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Ensuring a Better Future 36

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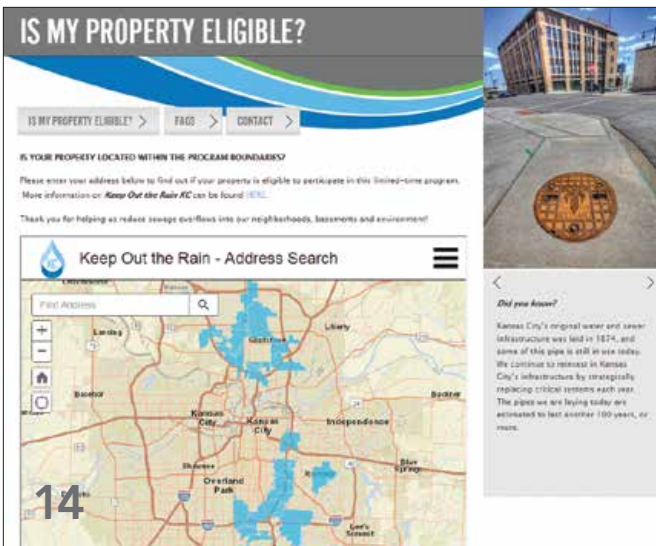### Empowering GIS
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Contents

Focus

8

Feature

14

Special Section

36

"Your life is a result of your choices. If you don't like your life, it's time to make some better choices."

This advice could be scaled from the personal to the societal. The decisions we make (or choose not to make) today will have consequences for the livability of our communities, the efficiency of our government, and the prosperity of our economy.

GIS provides the tools, data, and a geographic context for understanding and managing our world on scales ranging from the parcel to the planet. For decades, GIS has been a system of record. Deployed on servers and desktops, it integrates data in a spatial framework that reveals relationships and patterns. Its application across government, business, and other organizations has uncovered relationships, improved processes, and enhanced decision-making.

With the development of Web GIS, it has become a system of engagement, connecting people to geoenabled information that can be more easily understood and widely shared. ArcGIS Online, Esri Story Maps apps, and ArcGIS Open Data share geospatial information not only with the public but also within organizations. Public sharing fosters government transparency and innovation in business. Internal sharing has eliminated redundancy caused by organizational silos and improved efficiencies.

With the integration of powerful analytic tools and the ability to work with big data in real time, GIS has now become a system of insight. It can apply sophisticated domain-specific methodologies and take advantage of massive amounts of sensor data being gathered to produce information-driven decisions.

The Special Section in this issue highlights the development of these capabilities as they have been incorporated into Esri's Green Infrastructure initiative. Using the National Intact Habitat Cores database and the filtering and scoring tools available online, multiple scenarios can be modeled to understand future impacts of policy decisions made today. Using the insight gained from GIS, we can make better choices that lead to a future arrived at by design, not by default.

Monica Pratt

Monica Pratt
ArcUser Editor

editor's page

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Departments

Improved Item Details Pages
# Enhance Workflows

With the June release of ArcGIS Online, Item Details pages have been redesigned for easy access to the information and options you use most to improve your workflow, whether you are exploring an item or publishing data in ArcGIS Online.

Items are all the things you have stored on ArcGIS Online—your web maps, apps, layers, and data files. Item Details pages provide the description information about each of these items and options that let you configure or use the item.

The redesign of Item Details pages goes beyond the appearance of information. Information has been organized visually using type, color, and placement on the page. Opening a layer in the map viewer, creating a presentation, and sharing an item—the most common actions—are grouped in the upper right-hand corner.

Information is organized in tabbed views, which provide more information and options without overwhelming you. It is easier to find what you need. The tabs shown for an item depend on what the item is, your privileges, whether you are an administrator, and whether you are the owner of the item. The basic tabs are Overview, Data, and Visualization. The Settings and Usage tabs are available to owners and administrators.

The most important information is on the Overview tab. If you are the owner, this new format gives a much more efficient method of interacting with your items. Quick inline editing of an item summary and description makes it easier to keep the information contained in an Item Details page up to date and accurate. Layers can be opened or exported, time settings changed, or attachments enabled and the service URL accessed. You can view, sort, and reply to comments. When a new comment is posted to an item you own,
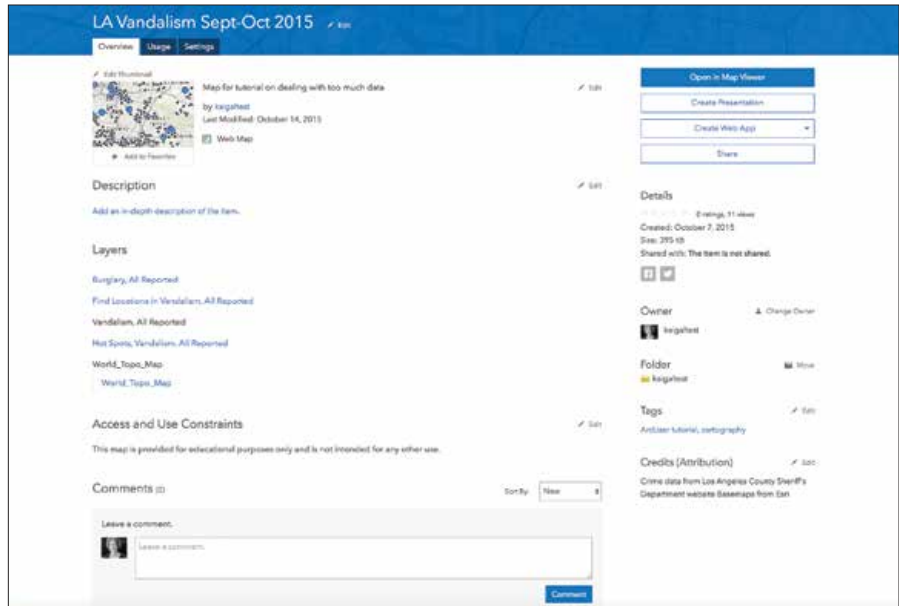
↑ The most important information is found on the Overview tab. It presents the most common tasks grouped in the upper right-hand side.

↓ The Data tab lets you edit and sort attribute data.

you will receive an alerting email. If you reply to a comment, the person commenting will receive an email.

Viewing and working with attribute data is a core part of Item Details on the Data tab. If you have editing privileges, you can view, edit, and sort attribute data easily without reloading the page. To update an attribute, just double-click a cell to edit the data in-line and your changes will be saved automatically. The table also gives you a new, integrated way to view and navigate through related records and attachments.

The new Visualization tab lets you not only see the data mapped but also change a layer's default styles using smart mapping capabilities, update pop-ups, and create labels from the Item Details pages. You can save these changes in a new layer. This new functionality lets you get more done more quickly.

The Usage tab, available when you are the owner or administrator of an item, will let you know how your content is being used and viewed. Its dashboard view lets you see how much and when the item is used. You can filter for specific time periods and get averages, totals, and a time-series view of what's happening with the item.

The new Settings tab puts all configurable settings for an item in one place. Deletion protection, setting the default extent, enabling editing, optimizing layer drawing, enabling data export, and enabling syncing for disconnected editing can all be set from this tab.

This redesign is just a beginning. Like the rest of ArcGIS, the Item Details pages will continue to be improved with feedback from you at arcgisonline_feedback@esri.com or ideas.arcgis.com.
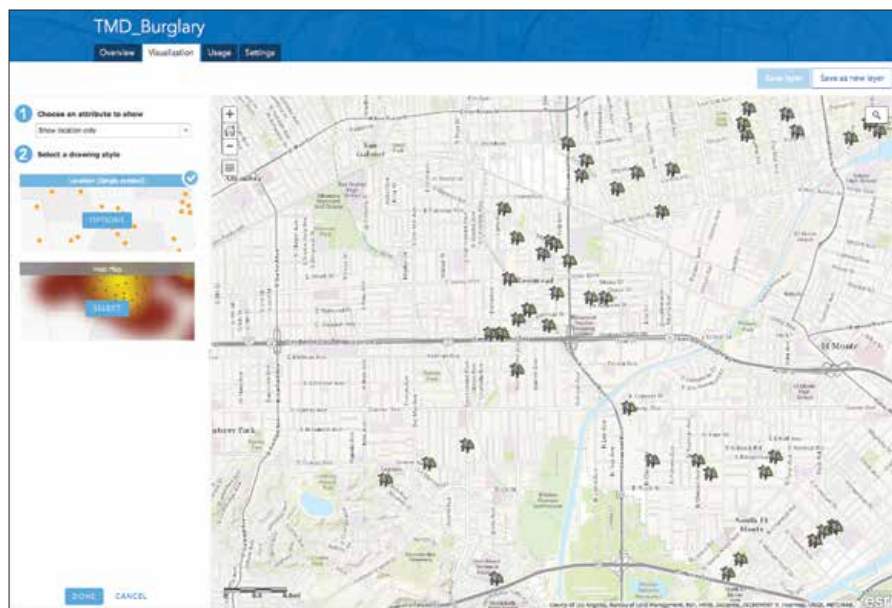
↑ The new Visualization tab lets you not only see the data mapped but also change a layer's default styles using smart mapping capabilities, update pop-ups, and create labels from the Item Details page.

More Flexible Licensing Options for ArcGIS Pro

Starting in 2016, there are three options for licensing ArcGIS Pro
- Named User license
- Concurrent Use license
- Single Use license

All licenses for ArcGIS Pro are provisioned as Named User licenses by default. With a Named User license, a user can sign in with ArcGIS account credentials to ArcGIS Online or Portal for ArcGIS on any machine that has ArcGIS Pro installed. ArcGIS Pro will run at the level and with the extensions specified by the organization administrator. With a Named User license, a user can run ArcGIS Pro on up to three machines simultaneously.

To use a type of licensing other than the default, convert a Named User license to Concurrent Use or Single Use licenses in My Esri. Concurrent Use licensing with ArcGIS Pro uses the same management and authorization steps as ArcMap.

With a Concurrent Use license, the machine on which ArcGIS Pro is installed is pointed to a License Manager Server for license authorization from a shared pool of licenses. Any license level and extension can be chosen if available from the pool licenses. Concurrent Use licenses allow more users to have ArcGIS Pro installed than the total number of licenses, and simultaneous use of ArcGIS Pro is limited by the total number of available licenses in the License Manager Server.

Single Use licenses are authorized on a single machine by one or more unique authorization numbers obtained from My Esri. Once authorized, anyone with access to that machine can use ArcGIS Pro on or off the network.

For more information, see the online help topic "Licensing ArcGIS Pro."

Crowdsourced "Open for Business" App Supports Flooding Response

By Monica Pratt, *ArcUser* Editor

Torrential rains in Louisiana during August 2016 caused historic flooding that affected 22 parishes. As part of response efforts, a web mapping app was implemented for the first time that combined crowdsourced data with official data in a way that could be immediately ingested by systems used by responding agencies at the local, state, and federal levels.

The Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) worked with the Louisiana Business Emergency Operations Center (LABEOC) and Esri to quickly stand up a web mapping app for updating and sharing the current status of businesses in flooded areas. The LABEOC Report Businesses Open or Closed app was developed by configuring the Crowdsource Polling app available from and

↑ Extraordinarily heavy rains in Louisiana during August 2016 caused devastating flooding that affected 22 parishes. Photo Credit: US Department of Agriculture/Petty Officer 1st Class Melissa Leake of the Coast Guard on Flickr

hosted on ArcGIS Online. It was linked to the LABEOC website so businesses, members of the public, and people involved in response efforts could learn or update the status of restaurants, grocery stores, pharmacies, and other businesses.

This information was valuable in helping meet the immediate needs of the public for food, supplies, and services. The app also provided current information that helped GOHSEP determine where to locate points of distribution (PODS) so it could place supplies in neighborhoods where they were needed without competing with businesses that remained open. This supported efforts to return businesses to normal operations and restore the local economy. GOHSEP also used the app to obtain a current overview of businesses that were open and could provide supplies, equipment, or services needed for disaster response.

Providing access to the app from the LABEOC website made sense. LABEOC is a web-based information sharing platform (www.labeoc.org) and an operations center that assists the GOHSEP in its response to regional disasters and subsequent recovery efforts. It is managed by the Informatics Research Institute of the University of Louisiana at Lafayette.

Since its creation in 2010, LABEOC has been activated during every federally declared disaster including the Deepwater Horizon oil spill and, more recently, the floods in northern Louisiana that occurred in March 2016. In addition to providing situational awareness

↓ LABEOC Report Businesses Open or Closed app lets businesses, members of the public, and people involved in response efforts update the status of restaurants, grocery stores, and pharmacies in flooded areas.
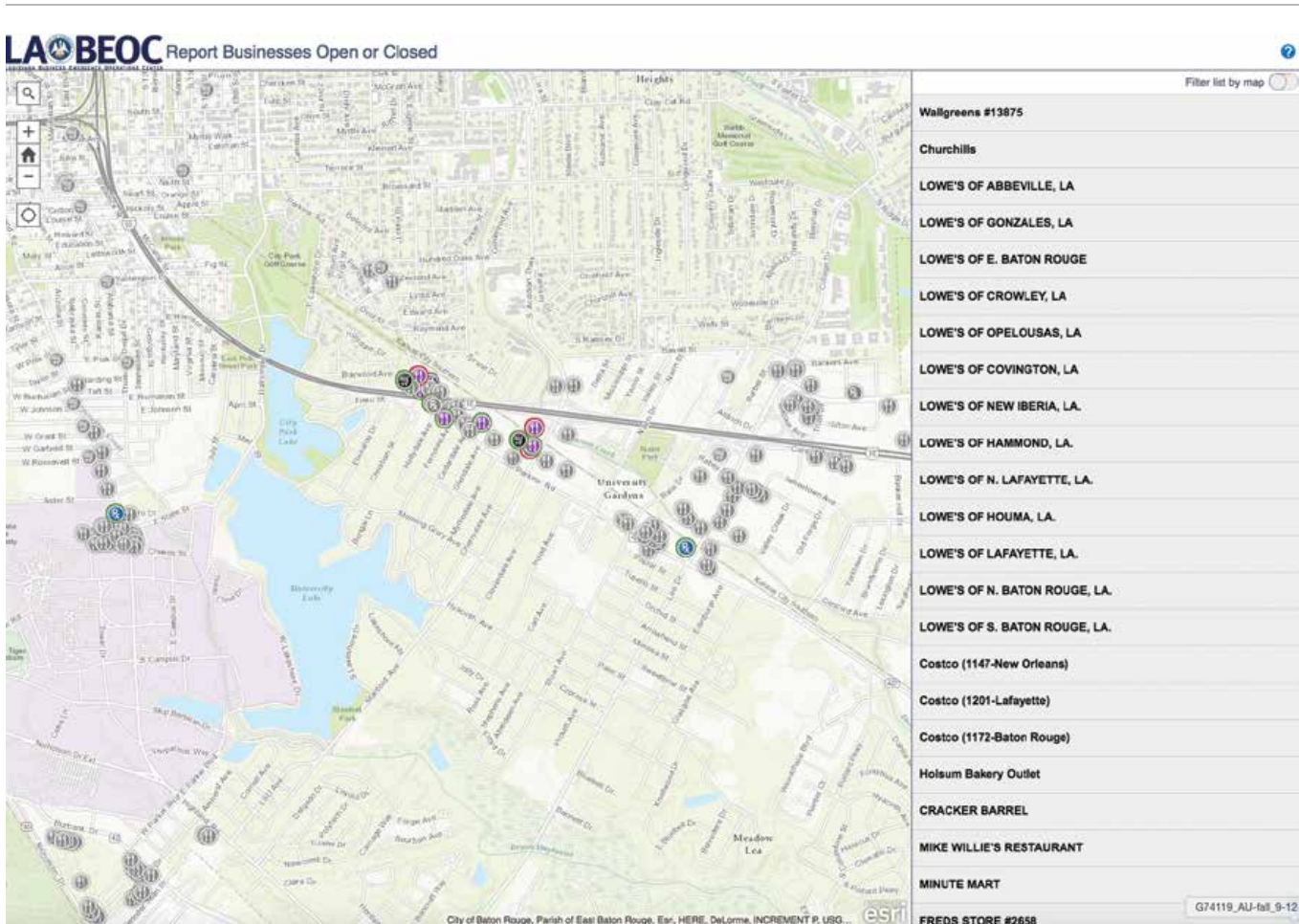
during a disaster and acting as liaison between GOHSEP and private sector entities in Louisiana, LABEOC is a resource management portal for member businesses.

LABEOC realized that coordinating information for all area businesses during the emergency required a public-facing app that could be accessed and updated by anyone, not just its members. By using a crowdsourced map, the most current information could be captured and shared with the public and GOHSEP.

Esri became involved in implementing the app when Louisiana made a request to the Esri Disaster Response Program to leverage Esri technology to crowdsource status information on businesses. An Esri staff member already deployed to assist in the Louisiana State Police Emergency Operations Center (EOC) coordinated efforts by Esri staff in Redlands, California. Andy Venuto at the Louisiana Division of Administration supplied data on area businesses in the affected area.

The obvious choice to meet the requirements outlined for the app was the Crowdsource Polling configurable web app, an ArcGIS for Local Government solution. This app is available at no charge with an ArcGIS Online organization subscription. Built on the ArcGIS API for JavaScript, it is responsively designed so that it can be used on tablets and desktop computers. Although LABEOC has hosted the Report Businesses Open or Closed app on ArcGIS Online, the app can be hosted on Portal for ArcGIS or downloaded and made available from an on-premises server. In addition to the tremendous time savings realized by simply configuring an existing template, the app was immediately compatible with the ArcGIS platform already used by both the state EOC and LABEOC.

The application presents a map that lets users record whether a business is open or closed and add comments about its status. The business to be updated can be selected from the map or from a list of businesses. Once the initial proof-of-concept iteration of

↑ As the public and businesses become more aware of its use as a communication channel in an emergency, LABEOC Report Businesses Open or Closed app will only become more effective in future events. Photo Credit: US Department of Agriculture/Petty Officer 1st Class Melissa Leake of the Coast Guard on Flickr

the application was accepted, it was fine-tuned with feedback from LABEOC. When chain stores found out about the application, they wanted a way to quickly update information about their stores, so another app was immediately developed by Esri staff to bulk upload updates. An additional app was created to let LABEOC staff and others add businesses that were not included in the original dataset.

The LABEOC Report Businesses Open or Closed app demonstrates the growing role of GIS, especially ArcGIS Online, in supporting disaster response and recovery efforts. "A Platform for Coordinating Disaster Response" in the summer 2015 issue of *ArcUser* describes another instance of ArcGIS Online playing a vital role in assisting responders.

Although the City of Napa, California, was not using ArcGIS Online when a 6.0 earthquake caused substantial damage to the city and surrounding areas in 2014, the city created an earthquake information map in less than two days with assistance from Esri. That map went viral because it satisfied the demand for current, easily understood information on the effects of the quake and the status of response efforts. A related ArcGIS Online group helped responding local, state, federal, and nongovernmental agencies share information and coordinate activities.

The Napa Earthquake Information map continued to be invaluable even after response efforts wound down. It helped communicate the extent of the damage sustained by the city to state and federal relief agencies, which helped residents receive aid more quickly.

Since 2014, Esri has expanded its portfolio of GIS-based, focused solutions that can be rapidly deployed because they only require configuration. The Crowdsource Polling app gave GOHSEP and LABEOC an easy way to acquire and share current data so they could respond more effectively to public and business needs. The ability to use the app to aggregate data and integrate it with existing ArcGIS workflows enabled better informed decisions.

There has been a growing recognition in the emergency response community that through developing and provisioning solutions before an incident, familiarizing staff members with tools (such as Collector for ArcGIS), and creating ArcGIS Online interagency groups before an incident, response time can be decreased.

Chi Smith, a GIS analyst at the California Governor's Office of Emergency Services (Cal OES), who was involved in the Napa earthquake response activation, found the use of ArcGIS valuable in gaining and maintaining a common operating picture (COP). She is actively building an ArcGIS Online community for sharing incident data between government agencies before disasters occur and invites members of the GIS community to join the Cal OES ArcGIS Online Group.

The LABEOC Report Businesses Open or Closed app has proved its technical feasibility and operational value. It has been used by both businesses and the public in the affected region. It will only become more effective in future events once the public and businesses become more aware of its beneficial role as a communication channel in an emergency.

The initial deployment of the LABEOC Report Businesses Open or Closed app was tailored to answer the immediate need during the flooding disaster in August 2016, according to Michael Dunaway, director of the National Incident Management Systems and Advanced Technologies (NIMSAT) Institute at the University of Louisiana at Lafayette. NIMSAT develops public- and private-sector partnerships through LABEOC and the Virtual Business Emergency Operations Center portal.

"In the future, we intend to continue development of both the concept and the capability and expand the reach of the application across the state as a normal function of the LABEOC portal and the state's disaster response capability," said Dunaway.

"With expansion of the app beyond the region immediately affected by the current disaster, and more frequent use by the public, we believe this will be an important additional function of the LABEOC for both businesses and the public."

"In the future, we intend to continue development of both the concept and the capability and expand the reach of the application across the state as a normal function of the LABEOC portal and the state's disaster response capability."

Michael Dunaway
NIMSAT Director

New Jersey Enforces Antidumping Laws
with Crowdsourced App

By Barbara Shields, Esri Writer

Lawless litterers beware.

The New Jersey Department of Environmental Protection (DEP) created and hosts a GIS-based crowdsourcing app that lets New Jersey citizen volunteers report and map cases of illegal dumping of debris throughout the state.

The app uses Esri ArcGIS technology, works on Apple or Android devices, and links to the web app hosted by DEP. The app lets people specify the type of debris dumped such as construction or hazardous materials and the size of the pile. They can take a picture of the debris with their smartphone and upload the photo. They can also then use their device's GPS to capture the location where they discover the debris and add the information to a map. DEP staff can then view the crowdsourced reports of dumping in ArcGIS Online.

"Because volunteers are using the GIS web app to report illegal dump sites, we can understand what's happening," said Arthur Zanfini, administrative analyst with Compliance and Enforcement for the State of New Jersey Department of Environmental Protection. "We can see the reports on a map, along with truck routes, transfer stations, or recycling centers. Then we can easily see correlations between dump site locations that clues us into what is happening,"

Sprucing Up New Jersey

DEP has a long history of using innovative ideas to keep the state clean. Each spring, thousands of people gather to clean up litter during the Barnegat Bay Blitz in Barnegat Light on the Jersey shore. Since 2011, local volunteers have been turning out to participate in the one-day blitz sponsored by the DEP.

The community was truly engaged in this environmentally worthy cause, but unfortunately, their efforts were being undermined. Volunteers soon realized that they had been cleaning up the same sites year after year. The wanton waste disposers returned to these areas and dumped garbage onto the newly cleaned landscape. It was time to make a stand.

The department launched the Don't Waste Our Open Space initiative to reduce illegal dumping in state parks and wildlife management areas. GIS is a driving technology for this initiative. The Don't Waste Our Open Space campaign task force is composed of numerous DEP agencies including representatives from Compliance and Enforcement, Water Resource Management, the state parks service and police, conservation officers, New Jersey Natural Lands Trust, and DEP's Bureau of GIS (BGIS). The team's objectives are to incorporate strict enforcement of illegal dumping laws while raising awareness of the dumping problem.

"We had people from the department sit down at a table and figure out a strategic way to work with what we have to attack a problem in our state," said Zanfini. "We leveraged the Esri platform to aid in our effort."

For decades, DEP has been using Esri products. Its enterprise platform is essential for sharing responders' data about environmentally sensitive areas. With the platform already in place, it was natural and cost-effective for the task force to rely on it as a core technology for meeting the campaign's goals: encouraging public participation in the project, changing people's perceptions about illegal dumping enforcement, and catching offenders.

Engaging Citizens

Public lands throughout New Jersey have become dumping grounds for litter, garbage bags, tires, televisions, electronic waste, appliances, yard waste, and construction debris. Illegal dumping threatens the local environment, wildlife, and the public. Moreover, it detracts from the natural beauty of public land, decreases property

← The ArcGIS Online map shows the reported locations of illegal dumping, along with the date of the report, so that investigators can analyze relationships and patterns.
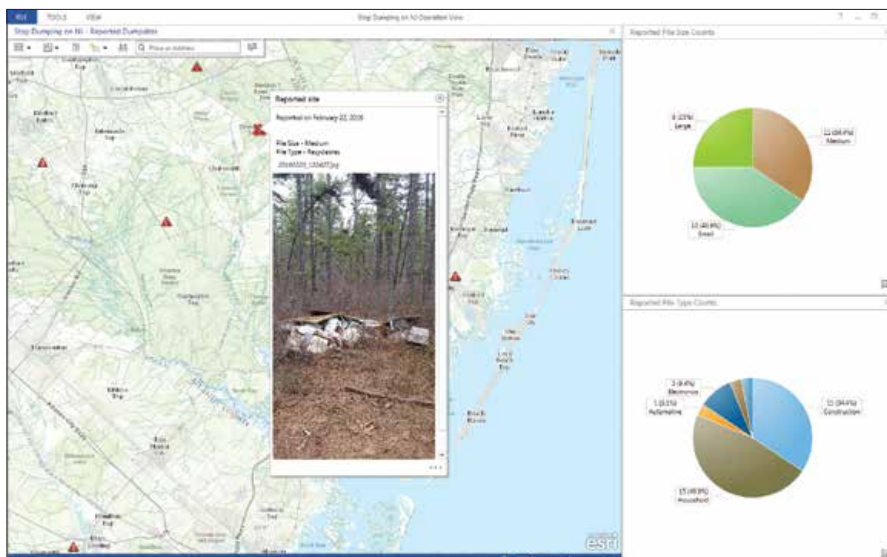
values, and costs the citizens of New Jersey tax dollars for cleanups.

The banner on the DEP's Stop Illegal Dumping website is "Don't Walk by While Your Park is Trashed." Citizens can use the crowdsourcing app that enables them to take action by taking geotagged photos at illicit dump locations. They can send this image to the DEP along with incident information that they enter on the app's form.

At each state park, DEP displays posters about dumping laws and enforcement. These posters include a QR Code that links to the informative "Don't Waste Our Open Space" landing page. The website tells visitors how to report illegal dumping to the DEP via the GIS web app on their smartphone browsers. App users can also use their cell phones to call a 24-hour hotline and make a report. GIS tracks the coordinates of reports and posts them to a map so that investigators know exactly where to find evidence.

Catching Offenders

Citizens use the crowdsourcing app to report incidents such as trash bag dumping, leaking tanks, or dumpsters that contain hazardous materials such as asbestos shingles. Having photos and GPS coordinates helps authorities respond quickly.

When a user hits the Submit button, an automated workflow begins. The app automatically writes the report and sends the photos to a feature service. At five-minute intervals, a Python script, run as a Windows task, checks the feature class to see if any new entries have been submitted. GIS processes categorize location reports to determine if they are within the state boundary, a state park, or a municipality and note if other illegal dump sites have been reported within 500 feet during the last two weeks, which may indicate this is a duplicate submittal.

The web app report triggers an alert that lets DEP staff know about an alleged case of illegal dumping. If the incident is on state property—within a state park or wildlife management area—the report goes to the DEP's communications center for investigation. Staff members send an email alert to the appropriate authorities for follow-up. If they send an email to the park police department, the incident is automatically logged into the department's dispatch system.

The ArcGIS Online map shows the reported locations of illegal dumping, along with the date of the report, so that investigators can analyze relationships and patterns. The image shows the magnitude of the incident so staff can prioritize responses. Photos show items at the dump site that may reveal whether the materials came from a nearby facility. Maps provide additional insight, such as the number of reports generated along a section of railroad track or a truck route.

Changing Perceptions

In a preproject survey, DEP discovered that most people do not believe that New Jersey enforces its dumping laws. The task force knew that its mission would not be successful if it had to rely on its small number of enforcement officers to decrease dumping on more than 814,000 acres of state land. It had to be smart. To deter potential perpetrators, it had to change the community's perception by proving that laws are enforced and offenders are prosecuted.

To convey this message, the team published an Esri Story Map app that shows the pictures of offenders who have been caught and the maximum fines they could face for their offenses. The map template lets DEP staff easily update photos and information.

Measuring Success

You can't tell if a program has succeeded or failed if you don't measure results. From the inception of the project, the DEP task force set up success indicators and established baselines for comparison. For example, the results of the initial public survey provided a baseline for measuring the program's ability to change the public perception that laws are not enforced. Perception can be measured over time. The number of reports submitted by the web app from recreational hikers and other park visitors is also a success indicator.

Mapping the number and location of arrests for illegal dumping over time makes it easier to understand data about law enforcement success. Furthermore, analysts can determine which arrests were related to citizen reporting. Mapping data from the Barnegat Bay Blitz cleanup day will show if volunteers find less trash in previously high-trash areas and will indicate if dumping activity has decreased. This is also a good way to advertise the effectiveness of the event.

Within the first few months of its trial launch, volunteers have already been using the app. It will take DEP a few years to gather the measurements that will show exactly how effective the Don't Waste Our Open Space program has been.

Locating More Opportunities

Zanfini is happy to spread the word about the GIS dumping solution and talk with other agencies interested in implementing similar projects. Crowdsourcing apps are also helping citizens participate in other action-oriented projects. For example, the DEP created a reporting app that members of the AmeriCorps NJ Watershed Ambassadors Program use to collect and report the stream data necessary for keeping waterways clean. Community volunteers use a DEP web application to verify the locations of public access to the New Jersey coastline. Their work contributes to a map that makes the shore open to everyone.

Keeping the Rain out of Kansas City Sewers

Quick results in the first three months of Keep Out the Rain KC

- More than 6,000 homeowners contacted
- 4,000 properties evaluated
- Nearly 400 inflow and infiltration sources confirmed
- More than 5 million gallons per day of rainfall identified for removal from the system
- 22,000 average requests per day on the field staff's online map

→ Keep Out the Rain KC staff having a homeowner sign an agreement to perform a property evaluation

Although rain is generally a good thing, when storm water makes its way into the separate sewer system for Kansas City, Missouri, the impact can be devastating.

Excess storm water creates an average of 6.4 billion gallons of wastewater overflow each year in Kansas City's more than 1,700 miles of sewer system. The city is one of more than 700 communities across the United States that must comply with regulatory standards for wet weather sewer overflows.

In 2010, Kansas City entered into a federally mandated agreement with the United States Environmental Protection Agency (EPA) to reduce sewer overflows by investing in the city's aging sewer infrastructure over a 25-year period. Kansas City's $4.5 billion Overflow Control Program will capture and treat 88 percent of combined sewer flows and eliminate sanitary sewer overflows during heavy rainfall events.

To leverage each dollar of the investment, Kansas City is asking homeowners to help reduce the overflow problem by voluntarily removing improper plumbing connections from the city's sewer mains. The program, called Keep Out the Rain KC, can help Kansas City save millions of dollars in future capital improvements. Kansas City adopted this targeted approach because private plumbing connections are believed to be responsible for more than half of the rainwater that enters the sewer system.

"Our sewer system is designed to collect and convey wastewater to one of our six wastewater treatment plants," said Andy Shively, chief engineering officer for Kansas City Water Services. "When rainwater gets into the sewer system, it can overwhelm our pipes, which, in turn, can cause overflows and basement backups. Once rainwater enters the sewer system, it must be treated, driving up maintenance and treatment costs."

"Kansas City is committed to achieving the requirements of the city's federally mandated consent decree in a way that improves neighborhoods and reduces program costs for our residents," said Shively. "ArcGIS is helping Kansas City to effectively manage the Keep Out the Rain program and report improvements to the Environmental Protection Agency and to our residents."

↓ Collector for ArcGIS showing property status
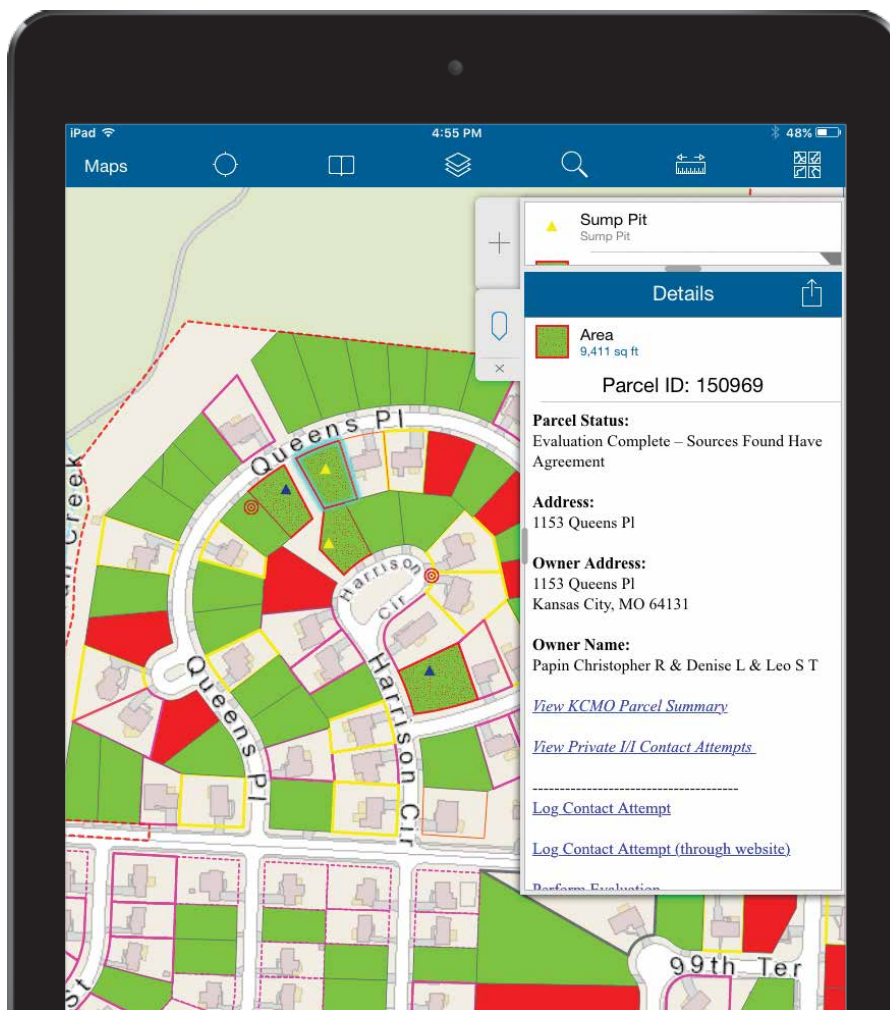
Meeting Project Challenges

To create the Keep Out the Rain KC program, Kansas City first turned to existing GIS data to pinpoint areas where wastewater from improper plumbing connections on private property might be entering the city's sewer mains. The city found 55,000 properties for which simple, cost-effective plumbing corrections could help make a big impact on reducing the city's overflow control issues.

Those 55,000 properties with improper plumbing connections were located in an area of more than 300 square miles. To get a high level of voluntary participation in the program, the city needed to effectively communicate the value of the program to the public. To perform a thorough evaluation in the field, the city also needed to share a large amount of data to coordinate and track the work being done by a team of city staff members and contractors from many different organizations. Finally, the city needed to analyze the effectiveness of the program in achieving its goal of removing rainwater from specific portions of the sewer system. The ArcGIS platform is being used for public outreach, project coordination, data collection and sharing, and results analysis.

Public Outreach

ArcGIS has been used to generate targeted mailings, based on location, to property owners to get them to sign up for the program voluntarily. By embedding an interactive map in the program website, ArcGIS has also been used to help the members of the public determine if their properties are located in the program area and eligible.

Project Coordination

Using ArcGIS, the project area was subdivided into sections to more evenly distribute the work across the project teams and allow the results to be tracked for a much smaller area.

Data Collection and Sharing

The teams in the field performing property evaluations are using the Collector for ArcGIS app so they can have current information on the location, status, contact information for property owners, and the locations of wastewater and storm water infrastructure for each of their assigned properties. The app can also supply the location of smoke testing observations, which may indicate that there is an inflow [water entering the sewer from inappropriate connections] or infiltration [groundwater entering the sewer caused by defective pipe joints] source on the property.

Collector for ArcGIS has also been integrated with smart digital forms built on the iFormBuilder platform developed by Esri partner Zerion software. This integration makes the process more efficient by eliminating the errors associated with manually entering property information. Once an evaluation is completed, the information is immediately available in ArcGIS Online and the Project Management Dashboard running in Microsoft Azure.

Results Analysis

Using ArcGIS mobile technology and ArcGIS Online allows the project team to see and analyze information in real time. The moment evaluation is completed, that information is available so the entire project team and all program stakeholders can analyze it using the online dashboard. That information is also available for on-demand reports that focus on the program's key performance indicators.

Having access to information in real time allows the project team to be agile in its approach. Management is able to see what methods have been successful and capitalize on those while working to address any weaknesses. The richness of data being collected in the Keep Out the Rain KC program allows the team to continually improve upon the approaches being taken to accomplish project goals.

To learn more about the Keep Out the Rain KC program and its ArcGIS implementation, contact Brian Parr, GIS manager for water services at Kansas City, Missouri, at Brian.Parr@kcmo.org or Brian Hiller, technology implementation project manager at Burns & McDonnell, at behiller@burnsmcd.co.

A SPATIAL FRAMEWORK SUPPORTS
ROAD INVESTMENT
DECISIONS

By Greg King, Arup

The Department of Transport and Main Roads (TMR) in Queensland (Australia), modeled the economic impacts of unplanned road closures to support investment decisions across the state-controlled road network.

With many competing demands, fiscal and physical constraints, and potential risks to the assets operation, making decisions about where to invest in road operations intelligent transport systems (ITS) infrastructure can be challenging.

Road operations ITS infrastructure is electrical- and communications-based technology that provides enhanced operation, efficiency, and safety of transport infrastructure through monitoring, informing road users, and controlling road use. ITS examples include variable messages (VMS), lane use management systems (LUMS), road condition information signs (RCIS), and various sensing and monitoring tools including closed circuit television and flood monitoring.

The road network controlled by TMR has a combined length of more than 33,000 kilometers (20,500 miles), which is divided into 2,200 separate segments based on annual average daily traffic (AADT) characteristics. This network includes high-density urban areas with high traffic volumes that run at capacity during peak periods. The network also encompasses mountainous landscapes with challenging road corridors to remote communities and isolated areas that are of strategic importance.

Queensland also encompasses many climatic regions, from coastal tropical areas to inland deserts. The combination of network characteristics and variable climatic conditions with an extremely distributed population and a landmass almost three times the size of Texas but only one-fifth the population makes the location aspect of investment prioritization very important.

TMR partnered with Arup, an independent firm of designers, planners, engineers, consultants, and technical specialists, and EY (Ernst & Young) to develop a spatial framework to assist in identifying road segments of interest for ITS infrastructure investment. As it is essentially answering

criteria, the total annualized closure duration can be determined.

The second part of this framework was modeling diversion routes for each of the 2,200 road segments. When a road segment is closed, vehicles will likely be diverted to other roads. Modeling these diversions and the increase in time and distance for each diverted vehicle allows for a more accurate representation of the impacts to the Queensland economy.

TMR maintains multiple databases that capture data for road closure events including these four criteria: date, location, duration, and closure description. The key to this project is the ability to take individual closure event data and spatially summarize by road segment extent. The range of analysis tools made ArcGIS the ideal platform for this analysis.

Each of the four criteria was assessed to provide a summary for all road segments. The summary statistics included the average closure duration caused by an event, the average number of closure events per year, and the average total duration of road closures throughout a year. Once this data was produced for each criterion, the information was aggregated to produce a total closure duration profile for all state road segments throughout Queensland.

The road closure event databases provided a detailed assessment of road closures for the previous five years. Some of the criteria in this framework have longer-term trends that won't be picked up within this time frame, and some road segments were overrepresented or underrepresented by closure events within the five-year data sample. Consequently, a second part was added to the framework to calculate alternative closure duration estimates for each road segment.

Instead of being based solely on databases of historical road closure events, the alternative method was based on industry-accepted assumptions and rule-based assessments. This alternative method used the same criteria—crashes, bushfires, landslides, and flooding—and produced the same type of results as the historical assessment method: the average closure duration caused by an event, the average number of closure events per year, and the average total duration of road closures throughout a year.

To summarize the spatial analysis methods of this framework, the historical road closure model primarily uses geometry-based analysis (i.e., assessing road segment polylines against locations of road closure event features). The alternative road closure model uses attribute-based analysis

the spatial question of where to prioritize investment, ArcGIS was chosen as a key technology platform to develop this spatial framework.

The results were fed into an economic model that calculated the annualized financial impact of unplanned road events on the Queensland economy and provided to TMR to assist with investment decisions across the state-controlled road network.

Spatial Framework Structure

The first part of the framework was based on quantifying how long road segments are closed from unplanned events, specifically crashes, bushfires, landslides, and flooding. From the assessment of each of these
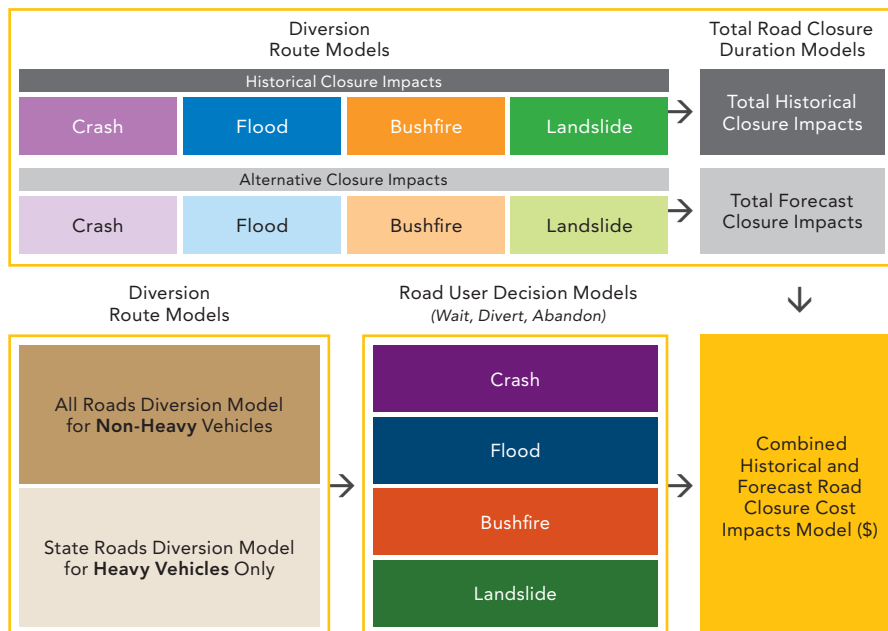
↓ Department of Transport and Main Roads (TMR) in Queensland evaluated the economic impacts of unplanned road closures using GIS to model historical and alternative data.

↗ Road closures caused by crashes, bushfires, landslides, and flooding are assigned to road segments based on spatial proximity. The durations of road closures were summarized for each year by segment.

↘ Diversion routes had to be evaluated separately for light and heavy vehicles because light vehicles can be diverted to any road (blue), while heavy vehicles must be diverted exclusively to state-controlled roads (black).

(i.e., applying rules and formulas based on road characteristics data within the road segment attribute tables). The historical and alternative results can be compared with each other, demonstrating the analytical capabilities of ArcGIS.
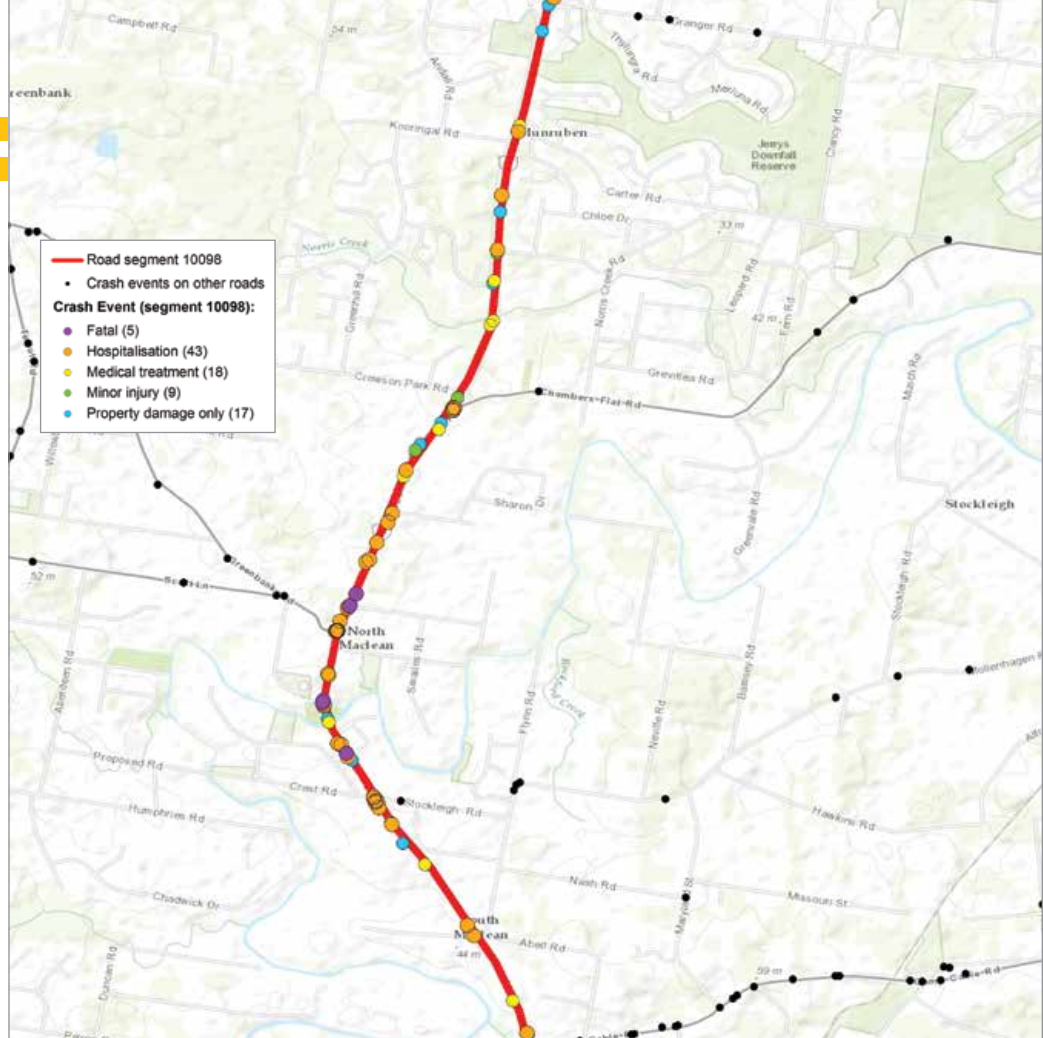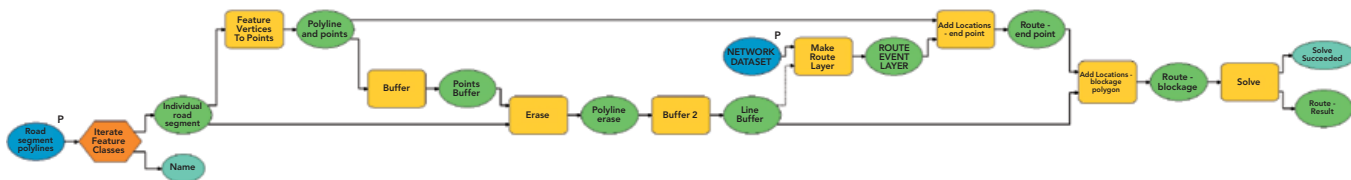
The Impact of Diversions

To properly understand the impact of road closure events on road users, more than just quantifying road closure duration is needed. When a closure event occurs, road users will either abandon their trip, wait, or divert around the closure to continue their trip. So modeling the distance and travel time of diversions around each road segment is a key aspect of this framework that will measure the significance of a road segment. Larger diversions have a greater economic impact on road users.

Developing a single ArcGIS Network Analyst scenario to calculate a route is a simple task. Using a network analysis layer, set the endpoints of the route (endpoints of the road segment). To model the road closure, a barrier is included along the road segment. This results in a route based on alternative alignments to the road segment itself.

The challenge was to create and solve this scenario separately for all 2,200 segments. Because the network scenario must be developed separately for each road segment, the solution requires iterating through each road segment, building each network routing scenario, and then calculating the solution.

In addition, diversions for light and heavy vehicles needed to be modeled separately. Light vehicles can divert along any road, but heavy vehicles will only divert along larger, state-controlled roads. This meant calculating two diversion routes for each road segment, resulting in calculations for a total of 4,400 separate diversion routes.

Road segment 10098
· Crash events on other roads
Crash Event (segment 10098):
● Fatal (5)
● Hospitalisation (43)
● Medical treatment (18)
● Minor injury (9)
● Property damage only (17)

Road segment 135725 (2.9 km, 2.2 minutes)
● Segment end points
Diversion - state and local roads (10.9 km, 9.9 minutes)
Diversion - state roads only (15.04 km, 11.3 minutes)

↑ Linking analysis tools with a ModelBuilder iterator allowed routing calculations to be performed over all road segments in a single model run as shown in this road segment diversion model.

The overall solution for modeling road segment diversions can be created by integrating ArcGIS Network Analyst tools with ModelBuilder iterators. This allows the network analysis scenarios to be built separately and solved for all road segments as part of a single model run. The output from the model was a feature class of all diversion route polylines with statistics for the diversion distance and travel time. The travel time was based on speed assumptions for all road hierarchy types.

The main steps for creating an iterative network analysis model are similar to manually performing the analysis for a single network scenario. This process includes

- Adding an iterator that will run through each road segment polyline in the workspace.
- Building the scenario with all relevant elements using the Add Locations tools from the Network Analyst toolbox. For this project, the scenario elements were the road segment endpoints (start and end of the route) and a barrier polygon that represented the road segment closure. The polygon was created by clipping a section of the road segment polyline and buffering it by an appropriate distance.

Solving the Scenario

Other considerations when creating an iterator-based network analysis model include saving the results to a geodatabase once the scenario has been solved and using in-line variable substitution to ensure the resultant feature class is named based on the feature variable from the iterator.

With both historical and alternative road closures and light and heavy vehicles route diversions modeled in GIS, the results were fed into the economic impact model so EY could calculate the financial costs to road users from road closures.

Results and Conclusion

GIS is an ideal tool for holistically modeling road closure impacts throughout Queensland. The ability to analyze road segments in terms of proximity to surrounding features is key to modeling road closures from a large array of base datasets.

ArcGIS came into its own when performing the diversion route modeling. The ability to calculate diversion routes using ArcGIS Network Analyst tools was important to producing accurate results. Linking analysis tools with a ModelBuilder iterator allowed routing calculations to be performed over all road segments in a single model run.

This linkage between ArcGIS Network Analyst tools and ModelBuilder iterators greatly enhances the potential for network analysis. Instead of creating and solving a single network scenario, any ArcGIS Network Analyst calculation can be performed across many features.

What also became apparent during the development of this framework is its potential to be implemented across various infrastructure network types. Governments currently must work with limited budgets to maintain and upgrade infrastructure networks. GIS can assist with infrastructure funding allocations. As shown by this project, GIS can provide a consistent and impartial assessment of whole infrastructure networks (and perhaps across multiple networks) that will provide the foundational information required for complex investment decisions.

Furthermore, this project highlighted the value of agencies maintaining comprehensive datasets that represent different facets of their business. Because TMR maintains multiple in-house databases and many datasets that are publicly available through the Queensland government open data policy, the barriers to undertaking such analysis

and achieving information-driven decisions have been significantly lowered.

For more information, contact Greg King (greg.king@arup.com).

About the Author

Greg King is a GIS consultant in the Brisbane office of Arup. He has a background in urban planning and is a member of the Geospatial Information and Technology Association (Australian and New Zealand chapter). He graduated from the University of Queensland with a bachelor's degree in regional and town planning and is currently completing his master's degree in professional studies (geodesign) at Pennsylvania State University through the Penn State World Campus.

Collaborative Quality Control Saves Money on Data Project

By Ashley Summers, Jenny Todd, and Josh Pendleton, Denver Regional Council of Governments

By working together, a regional organization acquired and vetted current data on the as-built environment that would otherwise have been too costly.

A recent data sharing endeavor by the Denver Regional Council of Governments (DRCOG) capitalized on the organization's reputation for working together and provided benefits for member governments, partners, community members, and entrepreneurs. DRCOG brings together more than 50 jurisdictions to address challenges that would be difficult or impossible to solve at the local government level. Through collaboration, the organization establishes guidelines, sets policy, and allocates funding in the areas of transportation, growth and development, and aging and disability resources.

One of the many services that DRCOG provides is the facilitation of regional geospatial data projects on behalf of local governments and public entities that could otherwise not undertake these projects on their own. DRCOG, through its aerial photography program, the Denver Regional Aerial Photography Project (DRAPP), has more than a decade of leading regional collaboration to make data projects happen.

Known collectively as planimetric data, it consists of building outlines, sidewalks, parking lots, and pavement information drawn through the interpretation of aerial imagery. Planimetric data has historically been cost prohibitive for most of the region's jurisdictions—which include 47 cities and towns—to acquire and maintain, so most planners and GIS staff use outdated information or nothing at all.

In 2015, DRCOG embarked on an unprecedented and ambitious project to acquire detailed infrastructure information for the nine-county region. In partnership with 21 cities, towns, and other public entities in

↓ The Planimetrics QAQC web map showing attributes for the footprints layer
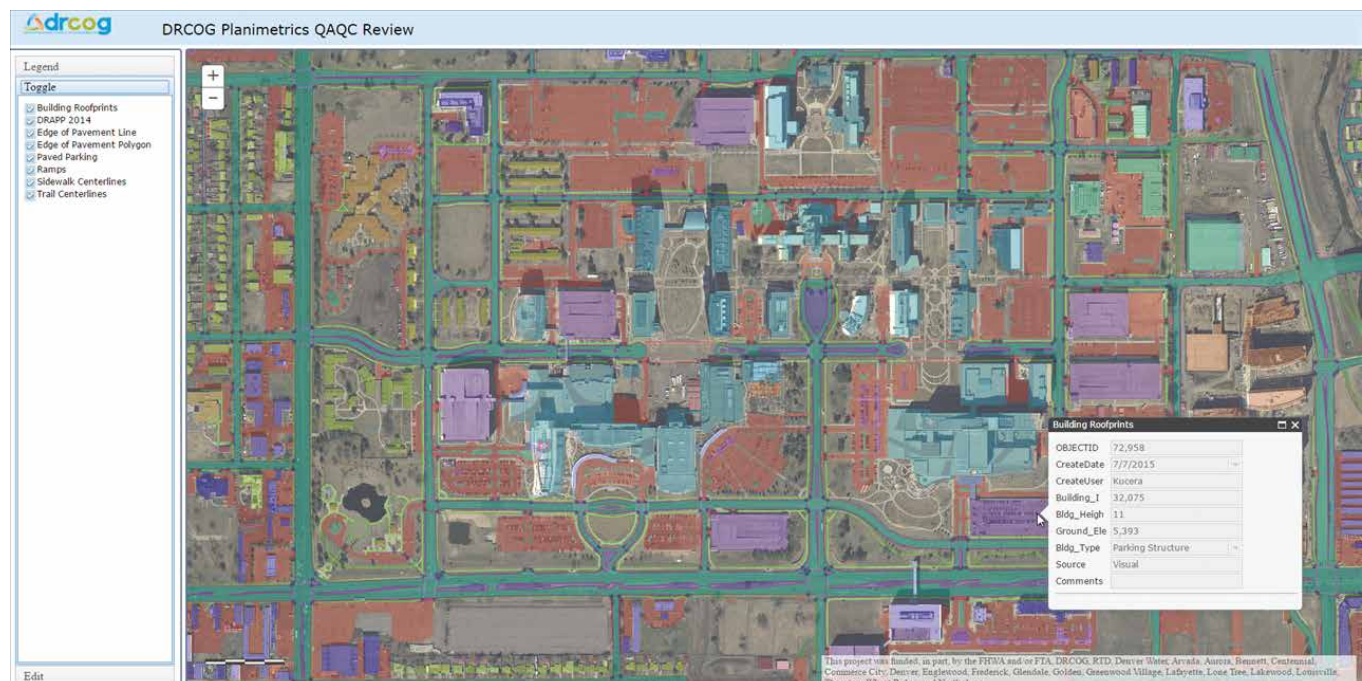
Colorado, DRCOG acquired imagery data covering an area of approximately 1,300 square miles. In addition to contributing funding, partners cut project costs by performing quality assurance/quality control (QA/QC) instead of paying for an independent quality control vendor. DRCOG used ArcGIS for Server to build a collaborative web map so that edits could be compiled and passed on to the imagery vendor, Kucera International, Inc., to be fixed.

DRCOG used ArcGIS for Server and the ArcGIS API for JavaScript to develop a web mapping application for the planimetric QA/QC map. This was the first project DRCOG had developed using these Esri products, but with the assistance of the API reference and sample code documentation as well as Esri technical support, DRCOG developed the application in a matter of weeks.

Project requirements included developing a password-protected application that could be used to capture edits from project partners. The IdentityManager module from the API was used so users could access secured services. A small but significant customization to manipulate the predefined text in the sign-in dialog improved the application design.

The Editor widget was used to capture the user comments. During the implementation of the widget code on an accordion pane, it was discovered that the pane that contains the Editor widget must be active for the widget to work properly. During development, a bug in the widget was found and logged. Rendering the data as feature layers provided quick drawing performance while allowing users to review layer attribution and toggle layers on and off.

The data needed to be checked against the imagery from which it had been extracted, so DRCOG's most recent aerial photography was added as an image service layer. Project partners were asked to review the quality, consistency, and accuracy of the data. The 21 partners recorded more than 4,000 edits using the QAQC map. DRCOG then evaluated and curated these edits before sending them to the vendor to be addressed.

The collaborative web map allowed DRCOG and its partners to quickly and easily leverage local knowledge to create a better data deliverable—all while saving money that otherwise would have been spent to have a vendor perform these tasks.

Now that the project is complete, the data is being used for the development of emergency response plans, pedestrian-routing and sidewalk quality studies, building inventories, and impervious surface analysis. The data has also been shared in the public domain, inviting innovators and entrepreneurs to tap the resource. The data is already being used by several new startups. They are creating mobile apps to aid the visually impaired, provide business intelligence for local restaurants, and help locate those potential oil and gas sites that will have the least impact on the community. Other emerging uses include 3D modeling, urban development scenario planning, and special district mapping.

For more information, contact Ashley Summers at 303-480-6746 or asummers@drcog.org, Jenny Todd at 303-480-6754 or jtodd@drcog.org, or Josh Pendleton at 303-480-6784 or jpendleton@drcog.org.

To download the data, visit DRCOG's Regional Data Catalog at gis.drcog.org/datacatalog/. Follow DRCOG on Twitter @DRCOGorg.

Project participants included City of Arvada, City of Aurora, Town of Bennett, Town of Castle Rock, City of Centennial, City of Commerce City, City and County of Denver, Denver Water, City of Englewood, Town of Frederick, City of Glendale, City of Golden, City of Greenwood Village, City of Lafayette, City of Lakewood, City of Lone Tree, City of Louisville, City of Northglenn, Regional Transportation District, City of Thornton, City of Wheat Ridge

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Best Practices
for Generating GIS ROI Momentum

By Wade Kloos, GIS Director, Utah Department of Natural Resources

Over the past year, GIS manager Wade Kloos has written a series of columns describing why and how you should document the return on investment (ROI) of your GIS department's work. In this article, he summarizes the previous columns and provides a list of best practices.

This is the final article in my GIS ROI series. A quick recap of the previous three articles is in order.

In the first article, I began with the reasons why GIS managers should document the ROI and benefits stemming from their good GIS work. I emphasized that a "growth" mind-set can be a pathway for discovering high-value GIS projects.

In the second article, I identified the target audience for ROI reports and also revealed that when you document GIS results, you are creating—*for yourself*—a portfolio of your relevance, competence, and accountability that you can keep for your entire career. In addition, I introduced the one-page, abbreviated GIS ROI and Benefits Report that allows you to hit the ROI road running. I provided that report as a Microsoft Excel spreadsheet template that you could download and use.

In my last article, I presented the ROI results from two years of documenting GIS outcomes at Utah Department of Natural Resources (DNR) and provided actual ROI reports that described business process problems and opportunities along with the GIS solutions that produced tangible business benefits and notable fiscal impacts.

So why am I (again) suggesting that GIS managers add GIS ROI workflows into their busy schedules?

Because without it, GIS will continue to be undervalued and misunderstood. I want to remind you that organizational leaders can be fickle. They tend to forget the accomplishments and impact of your GIS, especially when these results are anecdotal in nature.

As a business support function, GIS (along with its ROI results) will begin to be perceived by organization leaders as an integral part of business operations and the process of continuous improvement—a compass for progressive and successful organizations.

Perhaps the most beneficial reason for doing regular GIS ROI is that you will improve your skills as a GIS manager. Specifically, you will hone your ability to discern the difference between high-performing/high-value GIS projects and those projects with less organizational potential and lower value. You will be a more effective communicator of business-related GIS benefits. You can increase your ability to influence how work is done and how decisions are made within your organization. These skills can inextricably link your great work to your organization's success.

The more ROI reports you complete, the more you will find yourself focusing your GIS resources in areas that make the biggest organizational impact. You will better understand what GIS activities lead to specific outcomes and how those outcomes are valued by your organization—this is *organizational clarity*. With this clarity you will see which GIS activities *cause* specific organizational *effects* and the *value* of those *effects*. I have created the GIS Activities Pyramid (shown in Figure 1) to illustrate how certain GIS activities could relate to specific outcomes and organizational value.

Every organization assigns value differently, and the relationships, shown in Figure 1 as arrows, may not be applicable in all cases. However, it should be obvious to you now that only through the *measurement* and *documentation* of GIS results can a GIS manager provide the clarity necessary for their organization to assign an accurate value to GIS results. Without establishing a documented link between what you do, the outcomes achieved, and their value to the organization, your organization is left with *only* a list of the things GIS can do.

All these GIS activities—while somewhat general in description—are essential. To some extent, each successive level of the pyramid shown in Figure 1 requires the capabilities of the level below it. But as the graphic suggests, not all activities can produce the same organizational value.

Because GIS does not exist solely to create a representation of the world, GIS must transcend its technical and *GIS-centric* genesis and apply itself to the business needs of the organization via *business-centric* and high-value activities. Even if your organization does not define its mandate for GIS, you should take to heart that your employer chose to invest in GIS (and you) so that your organization can accomplish its business goals, eliminate problems, and maximize business opportunities. Therefore, your destination on this GIS ROI journey is to positively affect your organization's business systems
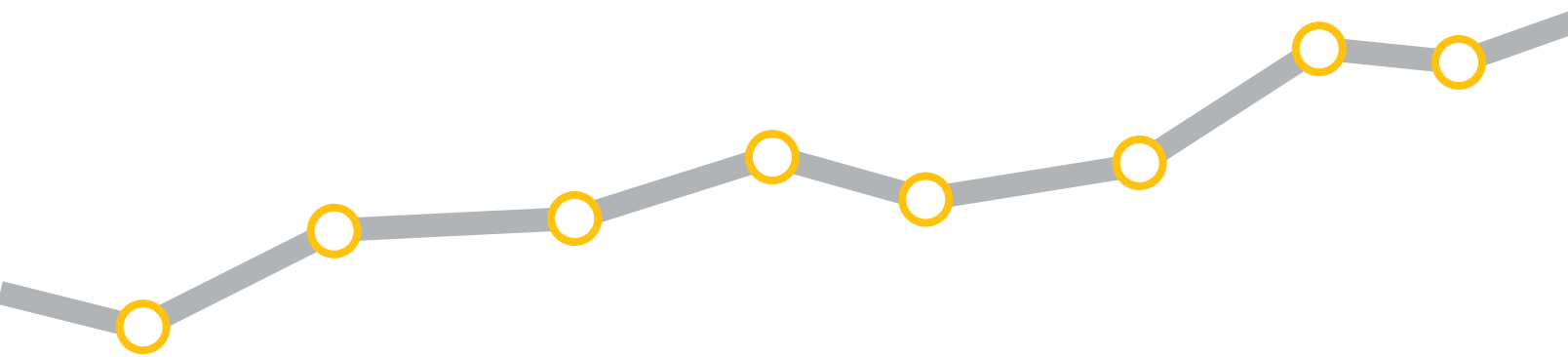
and inform your organization of the difference you make with ROI documentation.

GIS ROI Best Practices

1. As a GIS manager, allocate 10–15 percent of your time ensuring GIS results are being documented and communicated and that high-value GIS projects are being defined and pursued. If you can't afford the time, delegate some of your existing tasks to others. Remember, no one else can provide the needed clarity to your organization. ROI workflows need to become habitual for GIS managers.

2. Collaborate with your human resources and finance teams to define meaningful measures. Ensure that you are documenting success elements that are
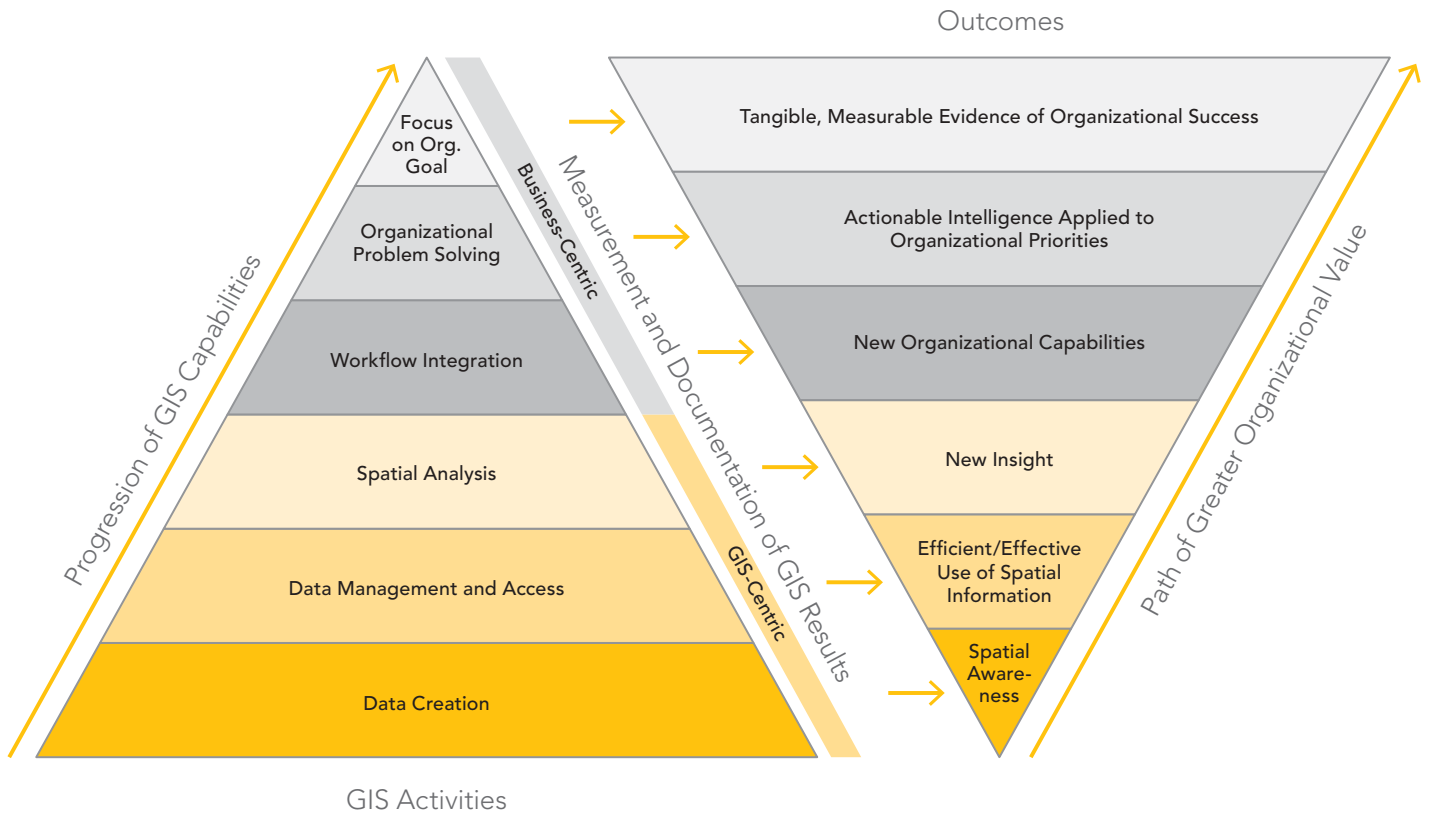
↑ Figure 1: The GIS Activities Pyramid shows the relationship between GIS activities, their outcomes, and their value to the organization.

relevant to your organization in your GIS project ROI reports.

3. Don't attempt to define the ROI for a GIS program first. Capturing ROI for an entire GIS program can be a daunting task. It is best pursued only after you have experience documenting ROI at the project level. Use GIS projects and the workflows they enhance to build a compelling business case for your work. Start small, build early victories, and seek greater returns from your future GIS projects.

4. Produce a biannual newsletter on GIS ROI that summarizes the business benefits attributable to GIS. Ensure your organization's leadership reads it.

5. Ask for more exposure to leadership-level management discussions so that GIS and its unique spatial thinking can be leveraged early on. Your documented, business-centric successes will provide you with credibility and demonstrate your usefulness in such discussions.

6. Know your organization's main business goals and current priorities as well as those at the program level. If they are not well-defined or promoted, ask that they be defined for you so that your business support function can help the organization and its programs succeed.

7. Deliver key business-centric solutions just as often as you conduct GIS-centric activities. "Map" your projects on the GIS Activities Pyramid to reveal where your team is spending its time and the corresponding value you are creating for your organization. This may reveal patterns you were not aware of relative to your GIS workload.

What can you expect once you have established the ROI habit and proved that the results from your GIS work are tangible, verified, and valued by your organization? You will begin to sense that GIS is wanted and expected more because you have your management's attention. Leadership will increasingly open up to GIS and better describe their business goals, needs, and opportunities to you.

Your ability to link GIS solutions to business needs will be tested. Program managers will seek you out to help redefine their workflows, primarily so they look good—and that's okay. GIS (and you) will become *the* business support function that is known to *make an important difference*. This will be partly due to how well GIS lends itself to—and integrates with—business processes and decision-making and partly because you know how to measure, document, and communicate the things your organization values.
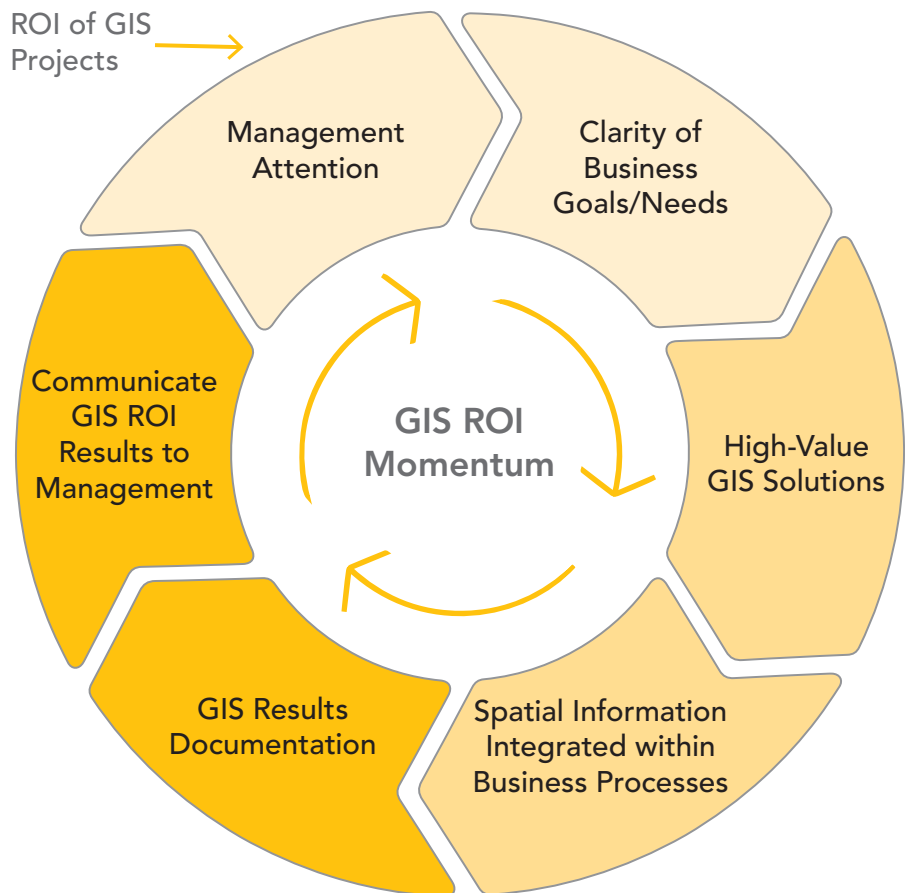
With ROI embedded within your GIS program's road map, I believe you will create and sustain a certain and beneficial momentum—the GIS ROI Momentum illustrated in Figure 2.

I hope that these four GIS ROI articles have provided you with practical advice, encouraging case examples, and ROI tools that you can use to begin or enhance your GIS ROI work. I firmly believe that GIS programs can hit the organizational ROI bulls-eye more often once they gain organizational clarity and develop the skill in measuring and documenting what they do, their results, and the value they deliver.

Best of luck to all GIS managers and GIS professionals who choose to embark on the journey to take their good GIS work to the next level via the GIS ROI path.

For more information, you can contact me at wkloos@utah.gov.

↑ Figure 2: GIS ROI Momentum

ROI of GIS Projects

Management Attention

Clarity of Business Goals/Needs

High-Value GIS Solutions

Spatial Information Integrated within Business Processes

GIS Results Documentation

Communicate GIS ROI Results to Management

GIS ROI Momentum

Make Your ArcGIS Online Home Page Discoverable

If your organization has a publicly accessible ArcGIS Online home page, you can make it easier for others to discover it by registering it as an item. While you can share your organization's home page via a link, registering it helps others discover it when searching ArcGIS Online. Follow these simple steps to register your organization.

1. Log in to your organization, and open your organization's home page.
2. Copy your organization home URL from the address line on the browser.
3. Go to My Content and click Add Item.
4. Choose From the web from the drop-down list.
5. Choose Document as the type.
6. Paste the URL from step 2 in URL.
7. Add a title and tags.
8. Click ADD ITEM. Complete the item summary and description, add a thumbnail, and *most important, Share publicly.*

Your organization home page can now be discovered via an ArcGIS Online search, making it easier to discover by others.

↑ After clicking ADD ITEM and choosing From the web from the drop-down list, follow steps 5 to 8 to add your home page as a searchable item.

Tips and Tricks to
Supercharge Your Web GIS

By Micah Babinski, Elyon International, Inc.

We hear it repeatedly at conferences, in blog posts, and in articles—Web GIS is the future and is here to stay. Web GIS, the latest paradigm shift in our industry, means that GIS experts can put the power of data, maps, and analysis in the hands of more users, both internally within organizations and externally to the public.

In this article, I'll describe techniques and ideas for managing geospatial data and author content that speed publishing, display, and organizational adoption of the data and maps served via the web. I developed these ideas while working as a GIS specialist in a county emergency management agency, a major city's enterprise GIS shop, and as a contractor for a federal agency that manages land and natural resources. The ideas presented don't necessarily reflect the practices or views of my current or previous employers.

Cultivate a Publisher Stable

All of the tasks we used to rely on desktop software for—mapping, analysis, and even data creation and updates—can now be accomplished easier, faster, and by more users using thin client applications accessed via a web browser or mobile device.

In the wonderful world of Esri software, ArcGIS for Server and ArcGIS Online are the Web GIS power tools of choice. Each has specific use cases, terminology, and workflows that may be unfamiliar to GIS staff

with a desktop background. Organizations and their GIS managers frequently designate a single staff member or small group to administer these systems. This is a good thing, because these Web GIS admins become the in-house experts who conduct research and development and lead the adoption of Web GIS for the organization.

The problem with this model arises when a mature GIS shop neglects to train additional skilled GIS staff in the essential workflows of Web GIS publishing and leaves the entire workload to just one or two admins. Preparing data and maps for web publishing involves some pretty specific steps above and beyond what is typically required for desktop mapping and analysis. Without a well-trained stable of GIS specialists familiar with the web publishing workflow (and the specific needs of the customer), publishing throughput decreases and productivity declines. Conversely, a well-trained roster of GIS specialists fluent in the language and processes of web publishing enhances an organization's Web GIS and speeds implementation.

The 90 Percent Principle

When managing data for Web GIS, strive to streamline workflows, develop tools, and provide training to cover 90 percent of publishing scenarios. Esri is adding new types of services and functionality all the time, so think about the most common publishing

```
# update_map_doc_properties_example.py
# An example of how to update map document/service
# properties with arcpy.mapping

# import the arcpy module
import arcpy

# collect the service metadata from the user
mxd_path = arcpy.GetParameterAsText(0)
service_title = arcpy.GetParameterAsText(1)
service_summary = arcpy.GetParameterAsText(2)
service_description = arcpy.GetParameterAsText(3)
service_author = arcpy.GetParameterAsText(4)
service_credits = arcpy.GetParameterAsText(5)
service_tags = arcpy.GetParameterAsText(6)

# create an mxd object with arcpy mapping
mxd = arcpy.mapping.MapDocument(mxd_path)

# update the map document properties
mxd.title = service_title
mxd.summary = service_summary
mxd.description = service_description
mxd.author = service_author
mxd.credits = service_credits
mxd.tags = service_tags

# save the map and clean up
mxd.save()
del mxd
```

↑ A listing showing how to update map document properties or map service properties using the ArcPy module

jobs and design the data management environment and protocols for those jobs.

Frequently, this means facilitating a streamlined process for publishing enterprise data as dynamic map services or editable feature services. I browse the public REST service directories of a lot of organizations, and from my observations, these types of services account for roughly 90 percent of what's out there. This does not mean that other types of services aren't important, but they are less common. If your publisher stable is able to handle the most common publishing jobs, the Web GIS admins can focus on more complicated publishing tasks such as cached map services, geoprocessing services, geodata services, and geoevent services.

Manage Data Upstream for Faster Publication Downstream

As data and its renderings flow from geodatabases to map documents; services; web maps; and, finally, full-fledged applications, data properties are inherited from each

```
# alias_update_example.py
# An example of how to update feature class or table name aliases with arcpy

# import the arcpy module
import arcpy

# create a variable pointing to the table which stores your aliases
alias_table = r"<Path to the table>"

# create a variable pointing to a tuple containing the alias names
fields = ("Path_to_Table_or_Feature_Class", "Alias_Name")

# read the table with a search cursor and update the aliases
with arcpy.da.SearchCursor(alias_table, fields) as cursor:
    for row in cursor:
        arcpy.AlterAliasName(row[0], row[1])
```
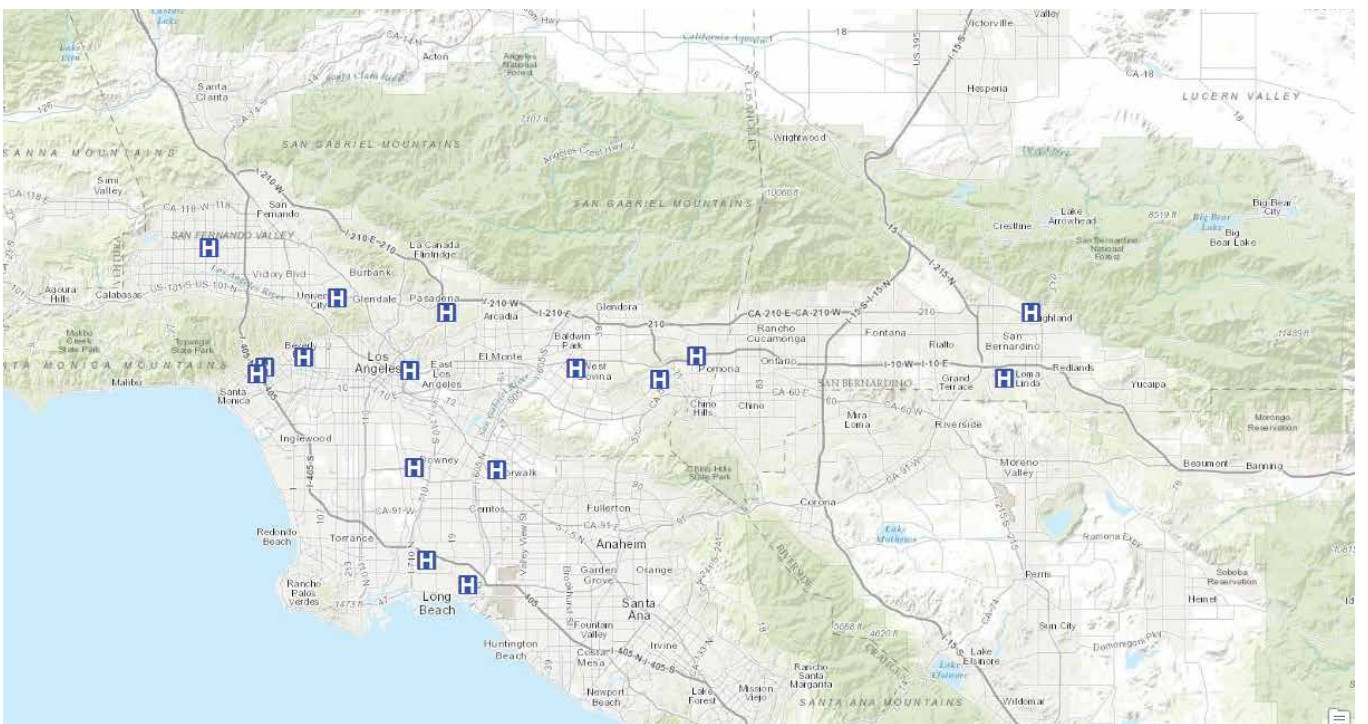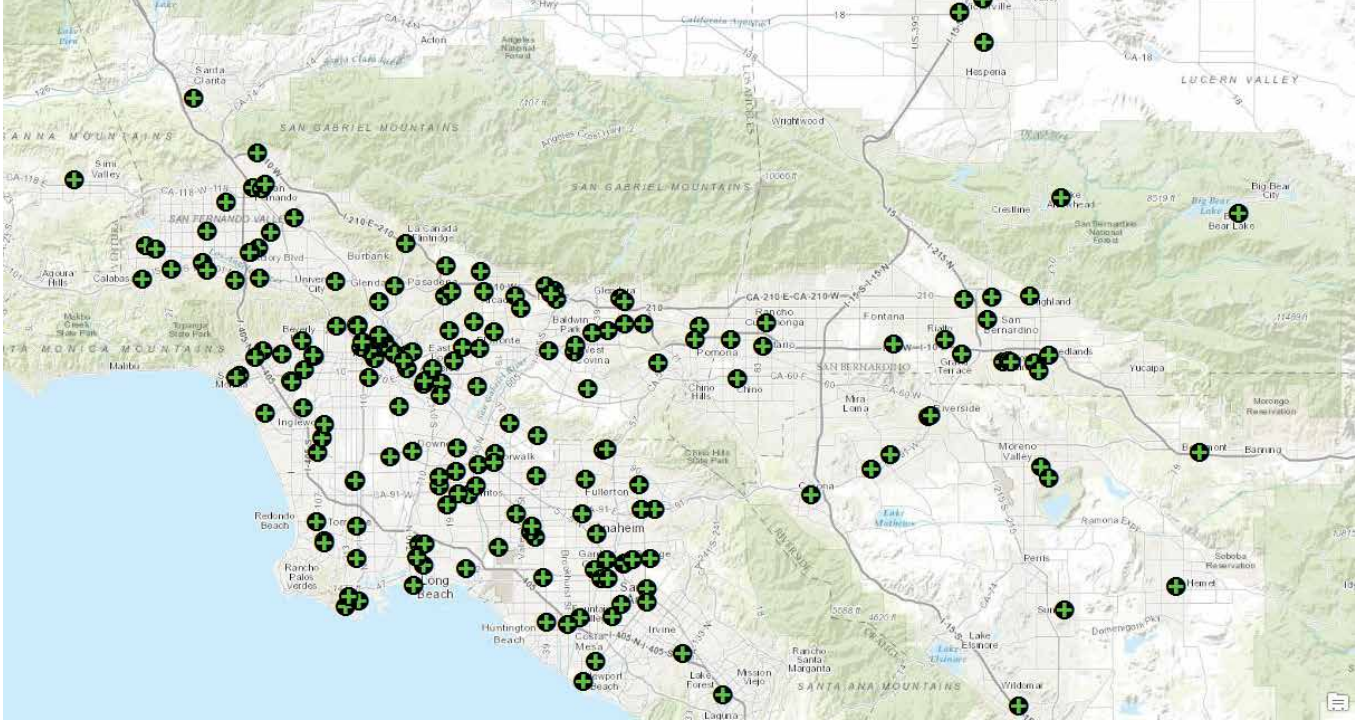
← A listing showing how to update a feature class or table name alias using the ArcPy module

↑ Filter features to display only those features needed in the published map or service using a query definition. The upper image shows all emergency facilities. The lower image displays only hospitals and symbolizes them appropriately.

previous step. This means that if you want a layer name formatted in a particular way in an application, that formatting must occur manually or automatically at some point upstream from that app. Data managers can aid their publisher comrades by implementing things like feature class aliases, field aliases, and proper metadata early in the publishing workflow. With rigorous implementation, an effective data manager can handle around

90 percent of the configuration that publishers would otherwise be burdened.

Suppose your organization maintains a roads feature class called "city_rds" that has field names that are similarly abbreviated. This type of naming convention is extremely common in desktop GIS environments—and for good reason. Table and column names are frequently constrained by naming conventions for file and

versioned geodatabases required so that names will be valid.

The good news is that there is no need to change the raw feature class or field names even if 90 percent of the time you want users to see "City Roads" as the name of that layer. The geodatabase allows data managers to implement user-friendly aliases in the raw GIS data. This can be done manually in ArcCatalog or automatically

using the arcpy.AlterAliasName function for tables and feature classes and using the arcpy.AlterField_management function for fields. Using Python, aliases can easily be managed in a table for hundreds or thousands of datasets. When added to a map document, the feature class alias will display as the layer name, and the field aliases will display as the column names by default. Python scripts or other programs accessing the raw names will not be affected, so there is no need to change any code.

Exercise care with field aliases when publishing map services for ArcGIS Open Data. ArcGIS Open Data is a fantastic way for organizations to make their data accessible to the public. However, as of this writing, datasets can only be downloaded from ArcGIS Open Data in CSV (nonspatial), shapefile, or KML format. Since shapefiles only allow 10-character attribute names (and do not support aliases), consider limiting attribute aliases to 10 characters for feature classes that will be shared via ArcGIS Open Data.

Data manipulation processes sometimes result in feature classes with a lot of duplicate, confusing, unused, or empty fields. It's a good idea to remove these in the master source data so that publishers don't need to hide them later on. Consider ways to identify and remove duplicate fields and fields containing 95 percent or more null values. Nothing confuses the public more than a pop-up with confusing or unhelpful attributes. Worse, extra attributes will hurt performance.

What about Metadata?

I've seen it again and again in REST service directories: loads of useful and interesting data published on ArcGIS for Server with zero documentation available to the user. How can organizations be confident that their authoritative data and services will be used appropriately in this situation?

If your organization uses Esri's framework for managing its metadata, which is stored in the geodatabase, modified in XML, and available in multiple styles, then good for you. Much of the work is already done. Your data is documented in its raw form, and the core metadata components will propagate down through the publishing workflow with minimal burden on your publishers. If not, think about ways to migrate your metadata content stored in some other system into the feature layer descriptions in your published map documents.

There is still the need for service-level documentation so users can access the description, credits, tags, and other information specific to a service. These properties are added using the frequently overlooked Map Document Properties dialog box in ArcMap. Fortunately, the ArcPy mapping module makes the metadata for map services (and the specific layers those services contain) quick and easy to add. ArcPy mapping enables programmatic access to nearly all the map document and layer properties that provide metadata to published map services. Savvy admins can easily design forms and tools to collect service metadata from the requester, publisher, or customer and update it in all the right places so publications are thoroughly documented.

Maximize Performance

As the number of end users for your Web GIS grows, you'll want to consider how you can maximize the performance of your

↓ If individual buildings within each hospital complex will be represented as polygons, set a scale dependency on the hospital building polygon layer so that it only draws at or below a neighborhood scale.

Item	At Scale	Layer Name	Refresh Time (sec)	Recommendations	Features	Vertices
1	8,960,961	Sensitive Areas	.03		502	67,560
2	8,960,961	Easement Lines	.31	set scale dependency: features fetched=15106;	15,106	846,740
3	8,960,961	Roads	15.33	set scale dependency: features fetched=1793328;	1,793,328	33,044,712
4	5,000,000	Sensitive Areas	.03		502	67,560
5	5,000,000	Easement Lines	.33	set scale dependency: features fetched=15106;	15,106	846,740
6	5,000,000	Roads	16.55	set scale dependency: features fetched=1793328;	1,793,328	33,044,712
7	2,500,000	Sensitive Areas	.03		256	27,912
8	2,500,000	Easement Lines	.13	set scale dependency: features fetched=5933;	5,933	237,742
9	2,500,000	Roads	10.80	set scale dependency: features fetched=1111729;	1,111,729	16,231,769

↑ An excellent (and free) command line performance diagnostic tool called mxdperfstat will clock the draw speed of every layer in your map document at a range of different scales and generate a user-friendly report that even recommends actions that can speed up slow-drawing layers.

Web GIS products. In most cases, this means keeping the draw time for map services as short as possible. Fortunately, the same practices that result in a fast map document will result in a fast map service. I consider three main areas when approaching map performance: filtering to limit the number of features, limiting vertices (or eliminating them altogether through rasterization), and creating indexes.

Effective filtering limits the number of features displayed at a particular scale or in the whole map. Fewer features equal faster draw time. Scale dependencies are a good place to start.

Consider at what scale range each layer should be viewed and set scale dependencies accordingly. If you are publishing a service to be used in a web map that will show state emergency planners the distribution of hospitals in their state, set a scale dependency on your hospital points layer that will make the points invisible beyond a statewide scale. If individual buildings within each hospital complex are to be represented as polygons, set a scale dependency on the hospital building polygon layer so that it only draws at or below a neighborhood scale.

Creating definition queries is another important technique for filtering data. Employ definition queries to filter out features not needed in the published rendering of your data. If hospitals are the only features you need to show, create a definition query

that prevents other types of buildings from being displayed.

Limiting the number of vertices returned by a request to ArcGIS for Server will help optimize the performance of dynamic map services. When a web client makes a request to ArcGIS for Server, the server delivers a text-based representation of the geometry, attributes, labels, and renderer. With that information, the application generates an image displayed on the map. For vector data, the coordinates of the vertices that form the points, lines, and polygons you want to draw make up a huge chunk of the information delivered to the client, so limit the number of vertices returned by each request to the server whenever possible. Consider using definition queries, scale dependencies, and cartographic generalization to reduce the number of vertices. Remember: if a layer draws slowly in ArcMap, it will also draw slowly in a web map.

If publishing a vector layer with only one important attribute, consider rasterizing the layer and publishing it as an image service. Raster datasets frequently draw much faster than vector datasets, especially when the vector dataset contains many long, skinny, snake-like features, which are hard to index efficiently.

Indexing GIS data is just like indexing a lengthy, complicated book—it helps find the information you need much faster than hunting through each page for a particular word or phrase. In GIS, we are referring to

spatial indexes and attribute indexes. File and enterprise geodatabases automatically generate spatial indexes, but they should be reindexed after lots of new features are added or if the extent of a feature class has been drastically changed. When preparing GIS data for publication, think about which attributes will need to be queried frequently and consider indexing those attributes. Although I haven't quantified this, I think it is a good idea to also index attributes that participate in label expressions, definition queries, and symbology schemes.

Luckily for draw speed freaks like me, there is an excellent (and free) command line performance diagnostic tool called mxdperfstat. Developed by the Esri Enterprise Implementation Team with ArcGIS Engine, mxdperfstat will clock the draw speed of every layer in your map document at a range of different scales and generate a user-friendly report. Mxdperfstat even recommends actions that can speed up slow-drawing layers. This tool can be run directly from the command line or called with Python's subprocess module within the Python window in ArcMap or in a custom script tool.

I hope these practices will help your organization embrace and optimize Web GIS. Wishing you happy publishing. For more information, contact

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About the Author

Micah Babinski has worked in GIS for more than six years in the nonprofit, public, and private sectors. He is currently a GIS project manager for Elyon International, working under contract with the Bureau of Land Management in Portland, Oregon. Babinski graduated from the University of Washington Geography program. His particular interests in GIS include Python, data management, natural resources, and open data. He is an Esri-certified ArcGIS Desktop Professional and hopes to continually improve his skills while helping others become more efficient GIS workers.

Sharing Geoprocessing Tools via the Web

By Benjamin Pross, Christoph Stasch, and Albert Remke, 52°North Initiative for Geospatial Open Source Software GmbH; and Satish Sankaran and Marten Hogeweg, Esri

The 52°North Initiative for Geospatial Open Source Software has developed an open-source extension to ArcGIS for Desktop that enables access to Open Geospatial Consortium, Inc. (OGC), Web Processing Services (WPS) so they can be used in the same manner as native ArcGIS geoprocessing tools.

Geoprocessing tools make it possible to analyze, transform, and combine geographic datasets and generate information that can be visualized in maps and used as an aid to decision-making. ArcGIS offers a wide range of geoprocessing functionality in its toolboxes and extensions. There are many ways ArcGIS users can use geoprocessing

↓ Figure 1: ArcGIS WPS Client architecture
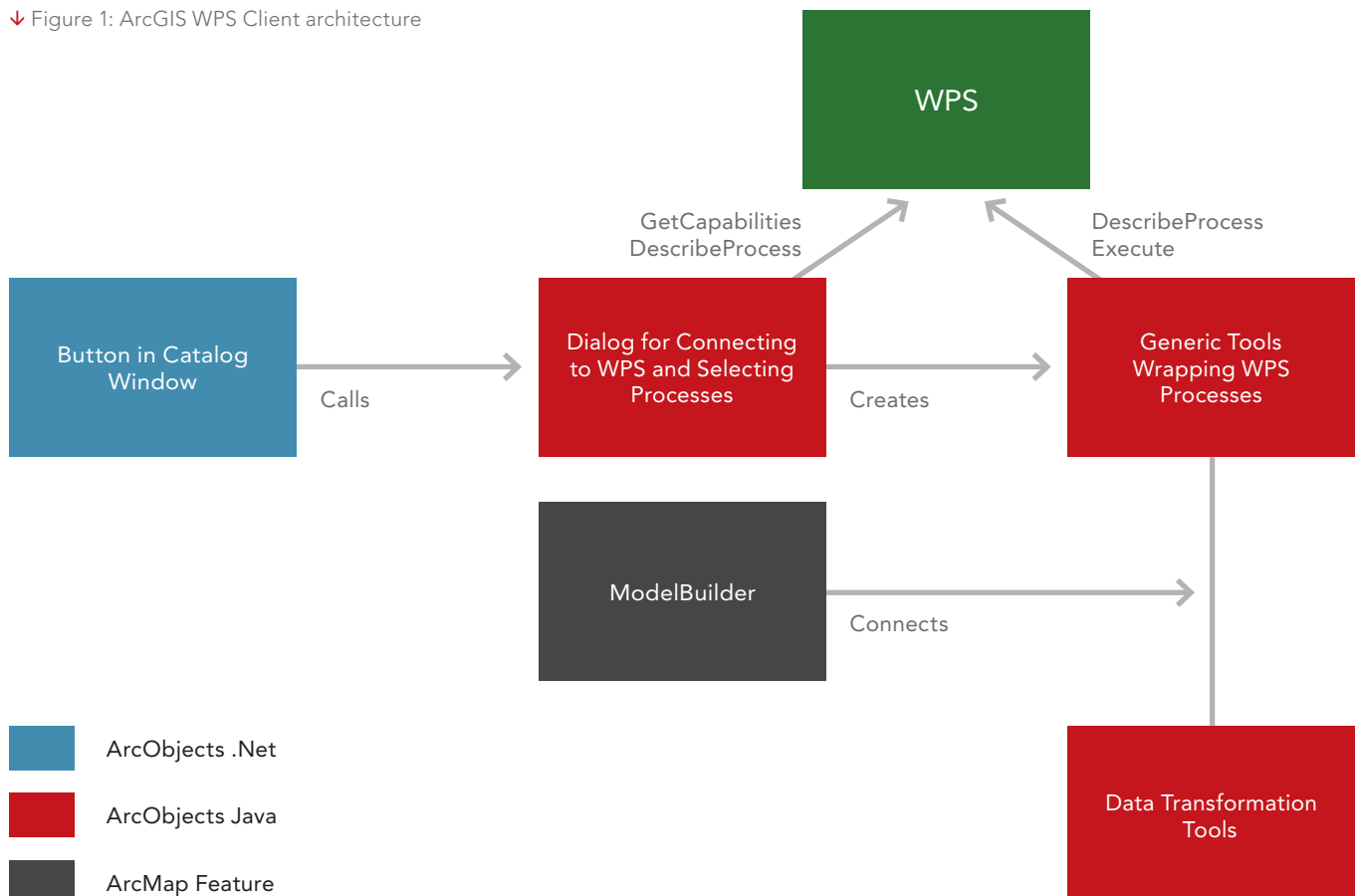
tools within the familiar desktop environment. They can download new tools from the Analysis and Geoprocessing Tool Gallery, build their own tools with ModelBuilder, use custom ArcGIS for Server geoprocessing services, and invoke services offered by ArcGIS Online.

Users can now also publish a geoprocessing tool as a WPS. The WPS interface specification is an international standard published by OGC that provides rules for standardizing inputs and outputs and (according to the OGC specification) "defines how a client can request the execution of a process and how the output from the process is handled." It supports the integration and mashup of geoprocessing functionality from arbitrary sources. A processing tool published as a WPS can be used by any client software that implements the WPS interface in line with the OGC WPS specification.

However, while ArcGIS allows geoprocessing tools to be published as a WPS, it does not offer a WPS client interface. Consequently, it is not easy to access external non-ArcGIS geoprocessing tools such as simulation models, rich data interfaces, or processing capabilities from any other legacy software that supports the WPS interface.

WPS Interface Standard Versions

The OGC released the first version of the WPS interface standard (version 1.0.0) in 2007. The goal was to facilitate discovery and access of geoprocessing tools via the web. Since version 2.0 of this standard was published in 2015, implementations of this new version are still rare.

The WPS 1.0.0 interface offers three operations: GetCapabilities, DescribeProcess, and Execute.

- The GetCapabilities operation provides access to general information about a WPS and its processing capabilities.
- The DescribeProcess operation provides detailed information on processing tools such as the input and output data formats.
- The Execute operation can be used to invoke the execution of a geoprocessing tool with specified input data and control parameters.

Lengthy computations can be executed in asynchronous mode so that the client can focus on other things while the computation is ongoing. It can query the status from time to time and fetch the results after the computation has been completed. Both the processing functionality and the formats of the input and output data may be of any kind, keeping the WPS highly generic.

In practice, there are numerous WPS implementations based on many different technologies such as the 52°North WPS, pyWPS, or Esri's WPS based on ArcGIS. Most of these implementations focus on the server-side provision of WPS. Many clients are tailored to a specific service counterpart, which limits their reusability. Only a few generic clients are available, such as the WPS client for QGIS or web clients based on OpenLayers. However, the limited support of data formats often causes significant interoperability problems.
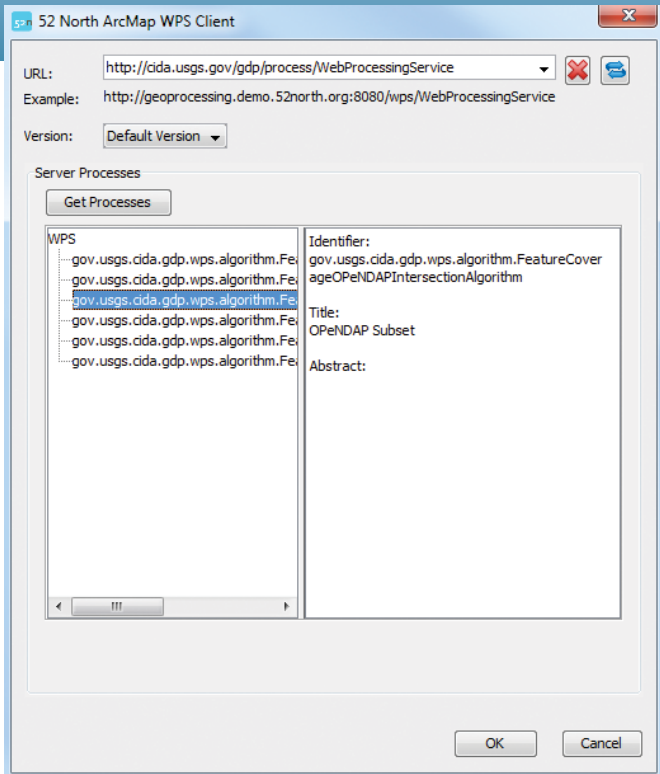
Using WPS with ArcGIS

The 52°North Extensible WPS Client for ArcMap was implemented as an open-source extension to ArcGIS that fully integrates into the
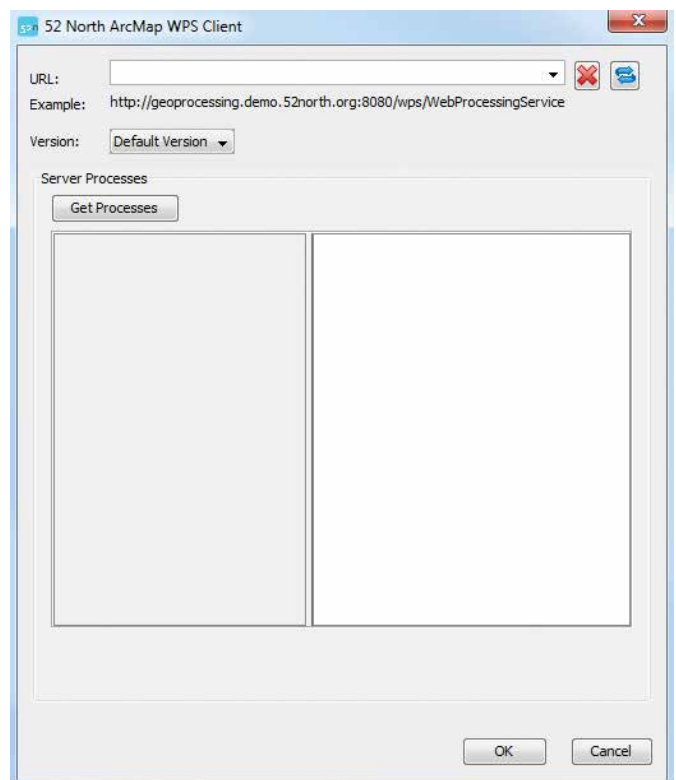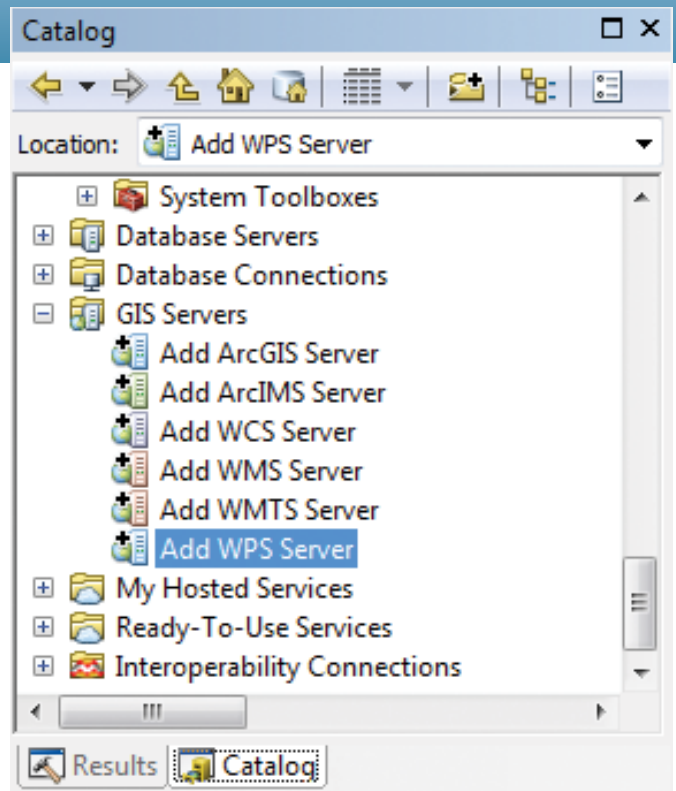
↑↑ Figure 2: Add WPS Server item in ArcCatalog window

↑ Figure 3: Entering a WPS URL

ArcGIS for Desktop environment. It enables OGC WPS to be accessed and used in the same manner as native ArcGIS geoprocessing tools. This makes it easy to run WPS-based processes and integrate the results of that processing into ArcMap for use with other applications. The diagram in Figure 1 illustrates the architecture of the software.

This example describes how to use the WPS client for executing an external process offered by the United States Geological Survey (USGS) to allow the download of coverage datasets that intersect a given vector feature. The desired parameter (in this case, precipitation) and the time period of interest can be specified.

Use ArcCatalog to add a new WPS by choosing Add WPS Server as a new item (as shown in Figure 2). Add WPS Server is located in the GIS Servers section with other OGC services (such as WFS, WCS, or WMS) that can be added to ArcGIS.

After clicking Add WPS Server, a dialog box very similar to the dialog box for adding a WCS service will appear (as shown in

← Figure 4: Displaying metadata describing the WPS and its processing capabilities

↓ Figure 5: WPS as a toolbox
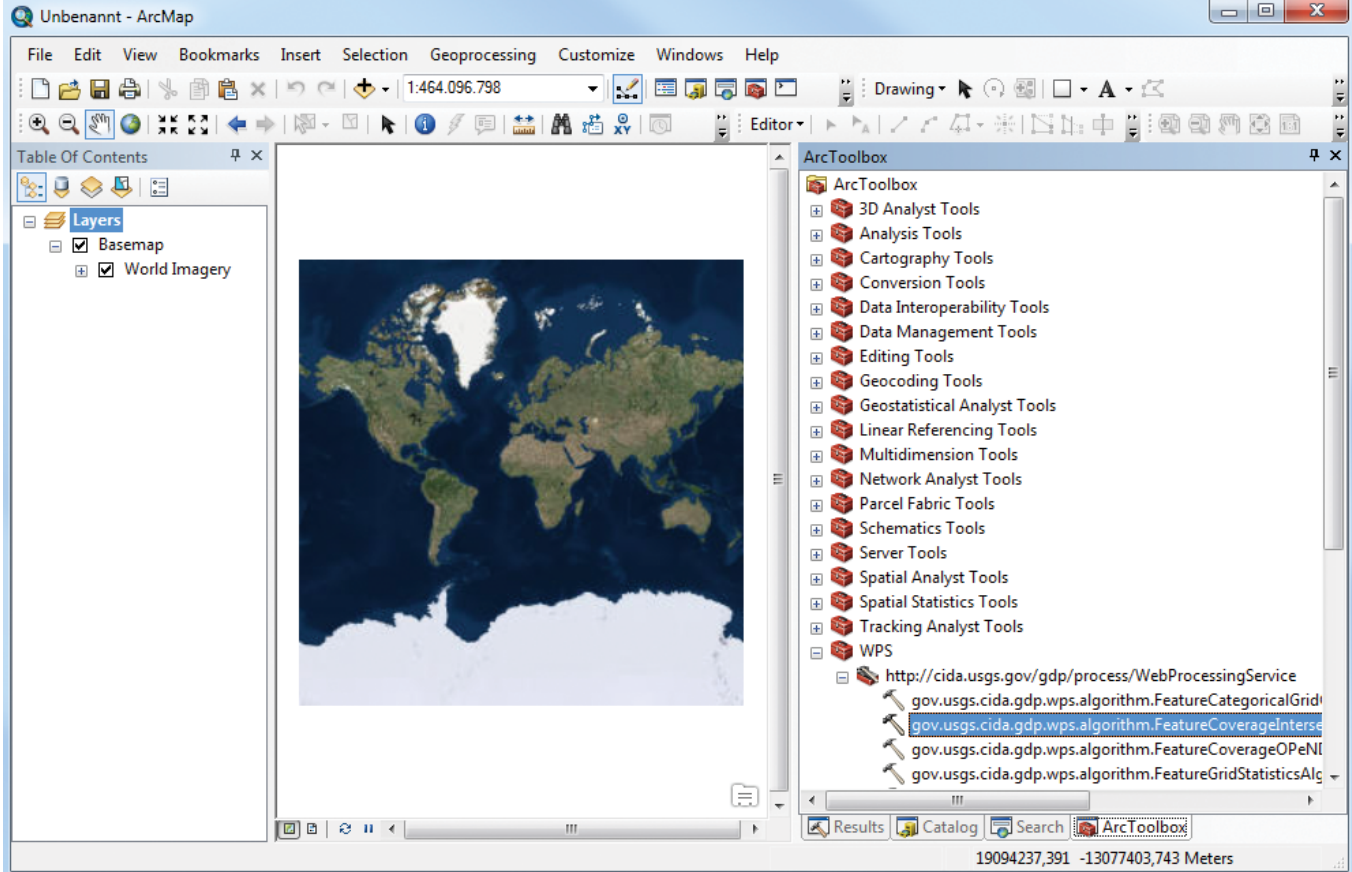
Figure 3). The installation comes with a predefined list of WPS URLs. Server URLs can also be typed into the text field and stored for later reuse. The currently supported default is WPS version 1.0.0.

After connecting to a WPS server, the processes offered will be listed in the center-left area of the client window (as shown in Figure 4). On the right, you will find additional information about the currently selected process.

After selecting one or more processes, click OK. These processes will be turned into geoprocessing tools (process tools) and will be added to the user's toolbox.

All processing tools made available by an individual WPS are grouped in a toolset with the WPS URL as its name. (Figure 5 shows a selection of WPS processing tools.) The overall WPS toolbox containing all WPS toolsets is added to the ArcToolbox for convenience.

Double-clicking a processing tool invokes the standard ArcGIS tool dialog box (as shown in Figure 6). This is where you can specify the inputs and outputs of the WPS process. For complex outputs, a file path is generated automatically.

The processing tools can be executed directly, depending on the format of the inputs and outputs. Figure 7 shows a process tool with completed input and output fields.

For complex inputs that are not sent by reference, ModelBuilder can be used to connect processing tools to custom import and export tools that transform ArcGIS layers into a format that the WPS can handle, and vice versa. Some of these tools are shipped with the client, while others can be downloaded or created by the user. This means that the client can be easily extended to support new formats. Figure 8 shows a processing tool connected to an import and export tool in ModelBuilder. (Figure 9 shows the results of model execution.)

Outlook

The Extensible WPS Client for ArcMap will be continually improved by the 52°North geoprocessing community. The next minor release will provide some extended logging capabilities. The next major step is to add support for the WPS 2.0 interface and for WPS profiles. In addition to improvements to the client itself, an increase in the number of specialized import and export tools is planned as well as improvements in methods for finding new tools.
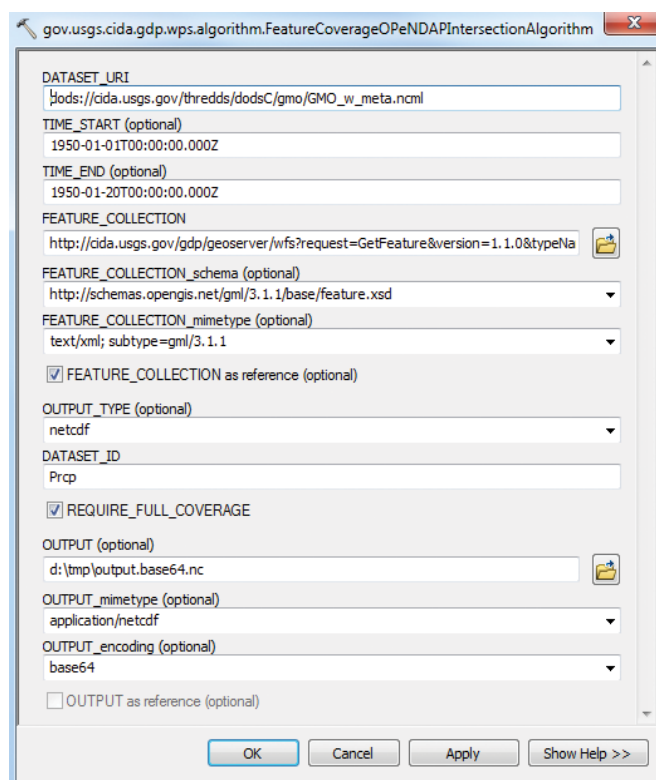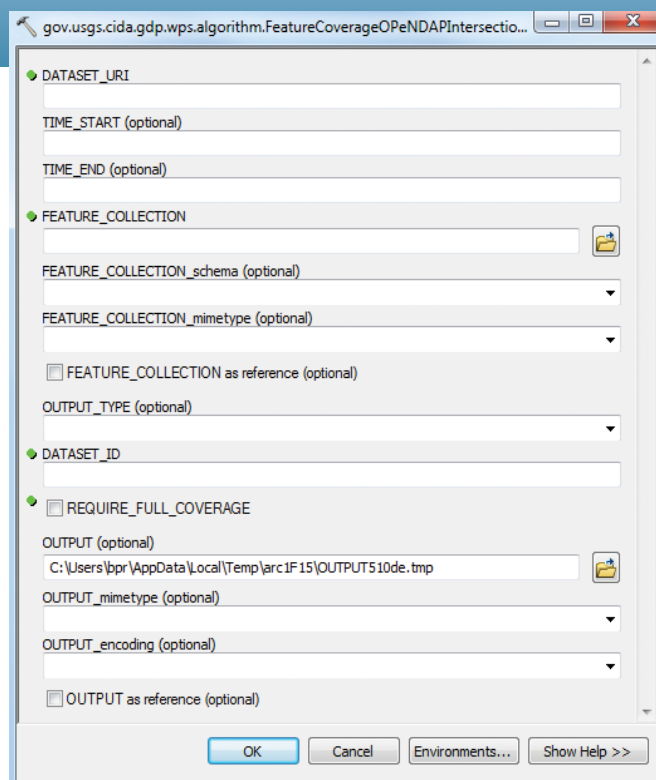
For more information, contact Benjamin Pross, software engineer at 52°North, at b.pross@52north.org or Satish Sankaran, product manager at Esri, at ssankaran@esri.com.

Additional Resources

Extensible WPS Client for ArcMap
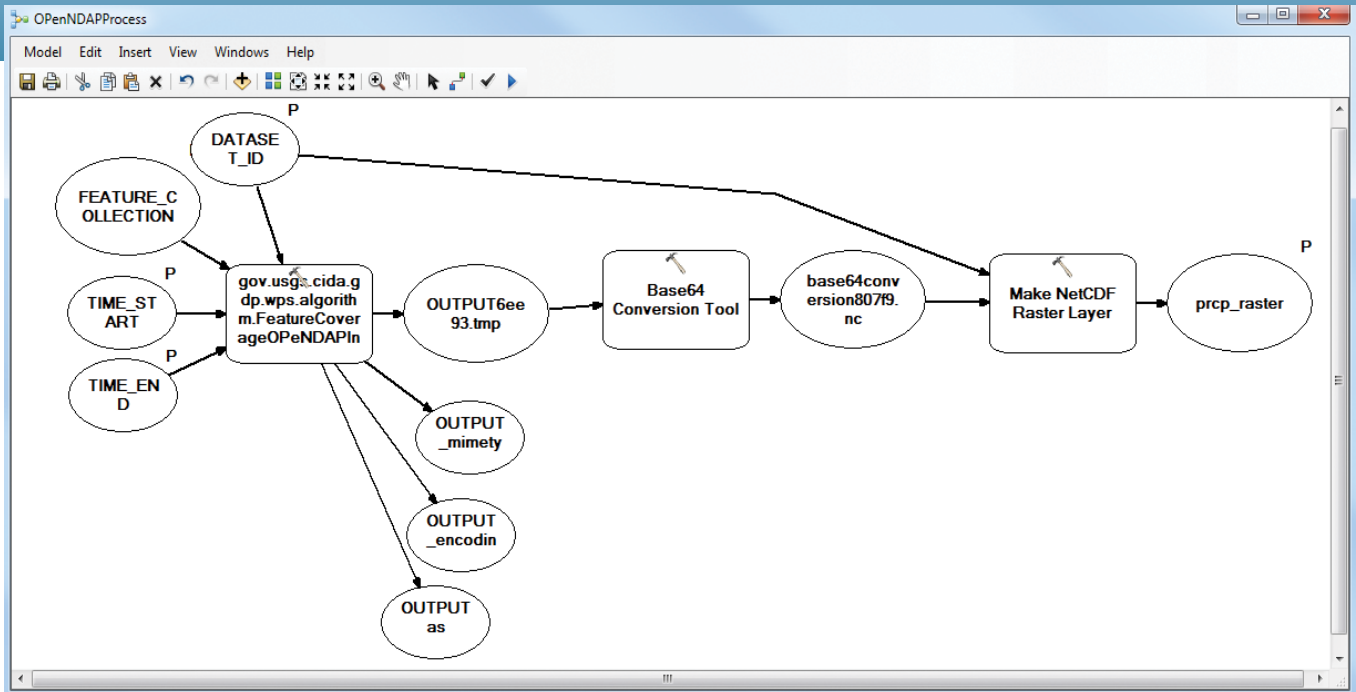52north.org/communities/geoprocessing/wps/clients/arcmapclient.html

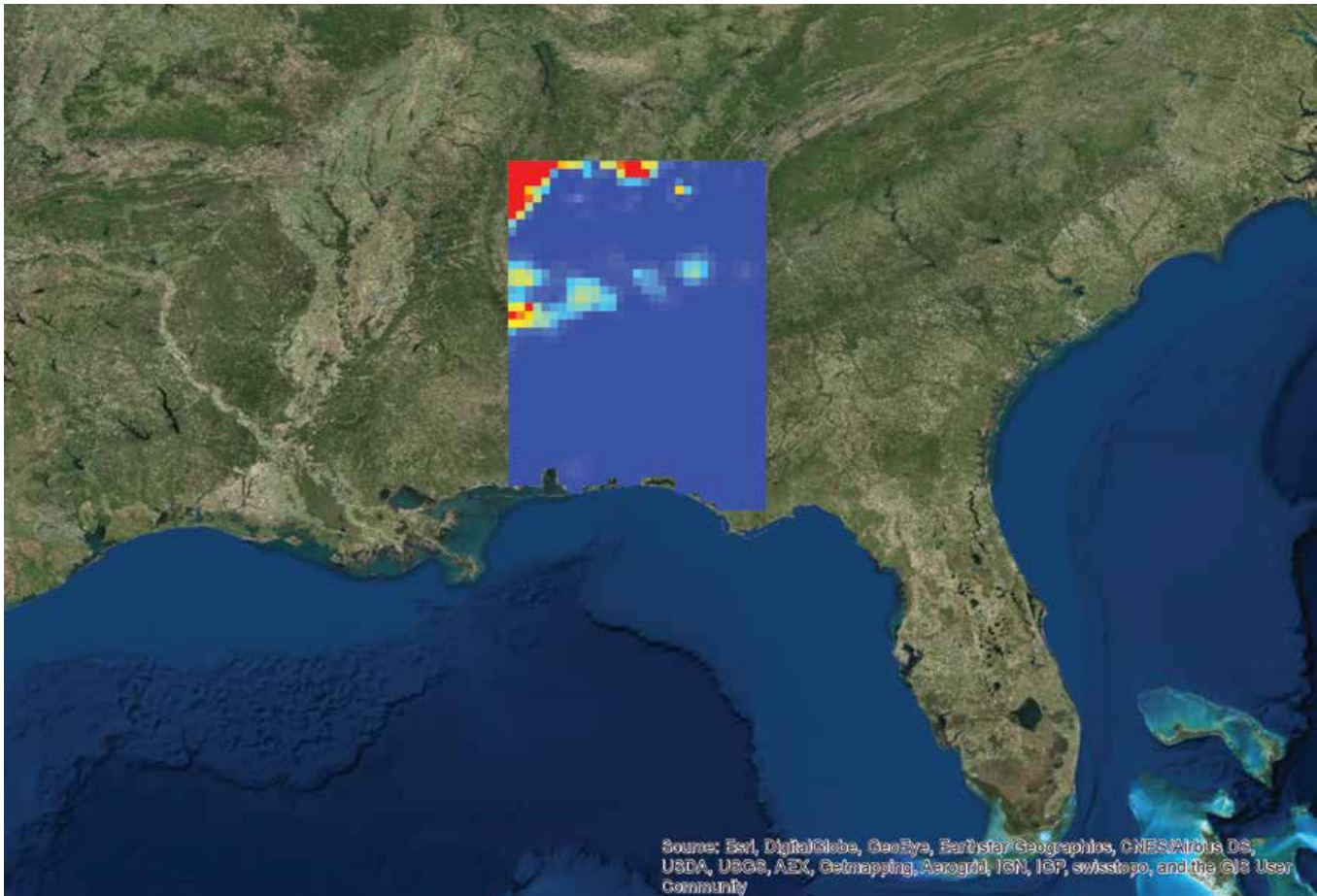## Source Code on GitHub

github.com/52North/wpsclient4arcgis

↑↑ Figure 6: Initial geoprocessing tool dialog box for a remote WPS process

↑ Figure 7: Completed geoprocessing tool dialog box

↑ Figure 8: Using ModelBuilder to work with WPS-based processing tools

↓ Figure 9: Precipitation in Alabama from 1/1/1950 to 1/20/1950 shown as a time-enabled NetCDF dataset

ArcGIS Code Sharing

Easily find and share scripts and code

For all of you who miss ArcScripts, you now have the ArcGIS Code Sharing site (codesharing.arcgis.com). This new site, announced at the 2016 Esri User Conference, fills the role of the popular code sharing site that was retired in 2010 and will include even more types of items.

With ArcGIS Code Sharing, you have a central location for discovering ArcGIS scripts, add-ins, and other code samples contributed by other GIS professionals and geodevelopers that will help you be more productive and learn how to do more with ArcGIS. It also is a place for sharing your own work with the GIS community.

ArcGIS Code Sharing has a simple user interface for discovering and sharing contributions. The site currently supports ArcGIS scripts, add-ins, and code samples and soon will support models, extensions, widgets, themes, styles, and other items.

Once at the ArcGIS Code Sharing site, simply log in using your Esri Global Account credentials and search or browse for items. You can filter items by language (C#, Python), software product (ArcGIS Pro, ArcGIS Web APIs), or result type (code sample, add-in, geoprocessing sample). Once you locate the item you want, you can download it or go to its associated web page.

To share your own work with others using the ArcGIS Code Sharing site, click the UPLOAD SCRIPTS button, fill out a few fields, add some tags, and upload the file. Because the ArcGIS Code Sharing site is part of ArcGIS Online, when you share things through it, those items will also appear and can be managed using the My Content tab of your ArcGIS Online account. When you share code and other items with everyone through your My Content tab, these items will automatically appear in and be searchable on the ArcGIS Code Sharing site. Don't forget, you can also locate and share code samples on GitHub as well as ArcGIS Code Sharing and ArcGIS Online.

↓ ArcGIS Code Sharing has a simple user interface for discovering and sharing contributions.

Ensuring a Better Future

Do you know what kind of future you are planning?

Is it a future that preserves the quality of air, water, and land systems for our descendants? Because a sustainable future does not happen by default or by accident, Esri launched the Green Infrastructure initiative to help you and decision-makers—both within and outside of government—plan a better future for the United States using GIS.

There is a pressing need to ensure that the nation's valuable landscapes are not sacrificed as a result of development that is haphazard or poorly conceived. Unlike the gray infrastructure of bridges, roads, dams, and other structures, this green infrastructure is precious and cannot be rebuilt once it is lost.

Green infrastructure is actually an old idea that has new vitality, thanks to GIS technology. Frederick Law Olmsted, the acknowledged founder of American landscape architecture, recognized the value of setting aside tracts of land and preserving natural scenery for the enjoyment of everyone, not just the wealthy. Olmsted was a board member of the commission appointed to oversee the first national park, Yosemite. In his 1865 report, Olmsted noted that the preservation of the area's scenic beauty would generate not only economic returns from tourism but also tremendous benefit to the physical and spiritual well-being of the nation's inhabitants.

The objective of the Green Infrastructure initiative is a systematic, information-based method for transforming communities in the United States into sustainable centers by identifying and preserving an interconnected system of landscapes at regional, local, and urban scales. This means addressing green infrastructure proactively at the beginning of the planning process, rather than reactively at the end.

A green infrastructure approach to development identifies critical landscapes of ecological, scenic, and cultural value and preserves them. Ecologically valuable landscapes contain features that benefit all living organisms in an area, not just people. Scenic and culturally valuable landscapes are characterized by recreational areas, viewsheds, and similar features that increase property values and promote tourism.

To be effectively safeguarded, these areas must be considered on multiple scales—regional, local, and urban. At each scale, maintaining the connectivity of open spaces, habitats, and parks is important because connectivity provides a resilience to the components of these landscapes that helps them survive challenges, such as climate change, better than isolated areas.

Previously, environmental concerns were set aside in favor of what was perceived as economic necessity based on the belief that these were competing rather than complementary aspects of a truly sustainable future. Green infrastructure makes solid economic contributions. Preserving watersheds protects the water supply and safeguards the health of human populations that use that water as well as the vegetation and wildlife that depend on it. Keeping coastal areas intact mitigates the effects of storm events and limits damage to buildings and other structures. Unmarred scenic views are valued and enhance property values.

Currently the majority of local government entities that regulate the use of the land base in the United States do so in isolation from each other and often without tools to effectively assess existing conditions or model the effects of proposed policy changes.

> Green infrastructure makes solid economic contributions.

How Green is Your Community?

Enter your ZIP code into the map on the "Current" tab to ensure you are balancing development with green infrastructure.
Enter your ZIP code on the "Future" tab to measure the sustainability of your planning decisions and compare current land-
use conditions with 2050 land cover predictions to see where you'll be.

Launch App Full Screen
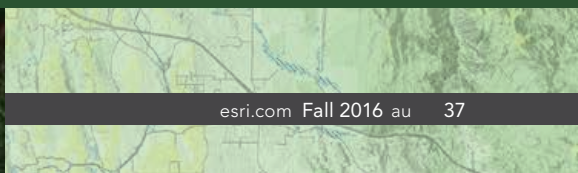
The time for implementing green infrastructure is now because GIS provides the tools needed to integrate, analyze, visualize, collaborate, and communicate this new vision for the nation.

GIS is essential to a green infrastructure approach to planning because it reverses the prevailing paradigm of developing first and relegating any leftover areas to green space afterward. Green infrastructure planning is fundamentally a spatial problem. With GIS, data about the natural world and built environment—from many sources, in a variety of formats and range of scales—can be combined and modeled to uncover patterns and perceive relationships.

Although GIS makes planning with accountability and metrics possible, a national dataset identifying intact, natural areas was needed. To enable a GIS-enabled approach to green infrastructure planning, Esri created a dataset using National Land Cover Database 2011 for the initiation definition of these "cores," or intact areas. The result was the National Intact Habitat Cores Database.

Using this dataset, Esri compiled the first national green infrastructure map depicting every intact natural area larger than 100 acres in the United States regardless of ownership or preservation status. This map shows areas of ecological, cultural, and scenic importance. Local and regional data can be combined with this national map to evaluate the current state and probable future of an area given planning policies. This lets decision makers determine what action will be required to preserve these valuable landscapes.

A suite of green infrastructure planning tools is available across the ArcGIS platform as online tools and desktop toolsets for use with the National Intact Habitat Cores Database. A simple online tool that lets anyone assess the current state of green infrastructure in their area is available at esri.com/greeninfrastructure on the Current tab. At the same site, on the Future tab, tools for modeling scenarios based on filtering and weighting the core data to reflect community values can be used to generate layers that can be viewed or used with GeoPlanner for ArcGIS.

GeoPlanner for ArcGIS is a web application for planning professionals that is integrated with ArcGIS Online and runs in desktop and tablet web browsers. A premium app offered in the ArcGIS Marketplace, it provides tools that support every step in an end-to-end, geoenabled planning and design workflow. Esri also provides toolsets for ArcGIS for Desktop and ArcGIS Pro that are available at no charge from ArcGIS Online.

Planners, elected officials, researchers, businesses, and the public can find out the status of the green infrastructure in a community now and extrapolate the effects of current planning on the landscape. Local and regional data can be combined with the national map to evaluate the current state and probable future given current planning to see what action is required to preserve these valuable landscapes.

Communities can preserve natural habitats, protect biodiversity, promote healthier lifestyles, and improve quality of life by supporting intelligent and balanced growth. This approach to planning evaluates likely results against values.

Applying a green infrastructure approach to a community encompasses these four steps:
1. Critically evaluate the community's land development policies.
2. Compare benchmarks for the community to other communities.
3. Include a green infrastructure element in the community's comprehensive land-use plan.
4. Use GIS analysis and tools to ensure that the community stays on track to preserve its green infrastructure.

You can take the first step toward a more sustainable future by finding out the green infrastructure score of your community by going to esri.com/greeninfrastructure and entering your location.

# The time for implementing green infrastructure is now . . .
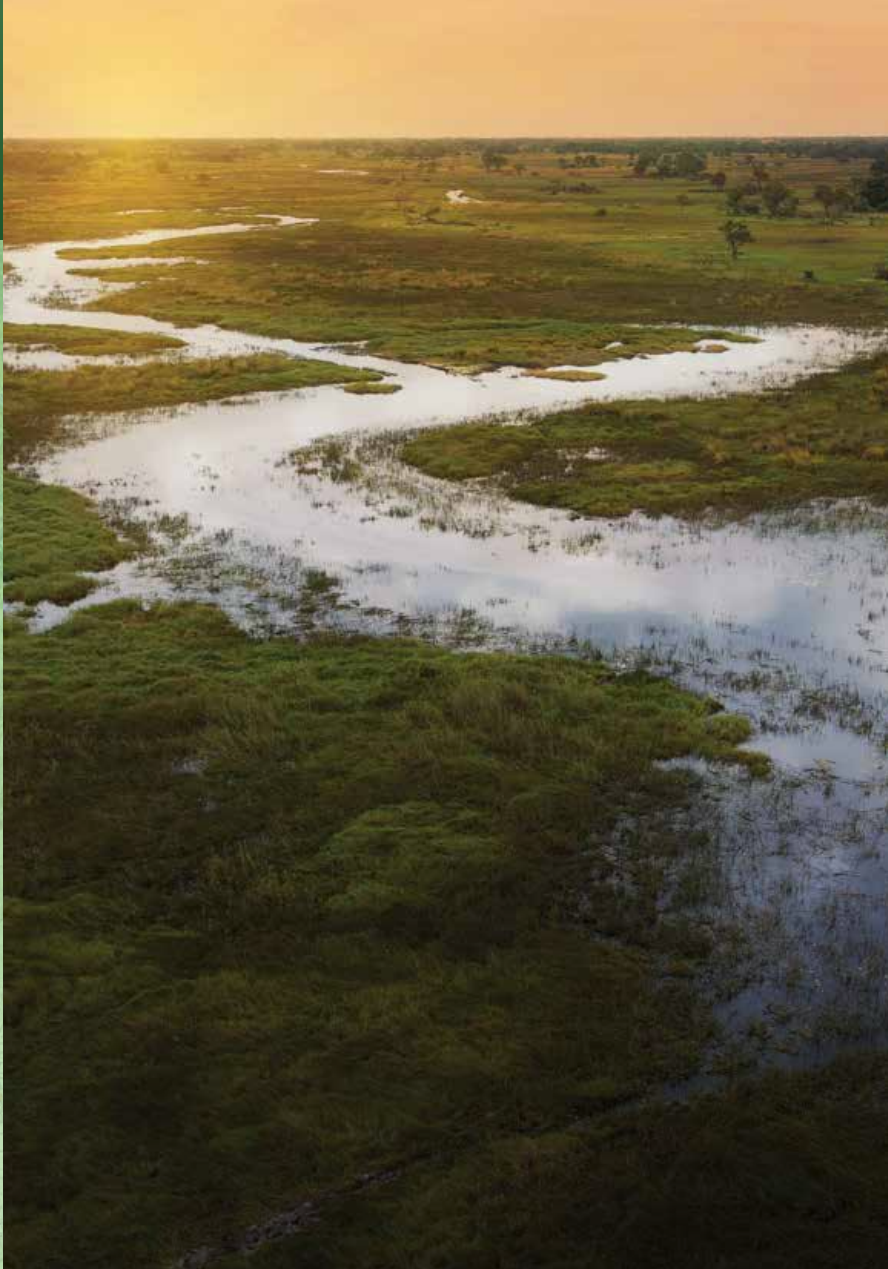
Green Infrastructure Planning
Using GeoPlanner for ArcGIS

What You Will Need

- An ArcGIS Online organization subscription with an administrator role
- A license for GeoPlanner for ArcGIS
- An Internet connection

You may have an ArcGIS Online organization subscription that you have not activated. If you have an ArcGIS for Desktop or ArcGIS for Server license that is current on maintenance, you automatically receive an ArcGIS Online subscription. Ask your ArcGIS Online administrator to provision your account with GeoPlanner for ArcGIS.

If you do not have ArcGIS Online and/or GeoPlanner, you can use evaluation copies to work this tutorial. Obtain evaluation copies of ArcGIS (which includes ArcGIS Online) and GeoPlanner for ArcGIS at esri.com/products/free-trials.
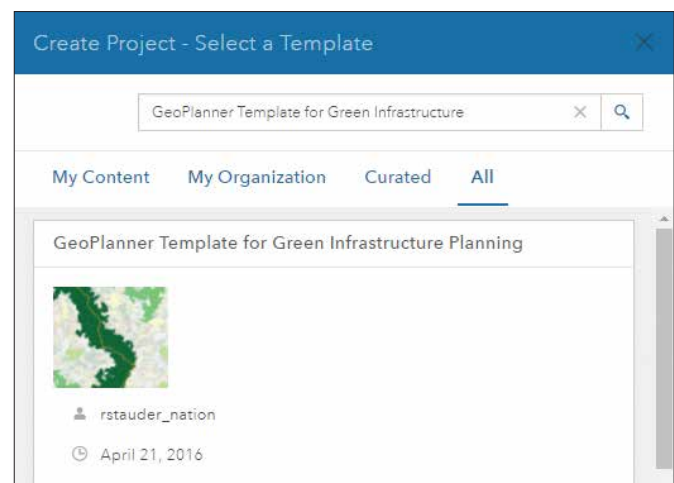
Using GeoPlanner for ArcGIS with the GeoPlanner Template for Green Infrastructure Planning provides the methodology and tools to help you apply geodesign principles and use the data on intact areas provided by Esri to identify green infrastructure and preserve it first. To learn more about the value of preserving green infrastructure, see "Ensuring a Better Future" in this issue.
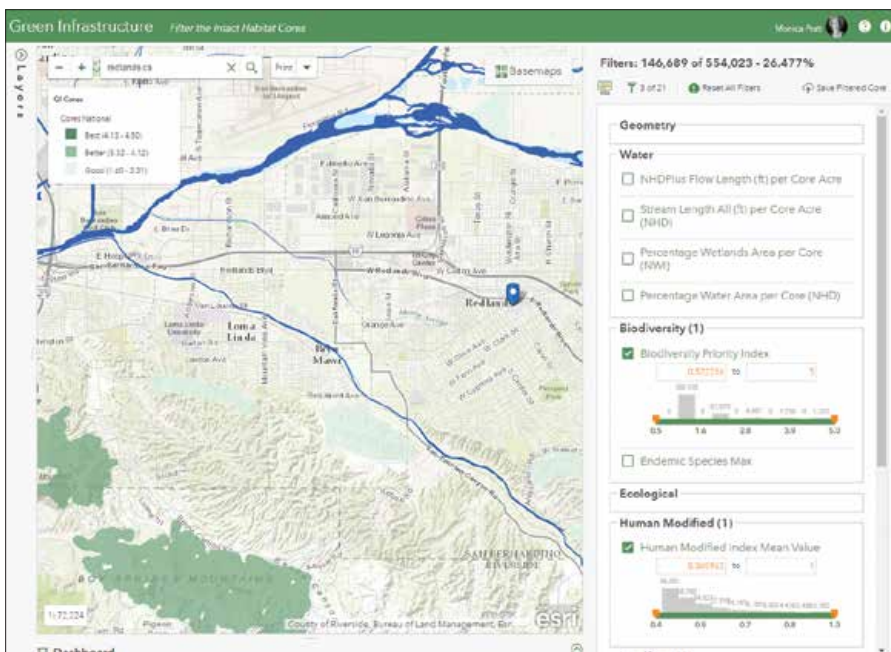
The GeoPlanner Template for Green Infrastructure Planning uses data about your community extracted from the Esri map of the National Intact Habitat Cores Database. With this data and the methodologies built into the online map, you can visualize and test land use, natural resources, and landscape architecture scenarios with real-time dashboards and sketch tools. This enables you to make evidence-based decisions about development and conservation.
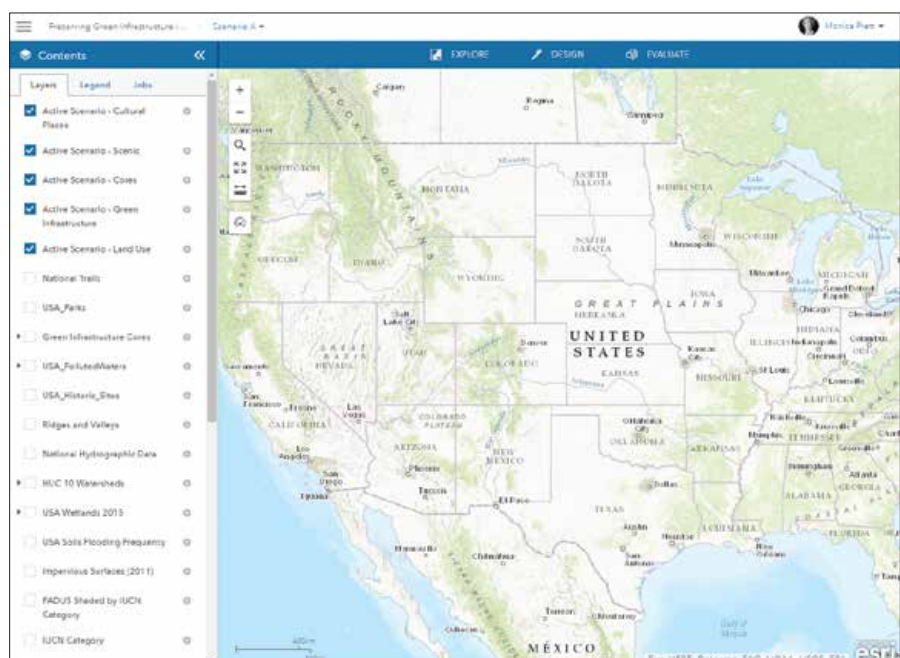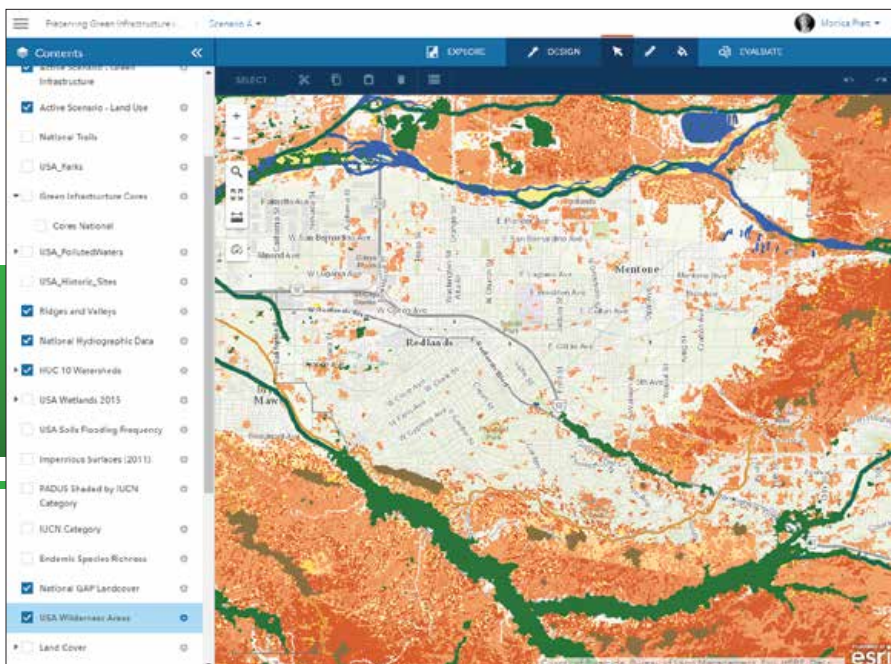
↖ The green infrastructure datasets that are automatically added have been symbolized.

↙ Filters are grouped into related topics and have a variety of settings and options. Hover over the name of a filter to learn more about it and the methodologies it employs.

↖ After signing into GeoPlanner, select All to search content for the GeoPlanner Template for Green Infrastructure Planning.

↙ Clicking Create causes the template to generate a design feature service, a scenario, and a project. When it completes this process, it opens a map that has been provisioned with green infrastructure datasets.

This tutorial provides step-by-step instructions on how to create a project in GeoPlanner that uses the GeoPlanner Template for Green Infrastructure Planning with the online apps and datasets available on the Esri Green Infrastructure website.

Getting Started

1. Go to GeoPlanner (geoplanner.arcgis.com) and sign in using your ArcGIS Online credentials if not already logged into ArcGIS Online.
2. Click Create New.
3. In the Search box in the upper-right corner of the app, type GeoPlanner Template for Green Infrastructure Planning and click All to search all locations.
4. After the search locates the GeoPlanner Template for Green Infrastructure Planning, click the Select button.
5. Provide a title, summary, description, and tags for your project. Click Create. GeoPlanner uses the template to create a design feature service, a scenario, and a project. When it completes this process, it opens a map.
6. Open the legend and notice that the template has automatically added green infrastructure datasets, such as watershed areas and green infrastructure cores, to the project and has symbolized them.

Generating a Filtered Layer

In the next steps, you will use the Set Priorities app located online at the Filter the Intact Habitat Cores page on the Esri Green Infrastructure website to filter data from the National Intact Habitat Cores database to set priorities for your community. The Set Priorities app lets you create layers that can be used for geoaccounting and assessment layers in GeoPlanner dashboards and gives a more complete understanding of how an area performs or behaves.

1. Go to the Filter the Intact Habitat

→ Once the map service is generated, open its item details page in ArcGIS Online, add information about the service, and share it with everyone.
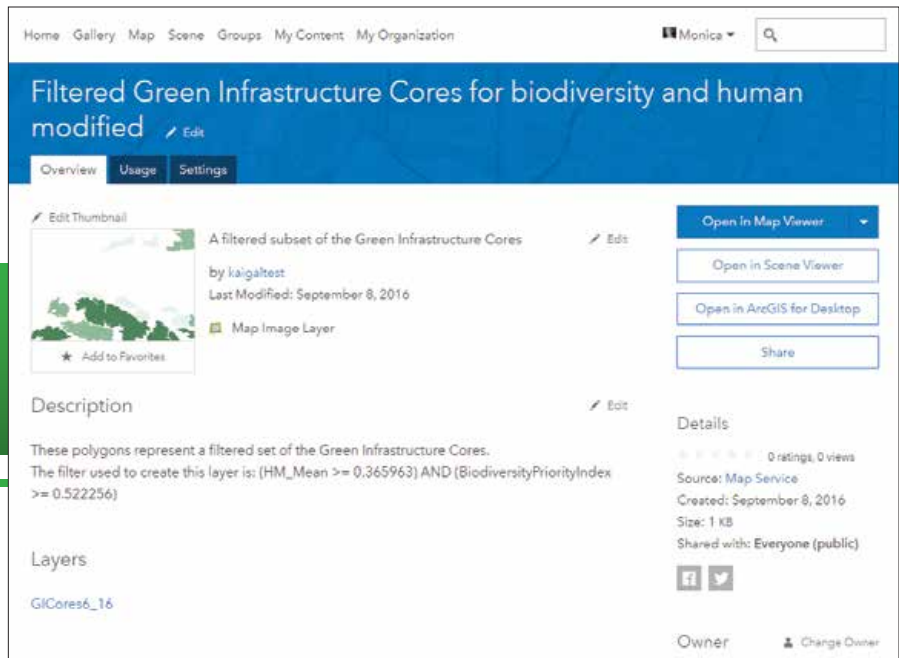
Cores page to access the Set Priorities app (green-infrastructure.esri.com/FilterCores/index.html). Sign in using your ArcGIS Online organization credentials. The list of available layers is located on the left side. The list of filters that can be applied is located on the right side.

2. Type a community name or ZIP code into the Search box to zoom to your community and enable the filters.

3. Examine the filters. They are grouped into related topics. Hover over the name of a filter to learn more about it and the methodologies it employs. Click the name of the filter then the settings wheel to see statistics, data range presets, and data range from slider values. Check the box next to the filter to view its options.

   • The Min and Max boxes let you enter minimum and maximum values for the filter.

   • The range slider sets the range of values used by the filter based on the values in the Min and Max boxes. The values used can be adjusted manually by using the + and – buttons or by clicking on the histogram bin to limit the range to that bin.

   • A histogram chart based on the current data range is displayed on top of the range slider. It uses 10 bins, and each bin is labeled with the count in that bin.

4. Adjust the settings for at least one filter to enable the Save Filtered Cores button. The map updates interactively to reflect any
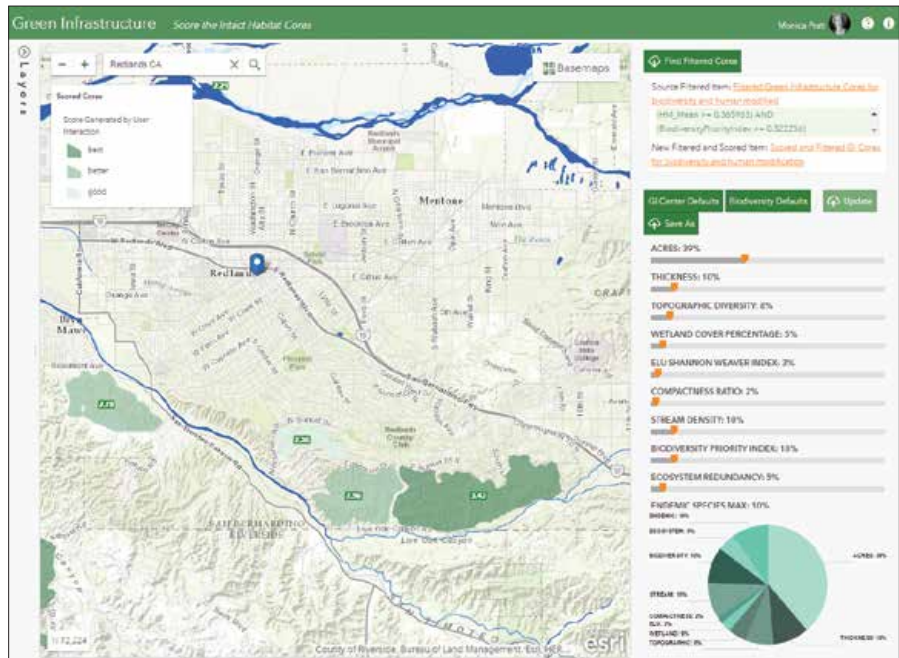

changes you make to the filter settings.

5. When finished choosing and adjusting the values for the filters, click the Save Filtered Cores button. Provide a meaningful name for the map service generated. You will receive notification when the map service has been successfully created and added as an item in the My Content section of ArcGIS Online.

↑ In the Score the Intact Habitat Cores web page of the Green Infrastructure site, change the weight for a parameter by updating the slider value. As you change relative weights, the chart will update with the new relative weights.

→ Back in GeoPlanner, add the scored and filtered core service.
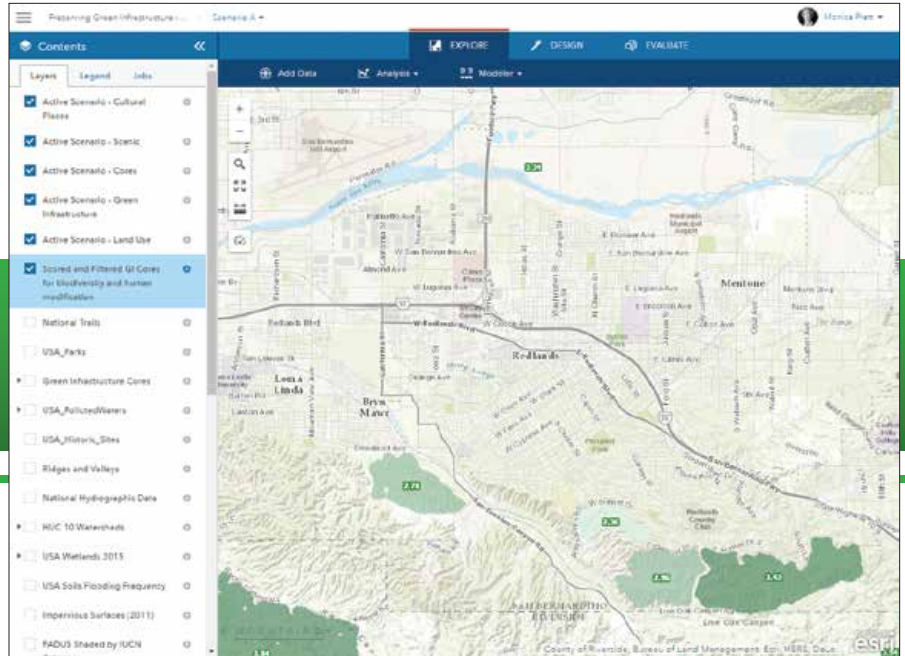
6. Open this item in ArcGIS Online and provide item details such as use restrictions. Click Share and share with everyone.

Weighting the Filtered Layers

The next steps take the filtered layers created in the previous process as input for the Set Weights app (green-infrastructure.esri.com/ScoreCores/index.html) located on the Score the Intact Habitat Cores web page of the Green Infrastructure site.

1. If you are not currently signed into your ArcGIS Online organization account, sign into the Score the Intact Habitat Cores again with your ArcGIS Online credentials.

2. Zoom to your community using the name of the location or its ZIP code to enable the Find Filtered Cores button. The filtered green infrastructure layers will be enabled if the number of filtered cores in the current view is less than 1,500 (the maximum currently allowed).

3. Click the Find Filtered Cores button and choose the filtered layers created in the previous process. Two presets are available: GI Center Defaults (default weights as defined by the Green Infrastructure Center) and Biodiversity Defaults (similar to the GI Center defaults with a slight bias toward biodiversity). The score for each core is calculated based on the user-specified weights for each parameter.

4. Change the weight for a parameter by updating the slider value. Note that all weights are relative to each other. As you
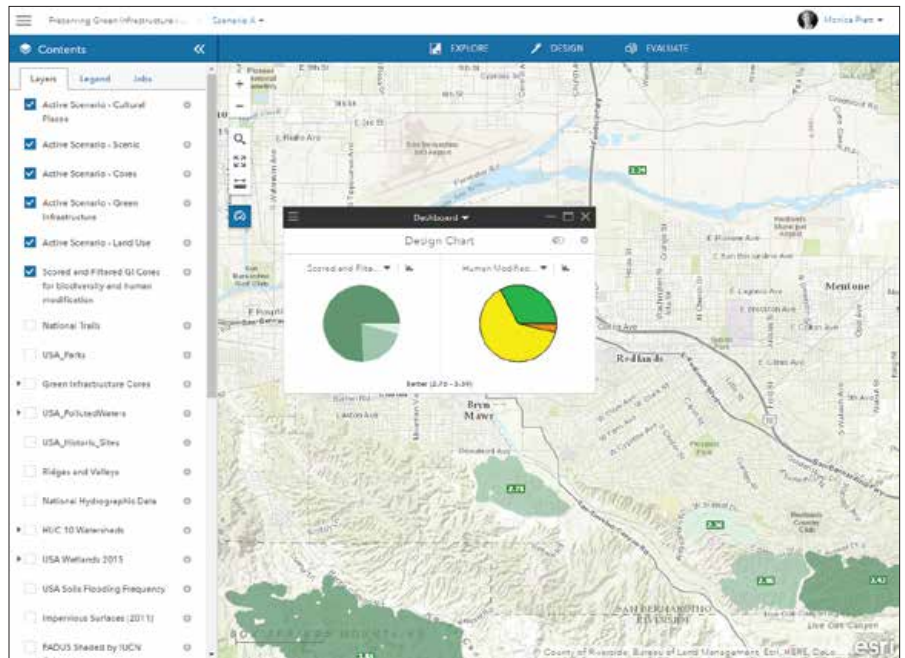
change relative weights, the chart will update with the new relative weights.

5. A hosted service will be created in ArcGIS Online based on the filters and map extent of the input. The app will ask you to name the service created from the filter map service and notify you when the new GI Cores hosted service has been successfully created.

↑ Use the Dashboard tool to create a chart of the scored and filtered core service and another data source for comparison.
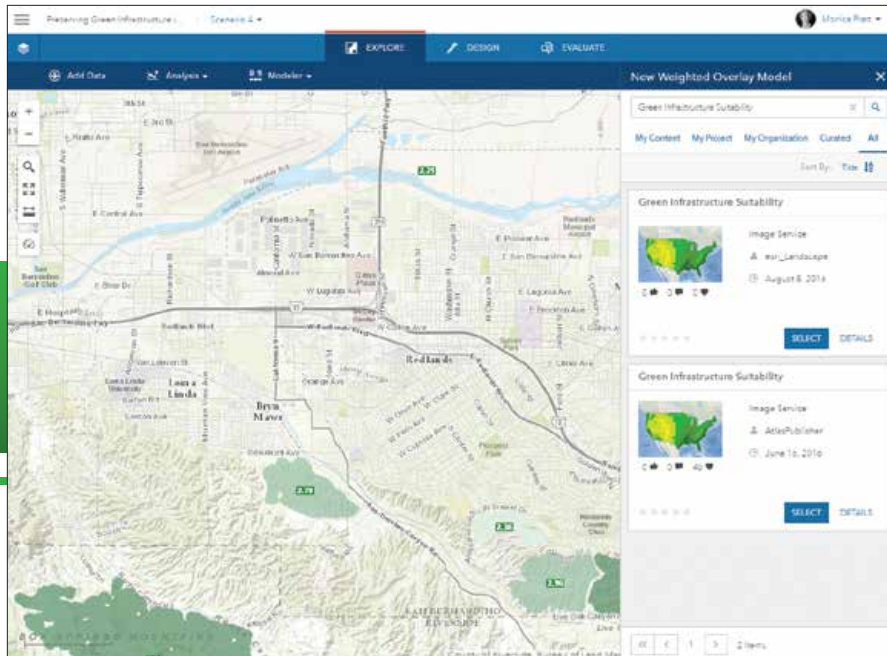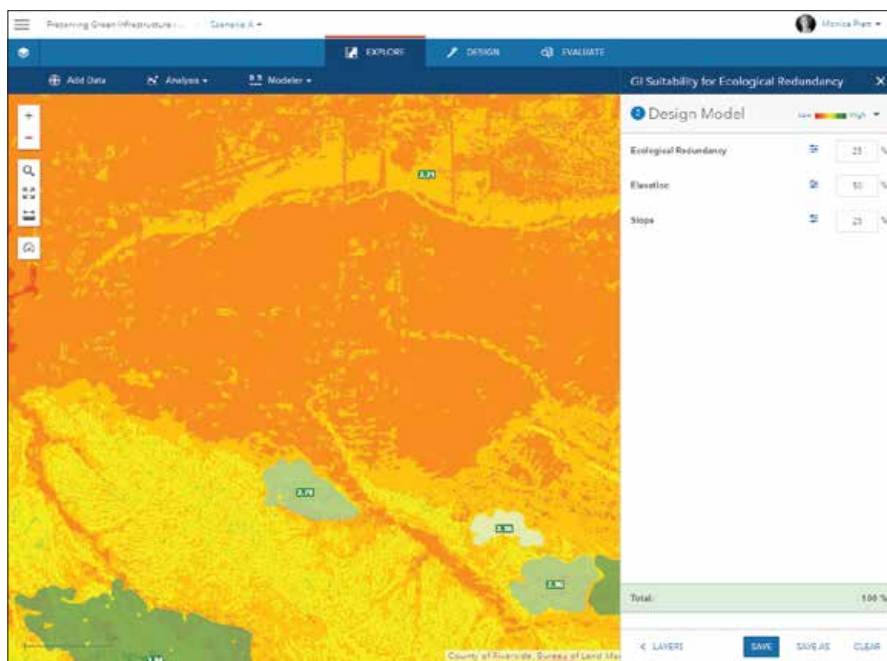
← Locate the Green Infrastructure Suitability analysis service to use it to generate a suitability model.

↑ Create a Weighted Overlay Model using the Green Infrastructure Suitability service.

Import Core Data into a GeoPlanner Scenario

Scenarios are unique planning alternatives. GeoPlanner allows you to sketch and paint scenario features to help you envision possible futures. Instead of sketching new features, you can start a scenario based on existing conditions by importing feature data into a scenario.

1. Return to GeoPlanner to use the hosted service just generated. Click the search icon and type the community name to zoom to the location.
2. In the top menu, click Explore > Add Data.
3. In the Search for Data, click My Content and sort results by date to locate and choose the scored and filtered core service. Click Add.
4. Click the dashboard icon (clock) and click the down arrow below Dashboard and choose Design a chart. Click the down arrow on the left side and choose the scored and filtered core service to generate a chart from it.
5. Click the down arrow on the right side and choose another data source to create a chart for comparison.
6. Hover over the charts to reveal the tooltips that show information about the data.

Generating a Model from the Green Infrastructure Suitability Service

GeoPlanner helps you locate areas of risk or opportunity through suitability analysis and evaluate multiple factors at once by

6. You can change the weights for a filtered layer by changing the sliders and either click the Update button to calculate the new score for each core and update the hosted service or click Save As to save the new weights as a new hosted service.
7. Additional filtered services can be processed if desired. When finished, close the Find Filtered Cores dialog box.

classifying, weighting, and combining different types of layers.

Suitability analysis in GeoPlanner uses a modeler widget that exposes services that have unique content that you can use to ask questions and visualize answers spatially. The latest update to GeoPlanner contains a new Green Infrastructure Suitability analysis service. This service contains layers useful for green infrastructure planning.

This example uses the Green Infrastructure Suitability analysis service to locate areas in the continental United States that are on steep slopes at high elevations and have a high ecological redundancy.

1. In GeoPlanner, click Explore > Modeler and choose New Model from the dropdown.
2. In the search box at the top of the New Weighted Overlay Model dialog box, type Green Infrastructure Suitability and click All.
3. Click Select. In the Select Layers pane, check on Ecological Redundancy, Elevation, and Slope. Click Design Model.
4. Click the color ramp dropdown and choose the Red to Green ramp (second choice in the dropdown list).
5. Set the following weights:
   • Ecological Redundancy: 25
   • Elevation: 50
   • Slope: 25
6. Click Save and type a name for your model. Click Save again.

You can now use the model just generated in GeoPlanner's dashboards to understand the performance characteristics of an area.

# ESRI® HARDWARE AND CONTENT OFFERINGS

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For more information, visit esri.com/hardware.
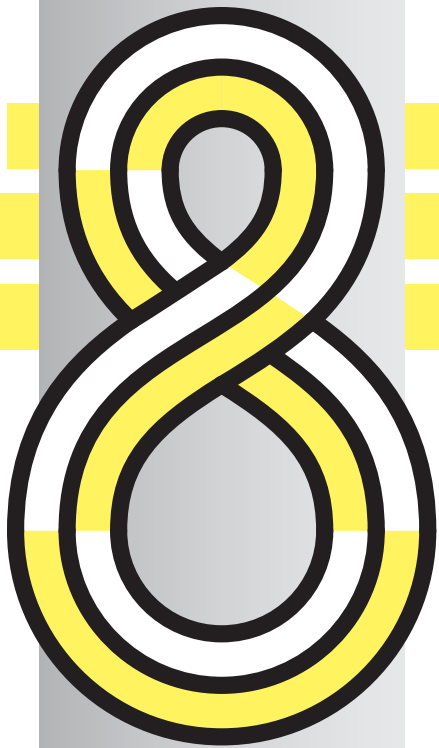
UNDERSTANDING DATA ANALYSIS USING 8 SCIENTIFIC TOOLS

By Susan Zwillinger, 4CTechnologies/4CGeoWorks

DID YOU EVER WONDER how expert analysts learned to analyze? How do chess grandmasters learn to think and plan their next move? They use a process. It may seem like analysis is something magical and hidden that happens in some people's brains naturally. To a certain extent, we are born with our intellectual capabilities, but most of what an analyst does can be learned through techniques and methodologies.

First, we have to improve our observation skills. Think about how crime scene investigators (CSIs) approach a crime scene. They might use all their senses to collect information: sight, sound, smell, touch, and—in rare cases—even taste. If we observe precisely, we can compose the proper context for our observations.

The problem is that our brains seem to be hardwired to bring our attention to the expected patterns rather than the unexpected. To overcome this "curse of knowledge," we have to train our brains how to analyze data and interpret what we see. The best way to become a better analyst is to use a systematic, sequential, and iterative thinking process. But what specific techniques should you use?

Benchmarking techniques are a great place to start. A term borrowed from surveyors, a *benchmark* is a point of known location and elevation. It's a point of reference. A benchmark ensures that surveyors can return to the same point in the future and have consistency in their measurements. Without benchmarks, the exact location can't be measured and understood.

In a business context, we also use benchmarks. The point of reference is a specific indicator such as sales per square foot. These key performance indicators (KPIs) allow us to evaluate and compare performance metrics over time as well as spatially. And more important, benchmarks help us find the unexpected in our data, which is the fun part of analysis. Each of the following scientific tools represents an analogy for the critical thinking process we can draw upon to analyze our data. We can create an intuitive approach to analysis and benchmarking techniques.
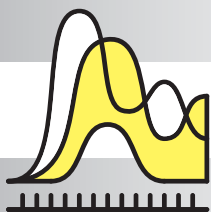
1 THE MASS SPECTROMETER

Scientists use a mass spectrometer to identify the individual components of a substance. In other words, to really understand something, you need to break it down into its individual parts. The useful thing about this technique is that once you have identified the parts, you can often begin to see patterns, groups, and subsets of different aspects of whatever you are studying.

However, no matter what your topic of study, make sure that you know what the whole is first. What is the total population or number of features? Then, see if you can break that whole into its parts and understand the percentage of each that makes up the whole. This will give you context and a point of reference that you can use to compare other groups, samples, or areas of interest.
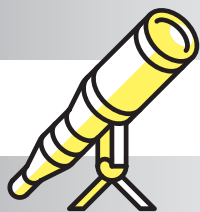
2 THE TELESCOPE

Most of us have looked up at the night sky and seen the Milky Way. This provides only one perspective of the stars. If we use a telescope, we can see the stars and planets in more detail. A telescope lets us see an individual star in the context of a constellation or even a specific type of galaxy. But this technique is not only about looking at your data at different scale levels. Underlying this technique is the idea that we need to expand our understanding by aggregating the data.

One technique that makes it easy to compare data at different scale levels is to use an index. For example, let's say that from the mass spectrometer technique, we learn that our target population is 18- to 34-year-olds who make up 24 percent of the total population of the country. We can measure that same target population percentage at the census block group level, or by ZIP code, trade area, county, metropolitan area, or state level. By dividing each area's percentage by 24 percent and multiplying by 100, we can create an index that compares any value to the base population percentage.

While it is relatively easy to remember a single benchmark like 24 percent, the value of converting all your variables to an index based on 100 is that you will be able to scan multiple variables and have an almost instant understanding of how any given area relates to the overall population based on an average, median, percentage, a target number, or a threshold value.

3 THE MICROSCOPE

In some ways, the microscope is simply the flip side of the telescope technique: drilling down to a small area with more details rather than aggregating data up to a larger geographic area. But the idea behind this technique is to validate assumptions or hypotheses that we may have made when viewing data at a higher level. If you only look at your data at an aggregated level, you may miss the specific variables that lead to unexpected conclusions that may change the way that you do business. So create a map series and zoom in to each location to check whether the patterns that hold true at a higher level need to be refined based on the individual characteristics of your data.

4 THE BALANCE SCALE

A balance scale compares a known weight to something that has an unknown weight employing a specific unit of measurement. It's the idea of comparing and contrasting one thing to another using some standard of measurement.

One of the simplest ways to do this is to rank your data. It could be as simple as numbering the values from 1 to the highest rank or using a calculation in Excel such as the RANK.EQ or RANK.AVG functions to ensure that when values are the same, they are given an equal rank. If you rank your data, it makes it easy to create five classes in your map layer symbology to show the top 20 percent and bottom 20 percent of your data. In business, it is common to find that 80 percent of sales come from 20 percent of customers, or (stated more generally) 80 percent of the effects come from 20 percent of the causes. By ranking and classifying your data, it is easy to see which features are most important.

5 THE BLACK LIGHT

Scientists often use a black light to highlight an object or substance that is different from the area surrounding it. The black light emits long-wave ultraviolet (UV-A) light that causes some substances to glow or fluoresce. A black light acts as a filter that highlights an outlier that is not visible when viewing the substance under normal lighting conditions.

You should always look for outliers in your data. Outliers are important because they should cause us to ask questions about why they occurred. What is different about that data point, location, or value that makes it an outlier? When we ask more questions and add more data to our solution, we can sometimes gain insight that affects how we approach our original hypothesis.

6 THE FUNNEL

A funnel is a simple lab tool that allows a scientist to pour different substances into a single container. For analysis purposes, we need to think about how we can combine and intersect our data. Doing this may prompt questions about what happened to create the convergence or correlation that we see in our data. If we are studying data over time, we might look for a change point or intersection to see if we can figure out what factors produced the change and why it occurred.

A good way to use the funnel technique in GIS is to aggregate data to equal-sized areas such as hex bins or grid squares. This helps us understand the density of our variables as well as identify areas with higher total values. This also makes it easy to combine multiple variables by using the Grouping Analysis tool in the Spatial Statistics toolbox or by creating a weighted score for each area based on the combination of multiple index values. In addition, we can use the standard geoprocessing tools to overlay multiple layers to find points of intersection between different datasets.

7 THE PETRI DISH

The Petri dish is used to culture organisms and watch how they change over time. If there is no change in a particular Petri dish, the scientist will try to identify why the change did not occur. For example, a scientist testing various disinfectant solutions to see which ones were better at preventing the growth of bacteria would look for changes in the Petri dishes that showed a decrease in bacteria.

In the same way, it is always helpful to try to understand our data from a historical perspective. Was the data always like this? If not, what changed? What was the rate of change as well as the total amount of change? Of course, you may not have historical data or a time variable in your data. If that is the case, you should make it your mission to start collecting and storing this data right now, because in several years, you will find that the data you collected will have significant value.

8 THE MIRROR

There are two ways that we can look at the mirror technique. The first and most obvious way is that we can use a mirror to look at the reflection of ourselves. It is often helpful to start from our own perspective or neighborhood and test that knowledge against the data that we have. Analytics is more meaningful to people when they understand the data within their own context. However, there is a danger in relying on our own point of reference. Many times, we think we understand our own neighborhood simply because we live there. This may introduce biases into our analytical process.

Mirrors also have an amazing ability to help us see things from a different perspective and to even see the invisible. Not only can mirrors let us see what is behind us but are also used in science to help us see things that we can't see with our eyes. As example of this use of mirrors is Schlieren flow visualization, which uses parabolic mirrors, a light source, and a camera to capture a picture of the sound of a clap.

It is important to expand the scope of our analysis beyond our personal experience and add data points and variables to that which was previously known. The mirror technique encourages you to ask whether you have considered your problem from all perspectives. This may mean using substitute or proxy variables when the data that you want is not available. For example, using Esri Community Analyst with Esri Tapestry Segmentation Data, we can gain insight into demographic patterns that would otherwise be invisible.

WHAT'S YOUR PROCESS?

These ideas are not new. They were inspired by Ben Jones's presentation "Seven Data Story Types," which was (in turn) inspired by Christopher Booker's book, *The Seven Basic Plots: Why We Tell Stories.* Many of you can add your own scientific tools to your analytics process. The list of tools described in this article is not comprehensive. The important thing to remember is to find a process that works for you.

If you are curious to see how I used these tools to analyze data and determine the best markets for craft beer and pizza in the United States, see the online version of this article for a link to the presentation I gave at the 2016 Esri User Conference. For more information, contact Susan Zwillinger, principal consultant at 4CTechnologies, at szwillinger@4cgeoworks.com.

Using Story Maps
Instead of PowerPoint

By Bern Szukalski, Esri Chief Technology Advocate

While Microsoft PowerPoint is the standard when it comes to presentations, using an Esri Story Maps app can offer a better option.

If you have to switch back and forth between PowerPoint and live demos, media, or websites, the process can be inconvenient and clumsy and the effect on your audience visually jarring and disruptive. While any story map can be used to deliver a presentation, some are better suited to the task than others.

My preference is the Esri Story Map Series, specifically the Bulleted or Tabbed layout, since those provide sequential access moving from left to right and do not require a side panel for additional text or media—something not needed for most presentations.

Here are some tips on using a Story Map Series app instead of PowerPoint for your presentations. In this example, the Bulleted layout is used, but the Tabbed layout works in a similar way.

Adding PowerPoint Slides
PowerPoint slides can be added to your story map by exporting or capturing them as images, hosting them on your website or in your ArcGIS account, and adding them via a URL. You can also use Flickr, Google Photos, Facebook, Box, or Google Docs to host images. Ensure your images are sized appropriately for web use.

Add the image of the slide as an Image with the URL as the source.

Once you have the image of the slide saved and hosted, open the Story Map builder and add a page (which will add a bullet to the interface). In the Add Bullet dialog, click Image, then click URL as the source of the

image and add the URL of the slide image.

Use Fit as the position for the slide—rather than the default option of Fill—so it won't be cropped. This provides the best results for slides with text. The entire slide will be displayed ensuring no text will be cropped. Fit also ensures slides will display well on any projection resolution or with any aspect ratio. The text panel can be left blank. You won't need it since your slides will include all the necessary text.

In rare cases, you may know the exact display resolution for your presentation. If you do, another option is to determine the size needed to fill the main stage, add a few pixels on all sides to ensure the slide completely fills the space, then use a position of Center. This technique only works when you build a presentation for a specific event and know the exact display size, since using Center (rather than Fit) to position your slides can crop your slides at different resolutions.

Changing the Slide Background
The main stage of a Story Map Series has a background color. When using the Fit option, the main stage background may be visible around the edges of the slide. To change the background, click Settings and choose the Theme tab. Choose a theme that will complement your slide background and click Apply when finished. Save your story map.

To eliminate the background, you can use a single color slide background and display the slide in a web page that has the background color set to match the page. Copy and paste

the markup shown in Listing 1 into a new HTML document and make the necessary edits for the background color and slide URL as noted in the comments. Host the HTML document, and add it to your story map as a web page, using the default Fill option. The HTML will display the slide responsively so that it fits any size or aspect ratio.

Adding Maps, Apps, and More
In addition to your slides, you will want to add web maps, apps, and other features. Add them using their URL and use the default Fill position. Since the map viewer and most apps and app templates are responsive, they'll fill the entire main stage area. When embedding apps or other story maps, some offer options to minimize the user interface. This is recommended for best results. Once again, the text panel is not necessary and may be left blank.

Maximizing Your Presentation
When displaying your story map presentation in a browser, maximize the display area by appending &embed to the end of your story map URL. This eliminates the title (and subtitle if you have one) and only displays the bullets or tabs. You can also hide all browser bookmarks to gain additional space and display the presentation in full screen mode in the browser to omit browser tabs and use all available space. *[For more information on embedding story maps, see the* ArcWatch *article "Learn to Embed a Story Map within a Story Map."]*

↓ The main stage has a background color, and when using the Fit option, the main stage background may be visible around the slide edges. You can change the theme of the story map to go with the colors in your slide.

↓↓ To eliminate the background, you can add a web page that sets the background to a color that matches the slide background.

↓ When displaying your story map presentation in a browser, you can maximize the display area by appending &embed to the end of your story map URL. This eliminates the title (and subtitle if you have one) and only displays the bullets or tabs.
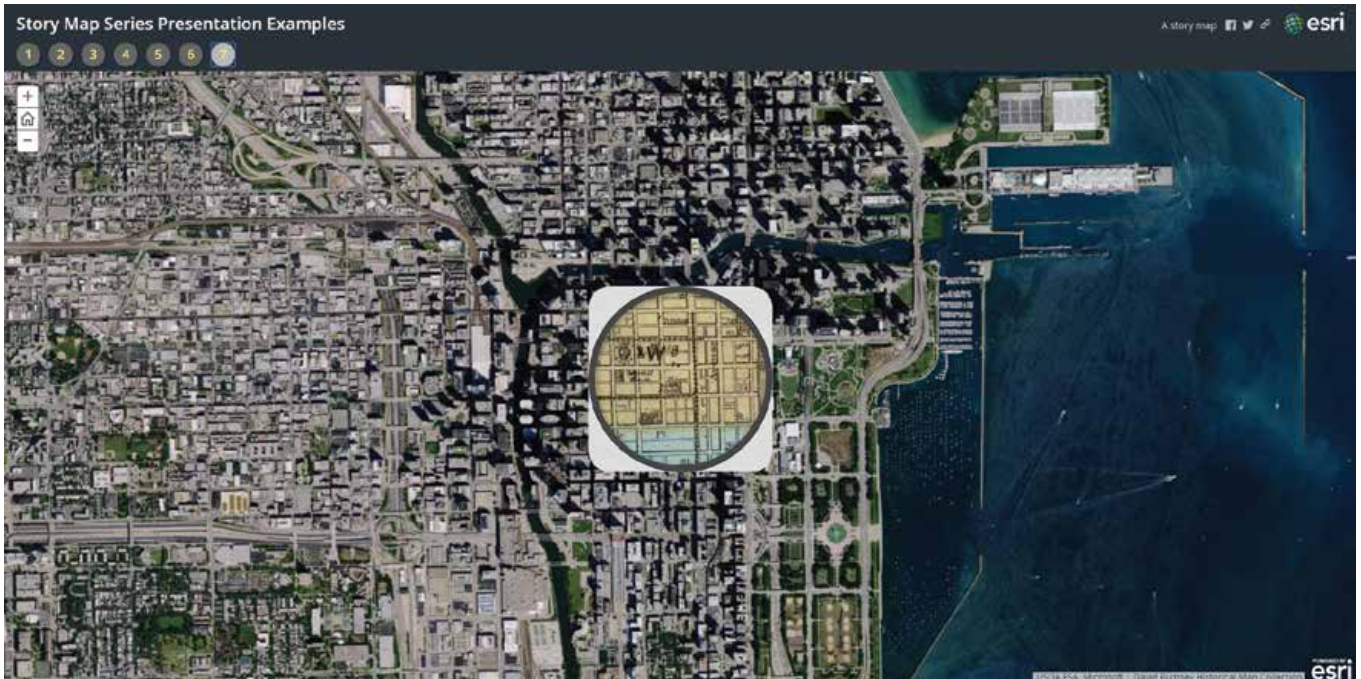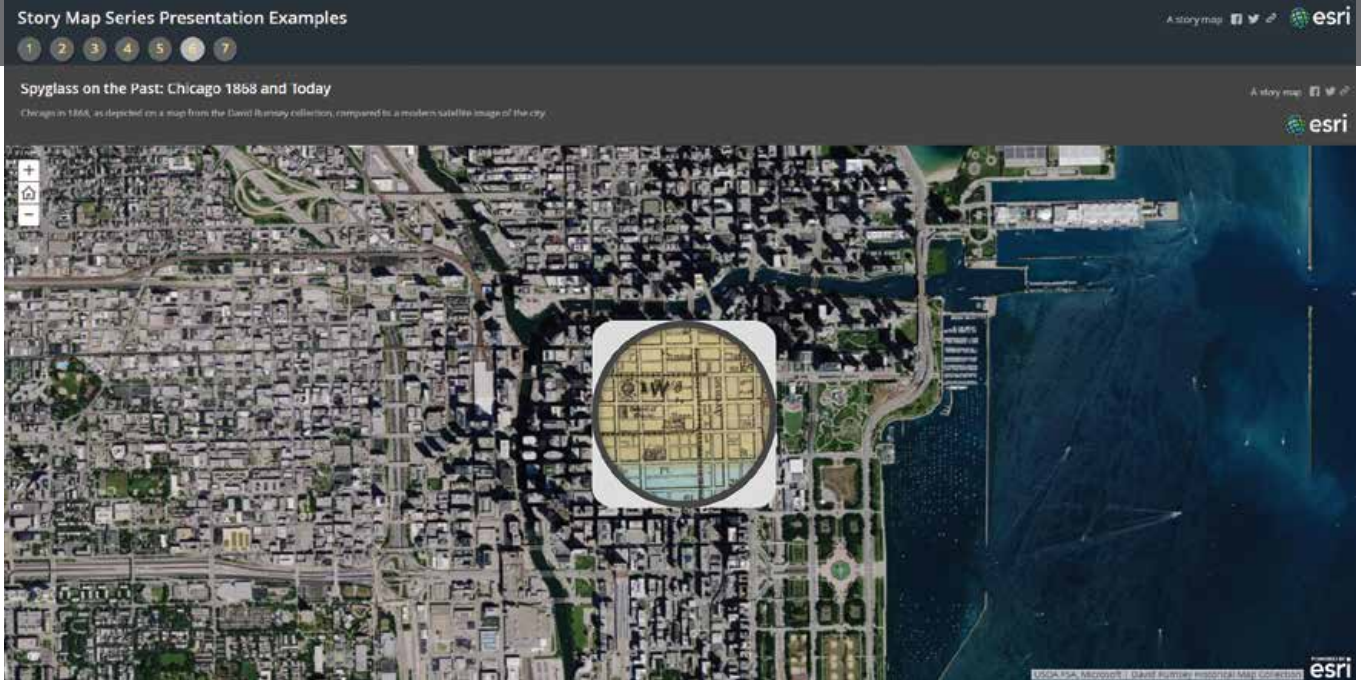
```
<!DOCTYPE html>

<html><head>
<style>
 html, body {
 padding: 0;
 margin: 0;
 }

/*

Specify background color of your slide

*/

body {
background-color: #3c5a76;
}
/*

Centering horizontally and vertically:

https://css-tricks.com/centering-css-complete-guide/

*/

#slide-pic {
position: absolute;
 display: block;
 top: 50%;

-ms-transform: translate(-50%, -50%);

-webkit-transform: translate(-50%, -50%);

transform: translate(-50%, -50%);

left: 50%;
 max-width: 100%;
 max-height: 100%;
}
</style>
</head>
<body>

<!--

Add URL to slide location

-->

<img id="slide-pic" src="http://downloads.esri.com/agol/blog/ppt-slide2.jpg">

</body>
div +
</html>
```

← Listing of the web page that sets the stage background to a color that matches your slide

you reach that portion of your presentation.

For more information, read Bern Szukalski's posts on the ArcGIS Blog (blogs.esri.com/esri/arcgis).

About the Author

As the chief technology advocate and product strategist at Esri, **Bern Szukalski** is focusing on ways to broaden access to geographic information and help users succeed with the ArcGIS platform. Follow him on Twitter at @bernszukalski.

Tips and Considerations

Story maps are a powerful way to tell a story using maps and media. They can also be a powerful way to deliver presentations, but to get the best results, some thought and planning are needed. Here are a few more things to consider when using story maps for presentations.

It's easy to author a terrible PowerPoint presentation. We've all suffered through our share of them. Crafting a great story map is somewhat of an art, and so is creating a great story map presentation.

Omit or limit the text in the story map so that the audience will listen to you, instead of reading words during your presentation.

Story map presentations work best when they are short. The Story Map Series app

supports a maximum of 30 tabs or bullets.

Story maps do not offer the slide transitions and animations that are available in PowerPoint. If you feel these are necessary, stick with PowerPoint.

Choose the best story map for your purpose. The Story Map Series app, with its optional text panel, is ideal if you want your audience to focus on your slides and live apps.

When adding content via a URL that takes a while to initialize (such as a link to a detailed web scene), ensure that the Unload when reader navigates away option is unchecked. Before your presentation, you can warm up all your maps and apps so they will be preloaded. Unchecking this option ensures they do not need to be reloaded when

GIS Bookshelf
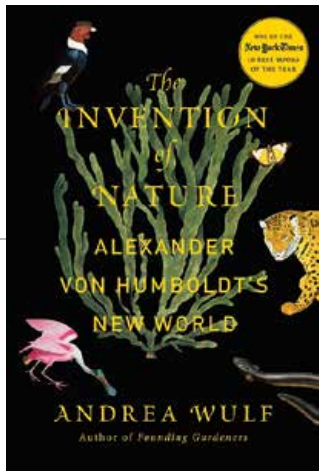
The Invention of Nature: Alexander von Humboldt's New World

By Andrea Wulf

The Invention of Nature: Alexander von Humboldt's New World winds back the clock to the early nineteenth century, when geographer and naturalist Alexander von Humboldt's scientific observations gave rise to the idea that the earth was "one great living organism." Author Andrea Wulf's biography of Humboldt recounts his scientific expeditions, including what he learned during a grueling 1802 trek up Mount Chimborazo in Ecuador. She writes about his meetings with US president Thomas Jefferson and how he deeply influenced people such as Charles Darwin, John Muir, and Henry David Thoreau. Wulf's recent article in *The Atlantic* magazine calls Humboldt the "forgotten father of environmentalism." Wulf shared some of the research she did for the book when she gave the Keynote Address at the 2016 Esri User Conference, where she paid tribute to Humboldt's contributions to geography, ecology, and conservation. Knopf Doubleday, 2015, 496 pp., ISBN: 9780385350662
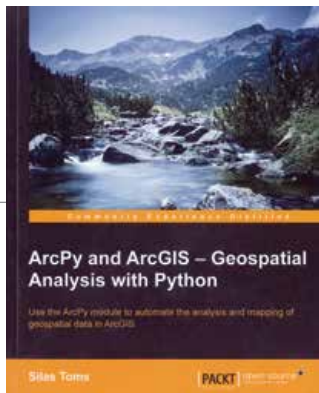
ArcPy and ArcGIS—Geospatial Analysis with Python

By Silas Toms

Learn how to be more productive by automating repetitive and analysis tasks in ArcGIS using the ArcPy module. Designed for working GIS professionals as well as students, *ArcPy and ArcGIS—Geospatial Analysis with Python* builds proficiency with Python scripting from the ground up. It introduces the ArcPy Python module, how to configure the Python environment, and how to write the first script and moves on to complex scripts, working with cursors and geometry objects and the ArcPy Mapping module as well as working with ArcGIS Network Analyst and ArcGIS Spatial Analyst. The author Silas Toms is a geospatial programmer and analyst with a background in GIS analysis for city governments and environmental consulting. In his work as both a programmer and analyst, he learned to use Python and GIS to quickly produce geospatial data and tools and shares these techniques. Packt Publishing, 2015, 210 pp., ISBN: 978-1783988662
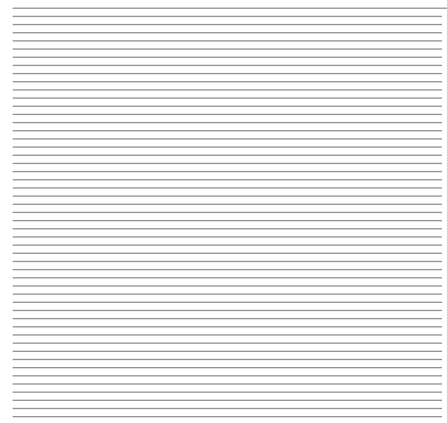
Put Imagery to Work in ArcGIS
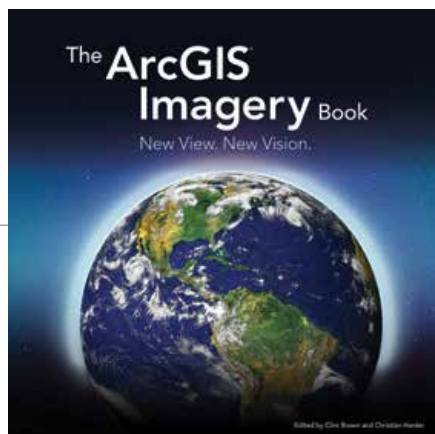
The current revolution in commercial earth observation is making unprecedented amounts of imagery available from smaller satellites, microsatellites, video cameras in space, and high-altitude drones as well as more traditional sources.

A new book from Esri, *The ArcGIS Imagery Book: New View. New Vision.*, will show you how to exploit these new sources using the image processing and spatial analysis capabilities available with ArcGIS. The target audience is broad and ranges from students to GIS professionals to armchair geographers.

Available in a print edition or as an interactive PDF, it will give readers a fundamental understanding of imagery and remote sensing and how it can be used with GIS. It provides hands-on experience working with imagery and remote-sensing data in ArcGIS via the book's interactive companion website. *The ArcGIS Imagery Book* is the second in a series of books from Esri that provides an online learning experience that demonstrates realistic applications of the technology. Both make ArcGIS software available via the companion website or the interactive PDF edition so that readers can begin working with imagery in ArcGIS.

The book looks not only at the fascinating history and rapid evolution of earth observation technology but also at modern earth imaging technologies being used in precision agriculture, forestry, mining, humanitarian aid, urban planning, natural disaster assessment, and climate and weather studies. Readers will learn what can be accomplished today, thanks to advances in ArcGIS, imagery, remote sensing, and cloud computing.

Through its 200 links, *The ArcGIS Imagery Book* and its companion website gives readers access to the following resources:

- Maps and apps to visualize and study imagery
- ArcGIS lessons on topics such as the interpretation and analysis of imagery in 3D and 4D and creation of GIS data from drones using Drone2Map for ArcGIS
- Videos about GIS and imagery
- Articles about the history of imagery

Thought leadership pieces were written by industry leaders, such as Esri president Jack Dangermond; remote-sensing pioneer Kass Green; National Oceanic and Atmospheric Administration (NOAA) administrator Kathryn D. Sullivan; satellite architect Sarah Parcak; and director of the Esri R&D Center in Zurich, Switzerland, Pascal Mueller.

Obtain the print version of *The ArcGIS Imagery Book: New View. New Vision.* (ISBN: 9781589484627) from online retailers worldwide, at esri.com/esripress, or by calling 1-800-447-9778. Outside the United States, visit esri.com/esripressorders for complete ordering options. Interested retailers can contact Esri Press book distributor Ingram Publisher Services.

Companion Guide to The ArcGIS Book

The *Instructional Guide for The ArcGIS Book*, a companion to *The ArcGIS Book: 10 Big Ideas about Applying Geography to Your World*, provides relatable activities and lessons to learn ArcGIS that correspond to each chapter of *The ArcGIS Book*.

The ArcGIS Book, which came out in print and online in 2015, helps GIS students and seasoned pros hone their GIS skills while building and publishing web map apps; using live data feeds in apps; creating and sharing Esri Story Maps apps; making 3D map presentations; and answering complex questions using web maps analysis tools. Some lessons require no software, while others use ArcGIS Online or cloud-based GIS apps such as Esri's Survey123 for ArcGIS, Explorer for ArcGIS, and Collector for ArcGIS.

Written by GIS instructors Kathryn Keranen and Lyn Malone, the *Instructional Guide for The ArcGIS Book* can benefit self-learners or those teaching GIS in a classroom. The guide provides materials to explore and apply GIS concepts and Esri ArcGIS tools to real-world problems.

Instructional Guide for The ArcGIS Book is available in print (ISBN: 9781589484702) or as an e-book (ISBN: 9781589484719). The book is available at online retailers worldwide, at esri.com/esripress, or by calling 1-800-447-9778. Outside the United States, visit esri.com/esripressorders for complete ordering options, or visit esri.com/distributors to contact your local Esri distributor. Interested retailers can contact Esri Press book distributor Ingram Publisher Services.

Building a Smarter World
with GIS

← "GIS—your profession, your technology—provides the framework and the process for creating…a smarter world," asserted Esri president Jack Dangermond.

"Your work is so interesting," Esri president Jack Dangermond told an audience of 16,000 people during the Plenary Session at the 2016 Esri User Conference. "You are working on virtually all the significant challenges and issues on the planet, from climate change to food production to humanitarian relief to making cities better."

"Smart GIS…is about integrating everything—connecting people and processes and things and all the data about them," noted Dangermond. "Smart GIS, for me, also means being able to engage communities."

Throughout the Plenary Session, Dangermond welcomed speakers from organizations that were using GIS to integrate data, create information, and make better decisions.

That's what the City of Los Angeles, California, is doing. Lilian P. Coral, chief data officer for the Office of Mayor Eric Garcetti, described the city's GeoHub in her plenary presentation. GeoHub brings data stored in different city departments together and provides an online public platform with ready-to-use apps that encourage residents to use this data. *[Read more about GeoHub in "Harnessing the Power of Geotechnology" in the spring 2016 issue of* ArcUser.*]*

→ Bryan Adams and Shannon Peterson demonstrated how Guy Carpenter, one of the world's largest reinsurance brokers, manages claims and assesses risk using GIS.

The City of New Orleans, Louisiana, is using GIS to make smarter decisions about where to build. By bringing together information about the community in a map that uses soil permeability, wetlands, and historical flood zones, policy makers can see areas where the ground is highly absorbent and likely not ideal for development.

"Using this map, we can think in completely different ways about how we build our environment and our neighborhoods," said Lamar Gardere, the city's chief information officer.

Gardere also exhibited the city's BlightStatus crowdsourcing web app, which not only educates residents about the blight remediation process but also enlists their help. The city collected street-level photos of every parcel in New Orleans and created an app that lets anyone online evaluate these properties for blight based on what they see in these photos by filling out a six-question survey. Having a baseline on blight before hurricane season helps New Orleans tremendously with recovery efforts.

"Running frequent surveys will give us a reliable layer of vacant lots and foundation type, giving us a sense of our housing resiliency," said Gregory Hymel, the GIS director for the City of New Orleans.

Using GIS, Guy Carpenter, one of the world's largest reinsurance brokers, helps its customers—insurance companies—intelligently manage claims and assess risk. Guy Carpenter used ArcGIS to visualize which neighborhoods were impacted by a massive wildfire in Fort McMurray, Alberta, Canada, earlier this year that destroyed 2,400 homes and buildings and forced more than 80,000 people to evacuate. By pinpointing individual homes destroyed by the fire, Guy Carpenter could enable insurance companies to estimate losses, prepare for expected claims, and put the resources in place to assist policyholders.

Esri unveiled a map that takes *smart* to a whole new level. The new Green Infrastructure map, along with its apps and tools, will help organizations in the United States design green infrastructure plans that will enable better planning decisions on a larger scale. The map includes all intact natural areas within the continental United States that are larger than 100 acres, regardless of ownership or preservation status. The map includes land cover (forests, developed land, land cultivated for crops, herbaceous and woody wetlands, and barren and scrubland) and the location of agricultural areas, ridges, and valleys. (See "Ensuring a Better Future" in this issue.)

"It's a series of methods and a series of tools that you [can use to] craft your own plans," said Dangermond. Since each community's plan would be unique and would require citizen engagement, Esri is providing the datasets and other resources for people to use at local, regional, and urban scales.

Green infrastructure mapping will show where the most valuable landscapes are before development occurs to preserve rivers, tributaries, critical habitat, wetlands, flat plains, and prime agricultural land and how they connect developed areas. Decision-makers can then identify how proposed new projects and urban growth will potentially impact existing natural resources.

"Geography, mapping, [and] GIS have never been so important," said Dangermond. They provide "the language of understanding of our world and…a platform for creating a better future."

With GIS continually getting smarter, humans today are aware of things they couldn't have known before—things about the built environment, about nature, about the planet. That engenders a different kind of understanding about the world—and that is just what Richard Saul Wurman, founder of TED Talks, wanted the audience to contemplate at the end of the Plenary Session.

"I'd like you to think about how you personally understand things," he prompted. "Don't measure yourself by what teachers or parents or others tell you…that this is the only way you can do things."

Instead, he urged attendees to figure out how they each go about understanding things. It will be different from person to person, he said, but he gave everyone "permission…to embrace that idiosyncratic, human way each of us understands things."

Because, just as GIS cultivates new understanding, so do different ways of understanding create a better, smarter world.
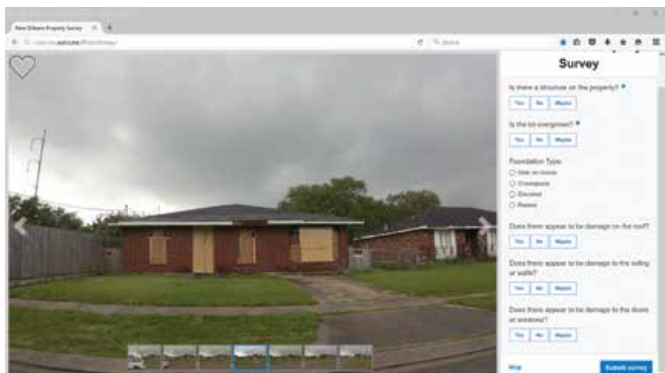
← The City of New Orleans is engaging citizens through BlightStatus, City of New Orleans, an app that lets them crowdsource a survey of damaged houses.

Looking at Nature through the Eyes of
ALEXANDER VON HUMBOLDT

By Carla Wheeler, *ArcWatch* Editor

← Alexander von Humboldt, the famous Prussian explorer, geographer, and naturalist, shaped the way we think about nature.

ALEXANDER VON HUMBOLDT, the famous Prussian explorer, geographer, and naturalist, was the subject of the Keynote Address by Andrea Wulf at the 2016 Esri User Conference (Esri UC) in San Diego, California, this past June.

At the dawn of the nineteenth century, Humboldt was the embodiment of a Renaissance man. During an expedition to the Americas, he climbed steep, icy Mount Chimborazo, an inactive stratovolcano in today's Ecuador; battled oppressive heat, rain, and mosquito hordes while trying to steer clear of crocodiles during a trip down one of South America's longest rivers, the Orinoco; and met two American Founding Fathers, president Thomas Jefferson and future president James Madison.

Perhaps you've never heard of Humboldt. Wulf, who wrote a book about his life called *The Invention of Nature: Alexander von Humboldt's New World*, doubts you have. But she hopes you will come to know and appreciate him as the world once did. Esri president Jack Dangermond gave *The Invention of Nature* a rave review. "I read

her book, and it was amazing," he told the Plenary Session audience.

Wulf extensively researched Humboldt and his writings, including his five-volume scientific crown jewel, *Cosmos: A Sketch of the Physical Description of the Universe*. She credits him for first raising the alarm about human-caused climate change, being a pioneering force in the fields of infographics and mapmaking, and bringing the arts and sciences together to understand nature.

"Humboldt invented a concept of nature that still very much shapes our thinking today. He came up with this idea that nature is a web of life," she said. "He described the earth as a living organism where everything was connected, from the tiniest insect to the tallest tree."

FAMOUS NAME, FORGOTTEN MAN

Perhaps you haven't heard of the man, but you may have heard of the Humboldt penguin; the Humboldt Current; the Humboldt squid; Humboldt's lily; Humboldt County, California; or, perhaps, even Humboldt, Saskatchewan. Though many places and things bear Humboldt's name in honor of his scientific observations and explorations, his story languished in relative obscurity for years until Wulf published *The Invention of Nature*, named by the *New York Times* as one of the 10 Best Books of the Year in 2015.

Wulf said Humboldt, who was born in Berlin, was "brazenly adventurous—not a cerebral scholar," a man considered the "greatest and most famous scientist of his age." Essentially forgotten over time except by a small circle of scientists, geographers, and naturalists, Wulf said her goal is to return him to his rightful place in the pantheon of science.

"Humboldt was a scientist who believed you can't sit in your study and learn from books," she said. "You have to go out and see the world. And it shaped his view of nature." He had an insatiable thirst for knowledge about nature. Fascinated by everything from fluttering butterflies to rumbling volcanoes, he was famous for his far-flung explorations and scientific observations that led him to view nature "as a global force." Humboldt witnessed this interconnected ecosystem as he journeyed through South America from 1799 to 1804. On that trip, he lugged barometers, thermometers, cyanometers—42 instruments in all—that he used to study the environment.

The intrepid explorer noticed signs of human-caused climate change. He warned of trouble after a visit to Lake Valencia in present-day Venezuela, where he saw that the land surrounding the lake was barren, having been cleared of trees for plantations

that grew cash crops like indigo, sugar, and tobacco. "Forests had been felled. Heavy rain was washing off top soil. The lake level was falling and *[farmers were]* diverting water to irrigate fields," Wulf said during an interview from her home in London, England, prior to the Esri UC. Humboldt noticed other ways that humans were negatively altering the ecosystem—for instance, depleting the ocean's oyster stocks from overfishing and damaging the land from mining operations.

BEFORE GIS, THERE WAS NATURGEMÄLDE

The Invention of Nature describes in detail Humboldt's quest through South America, where he mapped rivers, collected plant samples, studied rocks (he was a trained mining inspector and geologist), and even conducted experiments on electric eels.

Following a 19,413-foot climb up Mount Chimborazo that left him bloodied and ill, he took measurements—such as altitude, air temperature, and barometric pressure—at various locations and took extensive notes on the locations of plants and animals. He then began to sketch his *Naturgemälde*, or "painting of nature," loosely translated into English.

Wulf said that after Humboldt returned to Europe, he hired mappers and artists to create a color lithograph of the *Naturgemälde. Geographie der Pflanzen in den Tropen-Ländern,* or *Geography of Plants in the Tropical Countries,* was published in the 1807 *Essay on the Geography of Plants* by Humboldt and Aimé B onpland, the French botanist who accompanied him to South America.

Snow-covered Mount Chimborazo appears in the lithograph, with a small plume of ash spewing out of the top. The mountainside is annotated with the names of plants, positioned at the locations where Humboldt and Bonpland found them. Columns on the left and right sides of the lithograph contain the elevation, barometric pressure, temperature, types of soil, blueness of the

↓ A poster reproduction of the lithograph of Humbolt's *Naturgemälde* was given to everyone who attended the Esri UC Plenary Session.

↑ Andrea Wulf, author of *The Invention of Nature* about Alexander von Humboldt, was the keynote speaker at the 2016 Esri User Conference.

sky, boiling temperature of water at various elevations, and other observations as well as extensive notes on the men's geognostic view of the tropical world.

The lithograph of the *Naturgemälde*, with its mapped plants, looks like an early GIS observed Wulf. "That is exactly what it is," she said. "It is packed with complex information, yet it is simple to understand. It shows connections that no one knew before." Everyone who attended the Esri UC Plenary Session received a poster of the lithograph.

Humboldt used infographics to show the spatial distribution of the plants on the mountain and the relationship between the types of vegetation found at various elevations. Publishing the lithograph in a book was his way of sharing that knowledge with a wide audience.

"He so much believed that knowledge should be accessible to everybody," Wulf said. "He is similar to the GIS community. He believes in a free exchange of information *[just as it is done]* through Web GIS."

In April 2015, Wulf spent time at Esri headquarters in Redlands, California. There she spoke about her book and learned more about GIS. She was impressed with the creation of the Living Atlas of the World, which includes contributions of maps, apps, and imagery from many organizations.

She said Humboldt was a big believer in collaboration and of making knowledge accessible. "Humboldt created an incredible network of people who helped him collect all this information, and that's what you are doing when you are engaging with citizens, students, scientists, [and] coworkers," Wulf said. "You have contributed millions of datasets—it's a Living Atlas that Humboldt could have only dreamt of."

Wulf said she felt quite at home at Esri. "When I went to Esri, I thought I'd landed in a Humboldtian heartland." Wulf believes Humboldt would feel right at home, too, at the Esri UC. "I am pretty sure he would have loved this community, and he would have loved the possibilities of GIS, because what you do here is truly Humboldtian."

Esri UC attendees, such as Judith Bock from Elmhurst College in Illinois, were delighted by Wulf's talk. "Her passion about him came through, and I learned a lot about him," Bock said, adding that the information Wulf provided about Humboldt's Mount Chimborazo vegetation map was particularly enlightening.

Noel Cressie, an expert in spatial and spatiotemporal statistics and a distinguished professor and director of the Centre for Environmental Informatics at the University of Wollongong in Australia, was equally impressed by this year's keynote. "I thought it was wonderful to hear about Humboldt, a scientist for all of science," Cressie said. "He was probably the last scientist who saw the big picture."

> "HE WAS PROBABLY THE LAST SCIENTIST WHO SAW THE BIG PICTURE." *Noel Cressie*

SPATIAL THINKING SPREADS A

By Jim Baumann, Esri Writer

← Janine Glathar has helped faculty incorporate GIS into more than 50 courses from 22 different academic departments at Bucknell University.

Janine Glathar arrived at Bucknell University in Lewisburg, Pennsylvania, with a mandate to integrate GIS and spatial thinking across the entire campus in both teaching and research.

Over the past seven years, she has helped faculty incorporate GIS into more than 50 courses from 22 different academic departments. In addition, more than 80 research projects that made use of geospatial technology were completed during that time.

Before Glathar's arrival, ArcGIS had been used in the university's geography and geology departments for research and classroom projects. Geography professor Ben Marsh is particularly interested in applying GIS to community action initiatives. "Some activities may seem random, but when you look at them spatially, you see themes," said Marsh. "GIS maps can reveal practices or decisions that most people wouldn't realize as systematic without this type of analysis."

Interest in GIS began to grow among faculty members, and as a result, a core group of professors, including Marsh, started offering workshops to help other faculty incorporate the technology into their own classes and research projects.

After meeting with faculty and assessing the demand for GIS use across campus, Glathar got approval from administrators in Bucknell's Library and IT Division for an Esri site license. She then began to determine what would be the best infrastructure to support the university's expanding GIS initiatives. "It was clear in 2009 that everything was moving towards web-based mapping and analysis," said Glathar. "We are very lucky at Bucknell to have a vice president of library and IT, Param Bedi, who encourages us to be creative and innovative in coming up with ways to better serve faculty and students on campus. With the support of Param and our very talented staff in systems integration, we were able to design and build a back-end ArcGIS for Server infrastructure to support our classroom and research efforts."

Since faculty in the geography and geology departments already teach core GIS classes, Glathar is able to devote her time to championing the use of GIS, rather than working as a classroom instructor. Her activities include advising professors on the best way to implement GIS into their classes and research, conducting GIS workshops, and collaborating on a wide range of research projects with faculty and students.

"I'm currently working with a faculty member who teaches American economic history," said Glathar. "It's an upper-level class for economics majors, and the focus is on the regionalization of the US economy. The class is examining pre-Civil War and post-Civil War economic trends."

Glathar showed a student assistant how to get historical census data from 1790 through 1960 and create map layers. The layers allow the visualization of the development of regional economies in the United States by examining demographic and economic census variables in relation to things like the expansion of transportation networks.

"We wanted the students in the class to examine the shift from moving goods by canal, or water transport, to moving goods by railroad, and then to the modern day road transportation networks and air travel," said Glathar. "Studying spatial data and other factors provided a unique opportunity for the analysis of the way regional economies developed in the United States."

Thanks to Glathar's efforts, GIS is already used by a number of other departments for both instruction and research at Bucknell University. Song Chen, assistant professor of Chinese history at the university, developed a geospatial dataset from a collection of several hundred funerary biographies of Chinese civil servants and their marriage networks from the 10th to the 13th centuries. He used the dataset to map their locations to better understand the relationship between the imperial state and the local government leaders of that period.

"My research combines GIS, network analysis, and prosopographical research," said Chen. "I use GIS to map out geographical patterns of civil servants and their marriage networks. Though my recent work relies primarily on a dataset I personally built, I have also benefited significantly from other existing data collections and databases. I owe much to the China Biographical Database (CBDB) and China Historical GIS (CHGIS) projects."

CBDB is an online relational database that contains about 120,000 historical figures. It includes a large collection of data points that can be cross-queried and exported. CHGIS provides the most complete and authoritative point and polygon files for locations in Chinese history.

Eric Faden, associate professor of film studies, teamed with student Kate Matelan, a former Ms. Wheelchair USA, to create a documentary film and map detailing Matelan's difficulties in getting around campus in a wheelchair. This provided anecdotal evidence for

CROSS BUCKNELL UNIVERSITY

Yang Yungong (944–999)

Born

Buried

Gao Chong (1173–1232)

the university's Americans with Disabilities Act initiative. Matelan and an able-bodied student narrated their individual walks to the same location on campus. In addition to taking her 40 percent more time to get to class, Matelan encountered uneven pavement and a lack of routes she could safely navigate. Inside the campus building, an absence of automatic doors required backtracking along corridors to reach her destination.

Professor Richard Crago's civil and environmental engineering class recently calculated storm water flow patterns on local farmlands by analyzing land cover with the related elevation data. This project was done with the support of the Chesapeake Conservancy in an effort to devise watershed protection strategies for the Buffalo Creek watershed, which ultimately flows into the environmentally threatened Chesapeake Bay 100 miles to the south.

"The Chesapeake Conservancy taught us how to use aerial imagery and elevation data to create extremely high-resolution land-cover classification data," said Glathar. "With one-meter land cover classification data instead of the typical 30-meter resolution, you can pinpoint much more precisely what is happening in a given area and make better, more effective decisions."

The goal of this project is to identify those areas that have the greatest negative impact on the local environment and engineer solutions to mitigate that impact. This includes the creation of retention ponds bordered with vegetation to build buffers within the watershed. The conservancy calls this process precision conservation.

GIS use has spread across the university's departments. The biology department uses GIS for mapping species distribution in the Sudan. In the chemistry department, students measure the plumes of flow-back water used to extract natural gas from shale and test it for high salinity levels, radioactive elements, and toxic trace metals. Physics and computer science students teamed to create a drone to collect high-resolution aerial imagery that was combined with elevation data to map a creek that runs through the university. The subsequent analysis will be used for restoration and flood control purposes. Women's and gender studies students recently used GIS to map the occurrence and concentrations of sexually exploitive advertising in Brazil, United States, China, Thailand, India, and South Korea.

"At Bucknell we are not focused on providing technical training in how to use GIS from A to Z, but rather in how to help people ask and answer spatial questions," concluded Glathar.

← Two Cases of Career Paths. Song Chen, assistant professor of Chinese history, developed a geospatial dataset from funerary biographies of Chinese civil servants from the 10th to the 13th centuries and mapped their locations to better understand the relationship between the imperial state and the local government leaders.

ONE-STOP LEARNING

By Suzanne Boden, Esri Training Services

With the relaunch of the Esri Training website, you now have a centralized location for geospatial learning. Learning content produced by experts and teams across Esri is now accessible from a single place—esri.com/training.

"Esri encourages lifelong learning," said Esri president Jack Dangermond during the 2016 Esri User Conference Plenary Session when he announced that all customers with a qualifying product that includes current maintenance would receive unlimited, free access to self-paced e-Learning through the new Training site. "We are happy to offer organizations the opportunity to train more people in their workforce in how to use ArcGIS at no additional cost."

This easy access means that you and more people in your organization can take advantage of up-to-date, authoritative ArcGIS learning resources to acquire new technology skills, incorporate spatial thinking and problem solving in their work, and apply ArcGIS tools to gain location-enabled insight.

Esri produces content designed to help users at all levels be productive with ArcGIS. Hundreds of learning resources support experienced GIS professionals, application developers, students, educators, people who are not GIS professionals but want to use the technology, and anyone interested in learning geospatial concepts and building ArcGIS skills.
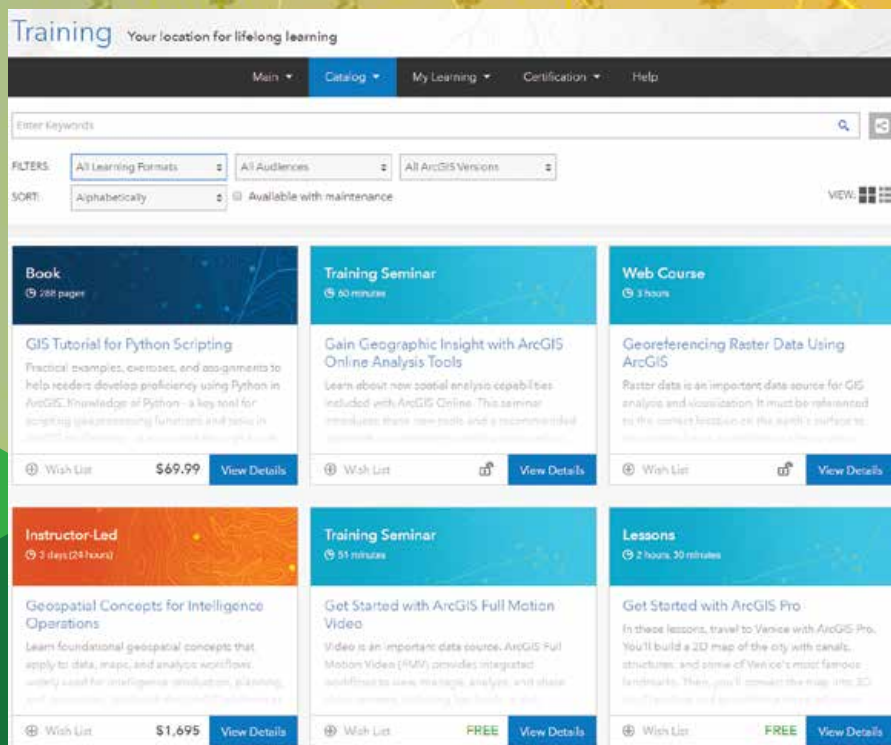
All content is professionally curated and vetted for currency. It ranges from a variety of self-paced presentations, courses, exercises, and books to MOOCs (massive open online courses) and instructor-led classes. This variety of formats supports different learning styles, schedules, and preferences. Self-paced e-Learning options can last from one to three hours, while instructor-led courses can last from four hours to five days. MOOCs, which have become extremely popular with working professionals, blend the instructor-led and self-paced learning experiences. Over four to six weeks, MOOC students watch video lectures; work through hands-on software exercises; and participate in lively, moderated discussion forums.

The Training site simplifies content discovery. You don't have to visit multiple sites to access all the learning resources Esri provides. While many Esri Press books, Learn ArcGIS lessons, E380 videos, MOOCs, and educator resources (including GeoInquiries, Mapping Our World lessons, and SpatiaLAB hands-on activities) are still available from individual Esri web pages, they have also been curated into the *Training* catalog to provide you with "one-stop learning."

Given all the learning resources available, you may want some guidance. Learning plans are a new way to jumpstart understanding and get hands-on experience applying ArcGIS to a focused topic or workflow. A learning plan contains a set of sequenced learning options, typically a mix of web courses; seminars; videos; Learn ArcGIS lessons; and, in some cases, instructor-led courses. Spatial analysis, ArcGIS Online administration, mapping, and more topics are available as learning plans that can be accessed by filtering the *Training* catalog.

For decades, Esri has realized the value of education and has been a leader in customer training. Early on, Esri

↑ The new Esri Training website (esri.com/training) provides a centralized location for geospatial learning.

developed instructor-led training courses. This was followed by the founding of Esri Press and the creation of the Virtual Campus, the Esri Technical Certification Program, MOOCs, and many popular K–12 and higher education programs. These investments have helped forge the dynamic and thriving user community of today.

Working professionals must continually build their skills and adapt to new workflows in this rapidly developing technology. The Training site was redesigned with lifelong learning in mind. New content is added regularly, and the learning environment is engaging and dynamic. Individuals can explore and have fun as they continually grow their geospatial knowledge and technology skills.

The open access model for self-paced e-Learning allows you to freely move from course to course and develop new skills as needed. You can find a course in the *Training* catalog and immediately start learning.

To explore the curated collection of ArcGIS learning resources, visit esri.com/training.

A PASSION FOR
GEOGRAPHY
LEADS TO THE
RAIN FOREST

By Carla Wheeler, *ArcWatch* Editor

"There was this dream I had to explore the world," said Richard Resl.

Resl was an Austrian teenager fresh out of high school in 1984 and ready for adventure when he went to see a travel agent. He wanted to go somewhere tropical, a place not in the grip of cold weather or the Cold War. He wanted to experience a new culture and be in touch with nature.

The travel agent told him about a cheap flight to Peru.

"I asked, 'What language do they speak there?'"

"Spanish," said the travel agent. "You will pick it up."

That first trip to Peru (with additional stops in Bolivia, Argentina, and Brazil) set the stage for what Resl would do with the rest of his life and where he would do it. "I fell in love with Latin America and the Americas. The people were so friendly," said Resl.

This is how Resl—a tall, lanky Austrian with long blond hair and a passion for geography—ended up in Ecuador running the nonprofit AmazonGISnet organization.

He teaches indigenous people from 11 nations how to use GIS and other geospatial technologies to protect their land in the Amazonian rain forest and their way of life.

After returning from his post-high school trip, Resl made a big decision. "I decided I wanted to become a geographer," he said. One day in 1988 while studying in Innsbruck, he saw a poster on a wall for a seminar on GIS. Intrigued, he attended and was hooked.

He went on to earn a master's degree in geography with a specialization in GIS from the University of Salzburg, where he was mentored in GIS by professor Josef Strobl. He then attended the University of Washington in Seattle on a Fulbright scholarship to do postgraduate work toward a PhD in geography and studied under well-known professors such as Nick Chrisman and Tim Nyerges.

Then, in 1994, fate stepped in and enticed him to return to Latin America. A physician

was on campus looking for researchers interested in working in Latin America. The doctor wanted to hire a researcher with GIS knowledge to help him do epidemiological research in Ecuador.

The work involved studying where outbreaks of malaria and other mosquito-borne diseases were occurring based on location factors, such as living near a pond or lake or in a secondary rain forest, and social parameters, such as dwelling in an urban area with a sewer system or in a home with a grass roof.

After arriving in Ecuador, Resl soon began to branch out into other areas besides health research. He created a GIS database for the City of Quito's municipal drinking water and sewer system. He got involved in a foundation called DIVA, sponsored by the Danish government, that studied biodiversity in relation to cultural diversity. Though he was becoming more fluent in the Spanish language, his other

language served him well. "GIS was my language to get to know people," Resl said.

The Day the Shuar Came Calling

Resl still vividly recalls the day in 1996 when strangers showed up at his house in Tumbaco. He was living in a small town in Ecuador that had views of the Ilaló volcano and—on a clear day—glacier-covered Mount Cayambe.

"They came from nowhere," Resl said. The small group of Shuar men stood outside and stuck a spear in the ground. *[The Shuar are indigenous people of Ecuador and Peru.]*

"I couldn't really [figure out] what they wanted. I brought them water," Resl said. "Then I had them enter the house."

Since Resl did not speak Shuar, he faced a conundrum. He needed to get work done, but the men would not leave. An idea came to him. He brought out a map and, using the language of mapping, asked "Where are you located?" They pointed to a place on the map. "I could see they were eloquent in using maps."

It turns out the Shuar wanted Resl to travel to their community. Three days later, he took an eight-hour bus trip to a small airport where a charter plane flew him into the Amazon. He was the only passenger in a small plane piloted by a man who said he absolutely would not stay with Resl once they arrived at their destination. "It's quite dangerous," he said.

"We flew over a vast ocean of trees with no gap in between. It was a one-hour flight, almost to the Peruvian border." The pilot dropped Resl off at a small airstrip and minutes later was gone.

Resl stood alone.

"It was five in the afternoon, and I waited there for a half hour. I thought, 'I am really lost.'"

Suddenly the Shuar appeared.

"I was so surprised. They were totally prepared," he recalled. "The whole community was there with a greeting ceremony."

As darkness fell, Resl grew uncomfortable as men with spears and painted faces approached him and told him to sit down. "I was really frightened." However, a young man who spoke Spanish told him to stay awake and accept all food and drink offered.

"If they give you something to drink and eat, don't reject anything," Resl recalls the young man saying. For 24 hours, Resl said he was observed and told to "defend yourself." He thought he was going to be on trial. Suddenly, people came up to him bearing gifts such as jewelry and other Shuar crafts.

The Shuar knew Resl was a geographer and wanted him to map their land. They wanted to create a map of their territory to provide to the Ecuadorian government and create a management plan for their community. Indigenous rights had long been an important issue in Ecuador. The Confederation of Indigenous Nationalities of Ecuador had been formed in 1986 to organize a group of indigenous nations with the goal of gaining those rights.

With no roads—just jungle—Resl knew the job of mapping a territory of 220,000 hectares would be nearly impossible. So he told the tribe the work would cost them $20,000. "I thought, 'They will now say no,' but they said okay."

Two years passed, however, before the Shuar returned to Resl's home in Tumbaco.

↓ Richard Resl (left) shown with friends during a trip to Peru, Bolivia, Argentina, and Brazil in 1986. (Photo courtesy of Richard Resl)

↓↓ The community supported efforts to measure the territories in Transkutuku in southeastern Ecuador with GPS and gather information from satellite images for mission planning. (Photo courtesy of AmazonGISnet, 1999)

"They said, 'We have the $20,000 and we need to go right now.'"

Resl went down to the water department where he was doing consulting work and got two GPS devices and a satellite image of the area. He also recruited a friend, a German engineer, to accompany him for the first two weeks.

Working with a small team of Shuar men, they spent weeks trudging through the dense Amazonian jungles collecting waypoints on GPS devices. They lived off the land, eating small animals and fish. Back at his office, Resl used Esri technology to make the map with the territorial boundaries using the waypoints collected with the GPS devices, the natural boundaries from the satellite imagery, and biodiversity information he collected during his time in the Amazon.

Resl later went on to do more mapping for the indigenous nations and out of that grew the nonprofit organization AmazonGISnet. He is now the coordinator of this network of members of 11 indigenous nations who use GIS as a tool for land planning and management. He works out of an office in Cumbayá, Equador, just outside of Quito.

AmazonGISnet offers training to indigenous students in GIS and other geospatial technologies. Resl said one goal is for the young people to create "life plans" for each territory that incorporate maps. These maps show how space is used within the territory, including where the women grow crops, where the men hunt, where the families live, and where environmentally sensitive land is located. The life plans also can include sacred and ceremonial sites.

Students also are embarking on a project to create story maps using Esri Story Maps apps, which they hope to share with the world via the web. "Maps are a means to explain identity and what makes up their identity," said Resl.

A Sustainable Way of Life

Going forward, AmazonGISnet plans to continue supporting the indigenous people from the Siona, Secoya, Cofán, Waorani, Kichwa, Zapara, Shiwiar, Andoas, Achuar, and Shuar nations as they try to protect their way of life.

Changes are coming to the Amazon.

↓ Map identifying land-use conflicts in the Cordillera del Cóndor mountain range shows that the Shuar territories are less conflicted than the areas by invaded settlers. (Map courtesy of AmazonGISnet/Geoinfo/Fundacion Natura, 2004)
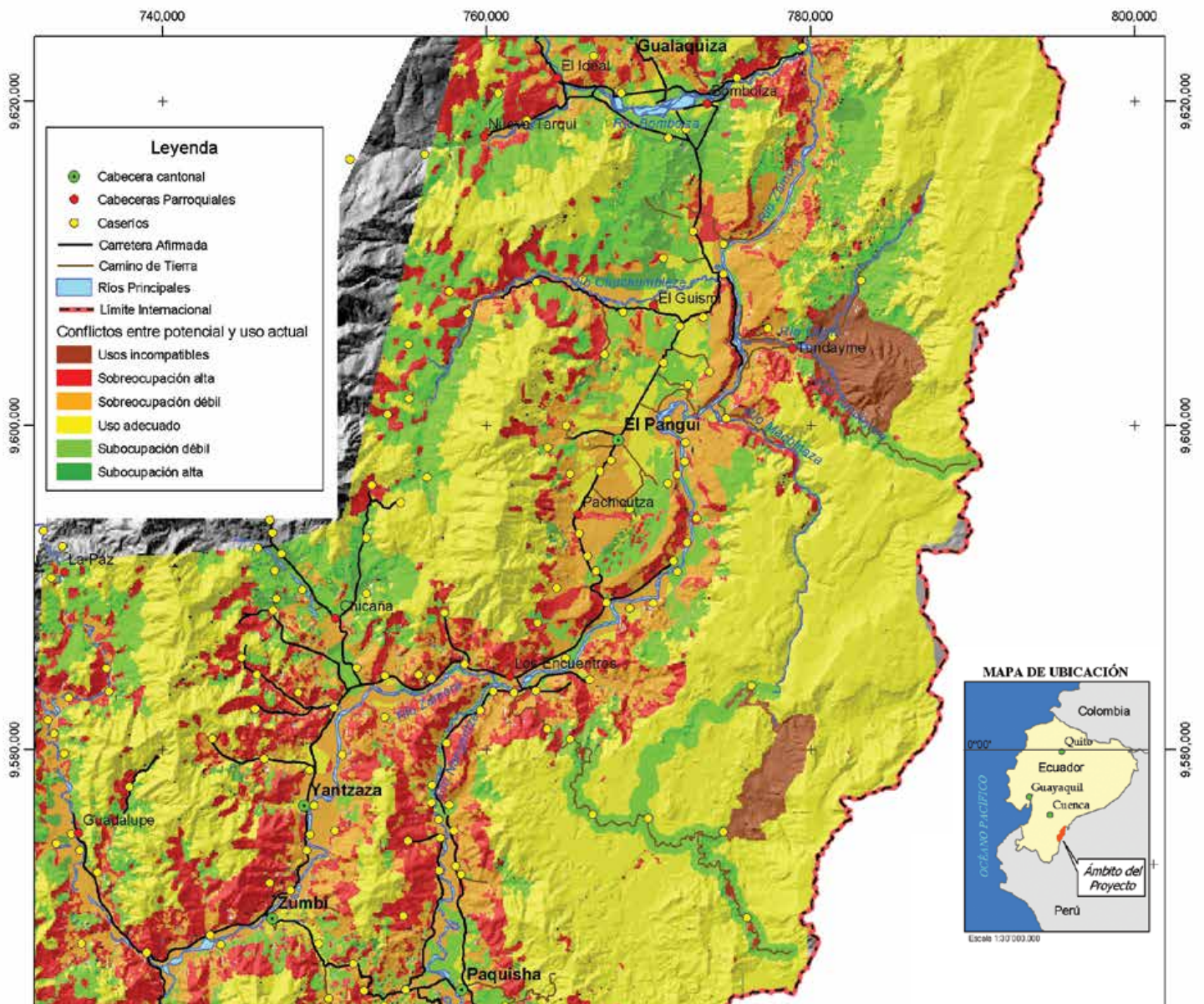
↑↑ Domingo, Telmo, and Nanki (from left to right) at the AmazonGISnet coordinator meeting in Mera, Ecuador, in 2016. (Photo courtesy of Richard Resl)

↑ Domingo Ankuash, a leader of the Shuar nation in Ecuador, presents a ceremonial spear to Esri president Jack Dangermond at the 2016 Esri User Conference in San Diego. The spear signifies friendship between the indigenous nations of Ecuador and the GIS community. Richard Resl of AmazonGISnet watches Dangermond receive the spear.

territories, Resl said. "Domingo *[Ankuash of the Shuar nation]* already mentioned to the city authorities that if they don't proceed with the project soon, he would take the lead with the Austrian cable car partners to build a transport system for his people over the canopy in the Cordillera del Cóndor *[a mountain range]* to connect his people and communities and avoid the construction of roads and the destruction that comes with them and show independence from the mining companies."

Accepted into their community two decades ago on a lonely airstrip in the Amazon, Resl stands with the Shuar and other indigenous people. At the 2016 Esri User Conference, with Ankuash beside him on the plenary stage, Resl accepted the Making a Difference Award for the work AmazonGISnet has done supporting participatory planning among the indigenous communities as they work to preserve their culture, create sustainable economic development opportunities, and protect the fragile environment in the Amazonian lowlands of Ecuador. They are continuing as the keepers of the rain forest, a role they fulfilled for the last thousand years, said Resl.

Increased government-backed mining, oil, and logging concerns are reshaping the landscape and how people live. Resl hopes the maps the indigenous nations are creating with the help of AmazonGISnet will give indigenous nations a stronger voice at the planning table when land-use decisions are made.

The passing years have also brought changes to Resl's life. Besides teaching workshops to the indigenous students through AmazonGISnet, he is an adjunct professor teaching geography and GIS at the Universidad San Francisco de Quito. He is also the program director of UNIGIS in Latin America. *[UNIGIS is a worldwide network of universities that work together on the design and delivery of distance learning in GIS.]*

He came up with the idea for a modern urban cable car system between Quito and the new growing central locations of the Tumbaco Valley and designed it. This system would help ease traffic jams on roadways and provide a high-quality public transport system at a low cost while decreasing pollution.

Cable car transportation would minimize fuel consumption and would limit the impact of the oil industry in indigenous

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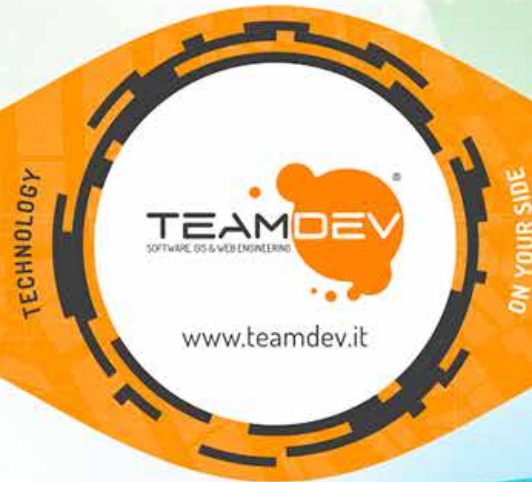
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