Spring 2013

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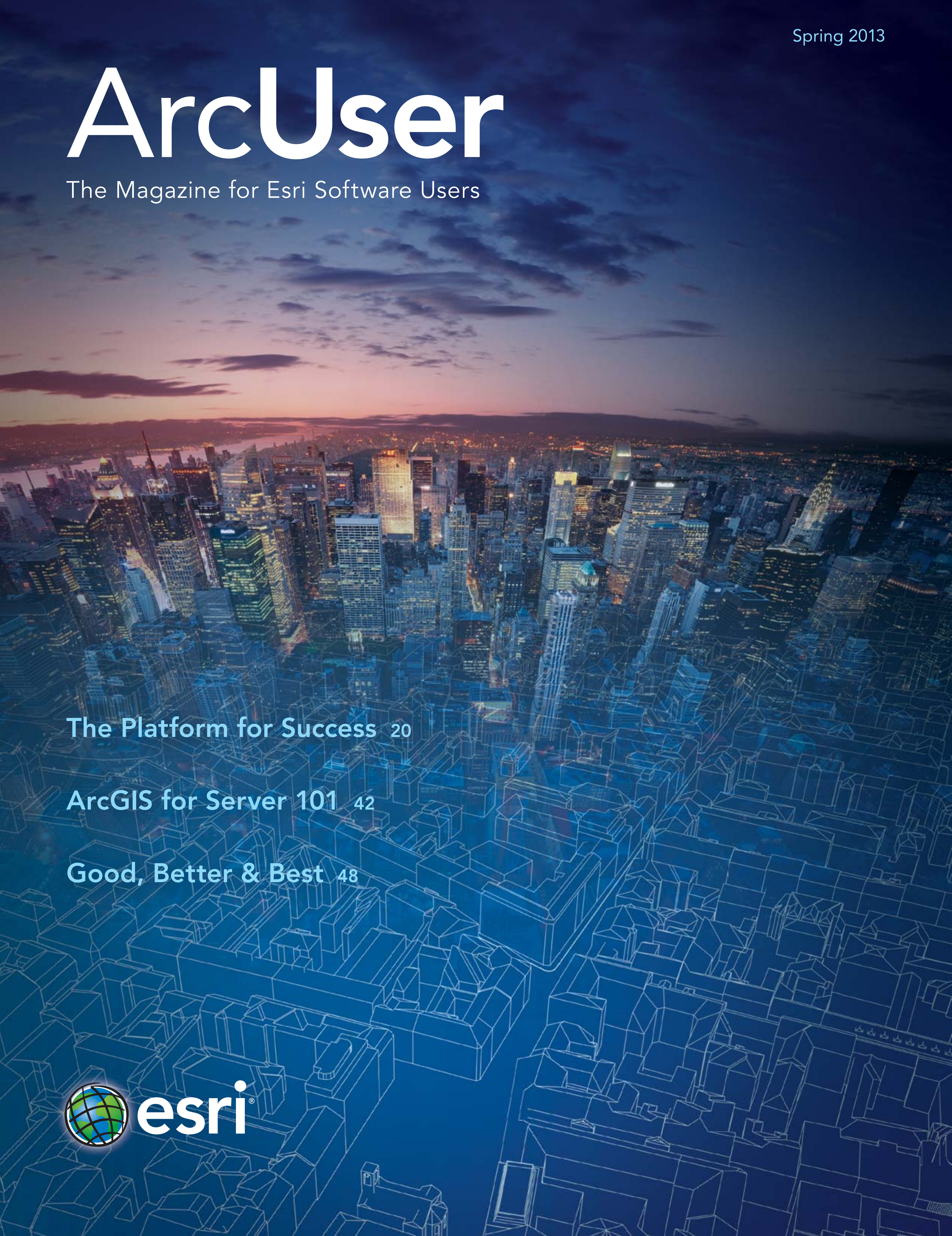

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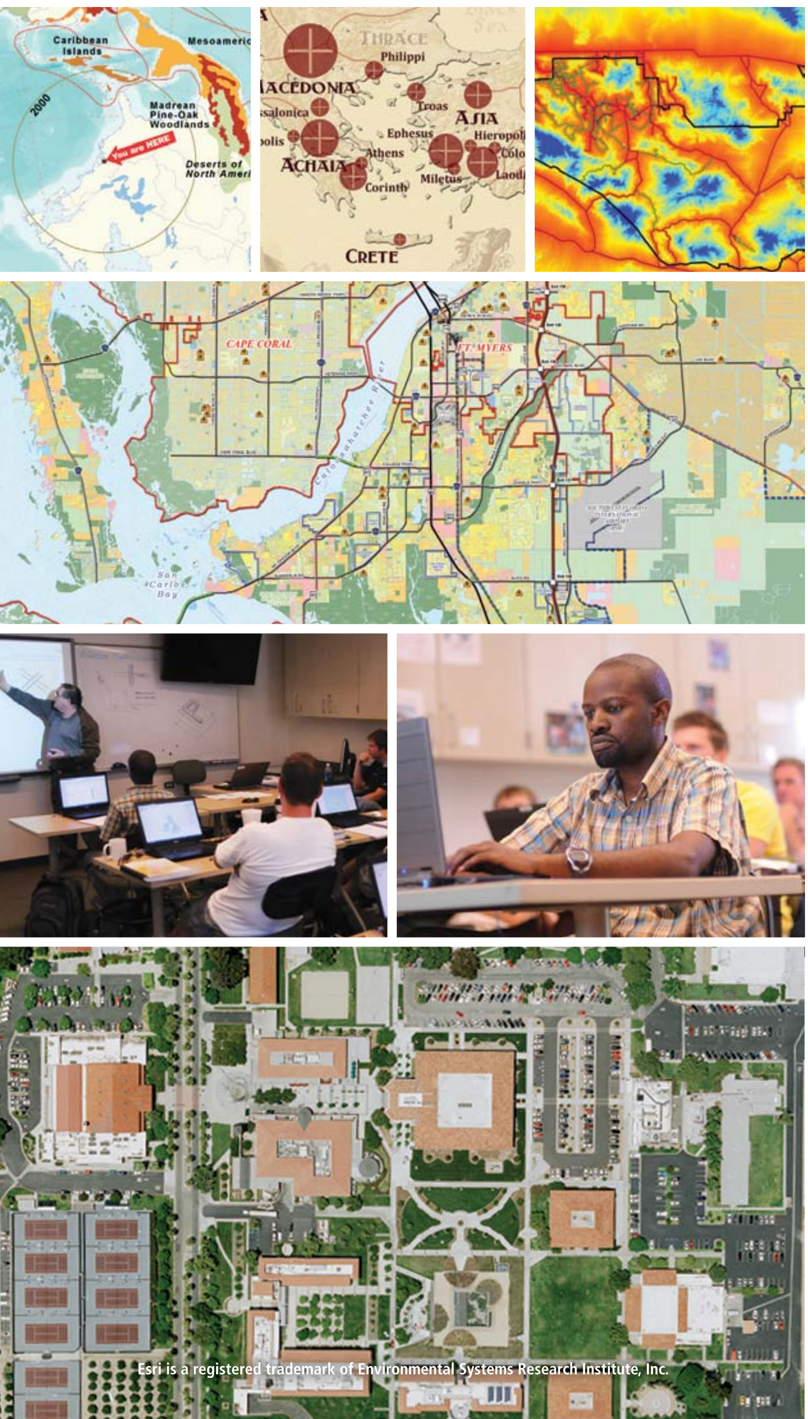

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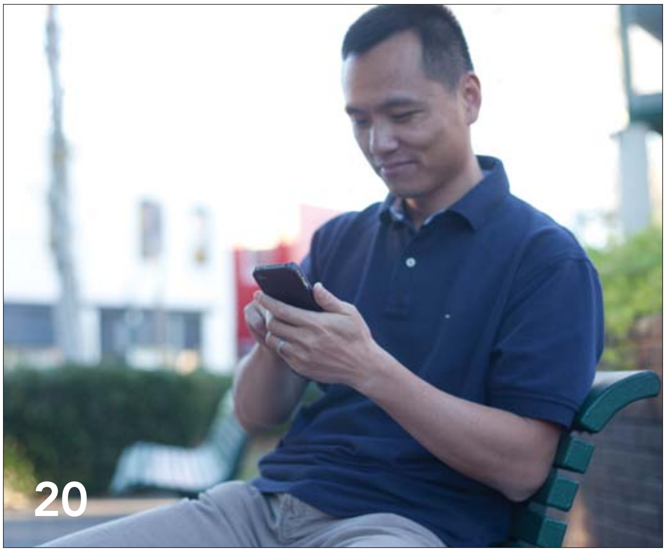

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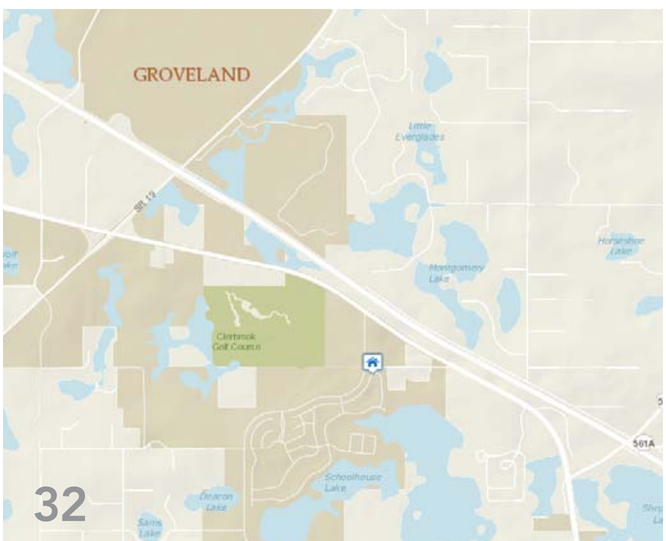

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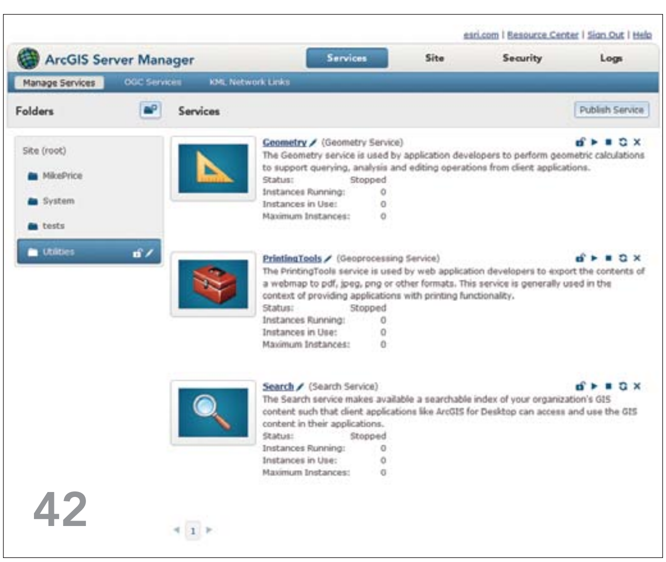

Special Section

Realizing the Vision

GIS has always been an ambitious technology with a mission to design a better world. Esri president Jack Dangermond, in an article in the Spring 2001 issue of *ArcNews*, envisioned a system that would provide geographic information services to whole new communities and let them cooperate more effectively by sharing and leveraging their knowledge. "The result of all of this will be a kind of social network delivering GIS capabilities to everyone."

With the advent of the ArcGIS platform, and especially the creation of ArcGIS Online, that vision of greater collaboration and deeper and widely shared knowledge is becoming a reality.

GIS gives context to phenomena. Taken to the next level, GIS—through geodesign—can provide perspective. Bran Ferren, keynote speaker at the 2013 Geodesign Summit, believes that perspective is sorely needed if we are to address large and complex problems like climate change. In his view, we don't need a bunch of five-year plans; we need a 250-year plan for the planet.

An era that favors 140-character responses and encourages fragmented attention spans tends to discourage extended discussion of anything. However, Ferren noted that, "Geodesign combines geography and data with modeling, simulation, and visualization to tell stories and [show] the consequences of your actions." Geodesign enabled by the ArcGIS platform, which fosters connection and collaboration, can be the vehicle for building thoughtful communities that tackle these challenges.

Monica Pratt
ArcUser Editor

editor's page

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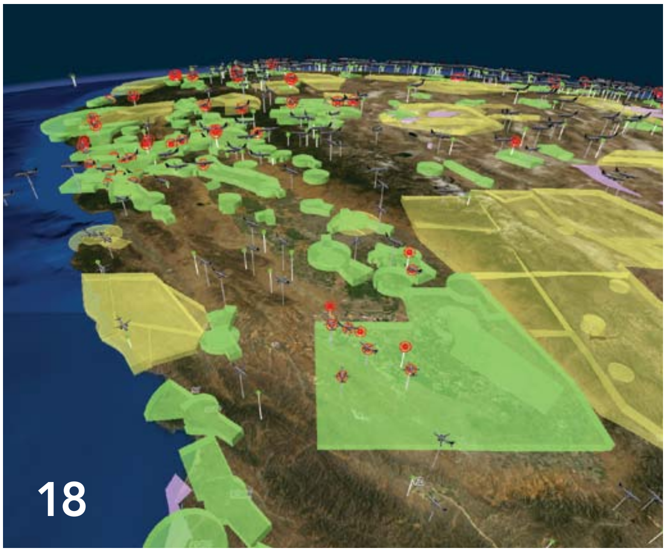
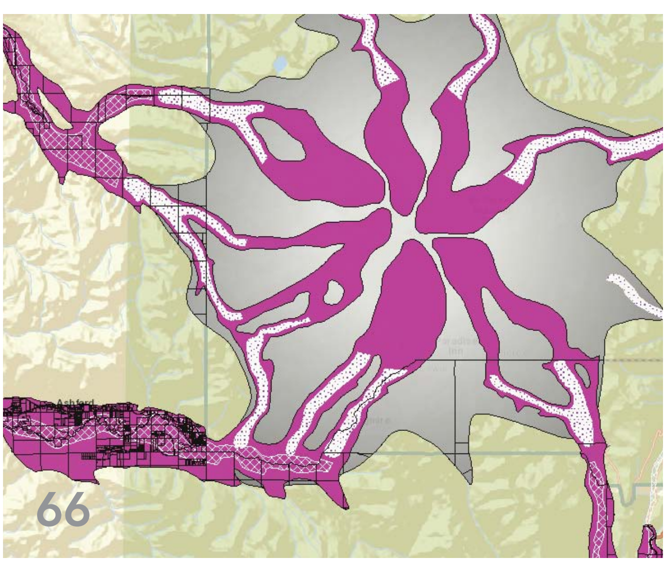
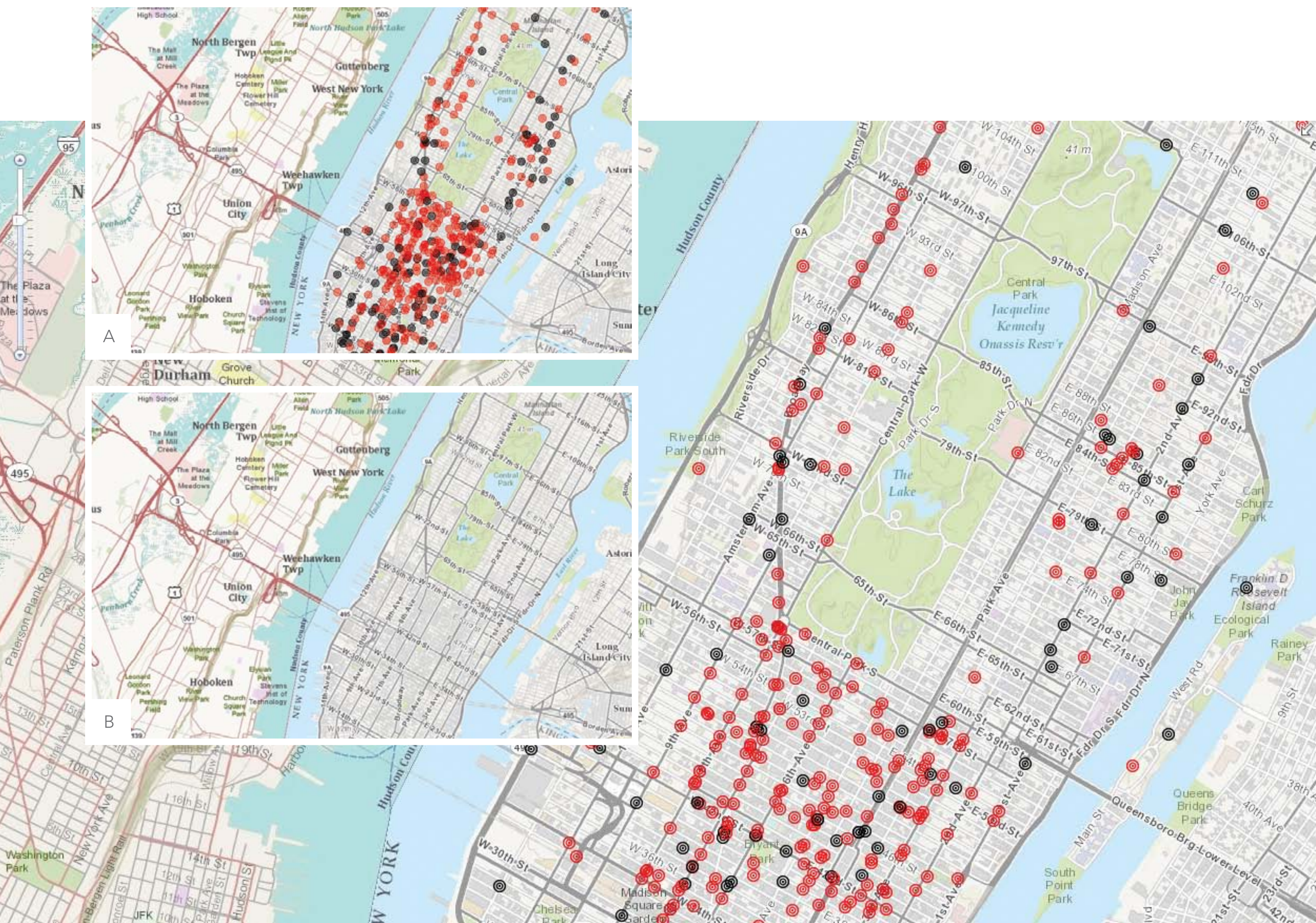
Departments



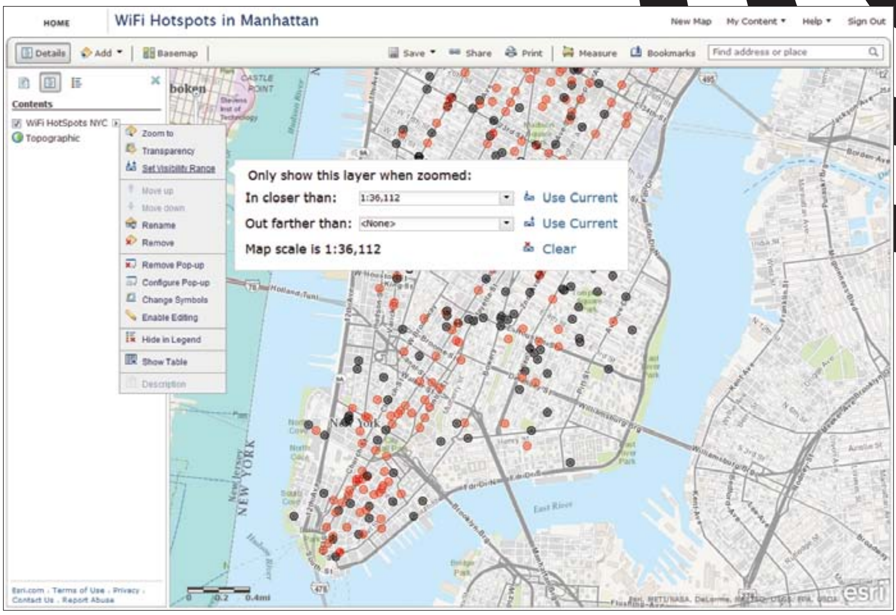


Controlling What Users See

New tools to focus map content



ArcGIS Online is ever evolving with new imagery, updated basemaps, and expanding functionality. Three new enhancements to the ArcGIS.com map viewer will give you more control over how your maps and associated information are displayed. Now you can set visibility ranges, create filtered views of feature layers, and display attribute table information for layers.



↑ Setting visibility ranges on a layer controls how that layer displays in a web map.

Setting Visibility Ranges

If a layer is turned on in the table of contents, the ArcGIS.com map viewer will draw it even if the current extent makes it difficult to see detailed information at that scale. Although you could turn off the layer at that point, this is cumbersome, especially if you change the map scale often as you work.

Now, you can set a scale range for each layer you own in your map. This visibility property is saved with the layer so it will display in the same scale range anytime it is used in a web map.

1. To apply scale ranges, log in to your ArcGIS Online account. Open a map that contains the layer or layers for which you want to set scale ranges in the ArcGIS.com map viewer.
2. Click the Details button, then click the Show Contents of Map button.
3. Right-click on the desired layer and choose Set Visibility Range. A pop-up window appears.
4. Choose the minimum scale range from the drop-down or click the Use Current button to use the current extent of the map. You can zoom the map extent in or out while the pop-up is visible.
5. Choose the maximum scale range from the drop-down or click the Use Current button to use the current extent of the map.
6. Click Save to save changes to the web map. Click Save Item Properties to save the scale ranges just assigned to the layer.

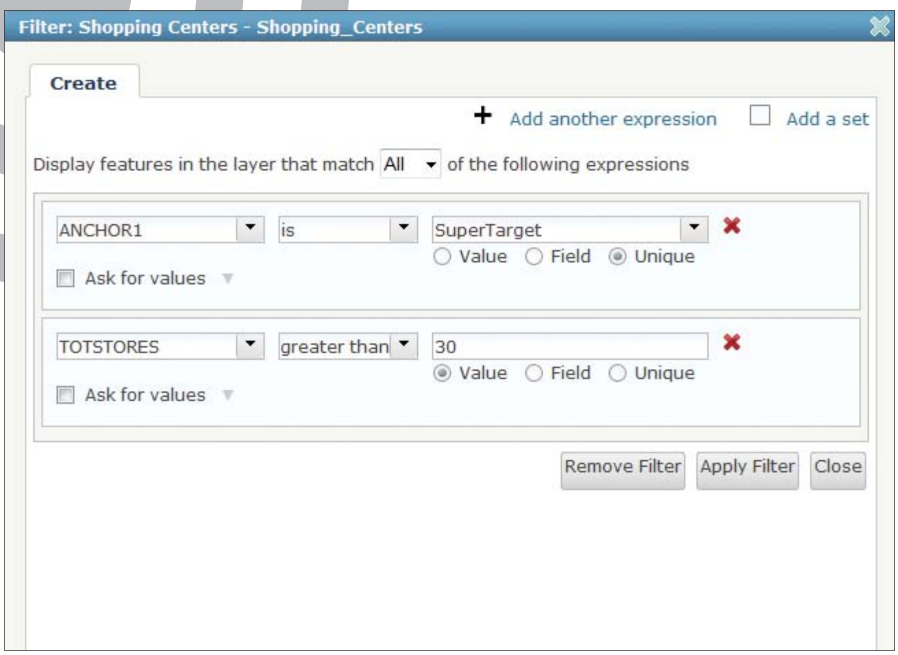
← Clarify the map's message using visibility ranges to show symbols at an appropriate scale (main). Default settings display symbols at all scales (A) while visibility settings turn off symbols until the map is sufficiently zoomed in (B).

Filtered Views of Feature Layers

To be effective, a map should present just the data needed to convey the map's message. New functionality in the ArcGIS.com map viewer lets you create filters for presenting just the data you are interested in showing the user of your map. Filters are like definition queries in ArcMap. You can also let people using your map interact with the filter by creating a map application using the interactive filter template.

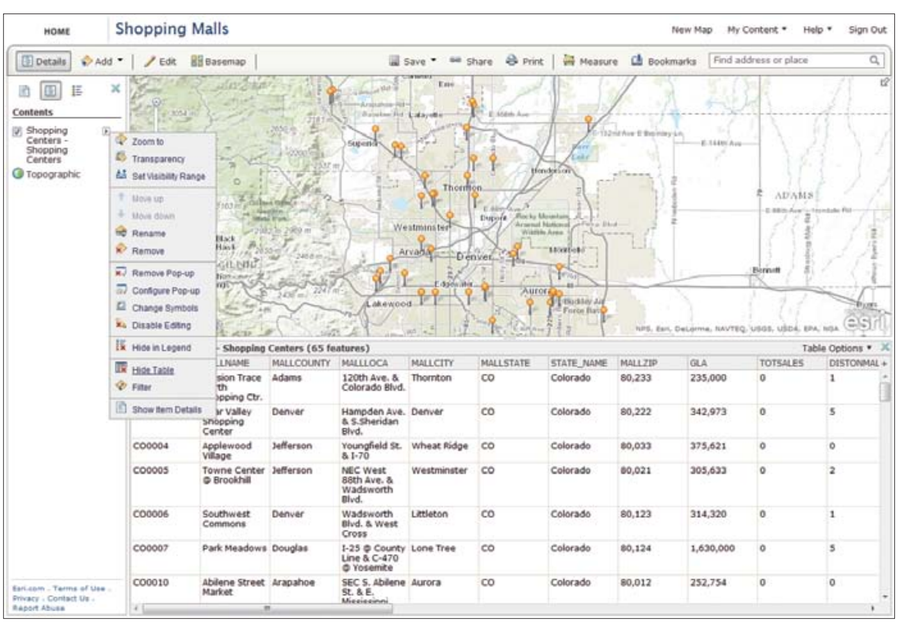
You can create more than one filter for a layer. You can create filters with multiple expressions. For example, a filter for school data might specify that Type is Elementary and enrollment is greater than or equal to 400. If you are using more than one expression, specify that matches to all or any of the expressions will be displayed. All means all criteria must be true for features to be displayed. Any means that only one expression must be true for features to be displayed.

You can create filters on hosted feature service layers, ArcGIS for Server feature service layers, and ArcGIS for Server map service layers that have associated attribute data. In each case, you will create expressions based on the attributes in the feature layer so that only features that meet that criteria will be visible in the map. →



↑ To show a subset of the data in a layer, create filters. Filters can combine single expressions and sets of expressions to limit features displayed to just the ones that meet your criteria.

↓ Attribute tables can be viewed and their display manipulated.



Creating a New Filter

1. Open the web map with the feature layer to be filtered in the ArcGIS.com map viewer.
2. Click the Details button, then click the Show Contents of Map button.
3. Right-click the arrow to the right of the layer name and choose Filter. The Filter window opens containing the Create tab.
4. On the Create tab, build the filter using the general format <Field_name> <Operator> <Value, Field, or Unique>.

   Click the Field drop-down arrow and choose the field to query against from the list. For the operator, click the Operators drop-down arrow and choose an operator from the list.

   - To filter based on a specific value, choose Value in the Filter window and enter a value in the field. The input box varies depending on the field type of the field name chosen.
   - To compare the value in one field versus the value in another field, choose Field, click the drop-down arrow, and choose the field for the expression.
   - To filter based on a specific value in the field selected for the expression, choose Unique and select that unique value from the values that populate the field.
5. You can set up an interactive expression based on values or a unique value, but you cannot ask for values on expressions based on a field. To set up an interactive expression, click the box to the left of Ask for values and enter information about the value in the Prompt field and a hint in the Hint field.
6. Click Apply Filter to enable the filtered view on the map. Use the Delete button to the right of the expression to delete an expression in the filter. To show all the features in the layer again, click Remove Filter.

Some Tips When Working with Filters

- Do not add special characters (such as quotation marks) to your expressions unless those special characters are part of the value. For example, the expression <City is "New York"> will not select a feature named New York. In this example, use the expression <City is New York> instead.
- If the field you are filtering on includes coded values, the Values list shows all coded values defined by the service for the field. Because the layer values may be a subset of the service values, this list may include codes for features not present in the layer. However, the Unique list shows only features in the layer.
- If you have multiple expressions, your results will vary depending on if and how you have grouped expressions. For example, if you create a filter that uses the expressions Type is middle or Type is secondary (a set of expressions) and Category is private (a single expression) and stipulate all expressions must be true, the filter will select private middle schools and private secondary schools because all conditions must be true. If instead your filter uses the expression set Type is secondary and Category is private and the single expression Type is middle, the filter will select all public and private middle schools and private secondary schools.

Show Attribute Tables

Tables can be a useful way to view the data in a feature layer of a map quickly. You can see the fields that you can use in filters and pop-ups. You can see tables for hosted feature services; hosted tiled map services with associated attribute data; and shapefiles, GPX files, and CSV (files and web), and ArcGIS 10 Server Service Pack 1 and later feature and map services.

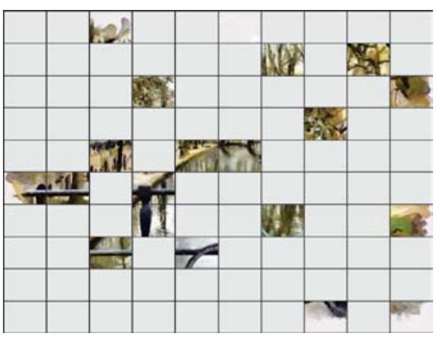
To view the attribute table for a layer in a map in the ArcGIS.com map viewer, click the Details button, then click the Show Contents of Map button. Right-click on the layer and choose View Table. You can change the field order by dragging the header for that field to a new location. To see the feature for a record, select it in the table, click the Table Options drop-down arrow on the right side of the table, and choose Zoom to Selection. The Table Options drop-down also has choices to show or hide fields, filter records in the table, and clear a selection. Tables and pop-up windows share the same attribute fields and formatting. You can change a field name by editing the field alias in the Configure Attributes window of the Pop-up Properties.

Conclusion

These new tools in the ArcGIS.com map viewer will help you focus the attention of users on your message by controlling what they see and when they see it.

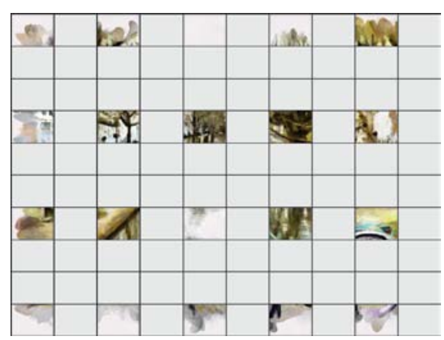
Unequal Probability-Based Spatial Sampling

By Konstantin Krivoruchko and Kevin Butler, Esri



The geographic approach involves measuring the earth, organizing the resultant data, and analyzing it to understand spatial processes and relationships. GIS technologies are used extensively for the latter stages of the geographic approach but less often for sampling, an important component of measurement. This article shows how to use ArcGIS 10 for Desktop to create an efficient spatial sampling or suitability design using the Create Spatially Balanced Points geoprocessing tool available with the ArcGIS Geostatistical Analyst extension and other geoprocessing tools provided with the core product.

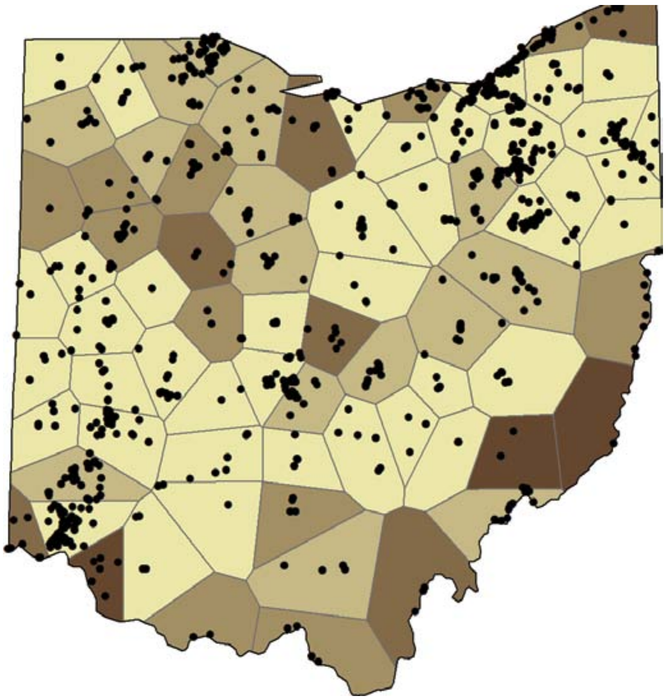
← A



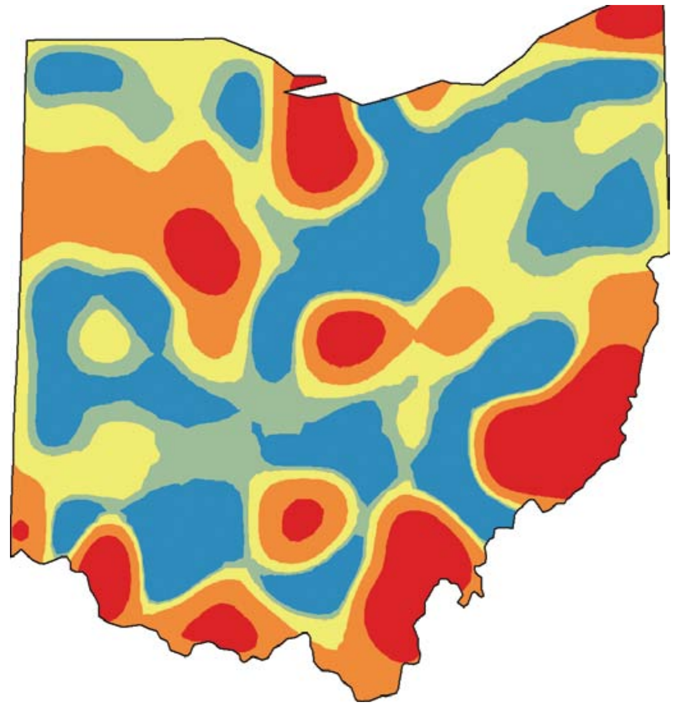
↑ B

← C

← Figure 1: Neither random nor systematic sampling is efficient if the underlying phenomenon is complex and changing rapidly; (A) random samples; (B) 20 systematic samples; (C) complete surface. (Source: Konstantin Krivoruchko)

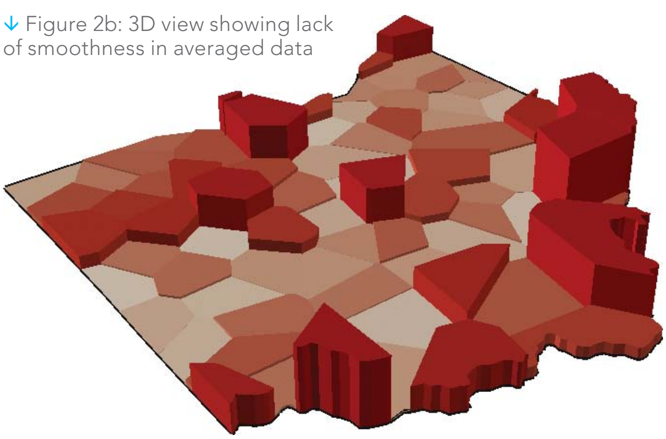


↑ Figure 2a: Ohio air pollution data aggregated to 75 random polygons



↑ Figure 2c: Averaged data smoothed using areal interpolation

↓ Figure 2b: 3D view showing lack of smoothness in averaged data



Scientists synthesize knowledge through the process of collecting and classifying empirical data (i.e., samples) with the ultimate goal of generalizing their observations, through inductive reasoning, into universal laws. The laws are required to make inference from the observed to the unobserved data.

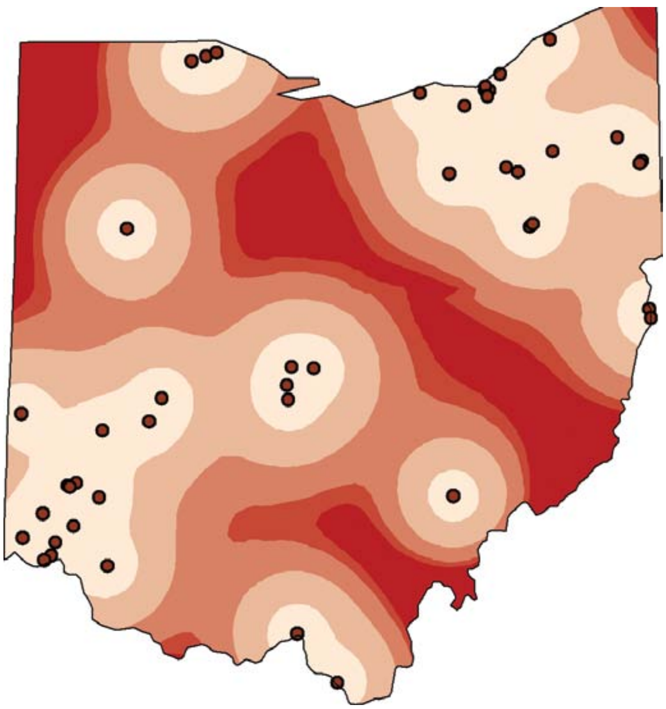
However, Immanuel Kant showed that empirical observations alone cannot lead to universal knowledge (although the knowledge that universal knowledge actually exists) but must be tempered by what researchers believe is the appropriate conceptual description of reality. This is independent of observational knowledge that exists in the researcher's mind and helps make sense of empirical data. Kant called this type of knowledge a priori knowledge.

This article describes a workflow for collecting a relatively small number of samples to reconstruct an unobserved or partially observed spatial variable with reasonable uncertainty using a priori knowledge about the phenomenon under study.

The set of geographic locations where measurements are taken is called a spatial sampling design. An efficient sampling design specifies sampling locations that allow the researcher to confidently estimate the value of the sampled variable, such as pollution, at unsampled locations. The workflow for developing a probability-based spatial sampling design that balances the conflicting goals of maintaining high prediction accuracy and minimizing cost and effort of sampling is discussed. This workflow can also be used to generate probability-based samples along a road or stream network for site selection analysis.

There are several classic sampling designs that can be used to select sites within a geographic study area. Simple random sampling randomly selects locations across the entire study area, clustered random sampling intensively samples around randomly sampled locations, and systematic sampling selects locations at regular intervals across the study area.

However, all these sampling designs assume that there is no prior knowledge about the variable of interest in the study area. An example of the inefficiency of random and systematic sampling designs is shown in Figure 1. Even with a relatively large sample size (20 percent), neither of the sampling designs shown in Figure 1a and 1b yields a clear picture of the underlying phenomenon shown in Figure 1c. These sampling designs may be adequate for a phenomenon that changes smoothly over the study area but are not efficient for data that is spatially correlated and changes rapidly across the landscape. There is a clear need for an alternative way of choosing optimal sampling locations.



↑ Figure 3: Ohio air pollution prediction standard error

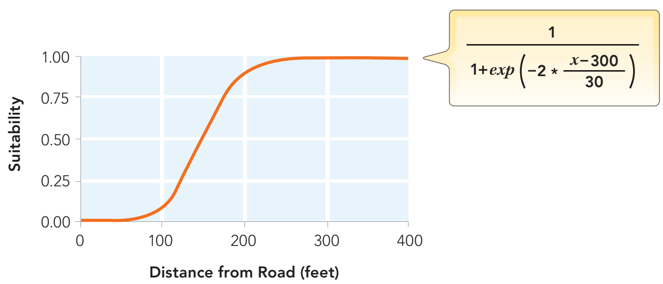
An Alternative Way of Sampling: Spatially Balanced Design

The number and location of samples are often influenced by economic considerations. Creating an optimal sampling design requires balancing accuracy of prediction (requiring more samples) with minimizing the cost of sampling (limiting the number of samples and attendant cost of gathering them).

If the variable of interest is spatially correlated (i.e., values nearby are more similar than values farther apart), then taking samples close to one another may not increase prediction accuracy and will increase costs. A well spread out sample is sometimes called *spatially balanced*.

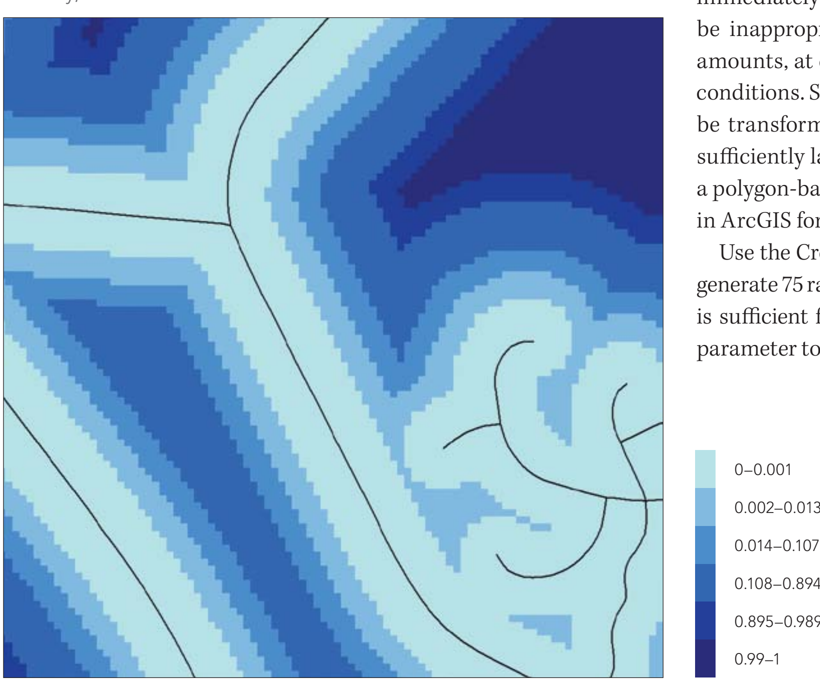
In a spatially balanced random sample design, a probability raster defines the a priori sample intensity function (or the number of samples per unit area). This inhomogeneous input raster layer is transformed into an equiprobable surface from which the required number of random points is selected using a systematic sampling algorithm (shown in Figure 2b). This guarantees that the samples are spread out over the study area. Since all raster cells with nonzero inclusion probability within a study area have a chance of being selected, the design is called a *random survey*.

Spatially balanced random survey design is very flexible because the inclusion probabilities can reflect both statistical data features (such as the kriging prediction standard error) and all relevant geographic information.



↑ Figure 4a: Sigmoidal function used to rescale distance from road to suitability score

↓ Figure 4b: Example of roads suitability surface in Summit County, Ohio



Creating a Sampling Design for Measuring Pollution Deposition

Like many Midwestern counties, Summit County, Ohio, is located in a region where there is significant manufacturing activity and coal power generation still takes place. The county has high population density and is bisected by seven major state and interstate highways. These factors suggest a need to accurately monitor the levels of atmospheric pollution deposition across the county.

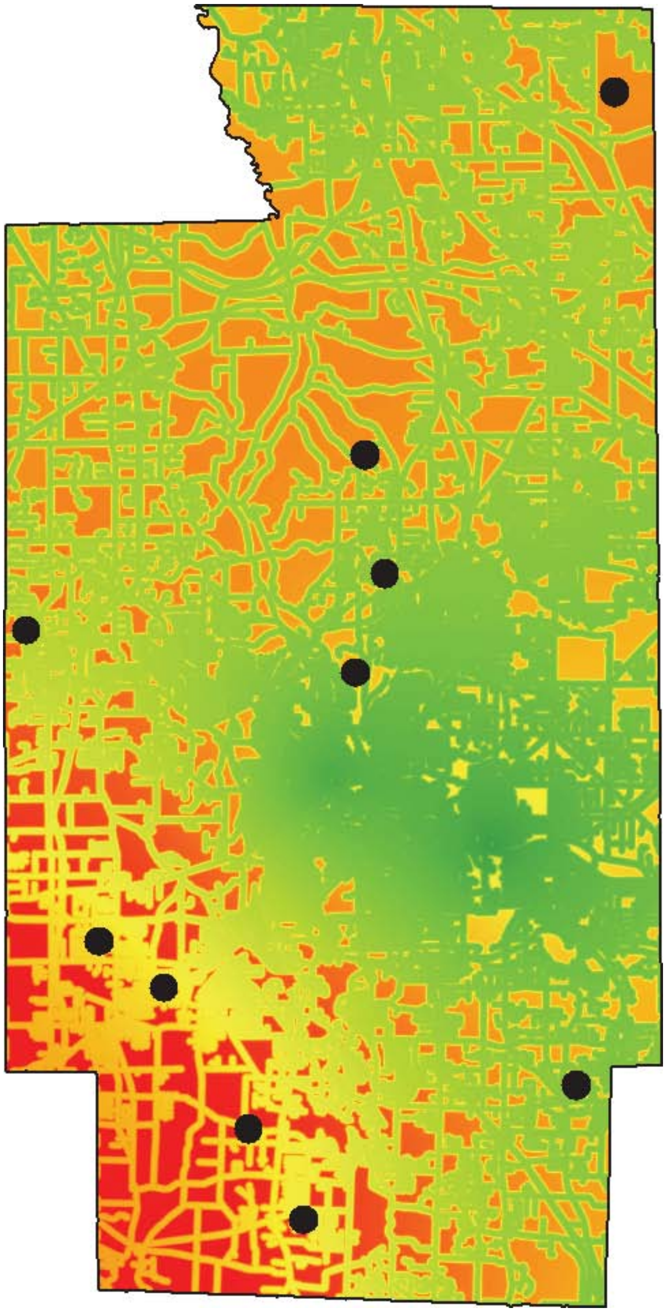
Data from Summit County will be used to demonstrate how to construct an a priori probability surface to select optimal sampling locations. Considerations in creating the a priori probability surface include estimating total air pollution from known pollution sources, predicting uncertainty of current air pollution measurements, and using best practices for selecting undisturbed sampling locations. The overall goal of the design is to select locations in the county that have both a high level of atmospheric pollution and a high level of prediction uncertainty from the existing air pollution monitoring network yet are located in undisturbed areas so measurements will be useful for environmental modeling.

Estimating Distribution of Air Pollution from Known Pollution Sites

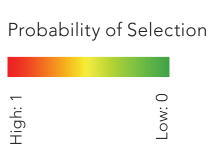
The US Environmental Protection Agency (EPA) maintains a database of the release of toxins to the air, water, and land called the Toxic Release Inventory (TRI) (www.epa.gov/tri/). The amount of pollution released to the air from 3,448 pollution sites in the state of Ohio was downloaded from the TRI database. Even though this workflow will select sampling sites only in Summit County, air pollution distribution should be estimated for the entire state to mitigate the external boundary problem common in ecological analysis.

An estimate of the air pollution levels across the state could be immediately created using one of the kriging models, but this would be inappropriate given that pollutants were released in different amounts, at different times of the year, and under different weather conditions. Some preprocessing of the data is necessary before it can be transformed into a prediction surface. Averaging the data to a sufficiently large number of random polygons and smoothing using a polygon-based interpolator can be done using geoprocessing tools in ArcGIS for Desktop.

Use the Create Random Points tool (Data Management toolbox) to generate 75 random points within the broader study area. This number is sufficient for use in kriging. Use the Minimum Allowed Distance parameter to ensure points are spread out across the study area.



↑ Figure 5a: Ten spatially balanced candidate sites in Summit County, Ohio



Generate Thiessen polygons around each of the 75 random points using the Create Thiessen Polygons tool (Analysis toolbox > Proximity toolset).

Spatially join and average the air pollution data to the Thiessen polygons using the Joins and Relates dialog box accessed from ArcMap's table of contents (Figure 2a).

Figure 2b shows a 3D representation of the pollution data aggregated to polygons. Geostatistical Analyst has a kriging model called areal interpolation, which has been designed specifically for data that has been averaged over polygons. Given the Thiessen polygons and the average air pollution estimates, a prediction surface is produced for all points in the study area (Figure 2c). This surface will serve as a smooth approximation of the industrial air contamination.

Determining Uncertainty of Existing Air Pollution Measurements

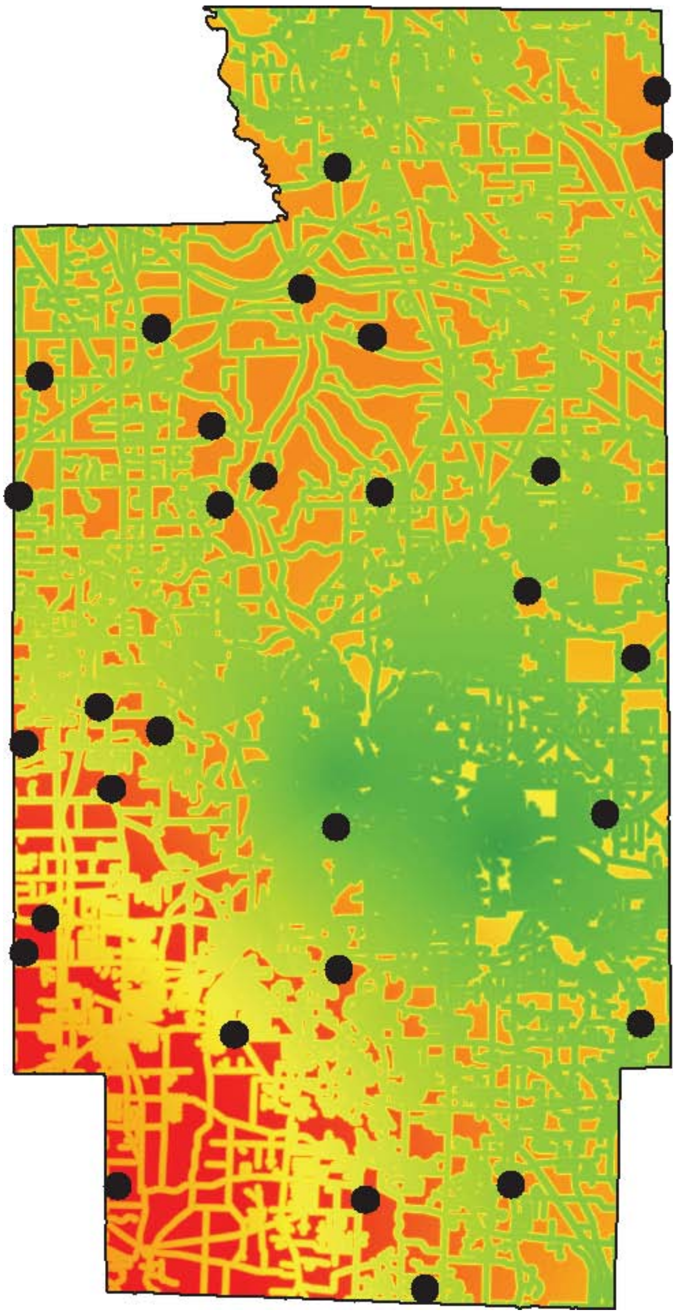
The US EPA maintains a database of air quality measurements taken throughout the United States and its territories (www.epa.gov/airdata/index.html). Data on particulate matter (i.e., matter 2.5 micrometers and smaller in diameter) was extracted for the 46 monitoring sites located in Ohio. These measurements serve as a proxy for estimating the uncertainty in the existing air pollution monitoring system.

One goal of the sampling design is to take new samples in areas where the uncertainty of prediction from existing measurements is high. Using the values from the 46 monitoring sites in Ohio, a prediction surface and standard error of prediction surface was created for the state using empirical Bayesian kriging. This tool was selected because it requires minimal interactive modeling and its standard errors of prediction are more accurate than standard errors of prediction from other kriging models. Darker areas of Figure 3 show higher levels of uncertainty of air pollution prediction.

Sampling in Undisturbed Areas

Because this study is looking at cumulative deposition of pollution, it is important to avoid taking samples too close to roads because road traffic resuspends particles, creating what is known as fugitive dust. The US EPA recommends siting air pollution and deposition monitoring sites in flat, uniform, and open spaces at least 200 meters (m) from a lightly traveled secondary road, 500 m from a heavily traveled secondary road, or 2 kilometers from a major highway.

However, in an urban county, such as Summit County, which has a dense road network, these parameters would exclude most of the county. As a compromise, the Euclidean distance to the nearest road was calculated, and the distances were rescaled using a sigmoidal function shown in Figure 4a. The effect of this function is that locations close to a road (0–50 m) will have a very low suitability. Once the distance from a road reaches 50 m, suitability begins to gradually increase. When the distance reaches approximately 250 m, suitability levels off and all distances greater than this distance are nearly equally preferred (as shown in Figure 4b).



↑ Figure 5b: Thirty spatially balanced candidate sites in Summit County, Ohio

Putting It All Together

Each of the three rasters generated from this workflow represents a goal of the sampling design. To consider all three goals at the same time, the rasters must be rescaled and combined. Rescaling transforms the rasters to a common measurement scale so that they will have equal influence in the site selection.

Rasters were transformed to a 0 to 1 scale using the formula (raster value - minimum raster value)/(maximum raster value - raster min). rasters were combined using the formula (pollution raster + prediction uncertainty raster) * roads raster. Multiplying by the roads layer (where locations close to the road have very low suitability scores) dramatically reduces the final suitability for locations close to a road.

The combined raster is a surface where higher values represent more desirable locations for sampling. This final raster was also rescaled to a 0 to 1 scale to represent a probability range. The higher the value in this raster, the more likely that the cell will be included in the sample design. In this example, the pollution and prediction uncertainty rasters were considered equally important in determining site suitability, so they were simply added together. However, more importance could be assigned to one of the factors by multiplying it by a weight before adding the rasters together.

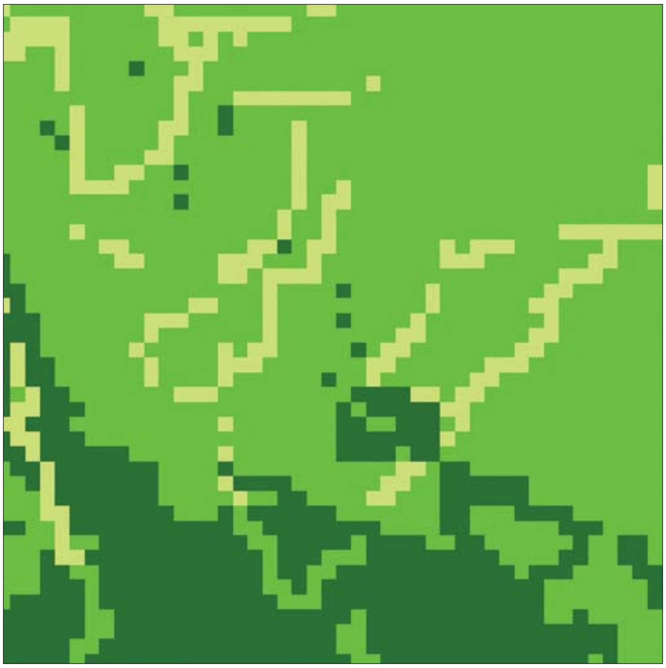
Figures 5a and 5b show the resultant inclusion probability raster and two sets of candidate sample sites. Note that each sample realization is related to the underlying spatial structure of the sampling suitability raster created earlier. The samples are also spatially balanced. If Thiessen polygons were drawn around each sample location, all polygons would have somewhat similar areas.

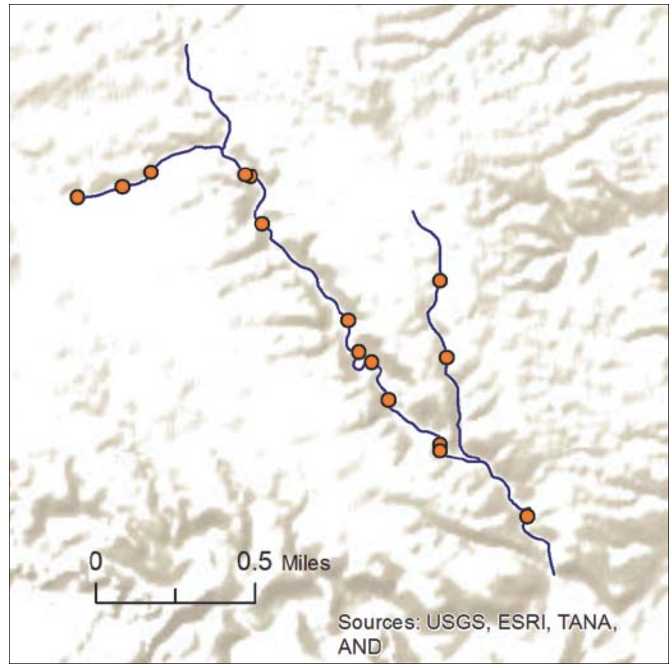
Other Applications of the Workflow

This workflow can be used for other applications such as locating sampling sites along a stream or road network, which is often a difficult task in GIS. Using the Feature To Raster tool (Conversion toolbox), the road or stream network can be converted to a raster, and locations on the stream or road can be assigned a value of 1 and all other locations assigned a value of 0. Using this raster as input to the Create Spatially Balanced Points geoprocessing tool results in a random sample of points along the network (Figure 6a). Alternatively, locations along the stream or road could be given higher inclusion probabilities based on proximity to features such as dams or environmentally sensitive areas.

Raster-based site selection is one of the most common workflows in GIS. In this method, raster layers are rated, weighted, and overlaid to create a final suitability raster. These analyses are often performed at fine raster resolutions using 30 m cells to capture rapidly changing criteria such as elevation or land use. This can result in a "salt and pepper" effect on the suitability raster that contains several isolated cells with high suitability values (Figure 6b).

To locate potential sites for three new large sporting goods stores, for example, individual cells of approximately 0.2 acres each (shown in Figure 6b) would be too small to site such large facilities. To solve this problem would require resampling the final suitability →

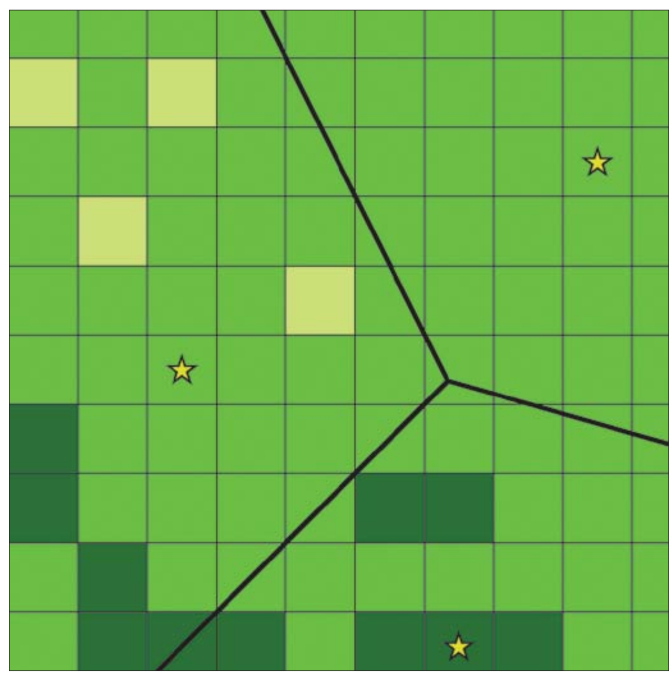




↑ Figure 6a: Fifteen spatially balanced sampling locations selected along a sinuous river. All locations along the stream are equally probable.

↗ Figure 6b: Suitability raster for siting a large sporting goods store. Notice several isolated cells, which have high suitability but are not large enough to site a store. Darker colors indicate higher suitability.

→ Figure 6c: Suitability raster resampled to approximately 5-acre cell size. Stars represent potential store locations. Polygons represent store catchment areas. Darker colors indicate higher suitability.



raster to a cell size appropriate for the facility being sited. Figure 6c shows the suitability raster resampled to a 5-acre cell size. After rescaling this raster to a 0 to 1 scale, it can be used as input to the Create Spatially Balanced Points tool. Figure 6c shows potential sites for three stores. These sites are spatially balanced and were selected based on their suitability. The Thiessen polygons around each of the sites can be thought of as the catchment area for each store.

Conclusion

Unequal probability-based sampling using the Create Spatially Balanced Points tool allows the researcher to use a priori knowledge of a problem to create an intelligent and efficient sampling or suitability design. The tool uses continuously varying inclusion probabilities that can be readily constructed using a variety of geographic layers and the researcher's expert knowledge. This powerful, flexible, and easy-to-use tool can lead to a reduction in the cost and effort of sampling designs used to evaluate patterns and trends in geographic data. For more information on creating spatially balanced points, see the resources listed under Further Reading.

Further Reading

ArcGIS Help 10.1. Create Spatially Balanced Points (Geostatistical Analyst).

Krivoruchko, Konstantin. "Empirical Bayesian Kriging," *ArcUser*, Fall 2012, p. 6.

Krivoruchko, Konstantin. "Modeling Contamination Using Empirical Bayesian Kriging." *ArcUser Online*, Fall 2012 (esri.com/news/arcuser/1012/modeling-contamination-using-empirical-bayesian-kriging.html).

Krivoruchko, Konstantin. *Spatial Statistical Data Analysis for GIS Users*. Esri Press, 2011, 928 pp.

Krivoruchko, Konstantin, A. Gribov, and E. Krause. 2011. "Multivariate Areal Interpolation for Continuous and Count Data." *Procedia Environmental Sciences*, Vol. 3, pp. 14–19. 1st Conference on Spatial Statistics 2011—Mapping Global Change.

Stevens, D. L., Jr., and A. R. Olsen. 2004. "Spatially Balanced Sampling of Natural Resources." *Journal of the American Statistical Association* 99 No. 465: 262–278.

About the Authors

Konstantin Krivoruchko is a senior research associate on the Esri software development team who played a central role in developing the ArcGIS Geostatistical Analyst extension. Prior to joining Esri in 1998, he was director of the GIS laboratory at the Sakharov Institute of Radioecology in Minsk, Belarus, where he developed GIS and spatial statistics curricula and supervised doctoral and graduate school candidate research pertaining to GIS applications and spatial statistical data analysis. He has taught numerous courses on applied spatial statistics and GIS. These activities are summarized in the book *Spatial Statistical Data Analysis for GIS Users*, published by Esri Press.

Kevin Butler is a member of the Spatial Analyst team working primarily with the multidimension tools. He holds a doctorate in geography from Kent State University. Prior to joining Esri last year, he was a senior lecturer and the manager of GIScience research at the University of Akron, where he taught courses on spatial statistics, GIS programming, and database design.

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Sensor to Service

ArcGIS enables real-time GIS

ArcGIS includes the capability to use real-time data in everyday decision making. Users will be able to answer questions, such as, Where are all the vehicles in my fleet at this moment? and Are my field personnel working within the designated project area? They'll be able to tell a customer that the delivery truck is 10 minutes away, get notified when a certain type of vehicle enters a dangerous area, alert the five nearest responders when an incident occurs, be warned when equipment begins operating abnormally, and even be able to monitor lightning strikes.

ArcGIS GeoEvent Processor is a new ArcGIS for Server extension. It gives users the ability to connect to real-time data streams from a wide variety of sensors, perform continuous processing and analysis of those data streams, and send relevant information to users or other systems.

Making Real-Time Information Available

ArcGIS GeoEvent Processor for Server delivers the flexibility to incorporate virtually any source of real-time data into a GIS. It contains ready-to-use input connectors for the most common data stream sources, including built-in GPS connectors for Sierra Wireless and Trimble, and specific data streams for air traffic control, vessel positions, and others. GeoEvent Processor also provides an extensibility framework for creating custom connectors. Connectors can be configured to work over common transport protocols, such as UDP, TCP, and XMPP, and tap into vehicle telematics used by CompassCom, networkfleet, and many others.

GeoEvent Processor is designed to process and filter events in real time. This means that it can be set up to receive large amounts of data and extract from it just the information that is relevant to users. For example, GeoEvent Processor can be configured to receive real-time weather and pollution measurements from a network of sensors and trigger alarms when specific pollution or wind thresholds are met. Or it can be used to detect and highlight vehicles that are speeding, stopped for a long period of time, or moving away from a predefined route. GeoEvent Processor provides a simple visual environment for configuring and processing data streams. It allows users to easily remove noise and filter the data into the most important and actionable information.

GeoEvent Processor provides the capability to share real-time information with users and other systems. Examples include sending an e-mail or instant message to a person when a particular alarm is triggered and writing incidents to a log file or sending messages to an enterprise messaging system.

ArcGIS applications, including the new Operations Dashboard for ArcGIS, can receive and display the output of GeoEvent Processor on a map. ArcGIS applications running on web browsers, smartphones, and tablets can also take advantage of GeoEvent Processor output. For example, a construction company can track expensive equipment and alert operators and supervisors when a piece of equipment moves outside the project area. The location of the equipment can be tracked in real time on a map at the headquarters and from a smartphone in the field. Alerts can be configured so an instant message or e-mail is issued to the appropriate persons when needed.

In another example, a city police department can maintain a common operating picture of units in the field, analyze their movement patterns, and then optimize their patrol routes.

Or a company can improve customer service by alerting customers that their package will be delivered within the next 15 minutes.

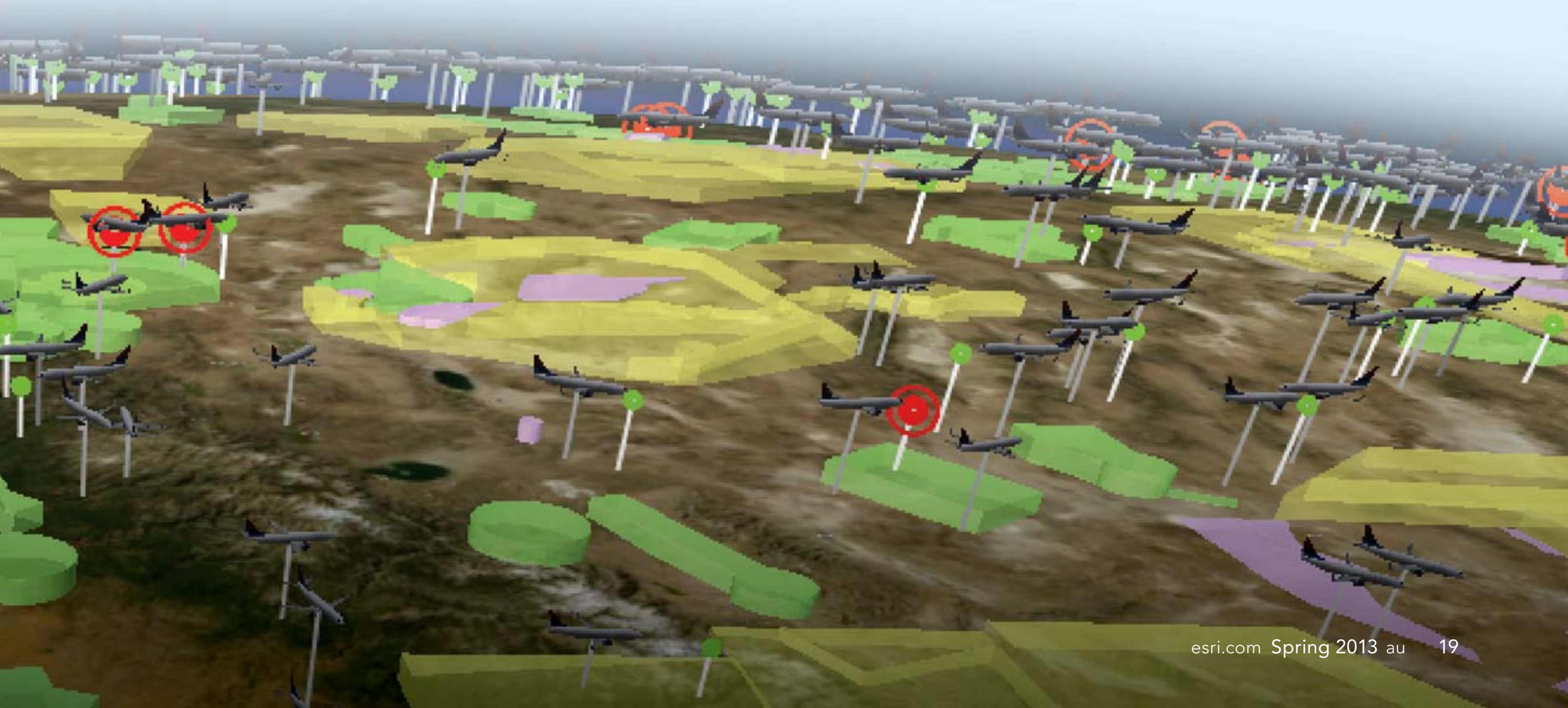
A New Paradigm for Geofencing

A geofence is a virtual perimeter for a real-world geographic area. In the case of GeoEvent Processor, the GIS server is detecting and using geofences to alert the user or an authority when the device approaches, enters, and leaves the geofenced area. GeoEvent Processor provides the ability to use any map feature as a geofence. This means that geofences can be defined using jurisdictional areas, such as a city boundary, or an area defined through analysis, such as a high-crime area, an area determined by specified drive time, or a hand-drawn polygon. For example, an operations center may want to monitor vehicle assets as they approach, pass through, and leave hazardous areas defined by spatial conditions, such as flooding or suspicious behavior. These GIS-based geofences will help end users deliver more accurate, real-time assessments of live events.

Conclusion

ArcGIS provides users with exciting new capabilities to incorporate real-time information into decision making. ArcGIS users can manage the flow of real-time data by collecting data streams from sensors; processing and analyzing this data in real time to determine the course of action; and finally presenting relevant information to users as a map via an e-mail, instant message, etc. These capabilities are delivered through the new ArcGIS for Server extension, ArcGIS GeoEvent Processor for Server.

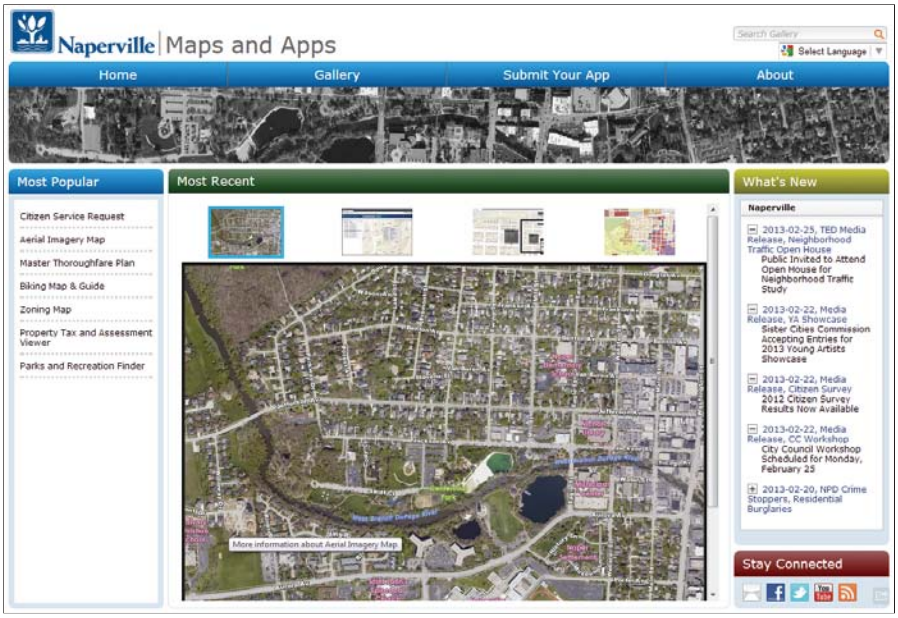
GeoEvent Processor is sure to be a game changer in many industries, including fleet and asset management, telematics, defense and intelligence operations, public works, public health, forestry, mining, water and petroleum management, public safety and emergency management, transportation, and utilities. ArcGIS GeoEvent Processor for Server is expected to be released with the next update to ArcGIS for Server.



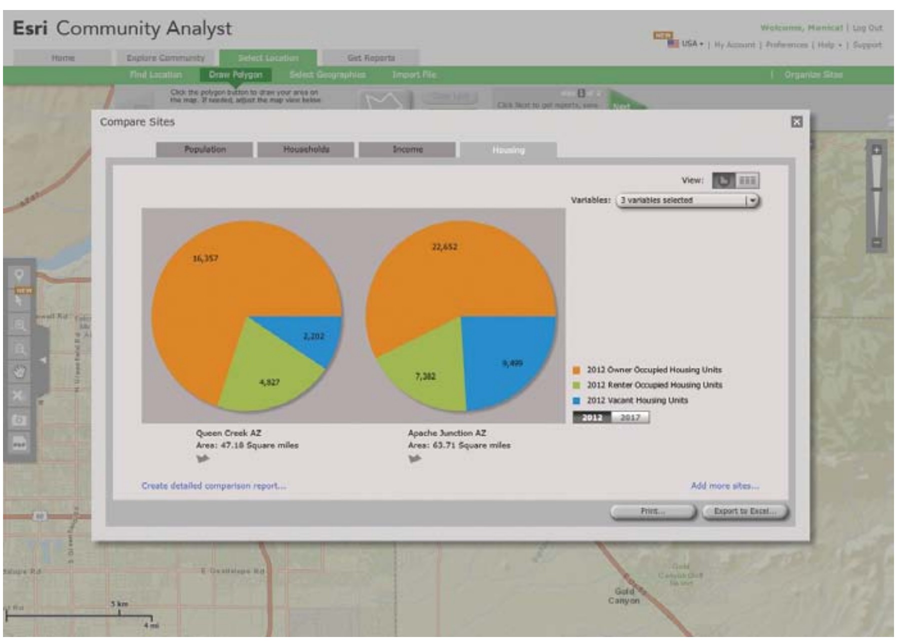
The Platform for Success

GIS for everyone

ArcGIS is at a turning point. It is becoming the platform *for* the organization.



↑ Applications, based on the Local Government Information Model, can be downloaded at no cost from ArcGIS Online. They help organizations realize benefits from GIS data they already have.



↑ Community Analyst is a web-based solution that provides analysis and mapping of thousands of demographic, health, economic, education, and business data variables, packaged with analysis functionality that meets business and organizational needs.

According to *The Age of the Platform* by Phil Simon, "A platform is an extremely valuable and powerful ecosystem that quickly and easily scales, morphs, and incorporates new features, . . . users, customers, vendors, and partners." It is ubiquitous and tolerant of change. Platforms are all about communication: they help people connect with each other, businesses communicate with customers, and governments stay in touch with citizens.

The platform ecosystem is open so it can work with complementary technologies and constantly expands existing capabilities and adds new ones. It must be agile and "plastic" enough to respond to new opportunities, many of which are generated by the application of business intelligence to various aspects of operations from customer service to supply chain management.

ArcGIS Platform

ArcGIS has evolved into a platform with an architecture that encompasses technology, information, and business layers. Beyond supplying innovative GIS in its technology layer, the ArcGIS platform provides the data and models in its information layer and targeted solutions, templates, and workflows in its business layer. The work of traditional GIS in organizations is enhanced and amplified, not replaced, by this platform.

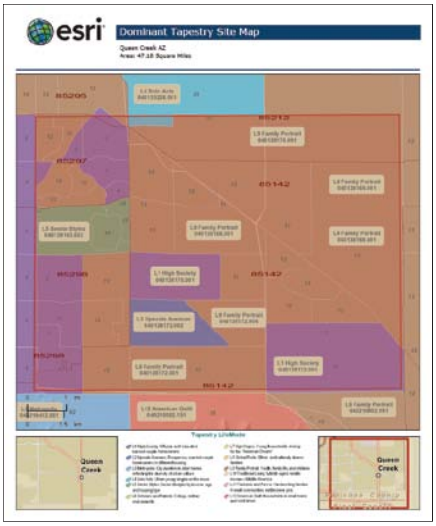
Unlike railroad and telephone companies that, in the past, dominated because they were monopolies, platforms like Amazon are tremendously powerful because they work cooperatively with other companies. The power of GIS has always come from its emphasis on collaboration, integration, and communication. The difference now is that, as a platform, the scale of collaboration and integration has increased, enabling much broader and more direct communication and interaction.

Change and Opportunity

Since its inception in the 1960s, GIS technology has changed with the larger trends in IT, moving from mainframes through minicomputers, workstations, desktops, client/server networks, and web servers. With the move to the cloud/device architecture, technological foundation for GIS changed more dramatically than at any other point in that long road. This change has been the most disruptive but, using ArcGIS, provides GIS professionals with an opportunity to reach a much larger group of geoinfo consumers in their organization. This new platform architecture brings together the familiar components of the enterprise GIS system—desktop and server—with pervasive applications that make GIS technology available to all kinds of clients through the cloud.

Your Content Management System

ArcGIS Online, the cloud-based system for creating and sharing maps and geographic information, is the infrastructure that leverages the change to the cloud/device paradigm. From an initial inventory of basemaps, it has grown to thousands of maps, applications, tools, and layers that can be shared selectively or with the public. The ArcGIS.com map viewer provides simplified mapping that people with no experience



↑ Solutions like Esri Business Analyst and Community Analyst can generate illustrated reports of the results of analysis.

with GIS can leverage. It has unlocked the benefits of GIS to a whole new set of users while supporting and extending enterprise GIS systems.

The integration of ArcGIS Online supports everyone in an organization through readily available tools, applications, basemaps, and operational data that enhance collaboration; improve communication; break down information silos; and support more informed decision making that can be accessed not only by GIS professionals but by knowledge workers, managers, policy makers, and staff, whether on-site or off-site. With hosted services through ArcGIS Online, making these resources available inside or outside an organization no longer requires installing and maintaining a server.

This new GIS pattern is exemplified by the work of the European Environment Agency (EEA). The agency uses GIS to meet the challenge of monitoring the quality of data about the condition of the environment of states in the European Union. EEA transforms terabytes of data into information that guides policy makers in these countries. Online content from ArcGIS feeds more than 80 maps and applications that enable integration of authoritative, citizen scientist, and crowdsourced data that can be contributed and shared in 32 languages.

A New Pattern

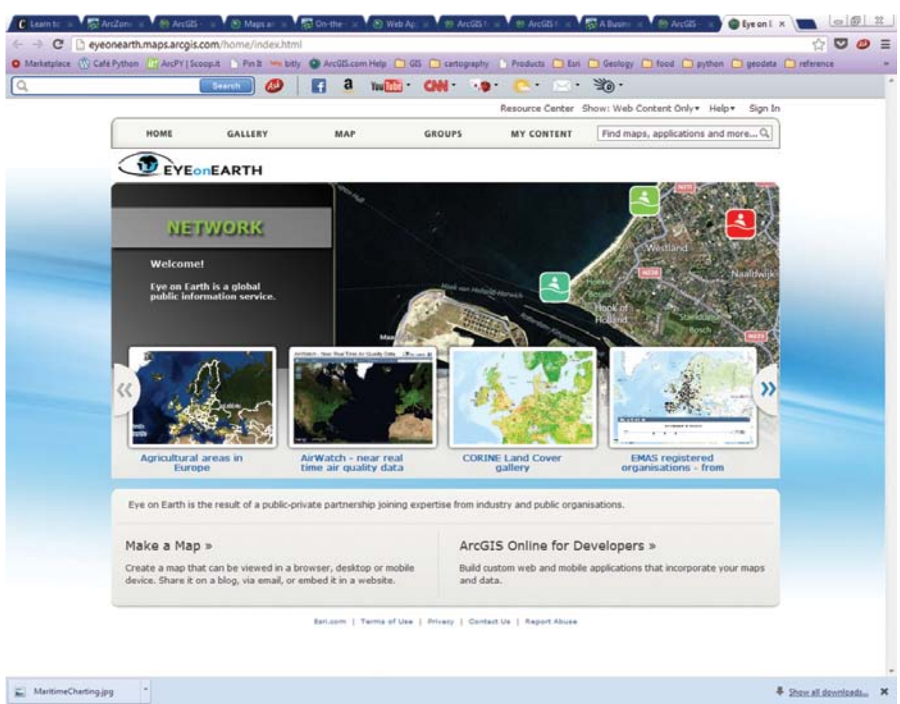
One defining characteristic of ArcGIS as a platform has been the adoption of the web map as a new pattern for finding, combining, and using content and functionality. It is not a departure from or replacement of traditional GIS work but a method for extending the value of the GIS work already done within an organization or by other organizations in a shared environment.

What is a web map? It is simple to use but not a simple thing. It can be most usefully defined as a specification for a map that can be used by all Esri clients and on all kinds of devices. It is a way to capture tradecraft and share it. It can encapsulate analytics performed in the background or abstract distributed services. Web maps can be used by the entire range of clients from desktops to iPhones. Map, feature, and image services available from ArcGIS Online, combined with basemaps and operational data using the ArcGIS.com map viewer, answer questions and provide insights without requiring GIS expertise. By allowing interaction with both a map and the data behind it, web maps can be used to crowdsource data.

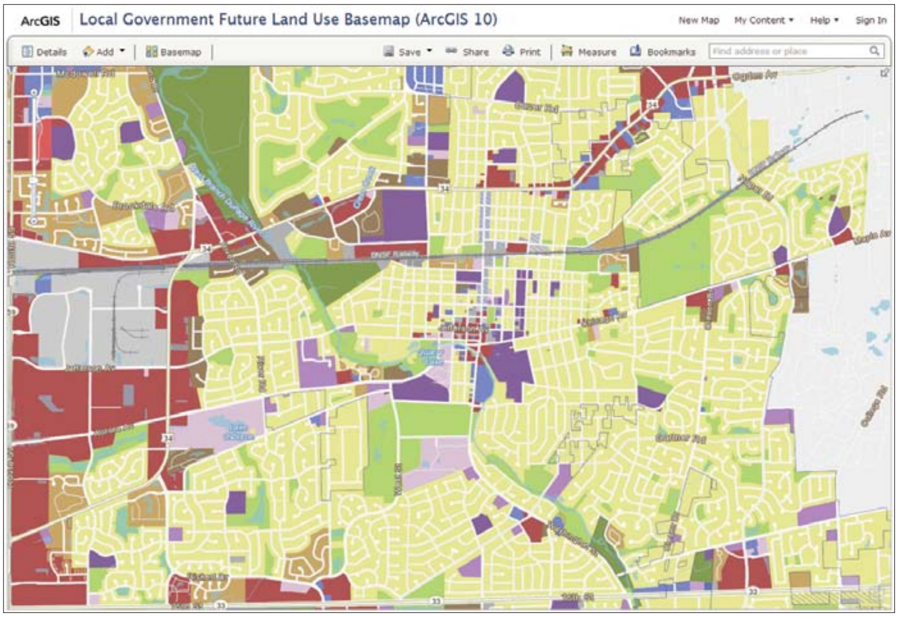
Web maps make the information contained in data layers come alive and generate new insights. Services hosted on ArcGIS Online or on an organization's own machines running ArcGIS for Server can be combined with basemaps or other types of operational data and persisted in a web map that can be shared by saving it to ArcGIS Online or by e-mailing it so it can be viewed using any device. Web maps support visualization, pop-ups, queries, and analytics and can be used to edit the original data on the server. A shared map can become the basis for additional annotation or analysis.

Story maps, a specific format for a web map, can reach new audiences. They combine web maps with web applications and templates to incorporate text, multimedia, and interactive functions to make maps that inform, educate, entertain, and inspire. Story maps can provide insight into an organization's operations and plans. Esri provides a form that users can pour their own and shared data into to communicate a specific message in a manner that is engaging and compelling.

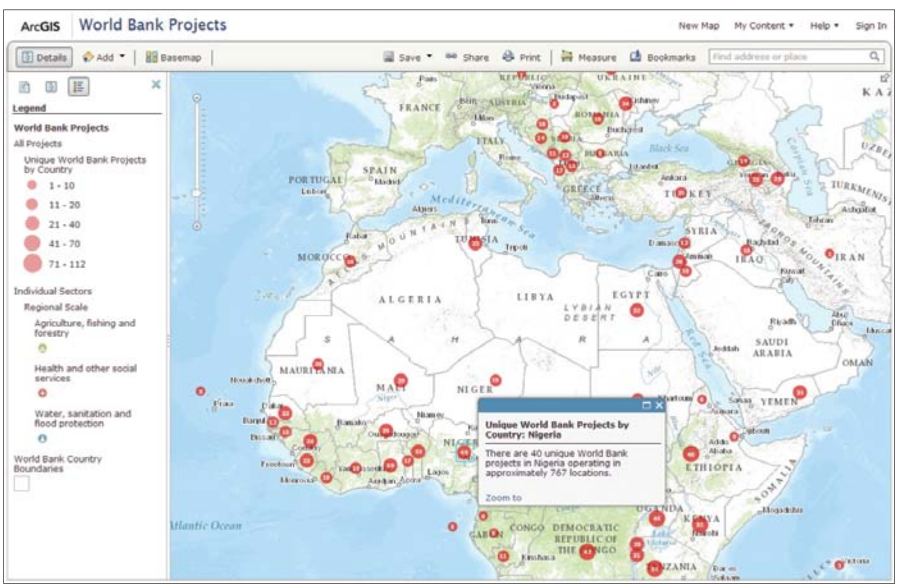
Web maps tranform organizations by getting rid of organizational stovepipes and enabling collaboration. The World Bank, a cooperative of 187 member countries that provides financial and technical assistance to developing countries to reduce poverty, uses web maps to improve transparency, communication, and collaboration. The institute's Innovation Team geocoded and mapped more than 30,000 geographic locations for more than 2,500 bank-financed projects



↑ ArcGIS feeds more than 80 maps and applications produced by the European Environment Agency that enable integration of authoritative, citizen scientist, and crowdsourced data that can be contributed and shared in 32 languages.



↑ Organizations can use configurable maps and applications, such as this Local Government Future Land Use Basemap, to make their own data more useful and accessible with any programming.



↑ The World Bank geocoded and mapped 30,000 geographic locations for more than 2,500 bank-financed projects worldwide under its Mapping for Results initiative. This map and many other maps and layers have been shared on ArcGIS Online.

worldwide under its Mapping for Results initiative, and all new World Bank projects are georeferenced. Development planners can track and deliver resources more efficiently and effectively and avoid work duplication. This publicly accessible data empowers citizens to follow the progress of projects and service delivery in their countries.

A Little Help

Configurable templates and applications can enhance the value of web maps by giving rapid and valuable insights. Existing web maps can be converted to web applications. An application available from the EEA website uses crowdsourcing to validate readings from monitoring stations on the quality of air and swimming sites. Feedback from citizens gathered using this application will be used to improve the quality of biodiversity, coastal erosion, and other types of environmental data.

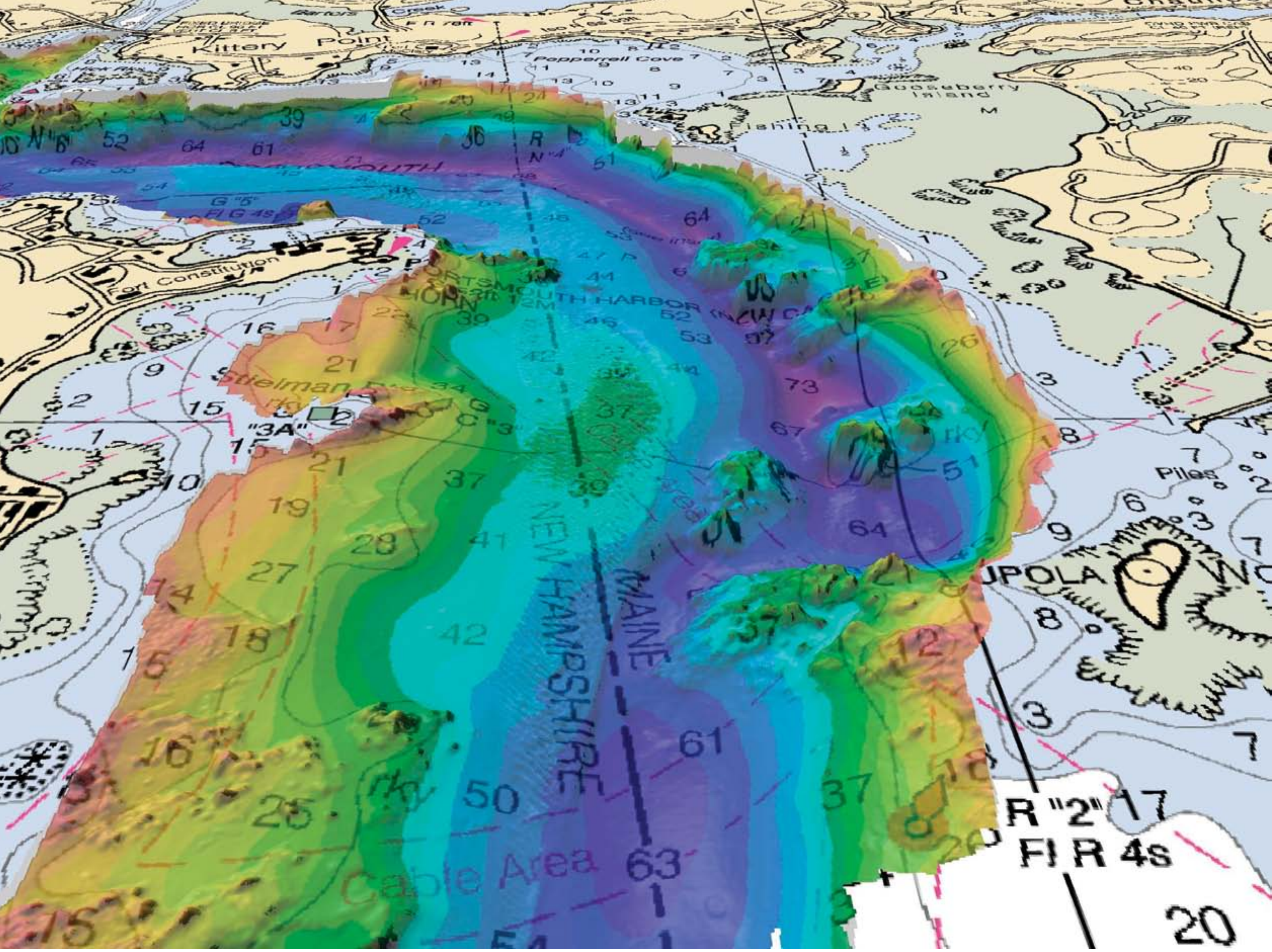
Many configurable applications that incorporated local data have been shared on ArcGIS Online. Applications, based on the Local Government Information Model, can be downloaded at no cost from ArcGIS Online. These applications help organizations realize benefits from GIS data they already have. "Better Than Scratch" in this issue describes how Lake County, Florida; the City of Fort Lauderdale, Florida; and Cabarras County, North Carolina, have met common web mapping needs using configurable applications from the Local Government Resources Center (resources.arcgis.com/content/local-government).

It's All about the Data

For most GIS practitioners, the most challenging aspect of any project has been finding, vetting, and massaging data by normalizing, reprojecting, and harmonizing it. Although Esri has always provided data resources with software and worked for decades promoting and facilitating data sharing and reuse, the process was time-consuming and complex. Now access to authoritative content is much easier, and the requirement that users assemble all or nearly most of the data needed for any project is significantly reduced or, in some cases, eliminated.

As its GIS technology continues to improve, Esri has also become a data company. ArcGIS Online makes accessible rich content that is constantly updated. This resource is a rapidly growing part of the ArcGIS platform. Ready-to-use, high-quality imagery, streets, shaded relief, topographic, and other geospatial data, as well as demographic data, is freely available from ArcGIS Online. Updated demographics, US Census, consumer spending, business, and marketplace data is included in some business solution products, such as Esri Business Analyst, or can be purchased separately.

In addition to simplifying access to structured data, ArcGIS is coevolving along with other information technologies to deal with ever-increasing quantities of data from sources such as sensor networks, crowdsourcing, and the digitization of historic records. A world of two and a half billion people connected with devices is creating an explosion of sensor and behavioral data. The original Big Data technology, GIS is uniquely suited as the platform for organizing and communicating knowledge



↑ ArcGIS for Maritime: Bathymetry, an extension to ArcGIS for Desktop, helps manage and combine massive amounts of bathymetric data and metadata in a GIS environment.

about anything on earth.

ArcGIS GeoEvent Processor, a new ArcGIS for Server extension, can connect to real-time data streams from a wide variety of sensors, perform continuous processing and analysis of those data streams, and sends relevant information to users or other systems. (See "Sensor to Service: ArcGIS Enables Real-Time GIS" in this issue.)

Intelligence Now

ArcGIS technology and information architecture are the foundation for the business layer, which targets organizational needs. The business layer enables people across the organization to accomplish work more efficiently and effectively. Organizations that don't have the time or expertise to build a solution using Esri tools can benefit from GIS using Esri solutions. Solutions like Community Analyst, web-based technology that provides analysis and mapping of thousands of demographic, health, economic, education, and business data variables, package appropriate data with the functionality that meets specific business and organizational needs.

Location has always been part of business analytics, often for site analysis and customer intelligence applications, but with the explosion of location-based data collected through smartphones and other devices, it is increasingly a source of competitive advantage. Esri location analytics software can provide invaluable insights to organizations and business. Location analytics is about dynamic, interactive mapping; sophisticated spatial analytics; and rich, complementary data. Esri Business Analyst, available as desktop and server and software as a service options, delivers data bundled with built-in analytical capabilities that support decision making. Esri Maps for IBM Cognos, Esri Maps for SharePoint, and Esri Maps for Office directly integrate mapping with common business technologies.

Some Esri solutions solve very specific problems. With Esri Address Coder, an organization can view the locations of US customers on a map and append latitude-longitude, FIPS codes, and Esri demographic and Tapestry Segmentation data to each record. Address Coder can use more than 100 of Esri's data variables. Customers can be grouped by geographic location, demographic characteristics, or consumer type for targeted marketing.

Feeding the Ecosystem

In the past, Esri supplied tools and some content that GIS professionals applied to solving problems at the project, department, and enterprise levels. Now, in addition to core professional GIS software that can be customized and extended with Python scripting and automated with ModelBuilder, the Esri technology layer has support for developers. Using Esri APIs and software development kits (SDK), developers can use just the analysis and mapping capabilities required to solve a customer's problem while working in a mainstream development environment.

For developers, Esri provides web APIs for JavaScript, Flex, and Silverlight and six service APIs that include ArcGIS for Server REST API, ArcGIS Spatial Data Server REST API, and the ArcGIS Server Administrator API. Native SDKs are also available for building applications for smartphones and tablets or desktop systems: ArcGIS Runtime SDK for Android, ArcGIS Runtime SDK for iOS, ArcGIS Runtime SDK for Java, ArcGIS Runtime SDK for Windows Mobile, ArcGIS Runtime SDK for Windows Phone, and ArcGIS Runtime SDK for WPF [Windows Presentation Foundation].

Another article in this issue, "The Year of the Developer: New program rolls out in 2013," describes developer programs that will be unveiled at the Esri International Developer Summit March 25–28, 2013, in Palm Springs, California. New monthly ArcGIS Online pricing for developers and a marketplace for applications on the soon-to-be launched developers.arcgis.com website will be a one-stop site for the development community.

Esri holds Meetups for developers across the United States and participates in events such as the Foursquare Hackathon held in New York City in January 2013. Esri will also sponsor hackathons at the Developer Summit and South by Southwest (SXSW).

Enabling Everyone to Access and Use GIS

The evolution of ArcGIS to the platform is changing organizations even more profoundly than adoption of GIS on the enterprise level did. It enfranchises the entire organization, breaking down the barriers between workflows, departments, and disciplines. Sharing data and collaboration using geospatial information have become much quicker and simpler. With web maps, applications, and solutions, internal customers can use data from inside and outside the organization without knowing the underlying GIS technology.

One effect of the adoption of cloud/device models for GIS is that the growing connectedness of the world makes the knowledge created through traditional GIS on desktops and servers accessible to a much wider audience. Consequently, rather than limiting the role of the GIS staff in an organization, that role is shifting and expanding into new areas beyond mapping. The work of GIS professionals has never been more important as GIS becomes ubiquitous. They provide the substrate that lets others benefit from GIS.

This platform brings the unique holistic approach of GIS to bear on the formidable problems faced by organizations. GIS has always been a tremendous tool for not only seeing specific aspects of a problem but the problem as a whole in context. Now GIS can be applied to solving problems in all areas more broadly. The result, in the words of Esri president Jack Dangermond, can be "better outcomes for the entire planet."

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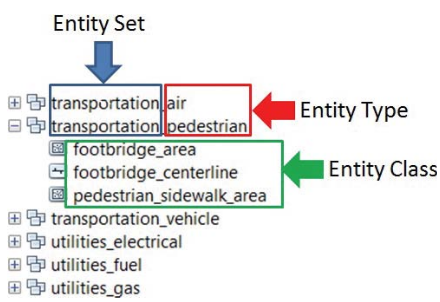
Swift and Lossless

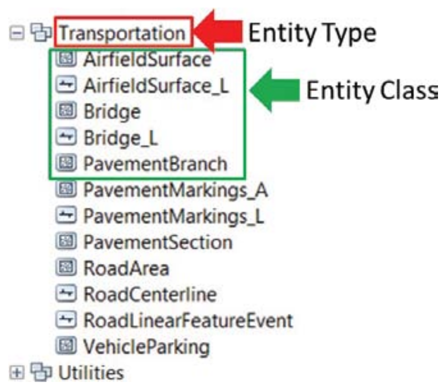
Automating the migration to a new data model

By Kyle D. Turner, US Air Force

Using ArcToolbox with Python tools, the Air Force (AF) created a repeatable process in ArcGIS for Desktop that enabled the translation of a very specific data model to a more generalized one. The AF solution transitioned the Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE) 2.6 geospatial data to the Air Force Adaptation of SDSFIE 3.0.



↑ Figure 1: SDSFIE v2.6 data model



↑ Figure 2: SDSFIE v3.0 data model

The AF GeoBase program supports the AF Civil Engineer (CE) and broader AF missions by providing accurate geospatial data of real-world features for all AF installations, ranges, and property. The GeoBase mission involves tightly integrated cross-functional collaboration across the AF to provide geospatial visualization and analysis of CE business data. Its mission includes managing geospatial data and serving as the authoritative repository of all installation geospatial data.

Per the direction of Executive Order 12906, *Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure*, published April 13, 1994, many government organizations implemented the SDSFIE logical data model. This model is based on standards from the Federal Geographic Data Committee (FGDC). Within the United States Department of Defense (DoD), SDSFIE is now the geospatial data standard for all the armed services and the Washington Headquarters Services. It is governed by the Defense Installations Spatial Data Infrastructure (DISDI) Group. The Department of Defense Real Property and Installations Lifecycle Management (RPILM) Investment Review Board (IRB) approved SDSFIE 3.0 on November 15, 2010.

Following this approval, the Office of the Under Secretary of Defense (Acquisition, Technology & Logistics) (USD[AT&L]) submitted the SDSFIE 3.0 to the DoD Information Technology Standards Registry (DISR) for listing as a mandated standard. To comply with the standard, the AF developed the AF Adaptation of SDSFIE 3.0, approved in January 2012.

The New Standard

The new standard is significantly different from the prior version, SDSFIE 2.6. The data model for SDSFIE v2.6 represents facilities, infrastructure, and environmental

One to one

Two6FCs	Three0FCs
elevation_contour_line	ElevationContour

Many v2.6 feature classes to one v3.0

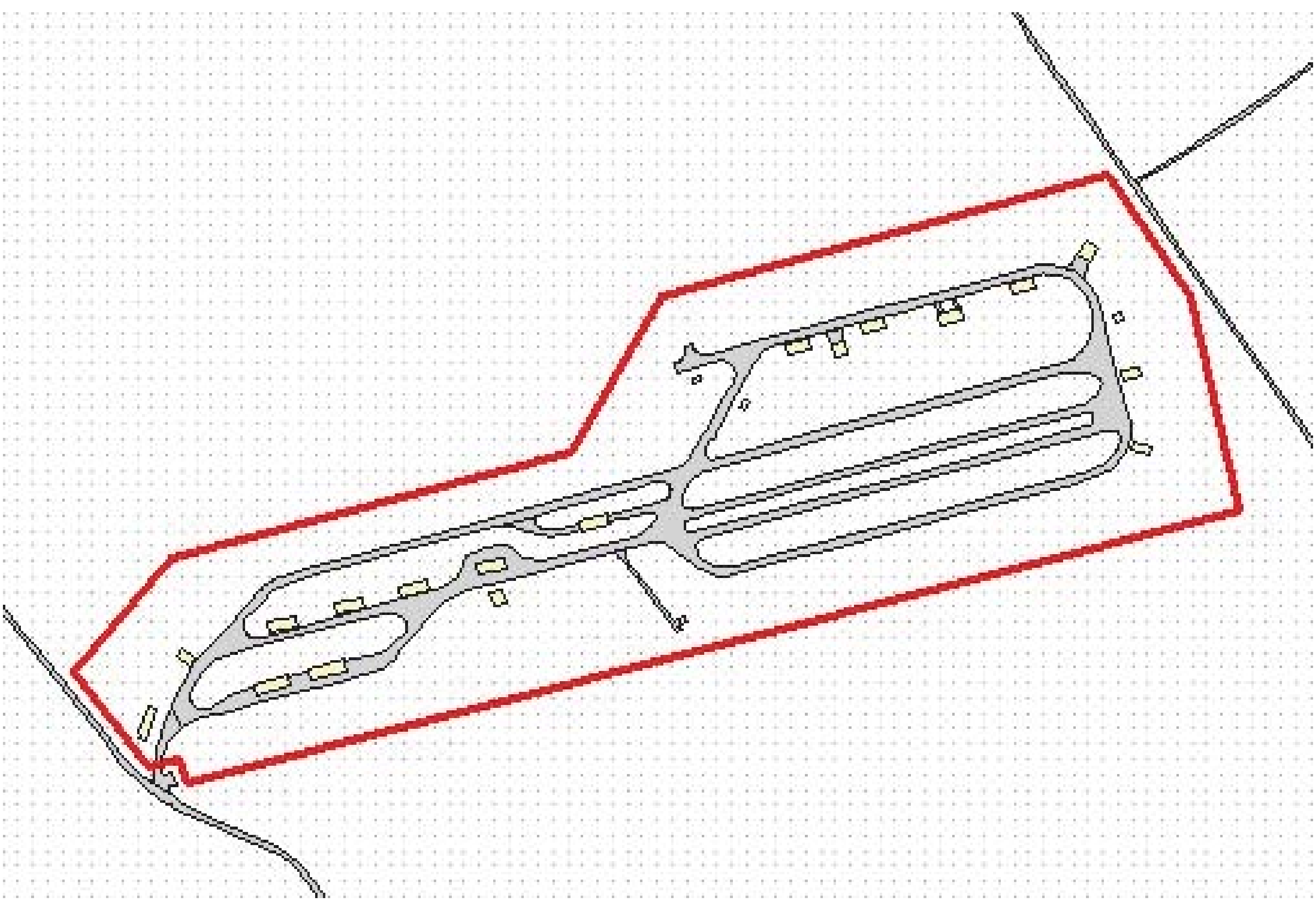
Two6FCs	Three0FCs
flora_spec_geo_range_area	SpeciesSpecificHabitat
flora_species_home_range_area	SpeciesSpecificHabitat
flora_species_population_area	SpeciesSpecificHabitat
habitat_area	SpeciesSpecificHabitat
hist_bald_eagle_nesting_area	SpeciesSpecificHabitat
marine_species_occur_area	SpeciesSpecificHabitat
migration_route_area	SpeciesSpecificHabitat
migratory_stopover_area	SpeciesSpecificHabitat
nesting_area	SpeciesSpecificHabitat

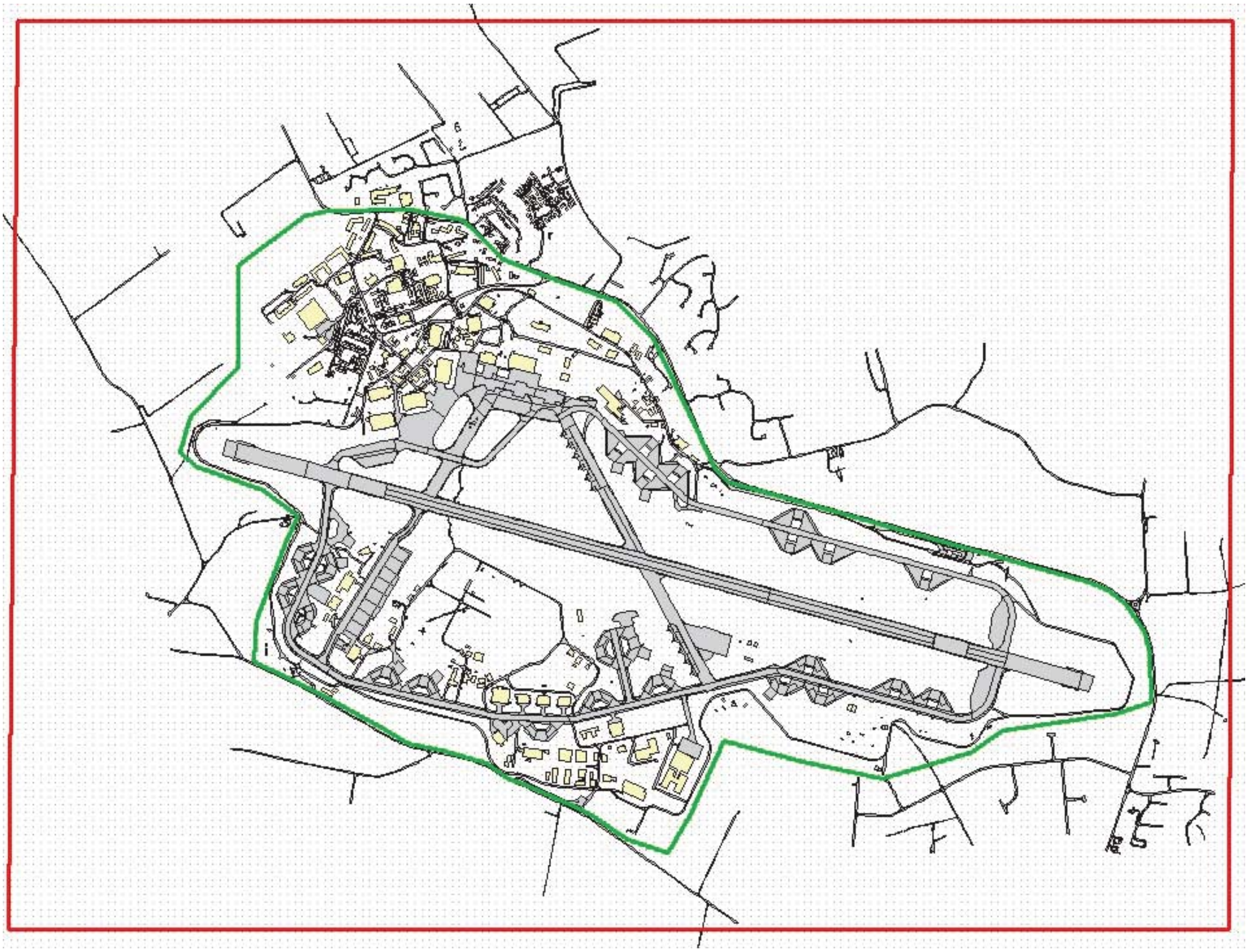
One v2.6 feature class to many v3.0

Two6FCs	Three0FCs
pedestrian_sidewalk_area	PavementBranch
pedestrian_sidewalk_area	PavementSection

↑ Figure 3: SDSFIE v2.6 and v3.0 feature class relationships

↓ Figure 4: A simple site where the site boundary is an appropriate choice for the clipping polygon





↑ Figure 5: A clipping polygon (in red) captures features outside the site boundary when off-site/non-AF features (green is the site boundary) are of interest for situational awareness purposes.

features in a broad, thematically based, hierarchical manner. Items are organized first by a broad theme, then to a more detailed description or type for a given theme, then to a specific class of a thematic type. Simply put, items are organized into entity set, entity type, and entity class.

The data model for SDSFIE v3.0 represents features similarly to v2.6 except that it is more general. For example, in v2.6 transportation features are broken out into several modes, whereas in v3.0, all forms of transportation are in one entity type or dataset.

In some cases, there is a simple one-to-one relationship between features in v2.6 and v3.0. However, this generalization can require multiple v2.6 feature classes to be merged into one v3.0 feature class. Also, one v2.6 feature class can relate to many v3.0 feature classes. Additionally, some v2.6 feature classes are not in v3.0, and some v3.0 feature classes do not have a corresponding 2.6 version. The variety of relationships between features in v2.6 and v3.0 complicated the task of automating the migration process.

The Migration Process

Successful data migration required meeting two key goals: rapid conversion and no data loss. During the transition process, each AF user had to stop editing the current SDSFIE 2.6 geodatabase while it was migrated to the AF Adaptation. Consequently, rapid data migration was essential. Significant differences in the two versions necessitated considerable data manipulation and required a carefully developed methodology that ensured no data would be lost.

Because migrating from SDSFIE v2.6 to v3.0 was a significant effort, automating as much of the process as possible was

↑ Figure 6. A clipping polygon (in red) with masks that exclude sites that fall within a site

essential. Once the migration methodology was envisioned, Python tools for use in ArcToolbox were developed to assist GeoBase personnel with the task. Using these tools, the transition process was accomplished more efficiently and resulted in minimal downtime for GeoBase. While creating the tools was not without difficulties, in the end the tools were used to migrate well over 1,000 sites in only a few months.

The Process Step by Step

ArcToolbox Python tools developed by the AF saved critical man-hours while ensuring rapid and lossless data migration. The method the AF developed requires an interim (transition) geodatabase. The interim geodatabase contains v3.0 feature classes, but each feature class includes both v2.6 and v3.0 attributes. Consequently, it was named the v2.6-3.0 merged geodatabase.

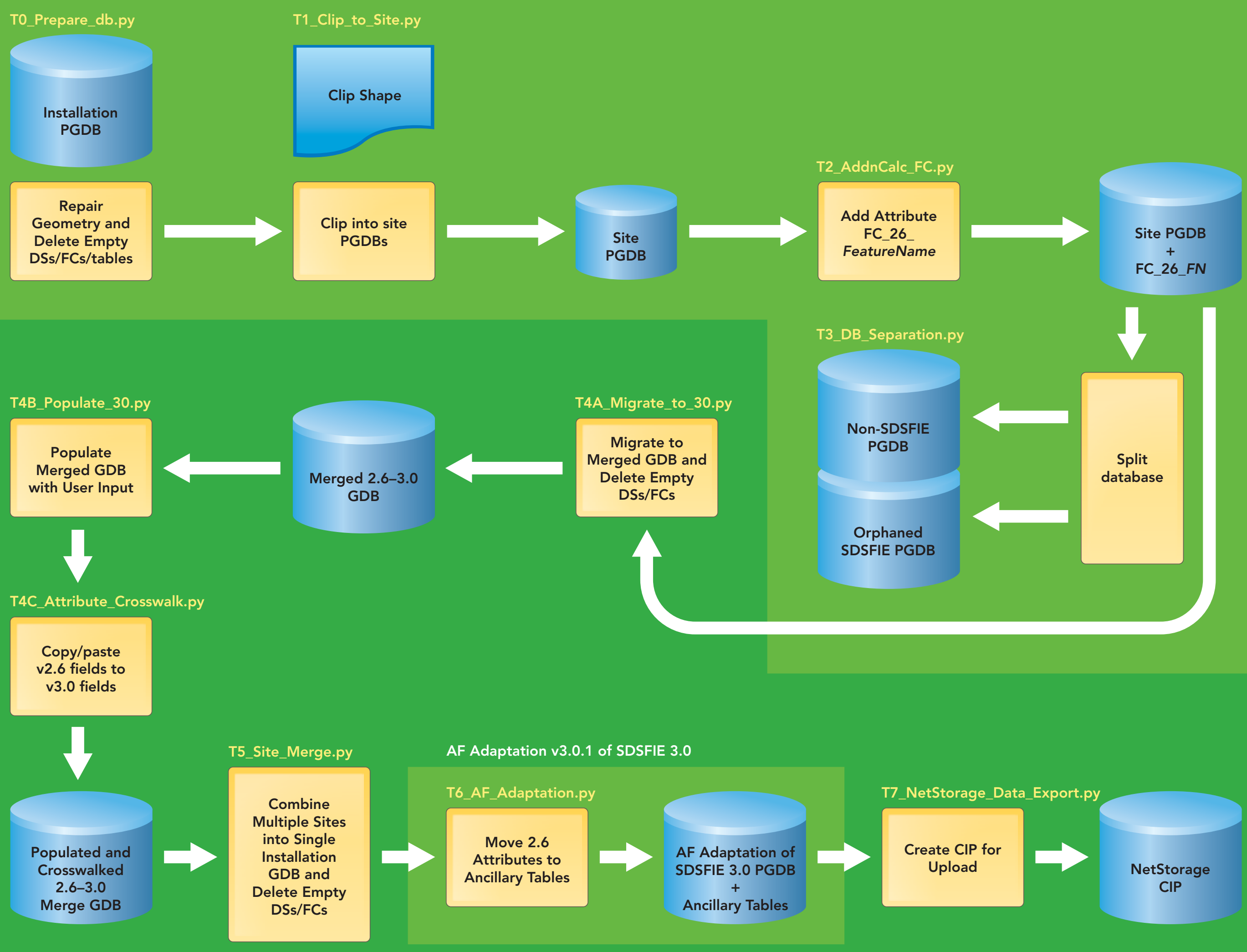
To automate the process, the AF developed a series of tools that were separately applied. This multistep approach was adopted because initial tests using a single script required long run times (as much as 18 hours in one case). A lengthy run time might cause users to conclude the tool had stopped in midprocess. In this multistep process, each tool prepares the geodatabase for the next step. This approach has the additional benefit of giving users an opportunity to check the results of one operation before moving to the next—a safeguard against data corruption or loss. Each tool and the processes associated are listed in "An Overview of the SDSFIE v2.6 to v3.0 Migration Process" on page 30.

Automating the Process

For more information, contact Kyle D. Turner at kyle.turner.1@us.af.mil.

An overview

of the SDSFIE v2.6 to v3.0 migration process



Migration Process

These Python tools were developed to automate the migration process and ensure no data was lost.

T0_Preparve_db.py

This tool checks the integrity of the geometry and repairs it if necessary. It also converts any multipart features to single-part features and deletes any empty datasets, feature classes, or tables.

T1_Clip_to_Site.py

Using a polygon chosen by the user, this tool clips an installation geodatabase into a site-only geodatabase. At this point, the user needs to consider how to define the geographic extent of the site geodatabase. This is important, because in some cases a site is within another site. Also, it may be necessary to include non-AF features to provide situational awareness.

T2_AddnCalc_FC.py

This tool adds new fields to each v2.6 feature class for use later in the migration process. The new fields provide information in the v2.6–3.0 merged geodatabase to determine where the features in a v3.0 feature class were previously stored in the v2.6 geodatabase. This is necessary because, in some cases, multiple v2.6 feature classes are merged into one v3.0 feature class.

T3_DB_Separation.py

To retain those v2.6 feature classes that are not migrated to v3.0, this tool saves any such feature classes to the Orphaned geodatabase. To ensure a lossless migration, any data not v2.6 compliant is stored in the non-SDSFIE geodatabase.

T4A_Migrate_to_30.py

This tool appends the geodatabase output from T2_AddnCalc_FC.py to the merged v2.6–3.0 geodatabase.

T4B_Populate_30.py

From user-specified input, this tool populates required fields in the merged geodatabase with site-specific information.

T4C_Attribute_Crosswalk.py

This tool operates on the merged v2.6–3.0 geodatabase to ensure that relevant data is not lost. For each feature class to retain important v2.6 data, some information is copied/pasted from the old v2.6 field into the corresponding new v3.0 field.

T5_Site_Merge.py

This tool merges all the site-specific geodatabases into an installation master v2.6–3.0 geodatabase.

T6_AF_Adaptation.py

Still working with the merged v2.6–3.0 geodatabase, this tool copies the v3.0 attributes to a v3.0-only geodatabase and the remaining v2.6 attributes are then saved as ancillary tables.

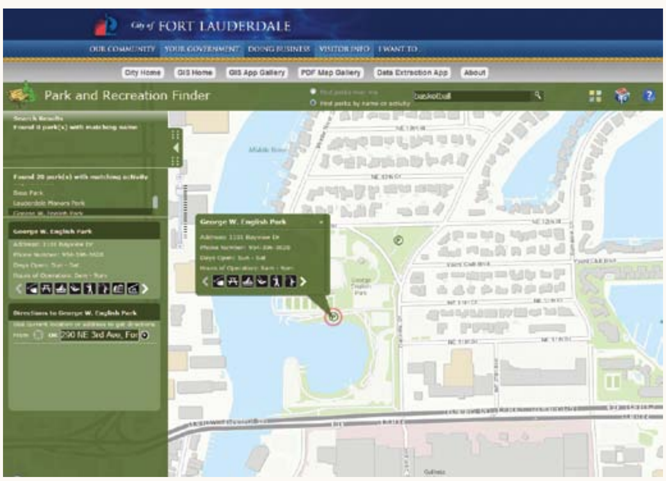
T7_NetStorage_Data_Export.py

Working with the v3.0 geodatabase, this last tool exports only common installation picture (CIP) feature classes to a geodatabase destined for the AF's Novell NetStorage web server.

Better Than Scratch

Use configurable applications to get results quickly

By Matthew DeMeritt, Esri Writer



↑ With the Park and Recreation Finder application, residents can find a park near them or a park that has activities that interest them.

What do Fort Lauderdale, Florida; Lake County, Florida; and Cabarrus County, North Carolina, have in common? All three local governments saved time and money by implementing configurable applications instead of developing those applications from scratch.

Esri's ArcGIS for Local Government maps and applications offer quick and configurable solutions for common web mapping needs. An attractive alternative to creating new services from the ground up, they can refine internal workflows and provide new services to the public. All of the nearly 100 applications can be downloaded at no charge from the ArcGIS for Local Government Resource Center (resources.arcgis.com/content/local-government) and are built on the Local Government Information Model.

A Quick Solution

Since 1999, the GIS division of the City of Fort Lauderdale has delivered geospatial services internally to city staff. With a population of more than 168,000, Fort Lauderdale is the largest city in Broward County. Recently, to meet growing demand by public and internal customers for increased transparency and additional services, the division began investigating the templates and applications available from the ArcGIS for Local Government Resource Center.

GIS manager Ian Wint and his staff discovered that simply by configuring the templates, the city could rapidly expand its collection of mapping applications in a fraction of the time that it would take if the city developed web maps from scratch.

The city's aging Parks and Recreation application, based on ArcIMS technology, was selected as the initial project. Residents value the park system, and proximity to a neighborhood park positively affects property values. Within a week, Fort Lauderdale's GIS division had migrated its old Park and Recreation database schema over to the new information model and stood up the Park and Recreation Finder, which lets residents find nearby parks, either by address or current location or by activity (such as basketball).

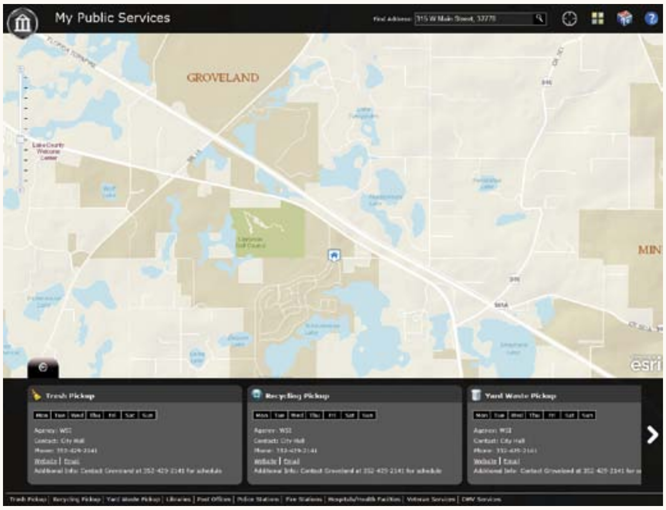
Inspired by that fast turnaround, staff members began replacing other dated and slow-running web maps. Rather than moving everything over at once, the templates from the Resources Center allowed Fort Lauderdale to take a one-at-a-time approach. "The gradual method of improving our services with increased quality and speed was a huge appeal," said Wint. "The templates allowed us to add new services to our application gallery at a comfortable pace without the risk of biting off more than we could chew."

Since publishing its Park and Recreation Finder application, Fort Lauderdale GIS has added several new ArcGIS for Local Government-based applications to its existing web mapping application gallery, and more applications are planned.

Minimizing Development Time

Lake County, Florida, needed a better way to inform both new and part-time residents about county services. It is the home of more than 1,400 named lakes and more than 300,000 residents. Although some information had been available on the county's interactive map, the GIS division wanted to provide applications that addressed specific needs.

Lake County's GIS programmer/systems coordinator Keyetta Jackson heard about Esri's local government preconfigured



← Using Lake County's My Public Services application, residents can find information on everything from trash pickup to nearby health facilities.

applications at a local user group meeting. She downloaded the My Government Services template from ArcGIS Online and, after updating the county database to conform to Esri's Local Government Information Model, had a new Public Services application published on Lake County's website in less than a week.

"The Public Services page works better than we imagined," said Jackson. "It provides our customers with a nice-looking interactive display, intuitive controls, and a scrolling window showing all the available services." Depending on the type of service, each tab includes contact information, driving distance, and links to websites of the particular service provider.

"The beauty of the template is that it minimizes development time," said Jackson. "I would have spent hours just making design decisions and developing my own code." Developers can still modify the modules for a more custom appearance as they see fit. For instance, Lake County's page also displays nongovernmental services, such as hospitals and health facilities.

Lake County next added the Parks Finder application and plans to eventually create other specialized maps based on the applications in the Esri Local Government Maps and Apps Gallery. The gallery contains a variety of focused web maps. "The Public Services and Parks and Rec pages are just the beginning," said Jackson. "Being able to individually improve our services with existing assets is a huge benefit."

Eliminating Calls

Voters need to know where to vote. With an estimated population of more than 180,000, that meant a lot of calls to the Cabarrus County Board of Elections office. To reduce the number of calls, members of the GIS staff at Cabarrus County, North Carolina, implemented Esri's Polling Place Locator template.

While visiting the county, Esri developers had demonstrated the templates, available at no charge from the ArcGIS for Local Government Resource Center, that can be used to rapidly create focused applications. With major elections approaching, the polling place locator—which helps voters by identifying their polling place—seemed an obvious choice as the first application to implement.

"Within a week of discussing how we could improve our service, we were demonstrating the completed application to our Board of Elections," said Zachary Woolard, GIS administrator for the county. "Starting from the ground up with no framework or guidance would have taken much more time and considerable effort to get the data to display on the map." The HTML-responsive design of the Polling Place Locator template also allowed Cabarrus County to deploy the application in the iTunes and Google Play stores.

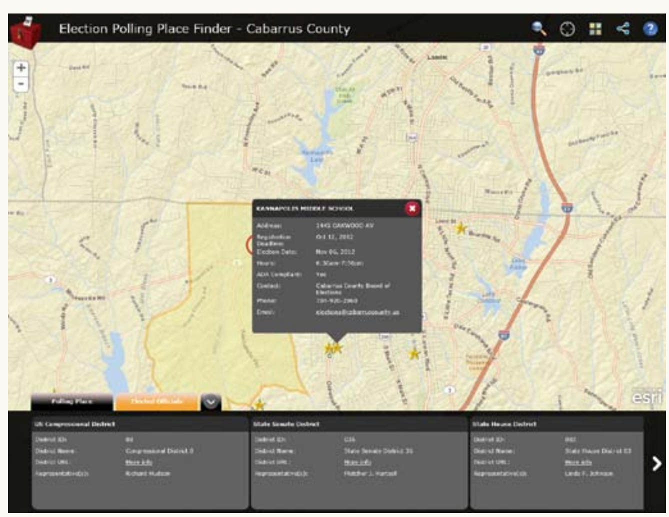
Since publishing the application in 2012, the county has experienced a significant drop in the number of phone calls received by the Board of Elections. The application, which was both successful and relatively easy to stand up, encouraged the county to publish the Parks Finder application and a maps and applications gallery page.

Woolard advises developers who are considering implementing these templates to learn the Local Government Information Model schema. "Studying the requirements of the local government model pays off in getting quick project turnarounds," he said. "That's fairly easy to do compared to starting a project from scratch. From there, it's just plug and play."

Getting Results

All three local governments created polished, responsive applications that meet specific needs in a short time frame. To see what resources are available and get started, visit resources.arcgis.com/content/local-government. To learn how the ArcGIS Data Interoperability extension can streamline migration to the Local Government Information Model, see "Making Data Fit the Community Maps Program: Migrating to the Local Government Information Model" in the Winter 2013 issue of *ArcUser.*

↓ Cabarrus County's Election Polling Place Finder gives the location, hours, accessibility, contact, and other information for each polling place, eliminating countless phone calls to the offices of the Board of Elections.



Paperless Inspections

Faster, more accurate, and spatially enabling

By Kurt Hassy, GIS Analyst
Santa Clara Valley Water District, San Jose, California

A pilot project by a northern California water district developed a GIS-based paperless process for inventorying and managing its assets that is simple for field staff and integrates with existing management systems.

The Santa Clara Valley Water District (SCVWD) manages an integrated water resources system. It ensures the supply of clean, safe water and provides flood protection and stewardship of streams on behalf of Santa Clara County's 1.8 million residents. The district effectively manages 10 dams and surface water reservoirs, three water treatment plants, a state-of-the-art water quality laboratory, nearly 400 acres of groundwater recharge ponds, and more than 275 miles of streams.

The District-wide Asset Management Unit (DWAMU) started a pilot program to help SCVWD manage assets along the streams and rivers under its care. Assets include the creek itself, bank lining, levees, outfalls, and many other waterway structures, both manmade and natural.

DWAMU assigns each asset a Business Risk Exposure (BRE) value, which is a numeric value derived from two other values: the consequence of failure (a relatively static number based on economic, environmental, and other similar factors) and the probability of failure (a number given to an asset during a condition assessment of that asset).

DWAMU wanted field staff not only to inventory assets in the field but also to locate and note problems associated with those assets. For example, field staff might document an eroded 20-foot-long section along a 1,000-foot-long bank lining. Both the asset (bank lining) and condition (eroded section) records need to be related. Even if this condition is corrected, an area may be inspected from year to year. Photos would need to be attached to these records to document conditions.

Paper spreadsheets, photos, and paper maps were initially used for field data collection. However, lots of asset data already existed in SCVWD GIS datasets, and DWAMU was interested in using mobile software and hardware for data collection to go paperless and help workers orient themselves in the field.

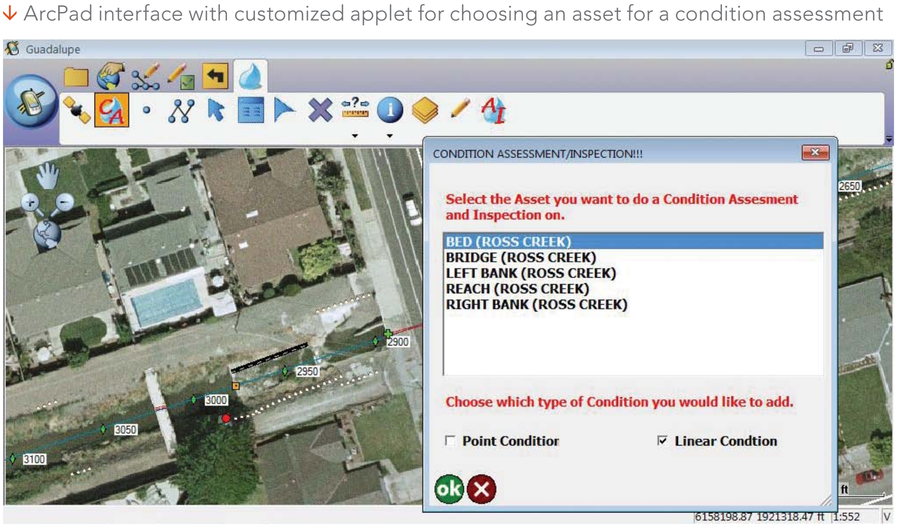
By managing asset data in IBM's Maximo, a computerized maintenance management system (CMMS), the district could leverage Maximo's reporting, preventive maintenance, work order, and asset management capabilities. This would allow SCVWD to track an asset's life cycle and monetary costs for use in reports and maintenance scheduling.

GIS and Maximo analysts sat down with DWAMU and field staff to gather the requirements for the data they wanted to collect. A geodatabase was developed with tables and coded domain values that would standardize data collection and apply codes already used in Maximo and other legacy systems. The relationships between assets, condition assessments, and inspections soon became apparent. One asset can have many conditions, and one condition can have many inspections.

Another DWAMU requirement was the use of an asset hierarchy structure. Each SCVWD flood control zone contains a certain number of creeks. Each creek has defined reaches. Each reach has a left bank, right bank, and bed. A left bank, right bank, or bed may have child assets such as bank lining, bed lining, or weirs. Collection of these child assets depends on whether an individual child asset warrants management or not.

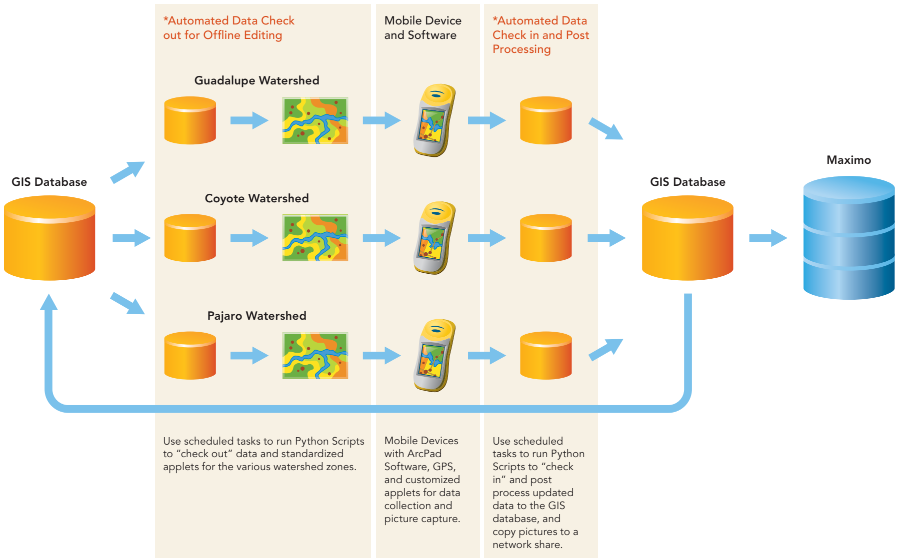
Finally, DWAMU needed both asset and condition assessment data to sync with Maximo. All data, including photos of conditions and assets, should be easily uploaded and postprocessed so that field staff would be comfortable using the system.

↓ ArcPad interface with customized applet for choosing an asset for a condition assessment



Implementing

After looking at these project requirements and available software products, DWAMU decided to use Esri's ArcPad mobile field mapping and data collection software. ArcPad was chosen because it can use multiple GIS layers and is compatible with equipment that had already been purchased for the project. ArcPad is also relatively easy to



↑ Mobile data collection workflow

customize. It can be used offline or online, can be used for editing existing GIS features and related nonspatial tables in the field, and allows photos to be attached to records.

District GIS analysts were given Trimble Yuma tablets, digital cameras with Bluetooth capabilities, and a few ArcPad licenses to develop a single solution that met all requirements. Staff members were trained to use ArcPad by GeoMobile Innovations Inc., a training and consulting company out of Corvallis, Oregon. The company also helped GIS analysts customize the ArcPad interface.

Once trained, GIS analysts could modify code and develop automated processes that made the system easy for field staff to use. GIS analysts leveraged ArcPad's ability to relate features to tabular records to build inspection record forms. Field staff record all scoring and measurement values in the inspection forms. This is also where the probability-of-failure scores are inserted as well as pictures.

A Simple Process

The process for a typical creek inspection is composed of just a few steps.

After getting oriented in the field using the GPS and background GIS layers, the user clicks on the map near the location of an asset being inspected and chooses the correct asset for assessment.

The user records the location of any condition related to that asset, either by digitizing it or using GPS data capture, and chooses the condition assessment category.

The user adds an inspection, takes measurements, scores the condition, and adds comments if necessary.

The user takes a picture, sends the picture to the Trimble Yuma using Bluetooth, and attaches that picture to the inspection record.

The asset inventory is very similar. In fact, the user can inventory an asset and do a condition assessment on the fly and preserve data integrity through the use of unique identifiers and a series of built-in validation steps for each record.

Postprocessing

GIS analysts used ArcGIS ModelBuilder, Python scripting, ArcPad Studio, and Visual Basic to create a series of automated processes that ensure data integrity and simplify the task of checking data in and out.

The ArcPad templates created for each flood control zone include customized data collection forms, along with the code and background datasets used, so every flood control zone project looks the same. Users simply pick the flood control zone they are working in for that day. Everything they need is transferred to the mobile device for offline editing.

Back in the office, the user can perform QA/QC on the data before checking it in. When the data is ready, the user docks the tablet and connects to the network. The user simply chooses which flood control zone worked in that day, and data and pictures are automatically copied to the network. Updates are seen the next day.

At night, a Python script runs a check-in to transfer the data into an Oracle database using ArcSDE. Next, a number of Python scripts update picture paths and extract and populate waterway linear referencing measures as well as coordinates. After postprocessing, Python scripts run again to check out a fresh set of ArcPad projects for use the next day. Once updates are in the enterprise geodatabase, an application developed by activeG, LLC, syncs asset and condition data with the correct Maximo tables.

Summary

Since this project went live in July 2012, more than 4,000 inspection records have been captured in the field, and more than 5,000 assets have been identified. SCVWD field staff members now perform paperless inspections in a uniform manner that saves time by avoiding hand entry of data into legacy systems. By adding a geographic component to this data, SCVWD managers and engineers can see patterns and perform spatial analyses using data they would previously have seen only in tabular format. The system also allows work to be prioritized in a seamless fashion while managing watershed assets. For more information, contact Kurt Hassy at krhassy@live.com.

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Show Off

Make GIS resources more visible and valuable

By Monica Pratt, *ArcUser* Editor

ArcGIS Online can become the platform for your organization's GIS resources. As the administrator for your organization's ArcGIS Online site, you can showcase the GIS resources your organization has developed so it can get a greater return from its investment in them. Here are some suggestions for doing just that.

Make Map Services More Valuable

Using ArcGIS Online with ArcGIS for Server makes your published map services more available and more valuable to your entire organization. By registering the map services you created in ArcGIS for Server with ArcGIS Online, non-GIS-savvy members of your organization, as well as GIS professionals, can create web maps.

Now map services depicting voting districts, property boundaries, parks, and building permits can become live, authoritative content for online maps that answer questions for your organization. These valuable services might not be well known internally, but by using ArcGIS Online, you can deliver the most current information to desktops, tablets, or smartphones for a new group of users in your organization.

You add ArcGIS for Server services to ArcGIS the same way you would add KML and Open Geospatial Consortium, Inc. (OGC), Web Map Service (WMS) resources—by referencing their REST endpoint (URL). After signing in to your organizational ArcGIS Online account, open My Content and click the Add Item button. In the Add Item window, choose On the Web and choose ArcGIS for Server web service.

Type in the REST URL for the service (e.g., http://myServer/map/wms/myService). Locate the REST URL for an ArcGIS for Server service by going to the Services Directory page (http://<server name>/<ArcGIS for Server instance name>/rest/services), browsing to the service you want to share, and copying the URL from the browser's address bar. If you are adding a secured ArcGIS for Server service, enter its user name and password and check whether these credentials will be stored with the service item. Type a title for the services as well as tags. You can click Choose from your tags to choose from the list of tags previously used. Click the Add Item button. Once the map service is added, it appears under My Content, where you can edit its item details and share it.

Status Check

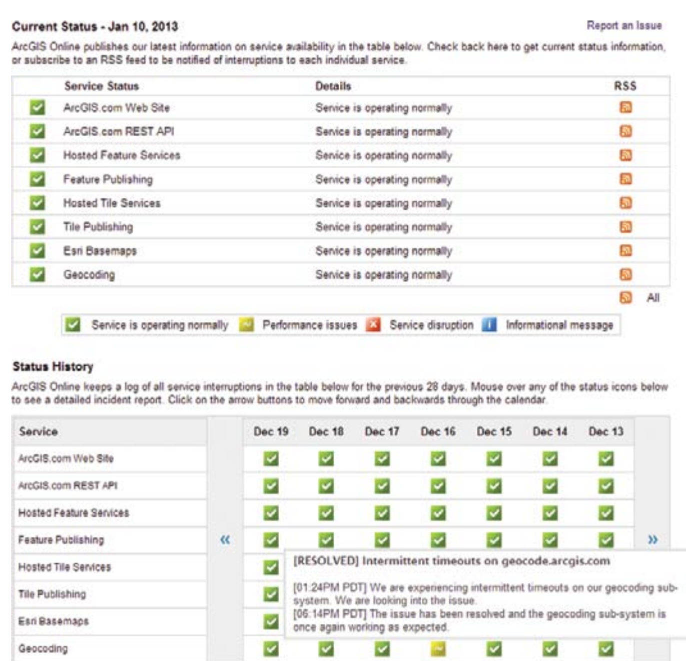
You and your users can monitor the health of the ArcGIS Online system using the ArcGIS Online Health Dashboard (status.arcgis.com) to keep abreast of any changes that might impact your work. This dashboard provides the latest information on the status of services, both current and historical. Messages indicate whether services are performing normally, have performance issues, or are disrupted. Hovering over the symbol for each state will give you more information on the service's state.

Sell Your Home Page

The home page is the first thing your users see when they come to your ArcGIS Online site. Make it interesting and easy for them to find resources. For ArcGIS Online sites that are accessed by people in your organization who may be unfamiliar with GIS and the resources available, use the description section to tell them what they can do and link them to any tutorial or help information you might provide. Alternatively, the description section can be used as a bulletin board for announcements.

You can change the appearance of your home page by customizing the site banner, the featured content ribbon, and gallery contents to make the site both attractive and easily comprehended. A custom banner that incorporates a photo or graphic image will make your home page more appealing. Use a graphics program to make a custom banner that is 960 pixels wide by 180 pixels tall. Go to the Banner section of Home Page Settings to add it to the site.

You can highlight your newest or most useful site content in the gallery ribbon on the home page. Create a group for the content you



↑ Monitor the health of the ArcGIS Online system using the ArcGIS Online Health Dashboard (status.arcgis.com).

```
<div style="width: 960ox;
background: url(http://www.esri.com/agol/logo.jpg);
height: 470px">
<div style+"margin-top: 180px; margin-left:40px;
float: left;margin-right: 20px">

a href="http://www.esri.com" style="background: #65a9d7;

/* border around the button
*/

border-bottom:#fff 1px solid;
border-left: #fff 1px solid;
border-top: #fff 1px solid;
border-right: #fff 1px solid;

/* spacing around the text
*/


border-bottom: 7px;
border-left: 15px;
border-top: 7px;
border-right: 15px;

/*text
*/
font-family: arial, helvetica, sans-serif;
color: white;
font-size: 14px;
font-weight: bold;
vertical-align: middle;
text-decoration: non;
text-shadown: rgba(0,0,0,.4)

target= _self"> Esri Home</a>
</div>
</div>
```

↑ Listing 1: Creates a button that links to the Esri home web page

want to feature and add that content to the group. Select this group by going to the Featured Content section in the Home Page Settings and choosing that group from the drop-down list.

One way to add visual interest to the ribbon is by placing a larger image that covers the regular banner area and the area behind the ribbon. Create an image 960 pixels by 470 pixels that will fill the banner space and the area behind the ribbon. Under the Banner section of Home Page Settings, click the HTML radio button, click the Insert Image button, and enter the URL for the image location in the dialog box.

If you know a little about HTML, you can also add buttons and other elements to your home page. With the HTML radio button clicked, click the View HTML Source button. Now you can enter HTML to create a button that opens a website, a map, a group, or anything else that can be accessed via a URL. Listing 1 shows the HTML that creates a button that opens a web page.

Find It Fast with Thumbnails

Thumbnails not only give users of your ArcGIS Online site a taste of the associated item, they can whet a visitor's appetite. To make your map, service, or application more alluring, you can improve on the default thumbnail with a custom one that might include an image.

Thumbnails can provide context (where in the world) and scale (city, state, or country). They can also indicate the map's subject (land use, geology, transportation) or content source (like a Twitter feed). Thumbnails for map applications can indicate the kinds of tools that are included. They can also feature a logo or other graphic that brands content from your organization or department.

Sometimes a photo or icon can provide users with a better idea of what the map service will provide. The use of icons identifying an item's type as a layer, map, or application can be especially helpful as the number of map services on your ArcGIS Online site increases. Simple visual cues supplied by consistent use of these icons can make it easier for users to find what they need, which will make them more likely to use your site.

Using any graphics program, create a replacement thumbnail image for the default thumbnail that is 200 pixels by 133 pixels. Save it as a PNG, JPEG, or GIF file. Click the associated map service in the My Content page and click Edit. Click the existing thumbnail and browse to the replacement you created.

Keep It Fresh

As more people in your organization use your ArcGIS Online site, you can tweak contents and appearance to continue meeting their needs and engendering interest in your growing collection of offerings.

AVOID GUI HEADACHES

A case for scripting geoprocessing tools

By Drew Flater,
Geoprocessing Team

> Sometimes the repetitive nature of a task can make using a tool dialog time-consuming and inefficient.

One example would be selecting a large number of fields for the Statistics Field(s) parameter of the Summary Statistics (Analysis) tool. With this parameter, you select fields from the input table that you want to summarize on (e.g., calculate the mean or sum of a numeric field). While this interaction for a single field is quick and easy, imagine if you had to do this for hundreds of fields in a demographic dataset. Repeatedly picking a single field and the corresponding statistic is time-consuming, inefficient, and frustrating.

Luckily there is more than one way to run a geoprocessing tool. One of those—Python scripting—is a very good way to make repetitive tasks easy. Let's consider how Python scripting can accomplish the task of getting a sum statistic for every numeric field in a dataset.

The ArcGIS scripting package ArcPy has functions for doing all kinds of GIS tasks. One, the ListFields function, is especially important for this scenario. The ListFields function, as its name suggests, returns a list of all the attribute fields in a specified dataset. Listing a dataset's fields and checking that the field type is numeric are key steps in scripting this task.

Another key step in writing the script is constructing the Statistics Field(s) parameter with the correct Python syntax. In a Python script, the Statistics Field(s) parameter is best represented by a list of lists. You can think of the outer/main list as the full Statistics Field(s) parameter table in the tool dialog box and each sublist as a single row in that table.

Just like the Summary Statistics (Analysis) tool dialog box, the Statistics Field(s) parameter table has two columns. The first column is for the field name, and the second column is the statistic to calculate for that field.

In Python scripting, each sublist (row) has two elements that correspond directly to the columns in the parameter table. The sublists are constructed by putting together the field name and sum statistic type while iterating through the list of fields. But remember, this is only done after checking whether the field type is numeric, because it is impossible to calculate the Sum of other types such as text or dates.

As Listing 1 illustrates, in just a few lines of code, this repetitive and time-consuming task has been automated.

Python scripting is one of several ways to run ArcGIS geoprocessing tools. Scripting a geoprocessing tool can often help work around problems that occur because a tool dialog parameter is tricky or requires repetitive action.

You can use the powerful and wide-ranging functions available in ArcPy to help you with many GIS tasks, such as using the ListFields function to return a list of all attribute fields in a dataset, which can be subsequently looped through. Using ArcPy functions together with geoprocessing tools can help you be more productive and avoid those awful GUI headaches. Learn more about the ways Python can make your life easier at Python for ArcGIS on the ArcGIS Resources site (resources.arcgis.com).

```
# Script that runs the Summary Statistic tool to Sum every numeric attribute
# of Census tracts by unique County IDs
import arcpy

# Local variables
intable = "C:/Data/f.gdb/CensusTracts"
outtable = "C:/Data/f.gdb/CensusTracts_SumStats_Counties"
casefield = "CNTY_FIPS"
# Create a new empty list to store pairs of field + statistic
stats = []

# Loop through all fields in the Input Tablew
for field in arcpy.ListFields(intable):
   # Just find the fields that have a numeric type
   if field.type in ("Double", "Integer", "Single", "SmallInteger"):
      # Add the field name and Sum statistic type as a list
      # to the list of fields to summarize (makes a list of lists)
      stats.append([field.name, "Sum"])

# After looping, the Statistics list of lists will look like
# [["HOUSEHOLDS", "Sum"], ["MALES", "Sum"], ...]

# Run the Summary Statistics tool with the Statistics list of lists
arcpy.Statistics_analysis(intable, outtable, stats, casefield)
```

↑ Listing 1: Python script automating parameter input for the Summary Statistics (Analysis) tool

新年快樂

The Year of the Developer

New program rolls out in 2013

Developers who use Esri technology will benefit from a multifaceted initiative that includes API improvements, a better app management experience, documentation, a new marketplace where developers can make their apps available for sale, and a one-stop website with all the resources developers need to get started. Esri will roll out these innovations over the first half of the year.

The new developers.arcgis.com website will be unveiled at the Esri International Developer Summit March 25–28, 2013, in Palm Springs, California. This website will provide code samples for JavaScript, Flex, Silverlight, Android, iOS, and Windows Phone, along with documentation, and a system for registering and monitoring apps.

A new ArcGIS Online developer pricing and licensing model will make it easy for developers to subscribe to ArcGIS Online on a monthly basis. Various plans give developers the flexibility to choose the number of credits based on their anticipated volume for a given month. Developers can then use their ArcGIS Online subscription to leverage features such as geocoding and place search, directions and routing, ready-to-use basemaps, and data query in the cloud. Along with this new developer licensing of ArcGIS Online, Esri will also begin offering a 90-day developer trial of ArcGIS Online. This trial will be available from the developers.arcgis.com website.

Later this year, Esri will make available a marketplace where developers can list apps for sale, manage their listings, and monitor usage. In the second quarter of 2013, developers can also look forward to having more tools available including GeoTrigger technology. GeoTriggers let developers build geofences into their apps that can be triggered based on time of day, speed, or position. This technology will be available as part of developers' ArcGIS Online subscriptions.

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ArcGIS for Server 101

Understanding architecture, deployment, and workflows

By Derek Law, Esri Product Manager

This article is for GIS managers and analysts who want an understanding of the fundamental concepts of ArcGIS for Server and its capabilities. It provides a general overview of ArcGIS for Server and discusses key features, architecture, and implementation. It refers specifically to the ArcGIS 10.1 for Server release.

The paradigm for GIS work has evolved over the last few decades. In the 1980s, GIS work was typically done on computer workstations. In the late 1990s to early 2000s, personal computers were more common, and GIS work was performed across an organization's internal network with the client/central server IT model. In recent years, the explosion of the Internet, mobile device usage (e.g., smartphones and tablets), and the desire to share and collaborate over the web have dramatically changed how GIS work can be done. Many organizations now have business workflows that require sharing GIS resources over the web, specifically by making them available as web services. A web service is a software function available at a network address over the web.

In ArcGIS for Desktop, you create, edit, analyze, and manage GIS resources such as spatial data, maps, and geoprocessing tools. ArcGIS for Server enables you to take these GIS resources and share them as web services. Web services are easily accessible over the Internet and can be consumed by clients such as smartphones, tablets, desktop applications, and web applications.

If you register and share your ArcGIS for Server web services with ArcGIS Online, other users can discover and use them, greatly expanding the number of end users who can consume and leverage your GIS resources. Using ArcGIS for Server to share GIS resources over the web empowers an organization and its members, enabling them to make better decisions because everyone can access, collaborate, and work with the same geographic knowledge. ArcGIS for Server includes a GIS Server, Web Adaptor, and ArcSDE technology.

GIS Server

This is the core software that installs on a server machine and enables an ArcGIS Server site to be created. An ArcGIS Server site is an instance of ArcGIS for Server that can share GIS resources as web services.

Web Adaptor

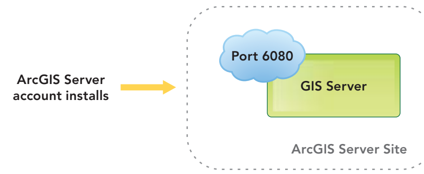
This is separate software that you can install into a third-party web server (e.g., Microsoft IIS, IBM WebSphere, Oracle WebLogic). The Web Adaptor is a lightweight application that allows you to integrate ArcGIS for Server with your organization's existing web server architecture.

ArcSDE Technology

This is separate software that you can install to manage connections to your enterprise geodatabases.

Architecture

When you install ArcGIS for Server, users can access it immediately by making web service requests through port 6080



↑ Figure 1: ArcGIS for Server architecture

(by default). An installation of ArcGIS for Server is called an *ArcGIS Server site*. An ArcGIS Server site can consist of a single machine (Figure 1) or be composed of several machines (a multimachine deployment). ArcGIS for Server is available for Windows or Linux operating systems, and can be either an on-premises solution or part of a cloud solution. Regardless of how it is physically deployed, its capabilities are the same.

When installing the GIS Server software on a machine, you must create or designate a single operating system level account called the *ArcGIS Server account*. This is the account used by ArcGIS for Server behind the scenes to execute its operations. Therefore you need to give this account permission to access and read from your data folders. After the installation, you can choose to either create a new GIS site or join an existing GIS site. When you create a new ArcGIS for Server site, you are creating a new ArcGIS Server instance on the machine. The option to join an existing GIS site will add the machine to an existing multimachine ArcGIS for Server site deployment.

Creating a new ArcGIS Server site requires a *primary site administrator* account. This is

Account	Hierarchical tier	Function	Permissions	Usage
ArcGIS Server account	Operating system	Install GIS Server and execute server operations	Read and write to data folders and certain ArcGIS for Server installation folders	Used by GIS Server behind the scenes
Primary site administrator account	ArcGIS Server site	Configure and manage site	Administrator role in site	Used by site administrator

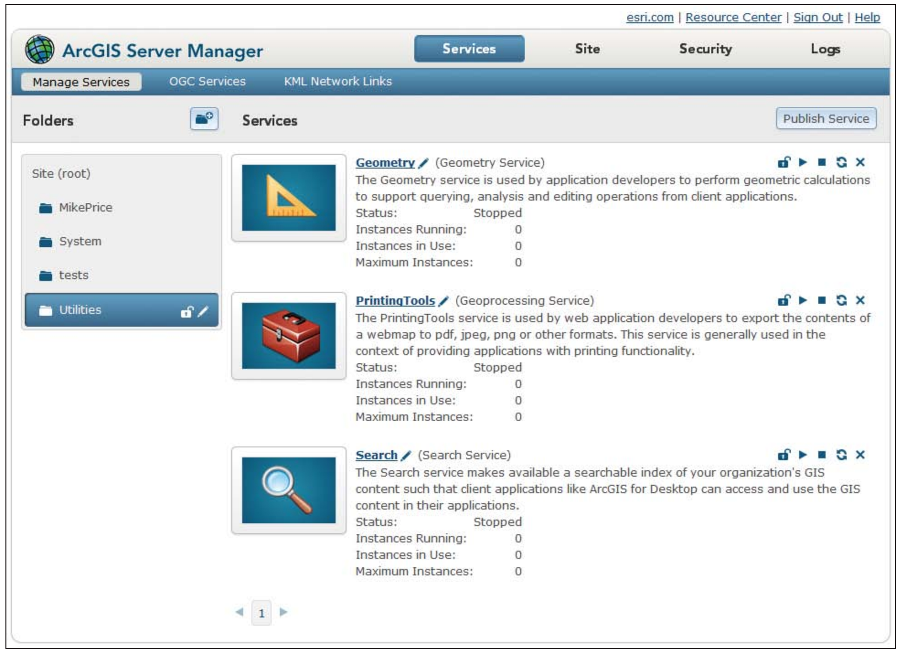
↑ Table 1: The ArcGIS for Server account versus the primary site administrator account the default administrative account for managing the site. The primary site administrator account is used to initially log in to and configure the new site. *Note that this account is a separate and different account from the ArcGIS Server account you use for the GIS Server software installation.* The primary site administrator account only exists in the ArcGIS Server site and is not an operating system account like the ArcGIS Server account. Table 1 compares the two accounts and their roles.

An ArcGIS Server site has three main access points: ArcGIS Server Manager, the Services Directory, and the ArcGIS Server Administrator Directory.

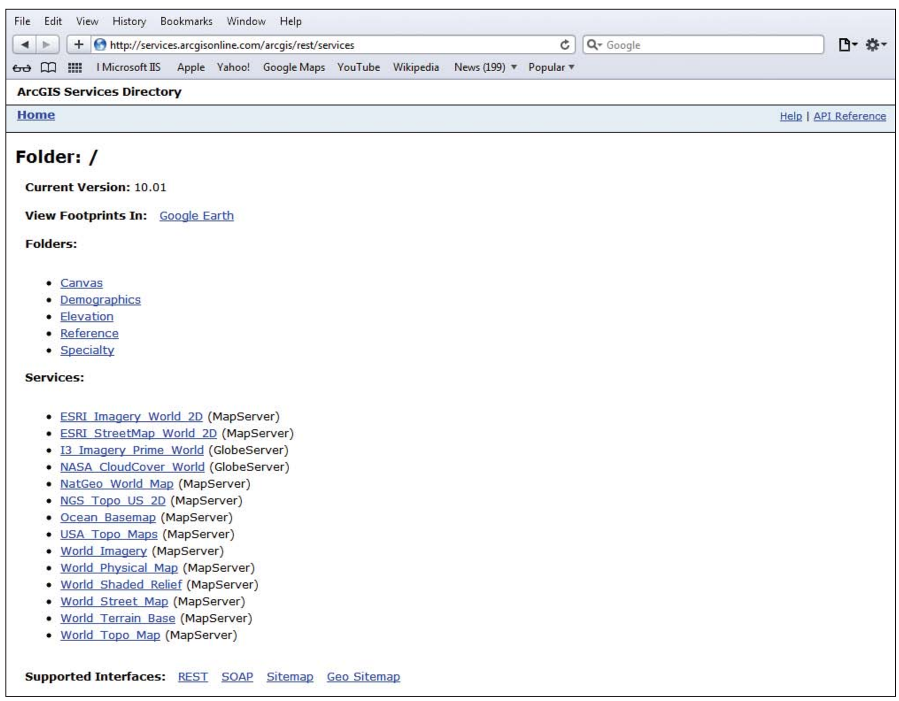
ArcGIS Server Manager is a web browser-based application that enables you to administer the site by managing web services, configuring site properties (e.g., manage directories, set security), and querying and viewing logs (Figure 2a). The primary site administrator account or another administrator connection is needed to use all the functions of ArcGIS Server Manager. Publisher connections can log in with limited functionality. The different types of connections that can be made to ArcGIS for Server will be discussed later.

The Services Directory is a web browser-based view of all the GIS resources that are available from the site (Figure 2b). A GIS resource, such as a map, geoprocessing model, or locator, is shared from the ArcGIS Server site as a web service. These web services communicate through a Representational State Transfer (REST)-based architecture. You can request information and actions from the server by structuring your request URLs according to a defined format. As you navigate the Services Directory, you can observe your browser's address bar to see how different URLs are used to retrieve information through REST.

ArcGIS Server Administrator Directory is commonly called the REST Admin API. It is a web browser-based view of the ArcGIS Server site's configuration settings (Figure 2c). It provides a programmatic endpoint to administer the site. You can write automated scripts (in Python, for example) to remotely access and configure the site. The primary site administrator account or another administrator connection is needed to log in and work with this access point. Publisher connections can access it with limited functionality.

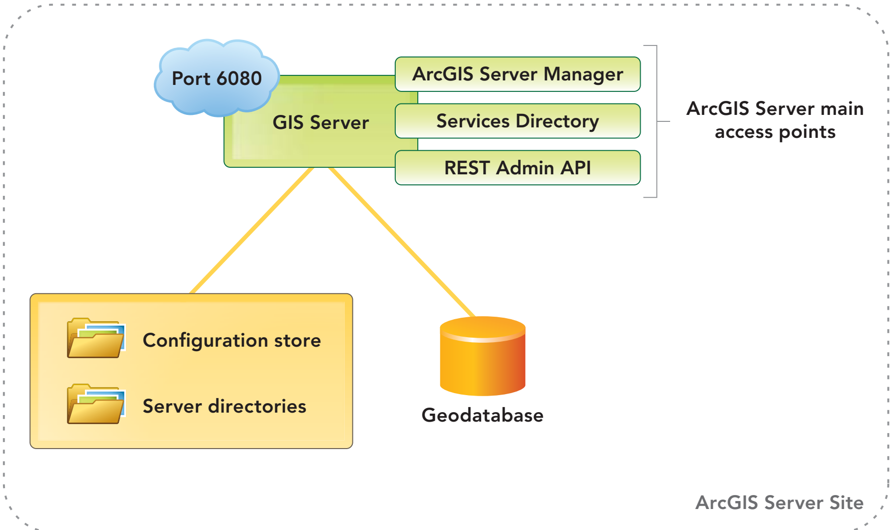


↑ Figure 2a: ArcGIS for Server main access point: ArcGIS Server Manager



↑ Figure 2b: ArcGIS for Server main access point: the Services Directory

↑ Figure 2c: ArcGIS Server Administrator Directory



↑ Figure 3: ArcGIS for Server architecture (single machine deployment)

In addition to the GIS Server, two other essential components of an ArcGIS Server site are the *configuration store* and the *server directories* (Figure 3). The configuration store is a folder that contains all the main properties of the site (e.g., information on its web services, users, roles, data, and security settings).

The server directories consist of four subdirectories: Cache, Jobs, Output, and System.

- The Cache directory stores a collection of pregenerated image tiles that are used by cached map or globe services for faster display. Cached services often require large amounts of storage on disk, so ensure your Cache directory is large enough to handle the tiles created during the caching process for your services.
- The Jobs directory stores files needed by geoprocessing services such as temporary files, information about current processes, and their results.
- The Output directory is for temporary files needed by the server.
- The System directory is used to maintain information for the site such as the status of services, machines, and database connections. *Files within this directory should not be manually modified or deleted.*

Both the configuration store and server directories are critical to an ArcGIS Server site. It is strongly recommended that both are created in a redundant storage location if the site is supporting mission-critical applications. If you're creating a multimachine ArcGIS Server site, the configuration store and server directories must reside in a network share that is visible to all GIS Server machines.

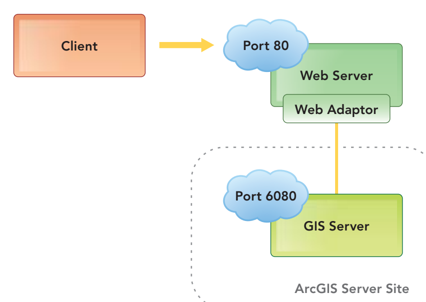
Another common component in an ArcGIS Server site is a multiuser geodatabase—the central data storage and management framework for the ArcGIS platform. Storing your spatial data in the geodatabase enables you to apply custom business rules and relationships, define advanced geospatial relational models (e.g., topologies, geometric networks, and network datasets), and support many multiuser workflows. A multiuser geodatabase is created inside a DBMS using ArcGIS geoprocessing tools.

Web Adaptor

When you are ready to deploy your ArcGIS Server site as an on-premises production environment, you should install the Web Adaptor. The Web Adaptor connects ArcGIS for Server with your enterprise web server. This configuration provides many benefits.

- The web server can host web applications, such as the ArcGIS Viewers for Flex and Silverlight, that use your GIS services.
- It provides a single endpoint into the site.
- You can expose your ArcGIS Server site through your organization's standard website and pvort instead of the ArcGIS for Server default port of 6080.
- It provides more security by blocking access to ArcGIS Server Manager and the ArcGIS Server Administrator Directory from the view of external users.
- It enables you to leverage the security and logging functionality of the web server.

The Web Adaptor facilitates communication between the web server and the ArcGIS Server site. ArcGIS for Server clients access GIS web services by sending requests to →



↑ Figure 4: ArcGIS for Server architecture (single machine deployment)

	Function	ArcGIS Server site access points
Administrator	Administers ArcGIS Server site	• ArcGIS Server Manager—All functionality • Services Directory • ArcGIS Server Administrator Directory—All functionality
Publisher	Publishes GIS web services on ArcGIS Server site	• ArcGIS Server Manager—Limited functionality • Services Directory • ArcGIS Server Administrator Directory—Limited functionality
User	Consumes GIS web services	• Services Directory only (if available)

↑ Table 2: Types of connections to ArcGIS for Server

	Functionality	Notes
Map service	Makes a map document available as a web service	
Cached	Contains prerendered images of the data content for faster display	Recommended for static data
Dynamic	Data generated on the fly on a per request basis	Recommended for most operational data
KML	Makes data available in the Keyhole Markup Language format supported by Google Earth and many other geobrowsers	
OGC	Makes data available in an open, internationally recognized, standard format (following the Open Geospatial Consortium, Inc., standards)	Supported formats include WCS, WFS, WMS, and WMTS.
Feature service	Streams vector feature geometry and attributes from a map or layer. The features are drawn by the client application, not the server. Typically used for web editing workflows.	Commonly associated with a map service
OGC	Makes data available in an open, internationally recognized, standard format (following the Open Geospatial Consortium, Inc., standards)	Supported formats include WCS, WFS, WFS-T, WMS, and WMTS.
Geoprocessing service	Enables geoprocessing through a web service (e.g., web printing)	Can only be published after the functionality has been successfully executed in ArcMap
OGC	Makes data available in an open, internationally recognized, standard format (following the Open Geospatial Consortium, Inc., standards)	Supported formats include WPS.
Image service	Enables fast serving of imagery and rasters as a web service	
Cached	Contains prerendered images of the data content for faster display	Recommended for static data
OGC	Makes data available in an open, internationally recognized, standard format (following the Open Geospatial Consortium, Inc., standards)	Supported formats include WCS, WMS, and WMTS.
Geocode service	Enables address matching functionality available as a web service	
Geodata service	Exposes the ability to perform geodatabase replication operations, make copies using data extraction, and execute queries in the geodatabase	Used with file and multiuser geodatabases
OGC	Makes data available in an open, internationally recognized, standard format (following the Open Geospatial Consortium, Inc., standards)	Supported formats include WCS and WFS.
Network Analysis service	Performs transportation network analysis operations such as finding the closest facility, the best route for a vehicle, the best routes for a fleet of vehicles, locating facilities using location allocation, calculating an origin-destination cost matrix, and generating service areas	Requires the Network Analyst for Server extension. Works with network datasets
Geometry service	Helps client applications do geometric calculations such as buffering, simplifying, calculating areas and lengths, and projecting	Also used by the ArcGIS Web Mapping APIs to create and modify feature geometries during web editing
Schematics service	Enables schematic diagrams to be accessed through a web service	Requires the Schematics for Server extension
Search service	Makes available, on the local network, a searchable index of your organization's GIS content.	Typically used in large enterprise deployments where GIS data is spread throughout multiple databases and file shares
Globe service	Makes a globe document available as a web service	Typically used for 3D data
Mobile data service	Allows an ArcGIS Mobile application to gain access to the source data of a map document through a web service	
Workflow Manager service	Exposes workflow management capabilities as a web service	

↑ Table 3: ArcGIS for Server can share different types of GIS resources as web services.

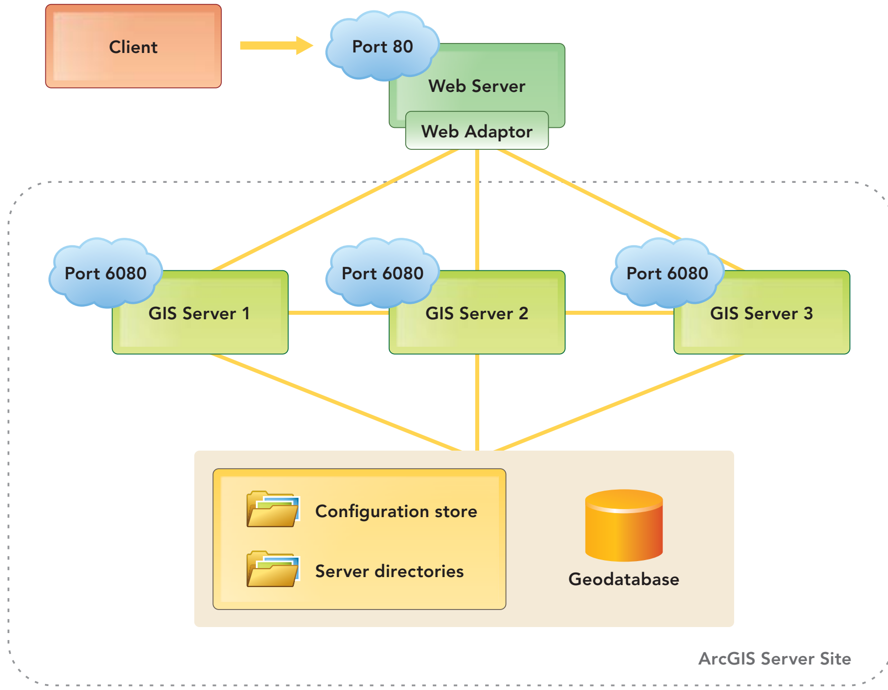
the web server; the request is then passed to the Web Adaptor and on to the GIS Server. A Web Adaptor can only be configured for a single ArcGIS Server site, but a site can support multiple Web Adaptors. In other words, an ArcGIS Server site can be configured to have many access endpoints by using multiple Web Adaptors.

Multimachine ArcGIS for Server site deployments

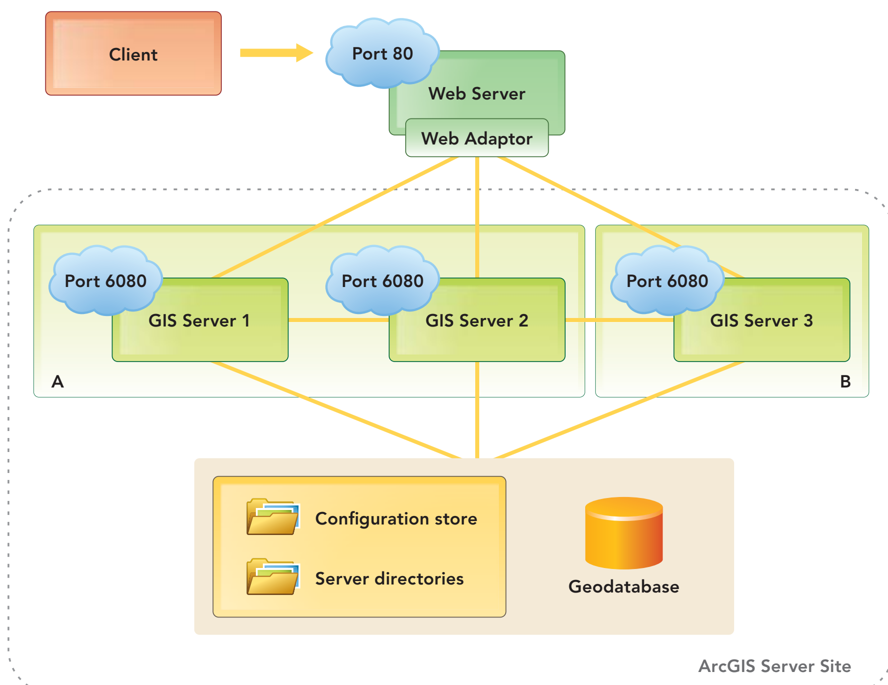
ArcGIS for Server fully supports large IT enterprise systems. Multimachine site deployments are applicable for organizations that have business workflows with high capacity requirements. In a multimachine site, every participating GIS Server machines has ArcGIS for Server installed (Figure 5). For example, in a site that has three GIS Servers, if one machine becomes unavailable, the site will still function properly because there are two redundant GIS Servers. The Web Adaptor acts as the single point of entry into the site. Communication occurs between GIS Servers, and every GIS Server must have access to the ArcGIS Server site's configuration store, server directories, and data sources for the web services (e.g., multiuser geodatabase). You could add as many GIS Servers to the site as are needed to meet your business requirements.

In multimachine sites, GIS Servers can also be grouped into a cluster. A cluster is a logical grouping of machines with the same hardware specifications Figure 6). Each cluster can be configured to run a dedicated subset of web services. For example, you could create one cluster to run map services (shown as n Figure 6 as GIS Servers 1 and 2 in cluster A) and another cluster with higher processing power to run geoprocessing services (shown as in Figure 6 as GIS Server 3 in cluster B).

A GIS Server can be moved from one cluster to another at any time, enabling you to reallocate your GIS Server resources as needed. By default, every ArcGIS Server site (both for single and multimachine deployments) consists of a single default cluster.



↑ Figure 5; ArcGIS for Server architecture (multimachine deployment)



↑ Figure 6: ArcGIS for Server multimachine deployment with clusters

A Workflow for Publishing GIS Resources as Web Services

The process of taking a GIS resource and making it into a GIS web service begins with ArcGIS for Desktop. In ArcMap, you create, edit, analyze, and manage GIS resources (e.g., spatial data, maps, and geoprocessing tools). Most GIS resources can be published to ArcGIS for Server using the Share as Service publishing wizard accessed by choosing File > Share As > Service. With this wizard, you can publish a new web service, overwrite an existing web service, or publish a service definition file. The first two options are self-explanatory.

The third option, publishing a service definition file, lets you define the properties of a web service and save the settings as a file on disk that can be published as a web service at a later time. As you progress through the wizard, you will connect to an ArcGIS Server site, configure the various properties of the web service (e.g., capabilities, cached versus dynamic, metadata) in the Service Editor dialog box. Optionally, you can register the web service with ArcGIS Online or Portal for ArcGIS so it can be easily discovered and used by others.

ArcGIS for Desktop can connect to an ArcGIS Server site as an Administrator, Publisher, or User. Each of these connections corresponds to a type of role in a site (Table 2).

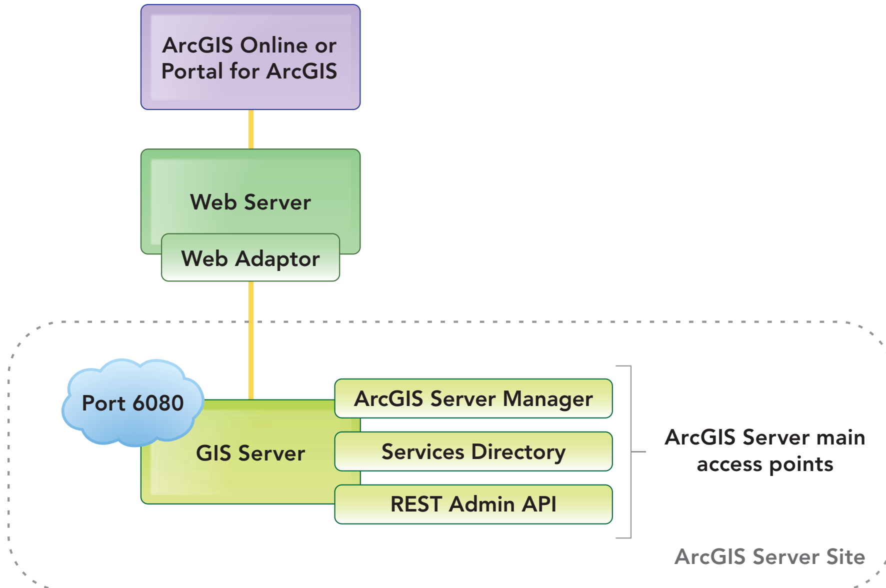
When the properties of the web service have been configured in the Service Editor dialog box, ArcMap will analyze the GIS resource to ensure that its web service properties have been optimized and report any performance problems or unsupported features in your map that should be addressed before it generates the web service. After the web service is published, it will be listed in ArcGIS Server Manager and the Services Directory of the site. Table 3 shows the different types of web services available from ArcGIS for Server. By default, web services are public, but they can be secured to restrict who can access them. ArcGIS for Server follows many web service security standards and fully supports the security standards associated with service-oriented architectures.

Clients to ArcGIS for Server

ArcGIS for Server's GIS web services can be accessed by a variety of ArcGIS platform clients and third-party clients. ArcGIS platform clients include ArcGIS for Desktop, ArcGIS for mobile (iOS, Android, Windows Phone), ArcPad, Esri Location Analytics (Esri Maps for Office, IBM Cognos, and Microsoft SharePoint), Business Analyst, Community Analyst, ArcGIS Viewers for Flex and Silverlight, and the ArcGIS Online and Portal for ArcGIS Map Viewer.

Working with ArcGIS Online and Portal for ArcGIS

ArcGIS Online and Portal for ArcGIS both provide a self-service mapping experience where end users can browse and discover GIS web services and create their own web maps and web applications. The former is hosted by Esri, and the latter is deployed on-premises in your organization. Both are complementary to ArcGIS for Server, because they can be conceptually thought of as providing an attractive front-end user experience to web services from an ArcGIS Server site.



↑ Figure 7: ArcGIS Online/Portal for ArcGIS with ArcGIS for Server

When ArcGIS for Server web services are registered with either ArcGIS Online or Portal for ArcGIS, the services become items that can be easily discovered and consumed by end users. Using the ArcGIS Online or Portal for ArcGIS Map Viewer, the GIS web services can be mashed up with online and portal basemaps that can be leveraged in online web maps and deployed in web applications. This can further expand the pervasiveness and usage of your GIS web services within your organization. Instead of finding your GIS web services through ArcGIS for Server's Services Directory, you can think of ArcGIS Online and Portal for ArcGIS as a fourth access point to your ArcGIS Server site—a more user-friendly one for finding and leveraging your GIS web services.

Summary

ArcGIS for Server is a key component of the ArcGIS platform. It enables you to share your GIS resources as web services that are easily accessed over the Internet and can be consumed by a variety of clients. A geoportal, such as ArcGIS Online or Portal for ArcGIS, can provide an attractive front end for the server that allows users with little GIS training to make and share web maps using your web services. These tools empower an organization and its members to perform better decision making because everyone can access, collaborate, and work with the same geographic knowledge.

About the Author

Derek Law works on the ArcGIS for Server product management team. He is involved with requirements gathering, software development, and product evangelism. His technical expertise is focused on ArcGIS for Server, Portal for ArcGIS, and geodata management technologies. He has an MSc in remote sensing from the University of Victoria, British Columbia, Canada.

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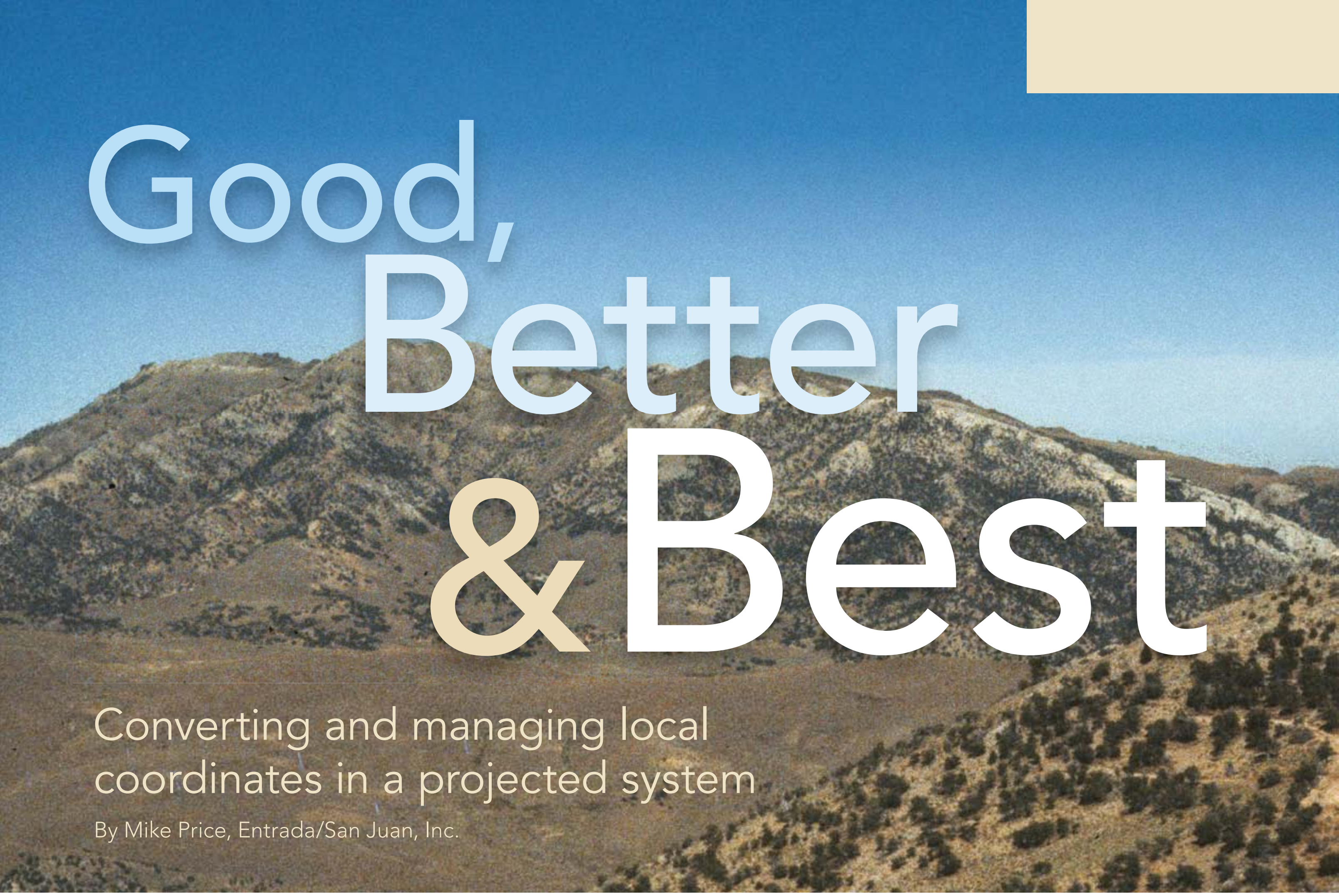


Good, Better & Best

Converting and managing local coordinates in a projected system

By Mike Price, Entrada/San Juan, Inc.

This tutorial is the logical sequel to "Unlocking Data Trapped in paper: Address geocoding legacy geological data" in the Fall 2011 issue of *ArcUser*. That article introduced a method for geocoding legacy point data originally collected along locally defined survey lines. This article provides methods for managing locally defined raster, vector, and computer-aided drafting/design (CAD) data in projected systems. It uses tools available in ArcGIS 10.1 to create a simplified workflow for georeferencing a scanned image and a CAD drawing.

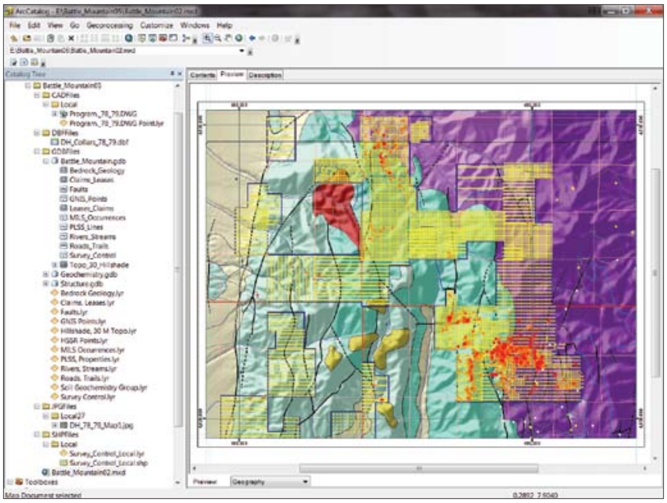
Getting Started: Back to Battle Mountain

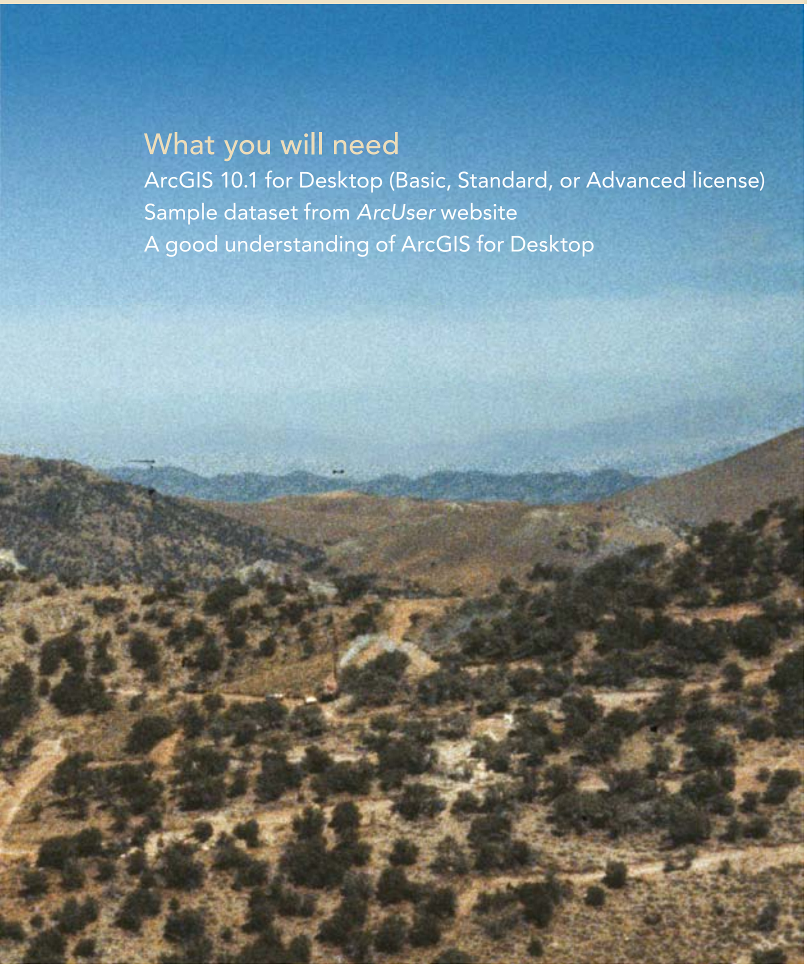
Download the sample dataset from the *ArcUser* website (esri.com/arcuser). Unzip the data locally. Like previous exercises, this exercise uses data from Battle Mountain, Nevada. The folder generated when the archive is unzipped is named Battle_Mountain05 to protect earlier work you may have done in this series. Start ArcCatalog, navigate to the Battle_Mountain05 folder, and inspect the data. Note that the subfolders CADFiles, JPGFiles, and SHPFiles contain a subfolder called Local. Preview the Battle_Mountain02.mxd file, which contains soil and rock geochemical points that were added in a previous exercise.

Legacy Programs, Legacy Maps

Close ArcCatalog, start ArcMap, and open Battle_Mountain 02.mxd. Zoom to the Anomalous Soils 1:20,000 bookmark. Notice the intense surface gold anomaly. This anomaly occurs on the Old Rattler Claims. During recent sampling, we noticed several old marked drill holes and many old reclaimed drill pads. Investigation revealed that this mineralized area was first identified back in the 1970s by field mapping, sampling, and shallow drilling. We also found a drill hole collar file that includes the drill hole name, date, coordinates, depth, and inclination for more than 80 holes drilled in 1978 and 1979. Let's bring this data into the project. Save the project as Battle_Mountain05.

↓ This exercise uses data from Battle Mountain, Nevada.





What you will need

ArcGIS 10.1 for Desktop (Basic, Standard, or Advanced license)
Sample dataset from *ArcUser* website
A good understanding of ArcGIS for Desktop

In the table of contents (TOC), collapse and turn off the Soil Geochemistry group. Click the Add Data button, navigate to \Battle_Mountain05\GDBFiles and add two Layer files: Claims, Leases and Survey Control. Maplex Label Engine is now available to all ArcGIS 10.1 users regardless of license level, so answer Yes if prompted to use the Maplex Label Engine. If necessary, update any broken data links. Save the project again to register Maplex for it. Zoom to the extent of the Survey Control layer and review the map.

Select the Survey Control layer. This data, carefully collected by our own surveyor, will be the key to posting early data on the map. These GPS survey points were captured in decimal degrees using the World Geodetic System 1984 (WGS84) datum that has been reprojected to universal transverse Mercator (UTM) North American Datum 1983 (NAD83) Zone 11 for this project. Open the attribute table for the Survey Control layer and observe that it also contains some local coordinate data and some decimal degree coordinates. Select records with [SURV_TYPE] = 4 or 5. Close the attribute table and use the Anomalous Soil 1:50,000 bookmark to zoom out.

The control survey data includes US Geological Survey benchmarks, hilltop survey stations, Public Land Survey System (PLSS) corners, and several special field points captured from the 1978 and 1979 drilling program. Notice that [SURV_TYPE] = 4 is a single drill hole collar representing DHA-78-001, the first hole drilled in the area. This hole marks the origin (0,0) of the local Old Rattler Grid. [SURV_TYPE] = 4 represents early line control on orthogonal lines 8,000 feet from the center. Notice that these points, labeled Control 1 through 4, appear to be rotated clockwise approximately 15 degrees. Coincidentally, magnetic declination in the late 1970s was approximately 17 degrees around Battle Mountain. *[Magnetic declination is the difference between north (as indicated by a compass) and true north (the direction to the north pole along the earth's surface)].* What do you think happened? Remember, not all early compasses allowed a user to set declination.

The 1978–79 drilling and survey map was scanned and is stored as DH_78_79_Map1 in \JPGFiles\Local\. Add it to the map. Click OK to create pyramids of this raster and OK again to dismiss the warning that it has an unknown spatial reference. Because it is not georeferenced, DH_78_79_Map1 will not appear near Battle Mountain. Click on the layer and choose Zoom to Layer. DHA-87-001 is located at the grid origin, and the four control points are located on 8,000-foot grid intersections. Look at the north arrow. Geographic north appears to be rotated counterclockwise about 15 degrees. Now to georeference this scanned map to look at drill hole collars at Old Rattler. Zoom to Previous, turn off the Bedrock Geology; Hillshade; and Claims, Leases layers and save the project.

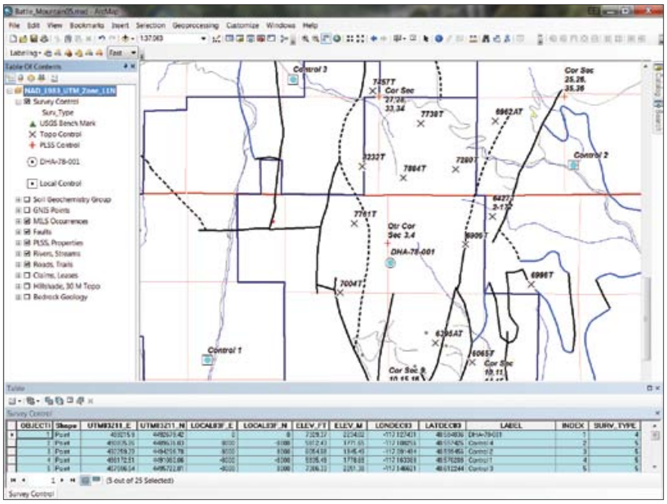
Georeferencing a Legacy Map

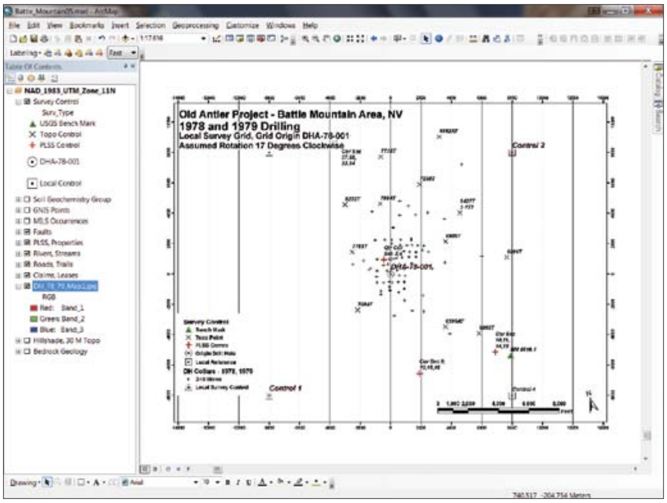
Now to register the scanned map and a CAD drawing file in the project's UTM coordinate system using the ArcGIS 10.1 Georeferencing toolbar. The surveyed control layer will be essential for this task. Load the Georeferencing toolbar by right-clicking anywhere in the open toolbar area and selecting Georeferencing. Dock this toolbar, choose DH-79-79_Map1.jpg as the active Georeferencing layer, and save again.

Make sure DH-79-79_Map1.jpg is near the bottom of the TOC layers. Zoom to the extent of the Survey Control layer, click the Georeferencing drop-down, click Fit to Display, and leave Auto Adjust on.

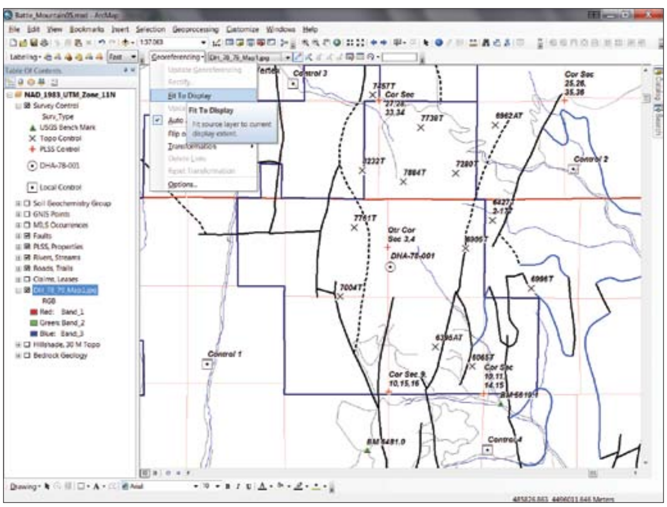
Start up in the northeast corner with Control 2. At this scale, ➔

↓ Select records from the Survey Control attribute table with [SURV_TYPE] = 4 or 5.





↑ Add the scanned 1978–1979 drilling and survey map, DH_78_79_Map1, to the project.



↑ Open the Georeferencing toolbar and, with DH_78_79_Map1 as the active georeferencing layer, choose Fit to Display from the toolbar drop-down.

it is hard to distinguish the control points, so zoom in closely to both the Control 2 points displayed. Control 2 on the scanned map now has a very large symbol and label, while survey point Control 2 appears much smaller.

Click the Add Control Points button from the Georeferencing toolbar. Hover over the center of Control 2 on the raster and left-click, then move the cursor to surveyed Control 2 and click it.

The raster layer will be repositioned. This is new in ArcGIS 10.1. If the snapping setting will not allow you to pick the exact center of the raster point, momentarily press the space bar to override snapping. The Control 2 points on the raster and the survey layer should be connected.

Zoom back to the extent of the Survey Control layer and zoom in to the southwest to the locations for both Control 1 points. Link these two control points. To more easily see the vector point, momentarily turn off the raster. As you create the link for Control 1, watch the scanned map rotate into place. In the CAD world, this two-point registration would be termed a Rotate-Scale-Move procedure. These terms will turn up again, so remember them.

This time, zoom to the extent of DH_78_79_Map1.jpg. If it looks reasonable, save the project to preserve this preliminary registration.

Continue linking the control points for Control 3 and Control 4 in the same manner. Be sure to link points even if they appear to be very close without being linked. Zoom way in and use the space bar to override snapping when linking to the raster point, if necessary.

Finally, zoom to the local origin at DHA-78-001 and link that point on the scanned map to the vector point.

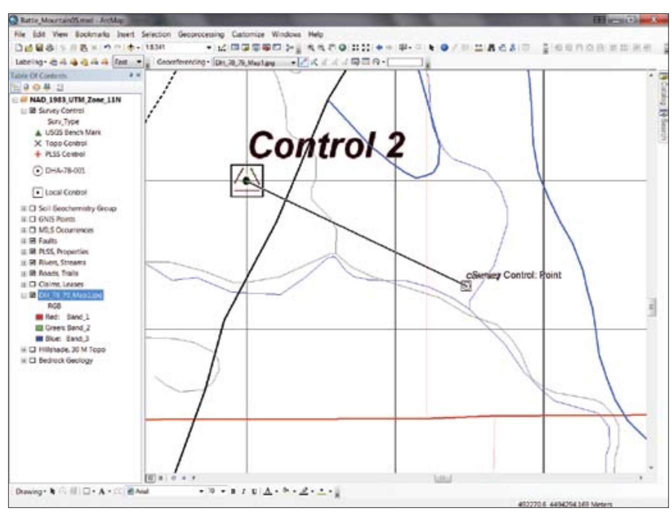
Inspecting the Link Table and Updating Georeferencing

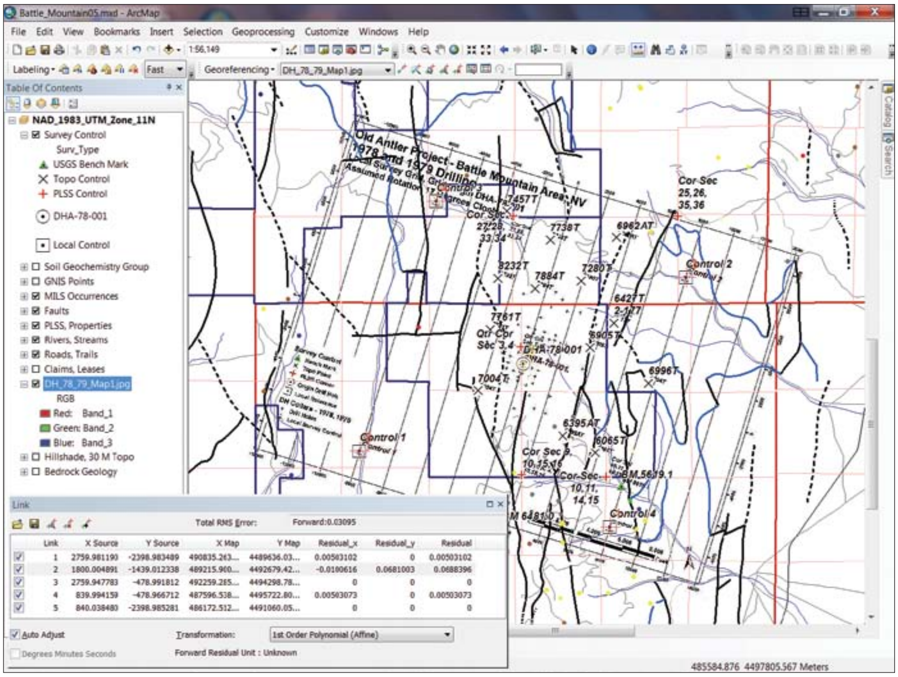
On the Georeferencing toolbar, click the Open Link Table button, stretch the table so all columns are visible, and check the links just created. Inspect each link's residual value and note the Total RMS Error. A total error of less than 5.0 feet (or approximately half the scanned pixel size) is considered acceptable. You can link other control points. With a bit of extra care, the Total RMS might drop below 0.10. The new Link Table tools in ArcGIS 10.1 are a bit different than in previous versions.

Finally, let's update the georeferencing. Zoom to DH_78_79_Map1 and click the Georeferencing drop-down from the Georeferencing toolbar. There is a choice to Rectify the scanned map. This choice creates a brand new graphic object with modified pixels and blended colors in a new coordinate system.

Because the map is so close, an updating is all that is needed. From the drop-down, choose Update Georeferencing and watch as the control point symbols disappear. If you reopen the Link Table, the control points will reappear (also a new feature). Save your project. In the background, ArcGIS just created several auxiliary and

↓ Use the Add Control Points button on the Georeferencing toolbar to link the survey points on the scanned map to the vector points.





↑ Click the Open Link Table button and check the links just created.

reference files that will always load this scanned map into UTM NAD83 Zone 11.

With the local grid map georeferenced, the locations of the 1978 and 1979 drill hole collars now appear as small tics on the map. These locations and points could be captured in an attempt to determine each drill hole's ID. Instead, let's post these collars as vector points using a different method.

Loading and Georeferencing a CAD Drawing

In the early days of field surveying and CAD drafting, many projects like the one that generated the 1978–79 drilling collar data were deployed. A central point was established, typically with coordinates 0,0, and other locations were measured along x and y axes extending from this origin. Many times, these axes were rotated to follow geologic structure or possibly point toward magnetic north. A CAD drawing file containing both the survey points and drill hole collars has been uncovered, and it appears several CAD layers and the drawing are registered in the same local coordinate system as the scanned map. Loading the drawing file will test that theory.

CAD in a Map

Zoom back to the extent of the Survey Control layer and click Add Data. Navigate to \CADFiles\Local and observe the CAD feature dataset and its Layer file. If you are curious, expand the CAD dataset and notice the other entity types and defined CAD point feature classes (DH Collars, Local Control, and Other Control). These special classes, exposed by the ArcGIS CAD model, can be loaded individually or in groups.

In this case, load the single Layer file that supplies predefined point symbology for the CAD data. Select and add Program_78_79.DWG. Answer OK when notified that the data does not include a spatial reference.

In the TOC, position the CAD points above the Survey Control layer. Select the CAD points layer and choose Zoom to Layer. Notice the range of coordinates and hover the cursor over the red crosshairs to confirm that they represent the survey control used earlier to georeference the scanned map. To make the red cross symbols more easily visible, change their color to purple.

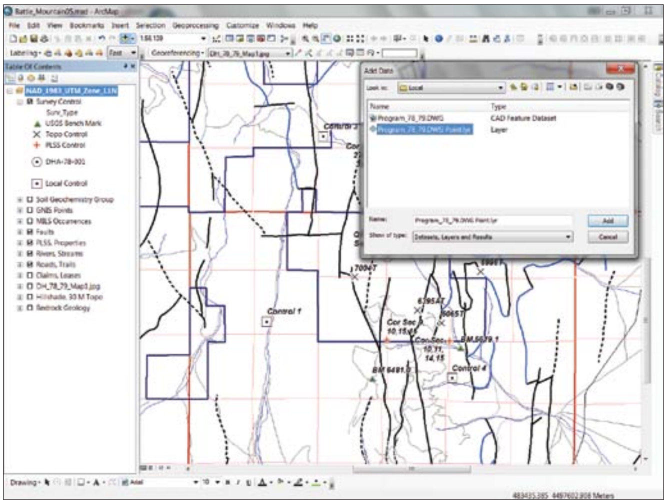
The Georeferencing tools can now be used to fit this CAD data into the Battle Mountain project. In the toolbar, identify Program_78_79.DWG Point as the layer to be georeferenced. Once this file is correctly positioned, the resultant CAD world file can be assigned to other CAD files (both DWG and DXF) without individually referencing each file.

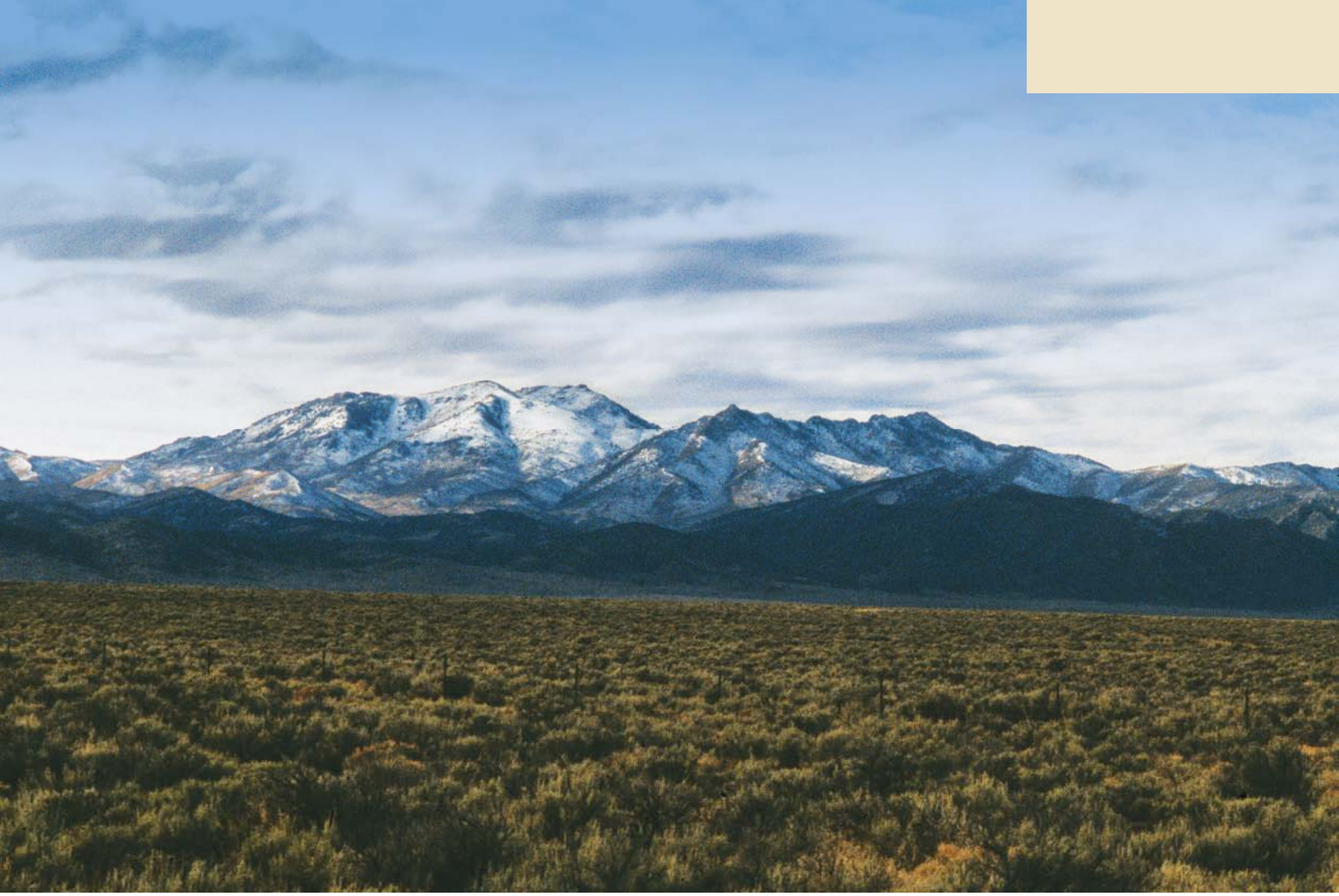
Zoom back to the extent of the Survey Control layer, click the Georeferencing drop-down, select Fit to Display, and watch the drawing file appear. Do you see the purple cross symbols for Control 1 through 4 and the central drill hole origin? This time, let's start linking control points with Control 1 first and finish with Control 2.

Two-Point CAD Registration—The Real Rotate, Scale, and Move

Standard CAD registration is limited to two control points. For maximum effect, these points should be located diagonally across ➔

↓ Load the single Layer file that supplies predefined point symbology for the CAD data.





the area. Also, if the CAD data is in the same conic projection and the destination data, distortion in areas that are not on the selected diagonal will be minimal. Bottom line: this method works great for some CAD files and not so well for others.

Zoom to the raster Control 1 point in the southwest. Use the Identify tool to learn the feature ID (FID) for the nearest purple cross. It should be FID 4.

Click the Add Control Points tool and create a connection between the purple cross symbol and Control 1. Resist the temptation to open the Georeferencing drop-down to apply Auto Adjust—the second point must be set first.

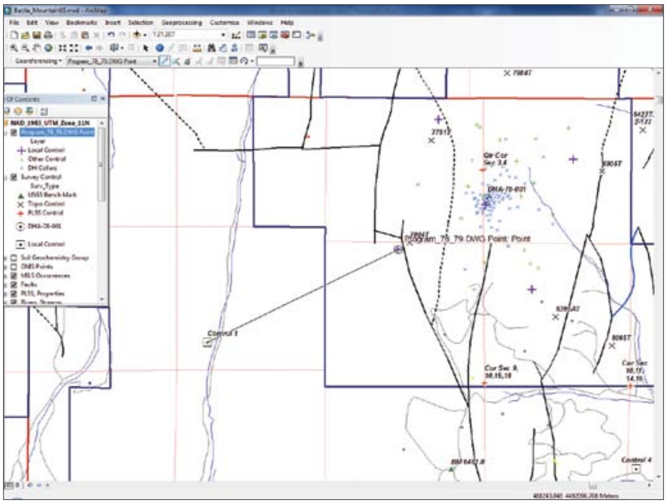
Zoom back out to the extent of the Survey Control layer. Zoom in to the area near Control 2. Use Identify to verify that the nearest purple cross is FID. Create the second tie from the CAD point to the Control 2 point. To cancel a link in the wrong direction that was created accidentally, right-click before placing the link and select Cancel Point. If the link is completed, remove it from the Link Table before continuing.

After placing both points, zoom back to the extent of the Survey Control layer, open the Georeferencing drop-down, and select Auto Adjust. Zoom in to each labeled control point and check the closeness of each. Using the results of careful surveying and snapping to help place points can place these points so they are off by less than 0.01 meters.

Preserving Georeferencing with a CAD World File

By creating a CAD world file, this careful georeferencing can be reused on other files. Click the Georeferencing drop-down and select Update Georeferencing. When the CAD World File dialog box opens, verify that the new file will reside in \CADFiles\Local and accept the name Program_78_79.wld. Later, you can open this file in a text

↓ Click the Add Control Points tool and create a connection between the purple cross symbol and Control 1.

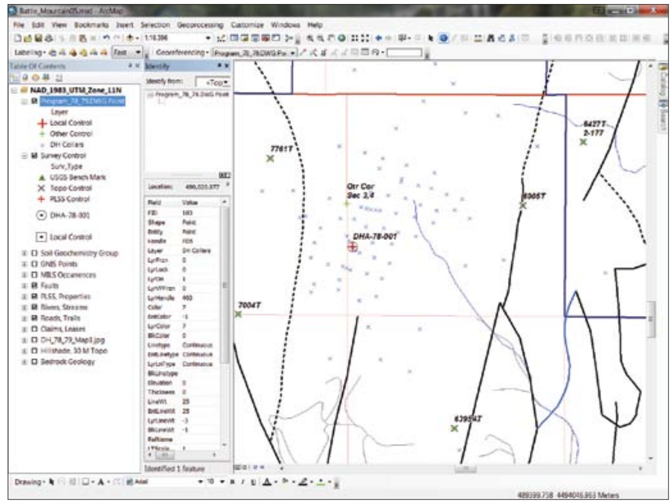


editor to see how it is built.

Finally, select the Identify tool and click any drill hole collar, symbolized as a small blue *x*. Inspect the Esri CAD model structure and look for fields that might help to assign a drill hole ID to the selected point. The collars are on a layer called DH Collars, but there is not much that can be gleaned from the attribute table. Unfortunately, early CAD shops did not post robust attributes with drawing entities.

Moving Forward

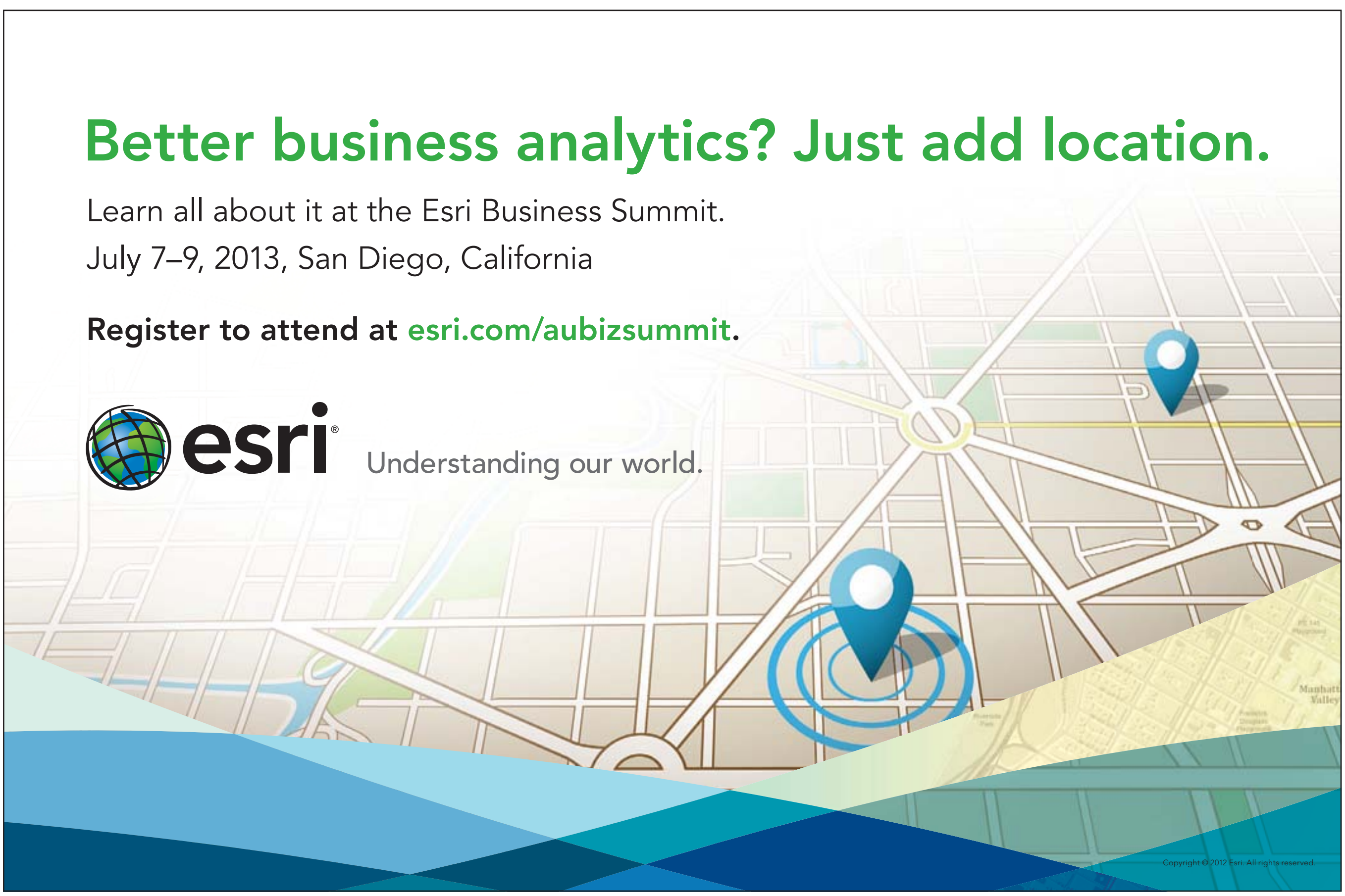
The carefully positioned drill hole collars registered in UTM space using the high quality CAD world file can be used to calculate NAD83 metric coordinates. This generic world file will reference more than the Old Rattler CAD files in the UTM system. To create a universal CAD world file, use a Windows file manager to browse to the folder containing CAD files that are in the same coordinate system. Copy Program_78_79.wld and rename it esri_cad.wld. With this special file in the CADFiles folder, the transformation will be applied to each CAD dataset that does not already have a companion world file.



↑ Select the Identify tool and click on any drill hole collar (small blue x) and inspect the Esri CAD model structure. Look for fields that might help to assign a drill hole ID to this point.

Summary and Acknowledgments

This exercise uses the same generalized training data used in several previous Battle Mountain training sets. The new data includes completely synthetic drill hole collars and synthetic or topographic survey control. Thanks to Chris Brod and his surveying and mapping students at Bellingham Technical College, Washington, for helping unravel, synthesize, and test data for this tutorial.



Workflows for Using and Building Hosted Cached Map Tiles

By Sterling Quinn of the ArcGIS for Server Development Team

One of the most effective ways to speed the performance of web and mobile applications is to predraw some or all of the map layers at various scales and save the images in a cache. Because of their small square shape and the way that they tessellate to form a complete map image, these images are often called tiles.

This is an overview of the different ways you can use tiles with ArcGIS and suggested workflows for building tiles. It highlights considerations that affect the appropriateness of each workflow. The first thing you need to decide is where you will host the tiles after they are built. The most common choices are to host the tiles on your own ArcGIS for Server site, on ArcGIS Online, or Portal for ArcGIS, or to send tiles to a mobile device.

On Your ArcGIS for Server Site

When you host the tiles using your hardware and software, they are exposed through an ArcGIS for Server map or image service that advertises its cache to client devices. Clients make web service calls to request the needed rows and columns to fit the map view.

On ArcGIS Online

When you purchase a subscription to ArcGIS Online, you can host your tiles on the cloud. The tiles are exposed through a basic REST web service that distributes the tiles to clients based on the rows and columns requested. You pay a monthly fee for tile storage.

On Portal for ArcGIS

The ability to host tiled map services on Portal for ArcGIS is coming later in 2013. If you implement Portal for ArcGIS, users in your organization can publish tiled services without directly accessing ArcGIS for Server. The portal is a website and content repository that behaves like ArcGIS Online, except your own ArcGIS for Server site is configured on the back end to create and host the tiles.

Send Tiles to a Mobile Device

To support mobile applications that may not always be connected to the Internet, you can create a special file called a tile package that contains your cache. You transfer this file to the mobile device bundled with the application download or as a separate download. The application can then take advantage of locally stored tiles when it displays a map.

Where you decide to host tiles may affect the hardware, software, and techniques you use when building tiles. Here are some considerations when using each approach to creating cached tiles.

Building Tiles for Your ArcGIS for Server Site

If you're hosting your tiles with ArcGIS for Server, you can also use ArcGIS for Server to build the tiles, maintaining full control over all hardware and software in the configuration. You might also choose to supplement your tile-building capacity with virtual machines that you've apportioned through Amazon Web Services.

All ArcGIS for Server caches are built using the Caching toolset in the Server toolbox. The Service Editor window in ArcMap provides an easy user interface for defining and building a cache. However, it's important to understand that the Service Editor is using the Caching toolset behind the scenes. The Caching tools work with both map and image services, so tiles can be created from map documents and large imagery collections.

Building Tiles for ArcGIS Online Hosted Services

If you host tiles on ArcGIS Online, you can either build the tiles in the ArcGIS Online cloud or build the tiles locally and transfer them to ArcGIS Online. To build the tiles on ArcGIS Online, choose File > Share As > Service in ArcMap. Use the wizard to define your cache. Building tiles on ArcGIS Online incurs an extra fee. The more tiles you build, the more credits you use. However, if you build tiles on ArcGIS Online, you do not have to procure or manage hardware.

Building Tiles Locally Using ArcGIS for Server or ArcGIS for Desktop

Instead of using ArcGIS Online credits, you can build the tiles locally and upload them to ArcGIS Online. This is accomplished using a tile package, a special file that contains all the tiles. You can upload a tile package to ArcGIS Online and expose it as a tiled map service.

You can use ArcGIS for Server to build tiles for a map or image service. This is done using the Caching toolset in the Server toolbox. Once you have the tiles, you can run the Export Tile Cache tool to get the tiles into a tile package. This tool is in the Tile Cache toolset in the Data Management toolbox. If you use ArcGIS for Server to build the tiles, you can scale out the computing power dedicated toward the job and build the tiles asynchronously so that you can continue using ArcGIS for other things at the same time.

If you don't have ArcGIS for Server, you can build tiles using ArcGIS for Desktop. The easiest way to do this for a small cache is to use the File > Share As > Tile Package option in ArcMap. This option reads the map, draws the tiles, packages them, and sends them to ArcGIS Online. (If this option is not available, enable the ArcGIS Runtime Tools from the ArcMap Options menu.)

A more appropriate way to build large caches with ArcGIS for Desktop is to use the Tile Cache toolset in the Data Management toolbox. At ArcGIS 10.1, these tools can build tiles for any single map layer containing a mosaic dataset or raster dataset. Later in 2013, they will be able to build tiles for the full map document.

The Tile Cache tools take advantage of multiple processor cores if they are available. They can also be automated using models or scripts. Typically, you'll use the Tile Cache tools in this order:

1. Generate Tile Cache Tiling Scheme to define the tiling grid and image format.
2. Manage Tile Cache to build the tiles.
3. Export Tile Cache to create the tile package.
4. Share Package (in the Package toolset) to upload the tiles onto ArcGIS Online. Alternatively, if your tile package is small (less than 1 GB), you can use the Add Item button on ArcGIS Online.

No matter how you create the tile package and upload it to ArcGIS Online, you must take the final step of publishing the tile package as a service. When you view the item details page of any tile package you own on ArcGIS Online, you can click the Publish button to unpack the tiles and host them as a web service. You can use ArcGIS Online sharing settings to expose the service to as many or as few people as you desire. Once the service is published, you can delete the original tile package to reduce your storage costs.

Building Tiles for Portal Hosted Services

The ability to host tiled map services on Portal for ArcGIS is coming later in 2013. When you publish tiled map services to Portal for ArcGIS, the tiles will be generated by an ArcGIS for Server site that has been registered with the portal. ArcMap provides a simplified user interface for publishing the map service and defining and building the cache. Context menu items on the portal connection in the Catalog tree allow you to access caching tools for finer-grained control of your jobs. Alternatively, you could use the Tile Cache toolset or use ArcGIS for Desktop and choose File > Share As > Tile Package to make a tile package, upload it to the portal, and then publish. This approach can reduce the load on the server, especially if many people are creating tiled services at the same time.

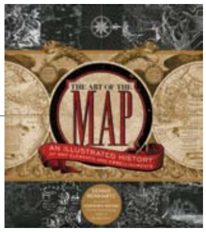
Building Tiles for Mobile Use

Building tiles for occasionally connected mobile applications requires a tile package. You can do this using either ArcGIS for Server or ArcGIS for Desktop tools as previously described. However, uploading the tile package to ArcGIS Online or a portal is not required. Instead, you bundle the tile package with the application download or provide it as a separate download that the application can retrieve later.

The ArcGIS Runtime SDKs for various mobile platforms all include an ArcGIS Local Tiled Layer class that can read tile packages. When creating tile packages that will be transferred to mobile devices, don't build any more tiles than are necessary for the application. This is an important rule for all tile caches, but mobile workflows are especially sensitive to application size. The Manage Tile Cache tool allows you to browse to an area of interest feature class that constrains the geographic area of tile creation.

For additional information, visit ArcGIS Resources at resources.arcgis.com to read blog posts and access help and forum posts.

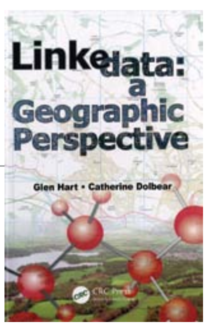
GIS Bookshelf



The Art of the Map: An Illustrated History of Map Elements and Embellishments

By Dennis Reinhartz

The art of mapping is sometimes forgotten in an era that benefits increasingly from the analysis made possible by GIS and other geospatial technologies. Cartography exists at the nexus of art and science. This book, which focuses on the embellishments we associate with old maps, makes the map-art connection readily apparent. A map can be so much more than just the subject or area that is depicted. The other elements of a map—the cartouche, compass rose, scale, inset, legend, commentary, and even the neatline and scale—can be works of art in themselves even as they have vital functions in communicating the map's message. As Reinhartz looks at these elements, he points out that they can also have other functions: storytelling devices or graphics that deflect the map reader's attention from the lack of information in areas of the map. The author uses historic maps from the 1500s to the 1800s that deal with exploration and discovery. Engravings depicting monsters and myths evoke the delight one may have felt as a child who spent hours paging through old atlases. Reinhartz has also edited *Mapping of Empire: Soldier-Engineers on the Southwest Frontier* and *The Mapping of the American Southwest*. He is professor emeritus of the University of Texas at Arlington, where he spent 35 years as a professor of history and Russian. Sterling; 2012, 240 pp., ISBN: 978-1402765926



Linked Data: A Geographic Perspective

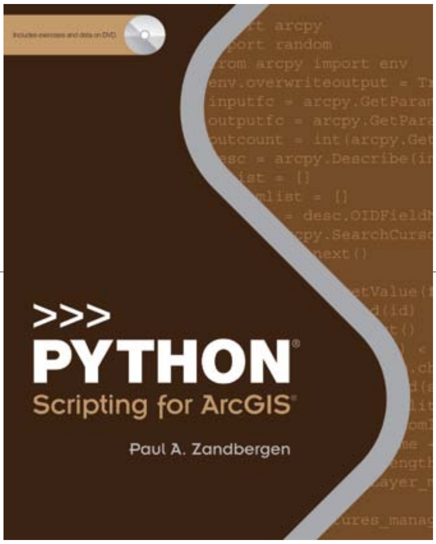
By Glen Hart and Catherine Dolbear

The avowed goal of this book is to help the reader look at geographic information through "the lens of the Semantic Web." As envisioned by Tim Berners-Lee in "The Semantic Web: A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities" (May 2001 article in *Scientific American* coauthored with James Hendler and Ora Lassila), this extension to the web would make information reusable. It could be queried from different points of view. In *Linked Data: A Geographic Perspective*, authors Glen Hart and Catherine Dolbear explain how geographic information can be modeled using Semantic Web technologies and published as Linked Data in simple English rather than technical jargon and use many code examples. This is a good introduction to a complex topic of growing importance as the web and GIS evolve together.

Hart, who leads the research group at Ordnance Survey, began investigating the Semantic Web in 2002. He has been involved in the publication of Ordnance Survey's Geographic Information as Linked Data and Linked Data as a way to enable more efficient and accurate data integration. Dolbear is currently a link data architect at Oxford University Press (OUP), working on strategies for linking content across online academic and journal products within OUP's discoverability program. The author of several papers in areas of geographic ontology development, semantic data integration, and information filtering using structured data, she is a previous cochair of the OWL Experiences and Directions Workshop and cofounder (with Hart) of the international workshop series Terra Cognita on geospatial semantics.

Filling the Gap

Python scripting for ArcGIS 10.1



While there are numerous introductory GIS books that cover spatial analysis and a treasure trove of general resources for learning the Python language, *Python Scripting for ArcGIS* by Paul A. Zandbergen fills the need for a book that specifically explains how to use Python with ArcGIS 10.1.

Python Scripting for ArcGIS was written for GIS professionals and upper-division undergraduate or graduate students proficient with ArcGIS for Desktop and basic GIS concepts who want to automate processes and extend ArcGIS 10.1 capabilities using Python scripting. While previous experience with programming or scripting languages, such as Visual Basic or Perl, is useful, no previous programming experience is assumed.

Python was introduced at ArcGIS 9.0 and has been embraced by Esri and the ArcGIS community as the scripting language of choice for geoprocessing. It is a free, cross-platform, open-source programming language that is both powerful and widely used. Although Python has many applications, this book focuses exclusively on its use with ArcGIS 10.1.

The book is divided into four parts. Part 1 introduces geoprocessing and the fundamentals of the Python language. Part 2 is the meat of the book. It teaches how to write scripts that work with spatial data. Part 3 covers more specialized tasks such as map scripting, debugging, and error handling. Part 4 shows how a script can be converted to a tool so it can be shared. Each exercise builds on the previous one, so they should be worked in order.

By the end of the 14 chapters in *Python Scripting for ArcGIS*, the reader should be able to create custom tools that automate tasks in ArcGIS for Desktop. In addition to saving many hours, the author hopes that "the book will contribute to demystifying what 'writing code' really is for those who may be a little intimidated by it."

Each chapter in the book has a corresponding exercise and its data on the accompanying DVD. ArcGIS 10.1 for Desktop is required to work the exercises. If it is not already installed, a free 180-day trial of ArcGIS 10.1 for Desktop can be downloaded.

The author is an associate professor of geography at the University of New Mexico in Albuquerque, where he teaches classes in GIS and spatial analysis. His areas of expertise include GIS applications in criminology, economics, health, and ecology, as well as spatial and statistical analysis techniques using GIS. Esri Press, 2013, 368 pp., ISBN: 978-1-58948-282-1

What Could Be

Crafting smart, sustainable solutions to big problems

By Carla Wheeler, Esri Writer

↓ The Geodesign Summit drew a record 260 attendees that included architects; urban and transportation planners; educators; and GIS, environmental, and design professionals from the United States and abroad.

Geodesign, the subject of a two-day summit held at Esri in Redlands, California, has become more than a buzzword. It is changing how projects are planned and has become a recognized academic discipline.

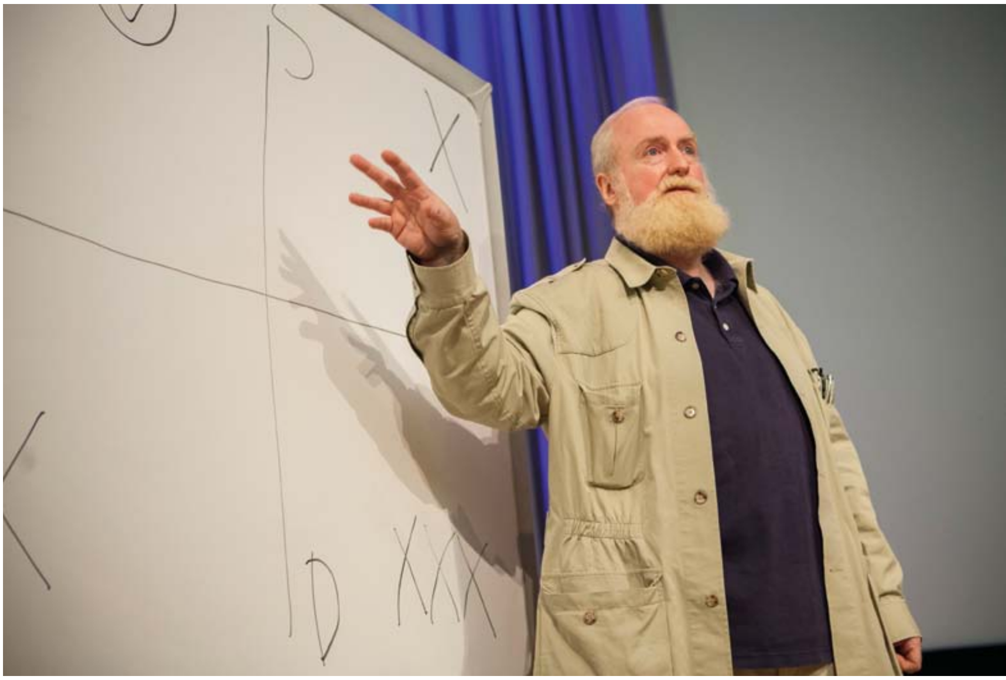
The Geodesign Summit, only in its fourth year, drew a record 260 attendees, including architects; urban and transportation planners; educators; and GIS, environmental, and design professionals from the United States and abroad.

Geodesign couples geography with design. Practitioners use both creative design techniques and geospatial technologies, such as GIS, to come up with design options to consider and eventually arrive at smart, sustainable solutions.

One attendee, Breece Robertson, is the national GIS director for the Trust for Public Land. She sees geodesign as a collaborative process that involves many stakeholders. "The words *iterative*, *futuristic*, and *impacts* come to mind as but a few of the key components that are involved in the geodesign process," she said. "I think a lot of us have been doing geodesign for a long time, but there is always room for improving our processes."

"It makes design decisions data rich," said Thomas Fisher, the summit's moderator and a professor of architecture and dean of the College of Design at the University of Minnesota. "It takes GIS analysis into the future to [show] not only what is but what could be."

One of the featured speakers was David B. Bartlett, who is known as the



→ Summit keynote speaker Bran Ferren challenged attendees to develop a 250-year plan for the planet enabled by geodesign to create a vision of the future.

Building Whisperer. The vice president of IBM Smarter Buildings, his job is to help make places like school districts and universities more energy efficient. At the summit, he talked about the role data and location-based analysis plays in achieving this goal.

IBM partnered with Esri and CitySourced to create a crowdsourcing application for smartphones that students, teachers, and staff at the Los Angeles Unified School District can use to snap photographs of and record the location of broken windows and faulty air conditioners at schools. Fixing these problems quickly led to energy savings. *[To learn more about this application, read "Smartphone App Aids District's Facilities Maintenance" in the Spring 2012 issue of* ArcUser *magazine.]*

In his talk "The Instant City—Geodesign and Urban Planning," Elliot Hartley, director of Garsdale Design Limited in Cumbria, United Kingdom, described how his firm, along with its Iraqi Planners Group, is creating a master plan for the city of Nasiriyah, Iraq. This plan addresses future housing, utilities, and infrastructure. Using Esri CityEngine, 3D modeling software for urban environments, the firm was able to change plans when new data was added or late changes were made. Changes that had taken four days using other software took just a half day using CityEngine.

Modeling the Future

CityEngine and other Esri technologies were used to model the potential plans for mitigating the impacts of population growth and traffic congestion on the rapidly growing city of Honolulu, Hawaii. Esri solutions engineer Eric Wittner showed how Esri software modeled alternative futures for Honolulu. First, data was prepared using Esri ArcGIS for Desktop. Then 3D GIS data from Pictometry and PLW Modelworks, representing realistic building models for portions of the city, were combined in Esri CityEngine. CityEngine used a set of rules to generate a 3D representation of the city as it looks now and then model series of scenarios showing how the city might grow.

One scenario showed significant urban sprawl if thousands of new single-family homes were built outside the urban core. In another scenario was a much smaller footprint in undeveloped areas if the city built up rather than out, with people living in tall buildings near the multibillion-dollar light rail system planned.

Technology Matters

Esri president Jack Dangermond spoke to summit attendees about his enduring belief in technology as an agent of positive change to tackle the planet's big problems. "In my life, I always believed technology could matter," he said.

GIS is becoming a platform technology that is widely available via the cloud, which supports applications on the web and on mobile devices. "This potentially has the power of making the concepts of geography, the models, the analytics—not simply the visualization—available to everyone," Dangermond said. For organizations, this means that geographic knowledge—including geodesign tools—will become available to a much wider audience than in the past.

This idea of GIS as a platform was brought home to the audience with demonstrations that showed the increasing simplicity of making online maps using ArcGIS Online and Esri Story Maps templates.

> "It is still in the shiny object stage, but it will be *very* important."
>
> Bran Ferren, Designer and Technologist

Esri technology evangelist Bern Szukalski gave the audience a sneak preview of Esri's landscape analysis services, (currently in beta testing), geared specifically toward geodesign work. He used these services to study the solar generating potential of the Ivanpah Solar Electric Generating System, currently being built in the Mojave Desert. He analyzed the slope of the terrain and proximity to the habitat areas of desert tortoises in relation to the solar project's location.

Tackling the Big Problems the Planet Faces

The summit's keynote speaker designer and technologist Bran Ferren had also been the keynote speaker at the first Geodesign Summit. This time he delivered a challenge: Develop a 250-year plan for the planet enabled by geodesign to create a vision of the future.

"Geodesign combines geography and data with modeling, simulation, and visualization to tell stories and [show] the consequences of your actions," Ferren said. He sees great potential for geodesign to ultimately help find solutions to complex problems. "It is still in the shiny object stage, but it will be *very* important," he said.

Geodesign technology will mature naturally, much like GPS and other technologies have done. But meanwhile, says Ferren, in this era of short attention spans, people need to start thinking far into the future to create a problem-solving template that can be built upon over time. "If we are going to address these big global issues facing us—whether that's disease, education, freshwater, war, or global warming—you actually have to take a long view," Ferren said. He said we need to post questions such as, What is your current state of affairs or the topic you are worried about? What is your desired end state? and How are you going to get there?

"I argue that just having the discipline to sit down for a day and think about that will change your whole thought process,"

This year's summit included hands-on sessions as well as presentations.

Ferren said. "It doesn't mean you are going to know exactly what the future is, but having a sense that in 250 years, you would like to address these things at least gives you an intellectual template and road map to test your ideas against."

This process will be collaborative, according to Ferren. "That's the power of geodesign," he said. "It's this network extension of shared intelligence where the insights of individuals can be shared among others and that can be used as the foundation to build upon."

Ferren also said that geodesigners in the future will be entrusted with the same power over life and death that doctors have today because the decisions they make will be critical to humans and other species. "The mistakes you make in planning and designing our cities may take 100 years until someone understands the consequences of those actions. The Hippocratic Oath for geodesign: First, do no harm," he said. "Understand what you are doing and the effect—if you know this is going to do long-term damage, it is not okay to do it. We aren't on this earth very long. It's a mere blip. Try to leave it a little better than how we found it."

A Worthwhile Event

Ferren's talk, the featured presentations, and the technology demonstrations were inspiring to many Geodesign Summit attendees such as Juan C. Perez, director of transportation and land management for the Transportation and Land Management Agency for the County of Riverside, California.

"The session that focused on the visual modeling and analytic tools when presenting land-use decisions to policy makers was excellent," Perez said, adding that he would like Riverside County to use some of the tools.

Perez also said Ferren's proposal of a 250-year plan was thought provoking. "While perhaps extreme at first blush, it really puts into perspective that the land-use decisions that we make have very long-term consequences."

For more information about the Geodesign Summit, visit geodesignsummit.com. Planning is under way for the Geodesign Summit Europe, September 19–20, 2013, at the GeoFort in Herwijnen, the Netherlands.

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Story Maps in the Classroom

By Sarah E. Battersby and Kevin C. Remington,
University of South Carolina

Incorporating Esri's story maps into the geography undergraduate senior seminar at the University of South Carolina helped students communicate results from their semester-long projects. The authors discuss the successes they had and the challenges they faced to help other instructors recognize the possibilities—and minimize the limitations—of using story maps in their own classrooms.

The story map concept allowed students with varying levels of GIS and mapping experience (from none to substantial) to clearly express the spatial story attached to their projects. Story maps let educators introduce students to the concepts and techniques involved with creating a dynamic, geocentric web application. Story maps can be created using basic prepared templates that are designed entirely using the ArcGIS Online web application tools or from downloadable template files that can be easily configured and customized by editing a few simple HTML or comma-separated value (CSV) files. While the incorporation of story maps was an overall success, it was a learning experience with technical challenges for students, the instructor, and the technical staff supporting the class.

About the Class and Projects

As part of graduation requirements, geography majors at the University of South Carolina must complete a semester-long, capstone project. Students, who enroll in a seminar class during their last year in the major, enter that class with varied backgrounds in geography that typically emphasize GIScience, human, or physical geography. Consequently, students are encouraged to tackle projects that use multidisciplinary approaches. In addition, no common level of experience in mapping or the use of geospatial technologies can be assumed.

The class is typically structured to partner a group of students (from a few students to the entire class) with local community agencies that have interesting spatial problems. Efforts are made to match agency work with students' expertise across major and other university coursework.

Given these constraints, Esri's story maps and ArcGIS Online were chosen to enable *all* students to feel comfortable preparing attractive, informative maps and spatially referenced media to communicate their results and meet the objectives of their partner organization.

For the fall 2012 semester, six groups of students were working on projects with three local agencies: the Gills Creek Watershed Association, Lexington County GIS, and Sustainable Midlands. Prior to the start of the semester, potential projects and how a story map or set of story maps developed as part of the class projects might be of benefit to the agencies were discussed. The agencies expressed interest in story maps as student-generated deliverables for projects. The story map format was viewed as an innovative, web-based way to help agencies explore their data, use it for internal organizational purposes, and communicate to the public about issues of interest.

Implementation Process

While all students in the class were seniors in their last year of coursework for the geography major, only about a third of them had worked with Esri's desktop or online GIS products. Most had no experience in map design. Because the class focus was on the projects and content, there was limited time to dedicate to learning geospatial technologies and cartographic practices.

To get the students familiar with ArcGIS Online and story maps, one of the authors, Kevin Remington, the campus GIS coordinator, presented a lecture on the basics of ArcGIS Online. The other author, course instructor Sarah Battersby, presented two additional follow-up lectures on customizing the HTML-based templates and creating maps using the ArcGIS Online hosted templates. In total, approximately four hours of class lecture time was dedicated to introducing the basics of story mapping. Throughout the remainder of the semester, the instructor and two GIS staff members assisted students in collecting and analyzing content and preparing data to make their story maps. To aid them in building and displaying their maps, students were given department-hosted web accounts, and each student created an ArcGIS Online account.

Five of the six project groups presented their project results using story maps. The group that did not create a story map used data that could not be distributed publicly due to privacy concerns from the partner agency.

Student Responses

Four of the 19 students enrolled in the course were interviewed about their experiences with story maps. These students were from different project groups and had varied backgrounds (i.e., not all GIS-focused).

Overall, their responses to the use of story maps for communicating their final project results were positive. They found story map templates easy to use, enabling them to design more exciting, interactive web-based maps than would have been possible with other technologies available to them. Students easily designed custom pop-ups with tables, photographs, and charts. The students also emphasized that ArcGIS Online and story maps were accessible to everyone in the class.

While the more experienced students had an initial advantage, most students quickly grasped the concepts and discovered that they didn't need to have that background to make a great map. This allowed for greater division of labor across the groups and emphasized that mapping "isn't just for the GIScience majors."

The partner agencies seemed to agree the projects were successful. A class-developed virtual tour of the Gills Creek Watershed was posted on the Gills Creek Watershed Alliance website (gillscreekwatershed.org/usc_seminar_report/), and additional maps are being posted by Lexington County to show the physical, cultural, and historical landmarks of the Riverwalk, part of the Three Rivers Greenway network of trails and parks.

While the students incorporated several different types of story maps into their projects, the Storytelling Map Tour template was the most popular. This template combines an interactive map, a photo panel with customizable descriptive text, and a carousel of photo thumbnails. The map template includes two different colors of map markers and is customized by simply editing the CSV file that lists the location where markers should be placed on the map that correspond to photos of each location. Additional customization of the basemap, level of zoom, and title can be done by editing a simple HTML file.

Challenges

The free Esri story map customizable templates and complementary hosting service using ArcGIS Online alleviate a number of instructional, IT, and administrative considerations. However, implementing these tools created some new challenges.

Students could supplement story maps data they produced as part of their project with map and feature services already published by Esri and hosted on ArcGIS Online. Often, students needed datasets that were specific to the class project. These students had to create their own services. While the students' personal ArcGIS Online accounts were sufficient in many instances, projects that required working with larger datasets quickly exceeded the ArcGIS Online personal account limit for importing files of 1,000 features or 250 geocoded addresses. To work around this, large layers were broken into many smaller layers and then symbolized individually—a challenge without manual classification options in ArcGIS Online. Alternatively, access to the data was made possible via map or feature services hosted on site at the university as an ArcGIS for Server instance.

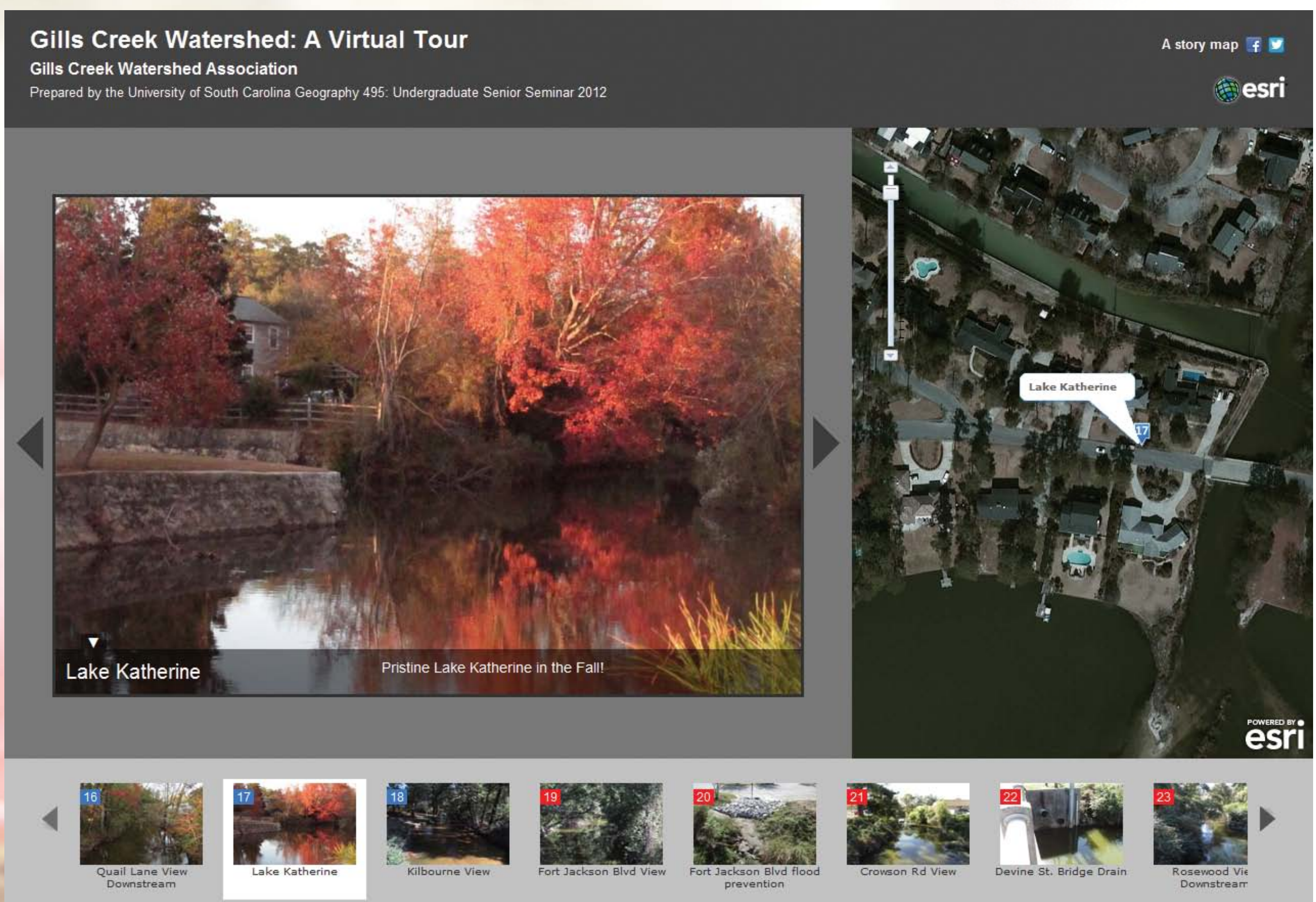
While working with the story map templates and ArcGIS Online, the authors began exploring the ArcGIS Online for Organizations account that had just been provided to the university through its site license agreement. With this additional functionality, student-authored maps and feature services could be hosted on Esri's cloud. These resources then become simple for the students to consume in their story maps. While the ArcGIS Online cloud provided a number of exciting new opportunities for helping the students present more complex datasets, it also introduced some general considerations for its successful employment in an academic environment.

One concern was the ArcGIS Online credits expended by the use of this cloud-based technology in the classroom. The site license agreement provided an initial allotment of credits. The authors assessed the feasibility of using institutional credits to host datasets for class projects to determine how far credits might go given expected use. Credits are generally spent for bandwidth, computation, and storage. With many class projects, the bandwidth usage cost is of little concern because the audience is often just the students in the classroom and the instructors.

Of greater concern, however, is the expenditure of credits for computation and storage. Although many student-built applications consume fairly small proof-of-concept datasets, this is not always the case for class projects when partnering with state- or county-level public organizations to address problems and provide real-world applications. For these projects, a student might build an application that exposes a large number of spatially discrete geographic units such as parcel and building footprint data. In this scenario, the project would require many gigabytes of data storage in the ArcGIS Online cloud and consume a large number of credits.

In one class project, a student could consume approximately

↓ The Storytelling Map Tour template, an interactive map and a photo panel with customizable descriptive text, was the most popular.



800 credits to publish and store a feature service that exposed approximately 1 GB of data. This scenario meant that, for a class of 15 to 25 students, the entire university allotment of credits could be expended in a single lab session.

Of course, storing feature data in the ArcGIS Online cloud and exposing it through feature services is more costly than storing data as a tiled map service. A tiled service provides a good alternative when much of the data that a student needs to expose can be utilized as view-only data. However, even this approach can be costly if the student needs to expose large areas of high-resolution imagery and raster data that may require tiling at many different scales for optimal performance. This approach can become costly because organizations are charged credits for the computation involved in generating the tiles on ArcGIS Online and for their storage.

The authors' experience indicates that using story maps requires active administration of an ArcGIS Online site. The site should be routinely cleaned to remove redundant or orphaned services and applications that are no longer needed. IT staff need to evaluate which approach (feature service or tile cache-based service) is best, in the long run, for distributing the data.

Other administrative concerns include the necessity of associating each student's Esri Global Account with the university's ArcGIS Online group. While this is a fairly straightforward process, care needs to be taken when assigning rights to a group member and ensuring membership is terminated when the class ends or the student leaves the university.

Conclusion

Even with these challenges, working with ArcGIS Online and story maps provided great opportunities to introduce students to web-based mapping and multimedia technologies. The story map concept enabled students with all levels of GIS experience to create professional-looking dynamic web map applications to support and present the research from their class projects. There were definite learning moments for everyone involved in these projects. Creativity was needed to work around the limitations of ArcGIS Online (which can't be expected to have the functionality of ArcGIS for Desktop). However, ArcGIS Online and story maps made high-quality mapping accessible to all students.

About the Authors

Sarah E. Battersby, PhD, is an assistant professor in the geography department at the University of South Carolina. Her research interests include cognitive issues in GIScience and geography education. She currently serves on the board of directors for the Cartography and Geographic Information Society (CaGIS) and the University Consortium for Geographic Information Science (UCGIS).

Kevin C. Remington, GISP, has been the campus GIS coordinator at the University of South Carolina for the last 15 years. His interdisciplinary role keeps him involved in many of the university's research, teaching, and outreach activities that have a GIScience component. When not immersed in the world of GIS and academia, he can be found homesteading, enjoying the outdoors, traveling, tasting craft beers, playing music, and building yurts.

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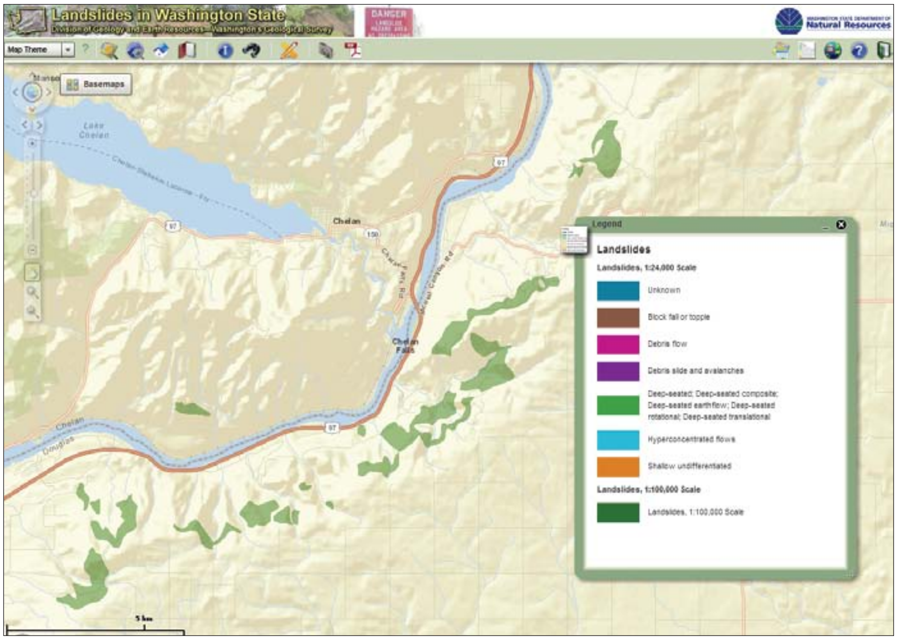
↓Landslides, like the one in 2009 that destroyed State Highway 503, cause significant damage.
(Photo: Adam DuBrowa/FEMA)

Guarding against Geohazards

Mapping aids mitigation and planning in Washington State

By Matthew DeMeritt, Esri Writer, and Monica Pratt, *ArcUser* Editor

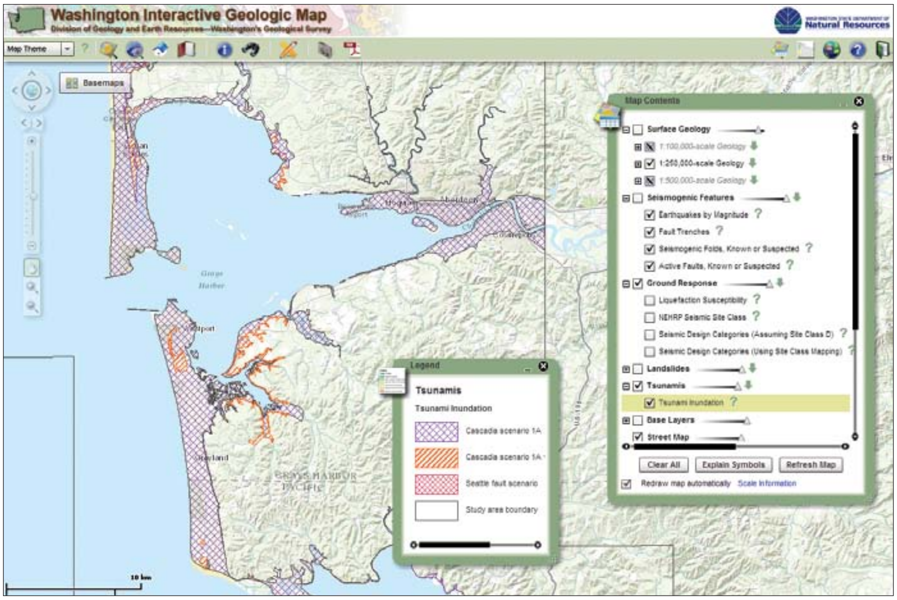


↑ The Landslides in Washington State interactive map shows the landslide history and potential in any given area.

Landslides, triggered by large storm systems and earthquakes, can cause hundreds of millions of dollars of damage in Washington. Along with landslides, tsunamis caused by seismic activity and lahars resulting from volcanic eruptions can threaten the safety and property of residents in Washington state. Geologists from the Washington State Department of Natural Resources (DNR) Geology and Earth Resources Division have been identifying, assessing, and mapping these geologic hazards for years.

Now the Washington State Geologic Information Portal makes this vital information available through interactive GIS-based hazard maps that aid land-use and emergency management planning, disaster response, and building code amendment.

"We have a lot of GIS-based geologic



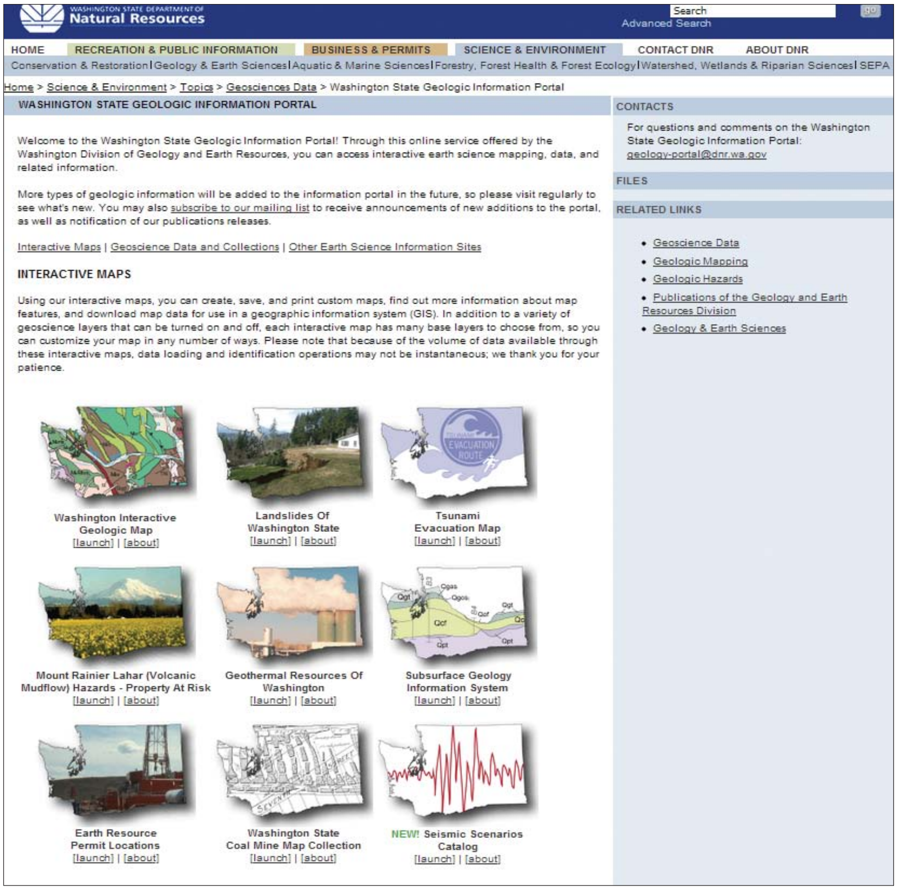
↑ A layer showing inundation from tsunamis is part of the Washington Interactive Geologic Map.

the department migrated its interactive mapping from ArcIMS to ArcGIS for Server, which provides faster performance, and has developed a gallery of maps that make its resources readily available.

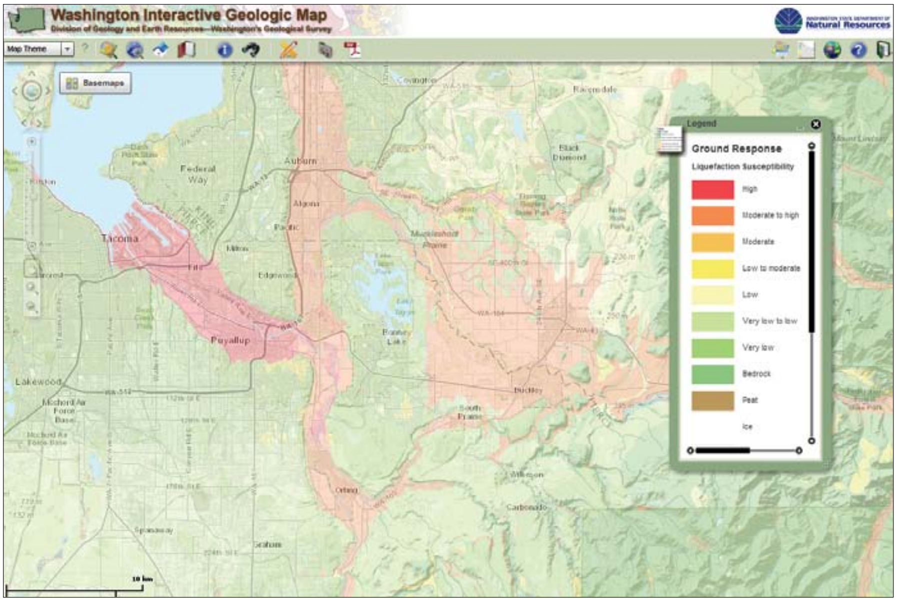
The Landslides in Washington State map exemplifies how these maps make DNR's work benefit a larger audience. Using ArcGIS for Server, DNR connected its basemap services to information from its landslide database so that anyone can see the landslide history and potential in any given area. "The landslide maps show which areas have been prone to collapse in the past so that local jurisdictions can draft their mitigation plans," said Meyers. "If they know a storm is coming, they can use these maps to focus their attention on areas known to be landslide prone." That helps DNR issue more granular data, and much of it is pretty complex," said Karen Meyers, an editor at the Geology and Earth Resources Division at DNR and manager of the Washington State Geologic Information Portal. "We wanted to give the public accurate data so that they can see the relationship of geology to where they are and how geology affects their life without having to know how to use GIS."

As Washington's population has continued to grow, so has the pressure to build in hazardous areas. The 1990 Growth Management Act mandates the use of the best available science to manage the state's growth intelligently. In 2000, the perspective on how DNR data could be used began to shift as the organization realized that maps and the spatial relationships they convey can be understood not only by specialists but also by a much wider audience. Anyone could discover patterns and relationships in digital maps and even make their own maps using a relatively simple front-end system that accessed cartographic information and processing power.

Initially the department adopted ArcIMS, Esri's first Internet map server, to map data from the department's databases and make it available through a website. Recently,



↑ DNR has created a gallery of maps that make its resources readily available.



↑ The earthquake-induced liquefaction potential layer helps emergency planners create safer and more efficient evacuation routes.

landslide alerts and be better prepared to deal with the problems when they occur.

Danger to Land from the Sea

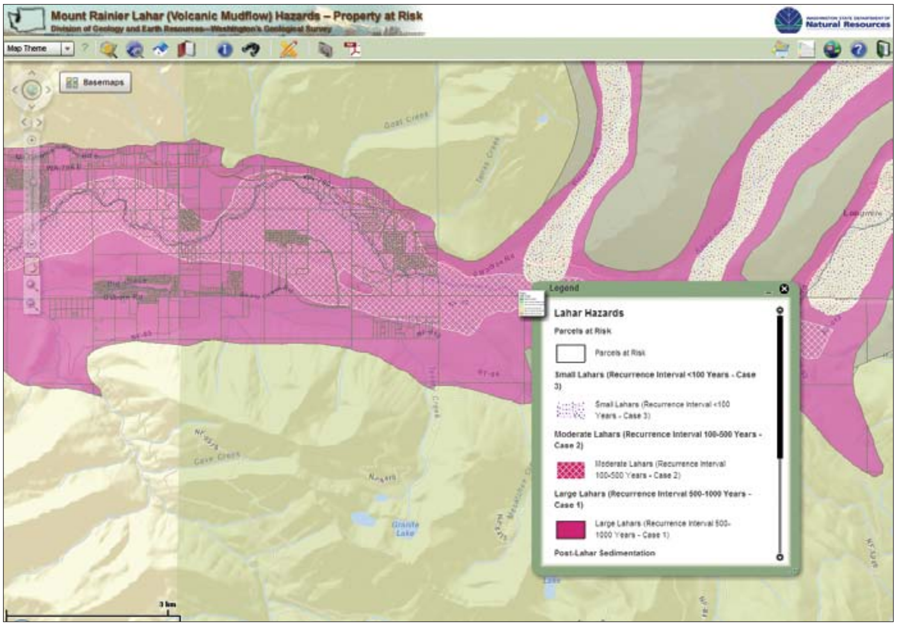
Although less common than landslides, tsunamis pose a real risk to coastal communities in Washington, which is located next to the giant Cascadia subduction zone, a fault of more than 600 miles that stretches along the Pacific coast from Northern Vancouver Island to Cape Mendocino. An earthquake in this region could generate a tsunami that would strike Washington with great force in a short time.

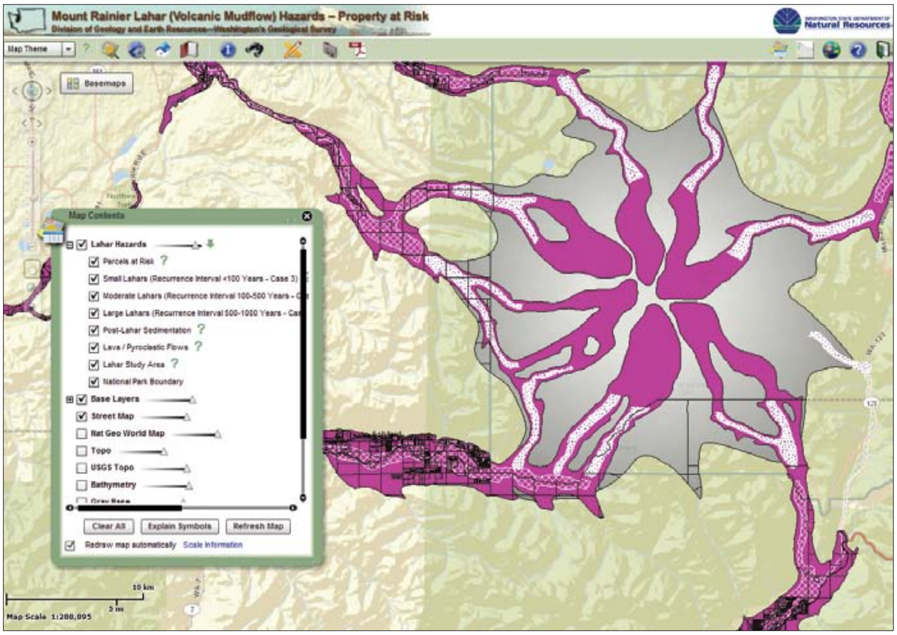
DNR combines land-use and land-cover datasets with inundation mapping to assess what areas would receive the greatest impact from a tsunami. "We calculate wave height, velocities, and amplitudes from topography and bathymetry and then feed it into ArcGIS for Server to show the extent of inundation on a map," said Tim Walsh, geohazards geologist at DNR. "That helps us better understand how these populations and structures will be affected." A layer showing inundation is part of the Washington Interactive Geologic Map.

This map also contains layers showing liquefaction. Walsh and his team used data from DNR's liquefaction susceptibility index, an engineering proxy to test load-bearing capacity for buildings, to create the map. "Taking into account earthquake-induced liquefaction potential in tsunami inundation zones makes it more than just pushpins on a map," said Walsh. "Incorporating information about soil helps jurisdictions create safer and more efficient evacuation routes that take into account the collateral damage from an earthquake."

Walsh and his team include data from landslide hazard maps when creating the evacuation maps and brochures, since extreme shaking would loosen soil in landslide-prone areas. This helps emergency response know the stable areas to send personnel to in such an event. Walsh and his team also created separate tsunami evacuation zone maps in ArcGIS that

↑ An eruption by Mount Rainier could cause billions of dollars of damage from lahar flows.





↑ Not only the lahar flows but the parcels at risk and their valuations are mapped.

were output as PDFs to make them available on-site.

Volcanic Neighbor

Washington's Mount Rainier has the potential for a major eruption. If such an explosion occurred, it could melt the mountain's picturesque snow cover and create huge mudflows called lahars. Historically, major lahars have occurred every 500 to 1,000 years, caused not only by volcanic eruptions but also as a result of avalanches and earthquake. DNR has estimated that an eruption of Mount Rainier could produce property losses of as much as $6 billion to communities in the Puyallup Valley.

Over the years, the US Geological Survey has collected and compiled data on hazard zones for one of North America's most dangerous volcanoes. DNR has used that data showing the predicted path and extent of such flows and a parcel layer providing the value of land and structures. This map not only aids in mitigation planning and emergency response for surrounding communities but also helps estimate losses from lahars.

Reaching Larger Goals

The Washington State Geologic Information Portal addresses two of the guiding principles set forth in state lands commissioner Peter Goldmark's strategic plan for 2010–2014: Make decisions based on sound science and make decisions in the public interest and with the public's knowledge. Although not a substitute for a site-specific assessment of a particular location by a qualified practitioner, these maps delineate areas based on hazard potential and let anyone create, save, and print custom maps; find out more about the geologic characteristics of an area; and download data for use in a GIS. The Washington State Geologic Information Portal has transformed a cumbersome system into one that anyone can access and use to better understand the geology of the state.

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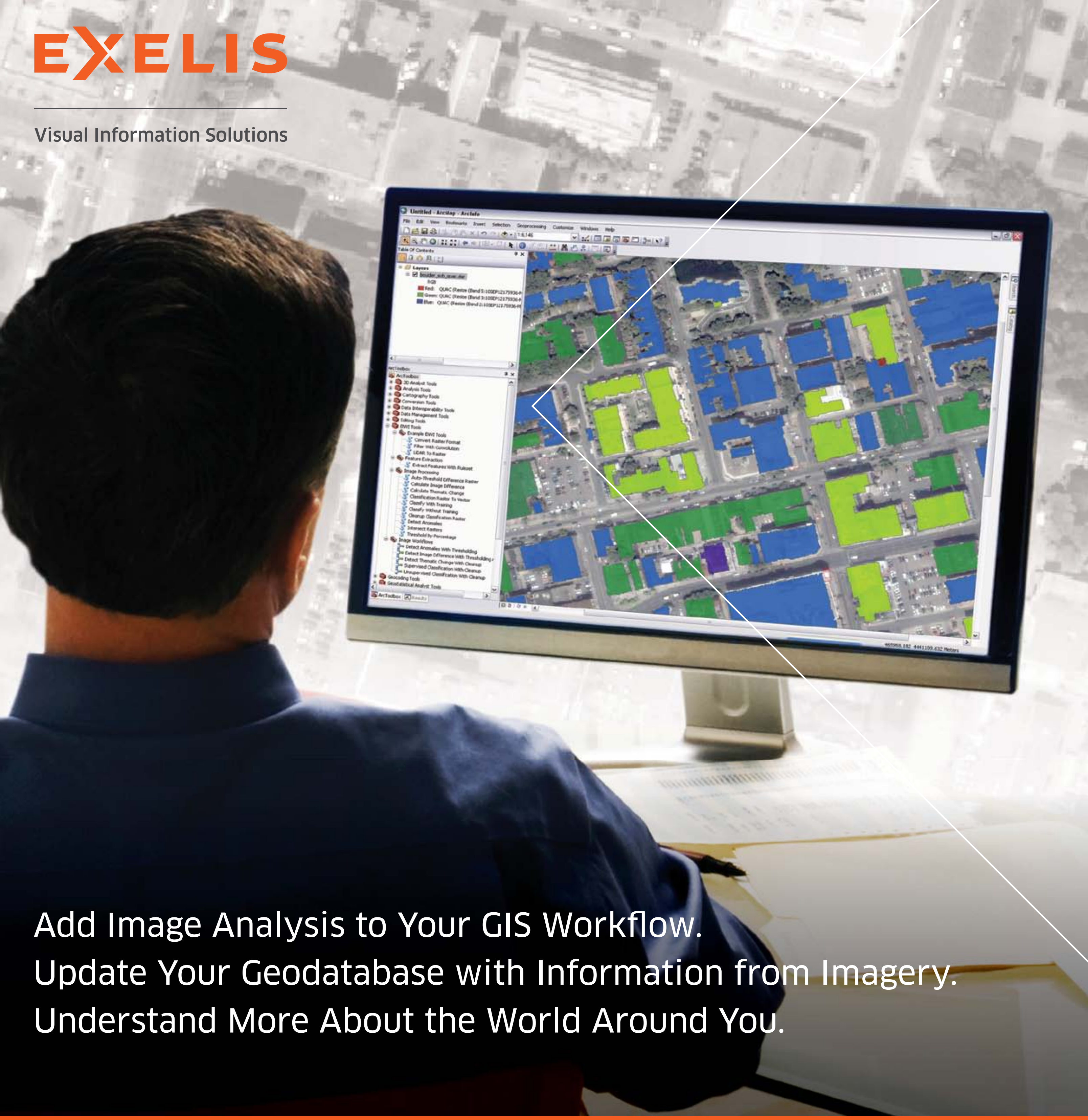

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