked a lot about the sharing and accessibility of image services. Why is this so important to remote-sensing professionals?

Becker: It's important not only for imagery professionals but also of interest to both the general public and GIS users. Image services are a fantastic way to provide this rich image, information to large numbers of users. The human brain is amazingly adept at extracting information out of imagery. See an image and, in an instant, your brain will extract information, especially when provided with a spatial context such as another image or basemap. Imagery is important for many applications as it provides the evidence that allows people to gain confidence in their decisions.

As more and more people depend on imagery from multiple sources, at different dates and using various spectral components, understanding this enormous range of data becomes more important. Moving the CPU processing to the data will allow remote-sensing professionals to apply more analysis on the data. Image services will be a big part of the transition in the remote-sensing industry to enable true access and analysis of imagery.

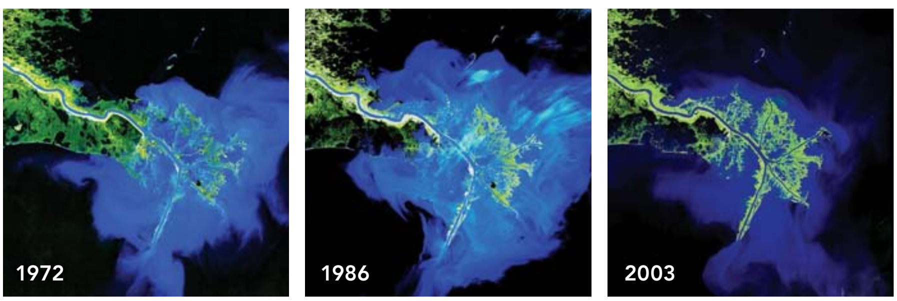
Richardson: Looking ahead three to five years, if we sat down again to discuss remote sensing, what would you hope to be telling me then?

Becker: I hope by that time that geoprocessing of cloud-based imagery will have really taken off. People will be using these services to run different models, ask specific questions, and get answers from multiple cloud-based services. I would hope to be talking about all these great examples and be able to say that we are getting closer to ubiquitous image access.

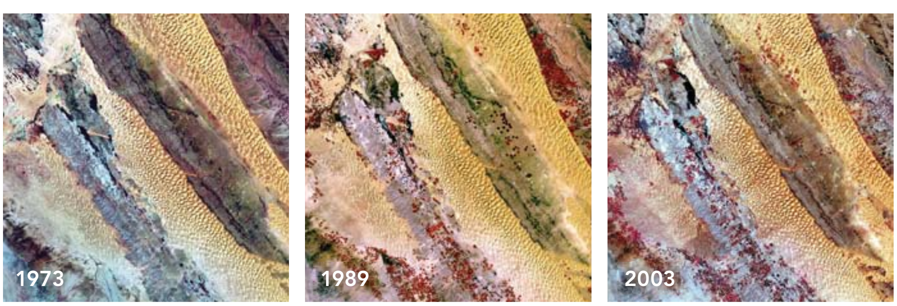
Here's Looking at You

40 years of earth observation

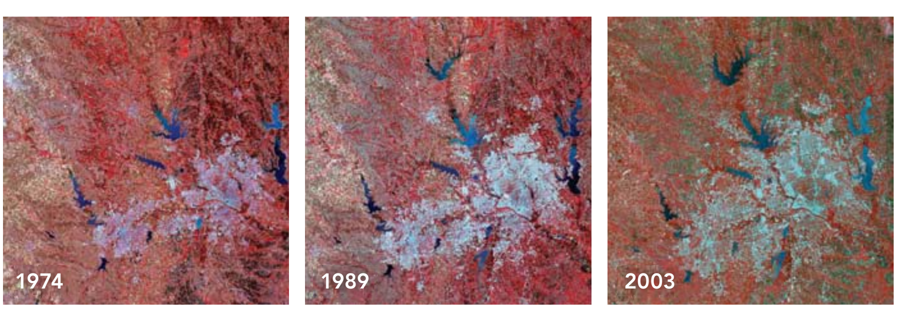
↑ Lake Chad, once the sixth-largest lake in the world, has shrunk to 1/20th its size in the 1960s.



↑ Changes to the shape of the Birdfoot delta at the termination of the Mississippi River are the result of sediment deposition.



↑ An area in the central portion of Saudi Arabia shows the effects of center pivot irrigation.



↑ This series of images documents the growth of the Dallas-Ft. Worth area of Texas.

Space missions of the 1960s, inspired by the impulse to explore the universe, also engendered a desire to learn more about the earth.

This eventually resulted in the launch of Landsat 1, originally known as Earth Resources Technology Satellite (ERTS), in 1972, which began a systematic inventory of the earth's resources that marks its 40th anniversary this year.

Landsat 7, the current earth observation satellite, has been called "the most stable, best characterized earth observation instrument ever placed in orbit." Its 30-meter, calibrated, multispectral resolution, coupled with the 185-kilometer-wide swath of imagery it captures, provides enough coverage in every season with sufficient detail to be useful for scientific and practical applications. Initially, its lower cost data made it affordable for research teams in academic institutions. Now it is free.

Thanks to nearly a half century of data collection, scientists now have a baseline knowledge of earth that is proving invaluable in evaluating environmental change and characterizing the effects of people on the landscape. It has also led to a better understanding of large-scale phenomena such as coral reef degradation or glacier loss. This data has become a rich data resource for agriculture, forestry, natural resource exploration, and other industries.

In 2009, all Landsat data from all missions was made free, leading to a 60-fold increase in downloads. Esri and the Department of the Interior (DOI) worked closely to make all Landsat Global Land Survey (GLS) scenes available as more than 20 dynamic, multispectral, multitemporal image services that were released on ArcGIS Online in 2011. In addition, Esri created an easy-to-use web-based Landsat ChangeMatters viewer (esri.com/landsat-imagery/viewer.html) for visualizing, analyzing, and detecting change using these image services.

The Top 10 for
ArcGIS 10.1 for Desktop

As the foundation for deploying GIS across an organization and on the web, ArcGIS for Desktop continues to play an important role in the ArcGIS system. With ArcGIS for Desktop, GIS professionals build high-quality cartographic maps, manage data, and perform analyses. These are the top 10 improvements for ArcGIS 10.1 for Desktop.

Number 10: **Locating Projections**

Using Search, quickly locate any of the 4,634 projections in ArcGIS 10.1 for Desktop. Search enhancements include searching for a spatial reference by name, well-known ID, and spatial extent. For example, to find a coordinate system for Sacramento, California, typing "NAD 1983 California" will return only projections that meet these criteria.

Number 9: **Tracking Feature Editing**

In a multieditor geodatabase editing environment, it is important to know who created or modified a feature and when it was modified, particularly when users are making edits through a feature service. Enable editor tracking from a table or feature class context menu or by using the new Editor Tracking geoprocessing tool. Editing information is maintained by the application. Access to features through a feature service can be restricted by enabling ownership-based access control on the feature service when it is published.

Number 8: **Geotagging Photos**

At ArcGIS 10.1, the locations of photos captured using GPS-enabled digital cameras, mobile devices, or smartphones can be imported to ArcGIS as point features that can be managed, modified, and analyzed using the geoprocessing tools in ArcGIS. The Geotagged Photos to Point tool makes it simple to display geotagged photos on a map. It reads the x-, y-, and z-coordinate information from JPEG and TIFF photo files with valid Exif (exchangeable image file format) metadata and writes the coordinates and associated attributes to an output point feature class.

Number 7: **Loading GPS Data**

The GPX To Features tool for 10.1 makes it easier to take GPS data from the field and load it directly into ArcGIS by converting the point information inside a GPX file into features for display on a map. GPX is a de facto standard for saving GPS waypoints, tracks, and routes.

Number 6: **Converting KML Files**

ArcGIS 10.1 for Desktop has tools for converting Keyhole Markup Language (KML) to an ArcGIS data format that can be viewed, edited, and analyzed. The KML To Layers tool for 10.1 supports the inclusion of the symbols, labels, and HTML pop-ups coming from KML files.

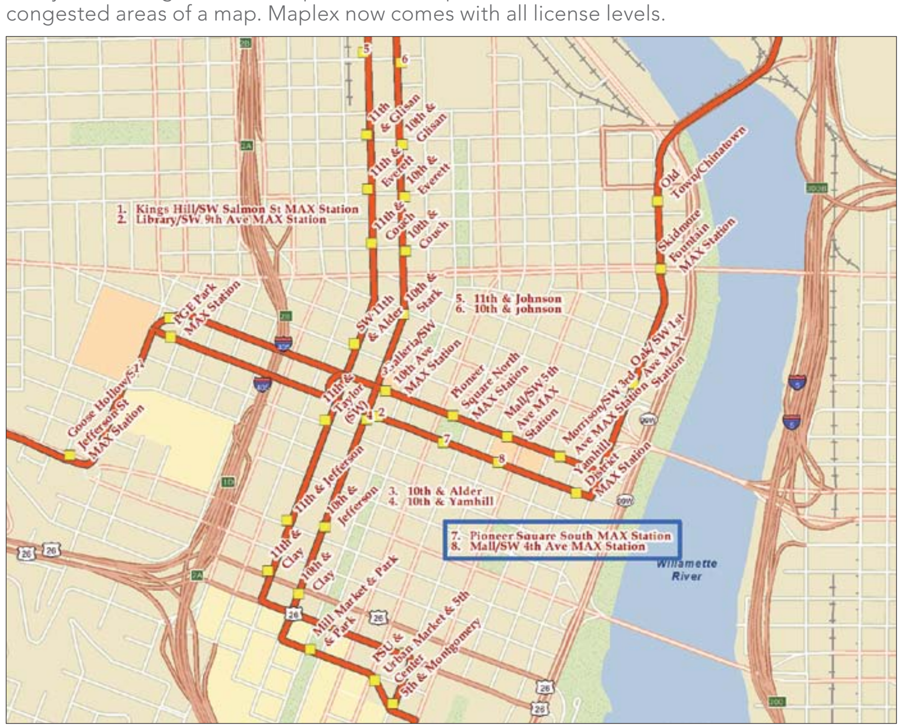
Number 5: **Making Multiscale Maps**

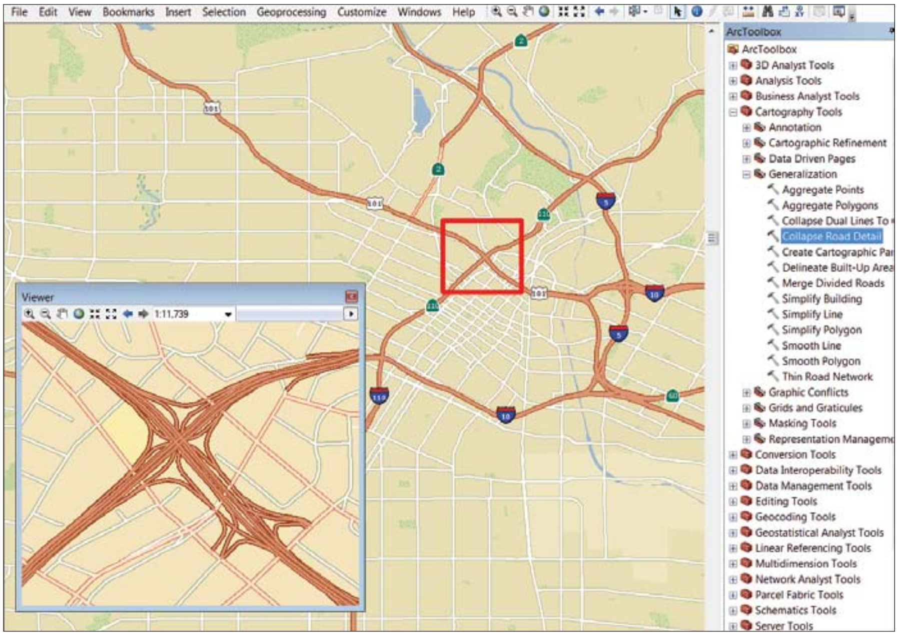
Additional geoprocessing tools and functionality for working with large datasets help create great maps at different scales. Two new generalization tools in the Cartography toolbox, Collapse Road Detail and Delineate Built-up Areas, provide the right level of detail for roads and buildings as the map scale changes.

Number 4: **Simplifying Geodatabase Administration**

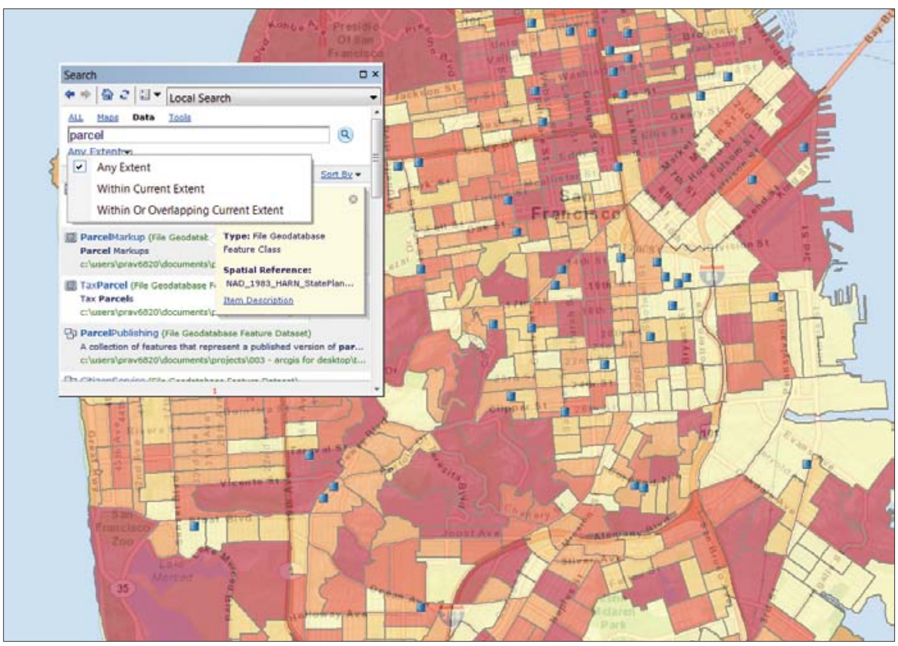
A new user interface for administering enterprise geodatabases shows connections and locks. A simplified Database Connections dialog box requires less input

↓ Key numbering, one of the options with Maplex, creates a numbered list of labels in congested areas of a map. Maplex now comes with all license levels.





← Collapse Road Detail, one of the new generalization tools, provides the right level of detail for roads as the map scale changes.



↑ Use the new Search to quickly locate any of the 4,634 projections in ArcGIS 10.1 for Desktop.

to make a connection and can connect to any supported database, whether or not it contains an enterprise geodatabase. The new Create Database Connection geoprocessing tool in the Workspaces toolset of the Database Administration toolbox takes the same inputs as the Database Connections dialog box and also allows definition of the version to use when connecting to a geodatabase.

Number 3: **Improving Labeling**

Advanced Maplex labeling capabilities are now included at all ArcGIS for Desktop license levels. Maplex supports key numbering, which creates numbered lists of labels in congested areas of a map. Features near the junctions of features and edges of the data frame can be labeled, and label text for linear features that straddle lines can be placed using other Maplex options. This version also supports Python in label expressions.

Number 2: **Using Dynamic Legends**

Legends become dynamic at ArcGIS 10.1 for Desktop. Only items in the current map extent are displayed in the legend. This is useful when working with large datasets with many classes and supports Data Driven Pages and web map printing. New legend fitting strategies include word wrap, column wrapping, and dynamic text sizing. Optionally, feature counts for legend items can be displayed.

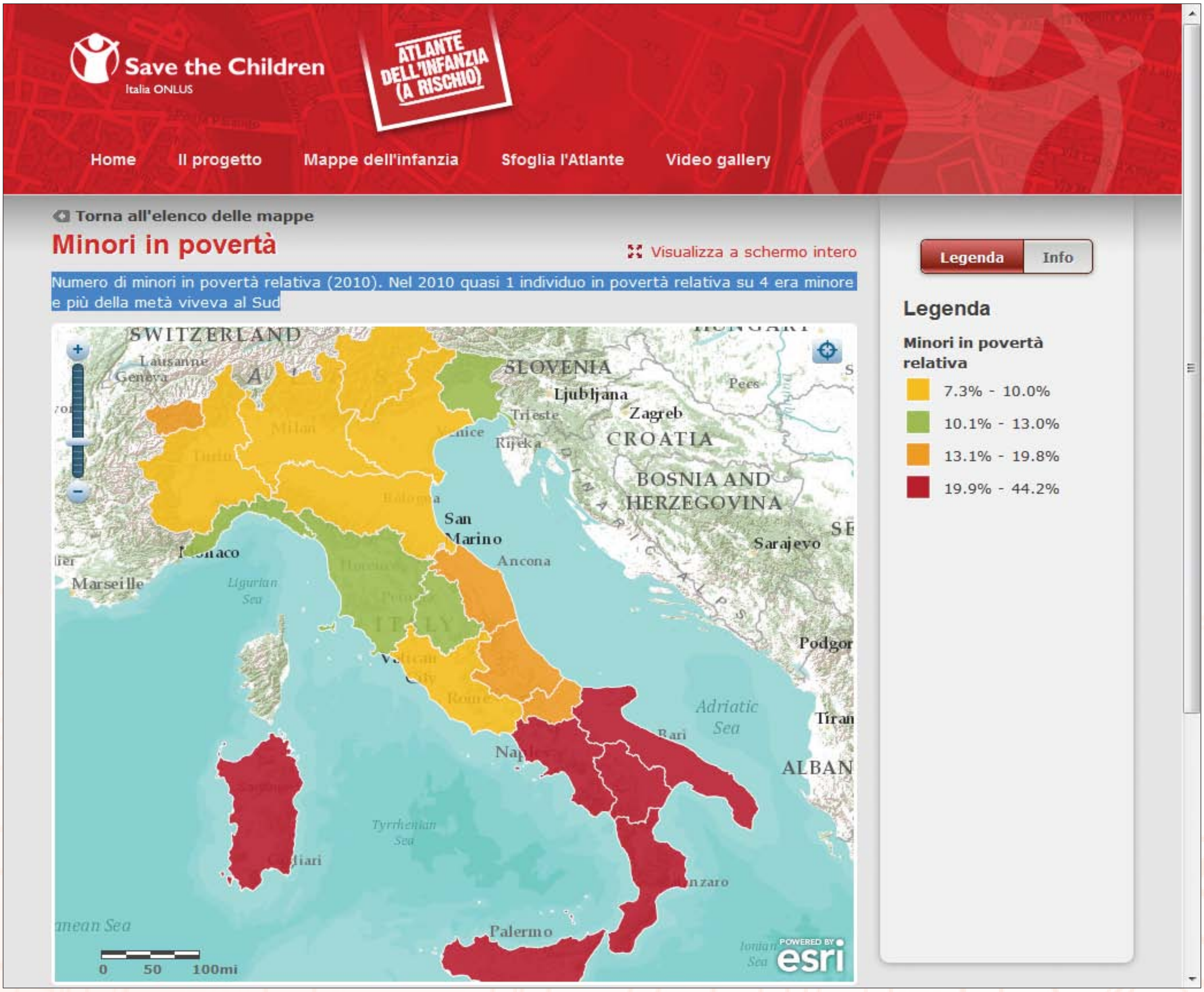
Number 1: **Simple Sharing with the Share As Menu**

The new Share As menu makes web enabling maps, data, and tools a straightforward process. From ArcGIS 10.1 for Desktop, choose File > Share As > Service to invoke a wizard-driven dialog box that takes the map from the desktop and publishes it to ArcGIS for Server or the cloud seamlessly. The workflow is the same whether a map, data layer package, or geoprocessing model is being shared.

Maximizing the Effectiveness of NPOs

"Thanks to this program, we are able to leverage cutting-edge GIS technology in the work we and our partners do. Using Esri tools to geoenable the data and platforms, Development Gateway makes the information much more powerful and easier to grasp, with a bigger impact on decision makers and international development efforts."

Jean-Louis Sarbib, Chief Executive Officer, Development Gateway (Esri Nonprofit Program participant)



↑ This map, created by Save the Children, shows the number of children in relative poverty in Italy. This international organization has created more than 70 maps that profile children and adolescents in terms of demography, environment, social spending, poverty levels, and other factors that indicate well-being.

Nonprofit organizations (NPOs) use GIS technology from Esri for the same reasons that hundreds of government organizations and businesses do: cost savings, increased efficiency, improved decision making, enhanced communications, and the ability to manage resources in a holistic manner using a geographic framework.

The Esri Nonprofit Program enables a worldwide community of conservationists and social activists to use GIS technology and data to fulfill their objectives more easily. Program benefits include the ability to get started with GIS technology in a quick and affordable manner and deploy it everywhere it is needed—on desktops, servers, the web, and mobile devices.

Extending Good Works

Currently, nearly 2,700 NPOs are participating in the Esri Nonprofit Program. Here are some examples of how NPOs are using GIS to make their organizations more effective.

Direct Relief International (DRI), which relies solely on charitable contributions to fund its work in supplying medicines and medical supplies to those in need, uses GIS to provide transparency to donors and governmental organizations. An interactive web map shows where and how contributions are spent on medical supplies and also helps coordinate relief activities between DRI and other agencies responding to disasters such as the 2010 Haiti earthquake.

NPOs use GIS to support sustainable development efforts around the world through analysis and visualization tools to manage growth and change. The Renewable Energy Atlas of Vermont (vtenergyatlas.com) is involved in local energy production and bolsters community projects that retain jobs and stabilize local economies through its interactive website that helps people identify and evaluate renewable energy opportunities for any town or county in Vermont.

Habitat for Humanity's mission is to eliminate poverty and homelessness. Habitat uses GIS in many ways to optimize its social programs, from presenting information to potential donors to determining the best sites for the homes it cooperatively builds.

Esri's Commitment to NPOs

Esri first began as a nonprofit organization more than four decades ago. "Ever since our founding, we have had a deep commitment to the goals and missions of the nonprofit world," said Jack Dangermond, Esri president. Today Esri is a privately held commercial organization, but the belief in and support of the nonprofit model has remained a core value at the company. A team provides software and services to the NPO community, as well as to national agencies focused on humanitarian affairs and sustainable development. See esri.com/nonprofit/faq.html for answers to common questions about the program.

Nonprofits with qualifying formal tax-exempt status can participate in the Esri Nonprofit Program. In the United States, this is signified by the 501 designation and National Taxonomy of Exempt Entities (NTEE) category. Nonprofit organizations outside the United States can contact their local Esri distributor for assistance to see if they are qualified. The primary criterion is tax-exempt status as granted by each organization's country. The specific nature of this status varies by country. Eligibility status and tax-exempt verification will be determined by the local Esri distributor as part of the request process.

Program Benefits

Eligible nonprofit groups enrolled in the Esri Nonprofit Program have access to the following resources:

- ArcGIS for Desktop: Eligible organizations can access one-year-term single use licenses as well as community and self-help support through the ArcGIS Resource Center and Esri Support Services. Ten ArcGIS for Desktop extensions are available through this program, including 3D Analyst, Network Analyst, and Spatial Analyst.
- ArcGIS for Server: NPOs receive the highest level license through this program—Advanced Enterprise. In addition to one-year-term single use licenses and community and self-help support, qualifying organizations also receive telephone support from Esri Support Services for one authorized caller. ArcGIS for Server extensions such as 3D Analyst, Geostatistical Analyst, Network Analyst, and Spatial Analyst are available through this program.
- Esri Community Analyst: Qualifying organizations receive 50 percent off the regular subscription fee for this Software as a Service (SaaS) mapping solution that provides GIS capabilities through a web application or as an add-in for ArcGIS for Desktop. Users are provided with an annual subscription license for single-, 3-, 5-, or 10-user licenses. The Community Analyst Add-in for ArcGIS for Desktop is included, as well as community and self-help support through the ArcGIS Resource Center and Esri Support Services.
- Enterprise License Agreement (ELA): The most comprehensive way to access Esri technology throughout an organization, an ELA has four options, beginning with licensing for 150 seats of ArcGIS for Desktop and 3 seats of ArcGIS for Server up to unlimited seats for both.
- ArcGIS Online: NPO users can freely use ArcGIS Online basemaps, services, and applications with no transaction limits. They can quickly create interactive maps and custom applications that can be published in Esri's secure cloud. Content can be shared with specific groups or the public, lowering IT costs and empowering users and stakeholders with easy-to-use, web-enabled content.

Esri provides a wealth of free self-service training resources for NPOs to help these organizations get started quickly.

How to Apply

NPOs can apply to the program by registering at esri.com/nonprofit or contacting nonprofit@esri.com for more information. Organizations outside the United States can contact their local Esri distributor for details.

A New Pattern for GIS

ArcGIS Online for organizations unlocks geospatial assets

ArcGIS Online for organizations instantiates a different pattern of GIS that is about solving new problems, not doing the same things on a new platform. Released in June 2012, it extends the benefits of GIS to everyone in an organization. Because it is integrated with ArcGIS for Desktop and ArcGIS for Server, maps and other products created by GIS professionals can be directly accessed by other members of an organization.

ArcGIS Online is an open data platform for maps and geographic information. This subscription-based service in the cloud makes content and tools directly available to an organization through intelligent web maps and applications that can be accessed from web clients, the desktop, and mobile devices such as smartphones and tablets. Non-GIS professionals can quickly create maps from the unstructured information in spreadsheets and text files and share these maps with others on any device. Through this common infrastructure, knowledge workers, managers, and even casual users can interact with the data and use information derived from it to get work done.

An annual subscription provides a private instance of Esri's secure, multitenant cloud that's scalable and ready to use. No additional hardware or software is needed to access basemaps and other content for creating and sharing maps and applications. Any user associated with an ArcGIS Online organizational account can quickly share maps by embedding them in a website or blog, through social media, or using

↓ With ArcGIS Online for organizations, administrators can apply fine-grained management and customize appearance and functionality.

a preconfigured web application template. The catalog of these maps and applications can be shared with specific groups, the entire organization, or the public. Note that organizations retain all rights, title, and interest to any content they publish in ArcGIS Online.

Extending ArcGIS Online

Initially, ArcGIS Online was made available through two types of free accounts: anonymous and personal use. Both accounts are for personal, noncommercial use. ArcGIS Online for organizations facilitates the pervasive use of geographic information for all types of uses.

Organizational use extends these capabilities considerably beyond making maps and mashups to creating map services and the unrestricted use of APIs, applications, and tools for commercial purposes. Registering data/services on ArcGIS Online makes them accessible from any device (browsers, mobile devices, and tablets) so anyone can use, make, and share maps. In addition to purchased subscriptions, ArcGIS Online can be deployed on premises. The two approaches, cloud and on-site, can also be blended in a hybrid solution.

With any of these scenarios, ArcGIS Online supplies fine-grained management and customization specific to an organization. It supports three roles: administrator, publisher, and user. Administrators can publish and use content, monitor service consumption, manage users, delete content and groups, determine security policy, and customize the appearance of their instance of ArcGIS Online. Publishers can publish and use content. Named users are the primary consumers of the content and can view and edit content made available by the organization.

The annual subscription plan for ArcGIS Online for organizations is structured to be flexible. Plans begin with five named users and 2,500 service credits. A service credit entitles an organization to consume a set amount of ArcGIS Online services (e.g., storage for feature services, geocoding). Credits can be used in whatever fashion best fits organizational workflows. More users and service credits can be added to the plan at any time. Organizations that have an existing enterprise license agreement (ELA) with Esri receive an ArcGIS Online subscription with a certain number of service credits allocated and unlimited users.

New Insights

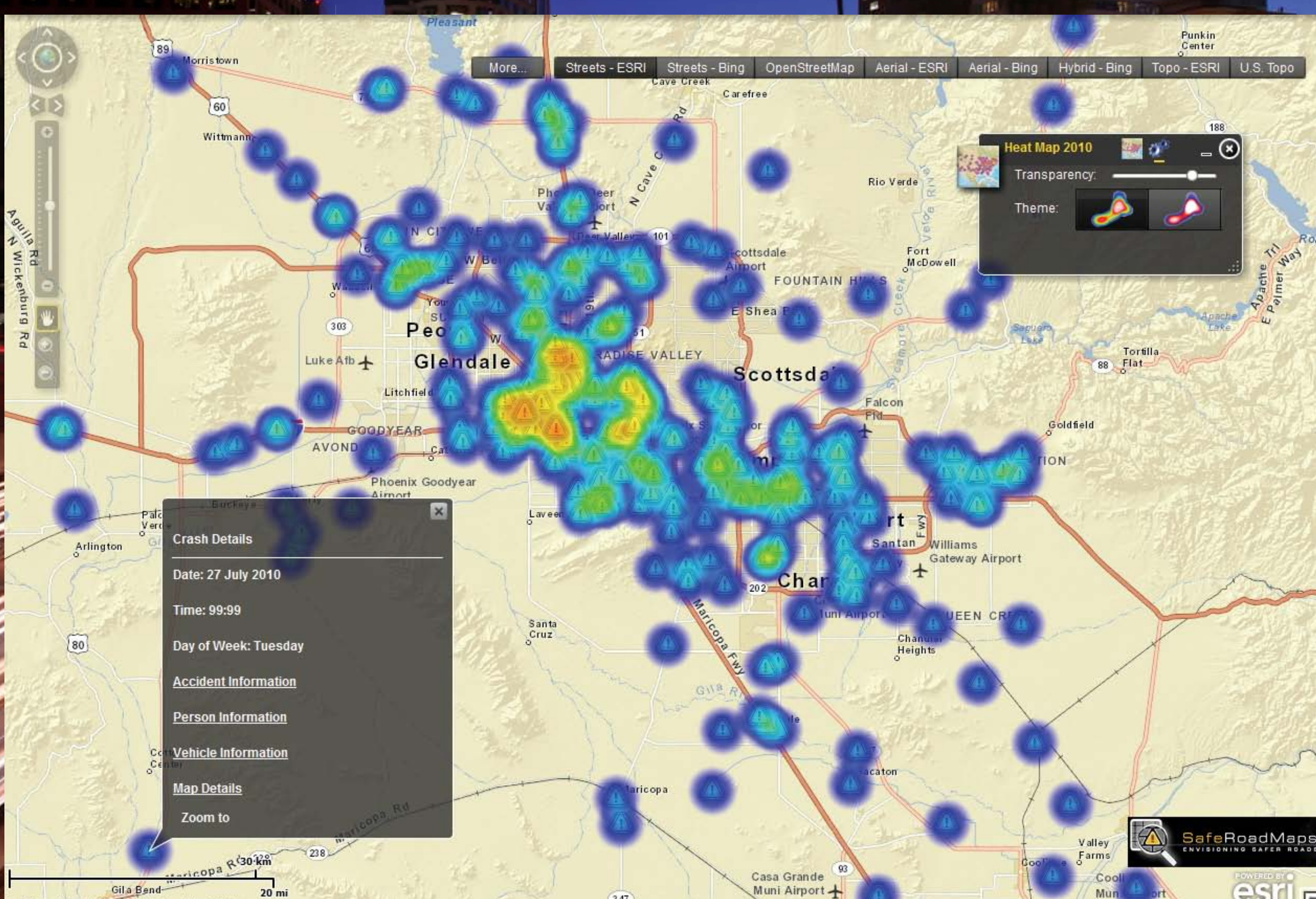
Making geospatial content accessible to anyone can create new insights and opportunities for organizations. On-demand and self-serve mapping frees GIS professionals from routine map requests and lets them spend more time creating and publishing authoritative information products. It also fosters better collaboration among teams and departments that can interact using intelligent web maps.

To learn more about ArcGIS Online, visit esri.com/agol.

Mapping Roadway Fatalities

Website increases awareness and understanding

By Brian N. Hilton, Claremont Graduate University



↑ The SafeRoadMaps website, built using the ArcGIS API for Flex, provides analysis and visualization of Fatality Analysis Reporting System (FARS) data. This heat map shows at a glance where concentrations of fatalities have occurred.

With tens of thousands of automobile fatalities each year, traffic safety is a major public health issue. Unfortunately, these alarming statistics do not always receive the attention they deserve. While researching the role of information technology in making emergency response systems more effective, Tom Horan, dean and professor at the School of Information Systems and Technology (SISAT) at Claremont Graduate University (CGU), noticed that geographic information about traffic fatalities was not used to its fullest potential.

"I've been working on a variety of research studies on health and transportation," said Horan. "I started to think about the public health problem that these fatalities represent." Automobile accidents are the number-one killer of teenagers in the United States. To increase understanding of this issue, Horan began a project to make traffic fatality statistics for the United States accessible from an easy-to-use website.

The SafeRoadMaps website was developed by SISAT research faculty member Brian N. Hilton, who directed a team of SISAT students. Hilton teaches classes in GIS solution development at SISAT. The website offers interactive maps that display where vehicular fatalities have occurred at the community level. When a visitor types an address or ZIP Code into SafeRoadMaps, the site displays information from state geodatabase records. SafeRoadMaps uses data from the Fatality Analysis Reporting System (FARS) provided by the National Highway Traffic Safety Administration for the years 2001–2010. FARS contains data on all fatal traffic crashes within the United States. Each case has more than 100 coded data elements that characterize the crash, the vehicles, and the people involved.

"SafeRoadMaps displays the key data on automobile accidents," said Horan. Visitors can discover when the accident occurred; how many people were involved; if the fatality was a driver, passenger, or pedestrian; and whether alcohol or some other inebriate was involved. The site also displays a photo of the location where the accident occurred.

Since its inception in 2008, the SafeRoadMaps website has logged almost 12 million hits. It serves a variety of user types and needs and houses an expanding spatial database. As Horan observed, "ArcGIS for Server provides us with the ability to more easily integrate our growing quantity and variety of data sources, allows us to perform more complex spatial queries, provides advanced geoprocessing functionality, and facilitates the creation of map tiles on the fly. In addition, we're using ArcGIS Viewer for Flex for rapid user interface development, something that was time-consuming and unwieldy with the previous implementation."

The first version of SafeRoadMaps was launched in 2008. It integrated a range of spatial data relating to motor vehicle crashes, transportation policy legislation, and driver behavioral data in a visual representation of traffic safety across the United States. In 2009, the second verson of SafeRoadMaps was launched. It extended functionality to include national heat maps to communicate the spatial density of traffic fatalities. Concurrent with the analysis and development of the national heat maps, the top 100 rural and urban hot spots were identified. The third version of SafeRoadMaps, launched in 2010, included data for all years that contain georeferencing information and featured new, user-friendly interfaces: My Travel, My Community, My State, and Analysis & Tools. Hot spot analysis was also extended across both spatial (rural/urban) and temporal (summer/nonsummer) dimensions. The release of the fourth version on May 16, 2012 was timed to coincide with the launch of Data.Gov/Safety (www.data.gov/communities/safety), a government website to increase awareness of public safety activities. SISAT participated in this event.

The SafeRoadMaps site is part of a multiyear collaboration between SISAT and the University of Minnesota's National Center for Excellence in Rural Safety (CERS). Lee Munnich, the center's director, noted that "SafeRoadMaps has provided an invaluable tool for communicating about the issue of traffic safety and raised national policy awareness of this public health problem."

Although the site was created for public use, Horan has been approached by organizations, such as driver's education programs, that are interested in creating specialized SafeRoadMaps modules. Throughout the website's development, Horan briefed James L. Oberstar, former US representative from Minnesota's 8th congressional district and chairman of the House Transportation and Infrastructure Committee (2007–2011). Oberstar has championed the site.

Although Horan's research is novel, he pointed out that it falls on the continuum of work that has created the field of public health. "Epidemiology got its start when there was a cholera outbreak in London. An intrepid researcher named John Snow mapped the cases and discovered it was originating from a specific public water pump. What we're trying to do is bring that same sensibility—a map, a visual tool that can help people understand the problem of public safety—and improve upon it."

For more information, contact Horan (tom.horan@cgu.edu) or Hilton (brian.hilton@cgu.edu) or visit www.saferoadmaps.org.

Keeping Traffic Moving during Bridge Repair Project

By Matthew DeMeritt, Esri Writer

↑ The Oregon Department of Transportation repaired the Snake River Bridge on Interstate 84 as part of the OTIA III State Bridge Delivery Program.

With 12 percent of US bridges declared structurally deficient by the Federal Highway Administration in 2006, bridge repair remains a top priority for most states. Three years before that, an extensive investigation of Oregon's bridges conducted by the Oregon Department of Transportation (ODOT) found that 365 of Oregon's bridges had structural problems that necessitated a large-scale bridge repair plan. Implementing that plan required that the department expand its GIS infrastructure and integrate a new traffic modeling application to ease congestion at multiple construction zones along the state's highway system.

Oregon Transportation Investment Act

From 2001 to 2003, Oregon passed a series of funding packages called the Oregon Transportation Investment Act (OTIA I, II, and III) to improve its highway infrastructure. For OTIA III, which included the State Bridge Delivery Program, ODOT turned to engineering consultants Oregon Bridge Delivery Partners (OBDP), a joint venture between HDR Engineering and Fluor Corporation, to create practices that would ensure the project finished successfully and within budget. One of the primary goals of the program was to reduce the impact on commuter and business traffic during large-scale construction on its road system.

Many of the bridges designed during the early development of Oregon's highway system used a reinforced concrete deck girder (RCDG) design specified in the regulations of that time. As specifications became more stringent in the 1960s, Oregon transitioned to prestressed and post-tensioned concrete bridges that improved structural integrity at a reduced cost. However, many RCDG bridges remained in service well past their expected decommission date and began to show signs of deterioration on deeper investigation. "In 2001, ODOT inspectors noticed that cracks identified in previous inspections had grown to the point of threatening

structural stability," said Jim Cox, assistant manager of major projects at ODOT. "We immediately placed load restrictions on these bridges and started discussion on how to plan repairs with the least impact on commercial and commuter traffic."

GIS and Geodesign

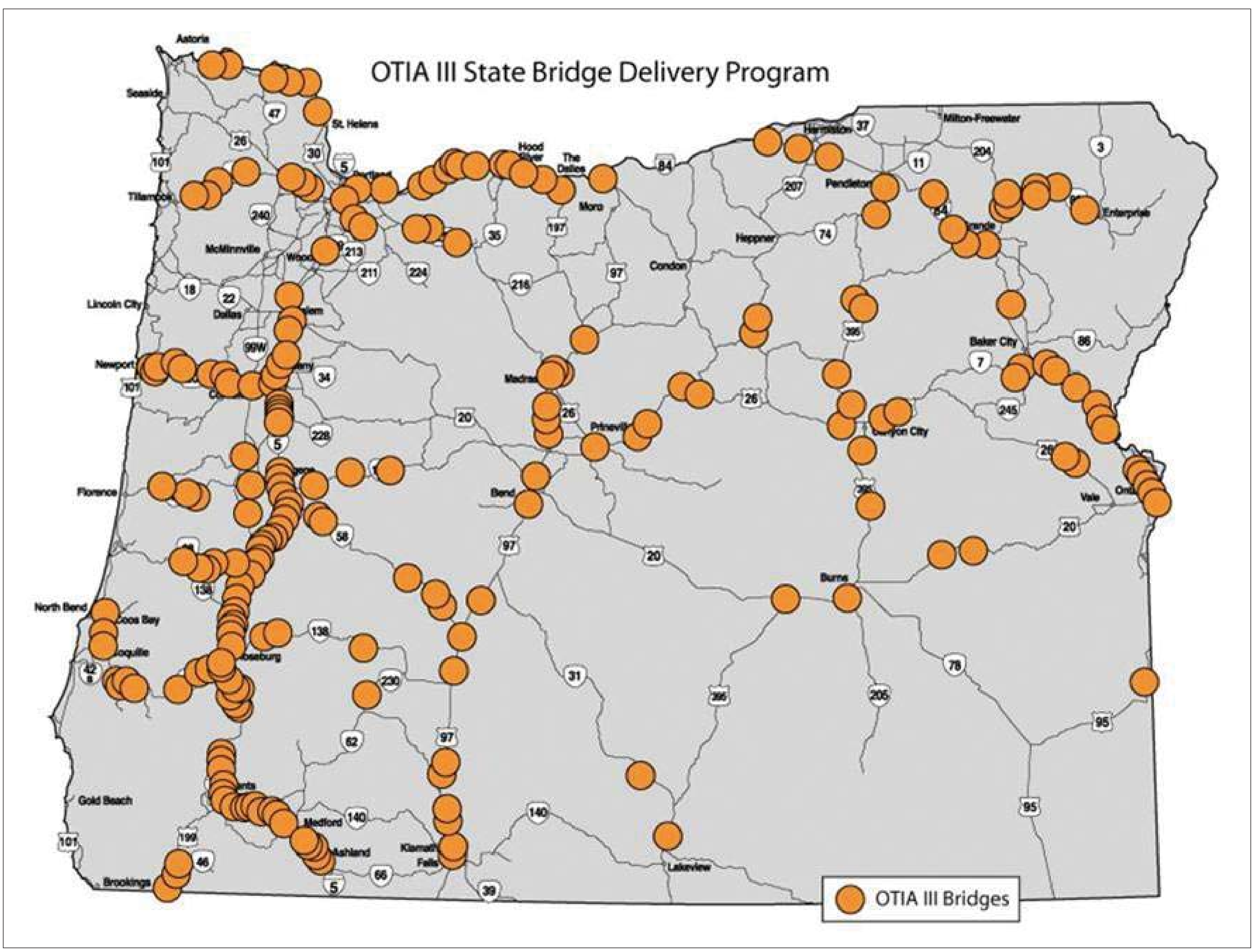
Established in 2004, ODOT's GIS comprised the department's information-sharing infrastructure to plan and manage roadway projects. To integrate with ODOT's GIS, OBDP designed its system on the same ArcGIS platform for flexibility and scalability throughout the project life cycle and beyond. "We wanted easy adoption of tools and practices to smooth transition during project closeout and ensure usefulness beyond that," said Robb Kirkman, GIS Services manager for HDR Engineering. "GIS provided the foundation to start linking program systems, automate tasks, and better mitigate environmental impacts."

Before any construction work began, ODOT collected comprehensive environmental data on more than 400 of its bridge sites to identify nearby environmental resources. Standard ODOT practice involves consultation with experts such as biologists, wetland specialists, and archaeologists to get a better understanding of the effects of construction zones in ecologically sensitive areas. "We took a different approach for the OTIA III Bridge Program by conducting environmental fieldwork before we did any design," said Cox. "In ArcGIS, we drew a box around a bridge site and identified all the resources inside the box. This allowed the engineers to develop designs that minimized impacts on the surrounding environment."

Improving Work Zone Traffic Analysis

Prior to its collaboration with OBDP, ODOT had been using spreadsheets containing traffic counts and automatic traffic recorder information from across the

↓ The OTIA III State Bridge Delivery Program is a 10-year, $1.3 billion program that will repair or replace hundreds of aging bridges on Oregon's highway system.



state to document and predict traffic impacts for its various road construction projects. That process could take up to four hours for each scenario because data had to be searched and collected from multiple databases within the agency and then inserted into a spreadsheet. "Gradually, that process evolved to incorporate GIS processes," Kirkman said. "Using macros and automation tools in ArcGIS, ODOT's traffic group was able to automatically populate the spreadsheets with information from the database."

Although much leaner, the spreadsheet-only approach experienced crashes as the database grew ever larger. The traffic team worked with OBDP to develop a more efficient GIS-based method for running traffic scenarios—one that tightly wove ODOT's geospatial data into a dedicated web-based analysis tool. Using common protocols, they worked on tying the datasets together to give ODOT staff direct access to the department's databases from a single interface. Called the Work Zone Traffic Analysis (WZTA) tool, the application allowed traffic scenarios to be run and shared in a web browser.

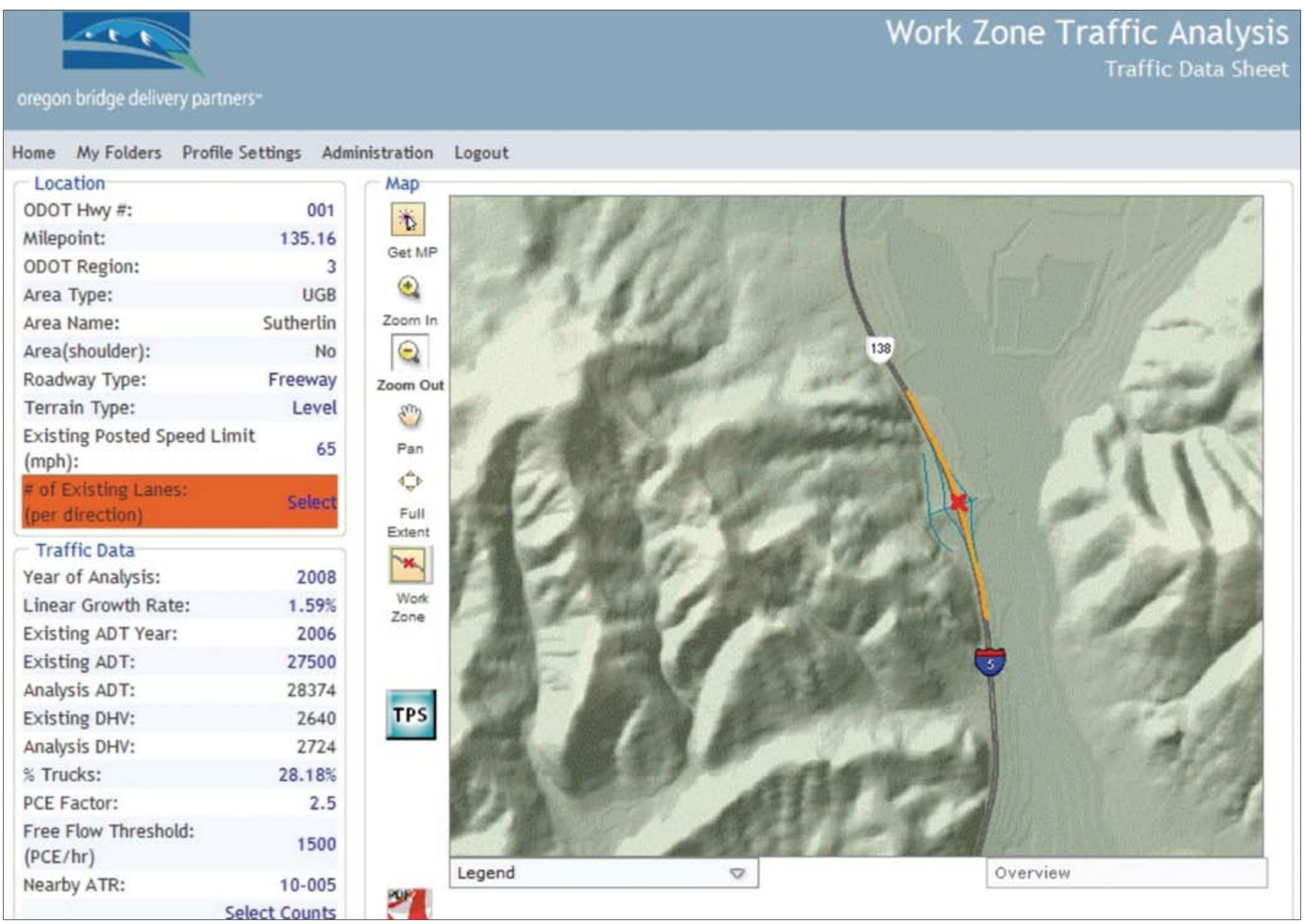
WZTA serves as a repository for information on traffic and road data that can be accessed and queried in a browser. The system allows users to view ODOT data to determine the effects on mobility created by lane closures related to construction and roadwork. Today, the department can run traffic scenarios in a matter of minutes, eliminating redundancy and enabling ODOT engineers to modify traffic plans on the fly.

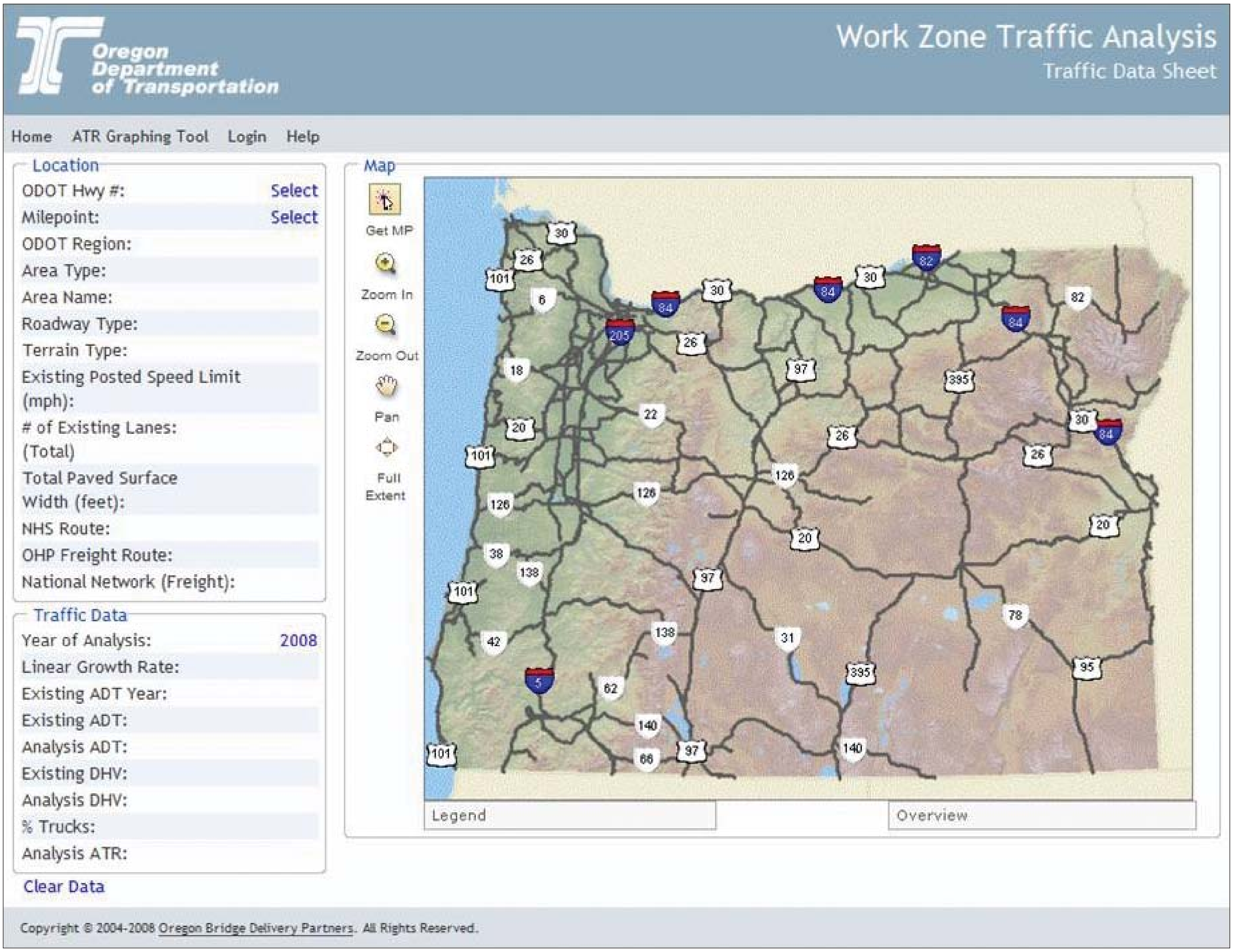
Using a GIS-based interface also improved accuracy by allowing ODOT analysts to select the location and other information for a specific project site from the map itself rather than tabular lists. "Lookup tables using numbering systems aren't intuitive to all users," Kirkman said. "GIS enabled users to find exactly what they were looking for and verify the correct project information within a more appropriate map-based user interface where spatial relationships are more obvious."

Documented Return on Investment

In 2010, ODOT and OBDP documented their experience with the tools to evaluate the impact of ODOT's

↓ The department can run traffic scenarios in a matter of minutes—rather than hours—enabling ODOT engineers to modify traffic plans on the fly. Easy access to reliable data helped the agency determine how to stage projects with minimal delays.





↑ Using a GIS-based interface, ODOT analysts can select the location and other information for a specific project site from the map itself rather than tabular lists. In 2007, WZTA received the Team Excellence Pathfinder Award from the American Association of State Highway and Transportation Officials.

investments and determine if they should be used after completion of the bridge program. With the assistance of economic consultant Mark Ford, they analyzed every piece of software OBDP created for the OTIA III Bridge Delivery Program to determine the economic benefits and cost to the department. The study concluded that ODOT experienced a combined benefit-cost ratio of 2:1 for all enterprise IT investments related to management of the bridge program.

ODOT's GIS infrastructure alone returned a benefit-cost ratio of 3:1. "Integration of formats and standards proved to be important in generating value from the investment," said Ford.

In addition to these tangible benefits, ODOT experienced three types of intangible benefits. Migrating the data from disparate sources into a unified system allowed OBDP to employ consistent analysis methods, reducing the risk of calculation errors. The centralized database also made it easier for ODOT to maintain data integrity and reduce the risk that analysts working at different locations could use outdated information. "Systems like ODOT's GIS infrastructure generate accurate, consistent, and timely information for reporting and responding to inquiries," Ford said. "WZTA, and GIS in particular, has resulted in improved coordination with other agencies and interest groups, increasing the credibility of both ODOT and the bridge program in the eyes of the public and the legislature."

At the beginning of 2011, 351 of the 365 bridges in the OTIA III Bridge Delivery Program were free of construction zone delays. WZTA played a primary role in expediting the construction process by allowing the team to run lane closure traffic analyses in minutes as opposed to hours. The tool is now being used by ODOT on other roadway maintenance and construction projects to quickly determine impacts from lane closures across the state.

Balancing Past and Future

Using 3D GIS analysis to route light rail through historic Mesa

By Cory Whittaker, City of Mesa, Arizona

↑ The Valley Metro Light Rail's Sycamore Station in Mesa has had the highest ridership of any station in the light rail system.

In December 2008, the Valley Metro Light Rail system debuted in the Phoenix Metro area. *[Valley Metro Rail Inc., a nonprofit public corporation, operates a high-capacity transit system in this region.]* In the months that followed, the City of Mesa's single station had more passengers than any other stop on the system.

When this trend continued, Valley Metro decided to expand the light rail system through downtown Mesa. This announcement was seen as a victory for revitalization efforts in the city. Neighboring cities have seen that light rail is a catalyst for transit-oriented development of nearby properties.

The proposed route takes the light rail line through the heart of downtown Mesa to cultural venues such as the Mesa Arts Center and the Arizona Museum of Natural History. The route also passes through the historical center of the city of Mesa, where buildings and places of historic significance—some listed on the National Register of Historic Places—are located.

To better understand how this project would interact with the nearby historic buildings, 3D GIS visualization tools were used. These tools gave decision makers and the public a virtual view of what downtown Mesa might look like after the light rail system was completed.

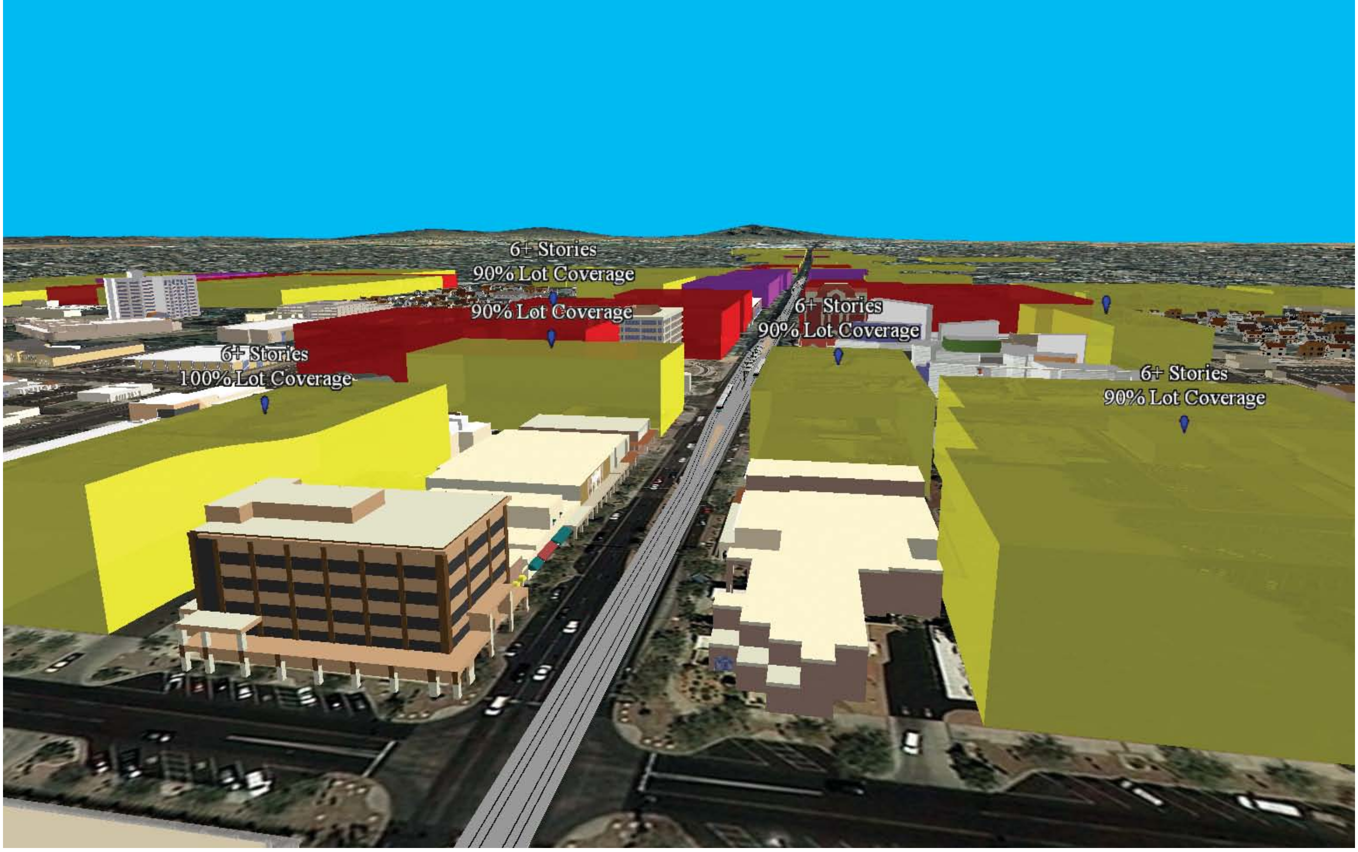
Modeling Downtown Mesa

Before the light rail expansion was proposed, the City of Mesa GIS staff conducted a pilot project to assess the feasibility of modeling downtown Mesa in 3D given existing departmental resources. This happened just as the economy began to nosedive and budgets were shrinking. Staff used readily available software to render Mesa City Plaza in 3D with minimal effort and cost, demonstrating to city management that modeling buildings in 3D was not only feasible but that staff members had the necessary skills. The results could be easily imported into the City of Mesa's existing Esri-based GIS system.

This successful pilot project provided the impetus to begin creating a 3D model of downtown Mesa. The first step in creating the virtual downtown was inventorying and estimating the heights of all non-single-family buildings. This inventory established a starting point for constructing virtual buildings.

Data for the inventory was collected in two ways. For some site locations, original, detailed building plans were readily available, and these were used to create individual building structures that were accurate down to the inch. For buildings that predated the city's founding, no plans were available, so oblique aerial photos were used to digitize these buildings. Although these buildings were not as accurate as ones created using detailed plans, they were sufficiently accurate for purposes of analysis. Much time and effort was expended to capture each building in enough detail so that it could be immediately recognized without a label.

↓ The 3D model of downtown Mesa



↑ This 3D rendering shows the proposed development intensity for residential (yellow), commercial (red), and mixed use (purple). The number of stories and lot coverage for each is shown.

Being able to see how downtown Mesa would look with the completed light rail system and subsequent redevelopment helped the public see the benefits of having this mode of mass transit in the city of Mesa.

Working with the Community

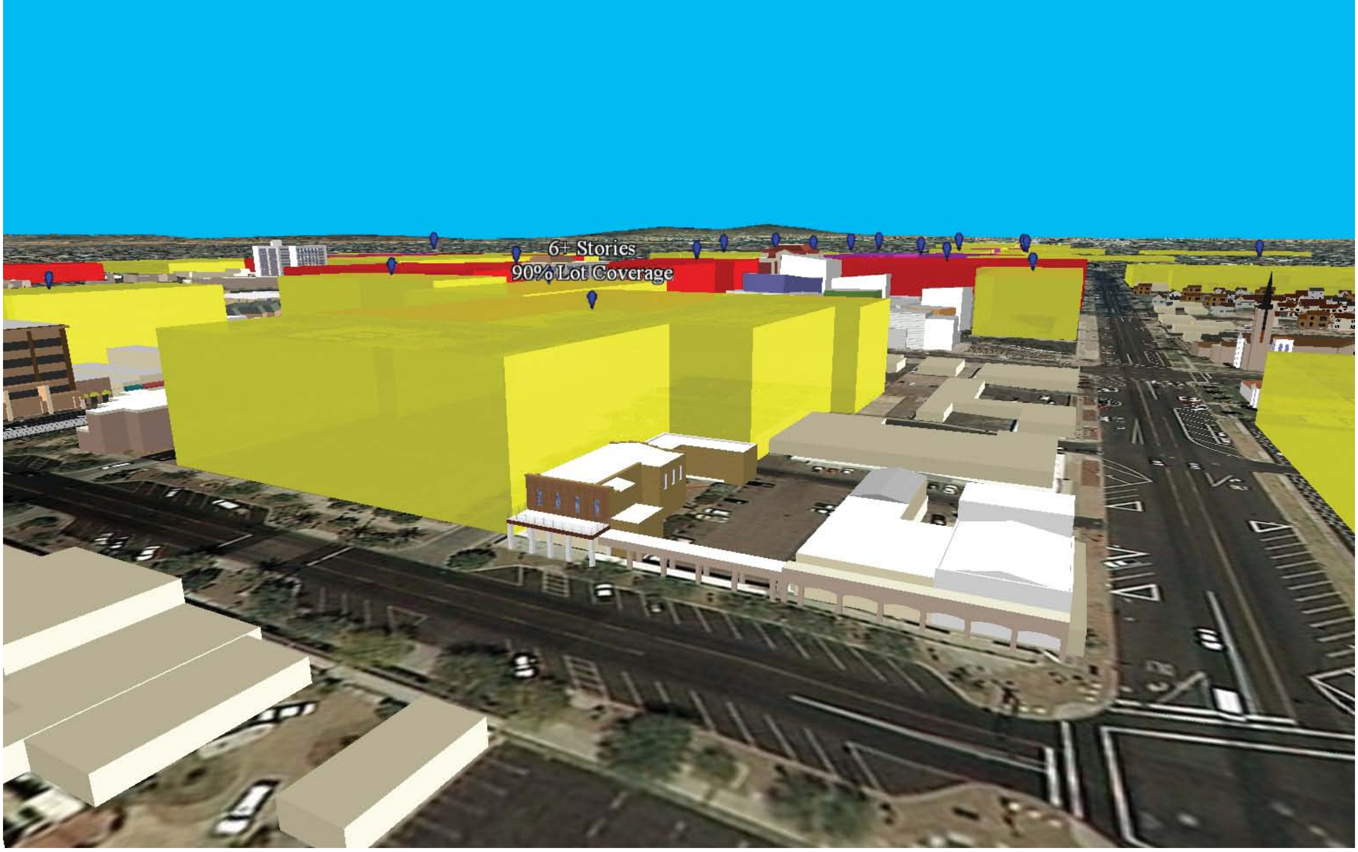
The city needed to establish policies for development along the light rail route. Upon completion and approval, these policies would be organized into a document called the Central Main Plan. A committee composed of city planners and local property owners, business owners, and organizations, such as historic neighborhoods and business alliances, was formed to gather different viewpoints from the community. The committee helped the city maximize the benefits of the light rail expansion.

The committee performed one key exercise, called the Reality Check, using the 3D GIS visualization tools to answer four important questions about the future development along the light rail route:

- Where should infill and redevelopment occur?
- What areas are off limits to redevelopment?
- What will be the intensity of the development/redevelopment that is envisioned?
- Is this achievable?

With these questions in mind, committee members were asked to map where they would put 4,000 dwelling units and 1.8 million square feet of nonresidential floor space. Committee members could incorporate their grand ideas for downtown Mesa. After compiling the results, city planners had a blueprint of where and how much redevelopment would be possible. Parking lots, a few existing buildings, and vacant lots were identified as potential redevelopment sites.

With the redevelopment areas, number of dwelling units, and the amount of nonresidential square footage defined for each area, city management requested a 3D GIS analysis for these areas. Calculations, based on the number of dwelling units, square footage, land use, and lot coverages, showed how tall buildings would need to be to fulfill the proposed requirements. Buildings at these heights were displayed in 3D next to existing building footprints. The three light rail stations and rail tracks associated with them were also modeled in 3D. This analysis explained complex development planning criteria to Mesa citizens in an easily digestible format that helped them envision redevelopment potential along the light rail path.



↑ The historic Alhambra Hotel shown with the adjacent proposed redevelopment

At first glance, the redevelopment areas had something in common. The majority of the buildings along the light rail route in downtown Mesa front along the street with large parking lots behind them. Because most of the proposed redevelopment is slated for these parking lots, they are a blank canvas for downtown revitalization efforts.

Seeing Today and Tomorrow

Preserving the historic character of downtown Mesa was a key priority. The Alhambra Hotel was built in 1893 and is located in the heart of downtown Mesa. Although it was partially destroyed by fire, the building was added to the National Register of Historic Places in 1993. No longer a hotel, it still has historic value and is located just south of the light rail route, next to a large parking lot that is the site of a proposed six-story building with 90 percent lot coverage. The proposed building, nearly three times taller, would dwarf the Alhambra and possibly harm its historic value.

Without a 3D GIS view, the magnitude of the disparity in the heights of these buildings would be lost. With this visualization, it was clear that caution would need to be exercised when redeveloping this site to ensure that the historic character of the Alhambra Hotel is preserved.

Light rail expansion through downtown Mesa spawned a significant 3D GIS effort that also provides potential benefits in other areas of the city. With this information in GIS, the city can conduct viewshed and line-of-sight analyses. City of Mesa Police and Fire departments want to use the 3D model in strategic planning for special events in downtown Mesa. The 3D model of downtown provides the flexibility and opportunity to model building interiors for asset management, real estate requirements, or similar purposes.

Being able to see how downtown Mesa would look with the completed light rail system and subsequent redevelopment helped the public see the benefits of having this mode of mass transit in the city of Mesa. This project has also opened the minds of city leaders and citizens to the benefits of 3D GIS analysis for standard city operations.

About the Author

Cory Whittaker, GISP, is a GIS specialist for the City of Mesa, Arizona.

Out of Harm's Way

Enabling intelligent location-based evacuation routing

By Kaveh Shahabi, University of Southern California

Editor's note: *The author has created a tool for ArcGIS for Desktop and the ArcGIS Network Analyst extension that performs evacuation planning more intelligently and efficiently. For his work developing this tool, Shahabi received the USC Esri Development Center Student of the Year award.*

Traditionally, evacuation planners use either simulation software (like agent-based modeling) or basic shortest path routing methods to predict and visualize emergency situations. The results are relatively static, one-size-fits-all evacuation plans.

ArcCASPER (Capacity-Aware Shortest Path Evacuation Routing) is a custom Network Analyst tool that uses a state-of-the-art routing algorithm to produce evacuation routes to the nearest safe area for each evacuee or group of evacuees. The CASPER algorithm determines realistic traversal speeds for each road segment based on road capacity and number of evacuees. It intelligently and dynamically takes into account road capacity and travel time to create routes that minimize traffic congestion and evacuation times.

Developed as an evacuation routing extension to ArcGIS Network Analyst, ArcCASPER is available from the ArcGIS Resource Center. The Network Analyst extension handles management of the transportation network dataset and computation of road attributes. Visualization of input points and final routes is done through ArcMap. ArcCASPER provides its three routing methods (shortest path, capacity constrained route planner [CCRP], and CASPER) as additional options to the standard Network Analyst capabilities.

Traffic Models and Evacuation Planning

In the 1970s, researchers began to estimate evacuation time for people living close to nuclear power plants. *[Following the Three Mile Island accident in Pennsylvania in 1979, the Nuclear Regulatory Commission requested that utilities operating nuclear generating plants provide estimates of the time required to evacuate the populations surrounding those plants.]* One of the early works that separated evacuation modeling from traditional traffic modeling was the NETVACI model. Later, the MASSVAC program was developed to simulate urban evacuation during a disaster. Until the early 1990s, the goal was simply to predict traffic conditions during an evacuation given population density and network topology. Today's research objective is more ambitious: attempting to enhance evacuation planning with optimality, applicability, scalability, and enforceability.

City transportation networks are not designed to handle the sudden evacuation of tens of thousands of people from their residences or workplaces to designated safe areas. Evacuees take what they think will be the fastest path, which most often results in heavy traffic congestion and an unsuccessful evacuation. Evacuations related to disasters such as fires, environmental incidents, or man-made events are not as predictable as tsunami evacuations and pose additional problems for planners.

ArcCASPER can help evacuation planners avoid such scenarios. The algorithm at the core of this tool combines the road capacity (number of lanes or road class) with its speed limit to macroscopically predict traversal speed. The algorithm then generates routes specific to each evacuee location while minimizing global evacuation time.

Looking at Evacuation Routing Solutions

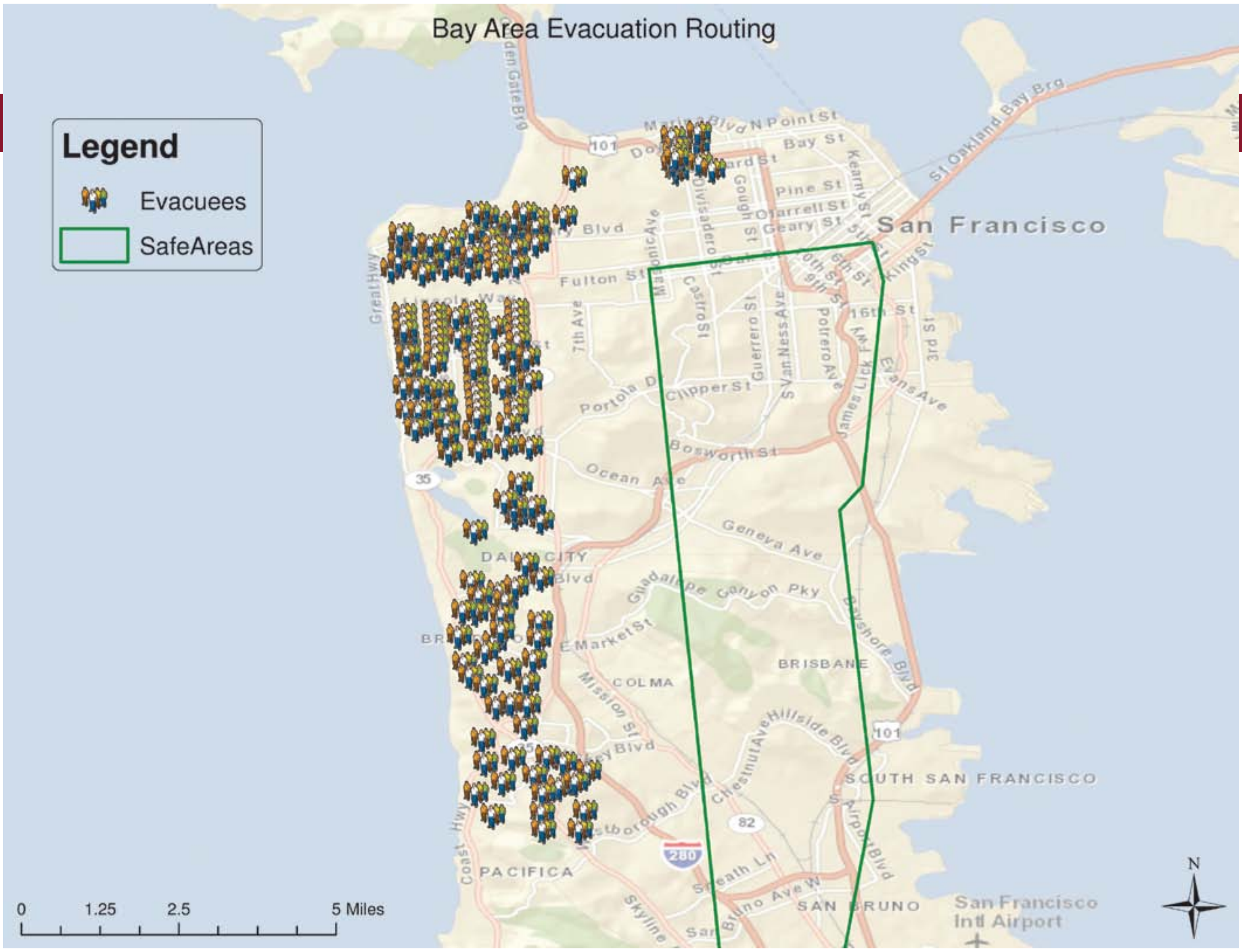
Evacuation routing solutions can be divided into two main categories: descriptive and prescriptive. Descriptive solutions show what would happen in a given condition using simulation techniques. In contrast, prescriptive solutions devise optimized routing strategies to achieve an evacuation goal without necessarily performing a microscopic simulation. ArcCASPER uses a prescriptive method.

Finding paths and flows are fundamental graph theory problems in computer science. To benefit from solutions to these rich problems in graph theory, GIS data must first be modeled into a graph. The usual practice is to assume a graph edge for every road segment and a graph node for every road intersection. The original shortest path algorithm is based on the assumption that a positive cost value can be put on every edge.

In GIS, this can be inferred from the road segment length and speed limit. Later development made this algorithm applicable to real-world GIS problems by implementing turn costs and turn

← In this 2005 photo, Texas residents are evacuating Galveston in advance of Hurricane Rita. (Photo by Ed Edahl/FEMA)

↓ San Francisco residential area evacuation planning



restrictions. Today, most driving direction services have this algorithm at their core. The maximum flow problem, which seeks to maximize flow within a network, also assumes that a positive capacity value can be put on every edge. Today, this algorithm is used to find utility network bottlenecks.

Evacuation routing is also another graph theory problem, which seeks to maximize evacuation flow while minimizing the cost. To do this, it takes into account two positive values for every edge: an edge cost and an edge capacity.

From the user's point of view, the process of planning evacuation routes is composed of three steps:

1. Gathering inputs
2. Selecting a routing method
3. Mapping the final routes

1. Gathering Inputs

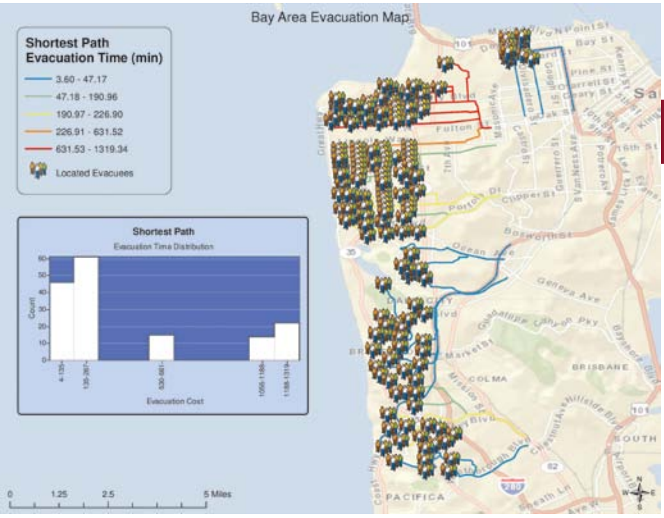
The basic input requirement is an ArcGIS transportation network. It is critical to build the network dataset from the most up-to-date street data and use accurate turn restriction tables. The evacuee locations can be collected in a number of ways. The most straight forward method is to use high-resolution population data such as census blocks. For evacuating smaller communities, such as university campuses, cell phone locations could be used instead.

2. Selecting a Routing Method

Of the implemented route optimization methods in ArcCASPER, shortest path, CCRP, and CASPER, the most basic and traditional method is shortest path. Since the shortest path algorithm ignores road capacities, the process is fast, but its accuracy is low.

CCRP generates routes while constraining them to road capacities. For example, if there is a narrow pathway that some evacuees need to use, CCRP gives more priority to evacuees who have a longer predicted evacuation time. Once the narrow pathway is fully saturated and becomes a complete bottleneck, the algorithm routes the rest of the evacuees on alternate routes.

The third method, CASPER, takes a fuzzy approach instead of using hard constraints. The algorithm first sorts evacuees by their distance from the closest safe area. Then, starting from the evacuee farthest away, it finds the shortest path and assigns the evacuee to that path. It iteratively continues this process until there are no more evacuees left. During the analysis, CASPER dynamically updates each edge travel cost based on the number of assigned evacuees and the edge capacity. This heuristically minimizes the global evacuation time without any hard constraints. This fuzziness is CASPER's main strength. Based on the evacuation routing method used, the ArcCASPER tool generates a route that will guide each evacuee to the best safe area.



↑ Evacuation map of San Francisco residential areas using shortest path method

3. Mapping the Final Routes

Each route has a shape, length, total evacuation time, and assigned population. Since ArcCASPER is integrated with ArcGIS, the entire process, from inputs to configurations to mapping final routes, is performed in ArcMap. ArcMap's visualization and quantitative symbology tools help identify groups of evacuees with slow evacuation times. Furthermore, each segment of the transportation network can be queried for predicted usage and possible traffic congestion. Taken together, the outputs generated enable the network to be better understood so the locations of safe areas can then be adjusted. Rerunning the process will then achieve even faster evacuation results.

Modeling a Real-World Example

Shortly after the Tohoku earthquake and tsunami near the coast of Japan in March 2011, the Pacific Tsunami Warning Center in Hawaii issued a widespread tsunami warning covering the entire Pacific Ocean. Local tsunami warnings were also issued for the coastal areas of California, all of Oregon, and some parts of Alaska.

The tsunami crossed the Pacific Ocean and hit California shores in less than a day. The impact of the tsunami on the continental United

Method		Shortest Path	CCRP	CASPER
Total Road Segment		1,614	5,933	4,493
Person per road segment	Min	320	1	52
	Max	64,033	38,475	25,177
	Mean	6,942	2,143	2,669
	Standard Deviation	8,444	3,923	2,384

↑ Table 1: Number of evacuees per road segment for all three methods

States was relatively slight. Only 6,000 residents were evacuated. However, if the event had been a nearby offshore earthquake, substantial numbers of the population may have required evacuation.

About 200,000 people live within a few minutes' driving distance from the coastline of San Francisco, California. This densely populated 30-square-mile area has local roads and few major highways. Without prior preparation, evacuating this many people to inland areas would not be efficient. The three methods available in ArcCASPER were used to plan evacuation routes for this scenario. This test used census block group population data for evacuees and a large safe zone inland.

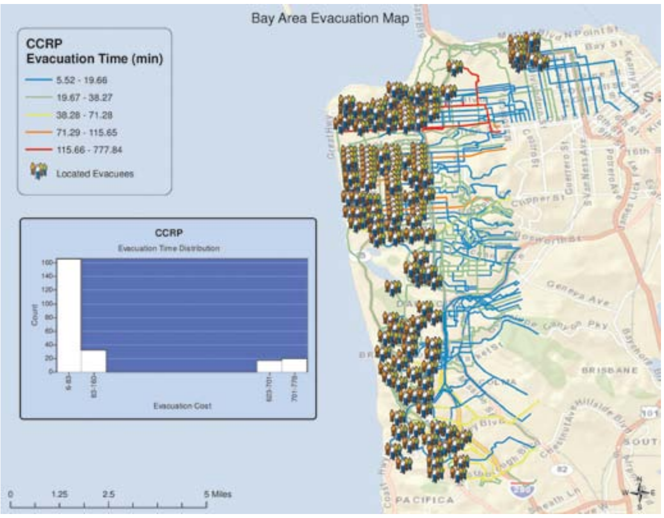
The shortest path technique resulted in an evacuation scenario of about 22 hours. Because road capacities were not considered, all evacuees were routed by the shortest routes. Although on a normal day, the evacuation routes used represent, at most, a 10-minute drive, routing ***all*** evacuees the same way resulted in heavy traffic congestion on the main roads and longer than usual evacuation times.

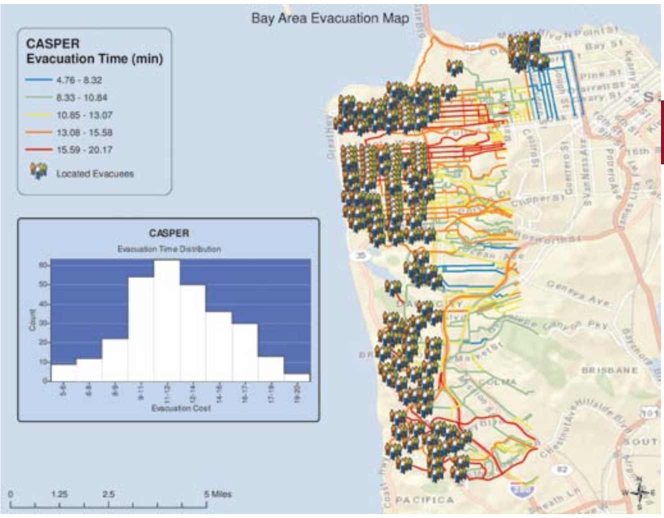
The CCRP method predicted a 13-hour evacuation scenario. It generated routes that took a little longer than on a typical day. However, about 80 percent of the population was rescued in about 2 hours—a considerable improvement over the shortest path scenario.

The CASPER route optimization method far surpassed the other two methods. CASPER achieved a 20-minute evacuation scenario using the same network, population density, and safe area parameters.

The CCRP and CASPER methods are similar. Both try to balance the population over as many road segments as possible to decrease evacuation time. CASPER achieves far better results using most of the same road segments because it can predict traffic congestion and road segment delays more accurately. Table 1 summarizes the number of evacuees per road segment. Note that the shortest path method uses far fewer road segments and has a larger number of people per segment compared with the other two methods.

↓ Evacuation map of San Francisco residential areas using CCRP method





↑ Evacuation map of San Francisco residential areas using CASPER method

Conclusion

Traffic modeling plays an important role in evacuation planning. ArcCASPER makes available the CASPER algorithm, which has a realistic traffic model that predicts traffic congestion more accurately. This intelligent traffic model is based on road attributes and population density and is applicable to any evacuation scenario for any geographic location. In addition to its traffic model, the CASPER algorithm heuristically solves any evacuation routing problem whether it involves students running during a campus evacuation or people driving cars during an urban evacuation.

Using ArcCASPER, emergency management officials and policy makers can better understand urban evacuation and confidently make life-saving decisions. For more information, contact Kaveh Shahabi at kshahabi@usc.edu.

Acknowledgments

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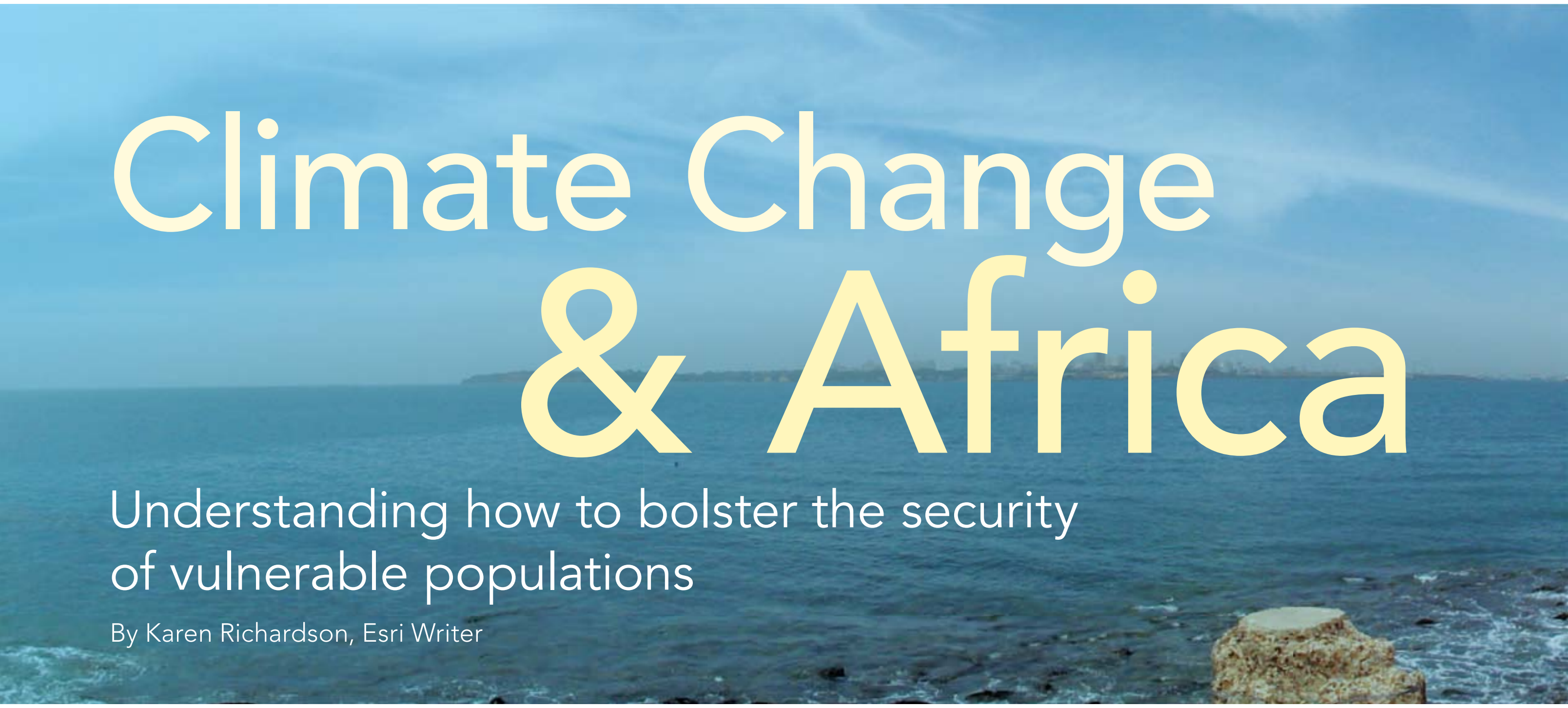
About the Author

Kaveh Shahabi joined the University of Southern California computer science master program in the spring of 2008 and immediately joined the USC GIS lab as a programmer. He is now a computer science PhD student at the USC Spatial Sciences Institute. He also interned at the Esri Application Prototype Lab during summer 2010. For more information, visit www-scf.usc.edu/~kshahabi/.

Download the ArcCASPER tool
esri.com/arccasper



Climate Change & Africa

Understanding how to bolster the security of vulnerable populations

By Karen Richardson, Esri Writer

A collaborative research program is using GIS to better learn how climate change, conflict, and humanitarian aid intersect to impact vulnerable populations in Africa.

The Robert S. Strauss Center for International Security and Law, based at the University of Texas, Austin, is known for addressing complex global problems with innovative ideas driven by policy-related research across many disciplines. Recently, the Strauss Center's Climate Change and African Political Stability (CCAPS) program implemented Esri technology to understand how to best manage complex emergencies in light of drought, crop shortages, and changing weather that could result from climate change.

In addition to the University of Texas, Austin, the College of William and Mary in Williamsburg, Virginia; Trinity College Dublin in Dublin, Ireland; and the University of North Texas in Denton, Texas, are collaborators on the CCAPS program. As the lead organization, the University of Texas receives funding from the United States Department of Defense through the Minerva Initiative. This initiative is a university-based, social science research program that focuses on areas of strategic importance to national security policy. Through quantitative and GIS analysis, case studies, and field interviews, CCAPS strives to produce research that can support US, African, and international policy responses.

Closing the Development Loop

The CCAPS program enlisted the help of Development Gateway, a nonprofit organization that delivers information solutions to government policy workers allocating scarce resource investments, aid workers building infrastructure, and citizens who want to have a voice in the process. Development Gateway created a dynamic mapping tool that could visualize program data and show the variables that affect vulnerable populations in a holistic manner.

Climate change poses an enormous threat to the livelihoods and safety of millions of people. "However, the level of risk is not evenly spread and certainly doesn't respect national boundaries," said Jean-Louis Sarbib, CEO of Development Gateway. "To ask critical questions about how development assistance can reduce vulnerability, you need hyperlocal data on climate and also on aid-funded interventions. This is what the new CCAPS mapping tool shows in a digestible, interactive way. It will no doubt be a valuable new tool not only for researchers but also policy makers, journalists, and citizens."

Development Gateway first partnered with Esri to create an application called Development Loop for AidData. A joint initiative with Brigham Young University and the College of William and Mary, AidData captures and interprets data on aid activities around the world to support aid transparency and decision-making processes. Development Loop is a simple, easy-to-use application that allows users to add and edit their own project information, including comments, pictures, and stories, at a subnational level. This information can be viewed and shared with others both on the web and offline.

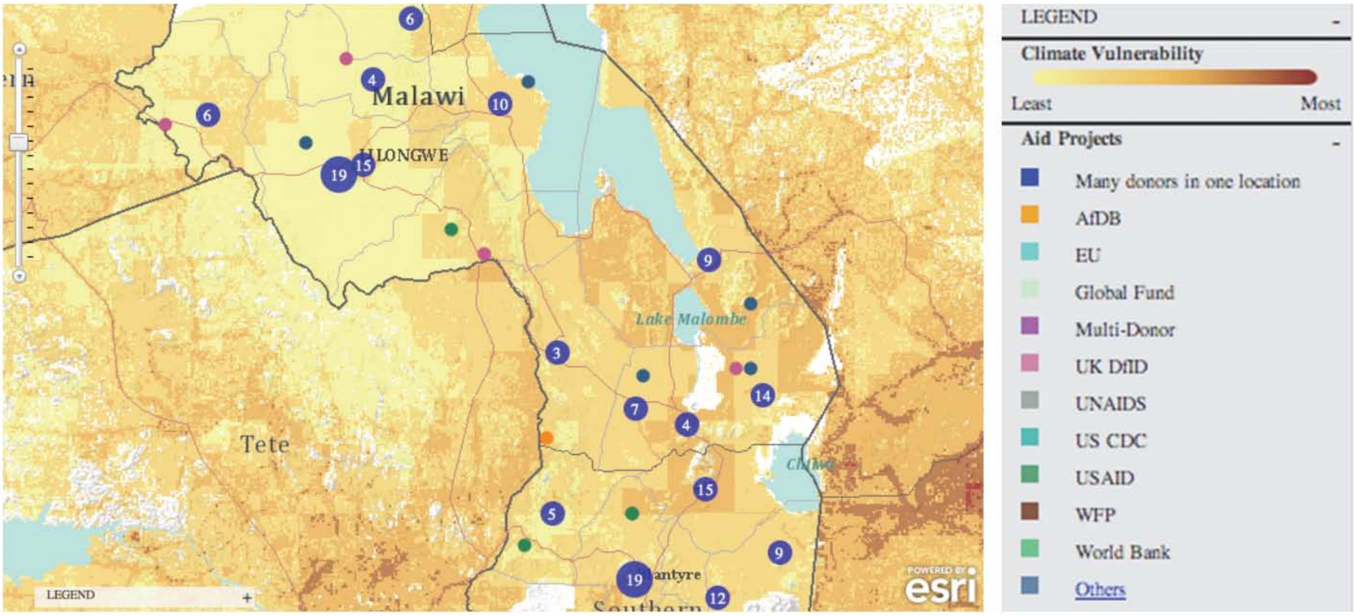
Users can view their own projects along with those of other organizations or with data on poverty rates, maternal mortality, or other important indicators. The application can also be linked to beneficiary feedback. The Development Loop prototype was built using the ArcGIS API for Microsoft Silverlight/WPF and ArcGIS for Server technology from Esri and incorporated World Bank and African Development Bank project data geocoded by the AidData partners.

↓ Africa faces unique challenges in coping with climate change caused by its dependence on rain-fed agriculture and the fragile social and political infrastructure of many of its countries. (Photo credit: Anustubh Agnihotri, CCAPS Program)

Understandable and Actionable Data

When Development Gateway staff members began working on the CCAPS program, they felt that the same technology and workflows created for Development Loop could be applied to this project. The CCAPS program had produced data in many research areas and needed a way to layer the data to analyze how various factors work together to compound or reduce vulnerabilities to climate change. "The best way to get a really clear picture of what is going on is by looking at it on a map," said Joshua Powell, GIS analyst at Development Gateway.

Viewing the CCAPS data on a map is very intuitive to users. "My experience is that once we sit down and show people what they are getting as part of the system, they get even more excited. The users are able to shift their thinking and understanding using what we consider to be simple tools by putting their projects on a map. By doing this, in return, they get powerful visualization that shows them where they are doing what. You can't get this out of a table or spreadsheet."



The mapping tool allows users to select and layer any combination of CCAPS data onto one map to assess how multiple climate change impacts and responses intersect. For example, mapping conflict data over climate vulnerability data can help one assess how local conflict patterns could exacerbate climate-induced insecurity in a region. Mapping aid and climate data together helps explore whether aid interventions are targeting areas of greatest climate security risk.

Democratization of Data

By integrating CCAPS research on climate change and real-time conflict tracking with existing datasets, such as topographic maps and imagery, the goal of the CCAPS mapping tool is to provide the most comprehensive view possible of climate change and security in Africa.

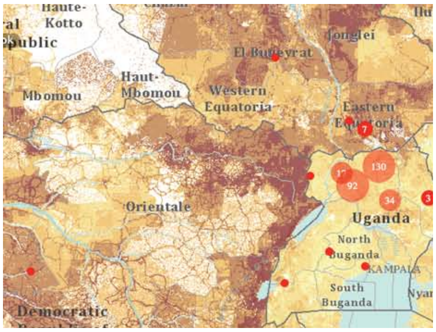
"The complex pathways from climate change to security impacts have demanded new datasets to fill knowledge gaps but also new ways of presenting the data to be of most use in policy planning," said Francis J. Gavin, director of the Strauss Center. "This mapping tool allows policy makers to analyze data from multiple sources at once, providing integrated analysis of the drivers and responses related to security risks stemming from climate change."

Being able to look at this data over time and space greatly enhanced analytical capabilities of CCAPS. "The mapping tool allows users to get a snapshot of trends across these issues or drill down to get the details on particular issues or locations where they have an interest," said Ashley Moran, CCAPS program manager. "We're able to make large volumes of data available to a wider audience of policy makers, researchers, and citizens in a format they can use for day-to-day analysis."

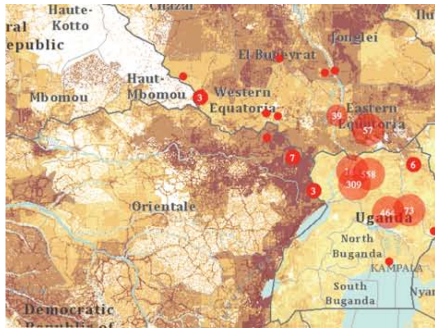
The tool is already being used in the country of Malawi for a solution that tracks and reports on the country's external funding. Aid information is mapped along with data on climate change vulnerability and incidents of conflict. This sheds light on whether aid is effectively targeting regions where climate change or conflict pose the most significant risk to the sustainable development and political stability of the country. The mapping tool is also a significant innovation in the context of the global aid transparency movement. It represents the first effort of the sort envisioned by the Open Aid Partnership, an initiative spearheaded by the World Bank to increase the openness and effectiveness of development assistance at the subnational level.

↓ Graduate students working with CCAPS used GIS to identify the regions in Africa at greatest risk from climate change, particularly as related to water resources. (Photo credit: Todd Smith, CCAPS Program)

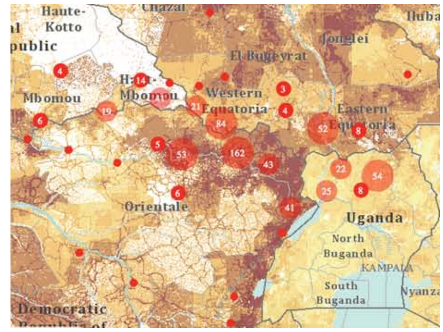
→ Wind turbines located in southern Kenya create electricity to offset losses in hydroelectric production caused by decreased rainfall. CCAPS helped produce a wind energy atlas the Kenyan government uses to promote investment in this technology. (Photo credit: Todd Smith, CCAPS Program)



1996–2000



2001–2005



2006–2010

↑ An examination of conflict and climate vulnerability data shows that conflict events involving the Lord's Resistance Army (red areas) have gradually diffused from Uganda into areas with less stability and more climate security vulnerability such as South Sudan and the northern portion of Democratic Republic of the Congo. (Source: CCAPS Vulnerability Model, ACLED data, CCAPS mapping tool)

CCAPS and AidData will continue to release upgrades to the mapping tool throughout 2012. The current mapping tool is available to use now at strausscenter.org/ccaps/mappingtool.

For more information on AidData, go to aiddata.org.

For more information on Development Gateway, go to developmentgateway.org.

Learn more about GIS solutions for climate change from Esri at esri.com/climate.

iPad Application Aids Map-Based Crop Reporting

Insurer improves accuracy and communication

By Karen Richardson, Esri Writer

Providing the right amount of crop insurance coverage to customers at a fair price is a balancing act. If too many acres are reported, the customer pays too high a premium. If too few acres are reported, coverage is inadequate in the event of a covered loss. To take the guesswork out of reporting acreage, Great American Insurance Group created an innovative ArcGIS-based reporting tool that is available on the iPad, and it's revolutionizing the business.

With corporate headquarters in Cincinnati, Ohio, Great American Insurance Group's Crop Insurance Division has 4,500 independent agents in the United States. It has been providing crop insurance to farmers for more than 100 years. The company is engaged primarily in property and casualty insurance, focusing on specialty commercial products for businesses. The insurance underwriting process requires that agents visit each farmer and complete an acreage report. Ultimately, that report is reconciled with acreage records at the Farm Service Agency (FSA), a department of the United States Department of Agriculture (USDA).

Depending on the type of crop planted, the time to submit these acreage reports can be limited, so efficiency is critical. During this reporting window, agents work with clients to determine accurate acreage for the crops that have been planted and, in certain circumstances, acreage that has not been planted. Insurance coverage is based on this report, so it must be complete and accurate. If the acreage FSA has on file for a farmer and the acreage reported by the agent don't match, coverage could be jeopardized.

Several years ago, USDA—through FSA—began moving the farming industry toward map-based reporting to improve accuracy. USDA mapped farmland in the United States and created the Common Land Unit (CLU) as a standardized GIS data layer in shapefile format. This layer, which includes all farm fields, rangeland, and pastureland in the United States, supports farm service programs including insurance. Having this data repository allows FSA to track crops, gather important data for trend analysis, and assist in determining whether fraud has occurred.

↓ GreatAg for iPad was developed using the ArcGIS Runtime SDK for iOS.

From Complicated to Easy

Six years ago, Great American's Crop Insurance Division started to use mapping software to communicate more effectively with its agents, policyholders, and the USDA. Great American implemented ArcGIS in its IT departments. It can download FSA CLU shapefiles into its system for use by agents when creating reports with clients.

Because FSA and Great American use the same standard format, information can be passed between them without additional preparation. This saves effort and improves accuracy. Now data is not lost transferring it from a paper form or from files in a different mapping format. "We are able to agree on what is planted in the field and roll this data up into our own systems right away," said Dale Perry, divisional assistant vice president of marketing for the Crop Insurance Division at Great American.

Initially, Great American provided data to agents as an ArcGIS for Desktop application. This was challenging for agents. They were not familiar with mapping programs and could not access the data when visiting clients' sites. Maintaining databases for individual agents

↑ GreatAg gives agents access to acreage and crop information. Agents can edit attributes such as type of crop and planting date and perform basic editing on field boundaries.

was a strain on the IT staff. "This was a complicated workflow for everyone involved," said Perry. "While we were one step closer to providing a great experience for both our agents and their clients, we knew we could do better."

Bringing Efficiency to the Workflow

Great American's IT department worked with Esri Professional Services to incorporate its workflow into a web-based, handheld solution that was fully integrated with the reporting system; had no extra logins; and, as Perry explained, "just worked."

The application, called GreatAg for iPad, was developed using the ArcGIS Runtime SDK for iOS. ArcGIS for Server capabilities, such as powerful mapping and geoprocessing, are now available embedded in maps in this line-of-business application, which connects Great American's team, agents, and customers. "The most important thing we got right was understanding that our agents are salespeople, not IT folks," said Perry. "We provided them with a solid web-based application that was very user-friendly."

The GreatAg application can be downloaded from the Apple iTunes store. All data, except for maps, is downloaded and stored locally on the agent's iPad so it can be accessed without an Internet connection. Agents have access to all the information about their clients' Multiple Peril Crop Insurance policies and claims. This is important because agents work in rural areas that often have limited Internet access. Agents can access policy documents and obtain electronic signatures from clients without worrying about finding an Internet connection.

If an agent has Internet access, the GreatAg application also provides access to acreage and crop mapping information. Agents access maps on their iPad from Great American servers and edit attributes associated with CLU shapefiles, including type of crop, farm name, and planting date, and perform basic editing on field boundaries such as splitting and combining fields. New fields can also be created directly from the CLU layer using freehand drawing. Once information is collected and both parties agree, policy forms can be uploaded with digital signatures for processing.

Extensive security controls ensure that personal information is properly safeguarded. "All this information is shared with the corporate database, so the same data is available in the traditional policy and claims web applications, as well," said Perry.

By keeping GreatAg for iPad simple and efficient, Great American has created a "win-win-win" solution for agents, policyholders, and the company. They have also created a companion marketing tool that can be used in the field. "Nothing speaks louder than being able to provide the right service for a client with the convenience of mobile computing," said Perry.

For more information, contact Dale Perry at DPerry@gaic.com.

DEFINING

By Richard Kachelriess, Esri Product Marketing

What is *open*?

It's a deceptively simple question. *Open* is a term that's thrown around in the GIS industry and in the technology industry in general: open systems versus open source; open source versus open standards; open standards versus open specifications. This can quickly become confusing. To clear up some of this confusion, this article explains the differences between open technologies, how they are related, and how they relate to ArcGIS and the GIS industry. Fortunately, every variation on the open theme can be placed into one of three categories: open source, open data, or open systems.

Open Source

Open source software is just that—software. The only difference between open and closed (or proprietary) source software is that with open source, the code used to create the program is freely available for anyone to view, edit, and redistribute. Any type of software can be open source software. The type of license under which it is released determines if it is open source. Examples of open source licenses include the Apache 2.0 license, the Microsoft Public license, and the GNU General Public license.

Open Data

Open data is information that is freely available for anyone to use and reuse. Data is completely open if there are no restrictions on its use for public, private, nonprofit research, or commercial applications. OpenStreetMap is the quintessential open data GIS project. Its goal is the creation of a free editable map of the entire world. The data from this project is available under the Creative Commons Attribution-ShareAlike 2.0 license that allows users to copy, edit, adapt, and transmit that data for any reason as long as OpenStreetMap is credited. Any edits can be redistributed under the same license. Many organizations use OpenStreetMap. While most organizations use it as a free basemap, a growing number of companies are building commercial solutions on top of OpenStreetMap data.

Just because data is open doesn't mean that it is easily accessible. Open data can still be stored in formats that are proprietary or rarely used and can be difficult to access. To be truly beneficial, open data should be stored using an open or established specification, such as shapefiles or file geodatabase specifications, or be accessible via an open or established standard service such as the ArcGIS map service definition, Web Map Service (WMS), or Web Feature Service (WFS).

Open Systems

Open systems, also known as open platforms, bring together programs, operating systems, hardware, and datasets. These are computer systems and platforms that support integrating data and other systems using established standards and specifications as well as support modifications via extensions and customizations. A system does not need to be open source to be open, and the standards and specifications used may or may not also be open source.

For example, many specifications for document file formats are not open. Adobe Acrobat can be called an open system because portable document files (PDFs) can be created and read by many software applications. However, it is not open source, or even completely open, because only Adobe Acrobat can truly edit a PDF. However, the PDF has been universally adopted for the electronic transmission of official documents because it is easy to create and read documents but difficult to edit them.

Open systems integrate hardware as well as software. Modern plug-and-play technology allows virtually any device to be connectd to a computer—printer, external hard drive, webcam, GPS device, cell phone, headset—and it will be instantly recognized and accessible by your computer's operating system. This greatly simplifies the use of these devices, eliminating the need to manually install a device driver for each device before it can be accessed.

While not open source, ArcGIS is an open system. It works on a wide variety of operating systems and with external software programs and technologies. ArcGIS is designed and engineered for

interoperability and extensibility and conforms to the open standards and specifications necessary to implement enterprise systems. This open systems approach allows ArcGIS to interact with CAD and raster data, geospatial files from third-party geospatial developers (e.g., ENVI EX), relational databases (e.g., Oracle, PostgreSQL, and Microsoft SQL Server), and web services (e.g., WMS, WFS).

Esri has created an extensive collection of developer tools that contribute to its open systems approach. ArcGIS Runtime is the latest product in Esri's line of developer solutions for creating and deploying focused, stand-alone GIS applications. This collection of GIS components and developer resources allows GIS functionality, dynamic maps, and GIS capabilities to be embedded into existing applications. It can also be used to build custom new applications.

Using the ArcGIS Runtime, native applications can be built for Java, WPF, Android, iOS, Windows Phone, and Windows Mobile. Technology like ArcGIS Runtime allows Esri partners to build custom solutions that use the power of ArcGIS technology.

Open Standards and Specifications

Open standards and specifications make up a subset of open source. Although not software applications, standards and specifications provide blueprints for data formats and Internet services. When these are open, the information to create, modify, and interact with formats and services is freely available for anyone to use, edit, and redistribute, allowing organizations to integrate these formats and services into their applications. Without these established standards, interoperability between systems would be impossible.

The difference between open standards and open specifications is vague at best. Generally, an open standard is an open specification that has achieved wide industry use and is governed by an organization made up of representatives from a majority of the competing organizations within the industry. Esri's shapefile format, a good example of an open specification, is still governed solely by Esri, but it has been almost universally adopted within the GIS industry.

How Open Is Open?

Any source software, data, or system is only as open as the license under which it was released. While there are many different open licenses, there are really only two types: permissive and restrictive licenses. Permissive licenses allow organizations to redistribute under a new license, while restrictive licenses do not. For example, if an organization modifies the source code of open source software that has a permissive license, that organization can then generally redistribute that modified software under any license but is not required to release the modified source code. In contrast, if an organizaiton modifies the source code of open source software with a restrictive license, it would be required to redistribute the software under the same license and make the modifications to the source code freely available.

Conclusion

Esri continues to increase its level of participation in the open source community. In addition to the Esri Geoportal Server and ArcGIS Editor for OpenStreetMap, Esri has released the ArcGIS Viewer for Flex as open source software. Its source code is available on GitHub. Esri is planning to release the source code for the ArcGIS for iOS and ArcGIS for Android mobile applications as open source software soon. The Open Geospatial Consortium, Inc. (OGC), is an international organization that develops and governs open standards for geospatial data, services, processes, and data sharing. Esri is a principal member of OGC and actively participates in the development and implementation of many of these standards.

Open is more than just open source software or open data or open systems—it requires all these components. Integration can't easily occur unless software uses established data formats and services. A system is useless without input and output data. An open technology approach means using the best combination of open source software, data, and standards and specifications with proprietary source software, data, standards, and specifications to build the best system possible. Esri is committed to promoting an open technology approach with ArcGIS. For more information, visit esri.com/open.

Making Good Things Happen

At the 2012 Esri DevSummit

By Monica Pratt, *ArcUser* Editor

"We are here for you entirely this week," said Jim McKinney, ArcGIS program manager and master of ceremonies for the Plenary Session of the 2012 Esri Developer Summit (DevSummit). McKinney noted that members of 30 Esri software development teams migrated to Palm Springs, California, for the event, held March 26–29, to spend one-on-one time with developers, "building community and making good things happen."

The 2012 DevSummit, "the conference for developers, by developers," had a record turnout: 1,700 developers, partners, and GIS professionals from all over the world gathered at the Palm Springs Convention Center to meet with more than 300 Esri development staff members. As in previous years, the event's goals were to align development efforts, share best practices, and develop working relationships.

Of the developers assembled, 30 percent came from outside the United States. The majority (60 percent) work for businesses. They are coding in .NET, Python, and Java and working on web, mobile, and desktop applications.

Not only were there more attendees this year, but the event itself grew. In response to developers' requests, a day was added, the number of technical sessions was more than doubled, the number of preconference sessions was quadrupled, and the showcase and demo theaters were significantly expanded. To make sure developers could see popular presentations, attendees could Tweet requests to repeat sessions that were packed.

A new conference event, Speed Geeking, set a playful and high-energy tone for the summit as well as helped attendees decide which topics among the conference's 72 sessions would prove most useful to them. The event used a speed-dating format. Groups of 8 to 10 attendees gathered around tables where Esri staff members told them about an implementation of Esri software, a cool sample, or an Esri service. A squeaking rubber chicken signaled the end of each five-minute session, and attendees moved on to the next table.

Biggest Server Release Since ArcGIS 9.2

Why do developers take a week out of their lives to come to DevSummit? Certainly building relationships with peers and Esri staff and learning how to become more productive are common reasons, but the overriding motivation for most developers is finding out what Esri is doing now and where its development strategy is going.

→ Esri president Jack Dangermond joined master of ceremonies Jim McKinney, ArcGIS program manager, to open the Plenary Session.

← Speed Geeking, a speed-dating-like event, gave attendees a taste of the agenda topics being presented. A squeaking rubber chicken signaled the end of each five-minute presentation by an Esri staff member.

ArcGIS 10.1, currently in prerelease, was the focus for much of the plenary and technical sessions. ArcGIS for Server is the centerpiece of this release. On both Windows and Linux, performance has been improved, and every service runs faster.

ArcGIS for Server has a completely new architecture that is simpler to install, configure, and manage. Now a native 64-bit application, it is a pure web services GIS server, and once installed, everything is done through HTTP calls. However, the REST specification for services has not changed, so applications written using the existing APIs are forward compatible to the new server. Although the completely rewritten ArcGIS Server Manager comprehensively handles sites, services, and security, server administration can also be scripted using any scripting language that understands HTTP.

Integration with Server

Although there are improvements throughout ArcGIS for Desktop, because changes to ArcGIS for Server are so central to this release, improvements to deployment from desktop to server were a focus of development efforts.

A demonstration showed how easily a map service can be published from the desktop to ArcGIS for Server running in the Amazon cloud. Data stored anywhere can be pushed up to the server and shared using wizard-based systems that perform several hundred analyses on a service to flag any issues before it is published for use in web maps and on devices.

Providing actionable information to end users by bringing GIScience into mapping was a major goal of this release. Many of the issues that previously hindered publication of geoprocessing services are now handled behind the scenes. At 10.1, it is much simpler to create and publish geoprocessing services so that spatial analysis can be incorporated into web applications.

GIS as a Service

ArcGIS Online, Esri's cloud-based system that provides GIS as a service, is →

available at arcgis.com for use on smartphones, tablets, and desktops. Since its launch in July 2009, more than 200,000 maps and applications have been created. On an average workday, the site receives five million hits (exclusive of requests for basemaps).

Local data can be used as tiles or feature services and used with the extensive foundation data (basemaps) and services (such as geocoding) at arcgis.com. These resources are constantly enhanced. Recently, Esri added 15 million square kilometers of new imagery to the service. ArcGIS Online is also the source for APIs for web (JavaScript, Flex, and Silverlight) and devices (tablets, phones, and desktop) as well as configurable viewers and application templates.

Using ArcGIS Online, developers can build custom applications that use hosted services that don't require installing hardware or software. They can also integrate content from ArcGIS for Server and register services, enabling centralized search and discovery, and easily administer users, content, and security.

ArcGIS Online will be available in organizational and enterprise plans. Alternatively, ArcGIS Online is available as a software product, Portal for ArcGIS. Officially released at DevSummit, Portal for ArcGIS is used on premises with ArcGIS for Server.

Being More Productive

In the area of developer tools, both existing and new with ArcGIS 10.1, Esri's approach focuses on improving developer productivity. "You don't have to write tons of code to make a great app" is the mantra.

Preconference seminars and technical presentations during the conference emphasized how to get more done using the web APIs, templates, and viewers that Esri has created for JavaScript, Flex, and Silverlight. "We have taken a lot of the hard work out of developing web applications, so all you have to do is abide by some coding rules," said Andy Gup, technology lead at Esri.

The announcement of a printing service that generates high-quality PDF maps was one of the high points for many web developers. Brandon B. Brown (@brandonbbrown), self-described "practitioner of GIS and lover of all things geographic," Tweeted "Bombtastic sweetness of new printing options in the web APIs #devsummit well done sirs, well done."

Going Native

To facilitate native application development, Esri created a runtime core written in C++ that delivers high performance but is compact. GIS runtimes for iOS, Android, Windows Phone, Windows Mobile, Windows, and Linux have been developed using this core and are accessed via APIs and software development kits (SDKs) Esri developed for these platforms for use by .NET, Java, and Objective-C developers. This enabling technology is fully integrated with ArcGIS on the web and desktop and encourages developers to think in terms of developing for devices rather than for mobile or desktop.

The new architecture for desktop developers runs on Windows and Linux and is available for 32-bit and 64-bit execution. It uses an asynchronous programming model so applications can remain responsive while operations are executed in the background. ArcGIS Runtime SDK for Java will also be available.

Members of the mobile development teams demonstrated applications built with the SDKs for Android and iOS devices that integrate organizational data through a new class, agportal. These applications incorporate services and use different components of individual devices, such as GPS, or other applications in the device's ecosystem, such as mail or address book applications. These SDKs also let developers build applications that let users stay productive offline while maintaining smooth and responsive performance.

Core runtime developments slated for off-cycle release include geocoding and network routing on mobile devices disconnected from the network and 3D visualization and spatial

← Competitors at the Dodgeball Game, a DevSummit tradition, who vied for free tickets to next year's event, were cheered on by a lively crowd.

↑ Summit keynote speaker Steve Riley challenged developers' assumptions about the nature of their work as he leaped from the stage and roamed among the audience.

→ The 2012 DevSummit had a record turnout, with 1,700 developers, partners, and GIS professionals from all over the world.

analysis across all platforms. Configurable applications that use widgets to deliver functionality are being created by Esri to help end users be more productive. Using the SDKs, developers can create specific widgets for their end users. New supported platforms include Windows 8 with the Metro Style touch experience and ARM processor support. In response to developer requests, Esri will also have an ArcGIS Runtime SDK for Mac and a Cocoa API for Mac Developers.

ArcGIS Runtime SDKs and an optional ArcGIS Online plan will be included in the existing Esri Developer Network (EDN) subscription. A new type of subscription, the EDN Enterprise subscription, will contain everything a developer needs to build enterprise-level applications.

"Everything You Think You Know Is Wrong"

For the keynote speech, the focus shifted from Esri software development to IT trends. Summit keynote speaker Steve Riley challenged developers' assumptions about the nature of their work as he leaped from the stage and roamed among the audience. He warned that the cloud has changed everything in their world and they must adapt or die. Riley has spent 23 years in IT, specializing in information security. He worked for Amazon Web Services and Microsoft before joining Riverbed, where he is the chief technology officer.

Riley's definition of the cloud was simple: "If you are still paying for it when it isn't switched on, it isn't a cloud." Scalability is the key to understanding this new landscape. Servers are now disposable horsepower. "If you need more performance, you throw more servers at it. You could never do that before." In the cloud, troubleshooting changes from hours and days spent diagnosing the problem to a few minutes killing off a problem service and spinning up another.

Change is constant, and failure is inevitable, so developers need to assume failure and build backward to account for it. New issues have joined familiar ones. Moving data could become a bigger issue than security. This observation struck a chord with an audience that knows that GIS is all about managing large datasets.

But security issues have not gone away. There are bad guys out there, they are out to get you, and developers should account for them in the system design. The real challenge with security is adopting a new style of thinking in a cloud era. "When a server is just one line in a shell script," its physical location is not what determines its security, said Riley. Security models should now be based on substantive service-level agreements, auditable security standards, and procedures that encrypt and sign everything.

To survive and thrive, developers need to make sure they remain relevant. The cloud is the way to make Esri data more available to users, and it will become essential to the way services are delivered. Developers need to embrace it.

Fun and Games

The conference wasn't all sessions and presentations. There was plenty of time for socializing in a relaxed atmosphere. An informal event held poolside at the hotel on the second evening, Meet the Teams, introduced Esri software teams to conference attendees. Wednesday night featured lots of food and the Dodgeball Game, a DevSummit tradition. Vying for free tickets to next year's summit, teams—with names like Tame the Python and the Ballbarians—faced off before a lively crowd.

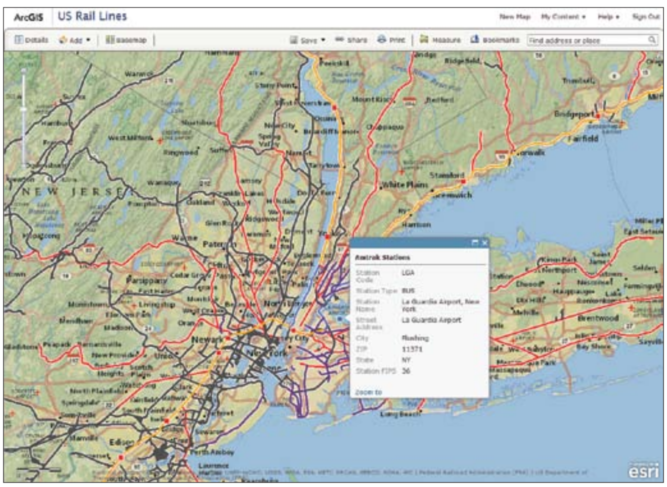
Bidirectional Communication

Developers had many opportunities throughout the week not only to learn how accessible and powerful the technology is but also how their feedback can shape the applications that are constantly being deployed via the web. "We constantly need input from you," said McKinney. "We can make course corrections very quickly in our APIs and our SDKs, so talk to us."

Esri actively seeks feedback, not just at the summit, but throughout the year. Developers need tools and support to be productive and successful. DevSummit provides a place and time to reconnect and reinforce that relationship. "We get our satisfaction through your success. Really. It's kind of a weird statement, but we get really jazzed when we see you guys building great stuff," said McKinney.

Creating Custom Web Mapping Applications without Programming

By Derek Law, Esri Product Management



↑ A web map created in the ArcGIS.com Map Viewer

Web GIS is becoming an essential component of many GIS application solutions. From federal government agencies and corporate enterprise solutions to state/municipal governments and private organizations, a website presence with mapping capabilities is now very common.

ArcGIS for Server lets you share and publish your GIS resources on the web as web services. To work with these services, you can develop web client applications using the web mapping APIs for JavaScript, Flex, and Silverlight. This is a great technology workflow, but for organizations with limited developer resources, enabling GIS on the web can be challenging.

Esri has been making it much easier for ArcGIS users to create and deploy custom web mapping applications *without programming*. The objective has been to empower traditional desktop GIS analysts to easily create and deploy GIS application solutions on the web.

Three easy-to-use solutions for creating custom web mapping applications are available. All are designed to work with services from ArcGIS for Server and ArcGIS Online as well as ArcGIS Online web maps. They provide a means to easily configure and deploy custom web mapping applications without having to write a single line of code. They are ideal for nondevelopers and novice web mapping application creators. They can also be leveraged by developers working with web mapping APIs who can use these viewers as a starting point for building custom client applications.

These three configurable web client viewer options—ArcGIS.com Map Viewer, ArcGIS Viewer for Flex, and ArcGIS Viewer for Silverlight—are ArcGIS Online application templates. Each option was built on one of the three web mapping APIs for JavaScript, Flex, and Silverlight technologies. All enable you to easily configure and deploy a custom web mapping application. Each follows a similar design pattern: specify the web application's data content, then its functionality, and finally its appearance.

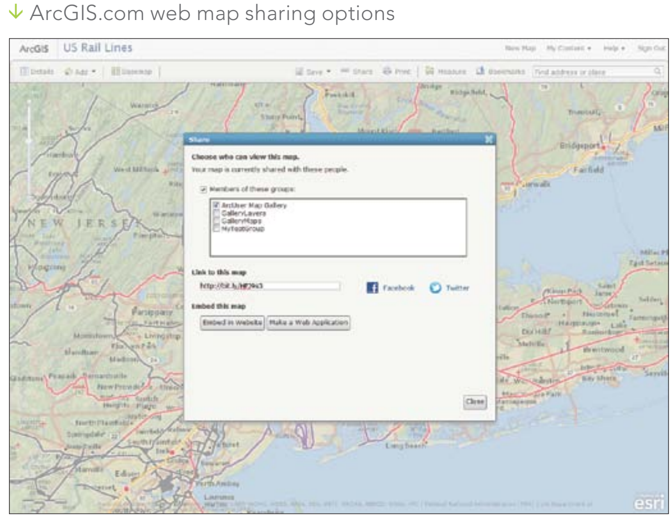
ArcGIS Online Application Templates

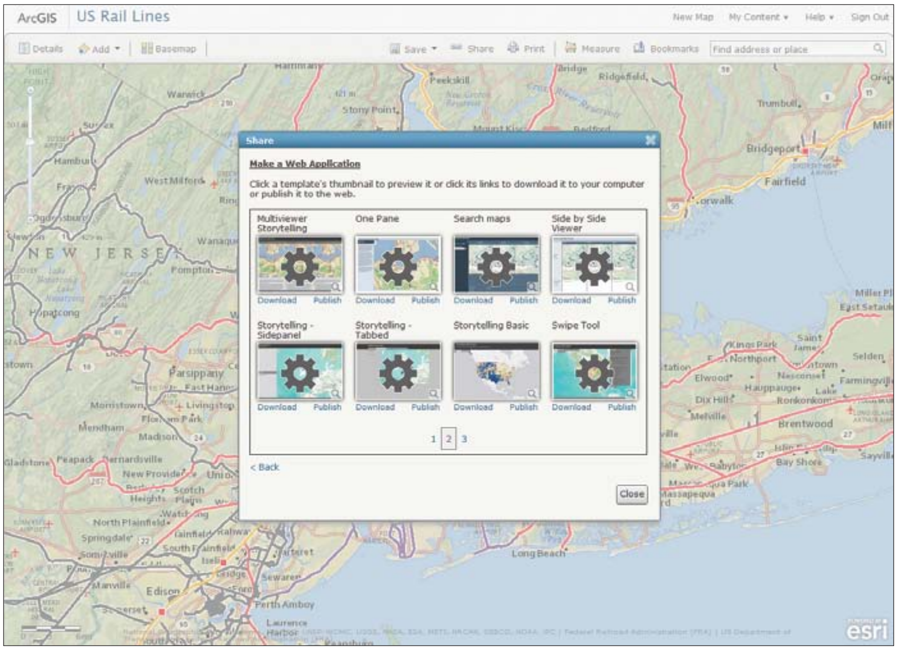
This is the simplest and easiest configurable client viewer option. All you need is an Internet connection so you can use the map viewer at ArcGIS Online (arcgis.com), the online component of the ArcGIS system. No additional hardware, such as servers or other resources, is required.

With the map viewer, you can easily create your own interactive map. To create a custom web map, just select a basemap; combine additional data content, such as web services, shapefiles, Microsoft Excel spreadsheets, CSV files, or KML data; and specify data layer display properties such as pop-up dialogs. Essentially, you create a mashup of data from your own data sources and online data sources. Once complete, save it as an ArcGIS Online web map.

Your web map can be consumed by many different clients. It can be shared with the public or with members of one or more

↓ ArcGIS.com web map sharing options





↑ Gear icons indicate that these ArcGIS.com application templates are configurable.

arcgis.com user groups. You can also share it via e-mail, Facebook, or Twitter or embed it in a website as an interactive map.

You have another sharing option. You can create a new web mapping application for the web map by using one of the web application templates available on ArcGIS Online for a variety of use cases. Approximately half these templates have some configuration options (indicated with a gray gear icon), and all were built using the ArcGIS API for JavaScript.

The web application template can be published to ArcGIS Online so the web application will be hosted on ArcGIS.com. Once published and shared, the newly created and deployed web application for your web map can be configured. Simply navigate to the web application's item page on ArcGIS Online and click the Configure App button on the web application template's configuration options.

Options for the Basic Viewer application template include turning on/off many of the viewer's capabilities such as the legend, print tool, and bookmarks. Some functionality, such as the Edit tool, will only be available if the web map contains editable data. The configuration options available will vary depending on the application template selected.

Alternatively, you can download the web application to your own machine as a ZIP file so you can host the web application on your own web server machine. Hosting the web application on premises lets you further customize it via JavaScript API development.

To learn more about ArcGIS Online application templates, navigate to help.arcgis.com/en/arcgisonline/help/ and choose Popular Topics > Videos > Working with Web Maps.

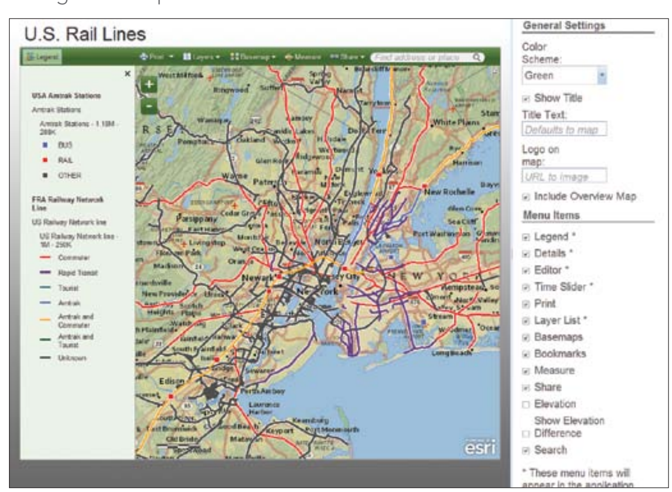
ArcGIS Viewer for Flex

Originally released as the Sample Flex Viewer, this application became an official product in summer 2010. Built on the ArcGIS API for Flex, it is a ready-to-deploy, configurable, rich Internet application (RIA) that requires the Adobe Flash Player plug-in on your web browser. With it, you can easily customize and deploy a robust and interactive web mapping client hosted on your web server (e.g., Internet Information Server, or IIS). This configurable web client viewer option is more comprehensive than the ArcGIS Online application templates.

You start with the ArcGIS Viewer for Flex application builder, an Adobe Air application that installs on your local machine and executes as a desktop application. The application builder provides a wizard-like interface for configuring the viewer's properties. When the application builder is run for the first time, it will prompt you for a default location to deploy the new web applications it creates. Typically, this would be in the web server resources directory. To begin, simply click the Create a New Application button and provide a name for the application.

The application builder user interface consists of five control tabs that follow the general design pattern for configuring web applications. By navigating to each tab, you configure different aspects of the viewer. On the Maps tab, you specify the data content. This can be an ArcGIS Online web map or your own basemap and operational layers. On the Widgets tab, specific GIS functionality, such as drawing, editing, charting, geocoding, search, legend, geoprocessing, or printing, is defined. ArcGIS Viewer for Flex includes more than 20 core widgets that provide the common GIS functionalities needed in web mapping applications. On the Layout tab, you select which user interface controls (overview map, navigation tools, show coordinates) to include in the application. On the Design tab, you set the application's look and feel by adding a title, logo, or theme colors.

↓ The basic ArcGIS Viewer for Flex application template configuration options



↑ Use the ArcGIS Viewer for Flex application builder to choose basemaps and operational layers for an application

The configuration workflow for a new application is nonlinear and dynamic, which is one of the application builder's strengths. For example, you can select the data content, define the functionality and appearance, and then go back and change the data content—there is no preset configuration workflow. You preview the final application with the Preview tab.

When you are finished, click Done to complete and deploy the new web application. The files that comprise the new web application are stored at the location specified when you first ran the application builder. The new web application can be accessed and used immediately in a web browser.

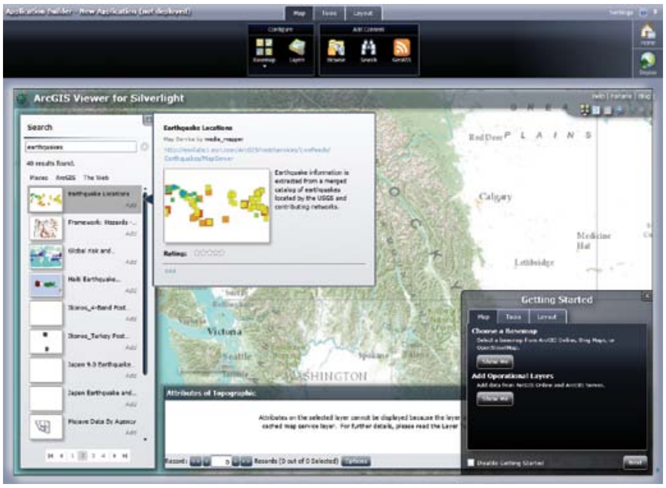
The ArcGIS Viewer for Flex application builder can also be used to manage the web mapping applications it has deployed. Web applications built on the ArcGIS Viewer for Flex can be further customized by directly configuring their XML configuration files. By making simple text edits to these XML files, you can apply more precise customization to your deployed web applications. Comprehensive documentation and samples for editing the viewer's XML configuration files are available online at the ArcGIS Viewer for Flex resource center. Learn more about the ArcGIS Viewer for Flex at links.esri.com/flexviewer.

ArcGIS Viewer for Silverlight

Released in the first quarter of 2012, the ArcGIS Viewer for Silverlight is another ready-to-deploy RIA option for Windows operating systems. It is built on the ArcGIS API for Silverlight and requires the Microsoft Silverlight browser plug-in. The ArcGIS Viewer for Silverlight provides an intuitive browser-based application builder with an interactive "what you see is what you get" (WYSIWYG) user experience. This option makes the process of creating new web mapping applications that are hosted on your own web servers very easy and, again, is more comprehensive than the ArcGIS Online application templates.

	ArcGIS Online application templates	ArcGIS Viewer for Flex	ArcGIS Viewer for Silverlight
Technology based on	JavaScript	Flex	Silverlight
Web browser plug-in required	No	Adobe Flash Player	Microsoft Silverlight
Installation location	Can be hosted on ArcGIS.com or on premises on your own web server	On premises on your own web server	On premises on your own web server
Supports ArcGIS.com login authentication	Yes	No	Yes
Works with ArcGIS Online web maps	Yes	Yes	Yes
Works with ArcGIS for Server and ArcGIS Online web services	Yes	Yes	Yes
Application builder GUI user experience	No	Yes	Yes
Configuration options	Varies between different templates	Many configuration options	Many configuration options
Extensible framework for developers	Yes, with JavaScript API, if the template is downloaded to a local machine	Yes, with Flex API (viewer source code available)	Yes, with Silverlight API (extensibility kit available)

↑ Table 1: Comparison of configurable web client viewer options



↑ The ArcGIS Viewer for Silverlight application builder steps the user through creation of a web application.

Three ArcGIS Viewer for Flex Download Options

You can get the ArcGIS Viewer for Flex as a compiled web client application that can be used immediately, or as an application builder used to create new web applications, or as uncompiled source code from GitHub that can be extended by Flex API developers.

The ArcGIS Viewer for Silverlight setup installs the application in your machine's web server resources directory (e.g., IIS). Its application builder runs in a web browser. When you start it the first time, the application builder will display some introductory text. Just click the Create New Application button to start creating a web application.

Deciding on data content for the new web application is the first step. You can create a new map with data you specify or use a web map from ArcGIS Online including your own ArcGIS.com items and content in groups that you belong to on ArcGIS.com.

After choosing the data content option, the application builder's main user interface appears, which includes three control tabs, Map, Tools, and Layout, located at the top above the main preview window. In the lower right-hand corner is an interactive Getting Started panel. This panel guides beginning users. Clicking an option in the Getting Started panel activates the corresponding application builder functionality on the control tabs.

On the Map tab, you can specify data content such as basemaps, operational layers, and GeoRSS feeds. You can also set the data layer symbolization properties and configure how attribute tables and pop-up dialogs appear. On the Tools tab, you define functionality, such as editing, geoprocessing, layer filters, printing, and selection tools, that will be available in the new web application. On the Layout tab, you can configure the application's look and feel by applying a custom logo, custom title, and colors and select from the prebuilt layout templates furnished. Any property changes will immediately be displayed in the main preview window.

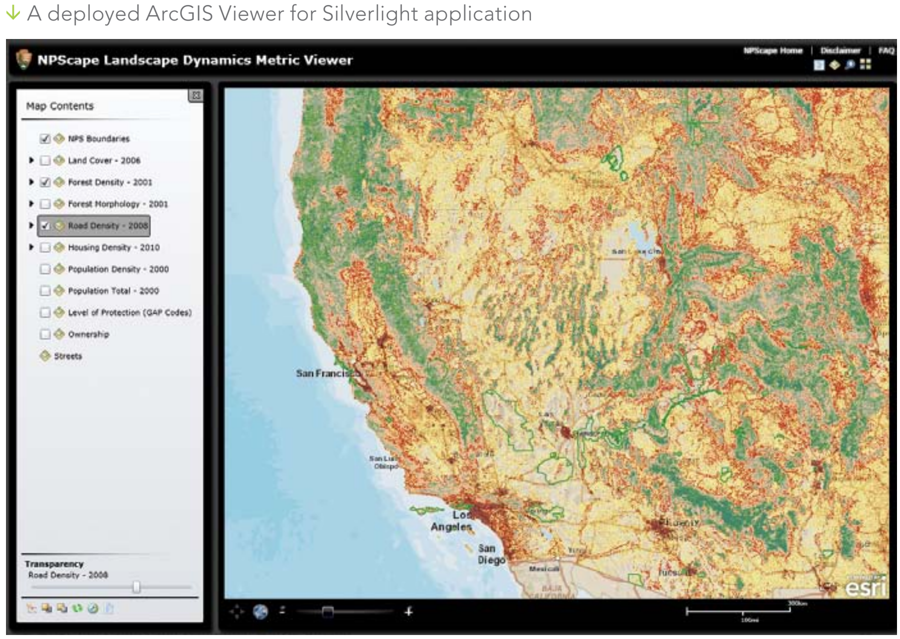
The ArcGIS Viewer for Silverlight workflow is also nonlinear, so you can configure web application properties in any order. Finish creating the new web mapping application by clicking the Deploy button, which creates the supporting files for the new web application in the web server resources directory.

The ArcGIS Viewer for Silverlight application builder can also be used to manage the web mapping applications it has deployed. With the extensibility kit, Silverlight API developers can create add-ins to extend viewer capabilities. To learn more about the ArcGIS Viewer for Silverlight, see links.esri.com/silverlightviewer.

Conclusion

Esri offers three configurable web client viewer options that benefit nondevelopers, novice website creators, and developers. The ArcGIS Online application templates are the easiest. The viewers for Flex and Silverlight offer more configuration options and include application builders. All are client applications to ArcGIS for Server and ArcGIS Online web services and work with web maps from ArcGIS Online.

↓ A deployed ArcGIS Viewer for Silverlight application



Compelling Thematic Cartography

By Kenneth Field, Esri Senior Research Cartographer

ArcGIS Online has opened up the world of mapmaking, supporting anyone to author and publish thematic web maps in interesting ways on an unlimited array of topics. This article explores why it is important to think about design when creating thematic maps.

A recent survey by the author and Damien Demaj identified examples of maps that exemplify great design. This survey found that only 23 percent of these maps were made by people with a background in cartography. Great thematic maps like Charles Minard's map of Napolean's retreat from Moscow or Harry Beck's London Underground map were created by an engineer and electrical draftsman, respectively.

The bottom line is that you don't have to be a cartographer to make a great map, but knowing something about how design helps tell your story will give you a head start. Design is an important part of the mapmaking process. It makes the author think about how the map (an information product) supports a particular message. In essence, design is a road map.

Whether a skilled map designer or a mapping novice, everyone can make a map, but how do mapmakers create compelling maps? It's simple: have a great idea and a clear objective and figure out how best to present the information by manipulating the data and displaying it effectively. Good content is crucial. Figuring out how to display it clearly and add creativity to grab the audience's attention will not only make them want to look at your map but be able to use and understand it easily.

Technological change has always challenged cartography. Huge changes were brought about by the printing press and the computer. Now, the Internet is creating new and exciting opportunities. However, until the technology matures and people learn how to deploy it successfully, it often leads to weak products. Fortunately, web mapping is maturing rapidly. Many early pushpin-style mashups have given way to more imaginative thematic maps that harness new ways of representing data.

Regardless of the type of map or the technology used to create it, consider these cautionary words by noted American geographer and cartographer John K. Wright: "An ugly map, with crude colors, careless line work, and disagreeable, poorly arranged lettering may be intrinsically as accurate as a beautiful map, but it is less likely to inspire confidence." Let's think about how you can make a great thematic map that is compelling and reaches or exceeds the expectation of its intended audience through the practical application of design.

Clarity of Purpose

You have some great thematic data and you want to share it. Establishing your goal is the first consideration. Without a goal, you won't have a plan to follow. Are you making a map that allows people to interrogate data? Do you want to convey a story or a particular message?

A goal is more than just mapping an interesting dataset. You have to define what the hook is for your map. Start by asking strong questions of the data. What will readers want to understand about the map's theme? The map is really just a graphic portrayal of the answer to a question. It helps establish how you are going to go about designing the visuals to support that goal. A great map should tell an honest story, so don't employ mapping techniques that distort. Some types of thematic map have specific data format requirements, so be careful that distortions don't creep in.

Figuring Out Your Readership

If you're not telling a story to an audience who will care, you cannot expect that audience to pay much attention. Once you've established your purpose, you need a design strategy that makes your map accessible to that audience.

This isn't necessarily about making your map simple and easy to understand. You shouldn't necessarily simplify a subject's complexity, because the detail in the data is often the interesting part. Instead, it's about developing clarity. Ideally, you want to make complex information digestible in visual form through an elegant representation.

The complexity of your data may require a little time to understand. That's fine. Not everything needs to be distilled to remove complexity. Maps don't have to overgeneralize or simplify the data. It's perfectly possible to present hundreds of thousands of pieces of information sensibly on a single map. Rich content often helps garner interest by presenting complexity in a simple way. Conversely, distilling a big chunk of data is not easy. Also consider the reader's patience and ability to consume the ideas in your map. Designing great maps requires understanding the quantitative skills of data presentation. The best-designed maps exist as a symbiosis between smart quantification and beautiful and elegant design.

Preparation and Authority

While it's true that it's easy to drag some data into a web map, it doesn't mean your map will have a clear purpose. A believable map often requires a good amount of background research and data preparation. This is all about approaching this task with a certain amount of rigor.

Making Thematic Data Work as a Web Map

By Kenneth Field, Senior Research Cartographer

Back in 2009, I created a thematic map for the Esri User Conference (Esri UC) that showed the location of Irish surnames from the 1890 census. It was a simple map, based on an idea by my coworker Linda Beale. The challenge was to create a persuasive map that was eye-catching and invited people to explore it by hunting for a particular name.

↑ The original print version of the *Geo-Genealogy of Irish Surnames* map, created for the 2009 Esri User Conference, mapped simple data in an engaging way.

The data was remarkably simple: a column of surnames, a column of Irish counties, and a column giving the number of people born in that county in 1890. Although simple, there was a lot of data. Presenting it in a compelling way was challenging. The eventual design was strong yet clean, and it was innovative because it took a standard thematic mapping technique (proportional symbols) and used it in a different way by making the name labels proportional so that they became part of the visual story. A lot of emerald green emphasized the theme. The map had a clearly defined readership, and it generated buzz at the Esri UC, creating a strong emotional response, particularly in people with Irish heritage.

Fast-forward to 2012. I wanted to create a version of the map for ArcGIS Online. I couldn't simply replicate the map in an online environment. Web maps offer new ways of seeing the data as well as alternative requirements for data manipulation, so I treated this as a new project.

In ArcGIS for Desktop, I had used the Maplex labeling engine and the Disperse Markers tool to create the proportional labels and position them on the previous map. ArcGIS Online doesn't offer the same tools, but by converting the labels to polygons using the Feature Outline Masks tool, exporting to shapefile format, and adding them to the ArcGIS Online map, I was able to replicate the proportional symbols. (See "Adding labels to ArcGIS Online web maps: Part 1" and "Adding labels to ArcGIS Online web maps: Part 2" on the Esri Mapping Center blog to learn about this process.)

While understanding your data is the first step, understanding how it might be processed into a suitable form for mapping is crucial. Rich data is great, but it is even better when presented by someone who clearly understands it and knows how to tell its story. Another way of thinking about preparing your map is to ensure your story has comparisons. Allowing your reader to compare one place to another promotes interest and a reason to explore the content. Without comparisons, it is hard to get a sense of what is important. What is an outlier? What trends might exist in the map? Good preparation and research answer these questions and make them visible on the map.

A related issue is demonstrating that you have created an authoritative map. While your map should be able to speak for itself, it should include a link to—and some explanation of—the raw data. An accompanying write-up provides an opportunity to explain why your map findings are important, as well as highlight other interesting findings. If your map warrants further explanation, but that explanation doesn't fit within the graphic itself, you can provide this information to help. Being open about your data sources also encourages readers to believe in your map. If you appear to have nothing to hide, you build trust in your map and you as its author.

Visual Prudency

Creating thematic web maps is not about putting all your data on the map. Being prudent about what you show at what scale and at what level of detail is key to creating a graphic structure that works at a range of scales. Many ambitious datasets call for a map that gracefully handles large scale to small scale while maintaining proper spatial relations. This allows the viewer to explore the data. Smaller scales can be quickly understood, but the viewer examines more minute details at larger scales.

A visually elegant map is achieved by paying close attention to how different elements interact visually. Color is often the most recognizable of these components. If it is used effectively, it highlights something unique or encodes a particular aspect of the data. Don't use color to attract attention: the map's theme should do that. Instead, use color to help tell the map's story rather than detract from it. Annotation is also important. By carefully using labels, explanatory text, and pop-ups, you help the reader understand the context of individual elements as well as how they hang together in the overall composition.

Diversity of Approach

It's easy to become familiar with one pattern of working. If you create maps regularly, your maps can end up looking very similar. Instead, try exploring alternative ways of representing data. Vary the type of map or the graphic treatment applied. Not only will you demonstrate flexibility and versatility, but you'll force yourself to approach each new map independently and figure out how to present that dataset in an interesting, engaging fashion. Begin each mapping task independently from those you've done previously and you will retain freshness. Try to induce the viewer to think about the substance of the map rather than about the methodology, graphic design, or technology used to produce it. Finally, your map should create an emotional response in the viewer, encouraging them to explore further.

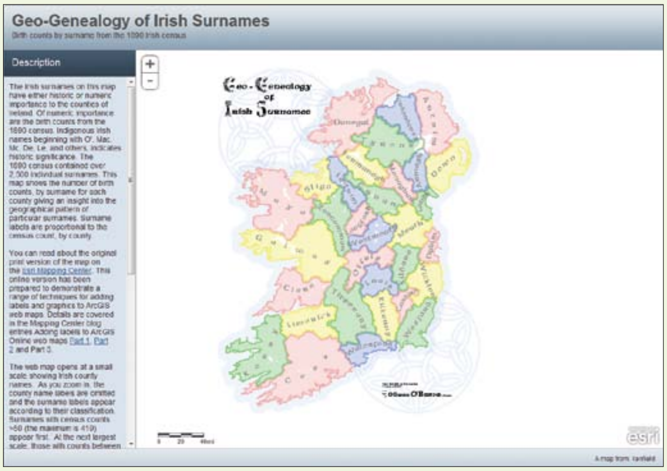
Summary

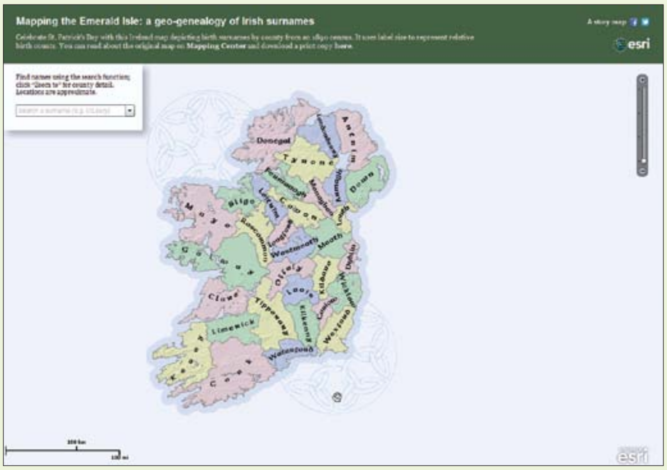
The new web mapping paradigm has created exciting possibilities for anyone to author and publish thematic maps using ArcGIS Online. You don't have to be a cartographer, but knowing what makes a successful map helps you design a map that people will want to use and explore. It will encourage you to develop imaginative ways of preparing and visualizing your data.

For an example of how these techniques can be applied, see the accompanying article "Making Thematic Data Work as a Web Map," which describes how the data was prepared for display as a print map, a web map, and a web map application. Each one required specific design considerations to take advantage of the medium used.

About the Author

Kenneth Field has more than 20 years of experience in cartography and GIS and holds a doctorate from Leicester University, UK. Prior to joining the Mapping Center, he was the course director of GIS at Kingston University. He has published and presented widely on cartographic design and is currently the editor of *The Cartographic Journal.*





↑ The multiscale nature of web maps and applications requires carefully structuring the information as demonstrated by the *Geo-Genealogy of Irish Surnames* web map created for ArcGIS Online (top) and Mapping the Emerald Isle map application (bottom).

I applied 100 percent transparency to the basemap and used my own simplified county boundaries. It was important to simplify the line work so the map would load, pan, and zoom effectively. The vignette effects and a detailed hill-shade with layer tints used for the print version would slow the refresh rate significantly for the web version. Instead, a simple four-color map showing the counties is a more functional, yet still visually appealing, approach that supports the performance of the map in this medium.

The multiscale nature of the web map required some careful thought because the previous print version was designed for a single scale. At a small scale, the labels on the web simply aren't visible. Because users can zoom to different scales, scale visibility ranges can be used to ensure certain labels appeared at certain scales. At smaller scales, only the larger labels are visible, supporting the idea that these surnames are the most common. As the user zooms in, smaller labels are added to the map. This structures the information and also takes advantage of the multiscale nature of web maps. (See "Using scale visibility ranges for symbology in ArcGIS Online web maps" on the Esri Mapping Center blog). I added some graphics and used simple pop-ups so users could mine the data, and the map was finished. View the web map application by searching for Geo-genealogy of Irish Surnames on ArcGIS Online.

The print and web map I created share a common ancestry but were designed very differently. However, this isn't the end of the story of this map. For St. Patrick's Day 2012, Allen Carroll and his Story Map team took the web map version of this map a little further.

Using the JavaScript API, the team modified the way the data was configured and presented as a web map application. The zoom levels were restricted to four scales that were purposeful for the map. Creating cached tiles of the basemap and the labels improved performance considerably so a subtle hillshade could be added back, giving the map more visual interest. Finally, a search tool was added that allows users to type in a surname (it uses autocomplete to give alternatives). It returns surname counts and zooms the extent directly to that part of the map. To make search results more legible on the map, other labels are temporarily grayed.

The search facility provides a useful way to explore the map that goes beyond what was possible in the print version. The web map application creates additional ways of engaging with the information while retaining the simplicity of the original design. You can view this web map application, Mapping the Emerald Isle, in the Storytelling with Maps gallery (storymaps.esri.com/wordpress/).

The *Irish Surnames* map went through three iterations: a print map, a web map, and a web map application. Each used a relatively simple thematic dataset but demonstrated how it was used to turn an idea into a great map suited, in each case, to its purpose and the medium for which it was created.

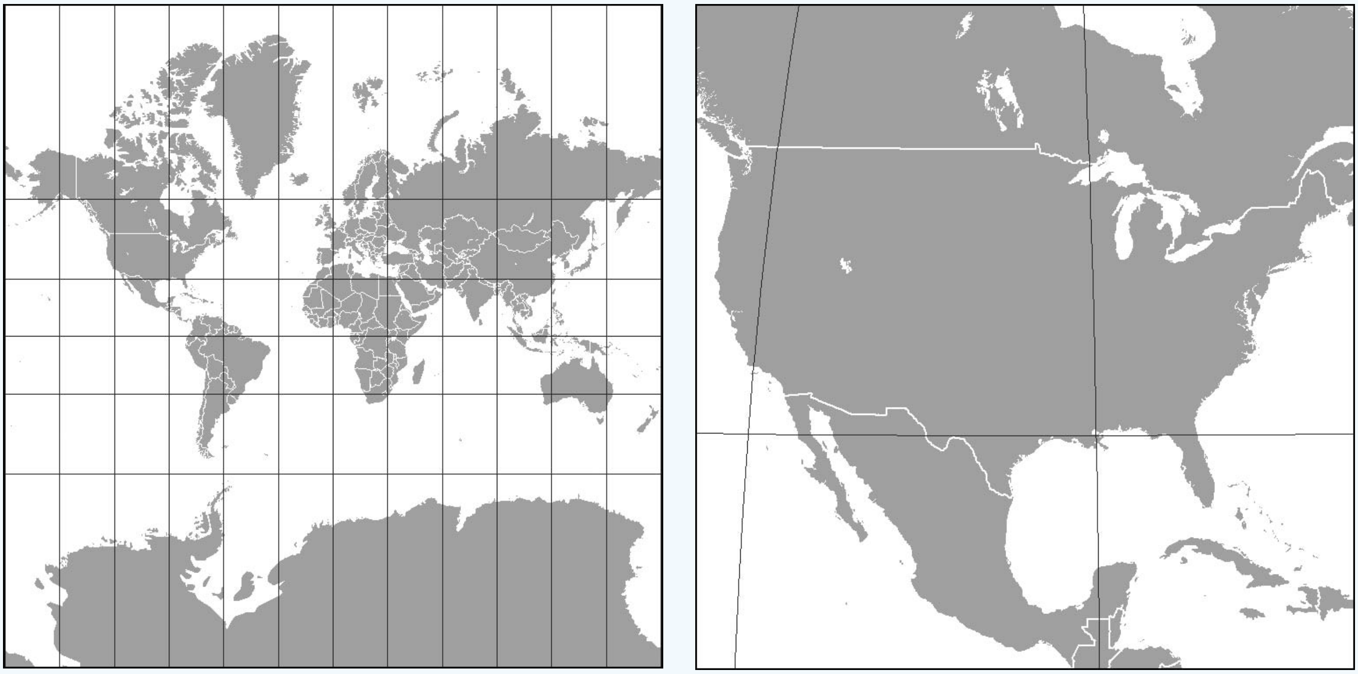
↑ The design for the print version of the *Geo-Genealogy of Irish Surnames* map used name labels as proportional symbols so that they became part of the visual story.

↑ The version of the *Geo-Genealogy of Irish Surnames* created for ArcGIS Online required new ways of seeing the data as well as alternative requirements for data manipulation.

↑ The Mapping the Emerald Isle web map application created additional ways of engaging with the information interactively while retaining the simplicity of the original design.

Designing Great Web Maps

By Aileen Buckley, Esri Mapping Center Lead



↑ Comparison of the web Mercator (left) and Winkel Tripel projections (right)

Web maps have characteristics that make them different from print maps or other on-screen maps. This article will help you take those differences into account and create more effective web maps.

A web map is a map and related content presented in an online environment with an appropriate interface and optional functionality for queries and reports. For mapmakers using Esri software, a web map is compiled in ArcGIS for Desktop's ArcMap, and the interface, map elements (e.g., legend, scale bar), query elements, and report elements are created using the ArcGIS viewers or ArcGIS APIs, available for JavaScript, Flex, and Silverlight. A web mapping application refers to both the script that is created to define the interface and the elements and functions provided through the interface.

When designing a web map, as with ***any*** map you make, the first thing to ask is, "What is the purpose for this map?" The answer will disclose the map's audience and how it will be used by that audience.

Why Web Maps Are Special

Typically, web users have relatively short attention spans and high expectations. They do not focus long on content or tasks before becoming distracted, so not only should a web map display quickly, its functions should respond rapidly and its purpose should be immediately understood. Users also expect what they are viewing to be of immediate and personal use to them. These characteristics challenge web mapmakers to design maps that possess high levels of graphic and information clarity.

Since the web environment is well suited for interaction, more information can be immediately shared using mouse-overs, ToolTips, information boxes, labels, and hyperlinks. It is possible to show less on the map itself (e.g., labels or detailed features) and still convey information. The map can be linked to databases that report attribute information, display images, play sounds when users click related map features, or perform analyses by accessing geoprocessing functionality. Web maps can also be portals for downloading or uploading content.

Web Map Content

Users will likely also have certain expectations for web map content. They expect current data and sometimes continuously updated data (e.g., maps that show monitoring sites). They also expect interactive maps that support zooming at a minimum but also potentially support query, analysis, and customization. For larger-scale maps, users expect detail and realism. They may even expect the data used to make the map to be downloadable and free. As with print maps, data should be complete, consistent, and authoritative.

Making Web Maps

The workflow for making web maps encompasses four primary activities: designing the information to be shown on the map, designing the map, designing the user experience, and promoting the finished web map.

When designing the information to be shown on the map, consider not only how the data is modeled but also its completeness, timeliness, and authority. Determine if there are aspects of the data that must be added when compiling the map. When designing the map, consider how the web interface can be used to communicate the map's message and make it appealing to its intended audience. When designing the user experience, consider how users will interact with the map and its related information. Once the map is finished, promote the map not only to its intended audience but also other potential audiences to maximize its value.

Compiling a Web Map

Before compiling a web map, you have to determine a few things. What size will it be and what geographic extent will it show? Given those parameters, the map scale and resolution can be determined. Next decide which map projection is best. Choose the colors, fonts, and symbols and decide what to show in the map margins. General guidelines will be given for each of these areas. While this is not an exhaustive set of recommendations, it should help you get started.

Size

Although web maps are usually designed for a 17- or 19-inch LCD monitors—because that is what most people have on their desktops—web maps can also be viewed on other devices such as Tablet PCs, smartphones, or iPads. Design for the ***primary*** delivery mode. Sometimes a map design will work well on devices other than the primary delivery mode. Sometimes it won't.

Geographic extent

Because users can pan and zoom, the geographic extent of the map can be greater than what is shown on the screen initially. Sometimes it is useful—and necessary—to restrict the map extent. Other times, it makes more sense to provide a global view. It will depend on the map's purpose.

Map scale

If readers can zoom in and out, the map scale will be variable. This means that ***a separate map should be compiled for each map scale*** to ensure that the zooming experience appears seamless. Learn more about how to do this in ArcMap by reading the Esri Mapping Center blogs "Creating a web map service" and "Working with layers and scale ranges: Tips for organizing the Table of Contents."

Map projection

The map projection you use depends on whether the map will be mashed up with other web maps. For example, if you want your map to overlay with maps on ArcGIS Online, Bing, or Google, you'll use the web Mercator projection.

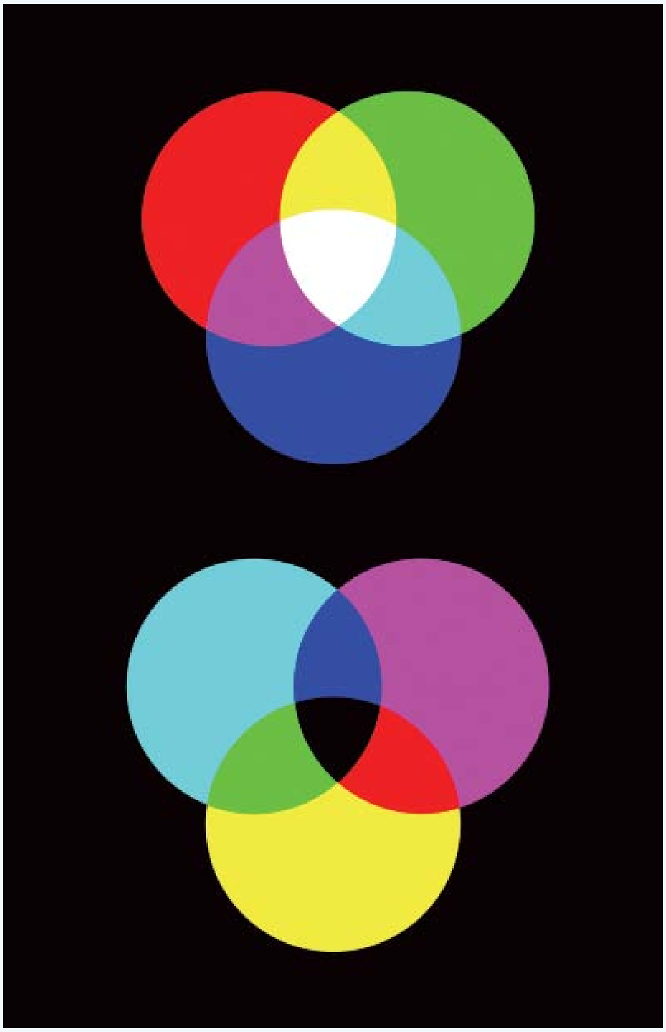
If you use a different projection, anyone who wants to use your map in a mashup will have to use that same projection. If you do not think anyone will use your map in a mashup, consider alternate projections such as modified Winkel Tripel projection.

Color

Today, computers can display millions of colors, so using web-safe colors is a moot issue. Almost every web map is in color. However, color on the web is different than color in print. This will have an impact on your maps' appearance.

In print, colors are comprised of ink pigments. Using the subtractive color system, these colors are perceived by the viewer as the reflection of light by the pigment on the page. On a computer monitor, colors are made up of colored light. Using the additive color system, colors are created by combining red, green, and blue light in different proportions and intensities. The color white is produced by combining red, green, and blue light at full intensity.

↓ The additive (top) and subtractive (bottom) color systems



One consequence of using an additive color system is that light colors viewed on a computer monitor are overly luminous and too harsh on the eye for extended viewing. Also, the intensity of the light radiating from a screen displaying pure white can affect the clarity of fine detail in type, point symbols, and line symbols as well as intricate patterns, such as rasters used to show hillshades or elevation tints.

Symbols

To be legible, symbols and text must be large enough to be seen and distinguished from the background. Although the height of a text character varies from font to font, a rule of thumb is that text and symbols should be at least 10 pixels high. That means using fonts 7 points or larger on a PC and 9 points or larger on a Mac.

The ability to distinguish a symbol from its background is called contrast. A table of color contrast metrics is a good guide for color selection that will promote contrast.

Fonts

When possible, use fonts designed for the web. A recent study identified Arial (or Helvetica on Macintosh), Verdana, Georgia, Trebuchet, and Century Gothic (all installed on Windows systems), and Lucinda Grande and Palatino (installed on most systems) as the most popular fonts for web design. Good web fonts have a generous amount of space between characters and within characters (i.e., punch width). A tall x-height also opens up the space within a character. These properties make fonts legible on screen.

With the exception of Georgia and Palatino, these are sans-serif fonts. Serifs are the small lines or decorations added to the ends of the main strokes of the character that theoretically help the letters flow and lead the eye across text during reading. Serif fonts are very popular in print. However, many designers and cartographers believe that sans-serif fonts are more suitable for web map design because serifs compromise the space between characters. This holds true for small blocks of text (e.g., labels on maps, titles, legend text), but for large blocks of text, serif fonts are still easier to read.

Resolution

Computer display resolution is low when compared to print maps. For desktop computers, it is common to design for a resolution of 96 dpi (dots per inch) because all LCD monitors support this resolution. Newer LCDs typically have a native pixel density of 120 dpi and 144 dpi. Choose resolution based on the type of computer your target audience will mostly likely use.

This low resolution, coupled with the color projection issue, will impact the cartographic design of a web map. Because screen displays are pixels, nonorthogonal lines and sharp edges appear jagged. These jagged edges can be softened by adding pixels of intermediate color between the object and the background (antialiasing), which fools the eye into seeing a jagged edge as a smooth one.

↓ The luminosity of an image that is primarily white is taxing to the eye when viewed on-screen.

↓ This table shows color contrast metrics for combinations of colors for symbols and their backgrounds. Combinations that have higher values result in better legibility.

Average Color Contrast

Y-W 32										
O-W 70	O-Y 44									
R-W 108	R-Y 81	R-O 39								
G-W 72	G-Y 46	G-O 38	G-R 73							
C-W 46	C-Y 55	C-O 63	C-R 90	C-G 32						
M-W 78	M-Y 85	M-O 46	M-R 33	M-G 78	M-C 70					
Bl-W 152	Bl-Y 157	Bl-O 98	Bl-R 61	Bl-G 108	Bl-C 103	Bl-M 55				
I-W 69	I-Y 76	I-O 38	I-R 60	I-G 52	I-C 44	I-M 34	I-Bl 64			
V-W 108	V-Y 118	V-O 73	V-R 38	V-G 95	V-C 88	V-M 32	V-Bl 28	V-I 41		
Br-W 111	Br-Y 92	Br-O 44	Br-R 35	Br-G 65	Br-C 84	Br-M 40	Br-Bl 57	Br-I 39	Br-V 35	
Bk-W 259	Bk-Y 233	Bk-O 121	Bk-R 73	Bk-G 159	Bk-C 193	Bk-M 108	Bk-Bl 41	Bk-I 115	Bk-V 66	Bk-Br 71
W	Y	O	R	G	C	M	Bl	I	V	Br

Background Color

Map marginalia

Maps have two basic components: the map itself and information about the map, commonly called marginalia (additional information outside the edge of the map displayed in the margins). Map marginalia includes titles, legends, scale bars, scale text, and north arrows, as well as information about the data used, map projection, author, and publication date. With web maps, it makes sense to include some of these items, but not all.

All maps should have a title. For symbology that may be unclear or confusing, include a legend, especially if the map is for an international audience. Cartographic conventions vary. Whether to include a map scale depends on how much area is shown on the map. If your map covers a large area or is 3D (i.e., is in a perspective rather than planimetric view), scale will vary across the map, and a scale bar or scale text would be inaccurate for all mapped locations. For 3D maps and maps that use a projection other than web Mercator, you may not want to include a north arrow because orientation may vary across the map. Instead, including a graticule (latitude and longitude lines) or other grid is a good alternative that helps address the scale issue as well.

For web maps, it is very useful to include the author and publication date and information on the data. Users of web maps expect data to be current and accurate and sometimes expect to be able to access the data. Knowing who made the map, when it was published, and what data was used to make it helps users assess the validity of the information on or linked to the map.

↑ Characteristics of good web fonts (from sitepoint.com/anatomy-web-fonts)

Conclusion

The web makes it easier for your maps to reach far more people, but knowing how to design maps specifically for the web will help you create maps with immediate and wide appeal that readers will find useful, interesting, and notable.

About the Author

Aileen Buckley is the lead of the Esri Mapping Center (mappingcenter.esri.com), an Esri website dedicated to helping users make professional-quality maps with ArcGIS. She has more than 25 years of experience in cartography and holds a doctorate in geography from Oregon State University. She has written and presented widely on cartography and GIS and is one of the authors of *Map Use*, Seventh Edition, published by Esri Press.

Prospecting for Gold

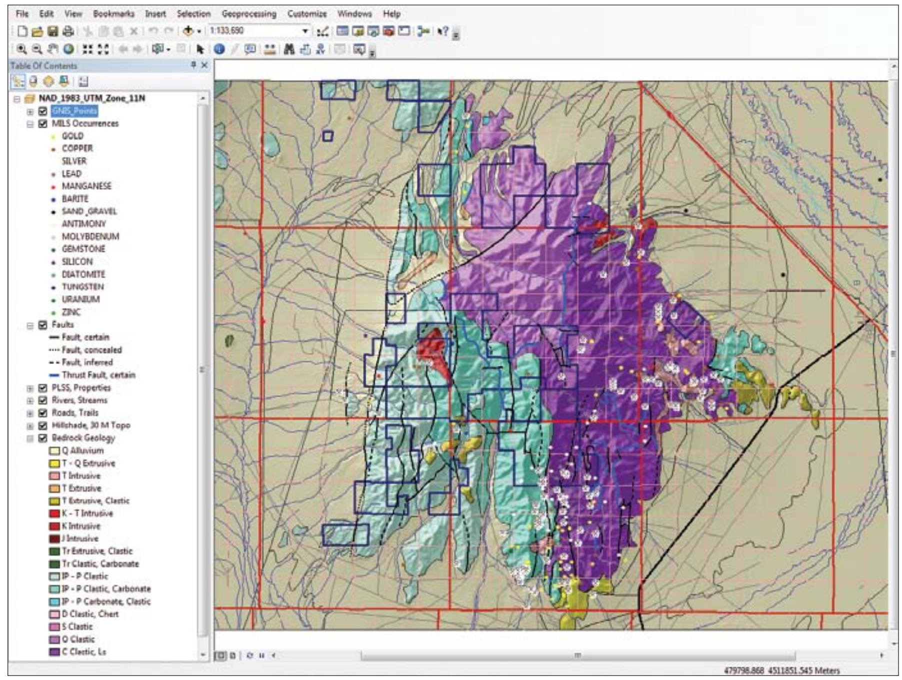
Building, mapping, and charting point geochemical data

By Mike Price, Entrada/San Juan, Inc.

Data that has been imported from Microsoft Excel spreadsheets and geoenabled can be further explored using the charting capabilities in ArcGIS. To do this, the data points are first mapped as XY event themes, then imported into a geodatabase as feature classes.

This exercise teaches ArcGIS skills and workflows that are used daily by exploration geologists and geochemists. These skills include tabular joins, posting x,y point data using coordinates, thematic mapping, and statistical sampling. Once the data is mapped, the multielement charts, or scatterplots, available in ArcMap are used to identify and characterize the occurrences of these minerals.

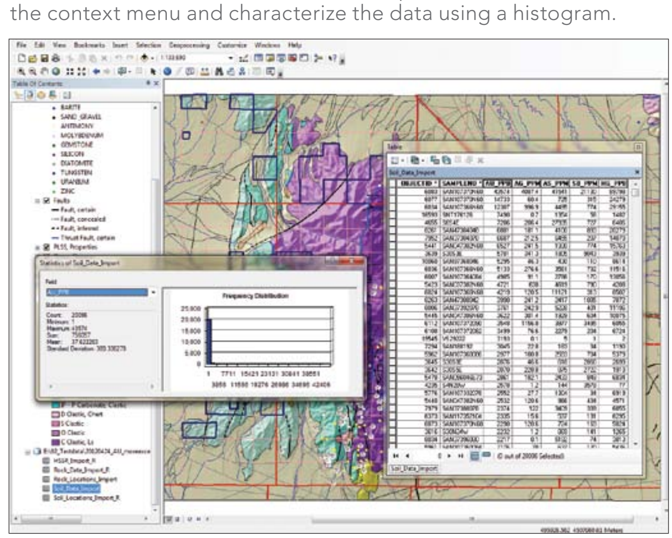
"Importing Data from Excel Spreadsheets: Dos, don'ts, and updated procedures for ArcGIS 10" in the spring 2012 issue of *ArcUser*, defined a methodology for importing tables containing soil, rock, and stream sediment geochemistry into a geodatabase. Data tables included separate sample locations and metals analyses for soils and rocks, plus actual multielement data for stream sediments that had already been merged with locations.



↑ This exercise uses a synthetic dataset developed from actual data that shows the location of anomalous gold occurrences in the Battle Mountain area of northern Nevada.

Tip: Follow the file naming conventions carefully, and this exercise will be a breeze.

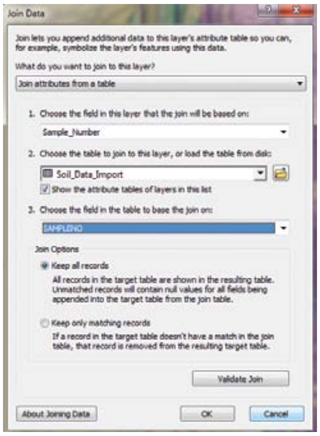
↓ In the attribute table for Soil_Data_Import, choose Statistics from the context menu and characterize the data using a histogram.



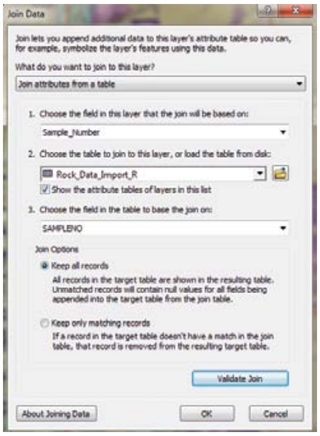
This exercise uses a synthetic dataset developed from actual data that shows the location of anomalous gold occurrences in the Battle Mountain area of northern Nevada. Battle Mountain, a region of active mineral exploration and production, has been extensively prospected for more than 100 years. Geological and geochemical data is available through public sources. Exploration companies also maintain extensive private databases.

Getting Started: Exploring Battle Mountain

Although this exercise uses the same dataset as the previous tutorial, "Importing Data from Excel Spreadsheets: Dos, don'ts, and updated procedures for ArcGIS 10," it is best to start with a fresh copy of it downloaded from the *ArcUser* website (www.esri.com/arcuser). Before downloading this sample dataset for this exercise, archive any data you might have from the previous exercise.



↑ Join the Soil_Locations_Import_R and Soil_Data_Import tables. In the Join Data wizard, set item 1 to Sample_Number, item 2 to Soil_Data_Import, and item 3 to SAMPLENO.



↑ Join the Rock_Locations_Import and Rock_Data_Import_R tables. In the Join Data wizard, set item 1 to Sample_Number, item 2 to Rock_Data_Import_R, and item 3 to SAMPLENO.

Download the current training data and store it locally on your computer. Unzip the archive and explore the data in ArcCatalog. Preview the layer files. The Hydrogeochemical and Stream Sediment Reconnaissance (HSSR), Rock, and Soil data used in the previous exercise are not present. The first half of this exercise presents a workflow to build feature classes for this data so that it can be displayed.

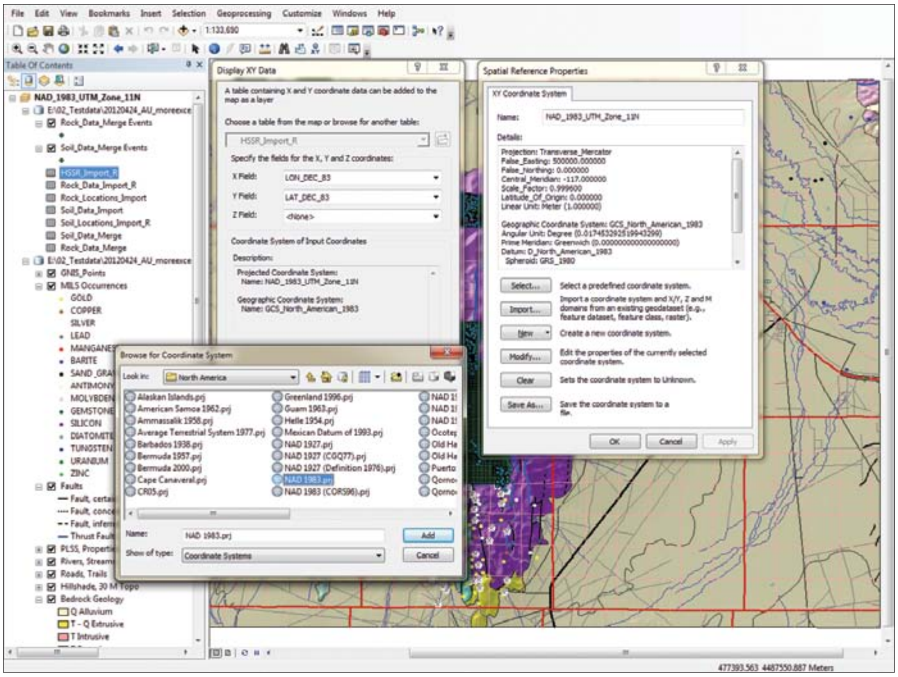
Close ArcCatalog and start a new ArcMap session. Navigate to \Battle_Mountain and open Battle_Mountain01.mxd. Explore the layers and become familiar with Battle Mountain geology. This region is characterized by Paleozoic sedimentary rocks that are more than 251 million years old. These rocks have been dislocated by extensive normal and thrust faulting. In many areas, older sediments occur above younger rocks—a geological oddity. Younger igneous rocks have intruded in the sediments, often bringing mineralizing fluids.

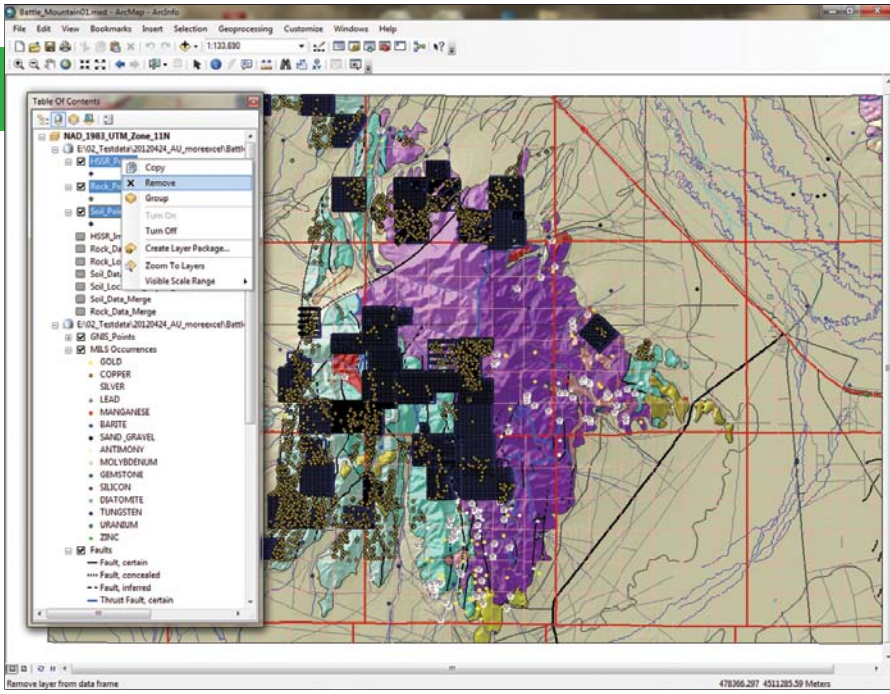
Battle Mountain includes many gold (Au), silver (Ag), and copper (Cu) mines and other mineral commodities, too. This exercise uses pathfinder elements in the synthetic dataset—arsenic (As), antimony (Sb), and mercury (Hg)—to guide the search for gold. Explore the US Bureau of Mines Mineral Industry Location System (MILS) points and compare the MILS commodities to the underlying geology. Check out the relationship between mines, prospects, lithology, and faulting.

Adding Geochemical Data

1. Before loading the geochemical data into the map, turn off labels for the GNIS points. Click the Add Data button, navigate to \Battle_Mountain\GDBFiles\, and open the Geochemistry geodatabase. Select and load all five location and assay tables.
2. As the tables load, ArcMap switches to the table of contents (TOC) Source tab so you can preview five geodatabase tables. Notice the location (Rock_Locations_Import and Soil_Locations_Import) and assay (Rock_Data_Import_R and Soil_Data_Import) data tables have identical record counts. Although this data has been carefully organized to enforce a one-to-one relationship between location and assay records, this is not always the case.
3. Sort the soil assay data by element and right-click on the field containing the statistics for each element. Choose Statistics from the context menu to characterize the data using a histogram. The highest Au value is 43,574 part per billion (ppb), which equates to 1.40 troy ounces per short ton (i.e., the US ton, or 2,000 pounds). There must be a gold nugget in this sample.
4. Inspect the HSSR and rock data. The rock samples are separated into location and assay files like the soil data. Rocks and soils

↓ Because HSSR_Import_R is in geographic rather than projected coordinates, set the coordinate system when creating the XY event theme by clicking the Edit button, then the Select button, and choosing North America > NAD83.prj.





↑ After permanently saving the soil, rock, and HSSR points by exporting the XY Event themes to file geodatabase feature classes, they can be deleted from the map.

data are both in universal transverse Mercator (UTM) North American Datum (NAD83) Zone 11 Meters, the same coordinate system as the map. HSSR coordinates are in NAD83 geographic (decimal degree) units. Explore the elements in these files using the Statistics tool. Remember that soil and rock data are both synthetic datasets, while HSSR points data is actual field data.

Joining and Exporting Soil and Rock Data

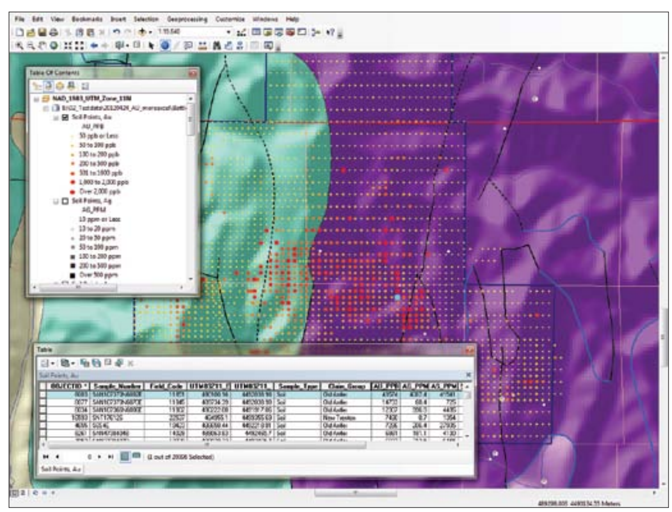
To place these datasets on the map will require joining and saving the soil and rock tables, exporting the joined table as a geodatabase table to preserve the short field names, and posting all three tables as XY event themes before exporting the XY theme to a geodatabase feature class.

1. Process soil data first, then the rock data. Right-click Soil_Locations_Import_R and select Joins and Relates > Join.
2. In the Join Data wizard, set item 1 to Sample_Number, item 2 to Soil_Data_Import, and item 3 to SAMPLENO. Click Validate to check the join, and click OK to complete the join. Sort the joined table as a second method of verifying that all records were successfully joined.
3. Export this dataset to a new geodatabase table **before** posting it as an XY event theme. Exporting joined data first maintains the short field names in the final dataset, which is an important consideration. Right-click Soil_Locations_Import_R and choose Data > Export All Records to \Battle_Mountain\GDBFiles\Geochemistry.gdb. Name the table Soil_Data_Merge. Add the merged table into the map.
4. Create a tabular join for Rock_Locations_Import and Rock_Data_Import_R. Inspect the join and export this table as Rock_Data_Merge.
5. Open and inspect HSSR_Import_R. These coordinates are decimal degrees. Because these coordinates are already posted, a join is not necessary. Save the map.

Mapping XY Event Themes and Saving XY Points as Feature Classes

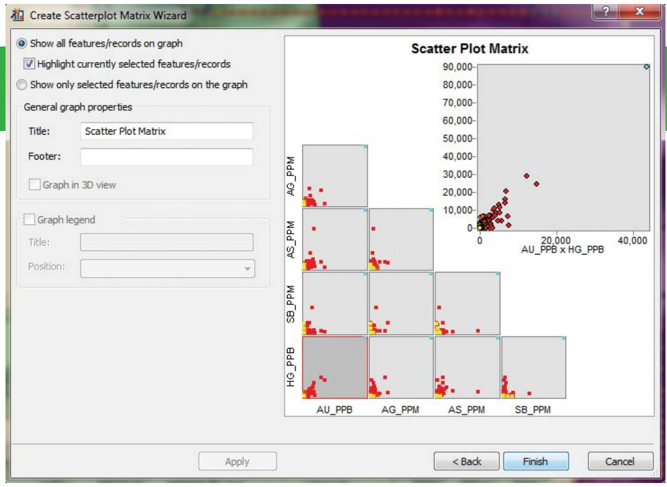
Now to post soil, rock, and HSSR data as XY points. Once posted, each event theme will be saved as a geodatabase feature class.

1. In the TOC, right-click Soil_Data_Merge and select Display XY Data. In the Display XY Data wizard, set the X Field to UTM83z12_E and the Y Field to UTM83Z12_N and leave the Z Field as <None>. The predefined coordinate system should be NAD_1983_UTM_Zone_11N. If it is not, set it manually now by clicking the Edit button and using Select or Import.
2. Click OK, and more than 29,000 soil points should appear on the map. Right-click Rock_Data_Merge and select Display XY Data. As before, set the X Field to UTM83Z12_E and the Y Field to UTM83Z12_N and leave the Z Field as <None>. The coordinate system should be predefined. Click OK to post Rock Points.



↑ Now load the Soil Geochemistry Group, a set of layer files to symbolize the layers for Au, Ag, As, Sb, and Hg elements, and one layer each for Rock Points and HSSR Points.

3. Post the HSSR Points. Since HSSR_Import_R contains geographic rather than projected coordinates, the coordinate system must be carefully redefined. Change X Field to LON_DEC_83, Y Field to LAT_DEC_83, and Z Field to <None>. Click the Edit button to modify the coordinate system, then click Select and choose North America > NAD83.prj. Click Add, then OK twice. Save the project and inspect the new point sets.
4. To permanently save the soils points, right-click Soil_Data_Merge



↑ The relationships between gold and other elements can be explored using scatterplot matrix charts.

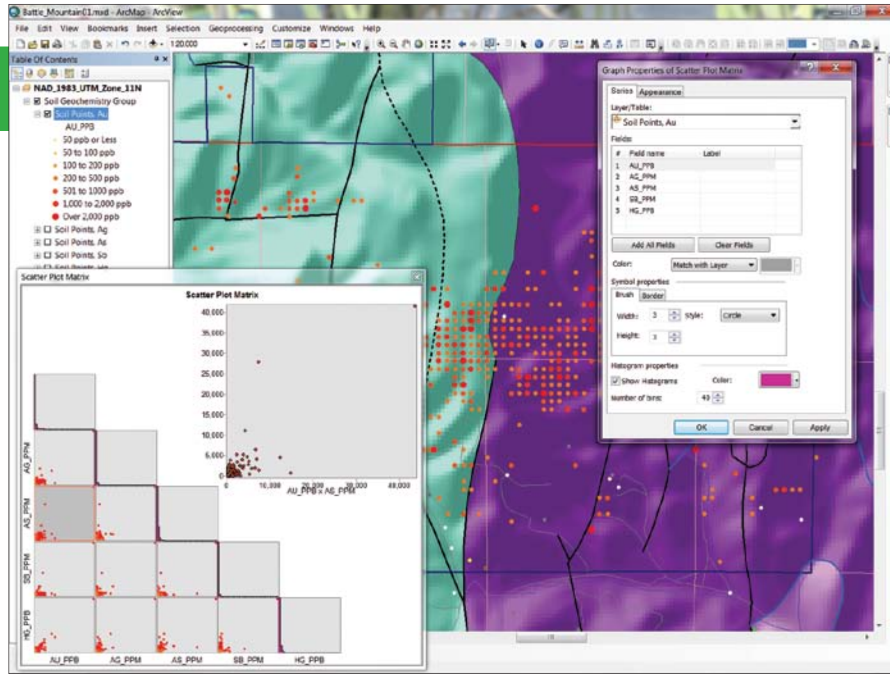
Events and select Data > Export Data. Save the dataset as a file geodatabase feature class located in \Battle_Mountain\GDBFiles\Geochemistry.gdb. Name this feature class Soil_Points. **Use exactly this file name.** Add the new feature class to the map.

5. After the Soil_Points layer appears in the TOC, export Rock_Data_Merge Events to \Battle_Mountain\GDBFiles\Geochemistry.gdb and name it Rock_Points.
6. Export HSSR_Import_R Events to \Battle_Mountain\GDBFiles\Geochemistry.gdb as HSSR_Points. The point set is nearly completed. Save the file.
7. Before continuing, simplify the project by removing the three XY event themes and deleting the two duplicated join fields (i.e., Soil_Points OBJECTID and SAMPLENO) in the tables for each new feature dataset.
8. Also remove the three new geochemistry feature classes (Soil_Points, Rock_Points, and HSSR_Points) from the map. Save the map.

Applying Prebuilt Geochemical Symbology

Remember the Soil, Rock, and HSSR layer files that could not be displayed properly when the map was opened initially? Now that the corresponding feature classes have been created, these layer files should load easily.

1. On the text menu, select Bookmarks > Anomalous Soils 1:20,000 to zoom in to an interesting project area centered on Battle Mountain.
2. Click Add Data and navigate to \Battle_Mountain\GDBFiles\. Select and load the Soil Geochemistry Group, seven point layer files that include five soil themes for the elements Au, Ag, As,



↑ Right-click (or double-click) the active scatterplot, open Properties, and select the Series tab. Check the Show Histogram box, set the color to Peony Pink (a bright magenta shade), and set the number of bins to 40.

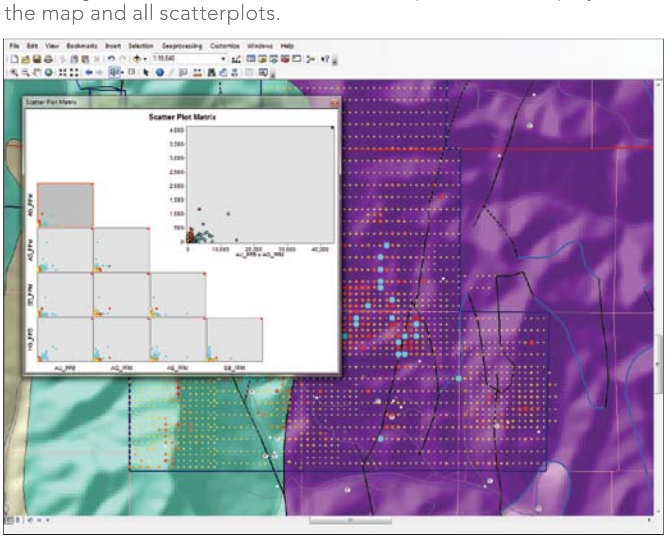
Sb, and Hg, and one layer each for Rock_Points and HSSR_Points.

3. If these files loaded properly, save the map again. If not, check the data paths and feature class names. You may need to rebuild data or change data pointers.
4. Inspect all datasets and look for anomalous data. Notice that each layer file contains seven symbolized and colored data intervals separating high-grade points from background data.
5. Notice the large red Au samples that appear above adjacent low-grade points. Symbol levels were applied to achieve this effect. Without symbol levels, many high-grade points would be covered by nearby low-grade samples, especially when shown at small scales. Symbol Levels changes the drawing order so low-grade points are drawn first and high-grade points are drawn last. To learn more about defining symbol levels, read the companion article, "Displaying Points: Using symbol levels to optimize point display."

Investigating Relationships Using a Scatterplot Matrix

In the Battle Mountain area, anomalous gold often occurs with elevated levels of silver, arsenic, antimony, and/or mercury. Using charting in ArcGIS, the relationships between the elements in the geochemistry data can be defined and plotted. In this exercise, XY scatterplots will be a quick and effective way to compare several elements. One chart will be created for each of five soil point element pairs for a total of 10 charts.

↓ Estimate the position of 5,000 ppb Au on the scatterplot and draw a selection polygon on the active chart to select all samples to the right of this value. The selected samples will be displayed on the map and all scatterplots.

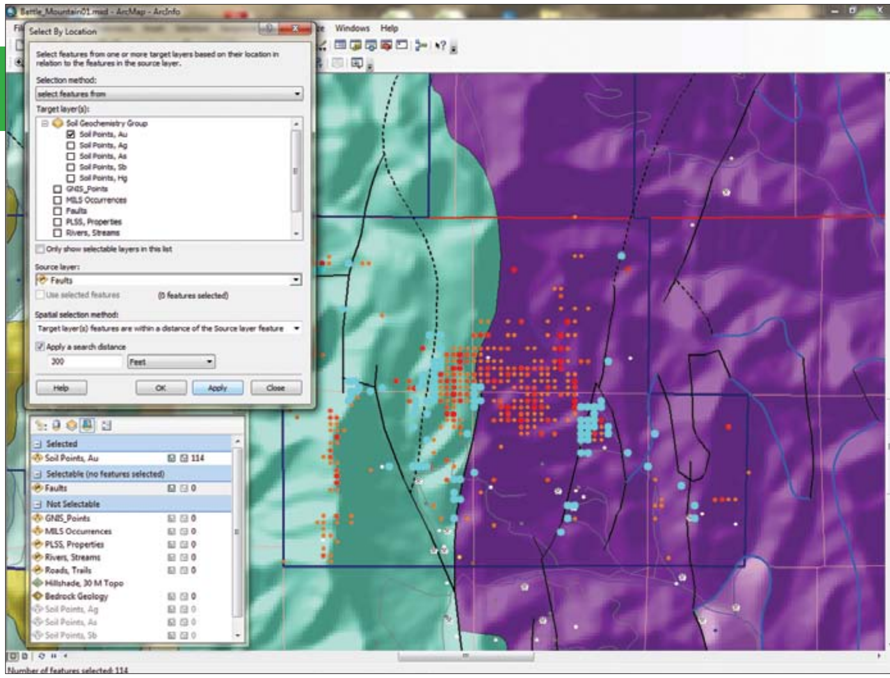


1. On the ArcMap Standard menu, select View > Graphs > Create Scatterplot Matrix. In the Scatterplot Matrix wizard, set Soil Points, Au as the Layer/Table. Load all five assay fields in this order: AU_PPB, AG_PPM, AS_PPM, SB_PPM, and HG_PPB.
2. Still in the same pane of the wizard, set the following parameters:
   Color: Match with Layer
   Brush Width: 3
   Brush Height: 3
   Style: Circle
   Show Histograms: Unchecked (for now)
3. Click Apply, and 10 histograms should appear. Click Next and then Finish. Study the arrangement of the 10 scatterplots that evaluate the combinations of the five elements. Au/Hg should be the active plot. To switch plots, click the desired chart in the matrix, and it will appear in the active window.
4. Right-click the largest, active plot to open Graph Properties. Preview the Series and Appearance tabs. Close this window. To display as much active mapping area as possible, dock the scatterplot window in the lower left corner of the display. If you have a dual monitor, move it to the other screen. Save the map again.

Let's Go Prospecting

One really useful thing about a chart in ArcGIS is that if you select data on a chart, the corresponding data will be selected on the map. You can also select vector data on the map and show the corresponding samples on each chart. These scatterplots show relationships between two elements, so we can chart them both, select interesting populations, and locate them on a map.

For example, with Au/Ag active, estimate the position of 5,000 ppb



↑ Because some of the highest-grade gold occurrences are closely related to high-angle normal faults, use Select By Location to select Soil Points, Au by proximity to faults.

Au and draw a selection polygon to select all samples in the chart to the right of this Au value. (Hint: Select from lower left to upper right.) Be sure to catch the outlier in the upper right corner. Watch as the selected anomalous gold samples in the plot are highlighted on the map and in all 10 scatterplots. There are many anomalous samples in the area. Let's go check it out.

1. On the Standard toolbar, select Bookmarks > Anomalous Soils 1:20,000. In the TOC, switch to the List by Selection tab and make only Soil Points, Au selectable. Select features by drawing a box around the largest group of red points in the center of the screen. These points will be highlighted on the map, in the selected scatterplot, and in each of the 10 scatterplot thumbnails.
2. This next step creates a subset of moderate- to high-grade samples and shows distribution histograms for the five elements. Based on regional knowledge, any soil sample containing over 200 ppb Au is significant. (Remember, this is synthetic data provided for training purposes only.) Clear the selection set, and in the TOC, right-click Soil Points, Au and click Properties. Open the Definition Query tab, create a query to display only samples containing 200 or more ppb Au, and apply this query. The scatterplots will be redrawn showing only the anomalous samples.
3. Right-click (or double-click) the active scatterplot, click Properties, and select the Series tab. Check the Show Histogram box, set the color to Peony Pink (a bright magenta shade), and set the number of bins to 40.
4. Switch to the Appearance tab and click the radio button to Show only selected features/records on the graph. Click OK to apply the changes and create histograms for the anomalous subset.
5. Here is another selection method. Because some of the highest-grade gold occurrences are closely related to high-angle normal faults, use Select By Location to select Soil Points, Au by proximity to faults. On the Selection tab of the TOC, click the Faults layer to make it selectable. Select all items except faults coded as Known thrust fault.
6. From the standard menu, choose Selection > Select By Location. Set Soil Points, Au as the Target layer and Faults as the Source layer. Set Spatial Selection method to Target layer(s) features are within a distance of the Source layer feature. Apply a search distance of 300 feet and click OK. Save the map.

More Experimentation and Additional Training

This exercise experimented with only the large soil samples dataset. The sample dataset also contains more than 4,000 rock samples and almost 100 stream sediment points. You can continue evaluating these samples and study other proximity relationships including bedrock lithology and drainage systems.

To learn more about how GIS can be applied by exploration geologists and earth scientists, consider enrolling in *Introduction to ArcGIS for Desktop for Mining Geoscience* (IMIN), an Esri instructor-led course. It introduces ArcGIS tools to create mining geosciences workflows. Exercises teach fundamental ArcGIS skills and apply them to solve mining and geosciences problems such as detecting mineral occurrence patterns, locating prospective deposits, and identifying optimal areas for mineral exploration. Visit training.esri.com to learn more about this and other courses.

Acknowledgments

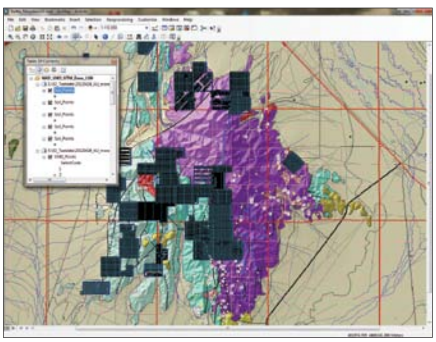
The data in this exercise is essentially the same data presented in the spring 2011 *ArcUser* tutorial. While the soil and rock data is synthetic, it does match underlying geology. Landownership is imaginary, yet it reflects exploration trends around Battle Mountain, Nevada, in the early 1990s. Bedrock geology was derived from the Nevada Bureau of Mines and Geology county mapping series. HSSR data was developed by the US Department of Energy National Uranium Resource Evaluation (NURE) program. All data has been transformed from UTM NAD27 into the current NAD83 datum.

Displaying Points

Using symbol levels to optimize point display

By Mike Price, Entrada/San Juan, Inc.

Because ArcMap typically draws points in ascending table order, when displaying a complex point set that has closely placed points, low-grade samples often cover nearby high-grade samples. To properly view and interpret the high-grade data often requires zooming in to rather large scales.



↑ To begin, save the completed Battle Mountain map document as Battle_Mountain02.mxd and remove all geodatabase point data.

One solution was to sort the data in descending order, save the sorted dataset as a new table, and repost the points as an event theme. Although this works, it requires separate sorts for all elements. If new points are added, all changed datasets must be re-sorted and reimported.

Symbol Levels, available in ArcGIS for Desktop 10 and 9.x, helps solve this problem. This layer property lets you override the default drawing order of features in ArcMap and control the drawing order and position in relation to other symbols. To see how Symbol Levels can help you draw low-grade points first and high-grade points last, use the data from the completed exercise described in “Prospecting for Gold: Building, mapping, and charting point geochemical data” to re-create the levels used in the tutorial using the workflow described here.

Posting Raw Data Points

To get started, save the completed Battle Mountain map document as Battle_Mountain02.mxd and remove all geodatabase point data.

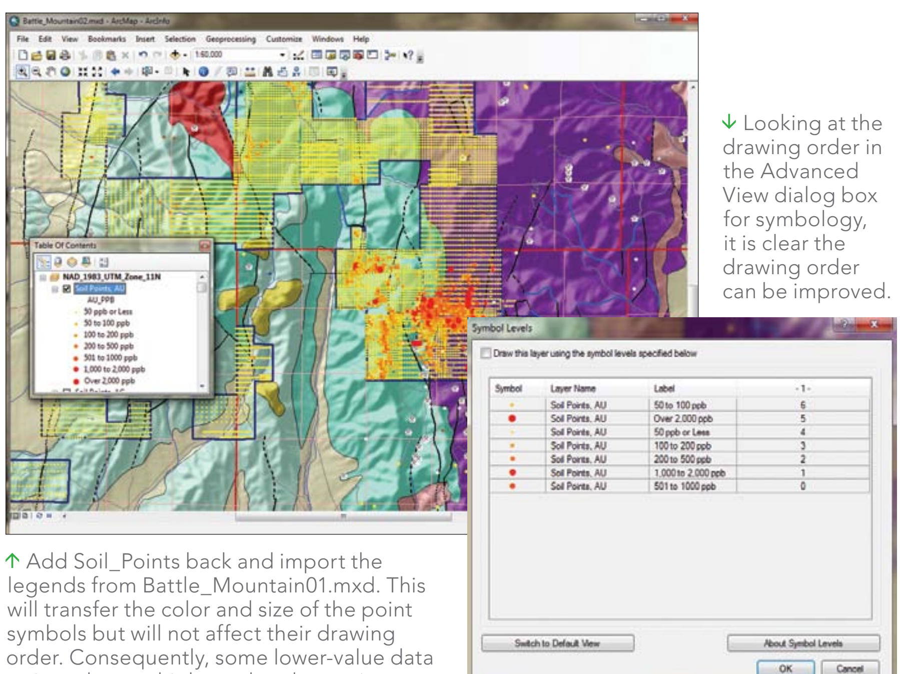
1. In data view, zoom to 1:120,000 scale and center the map extent on Battle Mountain. Click the Add Data button, navigate to \Battle_Mountain\GDBFiles\Geochemistry.gdb, and add Soil_Points.
2. If you would like to use Symbol Levels on all five elements, add or copy five instances of this dataset. Rename your dataset(s) using the convention Soil Points, <name of element>.
3. Import legends for these soil layers from Battle_Mountain01.mxd. Importing only the legend transfers the point size and color for each element but doesn’t change the display order.

Notice that many high-grade gold samples appear to be merged with lower-grade orange and yellow points. Even the larger size of the high-grade points does not make them easy to see at this scale. To properly view these clustered points, zoom in until they appear as unique features—probably a scale larger than 1:25,000 to eliminate overlaps. You could set a reference scale now, but as you zoom back out, points become too small to be meaningful, so try Symbol Levels.

Understanding and Applying Symbol Levels

The secret to building and applying symbol levels is to create a logical, well-designed legend for each point set. If you classify point or polyline data using Categories or Quantities, select a style that will separate your data into meaningful groups.

Because the gold geochemistry represents continuous numeric data with an approximate log-normal distribution, a graduated



↑ Add Soil_Points back and import the legends from Battle_Mountain01.mxd. This will transfer the color and size of the point symbols but will not affect their drawing order. Consequently, some lower-value data points obscure higher-value data points.

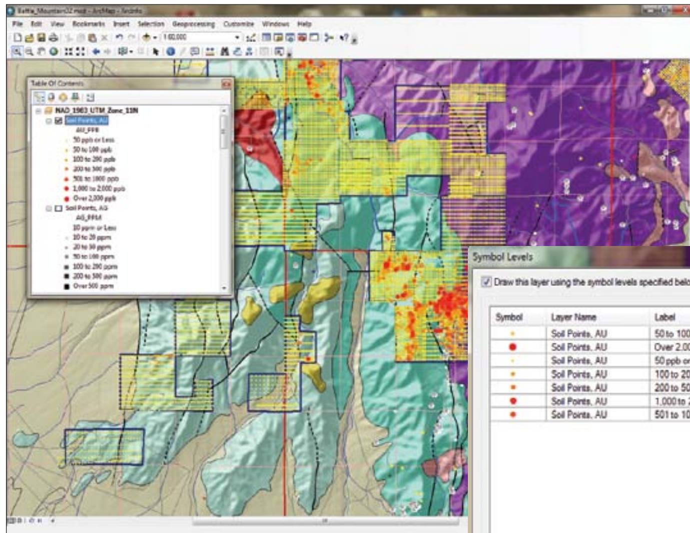
↓ Looking at the drawing order in the Advanced View dialog box for symbology, it is clear the drawing order can be improved.

color and symbol legend works well. Define breaks that divide the population into similar-sized groups or bins and place the most important bin at one end of the range. In the Battle Mountain exercise, gold data had seven breaks at 50, 100, 200, 500, 1,000, and 2,000 parts per billion (ppb). Because the high value points (those over 2,000 ppb) are spread throughout the dataset, they are often hidden by lower values that post later as the layer is drawn. Symbol Levels can be used to float these high-grade values to the top of the drawing order.

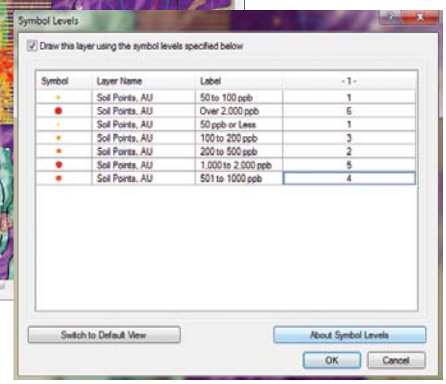
1. In the table of contents, right-click Soil Points, Au and choose Properties, and click the Symbology tab. Inspect this thematic legend. Click the Advanced button in the lower right corner and select Symbol Levels.
2. When the Symbol Levels wizard opens, inspect the sorting order. The high-grade points may be at the top of the display series, which would be desirable. If they are not in that order, the next few steps will fix that situation.
3. To activate Symbol Levels, check the box beside Draw this layer using the symbol levels specified below, and click Switch to Advanced View. In Advanced View, renumber the drawing order of symbols so the class with the lowest integer value will draw first starting with 0 or 1 and incrementing the number assigned to each level by one integer. Click OK twice to apply the changes and watch the map redraw.
4. The highest-grade gold values are now drawn last and appear on top of all other values. Now, it is easy to see the high-grade points.

Symbol Summary

It is easy to apply Symbol Levels to a well-designed legend, and it certainly contributes to colorful, informative maps. Import and apply symbol levels to the other soil geochemistry data used in the exercise.

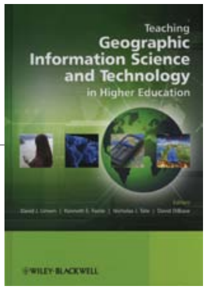


↑ By controlling the drawing order using Symbol Levels, the higher-value data points are now visible.



↓ To make sure low-value data points are drawn first, assign low numbers in the Symbol Levels dialog box.

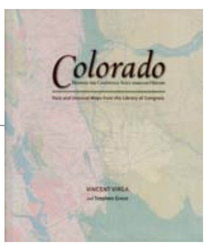
GIS Bookshelf



Teaching Geographic Information Science and Technology in Higher Education

Editors David Unwin, Nicholas Tate, Kenneth Foote, and David DiBiase

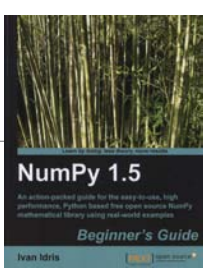
This collection of articles grew out of a series of meetings that began with sessions at the Association of American Geographers annual meeting. It charts the history and focuses on the challenges of teaching both the science and technology of the rapidly evolving field of geographic information to students who have goals that range from improving critical thinking skills to acquiring a powerful research tool to getting a job. Sections of the book are devoted to curriculum and course design and various perspectives on teaching geographic information science and technology (GIS&T) in a variety of settings. It covers the use of virtual worlds, distance and web e-learning, and the future of GIS&T. The editors underline that the collaborative approach of educators in this field has been one of its distinguishing characteristics and strengths. This community of practice continues helping educators succeed in this demanding environment. Wiley-Blackwell, 2012, 496 pp., ISBN: 978-0470748565



Colorado: Mapping the Centennial State through History; Rare and Unusual Maps from the Library of Congress

By Vincent Virga and Stephen Grace

In his introduction to this book, coauthor Stephen Grace observes, "Maps can help us find our way, not only through the mountains but through the past." *Colorado: Mapping the Centennial State through History* is a volume in the Mapping States through History series produced in collaboration with the Library of Congress. Each volume tells the history of a state through its geography. Organized topically and in roughly chronological order, this collection of historical maps with commentary tells the story of an area of North America that became the state of Colorado. Of particular interest are maps in the "Native People" chapter. A map created by the explorer John Wesley Powell maps the linguistic stocks of native peoples. Another shows the extermination of the American bison, a key event in subduing Indians in the state. Chapters contain historical maps relating to exploration of the state, the Pike's Peak Gold Rush, the expansion of the railroad network, towns, the boom and bust cycle of mining, and natural resources management. These maps illustrate the interplay of historical events and geography, providing a greater apprehension of both. Globe Pequot, 2009, 128 pp., ISBN: 978-0762745319



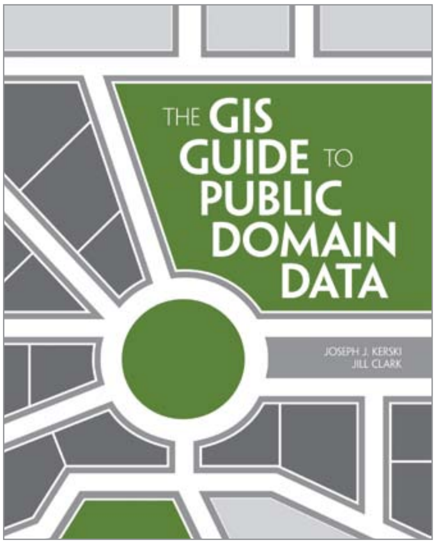
NumPy 1.5 Beginner's Guide

By Ivan Idris

This learn-by-doing book on NumPy, the open source Python library for scientific computing, is written from a user rather than a contributing developer standpoint. After covering the fundamentals in the first two chapters, the balance of the book is devoted to applying NumPy. Each chapter is highly structured with tasks, explanations, quizzes, and practical challenges. PACKT Publishing, 2011, 234 pp., ISBN: 978-1849515306

The GIS Guide to Public Domain Data

By Joseph J. Kerski and Jill Clark



Geospatial technology has evolved to answer specific questions, and much, if not most, of the data exists somewhere in the public domain. In an age characterized by exabytes (a billion billion billion bytes) of available data and Internet access to it, obtaining geospatial data shouldn't be a problem. However, as the authors of *The GIS Guide to Public Domain Data* observe, while it is easier to use geospatial data, it is also easier to misuse it.

Joseph J. Kerski and Jill Clark have written this text to help students, researchers, and GIS professionals locate and evaluate public domain data so they can use it more intelligently and responsibly.

The authors' goals are to make readers better understand the unique characteristics of spatial data, become more aware of the organizations and initiatives that produce spatial data as well as the associated history and issues, and develop greater proficiency in working with this data to solve real-world problems.

Just because data is accessible doesn't mean it is in the public domain. Even data that was initially released into the public domain can change status when compiled by a third party. Before examining various sources of public data, the authors clarify what is meant by *public domain* and the types of copyright licensing that determine how data can be used. The United States has a tradition of making the data collected by government agencies freely available, but that is not true everywhere. Consequently, while data may be in the public domain, it is sometimes not especially easy to access.

Beyond copyright and accessibility issues, questions about the appropriateness of the data for addressing the problem at hand must also be answered. The next five chapters discuss the strengths and limitations of data in terms of format and source. Understanding the characteristics of data formats allows their suitability and quality to be better assessed. Why an organization originally collected a dataset often determines characteristics such as accuracy, precision, and currency that are important when evaluating the suitability of a dataset for a specific use.

The authors note that free data is not really free, because labor costs are typically associated with processing the data before it can be used. Data preparation is a real cost. When this is taken into consideration, it can be more cost-effective to obtain data from a vendor.

The seventh chapter, on how to use public domain data in a project, looks at how to choose the right data and software tools, address any ethical concerns, and measure the success of a project.

The final three chapters consider the impact of new phenomena, such as data user as data provider and the rise of cloud computing, as well as the future of public domain data.

Many resources for additional information contained in articles, papers, and guidelines are highlighted throughout the text. Online exercises provide a reality check for readers. They experience the benefits and frustrations of working with public domain data to solve real-world problems. (The book assumes the reader has intermediate skills with ArcGIS for Desktop.)

This approach to understanding public domain data is both comprehensive and systematic. It presents a wealth of detailed information in one handy reference.

The book's authors both have backgrounds in GIS. Kerski, education manager for Esri, has been a geographer and cartographer at the National Oceanic and Atmospheric Administration, the US Census Bureau, and the US Geological Survey. He is past president of the National Council for Geographic Education. Clark, a freelance consultant and technical author, has worked in many areas of GIS, including application development and implementation, software development, service provision, and technical writing. Esri Press, 2012, 350 pp., ISBN: 978-1589482449

← Esri solution engineer Tom Murray

Evolving Job Keeps Motivation High

Instead of joining Esri straight out of college, some employees take a more circuitous route. Solution engineer Tom Murray, based in Esri's Denver, Colorado, regional office, belongs to the latter group.

Murray was introduced to GIS during an internship with The Nature Conservancy undertaken when he was a student at the University of Colorado, Boulder, where he majored in environmental studies and economics. He was asked to create a catalog of GIS resources on the web. "At the time I really didn't know anything about GIS, so I just started searching to figure out what it was and what resources were available," Murray said.

A couple of years later, when working as a field manager with an environmental consulting firm, he would take data he'd collected in the field, process it, and create maps. Sometimes, he just drew on paper copies of topographic maps. Recalling his introduction to GIS, Murray knew there was a better way. He enrolled in GIS classes at the local community college. After he began using GIS in his work, he became the "default GIS guy" at the firm.

However, it was his second internship that led Murray to Esri. While pursuing his master's degree from the University of Denver, he was selected as an intern for the Esri Denver office. His assignment to the technical marketing team also introduced him to the solution engineer role. Murray joined Esri full-time in 2004. He eventually became manager of the technical sales team in the region and held that position for five years.

In the last few years, Murray's role as a solution engineer has changed significantly. The position has evolved from giving presentations and demos to customers to spending time really understanding customers' businesses. "My role has gotten a lot more interesting because I enjoy the direct interaction with customers—asking what they are doing, assessing what their challenges are, and figuring out how Esri can help them," he said. He presents solutions that include Esri technology and shows customers how to use these solutions. Instead of working with GIS groups in organizations, he now works with whole agencies or departments in state and local governments.

Recently, Murray began working with Esri's Patterns and Practices team. He is focusing on customers who are interested in the new ArcGIS Online system. He uses skills learned while working with larger, traditional customers and applies them to early adopters of this new technology.

"It's a new product for us, and in some cases, I'm working with a new user, but the basic pattern of understanding their business needs and how to apply our technology appropriately to support those needs is consistent," he said. "It's been exciting to work with customers on a solution that represents a brand-new way of using GIS technology, including a new business model for deploying it."

"Esri has been a great place for me. I think the solution engineer role has been perfect. I like technology, but I didn't begin with a traditional computer science background. I found this great hybrid position that is both technical and solution-oriented." Murray gets to travel and meet customers, but he is also deeply involved with the technology. "It keeps me challenged and motivated," he said.

GIS *Flourishes* at Stanford University

By Jim Baumann, Esri Writer

Recognizing the power and potential of GIS technology, Leland Stanford Junior University (commonly referred to as Stanford) invested in a site license from Esri in the mid-1990s. The university has progressively expanded its use of GIS over the years. Today, Stanford provides a model for the inherent possibilities available with an enterprise GIS implementation on a university campus.

Founded in 1891 in Stanford, California, the university is recognized as one of the world's leading research universities. It served as one of the four original nodes that composed the Advanced Research Projects Agency Network (ARPANET), predecessor of the Internet. It is also home to SLAC National Accelerator Laboratory.

Stanford's GIS nerve center is located in the Branner Earth Sciences Library and Map Collections. There, a team headed by Patricia Carbajales, geospatial manager, conducts GIS training, support, and research consultation for the entire university.

"Our GIS lab has state-of-the-art computers because students working on major geospatial projects need powerful computers for geoprocessing and analysis," said Carbajales. "Often, they are plotting millions of points, and our computers are the best equipped throughout the library system for that kind of data processing." The GIS support team has also preloaded some large datasets that are frequently used so that the students can pull them directly from the hard drives on their computers, allowing them to do their projects more quickly.

Originally used in the university's Schools of Engineering and Earth Sciences, whose departments include Aeronautics and Astronautics, Electrical Engineering, Geological and Environmental Sciences, and Geophysics, GIS is now increasingly taught in the Humanities and Sciences School in the History, Political Science, and Classics departments. In addition, the university's Urban Studies program has integrated spatial thinking concepts into its curriculum and requires freshmen in the department to take a core class in spatial approaches to urban studies.

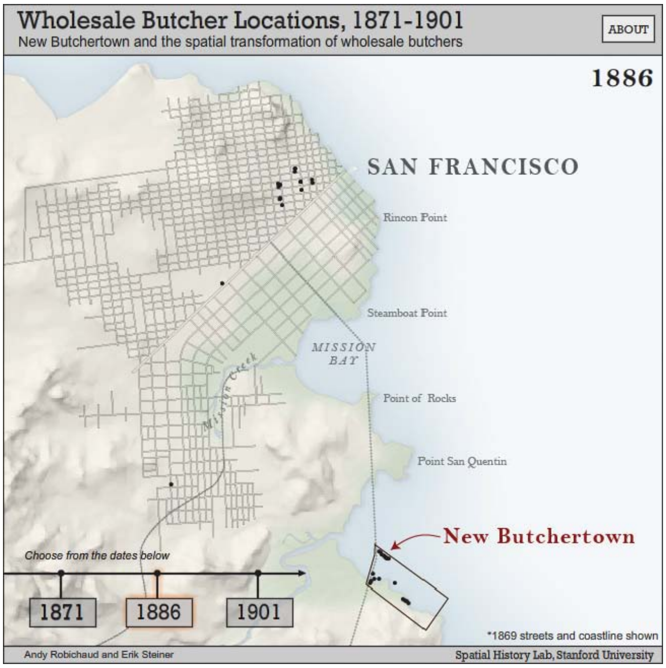
Carbajales attributes some of this growth to the outreach efforts of her GIS support team. She has conducted more than 80 workshops during this past year, as well as a number of ArcGIS feature-specific training sessions. One of the primary outreach projects for the team is the annual GIS Day celebration. "This is a big event for us," said Carbajales. "A variety of speakers are invited to present lightning talks to give students an overview of how GIS is used across the campus, and we organize a map gallery and geography-related contests."

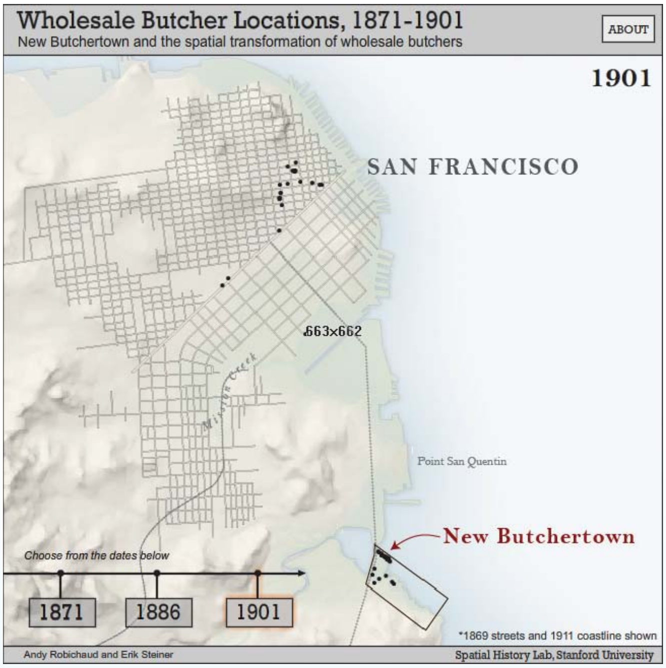
Several faculty- and student-led research projects around Stanford benefit from the GIS support by Carbajales and her team. For example, GIS is a major component of Stanford's Spatial History Project (spatialhistory.stanford.edu), which uses spatial analysis and visualization to further historical research.

Among current research projects is *Trail of Blood: The Movement of San Francisco's Butchertown and the Spatial Transformation of Meat Production, 1849–1901,* led by PhD candidate Andrew Robichaud. Until the 1860s, commercial slaughterhouses and butcher shops were common in downtown San Francisco. In 1869, because of health and sanitary issues, the city forced them to relocate to an area along Mission Creek, which became known as Old Butchertown. "Using city directories and insurance maps to determine the locations of slaughterhouses and retail butcher shops—then mapping those places using GIS—we are able to see surprising spatial trends in meat production and distribution in the last decades of the nineteenth century. These trends would not be visible without using digital tools to breathe life into old documents," said Robichaud.

Other spatial history lab projects include the analysis of the distribution of arrests for prostitution in the city of Philadelphia from 1912 to 1918, with variables incorporating age, ethnicity, and jail sentences, as well as an evaluation of the capacity of the Amito water system during the Oakland Hills firestorm of 1991.

Stanford is so committed to integrating GIS throughout its





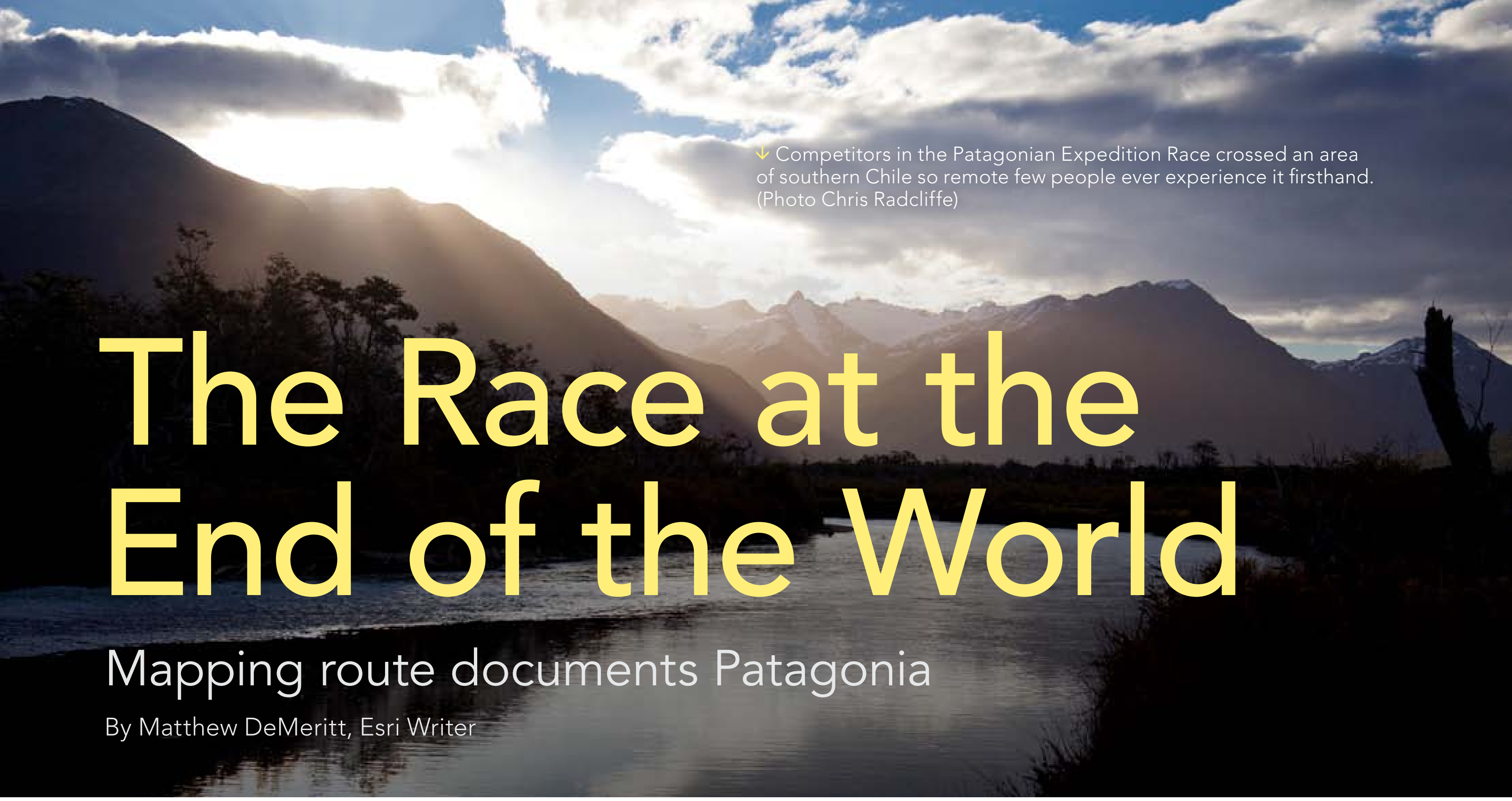
↑ Stanford's Spatial History Project uses spatial analysis and visualization to further historical research. These maps are from a research project, led by doctorial candidate Andrew Robichaud, that follows the spatial transformation of meat production in San Francisco, California, in the late nineteenth century.

academic research programs that the university librarian has mandated that all subject librarians take a GIS workshop from Carbajales' team to better familiarize themselves with its capabilities.

With this increasing interest in the technology, Carbajales is currently setting up a workshop program to teach the fundamentals of GIS to students who are required to learn GIS applications as part of their classes. "If we teach the essential capabilities of GIS to those students that will be using it for specific applications in class, it will lift some of the teaching burden off the instructor and make it easier for the students to learn the specific applications," said Carbajales.

Stanford's GIS lab participates in a cooperative program with the 10 University of California campuses called the University of California/Stanford Map and Geospatial Libraries Group. Formed in 1983, the group created the Unified Collection Development Plan to formalize its charter. It furthers the cooperative collection and sharing of data purchases; supports interlibrary lending of geospatial materials; and exchanges other relevant materials, such as training tutorials. The collaborative nature of the group allows it to share the cost of new acquisitions, while the greater university community benefits from having access to the extended paper and digital map collection held among the group's members.

Because Stanford has an extensive collection of historic maps that totals more than 60,000 individual works, Carbajales believes that an important area of future development for cartographic archivists is the creation of an optical character recognition (OCR) system for maps. "Historical maps hold a wealth of information that is yet untapped," said Carbajales. "Professors here regularly ask us about the availability of scanning technology that will easily allow the extraction of map features for their research. We have considered approaching a research group within our computer science department to see whether they may be interested in developing this sort of technology. I think there is a vast potential for data mining in historical maps."



Competitors in the Patagonian Expedition Race crossed an area of southern Chile so remote few people ever experience it firsthand. (Photo Chris Radcliffe)

The Race at the End of the World

Mapping route documents Patagonia

By Matthew DeMeritt, Esri Writer

Maps, created using GIS, helped athletes competing in the Patagonian Expedition Race hike, bike, and kayak across often dangerous topography in a 10-day physical and mental contest held in February 2012.

Although Patagonia, a vast region of diverse wilderness located at the southern tip of South America, spans portions of Argentina and Chile, the 600-kilometer (373-mile) race takes place only in Chile. In previous years, each racing team only had a crude, small-scale overview of the country's topography to guide them. This year, race organizer Nómadas International Group wanted to give racers a more comprehensive view of the course to help them safely traverse Patagonia's glaciers, rivers, and mountainous terrain.

Staff cartographers Jason Blair and Katie Panek created maps of the route using Esri's ArcGIS technology. ArcGIS was used not only to make maps that gave racers a more detailed picture of the route but also provided a new topographic record of Patagonia that will benefit ecological research.

Better Maps for Informed Conservation

Celebrating its 10th anniversary, the Patagonian Expedition Race has a larger purpose than pure competition. "The race calls attention to the uniqueness of the region," said Jack Dangermond, president of Esri. "GIS technology used to create maps for the race will also inform the work of conservationists trying to understand complex relationships within Patagonia's ecosystem."

The race aims to raise $20,000 before the end of the next race to enable scientific tracking of the guemal population—a critically endangered deer species that is a symbol of Chile—and increase awareness of and implement a viable conservation plan for the area. Constructing a more thorough cartographic picture of Patagonia will be invaluable in reaching these goals.

Building the Maps

To successfully cross Patagonia's ever-changing terrain, race teams needed maps that included the latest available data on the region. Last year, several racers were blown off their bikes by a freak windstorm on a seemingly mild day. Potential obstacles, such as deep snow and glaciers, are constantly in flux due to Patagonia's dynamic and unpredictable climate.

To begin plotting this year's racecourse, founder and director of the Patagonia Expedition Race Stjepan Pavicic digitally plotted the route based on his extensive experience hiking the mountains of Patagonia. Blair and Panek loaded the file containing the route into ArcGIS for editing and modified the route based on the latest data on the region. They obtained that data using online sources such as digital elevation models from the National Aeronautics and Space Administration (NASA) and publicly available Landsat imagery.

Patagonia's remote backcountry has virtually no topographic record—not even old maps of the region were available. "ArcGIS software helped facilitate creative approaches to mapping data and solving geospatial problems in uncharted areas within the park," said Pavicic.

"We digitized features by hand, organized them within a geodatabase, and processed it in ArcGIS," said Blair. "We also conducted watershed analysis in ArcGIS to determine the location of major river networks and potential streams. The ability to view the surface water system is critical when planning the route to avoid hazardous situations. The landscape of the region required crossing large rivers throughout the route, which we were able to plan for in advance to allow a safe crossing for the racers and volunteers on the course."

Blair and Panek created an accurate vegetation layer for the 2012 race maps by combining information from different government sources and layers that they digitized from satellite imagery. Vegetation maps were particularly helpful in planning the official route for the race. Hillshade, annotation, and symbology were added to all the race maps.

Adventure Is the Prize

Twenty four-person teams, each with a designated navigator, competed in the Patagonian Expedition Race. Often referred to as the Last Wild Race, this event tested the athletes' mettle as they crossed choppy rivers, hiked slippery glaciers, and biked up and down treacherous mountain terrain. Team Adidas TERREX Prunesco, representing the United Kingdom, took first place in this year's competition.

Although winners receive no monetary prize, racers are motivated by the journey through wild southernmost Chile—a region so remote that most people only experience it through literature. "One of the things that struck me was that we were racing in the Magellan Straits, the Darwin range, and the Beagle Channel—the kinds of places you read about in books," said New Zealander Stuart Lynch, one of the members of Team Adidas. "It's quite a cool thing to come here and race at the end of the world."

Participants from 20 countries were guided through this wilderness only by their orienteering abilities and maps. This year's route took racers into the Cordillera Darwin, a mountain range in Tierra del Fuego covered with glaciers and peat bogs.

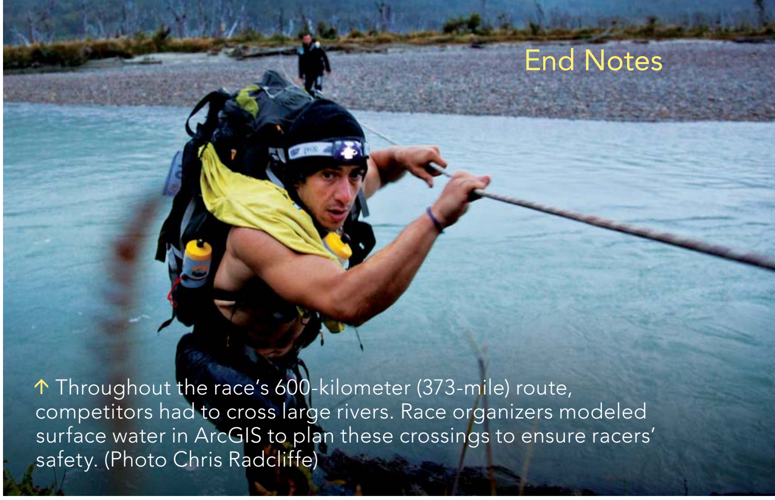
Distributing the Maps

Race officials distributed the map sets to participants and members of the media to plan and navigate the course through Tierra del Fuego. An overview map of the entire route included major streets for journalists and race organizers to follow to get them from the Punta Arenas to various locations along the course. The media used the overview map of the entire course to determine which locations to visit during the race.

The maps were not handed out until the day before the race, giving the teams only 24 hours after seeing the route to make final preparations and adjustments to their race strategies. "Each team's navigator received one set of maps," said Blair. "Navigators assumed responsibility for interpreting the maps and guiding the team through the course." Each map set consisted of 18 printed maps at differing scales for different needs. For example, the overview of the race course and surrounding region was provided at a 1:750,000 scale. More specific maps for navigating mountain bike trails and kayaking were scaled smaller.

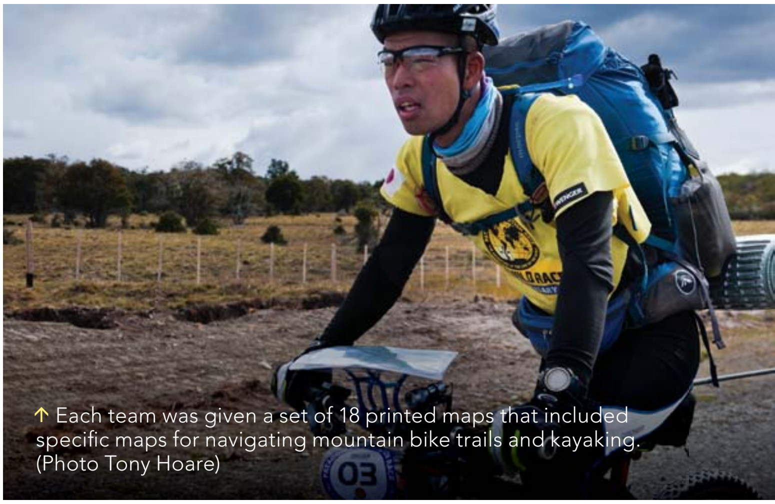
"We wanted to keep the number of maps to a minimum to decrease weight and confusion, so we decided to use the smallest scale that would be practical for each segment of the race," said Blair. "The mountain biking routes were very straightforward, typically following dirt roads, and did not require any complicated navigation. Therefore, smaller-scale maps *[1:200,000]* were acceptable. However, the trekking sections did not follow any trails, and the course is simply a suggested route, so by providing a large-scale map *[1:50,000]*, the teams were able to determine the best route for travel and safely navigate the complicated terrain with a detailed map."

"ArcGIS software facilitated creative approaches to mapping data and solving geospatial problems in uncharted areas," said Pavicic. "Helping to improve the quality of maps available for Tierra del Fuego in Chilean Patagonia will result in long-term benefits for the people and environment."



↑ Throughout the race's 600-kilometer (373-mile) route, competitors had to cross large rivers. Race organizers modeled surface water in ArcGIS to plan these crossings to ensure racers' safety. (Photo Chris Radcliffe)

↑ Participants from 20 countries traversed the Patagonian wilderness using only their orienteering abilities and maps created with ArcGIS. (Photo Chris Radcliffe)



↑ Each team was given a set of 18 printed maps that included specific maps for navigating mountain bike trails and kayaking. (Photo Tony Hoare)

↑ The 2012 course took competitors across the Strait of Magellan, Karukinka, the Darwin Range, and a fjord in the Beagle Channel. (Photo Tony Hoare)

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