Winter 2013

ArcUser

The Magazine for Esri Software Users

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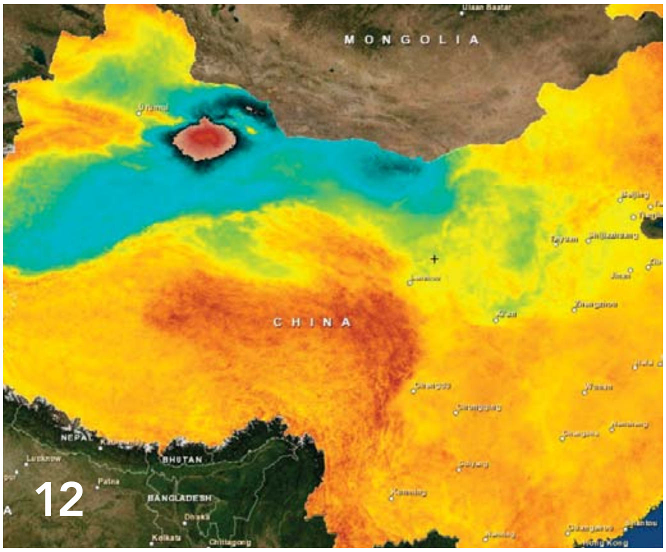

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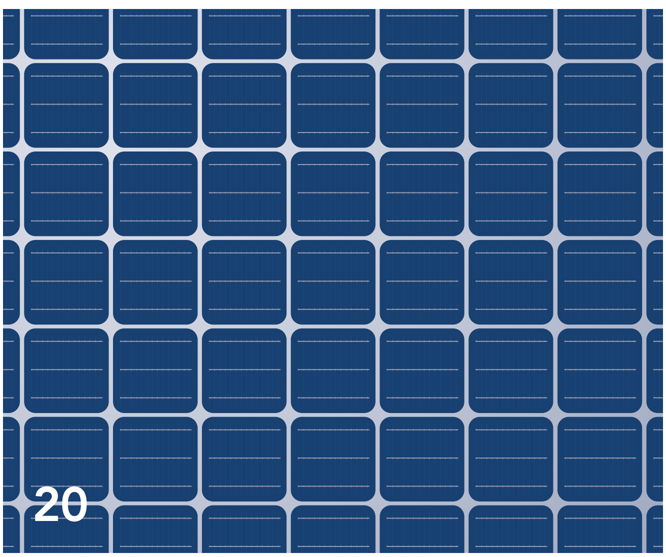

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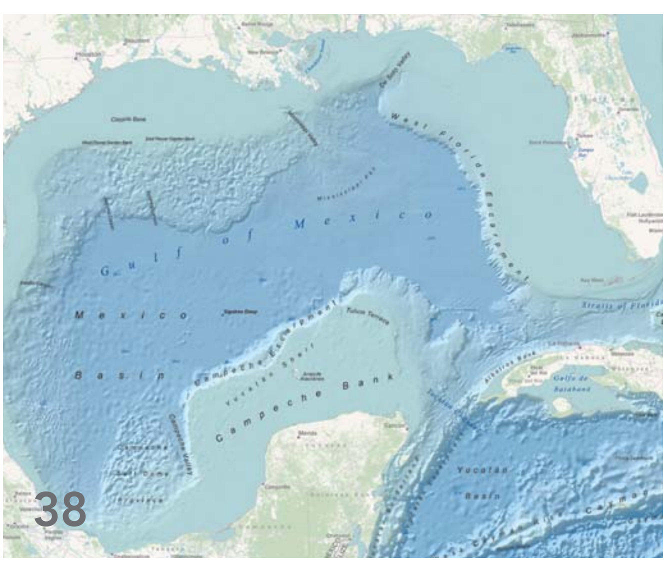

Special Section

Saving the Blue Stuff

Viewed from space, the earth's land mass looks insignificant. It is surrounded by expanses of ocean and obscured by clouds. Planet Water seems a more appropriate name.

Although our supply of water appears endless, it is actually quite finite. All the water we have is all the water we have. While water continuously moves on, above, and below the earth's surface as liquid, vapor, and ice, no new water is created by the hydrologic cycle. The vast majority of the planet's precious water supply (96.5 percent) is stored in its oceans, and it is saline. The balance exists in lakes, rivers, groundwater, the atmosphere, plants, and living creatures like you and me.

The importance of preserving freshwater supplies can hardly be overstated. Without water, you would likely survive only a few days. Articles in the Focus section of this issue describe how GIS is being applied to the challenges of wisely using and monitoring freshwater supplies.

While taking measures to safeguard freshwater, we shouldn't overlook the critical role of oceans. Our home is often called the Goldilocks planet because it is (for the most part) not too cold, not too hot—its conditions are "just right" for living things. The oceans that cover 70 percent of its surface, moderating the climate with deep currents and storing carbon, are responsible in large part for this fortunate state. According to the United Nations Conference on Sustainable Development, more than three billion people depend on the oceans for their livelihoods.

Yet despite the pivotal role oceans play in all our lives, we know relatively little about them. Exploring their vast reaches is a formidable task that will require extending GIS to more effectively deal with 3D and 4D data and analyze enormous datasets generated by sensor devices.

The Special Section in this issue reports on the historic Esri Oceans Summit held at Esri corporate headquarters in November 2012. At this event, key members of the ocean community working in many areas met with Esri staff to influence the evolution of ArcGIS. The summit is part of the Esri Ocean GIS Initiative, which in turn, is but one aspect of Esri's commitment to applying GIS to better understand and preserve our world.

Monica Pratt
ArcUser Editor

editor's page

ArcUser

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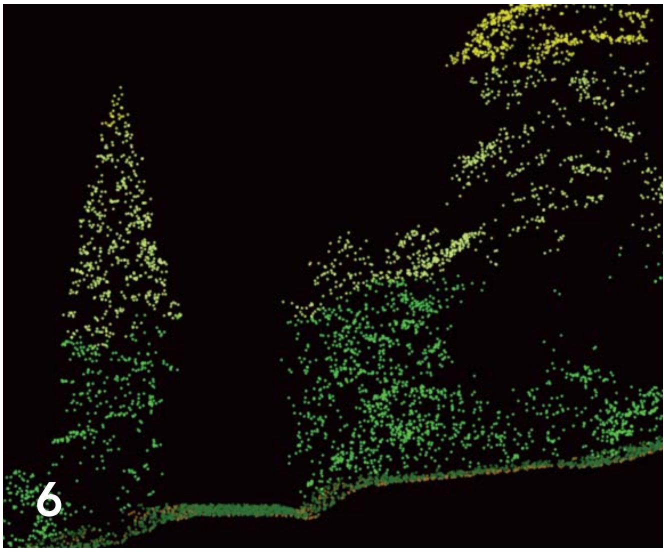

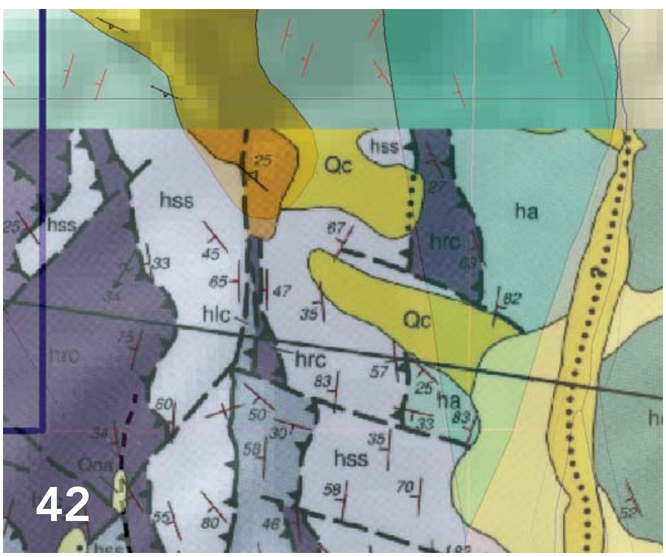

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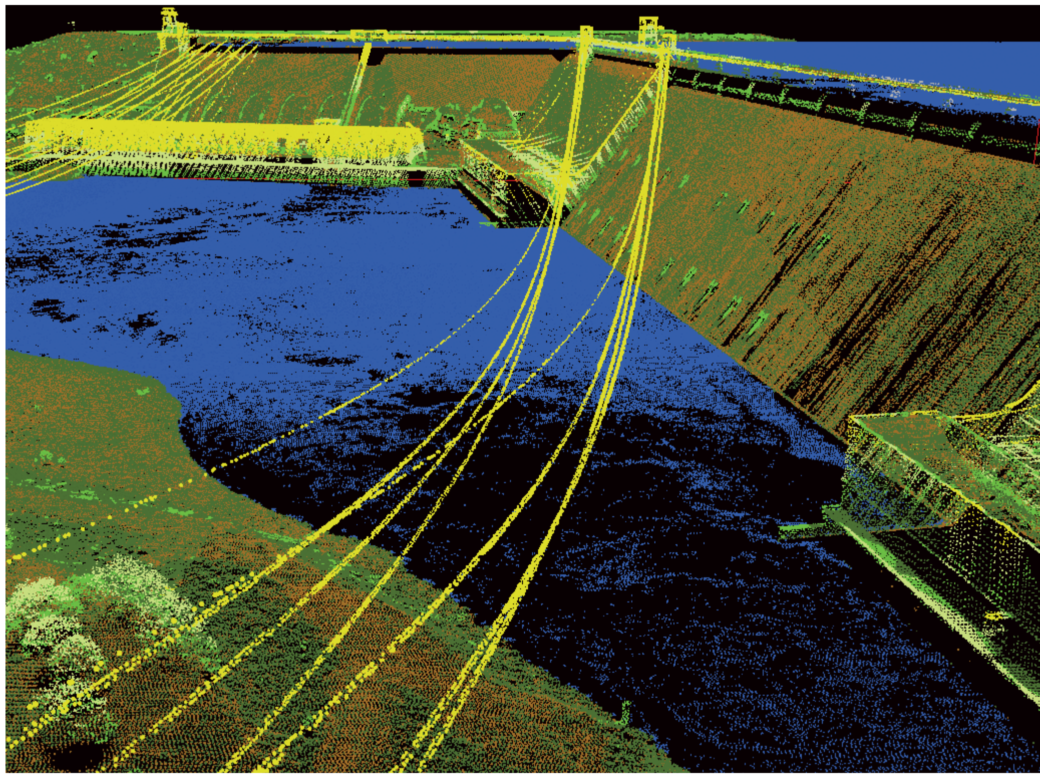
Working Directly with Lidar in Its Native Format

As part of its commitment to ensuring that ArcGIS is an open and interoperable system, Esri supports direct read and write capabilities in many formats. At ArcGIS 10.1, lidar data can be managed, viewed, updated, and shared while remaining in the industry-standard LAS format. Mosaic datasets in ArcGIS 10.1 can now incorporate lidar data, so vast quantities of lidar data holdings can be managed in the same way 2D imagery datasets are managed.

Clayton Crawford, Esri's lidar team lead, discussed the benefits of working with lidar data directly in ArcGIS and the additional enhancements to lidar data handling planned for the near future.



↑ Point cloud of the Grand Coulee Dam symbolized relative to height above ground (Source: National Oceanic and Atmospheric Administration Coastal Services Center)

↘ Point profile view of a vertical slice through a forest in the Pacific Northwest. With the profile view, it's easy to discriminate between individual trees and do things like measure height.

What are the advantages of working with lidar in the LAS format?

Working with lidar in its native format allows you to start working with the data immediately. Earlier versions of our software could import and process the data, but that involved a more protracted workflow. Over the years, that process has worked just fine for lots of users, and they've been able to do many wonderful things.

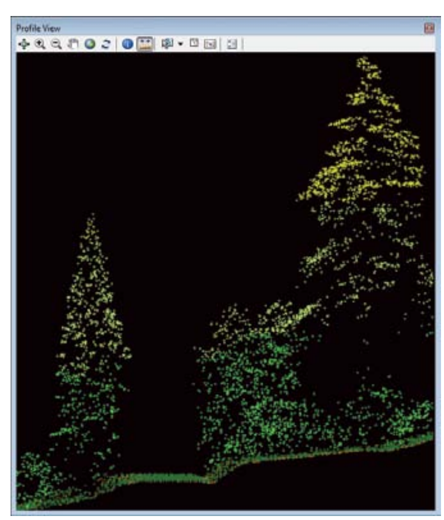
However, more time-critical users like emergency responders need faster turnaround. Also, just about everyone wants to get a sanity-level check on their deliverables before doing further processing. Many of our users needed to be able to immediately access the raw LAS files just as they access 2D imagery data.

Now the methodology for working with remote-sensing imagery like lidar has been greatly refined to the point where it's little different from 2D imagery in the way we work with it. You can have a directory full of lidar information that can be dynamically mosaicked into a continuous surface without having to load billions of points or hiring a vendor to do all that processing.

Previously, didn't lidar data require preparation before it could be consumed in a GIS?

Yes, by and large, what happened in the past was that data providers would process the lidar and sell their customers derivatives, such as high-resolution DEMs *[digital elevation models]*. Now, with the tools we've made available in ArcGIS, end users can do that themselves.

Another big advantage of that is being able to have access to the source



↑ Map showing the building height difference between 2008 and 2012 lidar datasets

↓ 3D perspective view of a lidar point cloud. Points are symbolized relative to height above ground, accentuating forested areas.

measurements and not just the derivatives. It's valuable to have that source data that those terrain models are based on to fix problems and make improvements. Serious problems need to be addressed by the vendor, but there are often simple things like a few misclassified points that are easier and faster to fix directly in the GIS. Also, if you get ancillary information, like water body shorelines that can be used to make improvements to the DEMs, it's easier to do that when you have the source lidar points.

Before, users couldn't make those edits on their own. They would have to go back to the vendor, ask for that information to be processed into new models, and pay for all that extra work. Now, users have been empowered with the tools to avoid having to request updates they can easily do themselves.

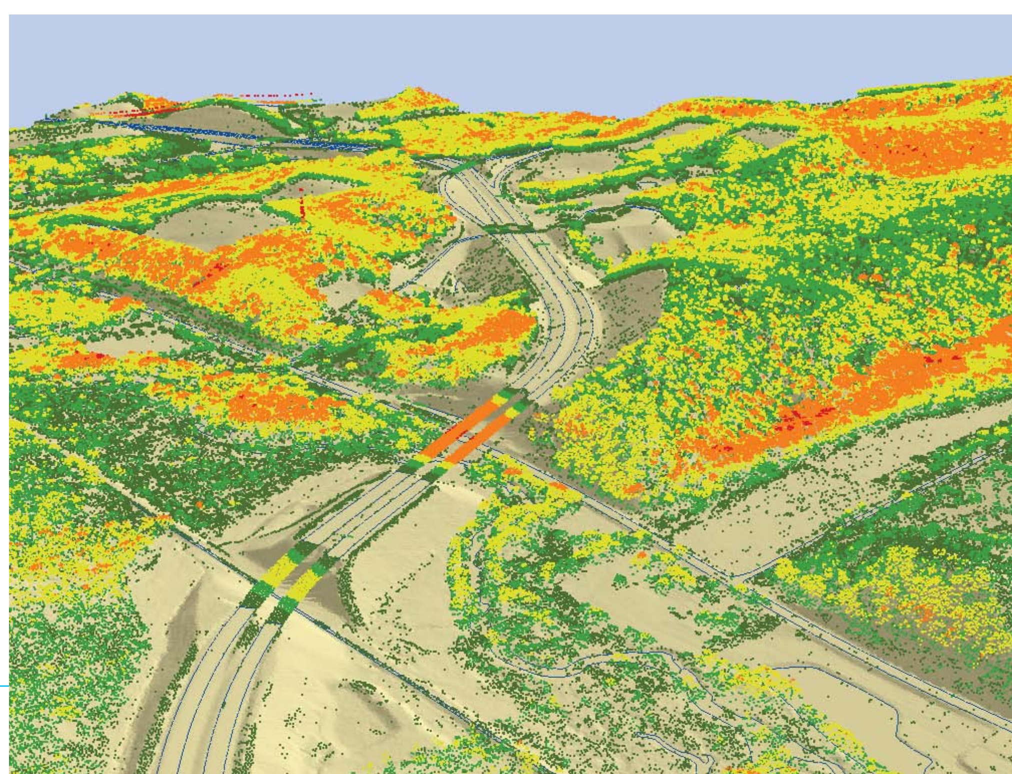
What kinds of things can now be done with lidar data in 10.1?

An example application is forest inventory. Since lidar often comes classified by the data vendor into ground versus nonground points, it makes it easy for us to derive both DEMs (which are elevation models of just the ground) as well as DSMs *[digital surface models]* (which include trees). Subtracting one from the other yields a normalized DSM, which is basically just height above ground. It becomes very simple to find tree height this way. In 10.1, we can also compare the relative number of lidar returns in tree canopy to those of bare earth. This provides an estimate of canopy density. So, very quickly, we get height and density. These are useful metrics for forestry and environmental applications.

What's the next phase of lidar support?

At present, we're working on adding support for spatial indexing on LAS files. This will dramatically improve performance for a lot of things. LAS files don't have built-in spatial index support. If you want to query a subset of data in a LAS file, you have to scan the whole file for the points you want. This is a huge I/O bottleneck. Adding spatial indexing capability makes querying more efficient. We'll see benefits when reading LAS both locally and especially across networks. Looking further down the road, we're investigating advanced visualization techniques, classification tools, feature extraction, and compression.

For more information on working with LAS files in ArcGIS, access the topic "Using lidar in ArcGIS" in the online help.



Play It Again

Using geoprocessing tools in batch mode

By Monica Pratt, *ArcUser* Editor

Do you have to run the same geoprocessing tool against many datasets? Perhaps you need to convert a bunch of shapefiles to file geodatabase feature classes, clip the spatial extents of some feature classes to the extent of an area of interest, or apply a specific projection to several feature classes. ArcGIS has a faster way to get this done: batch mode.

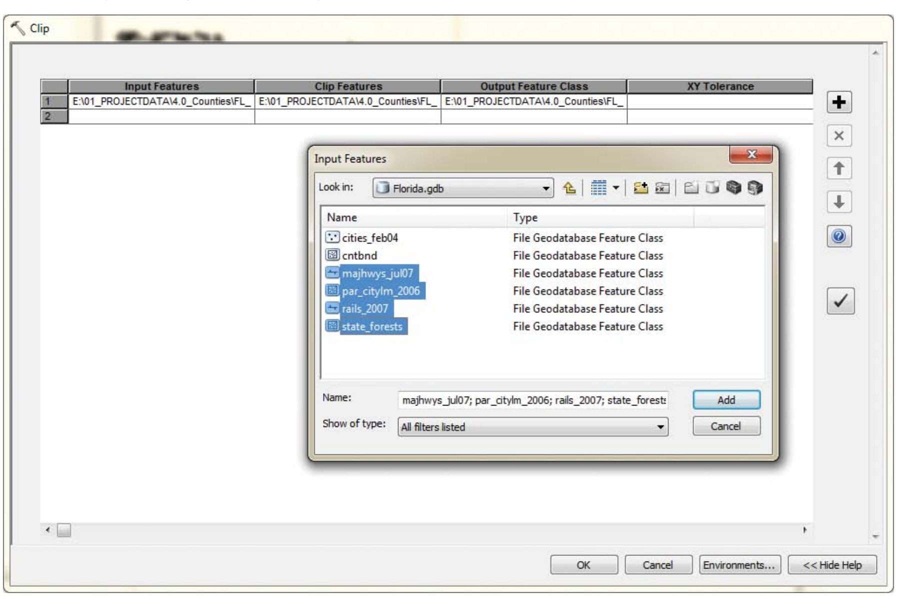
Using a geoprocessing tool in batch mode speeds repetitive processes by allowing you to specify multiple data sources and different parameters for each data source in a single operation. If background processing is enabled, you can do other things while ArcGIS executes the tool as many times as needed. Although batch mode capability has been available for some time, many users don't know this or forget to employ batch mode.

One Click Away

You can access a geoprocessing tool's batch mode from ArcCatalog or from the Catalog window in ArcMap simply by right-clicking the tool you want to use and choosing Batch from the context menu. The batch dialog box containing the grid for that tool opens. Each line in the grid represents the data and tool parameters for a single process. To more easily read the contents of each cell in the grid, you can resize the dialog box by stretching it and grid columns by dragging the column separators.

You use the grid to add two types of items: data and values. Data includes the location of the shapefiles, feature layers, tables, TINs, rasters, networks, or other files that will be processed. Values are the strings and integers that stipulate how the tool will operate.

↓ When adding data sources, save time by browsing to the location and choosing multiple datasets by holding the CTRL key.



More Ways to Streamline

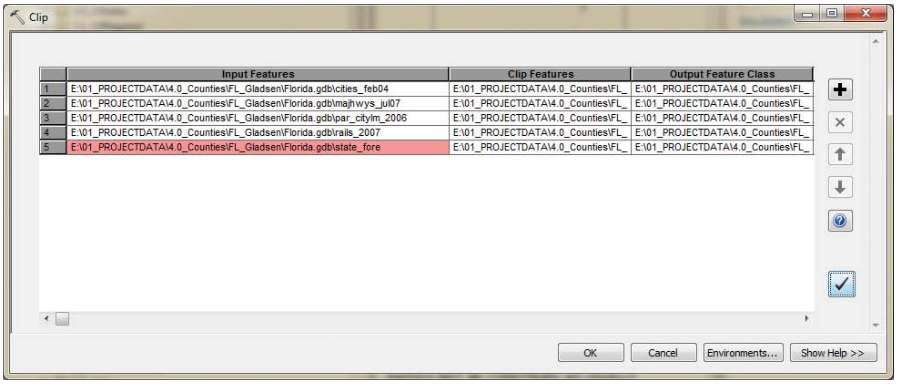
There are several ways to insert data and values in the grid besides just clicking in a cell and typing. Use shortcuts in combination to reduce the number of keystrokes and clicks needed to add all the information the tool needs to run.

For some parameters, the tool dialog box can be useful. Access it by right-clicking in the cell and choosing Open or (quicker) double-clicking in the cell. Clicking OK returns you to the grid.

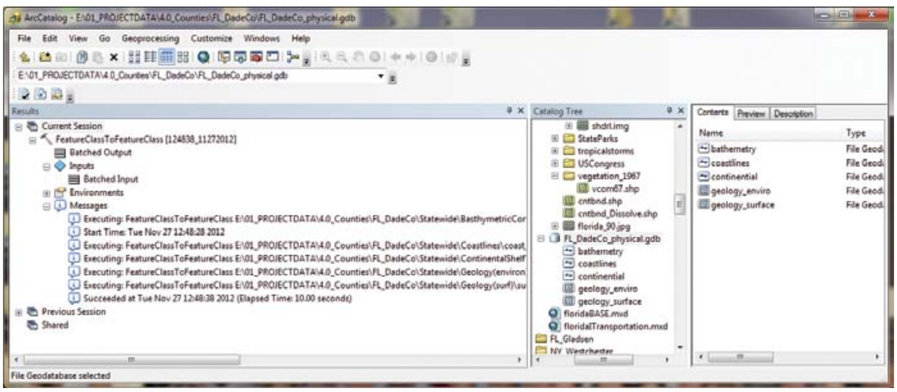
When adding a data source, typing the long path name to it is a tedious and error-prone task. Browsing and dragging are more efficient methods for inputting data sources. With the tool's batch grid open, right-click in the cell that will hold a data source parameter and choose Browse. Navigate to the location of the data source. To save time, you can choose multiple datasets by holding the CTRL key. (However, don't use this shortcut for tools like the Union tool that expect multiple datasets.) Alternatively, you can drag each data source file from Catalog to a grid cell.

The grid accepts values copied to and pasted from the system clipboard. You can use the classic CTRL+C and CTRL+V to accomplish this or the Copy and Paste commands available from the batch grid context menu.

To fill several cells with the same value, right-click the cell with the desired value and choose Fill to copy that value to all the cells in the column below. To copy the value to only specific cells, select the processes containing those cells first, then use Fill to copy the value to just those selected cells. To remove values from a column of cells, right-click the topmost cell and choose



↑ Before running a batch process, verify the data and values entered using Check Values.



↑ Make sure all the iterations of the batch process have run correctly by checking the Results window.

Clear. The values in all the cells below it will be removed. To remove the content of only specific fields, select the processes containing those cells first, right-click the first cell, and choose Clear to remove values in just those selected cells.

The buttons on the right side of the grid modify tool execution. Add or delete processes in the grid using the Plus and Delete buttons and rearrange the order in which processes execute using the Up and Down arrows. To make the best use of your time, enable background processing. This can be done in either ArcMap or ArcCatalog by choosing Geoprocessing > Geoprocessing Options from the Standard toolbar and checking the box to enable it.

Before Running the Tool

Because the batch grid does not perform error checking, the last step before running a batch process should be to perform value checking to ensure that you have not accidentally entered an incorrect string or a dataset that doesn't exist or have an output dataset with no name. Click the the Check Values button—the one with the check mark icon. In addition to scanning all the rows in the grid for errors, it will also create an output dataset name (if none has been specified). A white cell means the parameter is correct. Error messages are color coded. Table 1 provides an explanation of each code.

Color	Message meaning
Green	Required parameter is missing and a value must be supplied.
Red	Error: Process will not execute.
Yellow	Warning: Output exists but results may not be what you expect.
Gray	Unavailable: Parameter has no use given values of other parameters.

↑ Table 1: Check Values error messages

The Final Step

To make sure all the iterations of your batch process have run correctly, check the Results window. Choose Geoprocessing > Results to view inputs, environments, and messages for geoprocessing sessions run from the tool dialog box or in batch mode.

Remember these tips the next time you need to perform geoprocessing operations on more than just a couple of files. Batch mode can help you make better use of your valuable time.

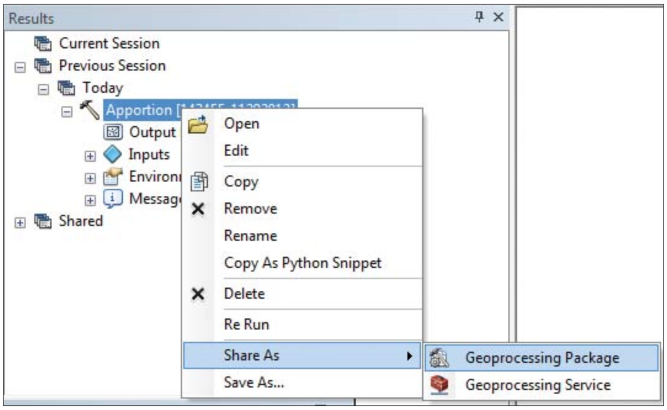
The Gift of Sharing

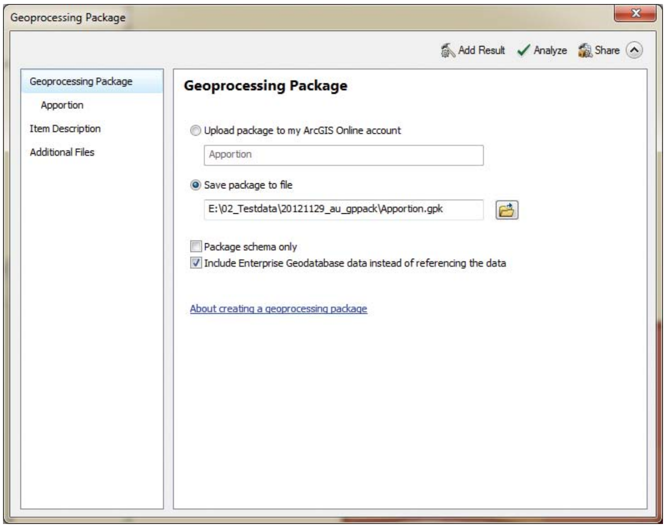
By Monica Pratt, *ArcUser* Editor

Sharing geoprocessing workflows with other GIS professionals has become a simple process using geoprocessing packages introduced in ArcGIS 10.1.

Prior to this version of ArcGIS, you could deliver all the components of a geoprocessing tool in a ZIP file, but assembling that file was an involved process that required translating paths and workspaces. Now geoprocessing workflows can easily be shared in three ways: as a package used by GIS professionals in ArcGIS for Desktop or in an ArcGIS Runtime application or as a service that can be accessed by anyone via the web using web-enabled clients, such as ArcGIS Explorer Desktop; ArcGIS Online; custom web applications built with web-based APIs such as JavaScript, Silverlight, and Flex; as well as ArcGIS for Desktop.

↓ Create a geoprocessing package by simply right-clicking the results of a process in the Results window and choosing Share As > Geoprocessing Package.





This article is concerned only with geoprocessing packages that joined four other kinds of packages—layer, map, locator, and tile—that ArcGIS generates. Packages bundle up data and expertise so they can be easily shared, standardizing and streamlining organizational processes.

A geoprocessing package is a single file that contains all the ArcGIS tools and data required for a geoprocessing workflow. It can be created as a local file that can then be shared as an attachment to an e-mail or a file upload or simply made available across the network. It can also be uploaded and shared to ArcGIS Online. In either case, it's all about sharing methodologies and tradecraft.

Why Use Geoprocessing Packages?

The most obvious reason for using geoprocessing packages is to share expertise. You might have an extensive background in a particular subject or technique that can help others. Conversely, you might need to learn more about a specific topic from someone. In addition to sample data and models that demonstrate the workflow, geoprocessing packages can include Microsoft Word files, PDFs, or other supporting documents that can further explain methods. You or the recipient of your geoprocessing package can study the methodology employed and apply it to other data.

Geoprocessing packages can enhance collaboration. Members of a team working on different aspects of a project at different locations can coordinate activities by periodically consolidating, packaging, and sharing the entire project with everyone. This conserves resources by avoiding duplicate efforts and enables more efficient teamwork.

Because they can contain other supporting documentation, geoprocessing packages are also a nifty way to supply training course materials to staff members or others outside your organization.

More Reasons

There are less obvious but quite valuable reasons to use geoprocessing packages. Consolidation—all by itself—is a great reason to use geoprocessing packages. A single map document and any model built from it can contain layers from a wide variety of sources. Some layers are on local disk, some are located on the network, while others may be obtained from enterprise databases. If you want to work on models in a disconnected environment, geoprocessing packages let you simply run the model to create results, then generate a package. Just the data and tools used by the model are included. Now your model is good to go.

Geoprocessing packages can be valuable even when you aren't sharing your workflow with anyone else. Perhaps you are tasked with a project that requires you to develop several different scenarios that make different assumptions. Once you have developed a particular scenario, you can bundle up all the data (edited for this scenario), models, and model parameters into a geoprocessing package that creates a snapshot of that scenario. Now you can move on to the next scenario. When you have developed all the scenarios needed, you can unpack the geoprocessing package for each scenario and compare them.

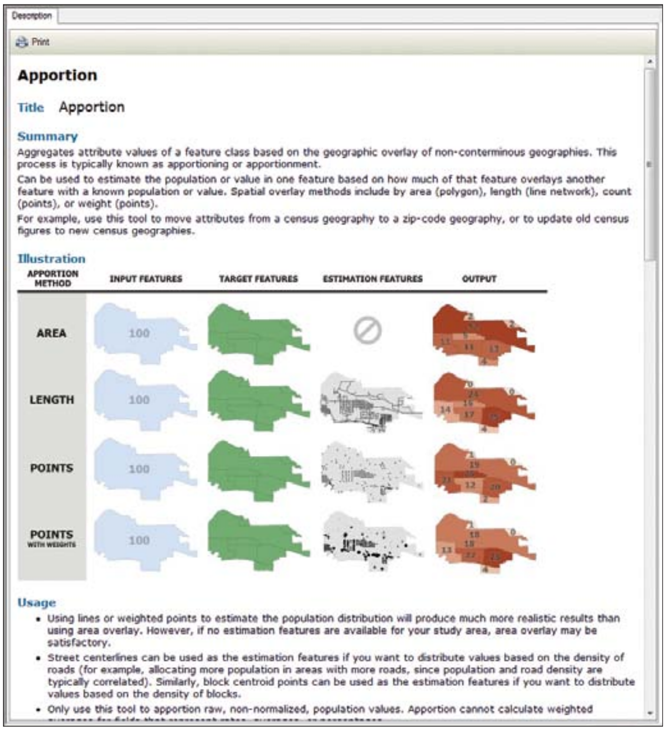
Creating and Using Geoprocessing Packages

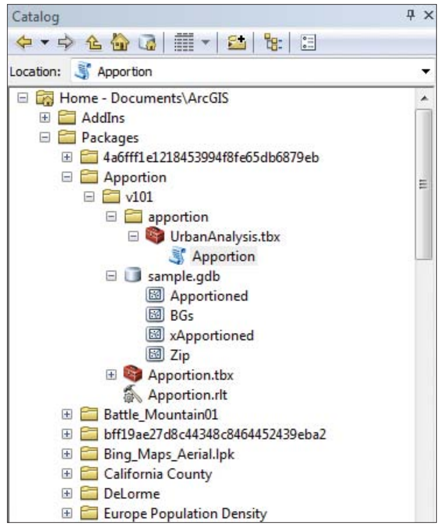
Creating geoprocessing packages is simple and straightforward. Make sure the process runs correctly, right-click the result in the Results window, and choose Share As > Geoprocessing Package. You can add additional files, such as Word or PDF files, but not executable files. You can check Include Enterprise Geodatabase data instead of referencing so any related data residing in an enterprise geodatabase will be converted to a file geodatabase and included in the package. The option Support ArcGIS Runtime will only appear if you previously enabled this support by choosing Customize > ArcMap Options in the ArcMap Standard menu. Use the Add Result button if you wish to add another result to the package.

Make sure you click the Analyze button. This process will identify any errors that must be corrected, issue warnings about aspects of the package that may impact its performance, and provide messages with suggestions for optimizing the package. Finally, click Share and let ArcGIS gather all the tools, models, scripts, data, environment settings, and documentation into one package for you.

Tip: If you get an error message that data was not found during packaging, the most likely cause is that you're packaging a result from the Previous Session node in the Results window. Since that result was created, the data has been deleted, moved, or renamed or for some other reason cannot be found. Fix this problem by re-running the result (choosing either Open or Rerun) and package the new result.

↓ Ensure the contents of your geoprocessing package are useful by documenting any custom tools and the package itself. Provide tags, a robust summary, code samples, and usage information.





← Unpacked geoprocessing packages appear on the Shared node in the Results window. The package file itself resides on your ArcGIS user folder.

Packages are not only easy to create but easy to use. They are supported in all ArcGIS applications. Unpacked geoprocessing packages will automatically show up in the Results window under the Shared node in ArcCatalog or the Catalog window in ArcMap. Like all package files, by default, the file itself is actually stored in C:\users\<username>\My Documents\ArcGIS\Packages (for Vista and Windows 7 users) and C:\Documents and Settings\<username>\My Documents\ArcGIS\Packages (for Windows XP users). ArcGIS recognizes a geoprocessing package by its checksum and won't download and unpack the same package multiple times to the same location.

Remove Mystery

ArcGIS requires a minimal level of documentation when packaging a result, but the minimum may not be sufficient if you are sharing this package with a wider audience, particularly if you are uploading it to ArcGIS Online. The quality of your documentation will be better if you write it before starting the packaging process.

System tools are already documented, but if the package is based on results from a custom tool, you will have to supply that documentation. Document a custom model or script tool in ArcMap by right-clicking it in the Catalog window or the ArcToolbox window and selecting Item Description. In the Item Description window, click Edit and add tags and the summary for the tool (the minimum requirement). Under the Syntax section, expand each parameter and make sure Dialog Explanation is populated. It's a good idea to add any credit or usage information or code samples that will make the tool more useful to someone unfamiliar with it. When finished, click Save. Note that adding labels to ModelBuilder models or comments to Python code will make them more understandable.

In addition to documenting the tools that created the result, you need to document the package itself. Do this in your favorite text editor beforehand and copy and paste it into the package description text box.

Online Community

Find and share geoprocessing tools, services, and samples by joining the Analysis and Geoprocessing Tool Gallery group, a public group on ArcGIS Online. Access the group using your organization's ArcGIS Online account or your free personal ArcGIS Online account.

More Crop per Drop

GIS-based water requirement maps optimize water use

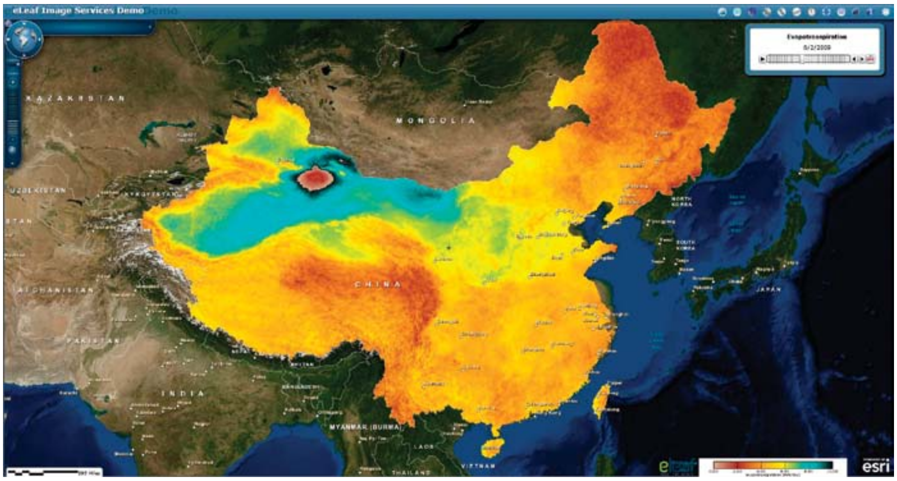
By Jim Baumann, Esri Writer

Existing GIS-based tools used by a Netherlands-based company that helps optimize water use are being ported to a standardized ArcGIS platform.

Two well-established companies in the Netherlands—WaterWatch and Basfood—formed eLEAF to support global solutions for agriculture and the environment with data they collect on vegetation, water, and climate. WaterWatch previously developed PiMapping technology, a family of GIS-based tools that delivers more than 50 data components.

"In the past, the efforts to expand agricultural productivity have focused on the land, commonly measured as a yield per hectare," said Maurits Voogt, manager of eLEAF Competence Center. "However, with the increasing global scarcity of water resources, the focus is shifting away from the land on which the crop is grown and to the productivity of the water applied to the crop, or a yield per cubic meter."

Optimizing crop water use efficiency requires quantitative measurements of crop water consumption. The physical process behind crop water consumption is called evapotranspiration. It is the combination of plant transpiration (the loss of water vapor from plants) and surface evaporation.

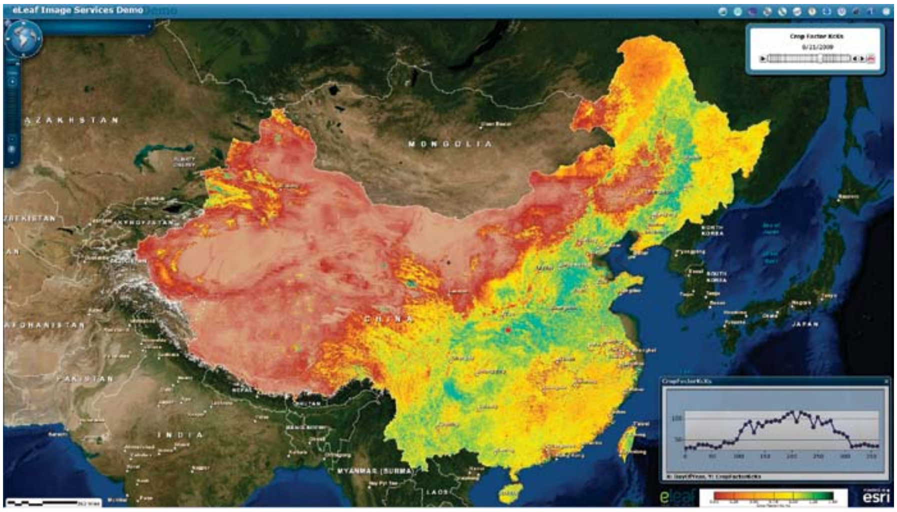


↑ The sum of evaporation and plant transpiration, evapotranspiration is calculated using satellite images and meteorological observations to determine optimum water needs for plant health. This analysis, and the others shown, were calculated in eLEAF and mapped in ArcGIS for a specified time period.

Utilizing Remote-Sensing Data

During the mid-1990s, professor Wim Bastiaanssen, a water resources modeling and remote-sensing specialist and founder of WaterWatch, developed the Surface Energy Balance Algorithm for Land (SEBAL) model to calculate crop water consumption from remote-sensing data. The model measures the energy balance that specific plants in a defined area require to sustain the hydrologic cycle. Basically, the energy driving the hydrologic cycle is equal to the incoming energy from the sun minus the energy reflected back into space and the energy used to heat the surrounding soil and air.

The model uses satellite imagery (spatially distributed, visible, near-infrared, and thermal infrared data) that includes the albedo (solar reflection coefficient), leaf area index, vegetation index, and surface temperature. This complex algorithm calculates evapotranspiration on a pixel-by-pixel basis to



↑ The amount of water required for crop under irrigation is calculated by multiplying the reference evapotranspiration by a crop coefficient (Kc).

determine the optimum amount of water needed to sustain healthy plant life in any part of the world. It can also calculate the biomass production (total plant life) in a specified area and soil moisture in the root zone.

Bastiaanssen established WaterWatch to pursue his research in water resource modeling and remote sensing. The framework WaterWatch developed for PiMapping is based on the SEBAL model. Along with supporting algorithms, PiMapping provides essential meteorologic input data such as wind speed, humidity, solar radiation, and air temperature. Combining those inputs with remote-sensing data, PiMapping generates weekly updates on biomass production, water productivity, crop water requirements, root-zone soil moisture, and CO_2 intake.

PiMapping Moves to ArcGIS

eLEAF is working with Esri's Professional Services team to port PiMapping's complex tools to a standardized ArcGIS platform. "The solution will leverage Esri's cloud infrastructure, opening many new exciting opportunities for data analysis and dissemination," said Bastiaanssen.

Time-series data collected from this framework is plotted in ArcGIS to create evapotranspiration and biomass production maps. Benefits are substantial and include the estimation of water requirements for different agro-ecosystems, drought monitoring, the identification of areas for possible water savings, and the potential volume of such savings. "Compelling visualizations of our results are essential to get the message across," Bastiaanssen explained. "In our day-to-day consulting work, we have seen substantial productivity increases thanks to the great mapmaking features of Esri's products."

Because they are GIS based, evapotranspiration maps can also be combined with land-use and biomass coverages. Combining these maps provides a great deal more information, such as the amount of water use by land-use class; the boundaries of areas where water consumption can, and cannot, be controlled; the impact of changes in land use on downstream water availability; crop water productivity; and the amount of water that can be saved while the same production levels are maintained.

"From our analyses, you can determine how much water is available in a specified area, what yield you can expect from the water that is available for your crops, and how efficiently water is used. This will enable farmers to produce more food in a sustainable way," said Voogt.

ArcGIS in Cloud Delivers Data

ArcGIS hosted in the Amazon cloud delivers eLEAF data to clients. "We are in the process of creating a worldwide database from our analyses that anyone can access using very simple web services," said Ad Bastiaansen, cofounder of eLEAF. "ArcGIS has the features we need to integrate with our clients' systems."

Once data is processed and quality checked, it is posted in eLEAF's data warehouse. ArcGIS for Server exposes the data in multiple formats, such as Open Geospatial Consortium, Inc. (OGC), web services, and through an image server so eLEAF can feed websites, as well as smartphone applications, that accommodate customer demands. To afford easy access to its global databases, eLEAF also provides its service via ArcGIS Online. "ArcGIS Online is a wonderful platform. People can experience our products and easily integrate them in their maps," added Bastiaansen.

The rollout of eLEAF's ArcGIS Online service has begun in South Africa. As new data is acquired, the service will expand to the entire African continent, then to the Middle East. Updates are applied to previously collected data on a weekly basis so users' decisions are based on current data.

"Initial reports from South Africa indicate that the eLEAF service has been well received by agronomists, particularly because of its portability to the field," Bastiaansen said. "We are happy that our efforts will help local farmers increase their productivity."

↑ eLEAF's biomass production analysis for northern India, mapped using ArcGIS, is displayed on a smartphone.

From Paper Maps to Accessible GIS Data

Providing valuable groundwater aquifer information

By Kevin R. Hayes, GISP, PG, City of Jacksonville, Florida

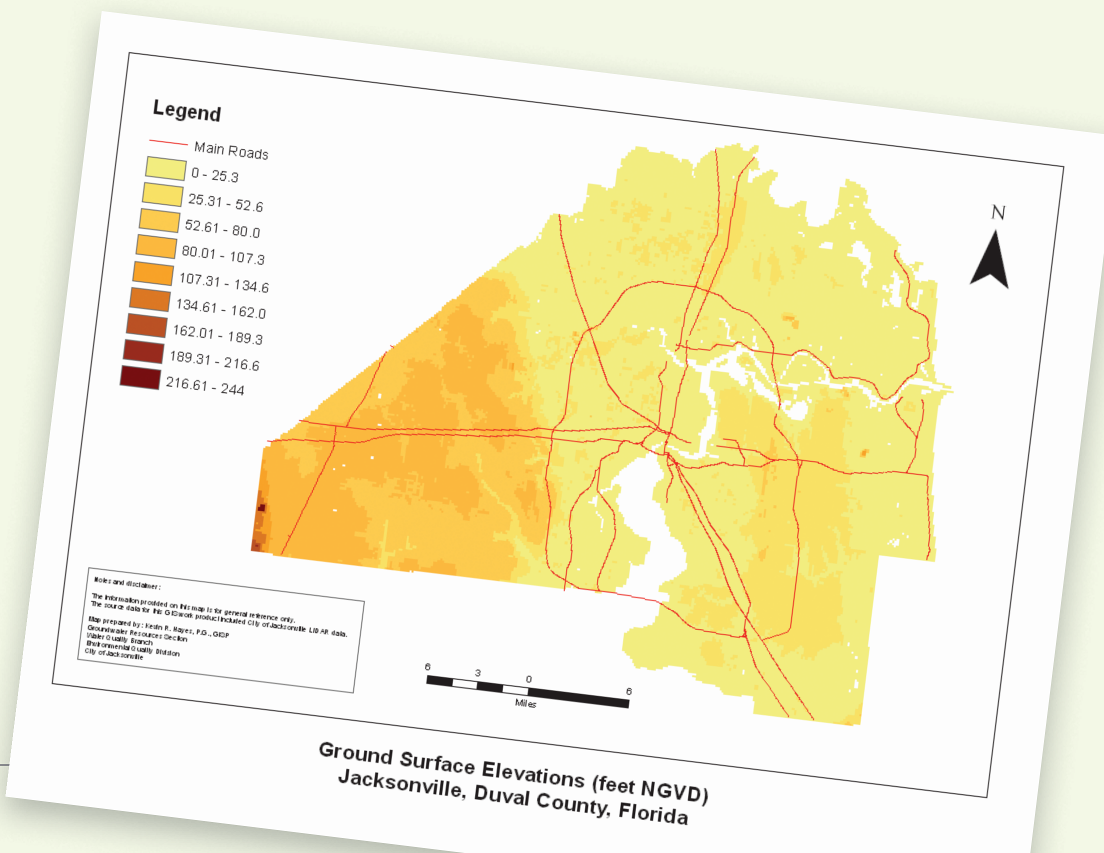
The Environmental Quality Division (EQD) of the City of Jacksonville, Florida, which issues water well construction permits, needed more timely access to accurate aquifer elevation information than was afforded by hard-copy maps.

Since 1978, EQD has issued water well construction permits in Duval County under a cooperative agreement with the St. Johns River Water Management District. Last year, EQD processed more than 1,200 well permit applications for wells serving a variety of purposes including domestic potable, irrigation, geothermal, industrial, environmental monitoring, and limited use public supply wells.

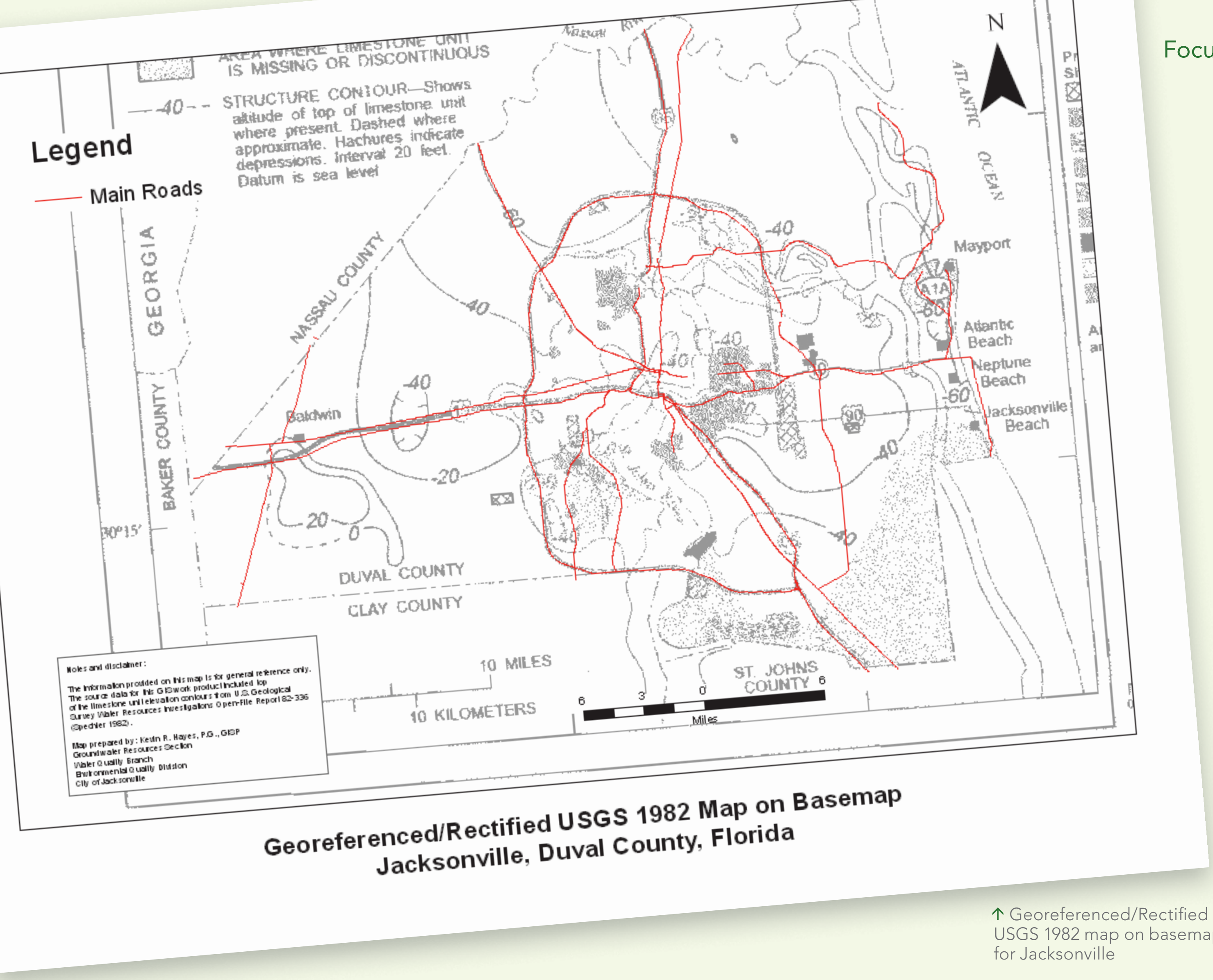
Well permit information is managed using EQD's Wellhead Information Management System, a custom, web-based application that interfaces with ArcSDE in a Microsoft SQL database. Well location and construction information for each well permit, including real estate parcel, street address, casing diameter, casing depth, and total well depth, are maintained in this database.

Prior to implementing GIS, EQD well permit application reviews depended on hard-copy information contained in paper maps, publications, and other reference materials. In 2004, EQD created the Groundwater Contamination Risk Management GIS using ArcGIS software. It is used to determine if known groundwater contamination issues are present in the vicinity of a proposed well.

Currently maintained in an ArcGIS 10 ArcMap document (MXD), the Groundwater Contamination Risk Management GIS includes contamination site information and private well sampling analytical data collected by state and local government agencies. Access to this information via GIS allows EQD to quickly evaluate potential contamination sources in the vicinity of a proposed well and provide notification to property owners and water well contractors when warranted by site conditions.



→ Ground surface elevations (feet NGVD) for Jacksonville, Duval County, Florida



↑ Georeferenced/Rectified USGS 1982 map on basemap for Jacksonville

Although the ArcMap document was a major step forward in quickly accessing contamination-related data for permit review, EQD staff still relied on hard-copy maps for most hydrogeologic information including subsurface aquifer elevation data. To determine depth to a target aquifer from the available paper maps, the top of aquifer elevation first had to be referenced to the ground surface elevation at the site, which required access to a separate topographic elevation data source.

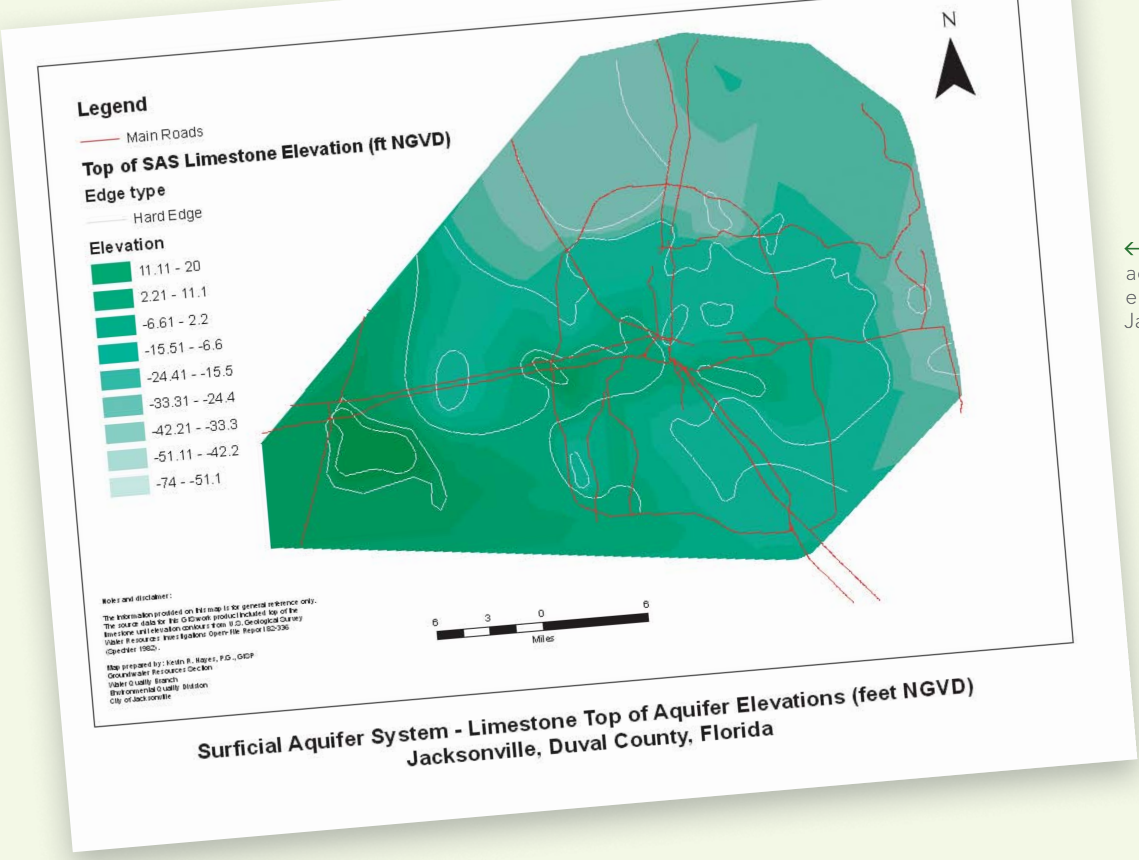
To improve accessibility to this type data, in spring 2012, EQD began creating a file geodatabase that would provide accurate depth to aquifer data across Duval County. The GIS mapping project focused on the surficial aquifer system (SAS), a productive and relatively shallow limestone aquifer of highly variable depth. EQD used top of aquifer elevation data provided in US Geological Survey (USGS) publications and City of Jacksonville lidar-based, topographic elevation data to create a feature dataset representing the depth to the top of the shallow limestone aquifer.

Local Hydrogeology

Duval County has a unique hydrogeologic setting that includes two other aquifer systems in addition to SAS: the Intermediate aquifer system (IAS), and the Floridan aquifer system (FAS). SAS is primarily composed of unconsolidated sands, clays, and a basal limestone rock unit and ranges in thickness from approximately 50 to 100 feet in much of eastern and central Duval County to more than 200 feet in the western portion of the county.

Numerous private, residential potable wells and irrigation wells produce water from SAS, particularly from the limestone aquifer at the base of SAS. According to the 1982 USGS Water Resources Investigation Open File Report 82-336, "Generalized Configuration of the Top of the Limestone Unit of the Lower Part of the Surficial Aquifer, Duval County, Florida," by Rick M. Spechler, SAS is not present throughout Duval County, and the SAS limestone aquifer generally ranges from approximately 5 to 40 feet in thickness.

Underlying SAS, the IAS includes the phosphatic sands, clays, and carbonate rock units of the Miocene-age Hawthorn Group. In addition to containing water-bearing layers capable of supplying adequate quantities of water for domestic supply and other uses, the approximately 400-foot-thick IAS serves as the confining unit for the underlying FAS. The FAS, a confined aquifer system that includes hundreds of feet of highly permeable Eocene-age carbonate rock units, is the primary drinking water source for Duval County and the northeast Florida region.



← SAS limestone aquifer—top of aquifer elevations (feet NGVD) for Jacksonville

Data Sources and Raster Dataset Creation

The 1982 USGS Open File Report 82-336 provided elevation contours referenced to National Geodetic Vertical Datum (NGVD) for the top of the SAS limestone aquifer. To create a depth to aquifer from ground surface dataset, the top of the SAS limestone elevation data was subtracted from the lidar-based, ground surface elevation data. Raster files for both elevation datasets were created in ArcGIS using ArcToolbox. Calculations were completed using the Spatial Analyst extension toolbox.

Creating the Depth to Aquifer Raster Dataset

The following steps summarize the process followed for the project.

Initially, the county-wide, two-foot contour interval topographic elevation feature class was converted to a raster dataset using a tool from the Conversion toolset in ArcToolbox. The raster topographic elevation dataset, which ranges from sea level to over 200 feet NGVD, was created using the Polyline To Raster tool.

To create a raster dataset for the top aquifer elevation data, an 8.5 x 11-inch hard-copy USGS Open File Report map was scanned and saved as a .tif file. The scanned map did not include the individual well data points, so the contours were used to extrapolate the elevation data. The scanned .tif file was added to an ArcMap document created for the project. This MXD included the Duval County road network and other basemap features. Using the Georeferencing toolbar, the scanned .tif (a raster) was referenced to the road network on the underlying basemap using control points. Finally, the raster was transformed using the rectify command.

The scanned, georeferenced/rectified top of aquifer contour map was then ready to provide a guide for the creation of a file geodatabase feature class of the top of the SAS limestone elevation. Using the Editing toolbar and heads-up digitizing techniques, two feature class datasets were created using the georeferenced/rectified contour map: one representing the top of aquifer elevation contours and the other a polygon feature class denoting areas where the limestone aquifer is not present.

Again, using the Polyline To Raster tool, the top of aquifer elevation data was ultimately converted to raster format. With raster datasets created for both the ground surface/topographic elevations and the top of the SAS limestone aquifer elevations, the Minus tool (Spatial Analyst toolbox > Math toolset > Trigonometric tools) was then used to calculate the depth from ground surface to the top of the aquifer.

The depths in the raster dataset range from less than 10 feet below ground surface (BGS) in limited areas of the county to depths of greater than 200 feet BGS in the extreme western portion of the study area. The SAS limestone aquifer is not present beneath the southeastern portion of Duval County and in isolated areas to the south and west of the St. Johns River, which runs through the area.

The depth to aquifer raster dataset and the areas of erosion/nondeposition for the SAS limestone feature class were stored in a file geodatabase format and added to the EQD Groundwater Contamination Risk Management GIS MXD for use by EQD staff. The depth to aquifer information is helpful in determining approximate well depths required to access the SAS limestone aquifer in specific areas of the county as well as determining the producing aquifer for wells based on reported depth and other well construction information.

Project Benefits and Future Plans

Incorporating the aquifer information into ArcGIS has allowed quicker access to the data and given EQD staff the ability to provide more accurate subsurface information to property owners, drilling contractors, environmental consultants, government agencies, and other interested parties.

Based on the highly permeable nature of the SAS limestone, the depth to aquifer data generated in this GIS project may provide insight into the potential vulnerability of the shallow aquifer to contamination. The proximity of the SAS limestone aquifer to the ground surface will likely have significant implications for subsurface contaminant migration within Duval County. Further evaluation of this issue is ongoing.

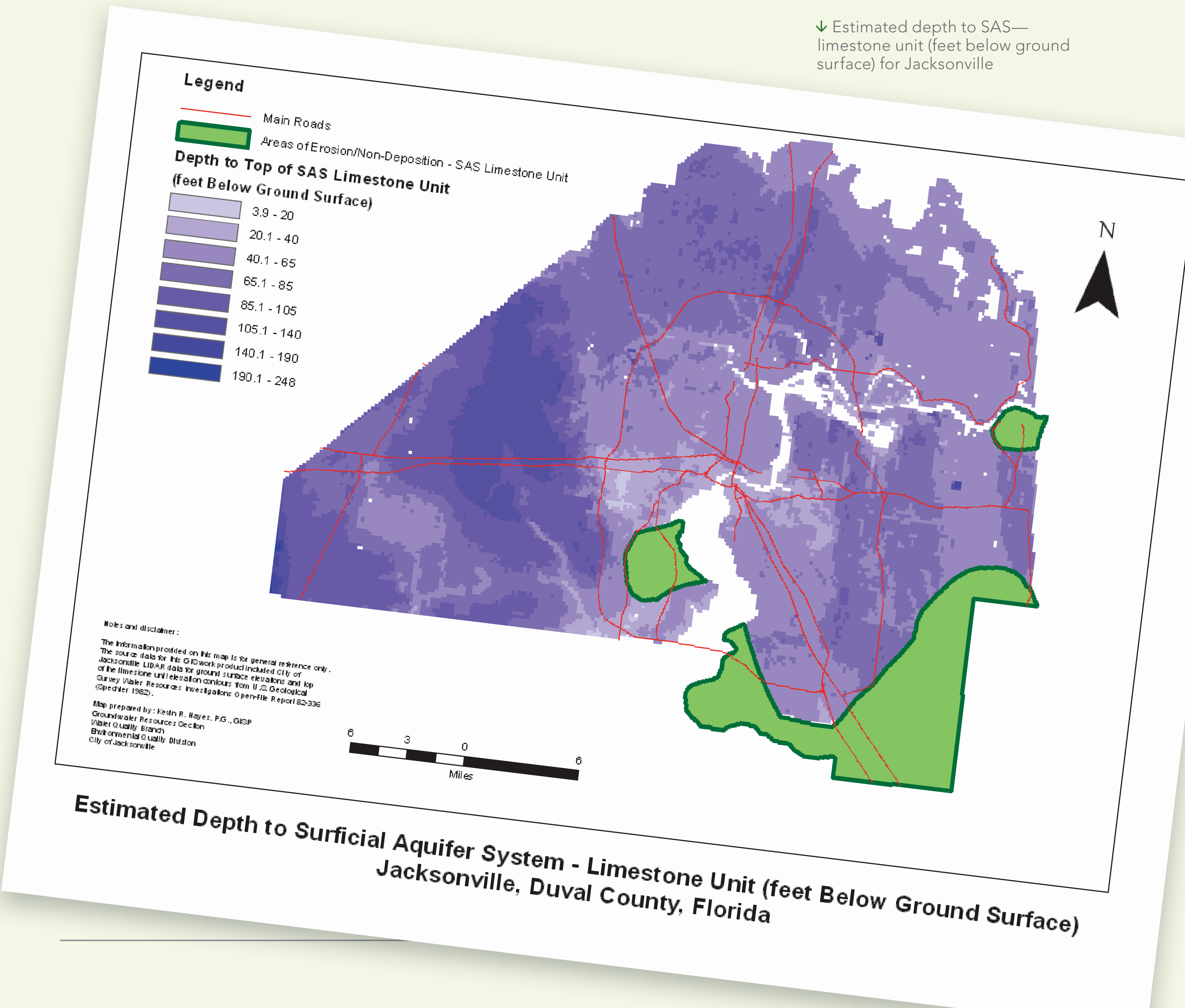
In the next phase of this GIS project, USGS data points from the 1982 Open File Report into ArcGIS will be incorporated. In addition, depth-to-aquifer data provided in Well Completion Reports submitted to EQD, site assessment reports prepared by environmental consultants, and other available hydrogeologic reports will also be included. Additional depth-to-aquifer data will further improve the accuracy of the products generated. Similar GIS project efforts for the IAS and FAS are also planned.

For more information, contact Kevin R. Hayes (kevinh@coj.net) at the City of Jacksonville, Florida Environmental Quality Division (www.coj.net).

About the Author

Kevin R. Hayes is an environmental programs manager with the City of Jacksonville, Florida, Environmental Quality Division. A certified GIS professional (GISP) and professional geologist (PG), he has more than 19 years of experience focused on site assessment and remediation, aquifer characterization, groundwater and contaminant transport modeling, and GIS. He obtained a master's degree in geosciences from the Pennsylvania State University and bachelor's degrees in geology and geography from the University of South Alabama.

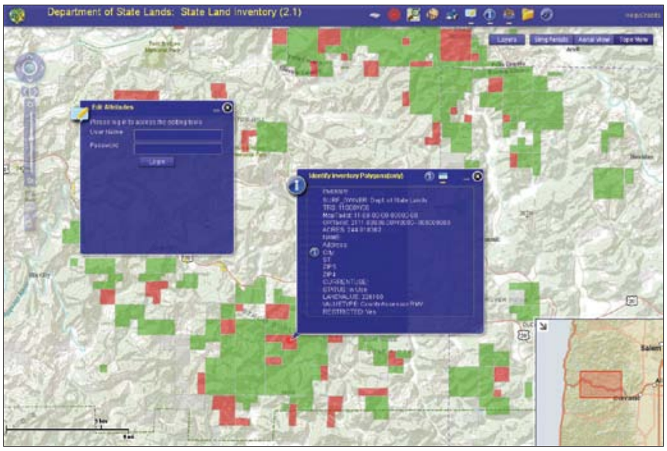
↓ Estimated depth to SAS—limestone unit (feet below ground surface) for Jacksonville



Improving Records, Reducing Costs

Oregon's online State Land Inventory system

By Randy Sounhein, GISP, Oregon Department of State Lands



↑ Personnel from each agency can go to an online website to quickly ascertain property ownership and update information about their agency's property assets.

Editor's note: Staff from each of the state agencies responsible for managing Oregon's real property holdings can now determine property ownership and update their own records using a web application created by the Oregon Department of State Lands (DSL).

In early 2004, the Real Property Service section, part of the Enterprise Asset Management division of the Oregon Department of Administrative Services (DAS), was tasked with developing a graphic and comprehensive inventory of state-owned lands that would be accessible to members of the governor's office, legislature, state agencies, and the public. DAS has the statutory responsibility, per Oregon Revised Statutes (ORS) 270.180 and 276.227, to maintain a current statewide lands inventory.

What DAS needed was an online web-based geospatial database that would allow members to conveniently ascertain information about state-owned land. DAS initially hired The Gartrell Group, a consulting firm and Esri partner, to determine the feasibility of this endeavor and come up with a cost estimate for accomplishing it.

At the same time, DSL had developed a comprehensive, statewide mineral rights ownership geospatial layer utilizing Esri technology (e.g., ArcInfo, ArcIMS, ArcSDE, ArcGIS). DSL is responsible (per ORS 273.790 and 273.099) for maintaining records of all subsurface minerals rights on state-owned lands. Since DSL had experience working with both ArcIMS web technology and ArcGIS for Server 9.3, both DSL and DAS determined that the best approach would be to utilize something based on ArcGIS 10 for Server. While ArcIMS had gotten the agency started using GIS on the web, that technology had become dated and didn't meet the agency's requirement for a contemporary ArcGIS enterprise environment.

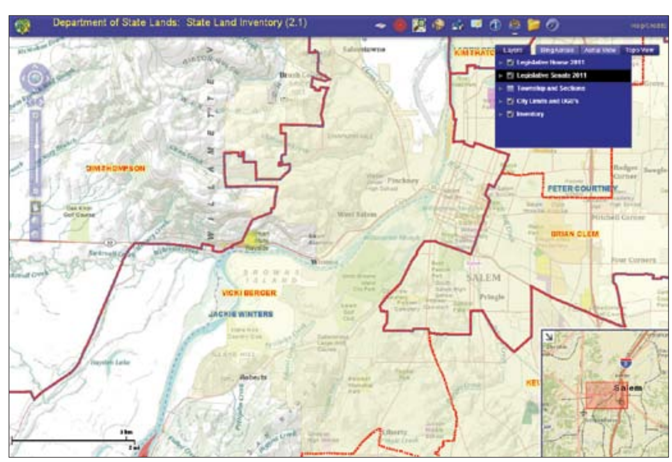
Taking Advantage of Newer Technology

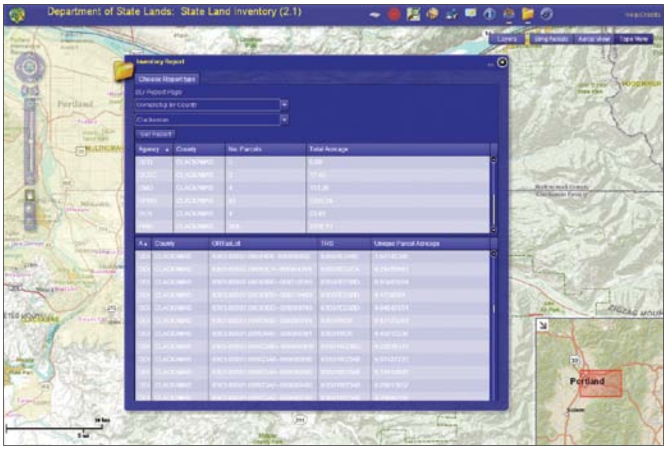
The latest version of ArcGIS 10 for Server software provides some sophisticated tools that allow for web-based capabilities that could be further leveraged via APIs for Adobe Flex, Microsoft Silverlight, and JavaScript. Esri had also created the ArcGIS Viewer for Flex, a GIS web client mapping application for ArcGIS for Server built with the ArcGIS API for Flex. This client application contains a number of functional widgets, which can be deployed out of the box without requiring any programming. The viewer also allows developers to extend its functionality by modifying or creating additional widgets via the ArcGIS API for Flex.

Because the Flex environment is more mature, it was selected over the others. The first step in utilizing the ArcGIS Viewer 2.1 for Flex was to download the uncompiled source code for the ArcGIS Viewer from the Esri website and import it into Flash Builder 4.0. Though Esri provides both uncompiled and compiled versions, creating customized applications with an API requires uncompiled source code and some programming knowledge.

Editing in the ArcGIS 10 for Server and Flex ArcGIS viewer environment is accomplished via feature services (i.e., map services with feature access), which create REST endpoints that are then referenced in the application. The feature services are accessible to the web API via a feature layer, where the attributes and geometry are actually edited. The features reside in an ArcSDE geodatabase. Similar to editing in ArcGIS for Desktop in a multiple user environment, if modifications are made by two or more users at the same time, the last edits in are committed to the ArcSDE geodatabase.

↓ The application incorporates agency and legislative district boundary information.





↑ It is easy to search on inventory parcels.

Real-World Application

Typically in an ArcGIS editing session, the user can edit not only spatial features but also feature attributes. In the past, each of the six state agencies that manage state lands had to keep track of the state's property assets. This was accomplished using a variety of tools and data formats. Data was then sent to DSL for record retention. The State Land Inventory site application brings the work of all these agencies together. Now each agency uses the same tools and data format.

When working with proprietary datasets that have restrictions, all editing should require that users be assigned privileges and recognized through special authentication. This is especially true when editing datasets online in web browsers. The base Edit widget was modified to allow online editing through an authenticated approach. The user first authenticates into the system, which starts a selection process similar to that used in ArcGIS for Desktop. This ensures that only authorized personnel can modify their agency's records in feature layer attribute tables.

The State Land Inventory application facilitates online editing through an authenticated approach so users can only edit data from their agency. This eliminates any chance that changes could be implemented by unauthorized personnel. Personnel from each agency can log in to the online application and make real-time edits to geospatial layer attributes in an easy-to-use web-based environment. This increases efficiency by eliminating involvement of specialized personnel trained in GIS in the workflow and reducing overall staffing cost.

Easy-to-Generate Reports

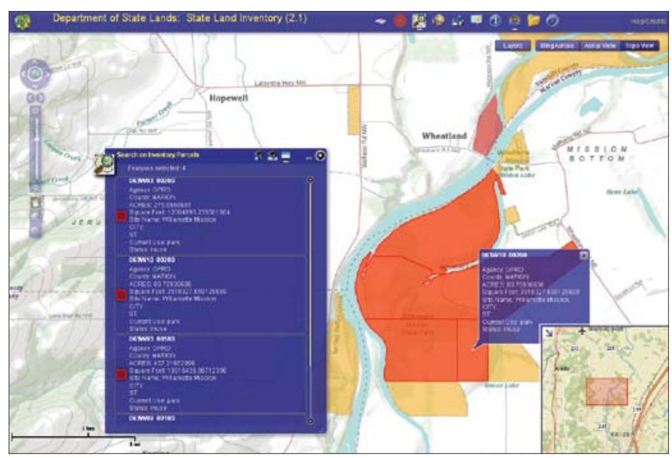
Several agencies wanted the application to generate online agency reports of surface ownership derived from queries against attribute tables for multiple layers. This is easily done by selecting the appropriate type of report desired and clicking the Get Report button. This runs a number of queries against an attribute field, and the results are displayed on the same screen near the bottom of the scrollable and resizable window. These results are helpful because queries are run against both agency boundaries and legislative districts throughout Oregon.

Conclusion

Overall, the value of this application to the state is that individual agency personnel can simply go to an online website and quickly ascertain who owns real property in the state and make updates to information about property assets managed by their agency. The State Land Inventory site also reduces the need for dedicated software licenses and staff trained in GIS. Esri has done a great job creating APIs that can be used to create efficient web-based GIS applications that provide an alternative to desktop GIS and further the movement of GIS to the cloud environment. DSL was able to organize the data, create the application, and get it up and running in just a few months. This resulted in a major cost savings for all stakeholders. The application will continue to evolve with the technology. View the current version at chetco.dsl.state.or.us/sli/index.html.

Acknowledgments

The author thanks members of Esri's Technical/Professional Support Services for their advice and input into the project; Eric Andersen, IT manager at the Department of State Lands; and the many people at the State of Oregon who helped make this effort possible.



↑ The application fulfills the desire of state agencies for reports of surface ownership derived from queries against attribute tables for multiple layers.

About the Author

Randy Sounhein has a master's degree in environmental science from Washington State University, a bachelor's degree in geology from Central Washington University, and more than 22 years of hands-on experience with geospatial technologies and Esri products. He worked as a senior groundwater quality/GIS analyst for the State of Idaho from 1990 to 1997. He is currently the GIS coordinator for the Oregon Department of State Lands in Salem, Oregon. He can be reached at randy.sounhein@state.or.us.

Infrastructure Planning for Solar Technology Recycling

By Michele Goe, Brian Tomaszewski, and Gabrielle Gaustad, Rochester Institute of Technology

An interdisciplinary group of researchers at Rochester Institute of Technology (RIT), drawn from GIS, material science, and engineering fields, used GIS in managing, determining, and visualizing data uncertainty as part of their analysis performed to fill a gap in renewable technology recovery policy.

RIT, located in Rochester, New York, is home to the new Golisano Institute for Sustainability building and several other Leadership in Energy and Environmental Design (LEED)-certified buildings that incorporate renewable technologies such as solar photovoltaics (PV). RIT has invested in this technology not only to mitigate climate change but also as part of a broader effort by New York State to meet its renewable portfolio standard that mandates the use of technologies like PV.

In addition to these mandates, state policies use financial incentives to further encourage renewable energy adoption. These programs are working, according to the United States Energy Information Administration. New York State has the fifth largest renewable energy capacity in the United States, despite its less than ideal climate.

One drawback of policies that expand renewable technology is they do not proactively consider how the waste produced by PV panels is managed once these panels reach the end of their life span. PV cells contain economically valuable materials, such as silver, indium, and gallium, and other materials, such as silicon and tellurium, that are extremely energy intensive to produce because they can require purities as high as 99.99999 percent. An additional concern with materials contained in PV cells is the potential for toxic metals, such as arsenic and cadmium, to leach into groundwater once these materials are in landfills.

For these reasons, discarded PV panel materials that become part of the waste stream must be recycled. However, it is uncertain whether New York State has the infrastructure to collect and sustainably recover these materials. For example, less than 15 percent of all material recovery facilities in the state can manage waste streams similar in composition to PV materials. Of these, only half of recovery facilities are located near existing PV installations. Therefore, the gap in renewable technology recovery policy represents a missed opportunity to divert potentially hazardous materials from landfills that cannot contain them and redirect economically viable materials to secondary materials markets.

Supporting Recycling Policy Making

An interdisciplinary group of researchers at RIT from GIS, material science, and engineering fields sought to address this policy gap by asking the following:

- How can we optimize infrastructure for collection and resource recovery?
- Does a centralized or a decentralized location-allocation strategy minimize cost?
- To what extent can existing infrastructure be used, or does it make sense to build new infrastructure?

Addressing these questions required compiling data on current recovery infrastructure and PV installations and then resolving data quality and quantity issues to build a decision model. Both activities proved to be challenging.

Data Collection

Recovery infrastructure data on transfer stations, landfills, and recycling facilities is managed by the New York State Department of Environmental Conservation (DEC). This data is publicly accessible but incomplete in terms of key parameters of organizational hierarchy, capacity, and cost information. In contrast, PV installation data points are available for 61 of New York State's 62 counties from the New York State Energy Research and Development Authority (NYSERDA). The NYSERDA data is detailed in terms of capacity and cost but with limited spatial resolution (only city- and county-level geospatial data is publicly available).

In this context of uncertain data quantity and quality, sustainability researchers sought to model the current recovery infrastructure and evaluate the cost-effectiveness of operations for solar panel waste recovery. Due to the geographic nature of this problem, ArcGIS for Desktop was an essential tool in helping to manage, determine, and visualize data uncertainty.

Uncertainty Model Development

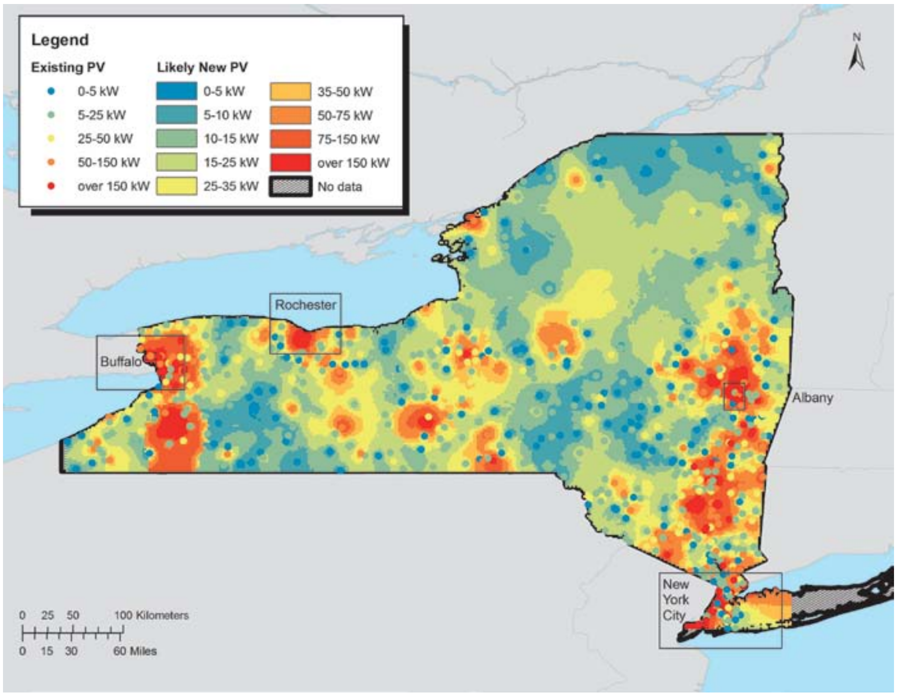
To address the first question of how to optimize infrastructure for solar PV recovery, a heat map of likely future PV installations was generated in ArcGIS 10.1 for Desktop using ArcMap and the Inverse Weighted Distance (IWD) tool available with the ArcGIS 3D Analyst or ArcGIS Spatial Analyst extension. A feature dataset of 840 current PV location points was used as input for this tool.

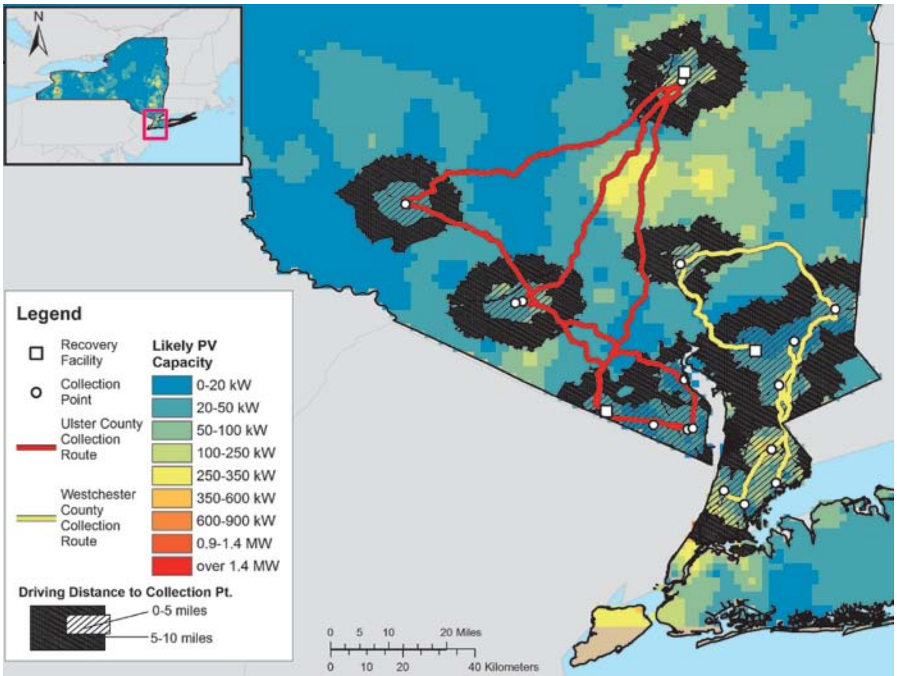
The IWD tool was chosen because PV growth is analogous in behavior to that of disease infection in that the number and the density of infected individuals in a population (or the existing PV locations in a particular area) determine the likelihood of additional cases (or additional PV facilities in that area). Despite the limited spatial resolution of the PV location points, the heat map showed interesting overall trends for likely future PV hot spots in Rochester, Buffalo, Albany, and New York City—areas that have younger populations that live in urban areas and have high incomes.

When compared to the current recovery infrastructure, the heat map revealed several challenges for the state of New York. For example, some existing and likely solar installations are located more than 25 miles from recovery facilities in upstate New York. From a waste collection perspective, a greater distance represents a decreased likelihood of recovery due to increased transportation costs.

To address long-term planning concerns that include multiple future PV growth scenarios, a minimum cost evaluation of centralized and decentralized infrastructure strategies was the next step. An optimization model (coded in Python 2.7) was

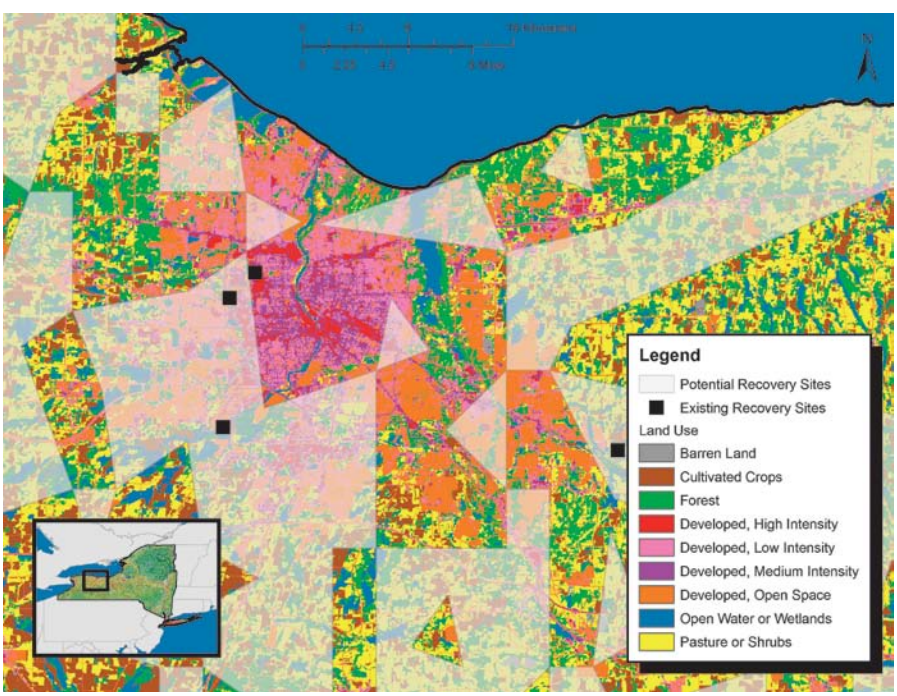
↓ This heat map represents where new PV installations would likely be located based on current PV capacity and location.





↑ Given the dispersion of PV locations in New York State, it is uncertain whether the existing collection infrastructure can, at a minimal cost, achieve collection and recovery at or above municipal solid waste recycling rates for all PV materials.

↓ This land-use map displays where new PV recovery sites could be located in comparison to existing sites given land use, elevation, and distance from public schools criteria.



used with the objective function of minimizing cost and constrained by PV material volume, facility cost, capacity, and collection route distances. Solar PV installations were set as origins and recovery points as destinations using the OD Cost Matrix tool available from the ArcGIS Network Analyst extension. Outputs were the collection route distance between each origin and destination point.

Several cost scenarios were tested to address the uncertainty in facility cost and capacity parameters. One strategy was to assume all facility costs, for example, capital, equipment, or labor, are equal for each individual facility. Another strategy was to characterize the best and worst cases based on the combination of processing steps, technologies, and resultant efficiencies. A third example was to develop a ranking system based on proximity to relevant infrastructure (in this case, preexisting landfills or material recovery facilities).

The model revealed the trade-offs between cost and collection. As the number of recovery sites increases, the collection rate and infrastructure costs increase, while the average collection route distance decreases. At this point, the analysis only took advantage of existing infrastructure. The question of whether infrastructure cost and collection could be improved by selecting different recovery sites still remained.

To address this question, a site selection model was developed using ModelBuilder in ArcGIS for Desktop that generated polygon features based on multiple criteria such as land-use, elevation, population demographics, and distance from communities vulnerable to toxic material leaching or air pollution such as wetlands and elementary and high schools.

New potential recovery facility points were generated from the polygon features using the Feature To Point tool in the Data Management toolset. The OD Cost Matrix tool then generated collection routes for the new potential recovery facility points to current and potential PV locations to help determine which facilities will be part of a minimum cost system of solar panel recovery.

For site selection, managing uncertainty consisted of varying criteria weights and values in the Weighted Overlay tool in the Spatial Analyst toolset to understand the relative impact on model output. For example, having a greater weighting for land use while restricting the use of forest and cropland produced the most limited solution space. In contrast, prioritizing the proximity of demand to landfills produced the largest area of potential new sites.

Conclusions

This work resulted in RIT policy and infrastructure recommendations for New York State policy makers that will enable the state to prepare for a looming volume of potentially valuable and/or toxic materials generated from solar panel disposal. To build on this work, RIT plans to apply these methodologies to solve other complex geographic problems such as investigating the sensitivity of location-allocation decisions to new demand information and resource availability constraints.

Summary

Infrastructure planning requires the meaningful organization of variables, data, and uncertainty assessment to understand the behavior of a system and the impact of assumptions on system outputs. In this case, for the study of waste recovery infrastructure design for PV panels in New York State, numerical and nonnumerical methods were used to evaluate the influence of uncertain variables on future demand, collection routes, and new facility site selection. This is an example of how ArcGIS for Desktop can serve as an essential tool for managing, determining, and visualizing data uncertainty. For more information, contact Gabrielle Gaustad at gabrielle.gaustad@rit.edu.

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Gabrielle Gaustad, PhD, is currently an assistant professor in the Golisano Institute for Sustainability at RIT. She received her doctorate in material science from the Massachusetts Institute of Technology. Her research focuses on evaluating the economic trade-offs for materials at their end of life and enabling resource recovery via blending plans, upgrading technologies, and design for recycling. Gaustad is active in promoting the participation of women and minorities in science, technology, engineering, and mathematics (STEM) disciplines including involvement in the McNair Scholars program, American Chemical Society SEED Project, and the TMS Women in Material Science and Engineering Committee.

Mapping Rural India's Health Facility Locations

By Samir Gambhir and Peter Rodriguez, Centre for Global Health Research

As part of its disease mapping efforts in India, an independent not-for-profit organization prototyped a process for digitizing health facility data so GIS could be applied to facility planning to improve health outcomes.

Disease mapping has become an important tool in health care decision making. Disease mapping informs policy makers and health professionals about the spatial distribution and patterns of health-related events and their underlying relationships to populations.

However, proximity and access to health care are also important determinants of health outcomes. This is certainly the case in India, where health disparities are especially pronounced, with many and varying causes. While disease mapping identifies areas of high and low incidence of disease, mapping access to health care can uncover some of the reasons behind the clustering of disease outbreaks and their impact on mortality.

While developed countries have created and maintained good data on the location of health facilities, developing countries lack this valuable data. It is either nonexistent, incomplete, or—if available—cost prohibitive for researchers.

Studying Factors Relating to Outcomes

To address this situation, the Centre for Global Health Research (CGHR) hand digitized health facility locations in India using input data from various sources. CGHR was founded in 2002 on the principle that effective health initiatives must be supported by reliable, evidence-based research. It conducts large-scale epidemiological studies in developing countries that support its mission to lead high-quality public health research that advances global health, with particular attention to the world's poorest populations. CGHR is cosponsored by St. Michael's Hospital in Toronto and the University of Toronto.

The Million Death Study (MDS) is one of CGHR's major initiatives. In collaboration with the Registrar General of India (RGI) office, MDS surveys 1.1 million nationally representative households to determine the death counts and causes. To complement CGHR's research on disease-related mortality, GIS techniques are now applied to the study of the impact of the health care system on mortality.

Cause of death (COD) reports from MDS provide only the deceased person's postal code. Joining COD data to an Indian postal code shapefile obtained from GfK GeoMarketing allowed spatial patterns for all deaths or for deaths attributed to specific causes, such as cancer or measles, to be displayed. According to the MDS, most deaths occur in rural areas in India.

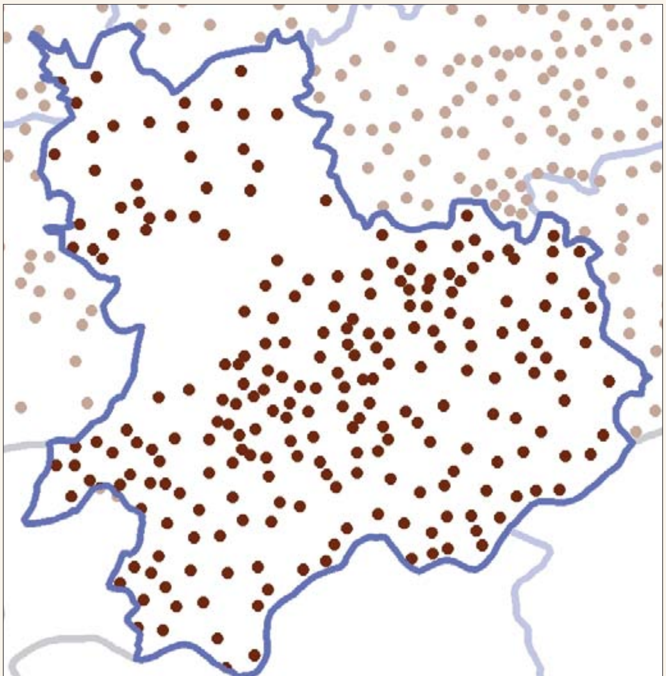
Availability and access to health care in villages in India is an important aspect of spatial epidemiology research. While urban populations have access to private health care networks, rural populations rely heavily on the public health system. The rural health system in India has three tiers: Sub-Centers (SC), Primary Health Centers (PHC), and Community Health Centers (CHC). PHCs are the basic health units where the members of a community come into contact with qualified doctors. According to Indian Public Health System, a typical PHC serves 20,000 to 30,000 people and is usually named after the village where it is located. Mapping the location of PHCs would be the first—and most important—step in conducting advanced spatial analysis on health outcomes using COD data supplied by MDS.

Increasing the Value of Village Amenity Data

In late 2011, CGHR's GIS team obtained village amenity (VA) data from the Census of India for the entire country. This dataset contains data about post offices, health facilities, educational facilities, and other amenities for every village in India along with a village identifier (ID) and some socioeconomic variables. The collection of this data at the village level presents a unique opportunity to map and spatially analyze data at a large scale. However, a big challenge remained—how to obtain data on the geographic location of villages.

After considering various options, the GIS team decided to use the 2001 District Census Handbooks (DCHBs) published by the Census of India. *[The GIS team is composed of the authors, Samir Gambhir and Peter Rodriguez, along with Hana Fu, Luka Ding, and Jonathan Critchley.]*

DCHBs provide Primary Census Abstract (PCA) data up to village level for the rural areas and also contains *tehsil [local administrative unit]* and block level maps showing the location of all villages as points with village IDs. If these village locations could be digitized based on the PDF maps, it would be possible to append VA data to these locations using village IDs and a shapefile could be generated for any amenity included for PHCs.



Prototyping a Process

DCHB maps for the states of Madhya Pradesh, West Bengal, and Gujarat were used in this project. Specifically, tehsil- and block-level PDF maps were used to hand digitize village locations. Also, village amenity data for the three pilot states was used. Moreover, a tehsil boundary shapefile downloaded from DIVA GIS (www.diva-gis.org/gdata) was used together with GfK's district and state shapefiles. Geocoding villages involved converting the PDF maps to an image format (JPEG) and georeferencing the image. The village points were hand digitized using ArcGIS 10.0 for Desktop.

Map georeferencing

Georeferencing maps was done with the aid of a tehsil shapefile. Although this shapefile contains less than 50 percent of the tehsils that existed in 2001, it was nevertheless useful in providing a reference point for these static maps.

Digitizing villages

Villages have unique eight-digit identifiers that run sequentially within a state. Starting from the first district in each state, all village points were digitized sequentially starting with the first tehsil in that district. This reduced the likelihood that any village point on the paper map would be missed. After completing digitizing points for the villages in each tehsil, relevant village, tehsil, or district IDs were added.

Although these maps display town boundaries as well, none of the towns were geocoded during this project because towns are treated as urban areas for census purposes. According to Census of India, a town must meet all three of the following criteria:

- Have a minimum population of 5,000 persons in the preceding census
- Have at least 75 percent of the male working population engaged in nonagricultural activities
- Have a population density of at least 400 persons per square kilometer (km)

Checking Accuracy

Once the village shapefiles were completed, they were compared with VA data to check for duplicates, erroneous village codes, and other aspatial errors. Some village codes seemed to be duplicated due to the nomenclature system implemented by the Census of India rather than any data error. Village IDs are unique within a state but not unique among states. Once these errors were identified, the GIS team ensured that records that had the same village code but belonged to different states were not marked as duplicates. A workaround was used that concatenated the state ID with village IDs to get a unique ID value for each village.

↖ Location of the state of Madhya Pradesh

← District and tehsil boundaries in the state of Madhya Pradesh

↙ Digitized village points in a tehsil

CGHR researchers needed to know the limitations of this spatial data. The methodology and data sources warranted a spatial accuracy check of the geocoding work. Spatial accuracy checks were conducted using stratified random sampling techniques and made use of Google Earth imagery. Four hundred random sample village points were extracted from a shapefile containing locations of villages in Madhya Pradesh in an attempt to identify likely sources of spatial error. The georeferencing process led the GIS team to believe that small villages and villages found close to tehsil boundaries were likely to show a higher number of spatial errors.

The village points from Madhya Pradesh were divided into three population strata, then into three geographic strata:

Population strata by village

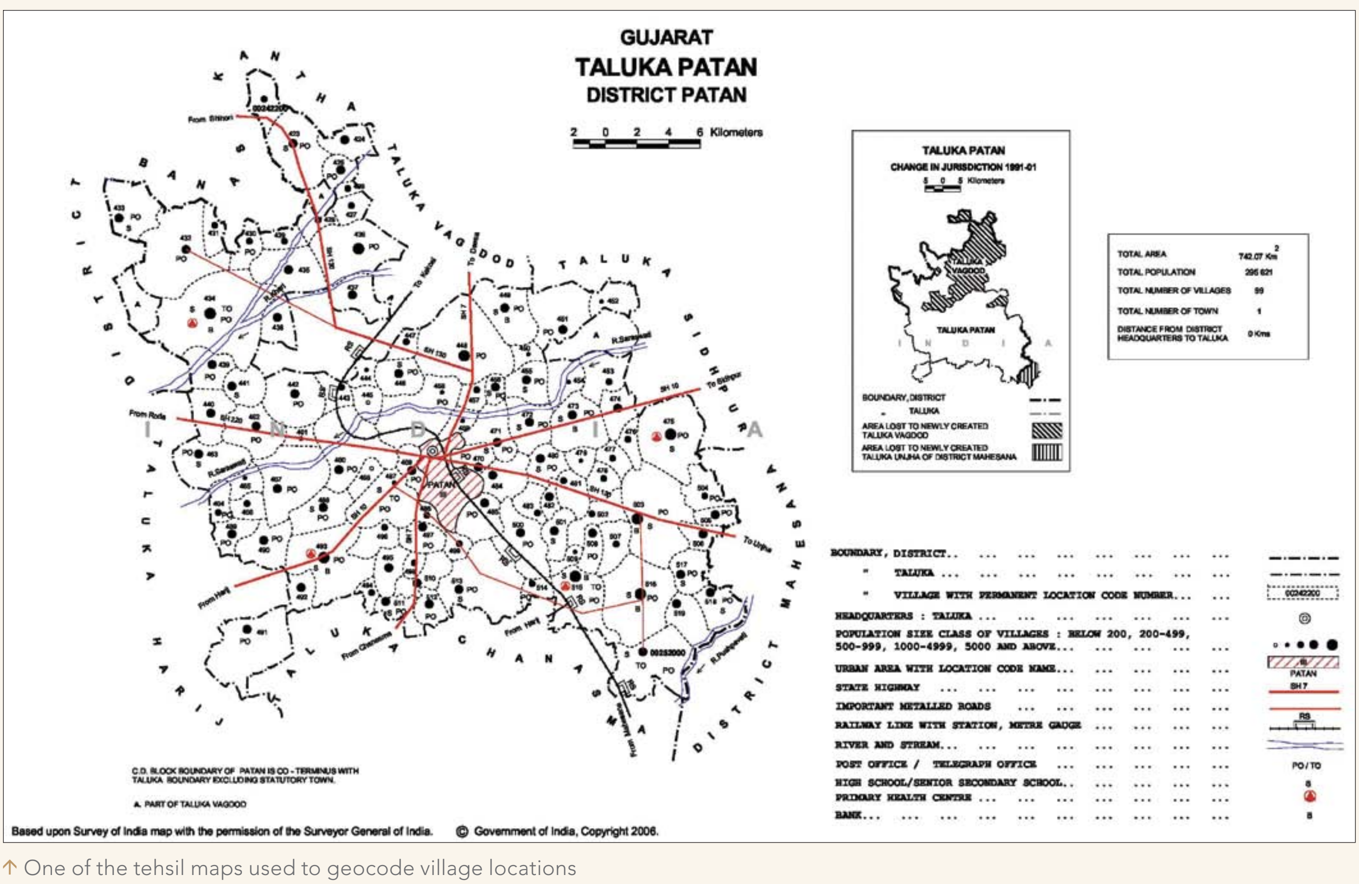
- Less than 500
- Between 500 and 999
- Greater than 1,000

Geographic strata

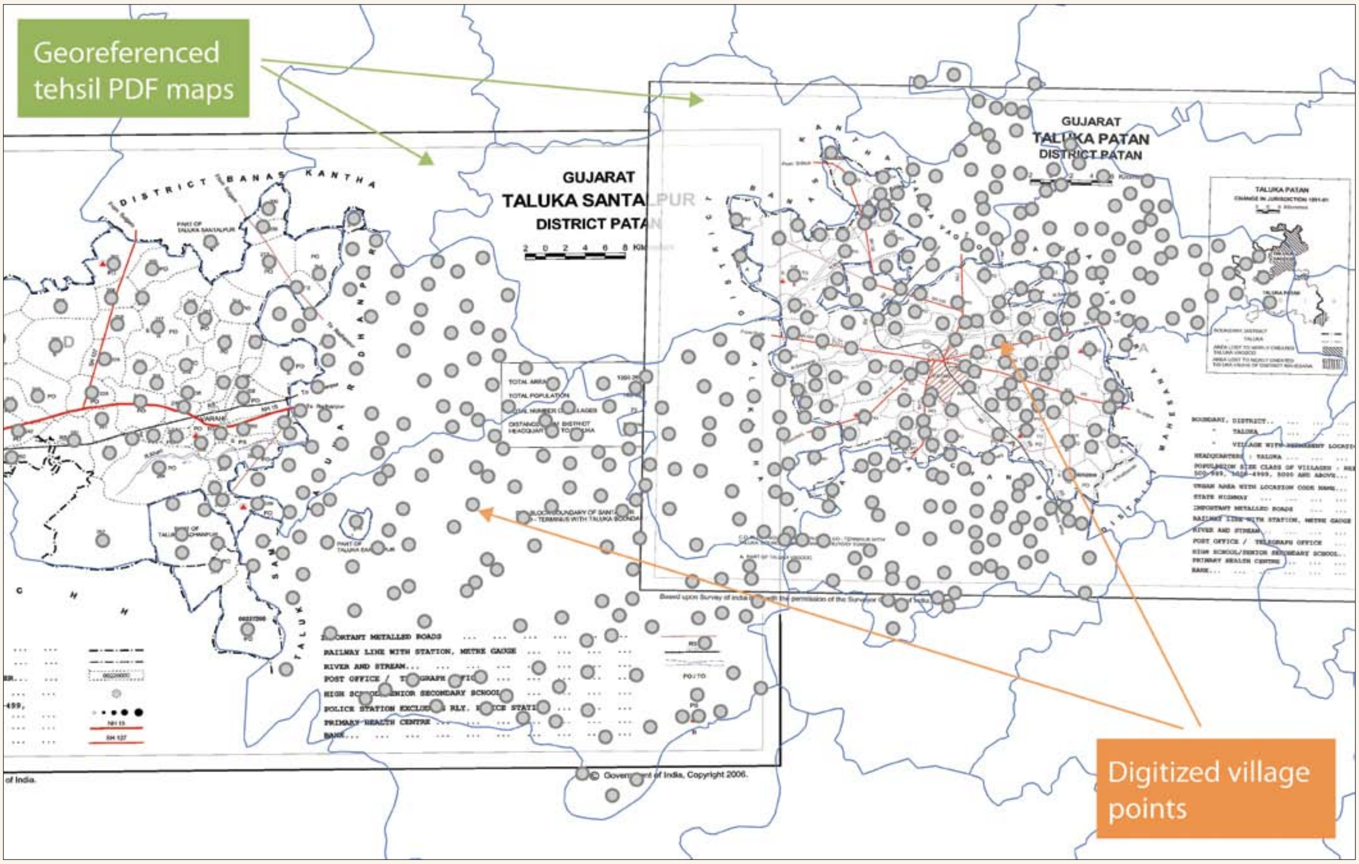
- 100 villages within 1.1 km (0.01 decimal degree) inside a tehsil boundary
- 100 villages from 1.1 km to 3.3 km (0.01 to 0.03 decimal degrees) inside a tehsil boundary
- 200 villages beyond 3.3 km (0.03 decimal degrees) inside a tehsil boundary

Considering the amount of data and the labor-intensive nature of the hand-digitization process, the GIS team decided on 1.1 km as the margin of error. A buffer with a 1.1 km radius was created around each of 400 random points. The resultant shapefile was exported and analyzed for proximity of a human settlement within the buffer. A binary scoring system was devised to record the outcome of this analysis. A score of 1 was assigned if one or more human settlements were contained within the buffer, and a score of 0 was assigned if no human settlements were contained within the buffer.

Spatial accuracy checks revealed that out of 400 buffers for Madhya Pradesh village points, 337 contained one or more human settlements and 63 buffers contained no human settlements. Thus, it can be stated with a confidence level of 99 percent that 84.25 percent (+- 4.71) of village point buffers in Madhya Pradesh contained one or more human settlements. However, this test did not confirm if the human settlements within the buffer were the correct villages. Further analysis and better annotated satellite imagery will help make this test more robust. VA data was joined to this shapefile using the unique concatenated IDs. The availability of amenities for each village was used to create subset shapefiles for PHCs, SCs, and post offices.



↑ One of the tehsil maps used to geocode village locations



↑ Georeferenced maps and digitized village points

Data Sources Challenges

Some of the discrepancies inherent in the PDF maps from DCHBs and shapefiles from various sources might have impacted the accuracy and reliability of this geocoding project. Some PDFs for West Bengal were unusable as they could not be opened, and about 600 villages could not be geocoded.

The PDF maps from DCHBs appear to have some degree of artistic rendering. Due to the amount of information needed to be displayed on these letter-sized maps, it might not have been possible to display all symbols accurately. Some facility symbols, like those for post offices, appear to have been drawn for identification rather than location purposes.

Due to discrepancies in boundary profiles in the shapefile downloaded from DIVA GIS, tehsil and block boundaries on the PDF maps did not match perfectly with the boundaries shown on the shapefile.

Conclusions

This project allowed CGHR to create village point shapefiles for three states in India. The spatial accuracy of these village points was assessed, and the results are encouraging. It proves that the methodology is sound and reproducible. Other developing countries can rely on this methodology to generate shapefiles for research and analysis. To develop a meaningful and useful shapefile, it is imperative to identify the right information sources.

The GIS team believes that the output shapefile generated utilizing this method may greatly assist researchers in conducting advanced spatial epidemiological analysis. This analysis can help policy makers and health officers understand where there are spatial mismatches between disease outbreaks and access to health care; plan health care facilities; analyze the availability and utilization of health facilities; and combine shapefiles showing health facilities locations with terrain characteristics to determine their accessibility, rather than just proximity.

To learn more about CGHR, visit www.cghr.org. For more information about this article, please contact Samir Gambhir at GambhirS@smh.ca or Peter Rodriguez at RodriguezP@smh.ca.

About the Authors

Samir Gambhir works as a GIS manager at CGHR. His work involves mapping, spatial analysis, and web GIS development for research projects at the center.

Peter Rodriguez works as a GIS specialist at CGHR. His research interests include spatial epidemiology, species/vector distribution, geostatistics, spatial databases, and conservation GIS.

Other GIS team members involved in this project include Hana Fu (GIS technician), Luka Ding (GIS technician), and Jonathan Critchley (GIS intern for winter 2012).

DO YOU HAVE A PEOPLE STRATEGY?

By Suzanne Boden, Esri Training Services

Lately, there's been a steady stream of articles telling how tech workers can ride the employment roller coaster and, specifically, which skills GIS professionals need to survive in today's business climate. The last five years have seen major shifts in expectations, and these have had a huge impact on organizations and their leadership. Many organizations are looking for ways not only to meet these expectations but also to create new products and services that reach new customers.

Grow Your People, Grow Your Business

According to the 2012 Employee Job Satisfaction and Engagement study by the Society for Human Resource Management, employee development is an important way to increase job satisfaction and reduce staff turnover. Higher job satisfaction is associated with increased productivity and higher customer satisfaction.

Despite the amazing technology that permeates modern life, humans remain indispensable. No gadget has yet invented a new gadget. No computer has ever created a web map all by itself, contributed to a white paper, or put together slides for an executive presentation (although Watson, IBM's cognitive system, may be honing its PowerPoint skills as you read this).

Organizations that work at motivating and retaining employees have leaders who understand that people are their most important asset. Employees execute day-to-day operations, engage with customers, and come up with the new ideas that move a business forward.

Esri Training Services has been preaching the value of staff development for some time. Note that staff development includes—but is not limited to—training. Fundamentally, staff development is a people-centric approach to achieving strategic business goals.

Staff Development Planning Process

Like anything done well, staff development requires planning. Planning should encompass support not only for current projects and initiatives but also for future projects and initiatives. Your planning process should start with strategic alignment. Directly connecting staff development with the achievement of strategic goals will earn executive buy-in and budget approval.

During this phase, identify strategic business goals. These goals are often articulated in your organization's mission statement. Next, assess how your organization's GIS program supports these strategic goals. Which staff roles create, manage, and use the GIS infrastructure and applications? What GIS roles are in place to support the applications that support the strategic goals?

Next, analyze the available educational resources and delivery methods to select those that will be most appropriate for the GIS roles just identified. Timelines, priorities, and budgets can be discussed and documented in a staff development plan. This plan should answer the following questions:

- What knowledge and skills are required for each role?
- Based on current and future plans, what are staff development priorities?
- What resources are available to develop the required knowledge and skills?
- What's the budget?

Time for Action

Once the plan is formulated, it is time to execute it. However, that is not the end of the process. It's important to periodically review the progress that has been made and the plan itself. Events like the retirement of a key staff member, reassignment of roles, creation of a new role, or the introduction of a new technology component may necessitate modifying the plan. It's critical to ensure that your plan remains aligned with your organization's strategic goals by adjusting it as needed. If not, your plan becomes irrelevant.

Higher job satisfaction is associated with increased productivity and higher customer satisfaction.

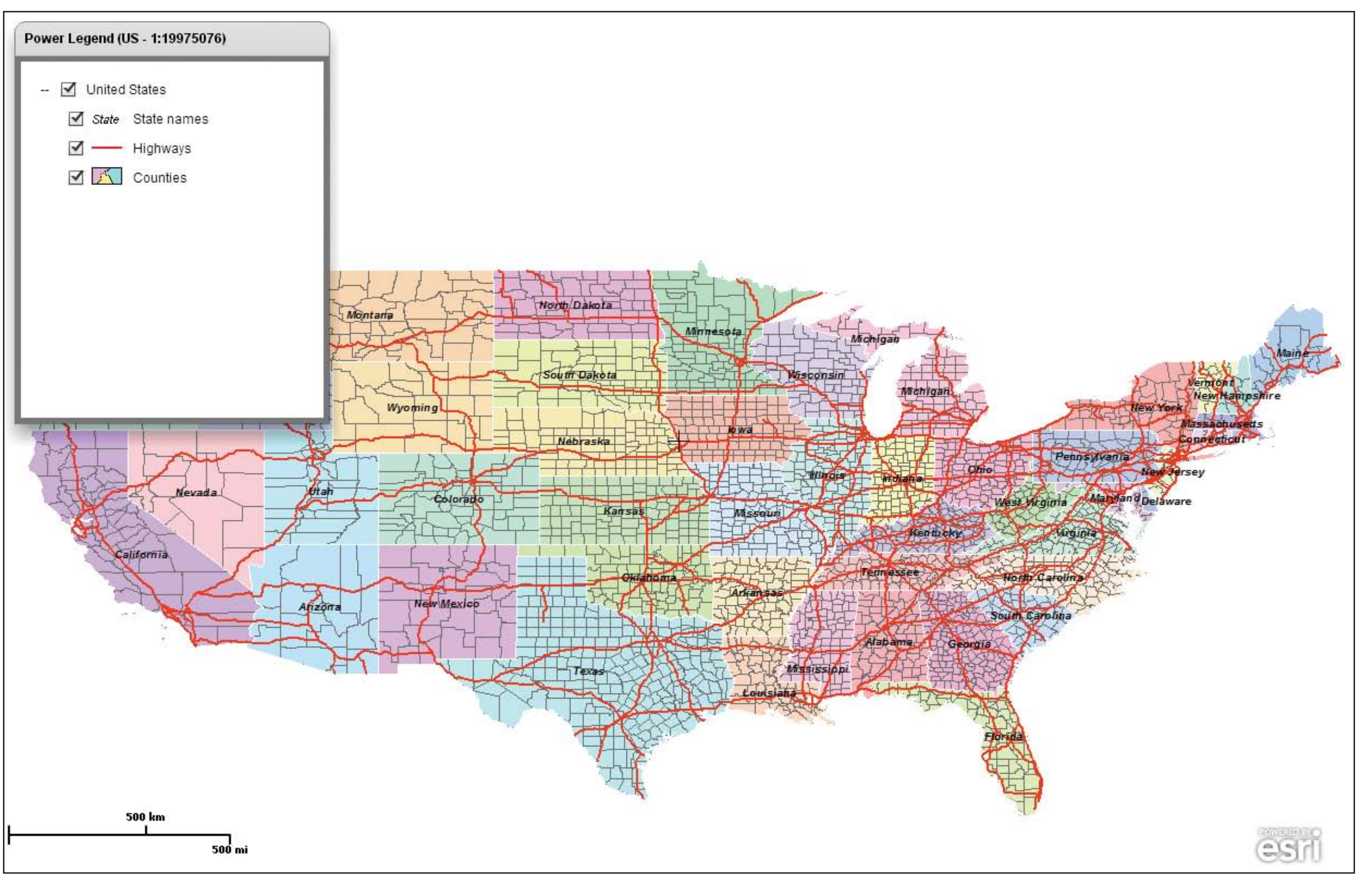
What are the results of all this planning? With an approved budget in place, your people develop the right skills at the right time. Staff members who possess the knowledge and skills they need perform day-to-day operations efficiently. Projects are completed successfully. Just as important, you can demonstrate that your team functions as a strategic asset. Your organization's leaders can appreciate the value of the GIS program. And finally, your employees will feel valued and excited about contributing to new projects.

Contact an Esri training specialist who can partner with you to help determine the best options for equipping your staff with the knowledge and skills they need to help your GIS program succeed. For more information, call 1-800-447-9778, ext. 5757, or send an e-mail to gistraining@esri.com.

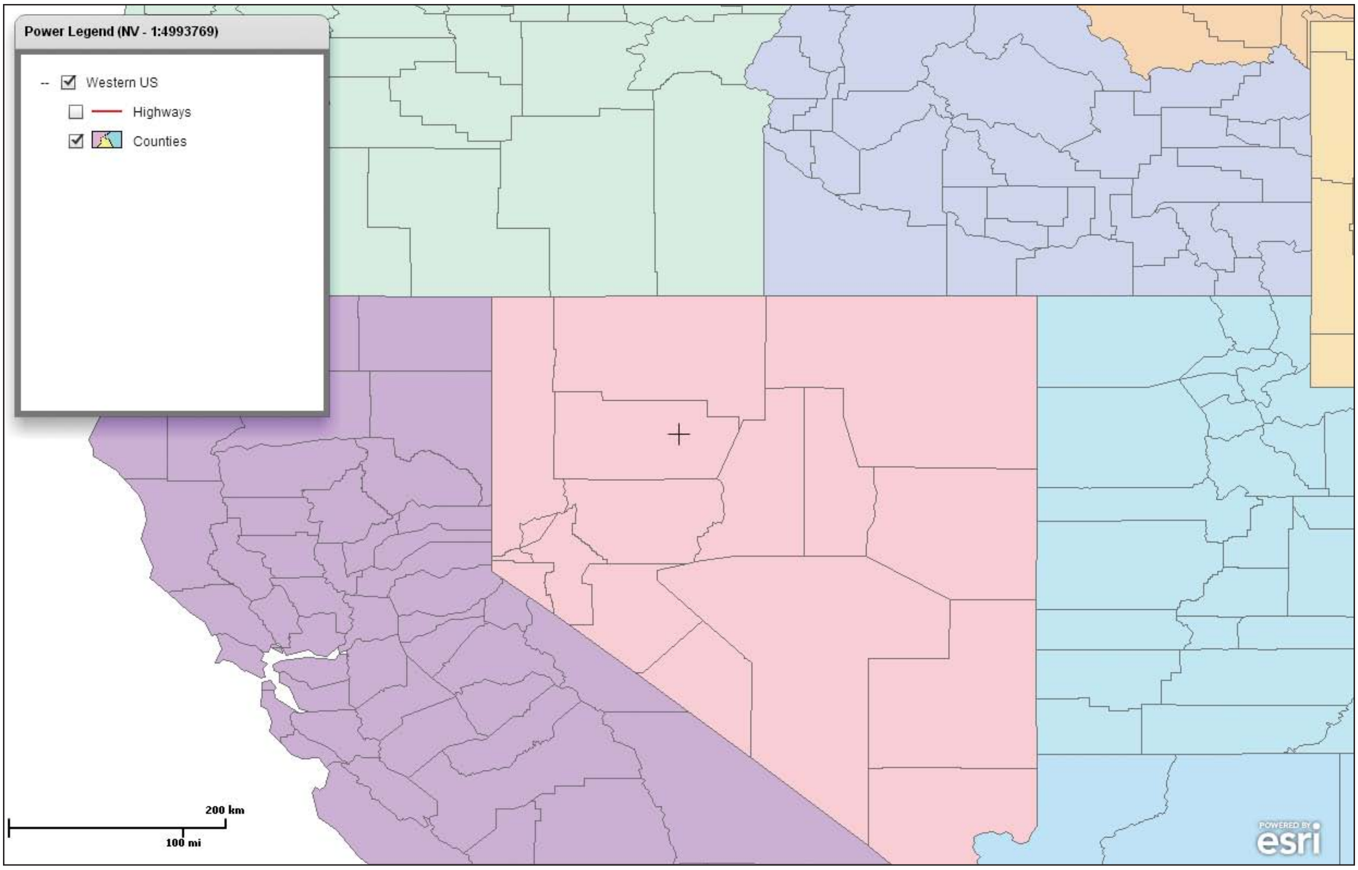
A Flex(ible) Power Legend

By Gido Langen, Surveyor General Branch, Government of Canada

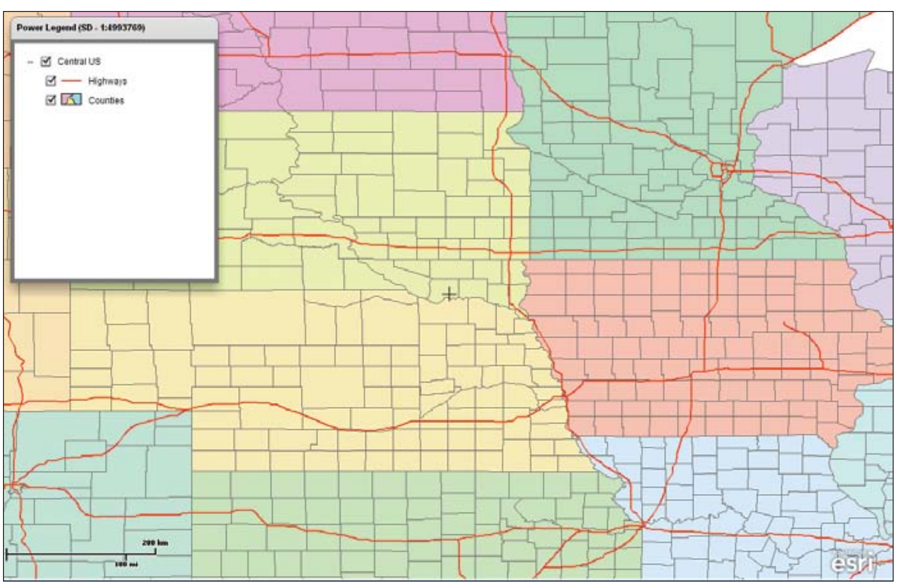
Editor's note: This article shows how functionality can be added to a web map application using the ArcGIS API for Flex. This example shows one way to implement a dynamic legend. To examine the listings referenced in this article, download them from the *ArcUser* website.



↑ The application at full extent with legend showing the United States



↑ One layer turned off in legend



↑ One layer invisible in legend

While the ArcGIS API for Flex legend class suits most web mapping applications perfectly well, it limits users' control over layer visibility. Sometimes it would be desirable to give users just such control, especially where features are concentrated in small areas. For example, small pockets of federally administered land spread across the country may contain many individual features from numerous classes. Users may want to change the visibility of one layer versus another dependent on their specific needs.

This article presents the implementation of a dynamic legend using the ArcGIS API 3.0 for Flex that permits scale-dependent layer availability similar to that of the native legend class but also gives users the capability of turning individual layers on and off. In addition, it is spatially aware—the legend changes based on the spatial extent of features in an associated graphics layer. Group and layer parameters are controlled by an XML legend file on the server; Listing 1 shows lines from a sample of this XML legend file. The entire file is available from the sample dataset for this article.

Listing 1: XML legend file

```
<group id="2002" name="Western US" minscale="9541235" maxscale="0"
    states="US,AK,WA,OR,CA,HA,HI,ID,MT,WY,NV,UT,CO,AZ,NM" checked="true" expanded="true">
  <layer id="1" name="State names" minscale="30000000" maxscale="5000000"
    states="US,AK,WA,OR,CA,HA,HI,ID,MT,WY,NV,UT,CO,AZ,NM" checked="true"/>
  <layer id="0" name="Highways" minscale="20000000" maxscale="1000000"
    states="US,AK,WA,OR,CA,HA,HI,ID,MT,WY,NV,UT,CO,AZ,NM" checked="true"/>
  <layer id="2" name="Counties" minscale="50000000" maxscale="0"
    states="US,AK,WA,OR,CA,HA,HI,ID,MT,WY,NV,UT,CO,AZ,NM" checked="true"/>
</group>
```

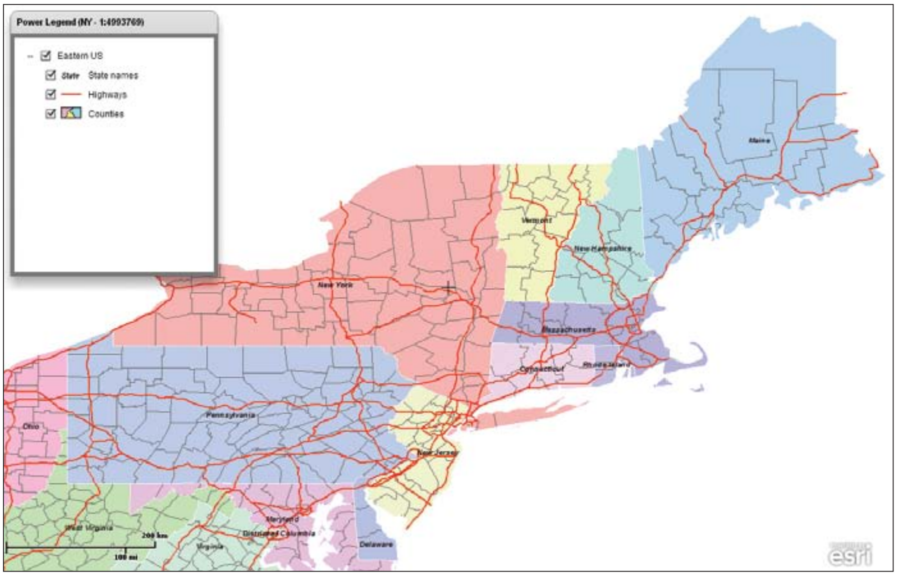
↑ Listing 1: A portion of the legend.xml file used to create the legend in the Flex panel

---

Listing 2: XMXL legend file

```
  // Establishes map layers and "spatially aware" states graphics layer
  private function initApp():void {

      var MapLayers:Array = new Array();     // Array that references that three layers of the map service
      MapLayers.push(0); //highways
      MapLayers.push(2); //counties
      MapLayers.push(1); //state names
      MapService.visibleLayers = new ArrayCollection(MapLayers);

      // Query on the States layer to get all the states as graphics to populate
      // "spatially aware" graphics layer
      qytStates.execute(qryStates, new AsyncResponder(onResult, onFault));
      function onResult(featureSet:FeatureSet, token:Object = null):void {
          States.graphicProvider = featureSet.features;
          refreshLegend();
      }

      // A problem might occur on initial load
      function onFault(info:Object, token:Object = null):void {
          Alert.show(info.toString(), "Query Problem");
      }
}

  // Reads legend.xml file and add an event if the loading is successful
  // onLegendLoaderComplete
  private function initLegend():void {
      var LegendLoader:URLLoader = new URLLoader();
      LegendLoader.load(new URLRequest("legend2.xml"));
      LegendLoader.addEventListener(Event.COMPLETE, onLegendLoaderComplete);

      // Populates global variable LegendXML on successful loading
      // this variable contains the content of legend.xml file
      // will be used to create the contents of legend panel
      function onLegendLoaderComplete(evt:Event):void {
          LegendXML = new XML(evt.target.data);
```

↑ Listing 2: A portion of legend.xmxl code showing that map layers are established and made spatially aware to influence the legend display (Visit the *ArcUser* website to download legend.mxml and legend.xml.)



↑ The legend showing only the eastern region

On startup, the compiled SWF file reads the XML legend file that is enclosed by the <layers> </layers> element. It includes two tags: <group> and <layer>. Each group tag can include multiple layer tags. Both tags have multiple attributes whose values are used to build the legend in the Flex panel. Each name attribute becomes a legend entry, and the minscale and maxscale attributes define the visibility of groups and layers.

So far, there is nothing new in this process. But wait—the code creates a check box for each <group> and <layer> tag, allowing users to interactively turn them on and off.

Better yet, all <group> and <layer> tag entries are spatially aware. The code uses a graphics layer to further control visibility. In this example, the graphics layer includes polygons that represent individual US states. The screen center location determines the currently active state and its FIPS code.

A group or layer only becomes visible if the FIPS code is within the range of values listed in the tag's states attribute. If it is, the legend dynamically changes. Each <layer> tag also has an id attribute that has a value that corresponds to the layer ID value used by the map service. These values are used to set the visibleLayers array of the map service. Tiny PNG files (measuring only 28 by 16 pixels) are used to represent the symbol for each layer.

To see an example of a larger web application built using this method, visit the Natural Resources of Canada website at clss.nrcan.gc.ca/map-carte/mapbrowser-navigateurcartographique-eng.php.

Making the Code Work

Follow these four steps to make the example in Listing 2 work:

1. Type the sample legend.mxml code into your Flash Builder code window.
2. Create the four PNG files and save them in the Flash Builder SRC directory.
3. Create the legend.xml listing as an ASCII text file and save it in the BIN-DEBUG directory.
4. Run the code. All spatial data referenced is available from ArcGIS Online.
5. Run the application, zoom in and out, and pan around in the web page.

This sample was compiled using Flash Builder 4.6 and the ArcGIS API 3.0 for Flex (adobe.com/devnet/flex/testdrive.html).

Further Information

For more information, contact Gido Langen, geomatics applications specialist for the Surveyor General Branch, at 780-495–2399 or gido.langen@NRCan.gc.ca.

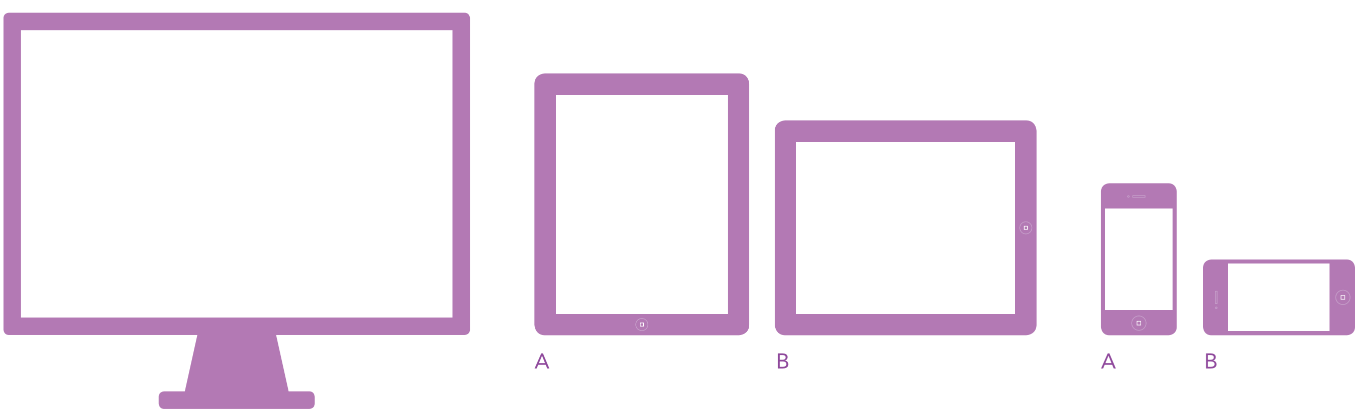
About the Author

Gido Langen has more than 20 years of work experience with Esri products. He loves making the software accessible to users and helping them exploit their data.

mobile media FRIENDLY

Applying media queries to ArcGIS API for JavaScript applications

By Chris Mahlke and the ArcGIS for Server Development Team



↑ Designing mobile-friendly web mapping applications using CSS3 media queries can provide an improved experience to your end users.
A @media screen and (orientation: portrait) B @media screen and (orientation: landscape)

Smartphone and tablet usage is quickly usurping the desktop. Targeting the dizzying array of browsers, screen sizes, and devices in a market experiencing hardware fragmentation is one of the challenges that developers encounter. Although responsive web design does not offer a panacea for all scenarios, designing your web mapping applications to be mobile-friendly using CSS3 media queries can provide an improved experience to your end users.

This technique enables developers to selectively style pages based on properties such as width or height, resolution, or orientation to better suit the browser rendering on the page. You can now style a page differently for the small screen of a smartphone, the slightly larger screen of a tablet, and a desktop screen.

Using the Legend Widget sample from the Help on the ArcGIS Resource Center as a starting point, I will show you how I modified an ArcGIS API for JavaScript application to support a smartphone (320 by 480 pixels) and a tablet (768 by 1024 pixels). Download the Responsive Web Design Sample Code from the *ArcUser* website so you can explore the sample application as you read along.

Device orientation and the ability to adjust the viewport zoom level make styling browser-based mobile applications significantly more complicated. Mobile browsers introduce two issues not encountered on desktop browsers: the user's ability to alter the screen orientation between portrait and landscape mode and the fact that the viewport does not display all sites at their native resolution.

↓ Media query can also be used to adjust styling based on device orientation.

Handling Device Resolution and Rotation

A media query can expand on the media type syntax, providing additional options to further enhance web pages to accommodate different display devices. For instance, a media query can be appended to a media type declaration screen by adding the media query in parentheses as shown in this following example:

```
and:
@media screen and (min-device-width:768px) and
(max-device-width:1024px);
```

This media query targets devices that have a minimum device width of 768 pixels and a maximum device width of 1024 pixels. Media query can also be used to adjust styling based on device orientation. To take advantage of this type of media query, use the orientation parameter. To apply styles to devices in landscape mode, use the following media query:

```
@media (orientation: landscape) {
/* styles go here */
}
```

Styling can also be adjusted based on the device's resolution. To target iPhone 4 and other devices with higher-density screens while ignoring lower-density screens on older devices, use the webkit-device-pixel-ratio.

```
@media (-webkit-min-device-pixel-ratio: 2) {
/* high resolution device styles go here */
}
```

Note that the vendor prefix is required. This code snippet uses the webkit vendor prefix. To target the Motorola Droid, which has a pixel density of 1.5, you would write the following:

```
@media only screen and (-webkit-min-device-pixel-
ratio: 1.5),
only screen and (-o-min-device-pixel-ratio: 3/2),
only screen and (min-moz-device-pixel-ratio: 1.5),
only screen and (min-device-pixel-ratio: 1.5) {
/* styles go here */
}
```

The viewport controls how much mobile browsers zoom in to a web page. I modified the sample's viewport tag to include a width attribute:

```
<meta name="viewport" content="width=device-width,
initial-scale=1.0, maximum-scale=1.0, user-scalable=0"
/>
```

Instead of hard coding the width attribute to a specific resolution (such as 320 pixels), use device-width to ensure there is a one-to-one relationship between the target device and the screen resolution. The width attribute and media queries let you tweak the layout of the application's user interface (UI) components as the device is rotated. For instance, on a device in portrait mode, the legend is not visible. However, when rotated to landscape mode, the toolbar disappears and the legend becomes visible.

On larger devices such as the iPad, Apple's iOS Human Interface Guidelines (HIG) recommend using a Split View Controller. In portrait mode, per the HIG specification, a toolbar button is provided for displaying the left pane as a popover. In landscape orientation, the smaller pane on the left side of the SplitView contains the legend, and the larger pane on the right displays the map.

Handling Variations in Screen Real Estate

Maps occupy a large amount of screen real estate, leaving little room for additional UI components. For this reason, the mobile version of the application does not include a zoom slider because users can use the pinch gesture to zoom in and out. However, the slider is included in the desktop version.

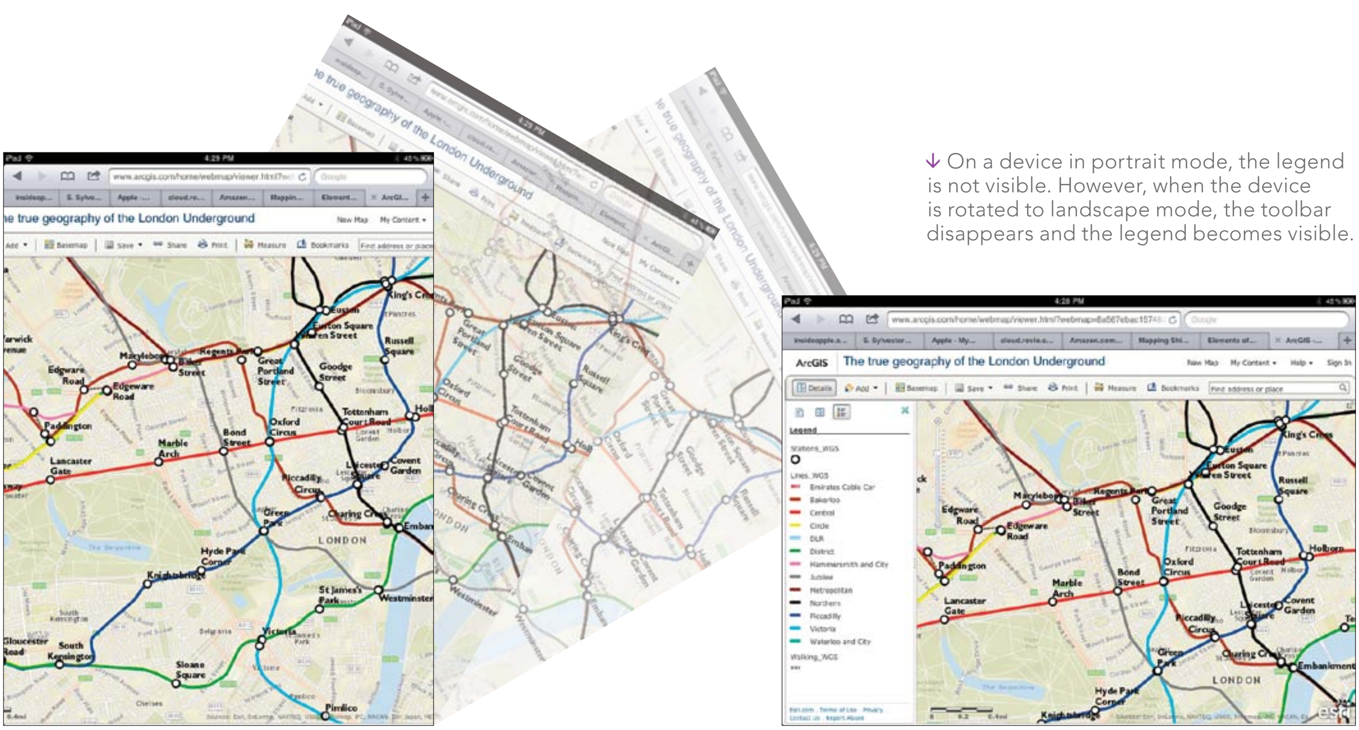
The CSS3 Working Group has proposed an extension to media query support in CSS3. JavaScript developers can evaluate media queries at run time and listen for updates in certain media query conditions. For example, the matchMedia method can be used to check for a certain device aspect ratio or width.

```
mediaQueryList = window.matchMedia(“(min-width:800px)
and (min-device-aspect-ratio: 1/1)”);
```

The returned object contains two properties: matches (a Boolean value indicating if the media query parameter matches the current state) and media (a serialized form of the associated media request). If the browser is 800 pixels or greater, this code adds the slider control. Otherwise, the slider is removed.

```
function toggleSlider() {
isDesktop = mediaQueryList.matches;
if (isDesktop) {
map.showZoomSlider();  // add slider
} else {
map.hideZoomSlider();  // remove slider
}
}
```

The call to matchMedia also checks for min-device-aspect-ratio: 1/1 to detect whether the application is being viewed on a tablet in landscape mode or on a desktop. Because a 1024 pixel width is common resolution on desktops, excluding the min-device-aspect-ratio causes desktop style sheets to be applied to a tablet in landscape orientation.



↓ On a device in portrait mode, the legend is not visible. However, when the device is rotated to landscape mode, the toolbar disappears and the legend becomes visible.

The Event for Developers, By Developers

Don't miss the Esri Developer Summit March 25–28, 2013, in Palm Springs, California. According to past attendee Diane Williams, principal engineer at the US Bureau of Reclamation, "If I had to pick one conference to attend each year, this would be it. Having access to the backroom folks is invaluable."

Technical workshops held during the conference will include deep dives into mapping APIs and SDKs and address the direction of future development at Esri. Hands-on presummit workshops begin March 24 and cover topics such as building iOS 6 applications, Dojo interface development, and introductions to HTML5, JavaScript, and Python programming.

- Network with peers and learn what they are doing.
- Participate in Lightning Talks and user presentations.
- And (of course) don't miss the dodgeball game.

To register, visit **esri.com/devsummit**.

Setting a New Course for Ocean Science

Unique event for the ocean GIS community

By Monica Pratt, *ArcUser* Editor

"How can we go fast with what we've got?"

That was the challenge Jack Dangermond posed to 50 key members of the oceans science and resource community who were invited to Esri corporate headquarters in Redlands, California, for the Oceans Summit on November 7–8, 2012.

↑ Members of the ocean science and resource community were invited to Esri's corporate headquarters for the Oceans Summit on November 7–8, 2012.

The first—and only—Esri Oceans Summit was held to identify the challenges to using GIS in the ocean environment and establish a community of GIS ocean interests independent of Esri. Attendees were associated with academic and research institutes, government agencies, nonprofit organizations, consultants, and ocean-related businesses that use GIS in the marine environment. They were led by Dawn Wright, Esri's chief science officer, and joined by 40 Esri staff members, many from software development.

Part of a Larger Plan

"The oceans are like our lungs and we are smoking," Dangermond said, underlining the urgent need to both understand and preserve the oceans. The Oceans Summit is part of Esri's long-term commitment to applying the lessons learned on land to the ocean: Esri's Ocean GIS Initiative.

Wright announced the initiative in July 2012 at the Esri International User Conference. In that speech, she emphasized the critical role oceans play. "The oceans provide over half the oxygen that we breathe. They regulate all our weather patterns, they feed us, they provide for our energy and economy—so in reality, the oceans are vital to all of us, no matter where we live." *[To learn more about the Esri Ocean GIS Initiative, download the free e-book at www.esri.com/library/ebooks/ocean-gis-initiative.]*

GIS has long provided the tools to arrive at solutions to problems such as competition for natural resources. Now Esri is joining the oceans community to extend that GIS to explore and preserve the earth's last frontier.

However, applying GIS in the marine

environment is challenging. The oceans—from the sea surface to the seafloor—are hard to penetrate with sensing devices. Satellites and lidar can't see all the way through the water in all places. Many marine research topic areas require capturing, managing, and analyzing 3D and 4D data. Datasets incorporating these dimensions are huge and currently problematic to ingest and analyze. Because of these and other issues, currently only 5 to 10 percent of the oceans are mapped at a level of detail comparable to land.

A Different Approach

Rather than a traditional conference, this was a high-level workshop that had just one deliverable: the Oceans Strategic Plan. Instead of listening to and giving presentations, attendees spent most of their time in breakout sessions with Esri staff.

The first day, sessions focused on identifying the barriers to GIS use in the ocean environment. Breakout groups were organized for marine geology and geophysics, physical and chemical oceanography and ocean observing, marine ecology, fisheries science, and coastal and marine spatial planning. The methodology for all groups was the same. Each group identified the positive ways GIS helped in their specific area and where functionality should be extended.

For example, members of the fisheries science group agreed that GIS was valuable for data integration, communication, and analysis tools. Because all regulation is spatially presented, GIS is critical to monitoring and enforcement work and facilitates analyses that are both defensible and repeatable.

A critical area for improvement was integration with OPeNDAP (Open-source Project for a Network Data Access Protocol), a data transport architecture and protocol—originally designed and developed by oceanographers and computer scientists for oceanographic data—that is widely used in the scientific community. The ability to handle 3D and 4D data was another top request as well as more domain-specific functionality and the ability to better handle huge datasets.

At the end of the day, all breakout groups reconvened and presented their findings. Many of the desires of the fisheries group were echoed by other groups. Additional areas for improvement included work with vertical datums, along with transformation issues generally, and quantifying uncertainty in data. The first day concluded with a sustainable seafood dinner in the Esri Café provided by summit participant Clearwater Seafoods.

On the second day, breakout sessions were organized around extending and integrating GIS technology. As Dangermond noted in his remarks opening the summit, the goal was more than just adding functionality. Ultimately, he wants Esri to equip this community with "tools that will actually change the workflows and the way we think about the oceans and the way we act in relation to them."

On this day, breakout groups focused on multidimensional data formats, primarily Network Common Data Form (netCDF), hierarchical data format (HDF), and OpeNDAP; working in 3D and 4D; analytic tools and associated workflows; and data distribution in the context of servers, services, and computing platforms. In

↓ Dawn Wright, Esri's chief science officer, led the event.

each group, members identified existing functionality in ArcGIS that was beneficial and suggested ways for evolving the software to better meet their needs and integrate with other software commonly used in their workflows.

An Ocean of Data

During the summit, almost every discussion revolved around data issues. Studying and monitoring the world's oceans, in all their vastness and complexity, requires staggering amounts of data and functionality not typically required for terrestial GIS.

There is a need to incorporate vertical coordinate systems and develop a true 4D data model. Ingesting, analyzing, and managing datasets on this scale is a formidable task. Dynamic views of constantly changing datasets are needed.

Some of the most important data is available in formats that are not commonly used in studying the landscape. The work of many marine scientists requires extensive use of netCDF data. The netCDF toolbox, released with ArcGIS 10.1, has proved helpful.

Summit attendee Tiffany Vance, who is a geographer with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, affirmed the value of "closely integrating new types of data into Esri—netCDF is a good example where the Esri team is continually working to develop new utilities and applications while also handling more and more types of netCDF files. For us, the ability to use netCDF in ArcGIS has been critical both in our day-to-day work and in making GIS a more usable tool for modelers and physical oceanographers."

In addition to these specific needs, attendees noted on their wish lists items familiar to all GIS users: the need for data structure standardization, for better and more easily maintained metadata, better discoverability of data and tools, and improved tool performance.

The adoption of Python as the standard scripting language for ArcGIS was hailed as a great improvement in customization and integration opportunities, but that did not negate the overwhelming call for integration with MATLAB, a tool for numerical computation and visualization that is used extensively by both the ocean and atmospheric research communities. There is also the continuing need to integrate with existing tools developed by the oceans community like Marine Geospatial Ecology Tools (MGET) developed by Marine Geospatial Ecology Lab at Duke University.

A new take on interactive data publishing was also suggested. In addition to publishing the data associated with a journal article, the geospatial tools used in analysis

↓ Attendees spent most of their time in breakout sessions with Esri staff.

↑ The topics for the second day's breakout sessions were organized around extending and integrating GIS technology.

would be shared. Such a strategy would "push ocean science forward."

Common Themes

The summit's final session summarized the directions for both GIS technology and ocean science and management suggested by the breakout groups, addressing the summit's first goal. Although members of the groups came from many disciplines, the same issues—management and analysis of huge datasets, the effective visualization of this data, and the challenge of working with 3D and 4D data—came up again and again. It was noted repeatedly that GIS capabilities required by the oceans community were very similar to those needed by the atmospheric community. This valuable feedback, along with clarification of GIS functional requirements for ocean science and various use cases, will guide future development of the ArcGIS system.

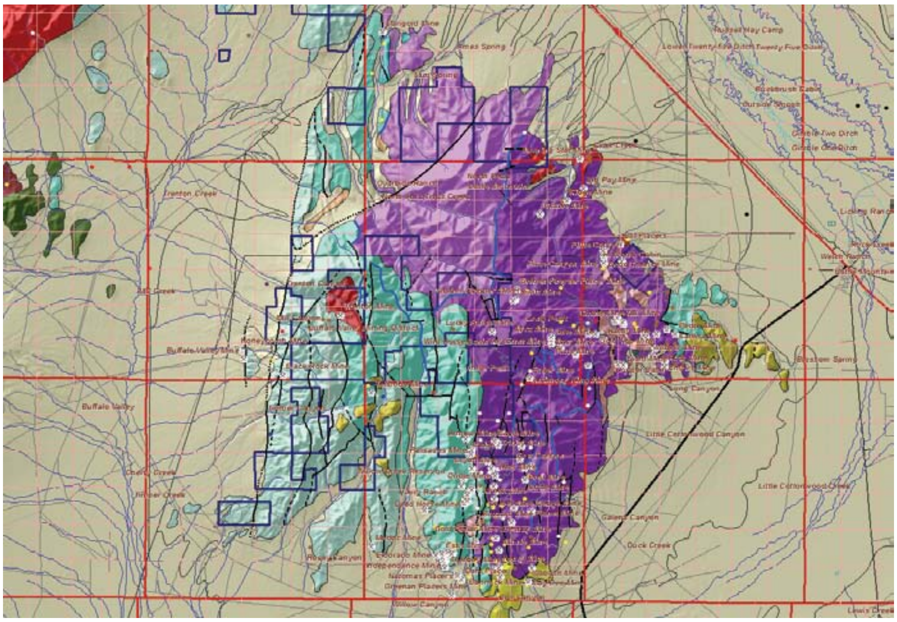
The second goal—encouraging the development of a community that uses GIS to promote ocean research and preservation—seemed to have also been met by the event. Summit attendee James Graham, who is a visiting professor at Oregon State University (OSU) within the Geography, Environmental Science, and Marine Resource Management (GEM) Discipline Group of the College of Earth, Ocean, and Atmospheric Sciences (CEOAS) and a research scientist at Colorado State University, enjoyed "meeting and talking with such a great group of folks who are interested in helping improve our understanding of the ocean."

The Esri Oceans Summit set the course for GIS development in the service of ocean science. The next phase is the inaugural Esri Ocean GIS Conference. This event, open to all comers, will have regular paper sessions and panels, map galleries, and demos. It is tentatively scheduled for November 5–7, 2013 in Redlands.

Strike It Rich with Maplex

Labeling oriented structure point labels in ArcGIS 10.1

By Mike Price, Entrada/San Juan, Inc.



↑ This exercise, like the previous two, uses data from Battle Mountain, Nevada.

Since the early days of ArcView GIS 3, geologists have tried many solutions for the complex problem of placing, orienting, and labeling structural points. With the release of ArcGIS 10.1, Esri users at all license levels now have the power and functionality of Maplex labeling. Maplex allows precise rule-based placement and sizing of complex text and numeric labels, greatly improving the quality, readability, and amount of meaningful information that can be placed on a map.

Structural geology—the study of rock units in three dimensions—relies largely on oriented measurements at or near the surface to project trends below ground. Structural geologists want to understand how rocks were formed, how they have been deformed, and how they might have become mineralized. Structural geologists study and map rock units to answer several questions. What do the rocks look like at the surface? How do they behave at depth? Outcrop properties are often easy to map, yet detailed surface measurements also provide clues to what may be happening at depth.

One of the most important orientation concepts is strike and dip. By measuring the orientation of rocks at the surface, structural geologists can "connect the dots in 3D" to project formations below the surface and define folded structures. With additional information, faults can be mapped and projected to define sharp displacements between offset blocks. If conditions are right, mineralizing fluids can travel upward along faults, depositing valuable minerals while causing temperature, pressure, and rock chemistry changes.

This exercise, like the previous two, uses data from Battle Mountain, Nevada. The 1:100,000-scale geologic mapping will be expanded to include extensive structural measurement data mapped at a detailed 1:24,000 (24K) scale. After adding 24K data for two mapped quadrangles, the next task will be to orient structural point symbols and use Maplex to place high-quality measurement labels on appropriate symbols.

Getting Started

Begin this project by downloading the sample dataset for this exercise from the *ArcUser* website (esri.com/arcuser). Use this dataset rather than the final version of the Battle Mountain dataset from the previous exercise. This new exercise requires new field data contained in this updated sample dataset. Rename any previous Battle Mountain master folders to avoid confusion.

Unzip the training data into a new Battle_Mountain folder. Use ArcCatalog to inspect this dataset. Inside the Battle_Mountain\GDBFiles folder, you will find a new file geodatabase named Geology_24K. This geodatabase contains one feature dataset named Structure, which contains a point feature dataset named Structure_Points1.

Start ArcMap, navigate to \Battle Mountain, and open Battle_Mountain01.mxd. Navigate to \Battle Mountain\GDBFiles\Geology_24K. Go inside the Structure feature dataset and add Structure_Points1. These points will load directly into the map. The coordinate system for the data frame is universal transverse Mercator (UTM) North American Datum 1983 (NAD 83) Zone 11 map. Open the Structure_Points1 attribute table and inspect the table's fields. Note that this point data is standardized and clean, a rarity in the real world. Leave the table open and save the project.

Strike, Dip, and Other Structural Measurements

Explore the attribute table for the Structure_Points1 layer. Sort on the [STRUCTTYPE] field and notice the various types of measurements. Inclined bedding is quite common, but there are also many occurrences of horizontal, vertical, and overturned bedding, along with something called compact foliation. All these records include values for [AZIMUTH] and [DIP]. Azimuth values range from 0° to 360° and dip values, measured down from the horizon, range from 0°

What You Will Need

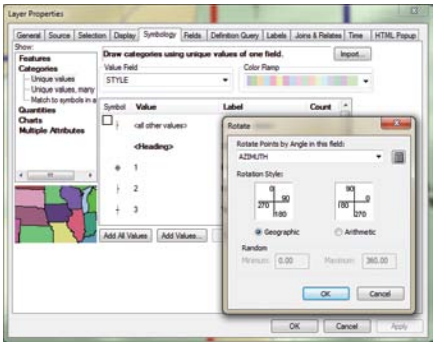
- ArcGIS 10.1 for Desktop (Basic, Standard, or Advanced)
- Sample dataset from *ArcUser* website

for horizontal beds to 90° for vertical structures. While the LABEL contains no values, no fields contain NULL (or missing) values. Close the attribute table table.

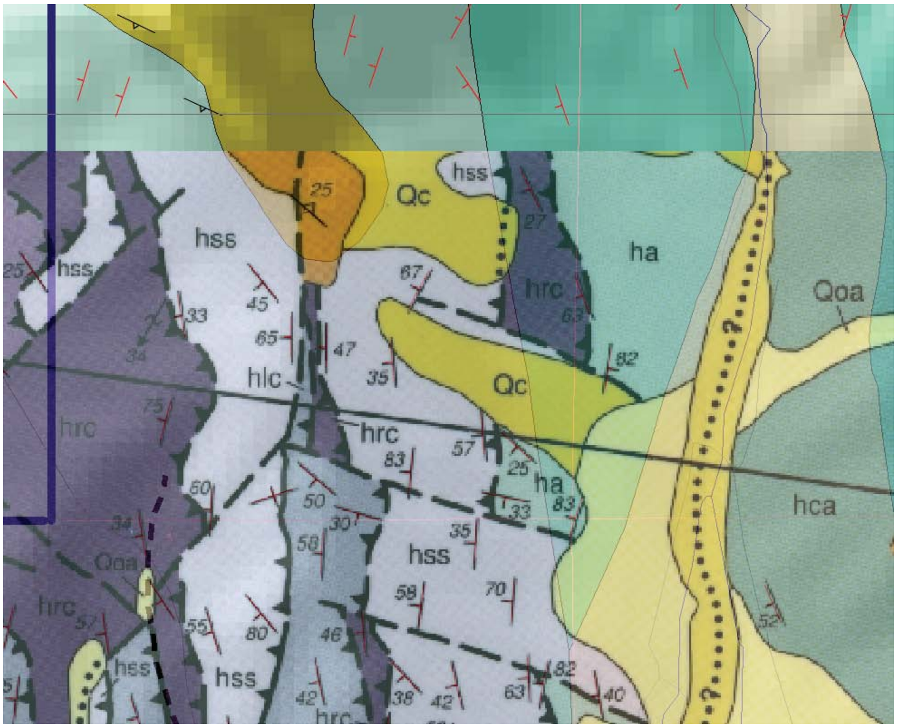
These structural points are derived from digital datasets created during the geologic mapping of the Antler Peak and Galena Canyon 7.5' quadrangles. These quadrangles, which cover a major part of Battle Mountain, provide excellent data for mapping and modeling. The point data in these quadrangles has been standardized so procedures behave well across both quadrangles. (See the "Summary and Acknowledgments" section at the end of this article for more information about and links to the source data.)

When measuring and recording geologic data, both strike orientation and dip parameters should be collected. strike is a bidirectional linear measurement that defines the intersection of an inclined plane and a horizontal surface. dip direction represents the steepest line of fall on the measured plane. It is the path a marble, influenced by gravity, follows as it rolls down the planar surface. Dip direction is a unidirectional measurement that is always perpendicular to strike. Dip angle is the angular measure of the difference between the inclined rock surface and the earth's horizon. Figure 1 helps explain the relationship between strike and dip.

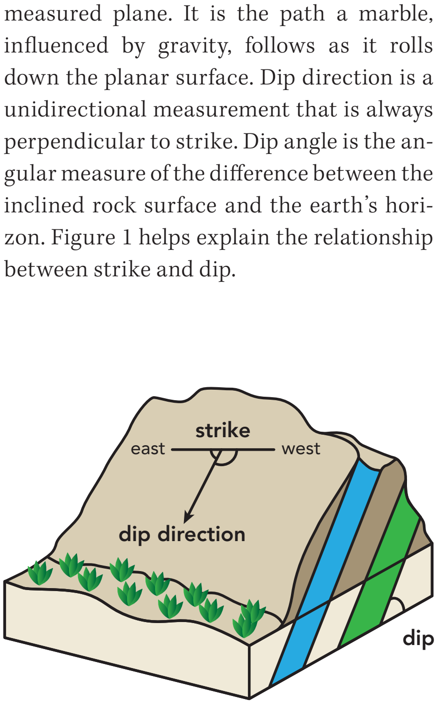
To simplify field measurements, dip direction is often combined with strike by applying the Right-hand Rule. To use the Right-hand Rule when measuring a strike azimuth, always keep the dip direction to the observer's right, as though your right hand, palm side up, has fingers aligned with strike and your right thumb points "downdip." Use this method consistently to record the dip direction in a clockwise rotation relative to strike. Figure 1 illustrates the application of the Right-hand Rule. When taking field measurements, record the azimuth and dip angle. If the strike is intentionally or accidentally measured using the opposing



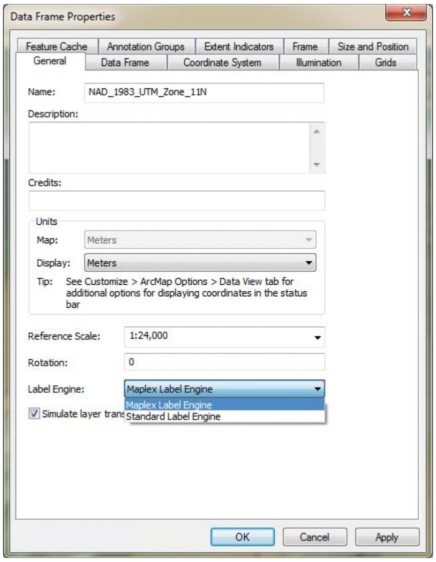
↑ In the Properties dialog box for the Structure_Points1 layer, click the Symbology tab, click the Advanced button, and click Rotation. Verify that Geographic azimuth is selected and set AZIMUTH as the rotation.



↑ To check the accuracy of the symbol rotation, load a small image of a clipped portion of a geologic map of Antler Peak.



← Figure 1: Strike is a bidirectional linear measurement that defines the intersection of an inclined plane and a horizontal surface. Dip direction, unidirectional measurement, represents the steepest line of fall on the measured plane that is always perpendicular to strike.

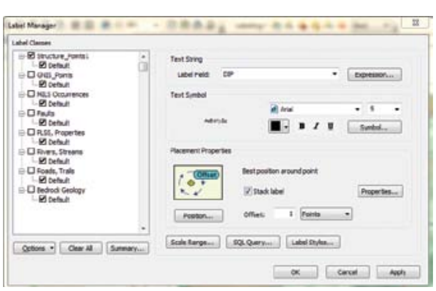


↑ In the Data Frame Properties dialog box, set a reference scale of 1:24,000 and choose Maplex as the label engine.

or Left-hand Rule, consider standardizing to Right-hand Rule measurements as discussed in the section "Digging Deeper: Mapping Your Own Data" later in this article.

Symbolizing and Rotating Points in ArcMap

1. In the table of contents (TOC), right-click Structure_Points1, choose Properties, and click the Symbology tab.
2. In the Symbology window, click Import, browse to the \GDBFiles folder, and locate the Structure_Points1.lyr file. This layer file does not load data but does contain appropriate symbology that matches the numeric Style field, so assign STYLE to the VALUE field. Click OK twice to apply symbology.
3. Zoom to the bookmark named Structure Points 1:24,000 and inspect the data. Notice that all point symbols are oriented with the long axis north to south and the dip to the east. These points all reference a strike azimuth of 0°, which will be fixed in the next steps.
4. Return to the Structure_Points1 Symbology tab, click the Advanced button, and click Rotation. Verify that Geographic azimuth is selected and set AZIMUTH as the rotation. Click OK twice and watch symbols rotate. While this looks "geologically good," is it correct?
5. To check the accuracy of the symbol rotation, load a small image of a clipped portion of a geologic map of Antler Peak. Navigate to Battle Mountain\JPGFiles\UTM83Z11, locate Antler_Peak_Sample.jpg, and load it into the map. Place the JPEG below the topography hillshade and inspect the rotated symbology to verify symbol position, type, and rotation. To see the symbols more clearly, temporarily change their color from black to a bright red or magenta.
6. Turn off the JPEG and change the symbols back to black.



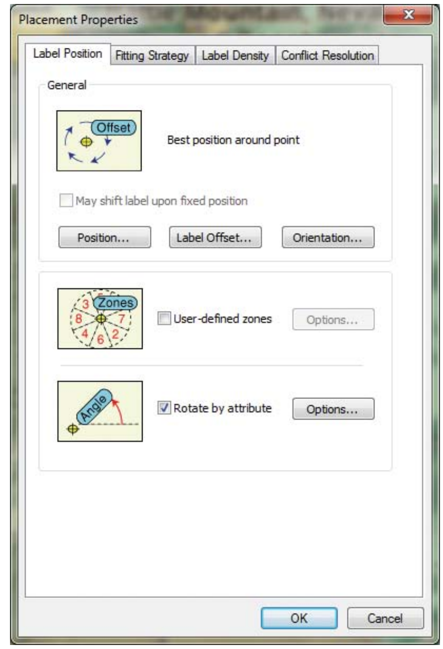
↑ Use the Label Manager to set the properties shown in the Preliminary Label Criteria checklist.

Before posting the dip values, some cartographic considerations are in order. The USGS 7.5' quadrangle series is mapped at a scale of 1:24,000 (1 inch = 2,000 feet). To properly match standard symbol and label styles requires carefully respecting this standard scale. To do this, all the production decisions will be made in layout view. Switch from Data view to Layout view. Center the layout and use the map bookmark named Structure Points 1:24,000 to adjust the extent. Turn off the other labeled data (GNIS_Points and MILS Occurrences).

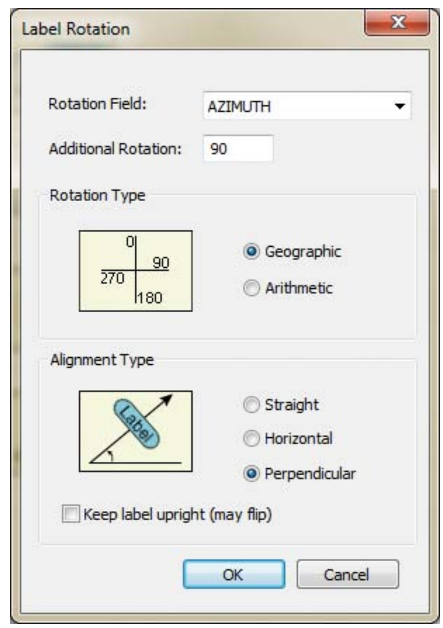
Next, set a reference scale of 1:24,000 for the data frame so the symbology and labels resize appropriately as the display is zoomed in and out. In the TOC, click the data frame and set a Reference Scale of 1:24,000. At the same time, set Maplex as the label engine. Click OK to close the data frame properties. Save the map.

Labeling Points with Maplex

Load the ArcGIS labeling toolbar by clicking in an unused toolbar area and selecting the Labeling toolbar. Save the map again. In the Labeling toolbar, open the Label Manager and select Structure_Points1 to start labeling that layer. Study the point Label Manager to become familiar with its features.



↑ After clicking the Properties button in the Label Manager, click Rotate by attribute and click the Options button.



↑ In the Label Rotation dialog box, set Rotation Field to AZIMUTH, Additional Rotation to 90, Rotation Type to Geographic, and Alignment Type to Perpendicular. Uncheck Keep label upright.

Preliminary Label Criteria

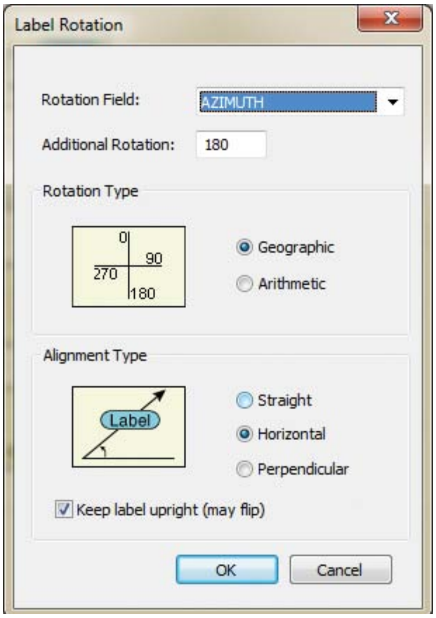
1. Check Structure_Points1 to place labels.
2. Under Structure_Points1, select Default.
3. In the Label Manager, set Label Field to DIP.

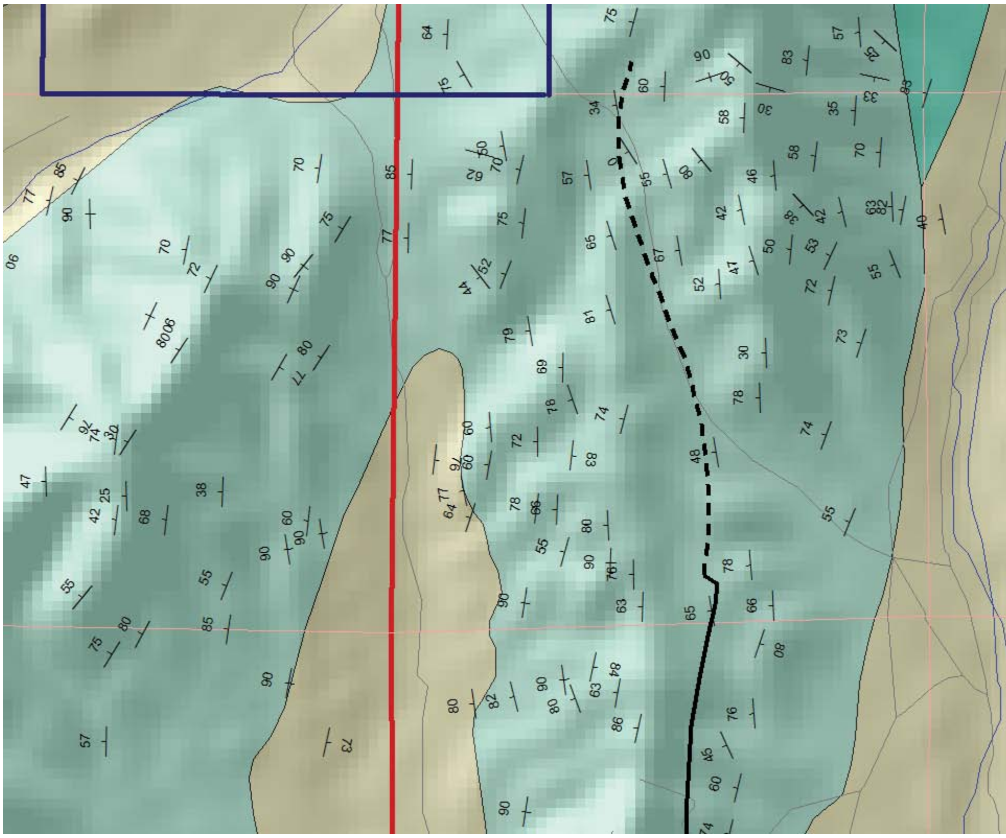
4. Set Text Symbol to Arial 5 point black.
5. Keep Stack label checked.
6. Set Offset to 1 Points.
7. Click Apply and continue to the Placement Properties Checklist.

Placement Properties Checklist

1. In the Placement Properties area of the Label Manager dialog box, locate and click the Properties button.
2. Click the Properties button to open the Placement Properties dialog box.
3. Click the Label Position tab. Check the box for Rotate by attributes.
4. Click the Options button next to Rotate by attributes.
5. Set Rotation Field to AZIMUTH.
6. *Set Additional Rotation to 90 (this is very important).*
7. Set Rotation Type to Geographic (rather than the default, which is Arithmetic).
8. Set Alignment Type to Perpendicular (from the default Horizontal setting).
9. Uncheck Keep label upright (at least for now).
10. Click OK twice to return to the Label Manager.
11. Review Label Manager settings and verify that Structure_Points1 is checked as the layer to label.
12. Click OK once more and watch the labels post. Save the map.

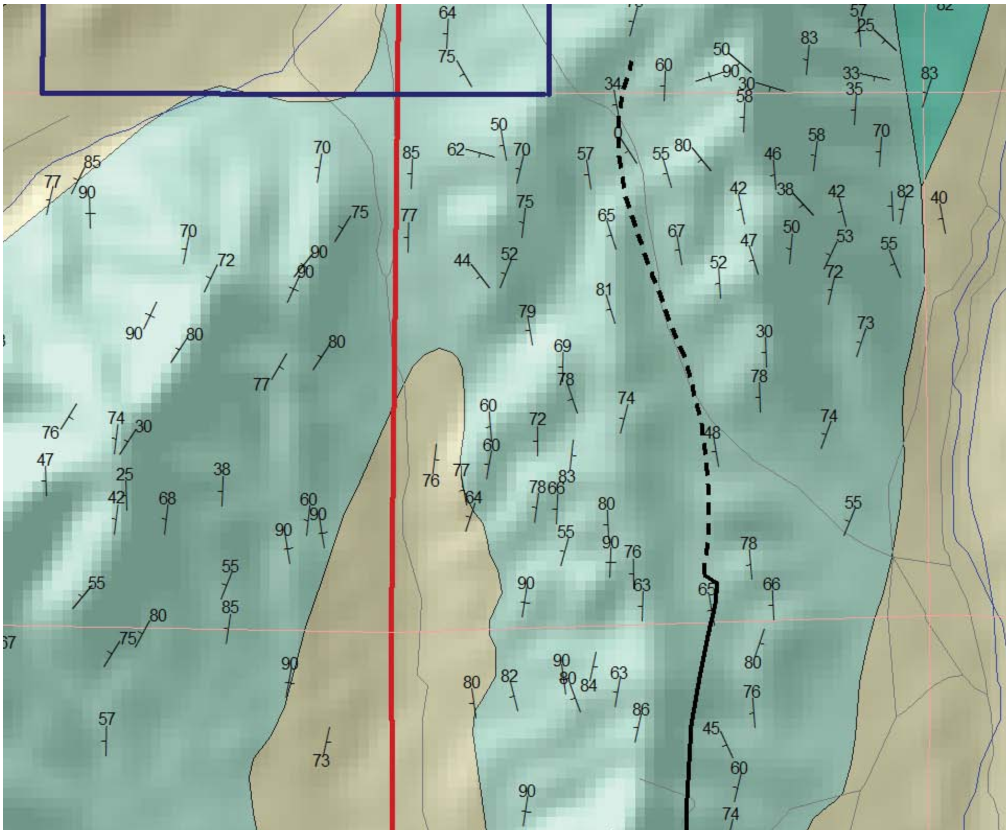
Using the Layout toolbar, zoom to a ➔

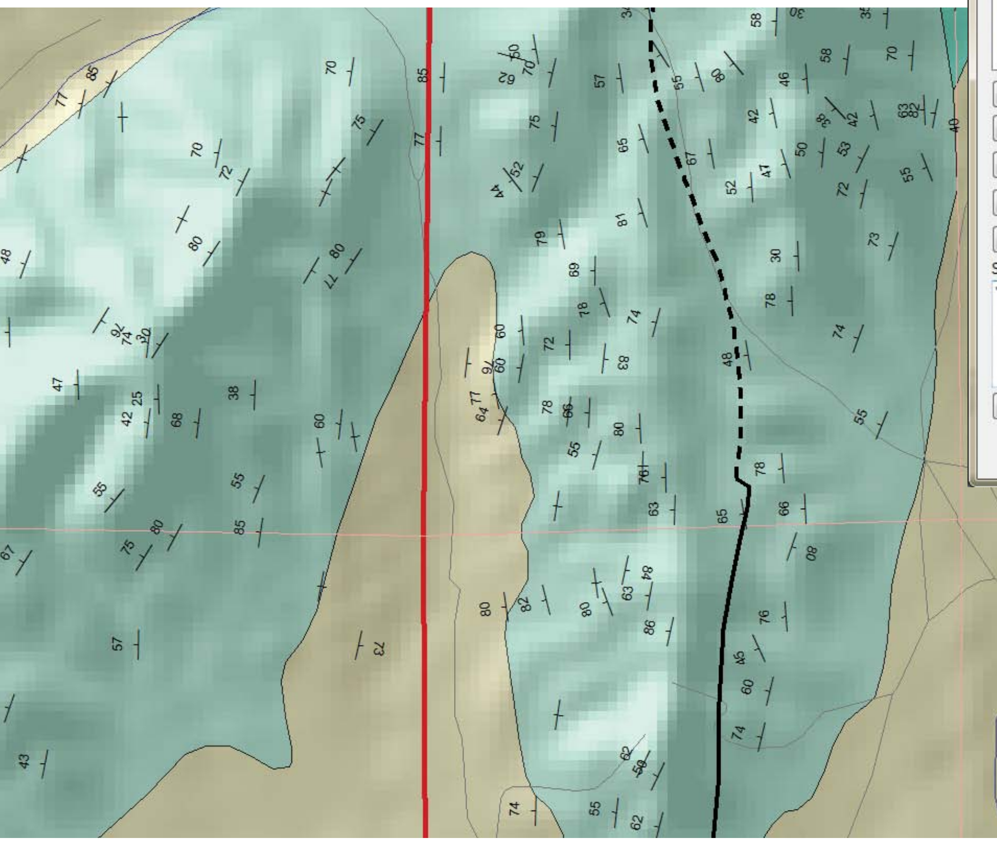


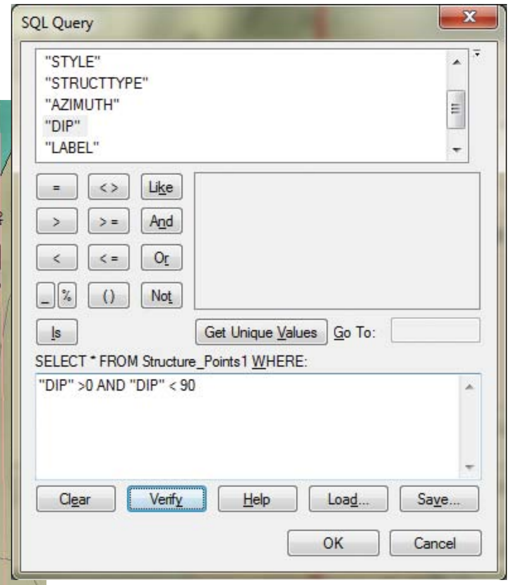


↑ Once the rotation properties have been applied, check the map symbols.

↓ Revisit the Label Rotation dialog box and experiment with various settings and note their effects.

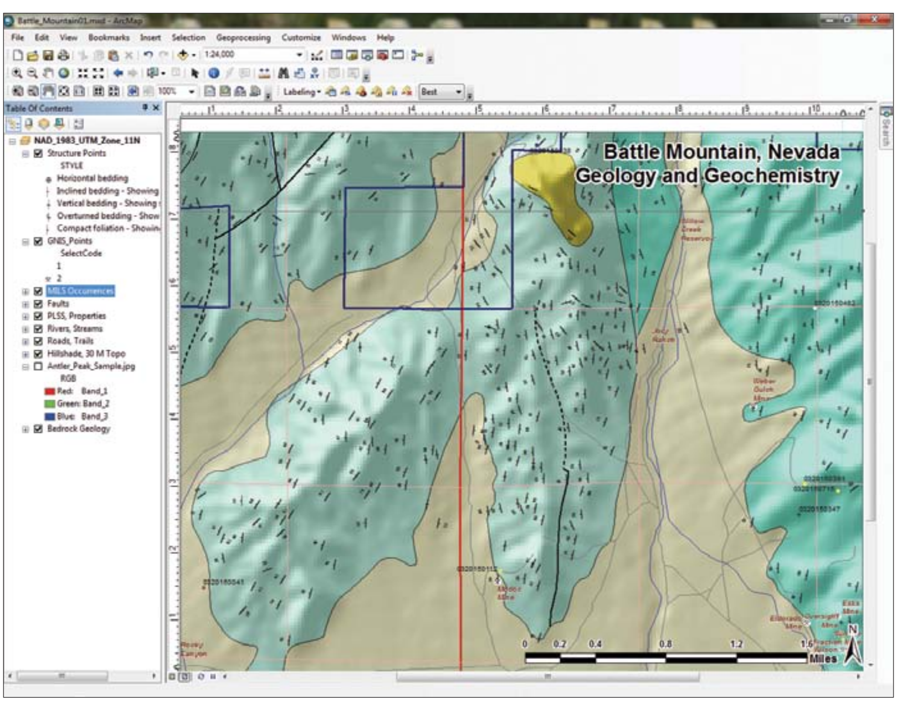






↑ To make the map less cluttered, set a SQL query to label points with dip values that are greater than 0° and less than 90°.

↓ In the last step, turn GNIS_Points and MILS Occurrences layers back on and zoom the layout scale to 100 percent to preview the final map printout.



layout scale of 200 percent. Carefully inspect symbol size and rotation and labeling on the map. Compare the labels in this map to the labels in Antler_Peak_Sample.jpg. The rules set just applied posts labels on the down-dip side of an oriented symbol with a label axis parallel to symbol orientation, while labels in Antler_Peak_Sample.jpg symbols are positioned beside the symbol and are always horizontal. Which do you like better?

Labeling is truly a cartographic art form, so experiment with parameters. Here are just a few to try, but save the map first:

1. Reopen the Label Manager and change the point size to 6.
2. Change Offset to 0.
3. Click the Properties button to open the Placement Properties dialog box.
4. Click the Label Position tab.
5. On the Label Position tab, click Rotate by attribute > Options to open Label Rotation.
6. Try an Additional Rotation angle such as 0, 180, or 270.
7. Try Straight and Horizontal alignment.
8. Check the Keep label upright box.
9. For future reference, check out other Maplex placement tabs, including Fitting Strategy, Label Density, and Conflict Resolution.

After reviewing how these setting changes affect label placements, use the Preliminary Lable Criteria and Placement Properties checklists to restore labels to the previous setting.

Let's set a SQL query to label points with dip values that are greater than 0° and less than 90°. The horizontal bed symbol indicates the dip is 0°. A vertical symbol indicates a 90° dip. These two labels clutter the map but can easily be removed. In Label Manager, click the SQL Query button. Create the SQL Query “DIP” > 0 and “DIP” < 90 to label only points with dip values that are greater than 0° and less than 90°. Save the map.

Reviewing the Map

This exercise teaches how to use Maplex to properly label geologic structural points. First, let’s review the map and its enhanced labels.

Turn the GNIS_Points and MILS Occurrences layers back on and zoom the layout scale to 100 percent to preview the final map printout. In the TOC, change the name of Structure_Points1 to Structure Points.

For one final look at the underlying 1:24,000-scale geology, turn Antler_Peak_Sample.jpg back on and study the Structure Points. Look over the mapped bedrock geology and structure lines shown in the image. Notice the additional detail not included in the original 1:100,000 data.

Digging Deeper: Mapping Your Own Data

Our sample data and its prebuilt legend have been classified, and appropriate symbols are associated with each data type. To use other geologic point data, thematically symbolize each individual data type using the Legend Editor. Classify the dataset using Unique Value and the field in the dataset that identifies the type of data. Assign the appropriate symbol from the Geology 24K style set.

If oriented field data or digitized points were recorded with a reversed field orientation that was improperly digitized, it may contain some Left-hand Rule points mixed with Right-hand Rule points. Since oriented symbols in the Geology 24K style set use Right-hand Rule, data that has both Right-hand and Left-hand points must be standardized by reversing the strike azimuth.

If you are certain that a strike azimuth must be switched, add 180 to azimuth values less than 180° and subtract 180 from values between 180 and 360. Keep notes listing the points that have been edited. If all data was captured using a Left-hand Rule, rotate all oriented symbology and placed labels by 180°.

Summary and Acknowledgments

The author truly appreciates the opportunity to use this excellent data to create training modules for geoscientists. The exercise uses the same basemap and regional geologic data presented in several recent *ArcUser* tutorials. New structural point data was obtained from two 24K quadrangle maps posted by the Nevada Bureau of Mines and Geology. If you wish to experiment with this data, it is available online: The Geologic Map of the Galena Canyon 7.5’ Quadrangle in Lander County, Nevada, USGS Open File Report 94-664 (1994) at www.nbmg.unr.edu/dox/USGS/Galena_Canyon_OFR94664d.zip and the Geologic Map of the Antler Peak 7.5’ Quadrangle in Lander County, Nevada, Bulletin 109 (1995) at www.nbmg.unr.edu/dox/zip07/AntlerPeak_B109d.zip.

Making Data Fit the Community Maps Program

Migrating to the Local Government Information Model

By Tamara Yoder and Mark Stewart, Esri

Learn a process for quickly and easily migrating source data to the Local Government Information Model using the ArcGIS Data Interoperability extension. This article is the sequel to "Preparing Data for the Community Maps Program," which appeared in the fall 2012 issue of *ArcUser* and described a process for evaluating source data when contributing maps to the Community Maps Program.

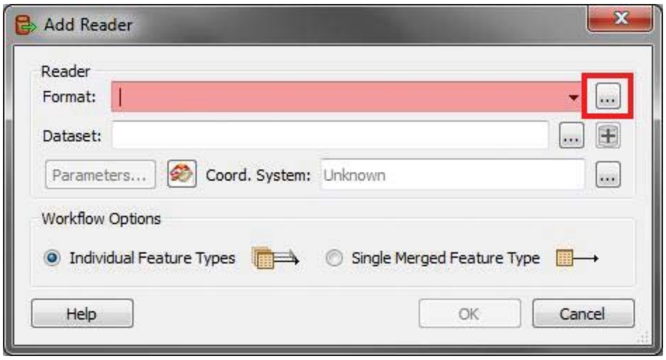
Adopting the Local Government Information Model allows data to be easily contributed to the Community Maps Program, a collection of fast, authoritative, and freely available web maps compiled from premier GIS data sources. It also makes it possible to use the many other maps and applications that work in conjunction with this model. These resources address local government needs that range from public works to emergency management. The Local Government Information Model can be downloaded from the ArcGIS Resource Center at no charge.

Getting Started

To begin, download and unzip the tutorial data from the *ArcUser* website. This sample dataset was provided by the City of Palm Desert, California. To complete this exercise, you will need ArcGIS 10.1 for Desktop at any license level and the ArcGIS Data Interoperability extension. If you do not have a license for ArcGIS Data Interoperability, you can request a 60-day trial.

The ArcGIS Data Interoperability extension provides an easy yet powerful method for creating spatial extract, transform, and load (ETL) tools. A spatial ETL tool extracts source data, performs some manipulation or transformation, and loads the results into a destination dataset. The Workbench application in this extension allows you to create new spatial ETL tools and edit existing ones graphically.

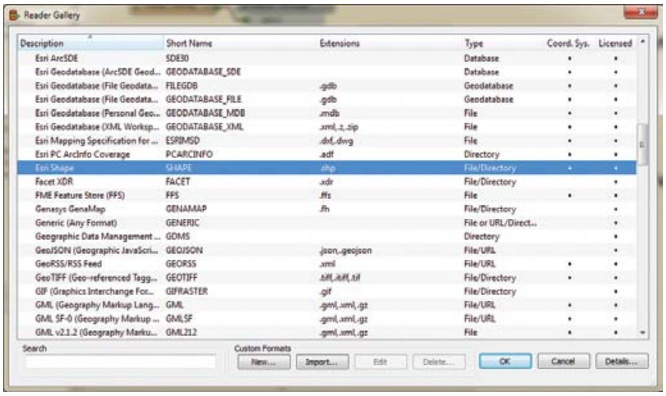
In this tutorial, you will finish creating a spatial ETL tool that you will use to migrate a shapefile containing road centerlines to the RoadCenterline feature class in a geodatabase that uses the Local Government Information Model. The RoadCenterlineETL tool has been partially created and includes several transformers (which perform data manipulation) and a writer (data destination). To complete the creation of this tool, you will add a reader for the PDStreets shapefile data source and adjust the parameters of some of the transformers so that they execute correctly.



↑ In the Add Reader dialog box, click the ellipsis button next to Reader Format to invoke the list of available readers.

What You Will Need

- ArcGIS 10.1 for Desktop (Basic, Standard, or Advanced)
- ArcGIS Data Interoperability extension (60-day trial available)
- Sample datasets



↑ In the Add Reader dialog box under Reader Format, click the ellipsis button and select Esri Shape.

Adding a Reader

After downloading the sample dataset from the *ArcUser* website and unzipping it locally, you will begin completing the RoadCenterlineETL by adding the PDStreets shapefile as a reader.

Open ArcCatalog and activate the ArcGIS Interoperability extension by choosing Customize > Extensions.

Navigate to the folder where you unzipped the sample dataset. In this folder, click the CommunityMaps.tbx. Right-click the RoadCenterlineETL tool and choose Edit. The Data Interoperability Workbench opens the RoadCenterlineETL tool.

In the Workbench, choose Readers > Add Reader. In the Add Reader dialog box under Reader Format, click the ellipsis (...) button. In the Reader Gallery dialog box, scroll down the list and choose Esri Shape, and then click OK.

In the Add Reader dialog box, under Reader, Dataset, click the ellipsis button. Navigate to the tutorial data and select the PDStreets shapefile and click Open. Click OK to close the Add Reader dialog box. The Workbench will open the PDStreets shapefile, and you should see it added to the main window.

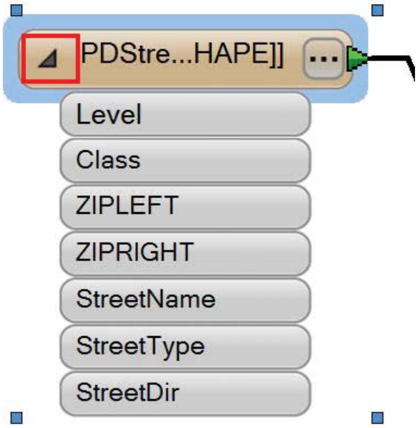
Now that the source data has been added to the tool, it needs to be connected to the first transformer. Use the Zoom In tool to zoom in on the reader and the first transformer. Connect the PDStreets.shp reader to the first transformer, RoadCenterlineCaseChanger, by clicking the yellow arrowhead on the reader and dragging it to the red arrowhead on the transformer.

In the reader, click the arrow to expand it and show the attributes. These attributes are from the PDStreets shapefile. This tool will change these attributes, so it is helpful to be familiar with the original attributes.

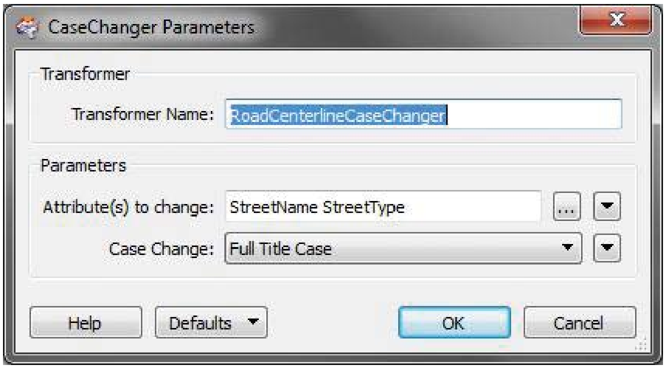
Edit the Transformers

Now that you have added the reader and verified that the writer is set correctly, you will complete the ETL tool by adjusting the transformer parameters. In the Workbench, scroll back to the left until you reach the beginning of the workflow.

Attribute mapping is carried out by dragging the output port (the arrowhead) of a source attribute to the input port of a destination attribute. Note the green, yellow, and red color coding showing which attributes have been connected. Green ports indicate a connected attribute, yellow indicates a source attribute unconnected to a destination, and red indicates a destination attribute unconnected to a source. Attributes with the same name in the source and



← Click the arrow on the reader to expand it and show the attributes.



↑ In the RoadCenterlineCaseChanger transformer, verify that StreetName and StreetType are the attributes to change.

destination are automatically connected. Attribute names are case sensitive, so a field named "TYPE" will not automatically be mapped to a field named "type" or "Type." This mapping is sometimes implied rather than visualized, with no connecting arrow shown.

RoadCenterlineCaseChanger

The first transformer in the tool is RoadCenterlineCaseChanger. This transformer will perform bulk case changes on all the values in the attribute fields you specify. This is helpful for field values that will be used for labeling, so all labels for a particular feature class can be changed to have a uniform appearance.

Verify that the port on the PDStreets.shp reader is green. If not, click it and connect it to the RoadCenterlineCaseChanger transformer.

Next, click the ellipsis button on the RoadCenterlineCaseChanger transformer to edit its parameters. In the CaseChanger Parameters dialog box, click the ellipsis button next to Attribute(s) to change.

Check StreetName and StreetType and click OK. Verify that Full Title Case is selected for Case Change. Click OK to close the CaseChanger Parameters dialog box and scroll to the next transformer.

RoadCenterlineROADCLASSValueMapper

RoadCenterlineROADCLASSValueMapper will take values from the Class field in PDStreets.shp and match them to values in the ROADCLASS field in the RoadCenterline output feature class. This is necessary because the Local Government schema has a specific domain of values for the different classes of roads. This cuts down on errors and ensures that roads of various types (e.g., highways, local roads) are symbolized uniformly throughout the map. Specify the PDStreets Class field as the source of values for the ROADCLASS field in the RoadCenterline feature class and identify specific value mapping that should take place.

Open the parameters dialog box for the RoadCenterlineROADCLASSValueMapper transformer. In the AttributeValueMapper Parameters dialog box, choose Class from the drop-down list for Source Attribute.

To import the Class values from the PDStreets shapefile to populate the dialog box, click the Import button. Although you could enter them manually, importing them is quicker.

In the first panel, click the Change button and the ellipsis next to Dataset. Navigate to the tutorial data, click PDStreets.shp, and choose Open. Click Next on the first panel.

On the Select Feature Types panel, verify that PDStreets.shp is listed, then click Next.

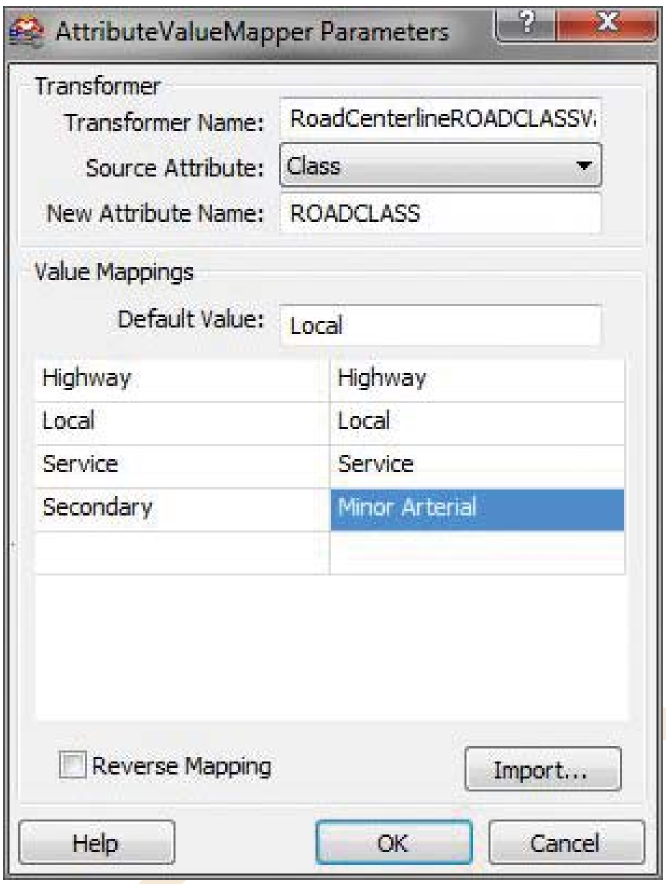
In the Key Attribute panel, select and double-click the Class attribute, then click Next. This will import the unique values for the Class field into the ValueMapper dialog box.

In the Value Attribute panel, click Class, then click Next. Wait while the Class field in PDStreets is scanned for unique values. There should be four unique values found.

Click Finish on the Scanning Attributes panel. Click OK on the message box that provides the result of the scanning. Click Finish on the final panel.

Now that the values from the Class field have been added, you will map them to their corresponding values in the ROADCLASS field in the RoadCenterline feature class. You could find these values by looking up the ROADCLASS coded value domain in the Local Government Information Model, but since there are only four unique types of roads in the source data, use the values in Table 1.

As you can see, there is only one value that needs to be changed.



↑ RoadCenterlineROADCLASSValueMapper will match values from the Class field in PDStreets.shp to values in the ROADCLASS field.

Roads with a Class value of Secondary in the source data will have a ROADCLASS value of Minor Arterial in the output. Use the values in the table to complete the mapping in the AttributeValueMapper dialog box. For Default Value, type Local. Click OK to close the dialog box.

Class values from PDStreets	ROADCLASS values
Highway	Highway
Local	Local
Service	Service
Secondary	Minor Arterial

↑ Table 1: ROADCLASS road type values

Populating the FULLNAME Field

Now that you have edited the parameters for the ROADCLASSValueMapper transformer, continue scrolling to the right to the next group of three transformers: the AttributeFilter, DirectionsConcatenator, and NoDirectionsConcatenator.

The three transformers in this tool work together to take multiple fields from the input source data and load their combined values into one field in the output. In this case, this is necessary because the full name of the street features is divided up into different fields in the PDStreets shapefile, but the Local Government model requires that the name be stored in one field called FULLNAME for labeling purposes.

AttributeFilter

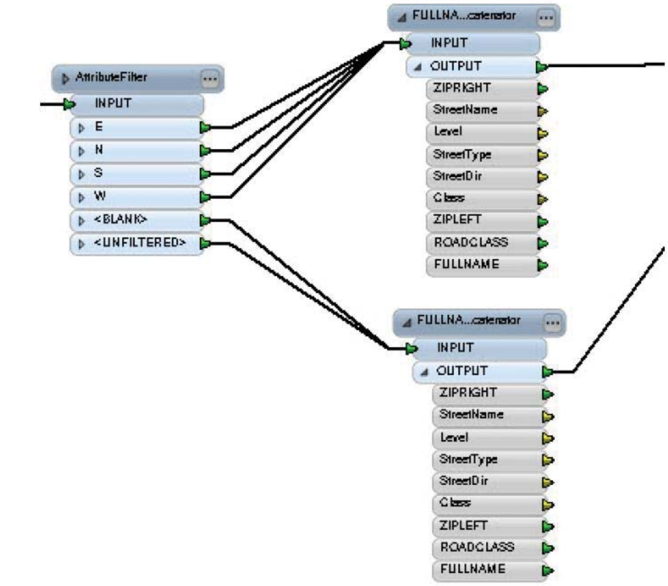
The first transformer in the group is AttributeFilter. It divides up the input records based on whether they have a value for the StreetDir field. This might not seem like an important step, but if you look at the attributes for PDStreets.shp, you will notice that the majority of streets do not have a StreetDir value. Click the ellipsis button to open the parameters for the AttributeFilter transformer to verify that StreetDir is selected as the Attribute to filter by. Close the AttributeFilter Parameters dialog box.

DirectionsConcatenator

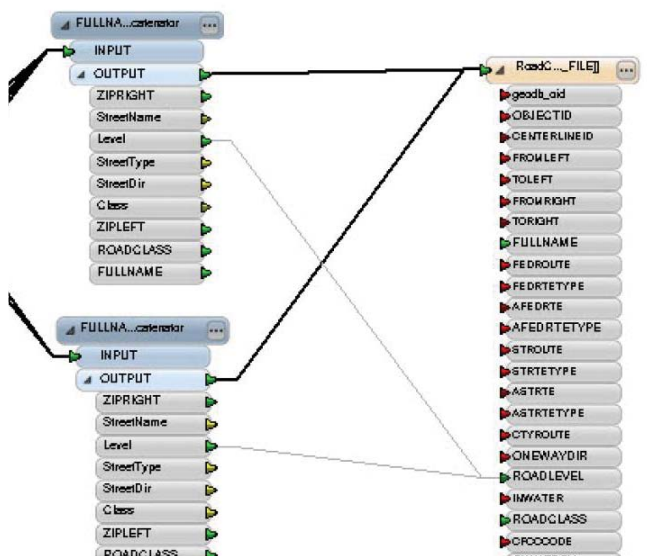
Now click the ellipsis button on the FULLNAME with DirectionsConcatenator transformer (the top one) to open the parameters dialog box. Notice that Destination Attribute is set to FULLNAME and that the Concatenated Items include StreetDir, StreetName, and StreetType. The constants between the items represent spaces. At the bottom of the dialog box, you can see a preview of the concatenation. Close the parameters dialog box.

NoDirectionsConcatenator

This concatenator does not include the StreetDir field. Only records that have a blank StreetDir value will go through this concatenator, which will avoid the possibility that an empty StreetDir field could be concatenated with the StreetName and StreetType fields. Open the dialog box for the FULLNAME NoDirectionsConcatenator



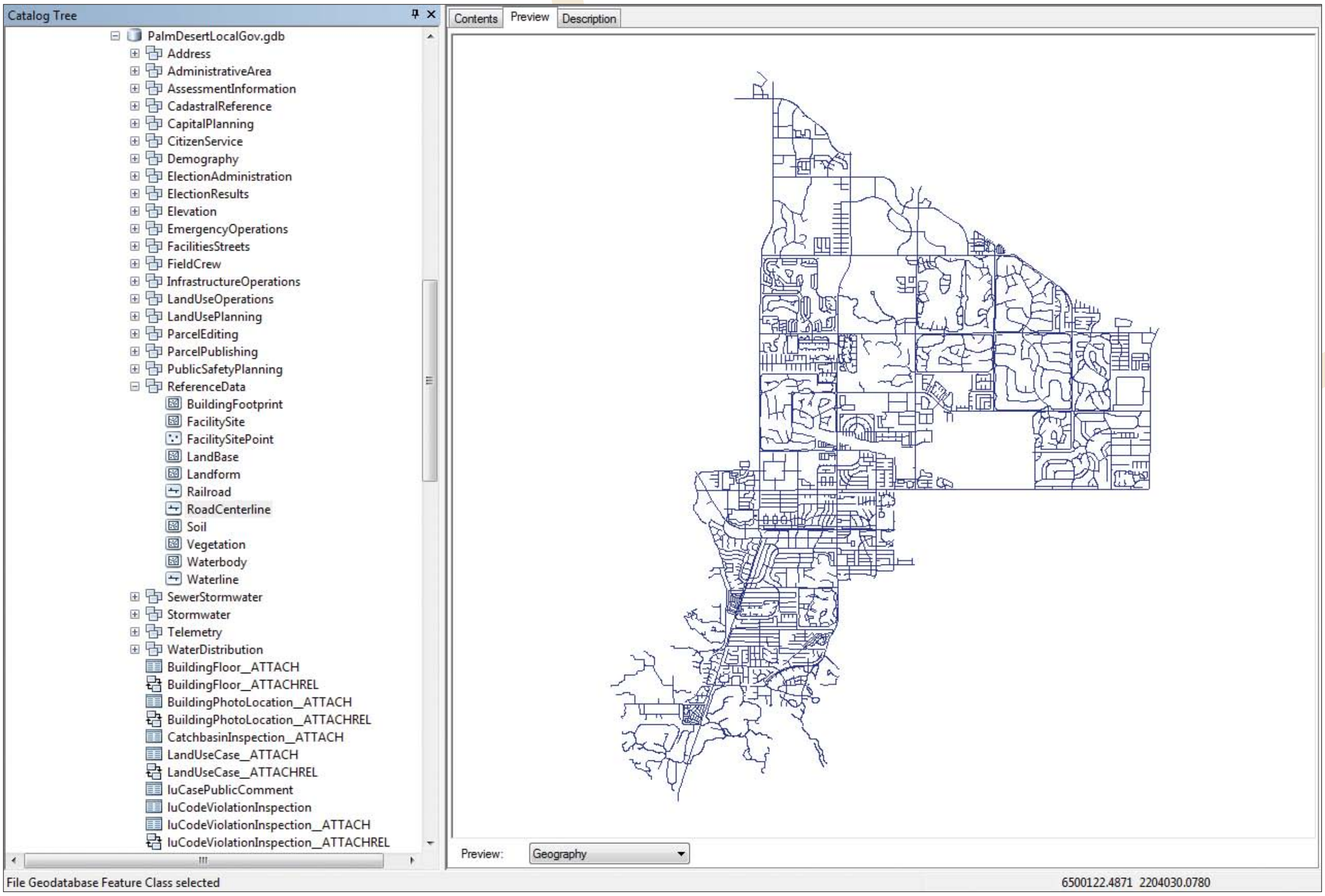
↑ The AttributeFilter, DirectionsConcatenator transformer, and NoDirectionsConcatenator transformer will take multiple fields from the input source data and load their combined values into one output field.



↑ For both the DirectionsConcatenator and NoDirectionsConcatenator transformers, connect the Level field to the ROADLEVEL field, clicking the yellow port and dragging it to the red one.

transformer to verify that it does not include the StreetDir field. Close the parameters dialog box. Scroll to the end of the tool so that you can see the two concatenator transformers and the writer. In the Workbench, click the Save button to save the changes you have made to the RoadCenterlineETL tool.

At this point, you can see which attributes from the PDStreets shapefile will be mapped to attributes in the RoadCenterline feature class. Since there are many transformers between the source feature class and the destination feature class, attribute mapping will be done from the last transformers in the workflow to the destination feature class.



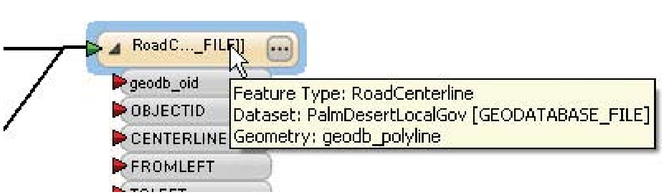
↑ After running the tool and verifying in the log window that it was successful, use ArcCatalog to check the RoadCenterline feature class.

Connecting the Level Field

The remaining unmapped field is Level. This field has a match in the RoadCenterline destination feature class, but the name is slightly different.

Connect the Level field to the ROADLEVEL field in the destination by clicking the yellow port and dragging it to the red one. *Make sure to do this for both concatenator transformers.*

There are still many attributes in the destination feature class that are not mapped to source attributes. This is acceptable. Every field does not have to be mapped to the Local Government schema—only fields that control labeling and cartography for the layer being contributed. Unmapped destination attributes will simply not contain values.



↑ Click the Prompt and Run Translation button and set the destination path for the tool output to PalmDesertLocalGov.gdb.

Run the RoadCenterlineETL Tool

One of the benefits of performing data migration in the ArcGIS Data Interoperability extension is that it provides comprehensive logging. Whenever a tool is executed, information about the process is sent to the Log window in Workbench and also stored in a log file. This log file can provide information that is helpful in performing quality control on the data migration workflow or troubleshooting problems with a specific ETL tool.

In Workbench, click the Prompt and Run Translation button (with question mark and green triangle icons). Here you will set the destination path and verify the source path. Click the ellipsis button beside Destination Geodatabase and navigate to where you saved the tutorial data. Choose PalmDesertLocalGov.gdb and click Open. Click the ellipsis button beside Source ESRI Shape File(s) and once again go to the location where the tutorial data was saved. Choose PDStreets.shp and click Open. Click OK.

Notice the information being sent to the Log window. When the tool has finished running, you will receive a message in the Log window that the translation succeeded. The number of translated features will be displayed on the connection arrows in the main display. If the RoadCenterlineETL tool did not finish successfully, go back through the prior steps in this tutorial and investigate the Log window information to determine what went wrong.

Once the tool has executed, verify that the PDStreets features have been migrated to the RoadCenterline feature class. Close the RoadCenterlineETL tool. When prompted to save, click Yes. In ArcCatalog, navigate to the tutorial data. Right-click the data folder and choose Refresh.

Navigate to the PalmDesertLocalGov geodatabase > ReferenceData > RoadCenterline feature class. Click the Preview tab to display the RoadCenterline feature class lines. Choose Table from the Preview drop-down list. Scroll over to the FULLNAME field and verify that the StreetDir, StreetName, and StreetType values from the PDStreets shapefile have been combined into this field.

Scroll to the ROADLEVEL and ROADCLASS fields to verify that their values were also populated from the PDStreets shapefile. Once satisfied that the migration was successful, close ArcCatalog.

Conclusion

In this exercise, you edited an existing spatial ETL tool to enable the migration of a shapefile to a geodatabase feature class using the Community Maps version of the Local Government Information Model schema. The ArcGIS Data Interoperability extension allows you to construct tools that complete an entire migration workflow in one operation. For more information on how the ArcGIS Data Interoperability extension is used in the Community Maps Program, visit the Community Maps Program Resource Center help documentation. For more information regarding the Community Maps Program, send an e-mail to communitymaps@esri.com.

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Understanding Statistical Data for Mapping Purposes

By Aileen Buckley, Esri

Many maps portray statistical or numerical data. If the map is effectively executed, you will intuitively and correctly understand the statistic mapped. Judging the effectiveness of a statistical map is easier if you understand the data being mapped and the method used to map it. This article explores issues related to mapping statistical data.

Qualitative versus Quantitative

Fundamentally, maps display only two types of data: qualitative and quantitative. Qualitative data differentiates between various types of things. Quantitative data communicates a message of magnitude.

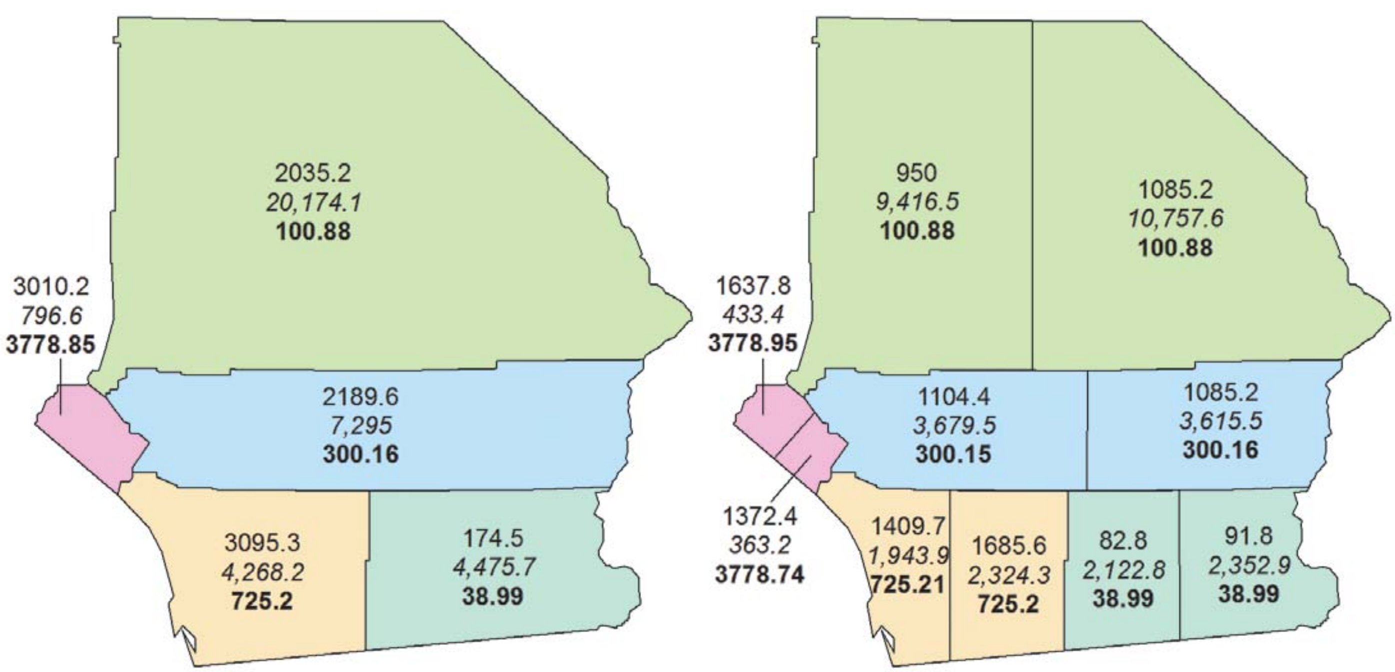
While either type of data can be expressed in a map using points, lines, polygons, and raster cells, the methods for mapping these two types of data are somewhat different. The categorical differences in qualitative data can be shown with symbols that vary by color hue (e.g., red, green, blue) and shape (e.g., circles, squares, triangles). Quantitative data can also be effectively portrayed using symbol variations such as orientation and pattern spacing, but hue, shape, lightness, and size are most often used because they are the most easily and correctly understood symbols.

A number of mapping methods have been developed that combine various map features and symbols. Choropleth mapping uses lightness to symbolize polygons. Proportional symbol maps display results as points that vary in size based on their associated values.

Because most statistical data is

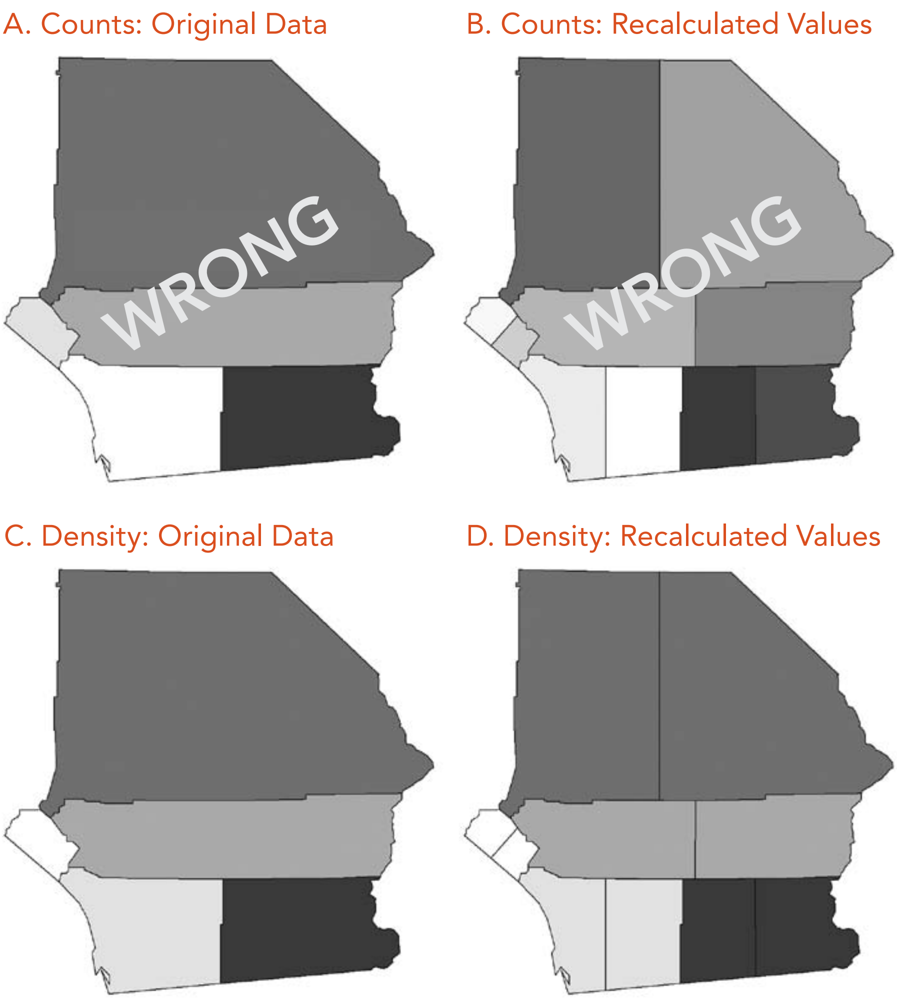
A. Original Data

B. Recalculated Values



Number of People (In Thousands)
Area (Square Miles)
Denisity (Number of People/Area)

↑ Figure 1A shows statistics for the number of persons, area, and density (people/area) for five enumeration units. Figure 1B shows the units arbitrarily divided into 10 new units.



↑ Figure 2: It is correct to use the chloropleth method to map densities but not counts.

quantitative in nature, this article focuses on mapping quantitative data. However, to appropriately map quantitative data, you must understand it. Not all methods work equally well for all quantitative data.

Demographic data provides an example. It shows the statistical characteristics of a population and is one of the most common types of statistical data shown on maps. Demographic data, which can include data for race, gender, age, employment status, and other factors, is tabulated over enumeration units such as counties, census tracts, ZIP Code areas, or school districts. The tabulations include the count of features, such as persons, households, housing units, or students, within those units. They can also include characteristics that describe those features, such as age, race, and income to describe people or age and type of housing unit.

Counts and characteristics can be used to derive measures that express either summarizations (e.g., mean, median) or relationships (e.g., densities, proportions). Tabulations and derived values for enumeration units are assumed to be uniform across the area and change at unit boundaries (i.e., they do not blend from one unit into another).

Landscape indicators for watersheds or subwatersheds and tax values in cadastral parcels are two examples of data collected for the unit as a whole that are assumed to be distributed uniformly across the unit and change at unit boundaries. In addition to determining whether the data being evaluated has these characteristics, there is another thing you need to know before mapping it.

Spatially Extensive versus Spatially Intensive Data

You must also consider whether the statistic being mapped depends on the size of the unit. Counts or totals and measures, such as area and perimeter, are summary statistics for the unit and are only true when they represent the unit as a whole. These statistics are said to be spatially extensive. The statistic is the sum of the properties of elements that make up the unit. For example, totals are the sum of the items counted in the unit. Perimeter is the sum of the length of line segments that make up the boundary of the unit. If you change the size of the unit, these statistics will change.

In contrast, values such as population density or cancer rates can describe any part of the unit (if the unit is assumed to be homogeneous). These statistics are *spatially intensive* and do not depend on the size of the unit. If you divide the unit, the value will stay the same. However, values for spatially extensive data cannot stay the same.

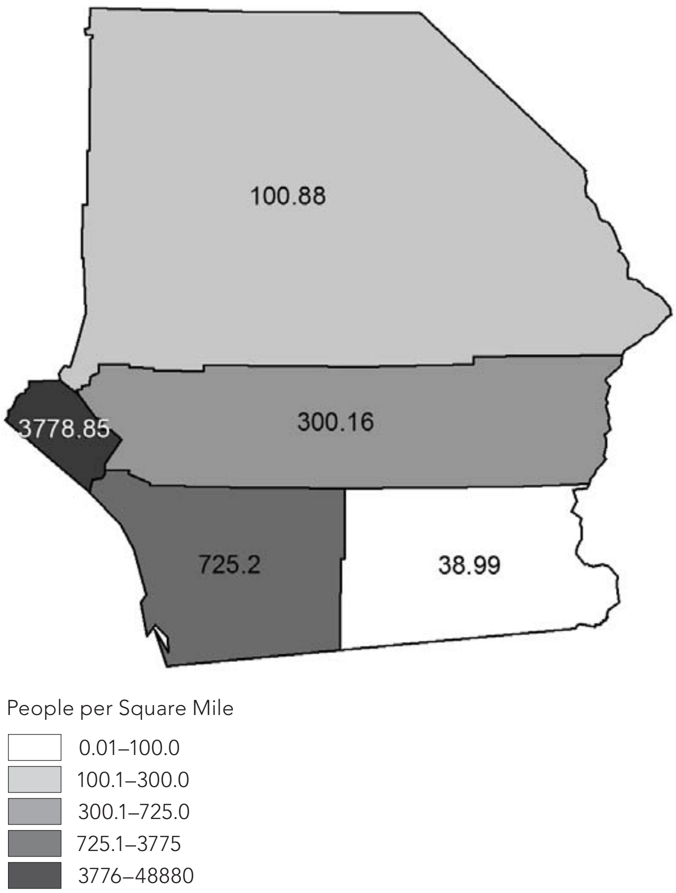
Spatially intensive data can be derived from spatially extensive data. For example, dividing counts by area yields density or dividing the count for one unit by the sum of counts for all units yields a proportion.

To understand this better, look at Figure 1. Data for the five enumeration units shows the number of people, area, and population density for each unit. Recalculating the values based on an arbitrary division of the original units reveals that spatially intensive measures, such as density, are not dependent on the size of the area, whereas spatially extensive variables, such as area or count, are spatially dependent.

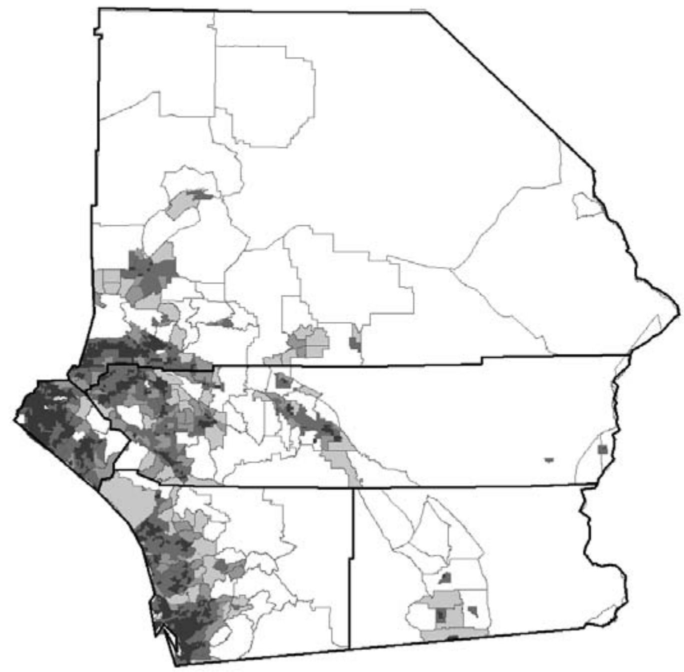
You can recalculate all the statistics if you assume the original counts to be uniform within the units, one of the assumptions of demographic data discussed earlier. The area can easily be recalculated, as can the percentage of the old area that the new area comprises (new area/old area). To calculate the new count, the old count is multiplied by the percentage of area for the new unit, resulting in a new value. This new value will only be correct if it is assumed that the number of people is evenly distributed within the unit. However, recomputing the density gives the same value as before, because the count changes in direct proportion to the area.

The maps in Figure 2 show the data mapped using the choropleth method. When counts are symbolized using lightness (noting that darker is always →

A. Counties: Population Density



B. Census Tracts: Population Density



↑ Figure 3: Mapping the population density for census tracts (B) reveals that the people are concentrated in the southwest—a fact obscured by the population density by county (A).

interpreted as more), the map of recalculated values varies greatly from the map of original values.

This violates the assumption that the values in enumeration units are uniform across the area. However, when density is mapped, the distributions appear exactly the same. Arbitrarily dividing the units does illustrate the properties of spatially intensive and extensive data, but it is not something you would probably ever need or want to do.

Let's look at the actual data. The data is not evenly distributed within the unit, as is the case with most areal data. The original units (shown in Figure 3) relate to counties and are further subdivided into census tracts. Mapping population density for these tracts reveals that for the entire area, the population is concentrated in the southwest. However, mapping population by county masks this variation in distribution.

There is also another problem with mapping counts or totals and other spatially extensive data within areas using the choropleth method. Distributions that are uniform will be masked. The maps in Figure 4A, 4B, and 4C show data mapped first as a uniform distribution, then as two choropleth maps that display feature counts and feature density. The count ranges widely by area, causing a range of lightnesses on the map in Figure 4B. Although the density is the same for all areas, this variation gives a false sense of the way the features are distributed within the areas. In contrast, the map in Figure 3C has the same density for each unit. The lack of variation in lightness between units gives the correct impression of feature distribution.

Figures 2 to 4 demonstrate a very important caveat: **counts or totals and other spatially extensive data should never be symbolized using the choropleth mapping method.**

Why?

Because this method does not accurately represent the nature of the data. Mapping spatially extensive data using a choropleth method masks the concentration of features within the areas because it assumes the distribution is uniform as shown by the maps in Figure 2. The choropleth method also masks distributions that are uniform, as shown by the maps in Figure 4. Different units on the map cannot be compared because no consistent denominator has been used to provide a basis for comparison. Although this is just one example of the use of a mapping method that is not appropriate to the type of data, it is one that is grievous and all too common.

Normalizing or Standardizing the Data

Now that you understand the need to match the mapping method to the nature of the data, the next step is to learn how to work with the data so that it is in the correct form for the type of mapping method you are using.

To correct the problems caused by mapping counts using the choropleth method, you can convert the data to the correct type so it can be shown by lightness within areas. This is often necessary for data represented as points, lines, or rasters and with other mapping methods such as proportional circle.

Do this by normalizing or standardizing the data. These two terms, often used interchangeably, are slightly different. Normalizing the data scales all numerical values to a range from zero to one. Standardization transforms the data so that is has zero mean and unit variance. Both techniques have drawbacks. If the dataset has outliers, normalizing will scale the normal data to a very small interval. When using standardization, the assumption is that the data has been generated with a certain mean and standard deviation, although this may not be the case.

Methods to Derive Appropriate Measures

In mapping, cartographers often use the term *derived data* to refer to data that has been transformed through normalization or standardization so it can be compared in a meaningful way. Transformations commonly used in mapping include ratios or rates, proportions, percentages, and densities.

It is important to differentiate between spatially intensive and spatially extensive measures. Density is a spatially extensive measure. A proportion, generated by dividing the number of items in a unit by the total number of items, is spatially extensive because the number per unit has been divided by a constant (the total number of things). For derived values such as proportions, percentages and rates, the resulting numbers can only be true for the *entire* unit, not parts of it. For units of intrinsic importance (e.g., counties) mapping the proportion of the value allocated to each unit should not be mapped using the choropleth method. In such cases, it may be best to use graduated symbols.

Transformation	Operation
Ratios express the relation of one observation to another.	Ratio or rate = n_a/n_b
Proportions express the relation of a single observation to all observations.	Proportion = n_a/N
Percentages express the same thing as proportions but using values that range between 0 and 100.	Percentage = n_a/N * 100
Densities express the relationship of an observation to the size of a unit area.	Density = n_a/A

↑ Table 1: Commonly used mapping tranformations computed using the following operations, where *na* is the number of observations in one category, *nb* is the number of observations in another category, *N* is the total of all categories, and *A* is the area of the unit.

Figure 5 shows maps for some types of derived data. Figure 5A shows two of the statistics in the original data that were used in the calculations—the number of students and teachers in each unit. The area of each unit can be calculated using GIS. Using the formulas in Table 1, maps were created that show the density of teachers (5B), the percentage of teachers (5C), and the ratio of students to teachers (5D) for each unit. These very different maps would be used to answer very different questions.

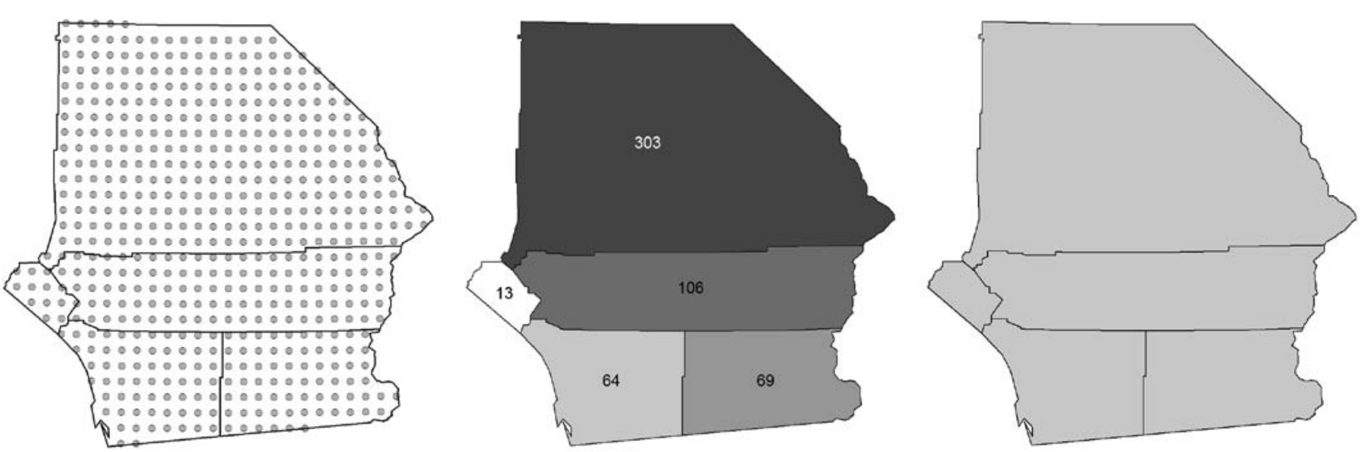
For example, knowing the density of teachers helps answer questions like, Where are a lot of teachers concentrated? This might be useful if you want to hold a meeting at a location that will minimize travel distance for most of the teachers attending. Knowing the percentage of teachers in each unit helps answer questions like, How many of all the teachers are allocated to each unit? This would be helpful for disbursing funds to teachers for school supplies.

One problem is that derived values can mask the nature of the data used in the calculations. For example, the map in Figure 3 can hide the fact that not all teachers →

A. Uniform Distribution

B. Choropleth Map of Counts

C. Choropleth Map of Density



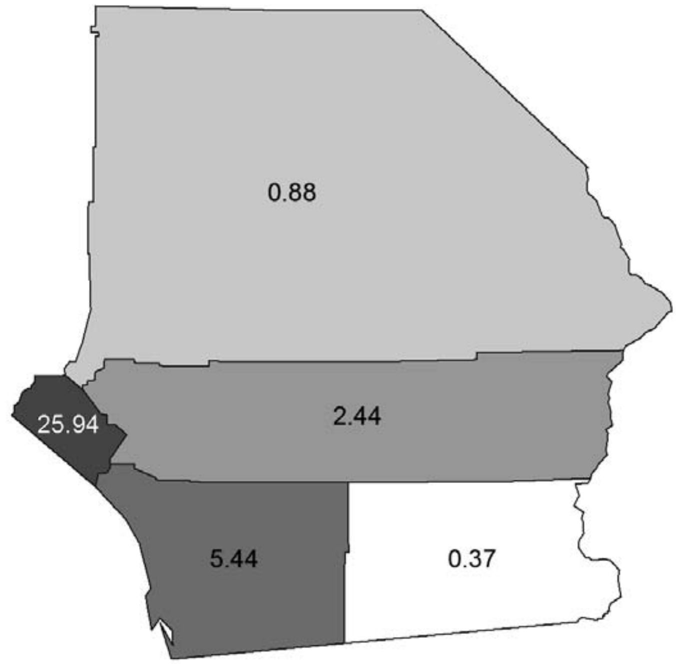
↑ Figure 4: Uniform distributions (A) are masked using the choropleth mapping method to show spatially extensive data, such as counts (B), rather than a statistic for spatially intensive data, such as density (C).

Number of People per Square Mile = 0.014

A. Original Data

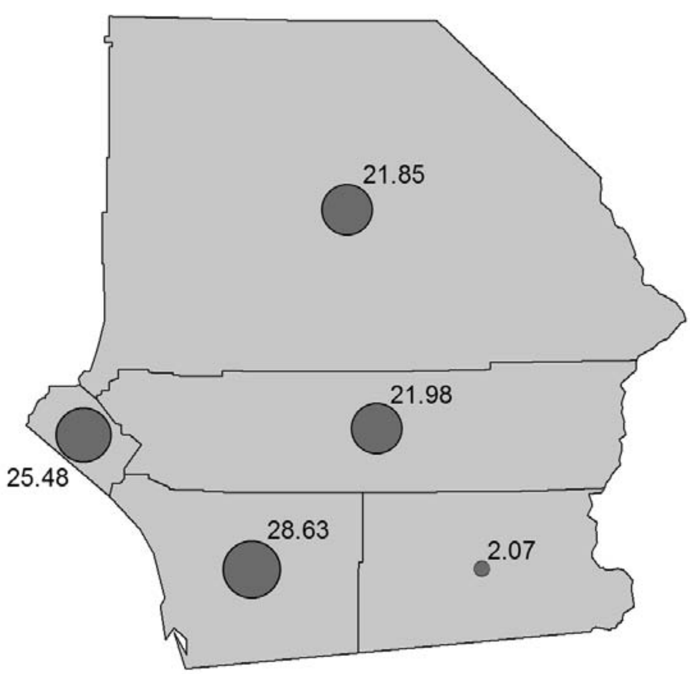
T: Number of Teachers
S: Number of Students

B. Density of Teachers



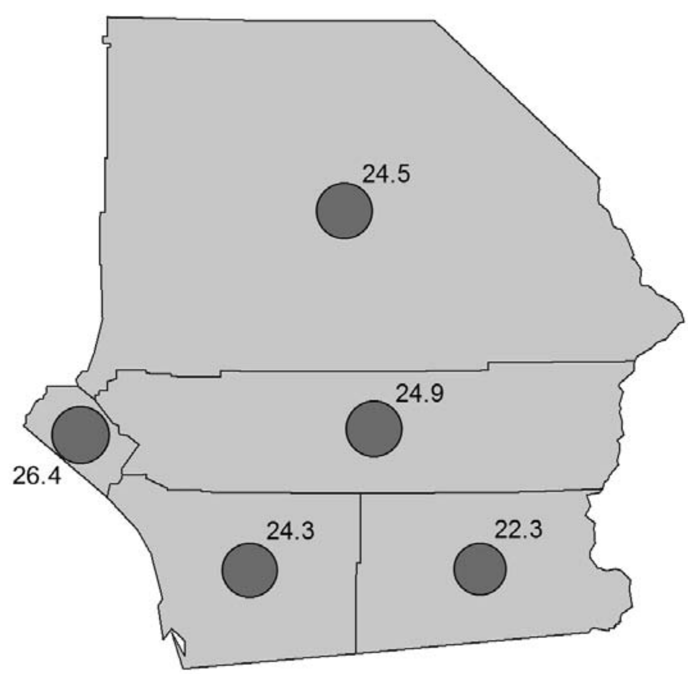
Number of Teachers/Area of Unit

C. Percentage of Teachers



(Number of Teachers/Total Number of Teachers (81,098)) * 100

D. Student to Teacher Ratio



Number of Students/Number of Teachers

↑ Figure 5: The original data includes counts of teachers and students. The area of the units was calculated with GIS. These spatially extensive measures can be converted to spatially intensive data that can be appropriate to be mapped using the choropleth method. Examples include densities (B), percentages (C), and ratios (D). (Data source: California Ed-Data website: www.ed-data.k12.ca.us) are employed full-time. Two half-time teachers may count as two teachers but together are only one full-time equivalent (FTE). This aspect of the data is not captured unless the number of FTEs is mapped rather than the number of teachers.

Also, quantities that are not comparable should not be used to calculate ratios. For example, you would not calculate (or map) the number of teachers per school unless all the schools were roughly equal in size. For this ratio to make sense, the schools have to be comparable.

Summary

Understanding more about the nature of the statistical data used for mapping purposes will help you better understand the methods that can be used to map it. Ultimately, the goal is to match appropriate data with the most effective method so that your map can be easily, quickly, and correctly interpreted by your readers.

About the Author

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

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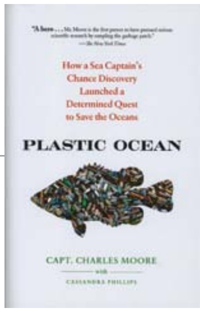
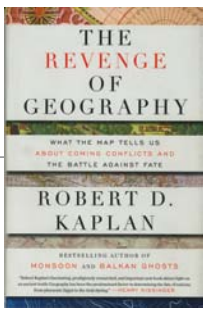
GIS Bookshelf



Plastic Ocean: How a Sea Captain's Chance Discovery Launched a Determined Quest to Save the Oceans

By Charles Moore with Cassandra Phillips

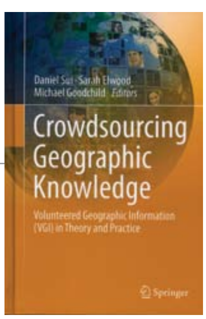
In 1997, Charles Moore was stunned by the quantities of plastic debris he found far out in the Pacific Ocean while sailing from Honolulu to California. The experience led him to found the Algalita Marine Research Foundation and become an internationally recognized pollution expert. He has worked tirelessly to save the oceans from this "plastic plague." His work has been the impetus for a global reassessment of the effects of plastics. This book recounts how plastics have come to pervade our lives, his findings on the threat they pose, and his research and activist work. Penguin Publishing, 2011, 368 pp., ISBN 978-1583334249



The Revenge of Geography: What the Map Tells Us about Coming Conflicts and the Battle against Fate

By Robert D. Kaplan

GIS practitioners, who in college had to fend off questions about why they were studying geography, may find this book particularly compelling. Using both trenchant analysis and historical anecdotes, it examines the importance of geography in shaping history. Kaplan discusses not only how pivotal geography has been but how its influence will likely shape human behavior in the future. A former member of Defense Policy Board under Secretary of Defense Robert Gates from 2009 to 2011, he is the author of 14 books on foreign affairs. Random House, 2012, 432 pp., ISBN-13: 978-1400069835



Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice

Edited by Daniel Sui, Sarah Elwood, and Michael Goodchild

Volunteered geographic information (VGI), a term coined by Michael Goodchild, one of this book's three editors, is transforming how we gather, use, and interact with geospatial information. The 20 articles in this book deal with both the theory and application of VGI. Some discuss the aspects of crowdsourcing that are novel and offer new strategies for dealing with the big problems faced by science and governments and the big problem of big data itself. Some discuss challenges that VGI shares with more mainstream GIS: incorporating time and 3D data. Metadata, which has always been important, now becomes invaluable in qualifying the data and integrating it with spatial data that has been gathered using more traditional methods. Springer, 2013, 396 pp., ISBN-13: 978-9400745872

Economic Development and GIS

Economic Development and GIS, a new book from Esri Press, demonstrates how the geographic approach is applied to analysis using Esri Business Analyst Desktop, Esri Business Analyst Online, and spatial statistics extensions for ArcGIS for Desktop. According to the book's authors, J. M. Pogodzinski and Richard M. Kos, "GIS is an essential tool in analysis because of its data management and data manipulation capabilities, analytic tools, potential for reporting and collaboration, and scalability."

The first section, which supplies background on GIS use in economic development, concludes with a chapter on best GIS practices for economic development analysis that provides an excellent working methodology. In addition to the familiar steps—ask, acquire, examine, analyze, and act—the chapter discussion includes caveats on examining the data being considered for inclusion in the analysis and evaluating the accuracy and validity of results. It also provides advice on documenting project methodology and presenting results effectively.

The approach outlined in the first section is applied to the analyses discussed in the second. Chapters focus on optimal site selection, determining enterprise and other zones, and addressing the mismatch between job location and housing and the costs of commuting. Each chapter emphasizes the importance of understanding the data being analyzed and challenges that may be inherent in it.

The third section addresses aspects of GIS of particular interest in economic development: geocoding, statistics and statistical methods, and the use of raster data and imagery.

Throughout the book, the authors stress the effective use of GIS tools and the application of automation through models when appropriate. Pogodzinski, a professor of economics at San Jose State University who also teaches at City College of San Francisco in California, has served as a consultant to the US Treasury Department on estimating tax revenues in developing countries and to the General Accountability Office (formerly the General Accounting Office) on the impact of federal programs on urban sprawl. Kos is a certified urban planner who specializes in the use of GIS to study land-use change, alternatives to suburban sprawl, and public transportation. He teaches graduate-level courses in community-directed urban planning and GIS at San Jose State University and GIS workshops at City College of San Francisco. Esri Press, 2012, 244 pp., ISBN-13: 978-1589482180

More Than Wishful Thinking

Applying GIS to make the world a better place

By Monica Pratt, *ArcUser* Editor

"If our hopes of building a better and safer world are to become more than wishful thinking, we will need the engagement of volunteers more than ever."

Kofi Annan, Secretary-General of the United Nations (1997 to 2006)

The need has never been greater nor the opportunities more diverse to use your GIS expertise to improve the world. Your commitment can vary from a mission lasting several months in a location halfway around the world to a project accomplished in a couple of hours working remotely from your home.

The phrase *volunteer GIS* often brings to mind disaster response and recovery work. GISCorps (giscorps.org) and MapAction (www.mapaction.org) are GIS-focused volunteer organizations that have received well-deserved recognition for their missions to the sites of natural and man-made catastrophes.

GISCorps, operated under the auspices of URISA, was created in 2003 to provide GIS services to underprivileged communities using the expertise of its volunteers, who participate in short-term missions. GISCorps partners with other agencies and provides a wide variety of services to host countries that can include technical training; developing web applications; and designing data models, data collection strategies, and GIS systems. In 2012, GISCorps received the Presidential Volunteer Service Award for its work.

Since 2002, MapAction has been using GIS to help aid agencies make evidence-based decisions that improve their response to disasters. This unique nongovernmental organization (NGO), based in the United Kingdom, can mobilize a team trained in humanitarian mapping and information management anywhere in the world in just hours. For its work, MapAction received the Esri Humanitarian Award in 2009. MapAction volunteers are recruited for specific roles and make a substantial commitment in time and availability.

Even if your personal and employment obligations preclude participation in long-term or distant missions, your GIS skills can be applied across a spectrum of worthy causes, some located in your own community. Many nonprofit, humanitarian, and conservation organizations use GIS and can use your help. Opportunities exist to work in well-established programs sponsored by these organizations at national, state, regional, or local levels. You can also find volunteer opportunities related to your current activities or interests. Perhaps your child's sports team could use some maps, or a local park needs assistance mapping hiking trails. Participating in GIS Day activities can be the starting point for volunteering your GIS skills.

Volunteering continues evolving with GIS technology. The expansion of GIS capabilities across web and mobile platforms has changed the nature of GIS volunteering missions. After Superstorm Sandy in November 2012, four remote-sensing specialists who are GISCorps members participated in a project that analyzed radar imagery in regions affected by the storm. This mission was conducted remotely over a two-week period.

Crowdsourcing has become a way to quickly focus the energy and expertise of GIS practitioners on a specific problem. In 2012, the US Agency for International Development (USAID) used crowdsourced volunteers to process 117,000 records containing international development data to make it accessible. Volunteers, who included members of Standby Task Force and GISCorps, cleaned up and geocoded the records in just 16 hours—44 hours earlier than had been projected.

Why Volunteer

There are many reasons to become a GIS volunteer. For any GIS practitioner, volunteering is an opportunity to meet new people, have new experiences, and feel the satisfaction of knowing your skills are changing the world for the better. You can combine your interest in GIS to further the work of organizations that resonate with your values.

Because volunteering is a way to gain experience and hone GIS skills, it has special appeal for students and recent graduates of GIS programs or job changers who are looking for a new position that might focus on or significantly use GIS. Volunteering is also a way for employed GIS professionals to enhance their resumés and fulfill professional service requirements for geographic information systems professional (GISP) certification. For GIS professionals who are retired or semiretired, volunteering is a way to keep active in the field and give something back.

Exploring Volunteering Opportunities

Some organizations, such as the Cornell University Cooperative Extension Dutchess County (CCEDC) (ccedutchess.org), have specific programs for GIS volunteers.

CCEDC volunteers have made significant contributions, according to Neil Curri, senior GIS resource educator at the CCEDC Environment & Energy Program GIS Lab. "These volunteers have helped their communities become more geospatially literate," said Curri. "They've also helped create an awareness of the CCEDC GIS Lab as a go-to resource for municipal leaders, watershed organizations, educators, and researchers throughout Dutchess County."

Although Ducks Unlimited (DU) (www.ducks.org)doesn't have a formal GIS volunteer program, some of its many volunteers have worked on GIS projects. DU has been using GIS and remote sensing to carry out its mission to conserve, restore, and manage wetlands and associated habitats for North American waterfowl. DU uses GIS to produce maps, graphics, and statistics that communicate its conservation activities to the public and support its fund-raising activities.

Land trusts are another type of conservation organization that is a natural fit for GIS. Located across the country, land trusts work to preserve sensitive natural areas, farmland, ranchland, water sources, cultural resources, and notable landmarks. These organizations often use GIS and depend on volunteers.

If improving local government is your passion and web GIS your area of expertise, and you want to commit a significant amount of time, consider volunteering for Code for America (codeforamerica.org). Applicants chosen for its fellowship program devote a year to public service helping cities leverage technology to become more efficient and engage their citizens.

If you enjoy teaching people about GIS, especially young people, there are many organizations and programs available. The National Geographic Society and Esri created the GeoMentor program (edcommunity.esri.com/geomentor/). Volunteers adopt a school, class, or club and support educators or club leaders in teaching geographic thinking to youth. Local historical societies, museums, and libraries have been adopting GIS as a framework for organizing assets and making them available online digitally. These organizations often work with schools to support teachers with curriculum resources and can use web GIS skills.

Sometimes a volunteer opportunity can be as simple as seeing a need and using your GIS skills to fill it. As a returning student at the University of North Florida in Jacksonville, Candace Tshirki initially used Esri Community Analyst to study the availability of fresh food in cities. However, she realized she could also use Esri Community Analyst to help her church better understand its congregation. After learning more about the neighborhoods surrounding the church, church leaders now create services that meet the needs of the community.

Finding the Right Fit

The key to a successful volunteering experience is matching your interests, commitment, and skill level to the opportunity. What causes are you already interested in? How far can you travel, and how much time (realistically) can you devote? When considering an opening with an established program, find out what its expectations are in terms of time and the amount of responsibility you would assume. Will you need additional or continuing training? Who will you be working with? The level of expertise required varies greatly from a very high level for some organizations, such as MapAction, to limited skills and a willingness to learn in local groups.

Tia Morita, a GISCorps volunteer who served with the Wide Availability Response Project (WARP) in the Caribbean carried out with MapAction in 2011, observed that "Volunteering is not easy, and certainly requires careful planning of one's time, but it is well worth it. GIS is a powerful tool and a unique skill set that only a few across nations have. It is incumbent upon us skilled GIS users, creators, and developers to put our unique trade to use to impart positive results for changing lives, policy, and decision making for the better."

Happily Ever After

The importance of long-term geospatial data storage

Editor's note: Punch cards, tape drives, ZIP drives: If you have been involved with computers for any substantial amount of time, these media formats represent stops along the march of technological progress. They also represent just one of the many challenges associated with long-term digital data storage. In addition to media formats that get left behind, file format obsolescence, operating system migration, device death, antiquated applications, and organization reorganization all threaten the long-term preservation of the digital datasets that can be invaluable for research and historical purposes. Geospatial digital datasets, which are typically large and often poorly documented, are a special case of this larger issue.

Esri writer Jim Baumann interviewed Stanford University's Dr. Julie Sweetkind-Singer about her work in preserving geospatial datasets. Sweetkind-Singer currently serves as both the assistant director of Geospatial, Cartographic and Scientific Data and Services and the head of the Branner Earth Sciences Library and Map Collections at the school. She is the former librarian for the David Rumsey Historical Map Collection at Cartography Associates and is recognized by the Library of Congress as a digital preservation pioneer.

Baumann: As a recognized authority, please discuss the primary considerations for archiving and preserving digital information over the long term.

Sweetkind-Singer: From a librarian's point of view, digital data is very different and much more difficult to preserve for extended periods of time than paper-based data. For example, a book on acid-free paper can be kept on a shelf in a cool, dark place for 100 years, and if it is well taken care of, one would expect it to remain in pretty good shape.

With digital information, you have to implement a process from the very beginning that will allow you to preserve it well into the future. This includes making sure that the data is well managed technically: that metadata exists to ensure someone in the future will understand what the data represents and how it has been stored and that legal documents are in place indicating how the data may be used in the future.

It's important for digital archivists to develop long-term preservation plans that include both technical and legal stipulations. Unless digital files are correctly preserved and documented, we run the risk of losing the information, which is then unavailable to future generations.

Baumann: From an educator's perspective, what are some of the key reasons to preserve geospatial data?

Sweetkind-Singer: For both educational and research purposes, it is critical that we preserve data for the long term. For example, the opportunity to trace the development of a region using historical maps is useful to researchers who are studying population growth or the change from an agriculture-based to an industry-based economy. A historian may want to know when the railroad first reached the study area, what effect the railroad played on it, what agricultural crops formerly grew there, in which direction the area began its expansion, when major roadways were built through it, and which cities they connected. You can analyze all this over time by studying geospatial data, but only if you have the content to do so. Preserving historic data and continually adding to that collection on a regular basis is a critical part of change detection research.

Baumann: How did the National Geospatial Digital Archive *[NGDA]* come about, and what role does it play in preserving geospatial data?

Sweetkind-Singer: The NGDA *[www.ngda.org]* is a collaborative research effort between Stanford University and the University of California at Santa Barbara, with funding from the Library of Congress to examine the issues surrounding the long-term preservation of geospatial data. The program funded by Library of Congress is called the National Digital Information Infrastructure and Preservation Program *[NDIIPP].*

One of the goals of the NGDA was to set up the structure for a preservation network and eventually add more partners covering a variety of regions around the United States including both libraries and state archives. Maintaining geospatial data in various locations is one important aspect for its long-term preservation in case of man-made or natural disaster. In addition, I think it's important to remember that many organizations may produce geospatial data but aren't involved in its collection or preservation. However, the mandate for libraries and government archives is to preserve valuable documents for the future.

Baumann: What procedures has the NGDA recommended to facilitate the long-term storage of geospatial data?

Sweetkind-Singer: You have to assume that both the software and hardware components that originally created the data will change in the future. Given that, it's important to have metadata for all geospatial data that is archived including details about the software that was used to create it and related white papers. We developed a registry to track information about formats because they will certainly change over time. This information was the basis of the Library of Congress' Geospatial Content section on its Sustainability of Digital Formats website *[www.digitalpreservation.gov/formats/content/gis.shtml].* Regarding the preservation of remotely sensed imagery, you need to know which sensors were used, when they were updated, and what software was used to interpret the data format.

Legal documents are another important part of the long-term data storage process. We drafted agreements with the participating NGDA members about collection development policies specifying what each institution is going to collect and curate. There is another contract that brokers the relationship between copyrighted or licensed data and the university that wants to archive it. Data providers want their data preserved, but as a university, we have to have assurances that our faculty and students can use that data for research and educational purposes. So we have contracts that specify the acceptable use of the archived data. I think long-term data preservation is a matter of developing a plan that includes technical solutions from the IT department, as well as recommendations from librarians, archivists, and lawyers, to make sure geospatial data is properly and legally preserved for the future.

Baumann: Please describe some of the key datasets that you have collected for the Stanford University archive.

Sweetkind-Singer: One of the first datasets we archived was the David Rumsey digital map collection *[www.davidrumsey.com]*. David Rumsey is a map collector in San Francisco who has spent many years building a fine collection of maps, atlases, and books detailing the growth of cartography in the United States during the eighteenth and nineteenth centuries. About 10 years ago, he decided to enhance his collection by scanning it and making those images available to the general public. Today, he has more than 29,000 items in the digital collection. David uses the digital maps in a variety of ways that are impossible with the printed versions. However, he doesn't have a robust and secure way to store those digital images for the future. Working together, we were able to provide secure, long-term preservation of the imagery as well as the accompanying metadata.

We also worked with the CSIL *[California Spatial Information Library]*, a government agency tasked with maintaining geospatial data for the state of California. CSIL collects transportation data, Landsat imagery, SPOT imagery, and other content. CSIL is the primary source of California statewide data. In addition, we have downloaded data from the USGS *[US Geological Survey]* Seamless Data Warehouse. In conversations with John Faundeen, the archivist at the USGS EROS *[Earth Resources Observation and Science]* Data Center, he was happy to hear that we were downloading high-resolution orthoimagery of the San Francisco Bay Area from the site and archiving it as part of our collection process.

Baumann: As Stanford continues to build its spatial data archives, what do you hope to add to your collection in the near future?

Sweetkind-Singer: We have collected a fair amount of high-resolution orthoimagery for the Bay Area and recently added the elevation data that goes along with it so that researchers can do three-dimensional modeling using the imagery sitting on top of the elevation data. I would also like to collect more datasets for the California National Parks and the state's coastline data. Important content for our collection is local data from places like the Hopkins Marine Station, which is Stanford's marine biology station in Monterey *[California]*. *[At Hopkins,]* they've collected a large amount of heterogeneous data types: imagery, fish populations, transect information, and weather data. Our future data collection activities range from very specific content, such as the Hopkins Marine Station data, to very broad layers like the National Elevation Dataset for the United States.

Baumann: Are standard procedures for the preservation of geospatial data widely implemented in libraries and government archives today?

Sweetkind-Singer: I think that the long-term preservation of data is something that is just emerging as an issue for libraries. While many libraries and state archives are aware of the problem, they don't really know how to tackle it yet. It may seem at first like an overwhelming task, but breaking the procedure down into its component parts will make the process achievable.

One important effort that has emerged over the past few years, also funded by NDIIPP, is the Geospatial Data Preservation Resource Center *[www.geopreservation.org]*. This site has been designed specifically to bring together "freely available web-based resources about the preservation of geospatial information." It also gives practitioners a place to start, discover best practices, and get their questions answered.

As we go forward, we will figure out sustainable methods to manage, archive, preserve, and create access to digital information, but relatively speaking, we're in the early days. It's a process that we'll develop and refine as we continue to work with this type of content. Long-term data archiving is a very interesting and challenging area for libraries because we are building the digital collections of the future. Libraries have an important role to play in making sure that we provide proper stewardship and preservation of geospatial data.

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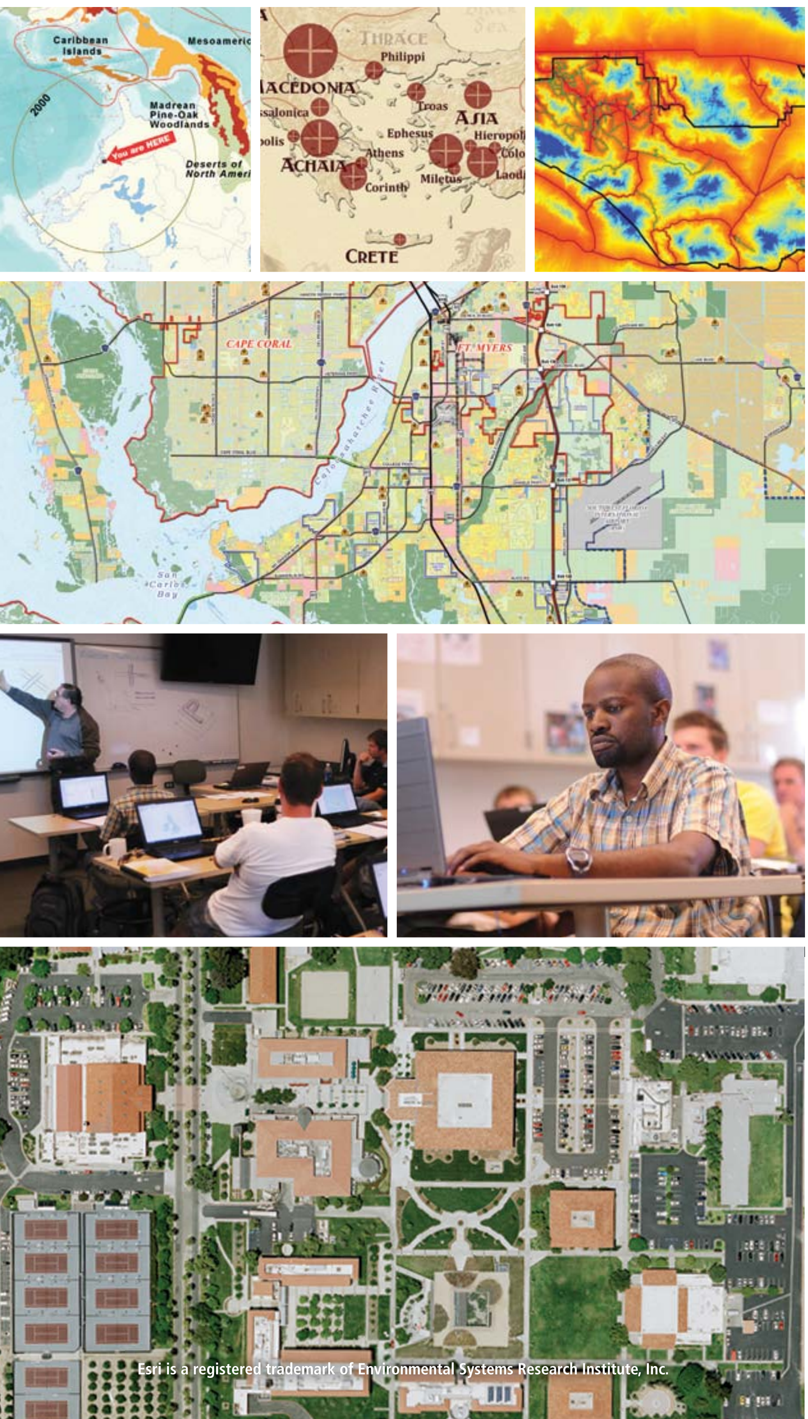

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Spatial Analysis Brings Focus to Mars Mission

By Matthew DeMeritt, Esri Writer

The historic and picture-perfect landing of Mars Science Laboratory (MSL) on the Red Planet in 2012 captivated the global community.

More grand in scope than any previous Mars lander or rover mission, MSL is equipped with an array of sophisticated sensors and optics to investigate the planet and uncover its history. Mission planners, preparing for the gargantuan task of collecting Martian data for two years, needed to know about the Martian surface down to the finest possible detail. The National Aeronautics and Space Administration (NASA) and Jet Propulsion Laboratory (JPL) performed spatial analysis on data gathered from prior Mars missions. GIS was critical in landing site selection and navigation planning for *Curiosity*, the car-sized rover that is carrying out the MSL mission.

MSL is the latest in NASA's multimission project Mars Exploration Program (MEP). Each MEP mission informs and refines the plans made for subsequent expeditions. The most critical aspect of MEP is the collection of Martian survey imagery by remote-sensing orbiters that have been circling the planet for years. Launched in 1996 and arriving the following year, Mars Global Surveyor (MGS) provided scientists with critical elevation data on the topography of Mars collected with its Mars Orbiter Laser Altimeter (MOLA).

In 2005, NASA launched Mars Reconnaissance Orbiter, which collected the highest-resolution images of the Red Planet's surface ever acquired. The High Resolution Image Science Experiment (HiRISE), its powerful camera, views the Martian surface in stunning detail. Imagery and data from HiRISE and MOLA and the European Space Agency's Mars Express orbiter vastly improved the landing site selection process over previous rover missions that relied on grainy coverage taken from 1970s orbiters and flybys.

Two factors have traditionally determined where NASA lands craft on Mars: the scientific richness of an area and the engineering constraints of landing a craft on the planet's hazardous and boulder-strewn terrain. The locations in the initial list of possible landing sites must also be able to sustain MSL long enough for the onboard instruments to complete their investigations.

For mission planners, that process of site selection began with a global basemap of Mars constructed with various layers of geographic data derived from MGS instruments like MOLA and the Thermal Emission Spectrometer (TES). Areas located at latitudes greater than 30 degrees north and south—more than one-third of the planet—were immediately eliminated from landing site analysis because of the extremely low temperatures that dominate those regions. Deep cold would threaten the operation and stability of the craft and risk bringing the mission to a halt. The landing site chosen also had to be located equatorially to ensure stable communication with MSL during arrival.

MSL's main mission objective is to provide a more thorough understanding of Mars chronology, geological dynamism, and life-harboring potential. To do this, MSL requires a landing location that is geologically rich but that also contains relatively flat terrain so that the rover can land safely and navigate freely. The MEP landing site selection team produced a list of 33 of the most feasible landing areas. Each site contained a geological formation that had undergone obvious dramatic change and, thus, was more likely to yield information about the planet's history through the exposure of previously buried layers. From that list, four areas were chosen.

This raw-color (unprocessed) panorama is a mosaic of images taken by MSL's mast camera while the rover was working at a site called Rocknest in October and November 2012.

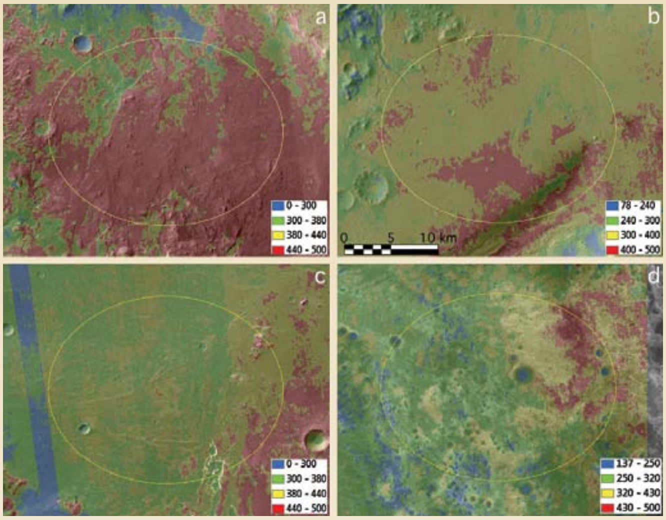
Each of the final four landing sites has the potential to answer many questions regarding the possibility of human habitation and the existence of an ancient water system on Mars. To select an optimal final landing site, planners evaluated the traversibility of the areas of scientific interest within these four sites.

Small-scale HiRISE imagery with derived rock density and abundant data was essential in determining if these sites were safe for landing as well as accessible so that MSL could conduct fieldwork. Landing ellipses were drawn in these areas to delineate where the rover could roam. Teams used maps constructed from HiRISE imagery and geographic data on four Martian locations: Holden Crater, Gale Crater, Eberswalde Crater, and Mawrth Vallis. This organized the process used when evaluating each area for scientific significance and navigability. Gale Crater was finally chosen as the study area because it best met both the science and safety requirements.

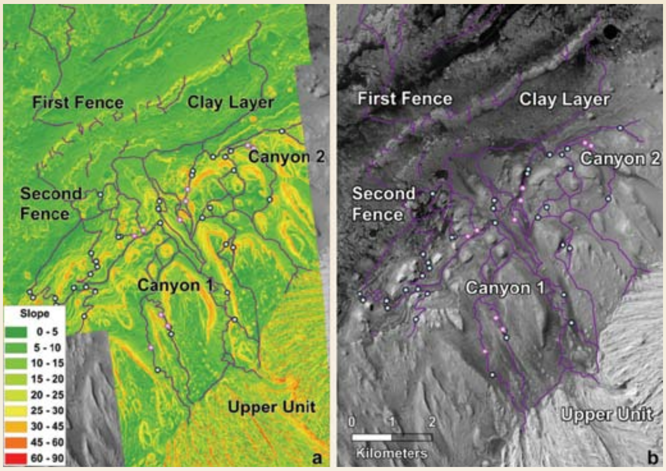
Martian imagery and other remote-sensing datasets were compiled and processed by the MSL engineering team. The datasets included digital terrain models (DTMs), delta radii files (elevation models measured from the center of mass of the planet), orthophotos, and maps displaying rock densities and slopes.

All maps and models were georeferenced to place them accurately on the surface of Mars using ArcGIS. Once all the images for each landing site were rectified, GIS staff on the engineering team mosaicked the tiles together to create complete maps of each site. MSL engineers used the finished maps for conducting landing simulations and preliminary analysis to understand the traversability and safety of the terrain.

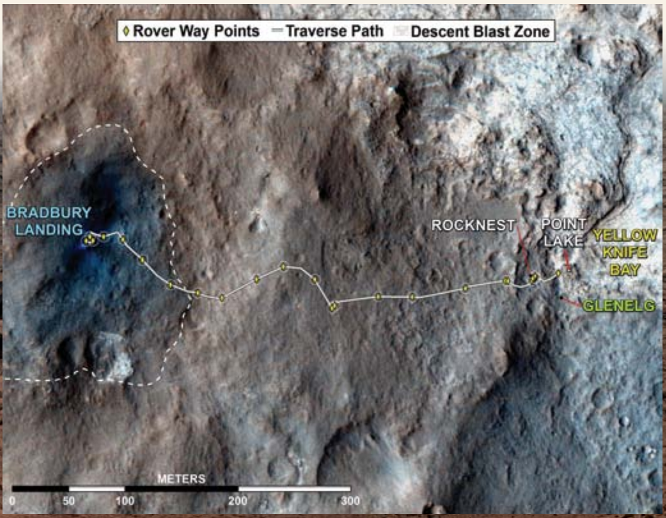
Analyzing existing remote-sensing and imagery data within a geospatial framework is crucial for terrestrial planetary mission planning. Information from Mars Global Surveyor, Mars Reconnaissance Orbiter, and Mars Express provided NASA and JPL scientists with unprecedented detail of the Martian surface and comprised the foundational information for the creation of MSL mission maps. Expeditions of such inherent complexity require a platform for conducting comparative analysis and processing raw data returned from MEP missions. GIS brought clarity and focus to the evaluation process, making it easier to narrow sites to those areas within which MSL could conduct its work.



↑ Potential landing sites JPL evaluated during the mission planning stage: (a) Eberswalde, (b) Gale, (c) Holden, and (d) Mawrth



↑ One-meter slope map (a) and HiRISE image (b) showing access to the Eberswalde delta



↑ Gale crater traverse path as of Dec. 6, 2012

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Who is GIS?

Jesusa Romero is.

Romero, a GIS analyst for Riverside County, California, intended to study astrobiology in college. "But my dad said, 'Why would you focus on space when you can focus on our problems here on earth?' That changed my whole outlook. I started looking for that human component. I took a GIS class and thought, I think this is it."

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