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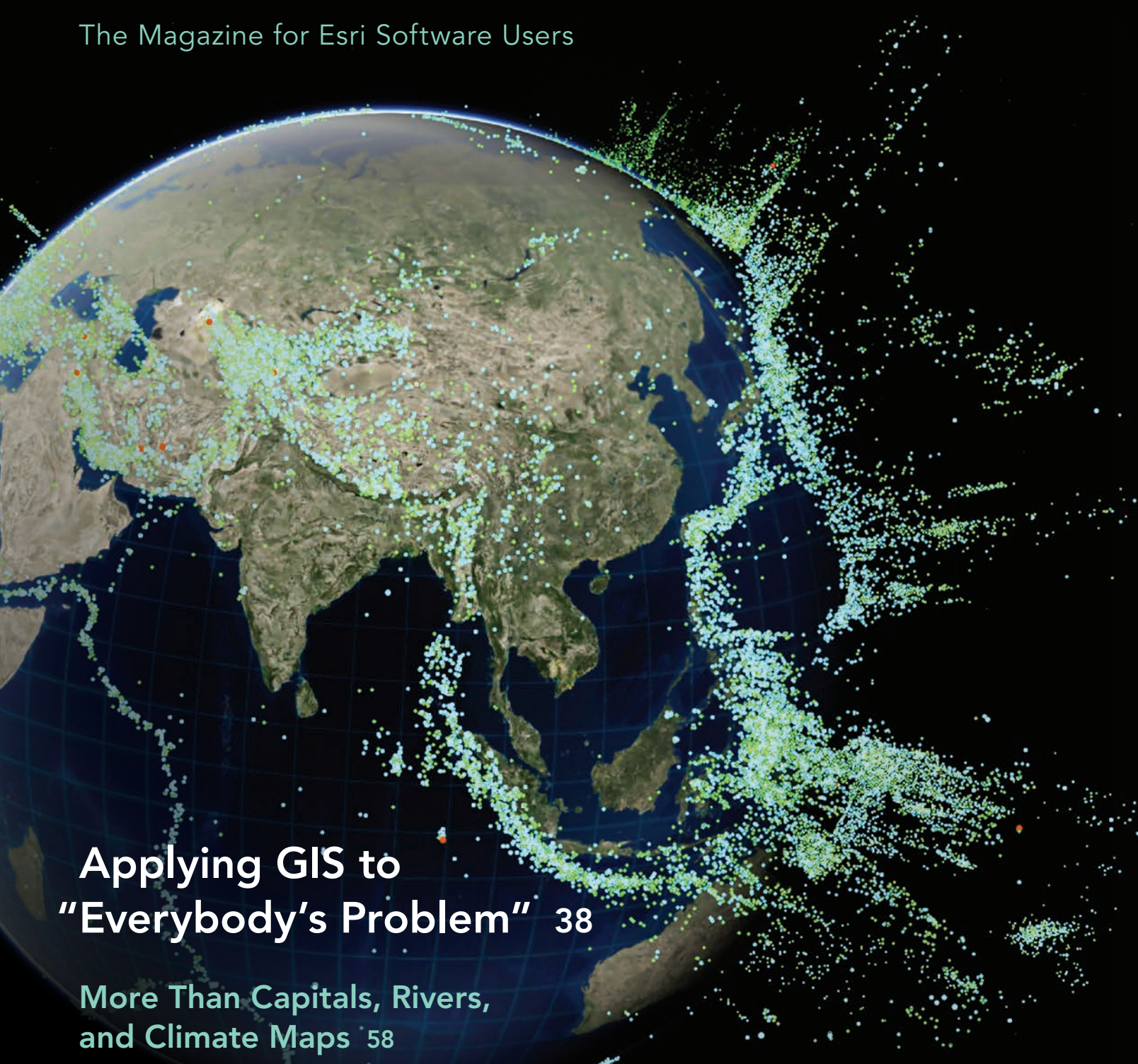
The Magazine for Esri Software Users

Applying GIS to "Everybody's Problem" 38

More Than Capitals, Rivers, and Climate Maps 58

Making the World More Accessible 66

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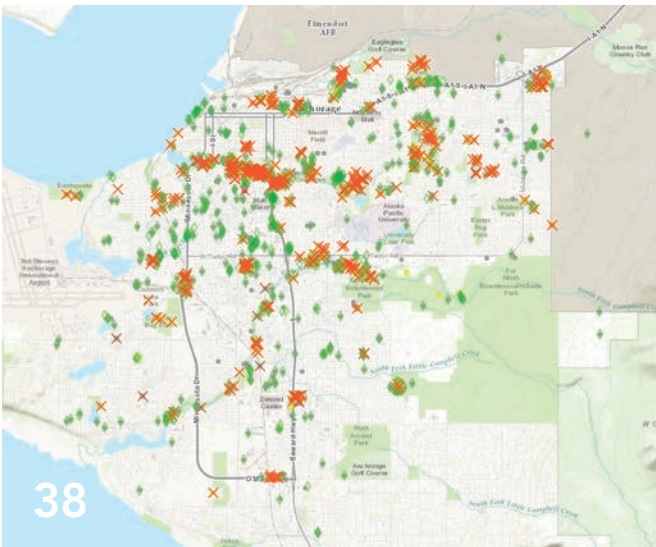TRIMBLE AND ESRI:

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On the Cover

The image on the cover was captured from a web app developed using the ArcGIS API for JavaScript by Raluca Nicola. It displays earthquake data for more than 245,000 earthquakes that occurred between January 2008 and start of May 2018 that had a magnitude greater than 2.5. The depth of the earthquake is inverted and displayed as altitude. The size is proportional to the magnitude.

Critical Information for Today and Tomorrow

One of the defining characteristics of GIS is its capacity to integrate all types of data, analyze it in a geographic framework, and produce and effectively communicate information that not only can improve lives, but sometimes save them.

When Hurricane Florence threatened the City of New Bern, North Carolina, in September 2018, city officials used ArcGIS field apps and dashboards to locate and coordinate the rescue of hundreds of residents threatened by floodwaters. Beyond safeguarding the immediate welfare of its residents, the city's use of GIS to quickly document losses enabled residents to receive federal aid as rapidly as possible, thus ensuring their long-term well-being.

Using RC View, the American Red Cross gives its organization—from its directors to its volunteers—access to the GIS technology that helps it so effectively deliver services to victims of disasters. Using GIS, the Red Cross can understand and respond to crises by determining what will be needed and where it will be needed.

GIS has been instrumental in addressing a slower moving but no less serious crisis that has been developing along the margins of cities in the United States. GIS is being used by cities to mitigate the impacts of the encampments of thousands of homeless people. It is also helping government workers connect homeless people with services that can improve their lives.

Teachers are extending and expanding the capacity of GIS to improve outcomes in the future. By incorporating spatial thinking into curriculums, they are challenging students to explore issues in their communities, gather and analyze data, and use the information produced to come up with new solutions. Students recognize the value of these problem-solving skills. As Claire King, a high school student in Virginia, observed, "Knowing that I can answer my own inquiries and represent my finding in a way that is presentable to others is empowering."

Monica Pratt
ArcUser Editor

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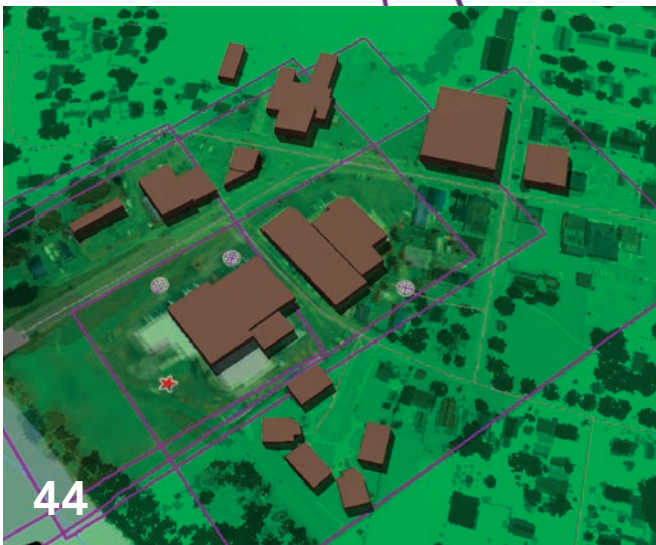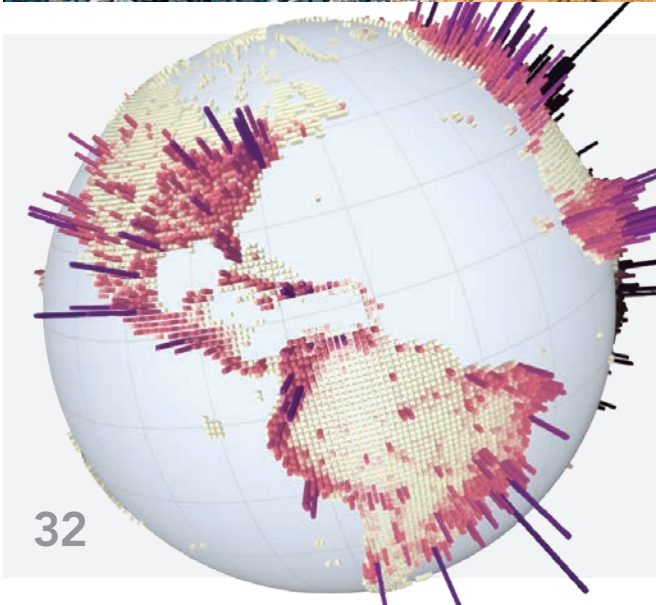
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Departments

↓ USNS *Lewis and Clark* departs Naval Station Norfolk in preparation for Hurricane Florence. The Navy supports local and regional organizations during humanitarian and ecological crises. (US Navy photo by Mass Communication Specialist 3rd Class Caledon Rabbipal/Released)

HACKtheMACHINE

Brings Devs and Geospatial Tools Together

Talented and innovative software engineers, data scientists, and security researchers teamed up over the weekend of September 21–23, 2018, in Seattle, Washington, to participate in HACKtheMACHINE.

The hackathon, presented by the Naval Sea Systems Command (NAVSEA) and cosponsored by Esri, was held to work on some of the most challenging problems facing the United States Navy in its mission to protect sea, air, space, and subsurface domains. NAVSEA hoped that by exposing its interesting problem set HACKtheMACHINE to a largely untapped talent pool, it could gain new perspectives and develop innovative digital capabilities.

"I am a firm believer that these developers are the explorers of the twenty-first century. In this age of data-driven exploration, people need a framework to explore

→ Developers at HACKtheMACHINE were tasked with discovering cybersecurity vulnerabilities of shipboard systems.

through," said Cameron Kruze, an associate at Booz Allen Hamilton. "Partnerships like HACKtheMACHINE with Esri and Booz Allen is empowering these explorers." (Booz Allen Hamilton, an Esri partner, was an event presenter.)

HACKtheMACHINE participants used ArcGIS APIs and software developer kits (SDKs) to bring a geospatial context to maritime security situations that were the focus of two of the tracks at the event. Teams that developed innovative uses of the ArcGIS platform received annual ArcGIS Developer Subscriptions.

The Data Science and the Seven Seas track focused on the navy's use of artificial intelligence to better use the technology in its ships and submarines. Participants in this track used data from ships under way on the high seas to develop algorithms to assist the navy with preventing collisions of human-operated and autonomous vessels.

The Hack for the Oceans track addressed the navy's need for the app development community to support its new onboard service architecture and help coordinate with local and regional organizations during humanitarian and ecological crises. Participants put

↑ The team of Abhi Banerjee, Mark Chuna, Kevin Africa, Andrew Nicholls, Austin Krauss, and Jared Anderson won the award for excellence in development on the ArcGIS platform. Curt Hammill of Esri stands behind the team.

themselves in the position of first responders after Hurricane Katrina in 2005.

Abhi Banerjee, Mark Chuna, Kevin Africa, Andrew Nicholls, Austin Krauss, and Jared Anderson were on the winning team. They had recently graduated with data science degrees and were participating in HACKtheMACHINE because they are looking for jobs. Although they had no prior ArcGIS experience, they built a data science analytic pipeline with ArcGIS Pro in just 28 hours and presented their findings using an Esri Story Maps app.

ArcGIS gave the team functionality that was both valuable and accessible. "Certain data is impossible to inspect without a tool like ArcGIS," said Krauss. "I was impressed at how easy it was to connect my data into ArcGIS," said Banerjee.

Hackathons have been around for nearly 20 years, and in the last decade, many have focused on ways to improve government. While these gatherings can't solve the world's problems in a weekend, these events expose problems to fresh eyes, yielding new approaches to problem solving—and that does have lasting value.

"HACKtheMACHINE brings technology developers together to fix problems," observed Francis Toto of Booz Allen Hamilton. "They have been working all weekend to assemble their disparate technologies on the ArcGIS platform to make something worthwhile."

← Cameron Kruse of Booz Allen Hamilton and Michael Shareghi of Esri supported the event.

Briefly Noted

→ ## Geospatial Data Act Enables National Collaboration among the GIS Community

The US Congress passed the Geospatial Data Act (GDA) of 2018 as part of the Federal Aviation Administration (FAA) Reauthorization Act (H.R. 302). The bill's sponsors were Sen. Orrin Hatch, a Republican from Utah; Sen. Mark Warner, a Democrat from Virginia; Rep. Bruce Westerman, a Republican from Arkansas; and Rep. Seth Moulton, a Democrat from Massachusetts.

Agreeing to this common vision will make it easier for federal, state, and local agencies of all sizes to integrate location data into widespread practice. The passage of this bill presents new and exciting opportunities for the public and private sectors, universities, organizational stakeholders, and the public to strengthen the geoplatform and ensure that geospatial data is made more widely available to support government programs.

"We are grateful for the efforts of the GDA's sponsors, as well as the geospatial organizations that have taken a leading role in shaping this bill," said Jack Dangermond, Esri founder and president. "This legislation will significantly address how location intelligence is organized and disseminated and will foster continued strength in our industry's partnership with government users."

As federal agencies implement the GDA in the coming months and years, it is critical that leaders build upon and augment the incredible work the government is doing with geospatial data and tools. Federal missions will be best served by agencies working collaboratively to utilize geospatial data for analysis, problem solving, and enhancing situational awareness.

Esri stands ready to support congressional leaders, agency heads, the Federal Geographic Data Committee, and the entire ecosystem of geospatial data users and providers as the GDA is put into practice. The power of geospatial data is transformative. This act has paved the way for improved data standards and accessibility, which will fuel innovation throughout the nation.

→ ## New System Tracks Vessels in Real Time

Prefectura Naval Argentina, the Argentine Coast Guard, and Aeroterra S.A., Esri's distributor in Argentina and Uruguay, have partnered to implement a real-time tracking system using the ArcGIS platform. The new system, called Guardacostas Pro, uses satellite imaging and signal processing to monitor vessels for illegal activities such as drug smuggling and fish poaching in the coastal waters of Argentina's exclusive economic zone (EEZ).

Prefectura Naval deploys patrol vessels, helicopters, and airplane spotters to protect its economic interests and preserve its fishery. This year, Guardacostas Pro assisted Prefectura Naval in catching a ship that had poached approximately $380,000 worth of fish from Argentinian waters. The ship was impounded and fines levied based on the data collected.

Until recently, Prefectura Naval's primary enforcement tool was constant patrolling and investigating ships. Now Guardacostas Pro monitors the collision avoidance signals that every vessel transmits. These signals provide data on vessel type, speed, and location. When combined with satellite imaging and the spatial analytics capabilities in ArcGIS, this system sends coast guard personnel real-time alerts when vessels enter EEZ waters. Once the system was proved at sea, it was moved ashore and has become a multiagency tool that aids the Ministry of Security's homeland security mission.

→ Digital Archive Lets You Turn Back Time

Wayback imagery is a digital archive of the World Imagery basemap available from Esri that allows you to access more than 80 different versions of world imagery that were captured over the past five years. This imagery can be viewed in the World Imagery Wayback app and added to ArcGIS Online, ArcGIS Pro, or ArcMap.

These layers are useful for monitoring changes to the landscape that result from expanding urban areas or events such as volcanic eruptions, earthquakes, or mudslides.

The best place to explore previous world imagery versions is through the World Imagery Wayback app, which can be accessed from ArcGIS Living Atlas of the World. The app presents the versions within a map along with a timeline and list of available versions. Preview changes between versions by hovering over or selecting individual layers.

The desired Wayback layers located in the app can be added to an export queue and pushed to a new ArcGIS Online web map and incorporated in Esri Story Maps apps, such as Swipe and Spyglass.

In addition to adding individual imagery layers to an ArcGIS Pro map, you can browse, search, and load Wayback imagery items through the Catalog in ArcGIS Pro with a direct connection to the Web Map Tile Service (WMTS). WMTS is a standard protocol for serving prerendered or runtime computed georeferenced map tiles over the Internet.
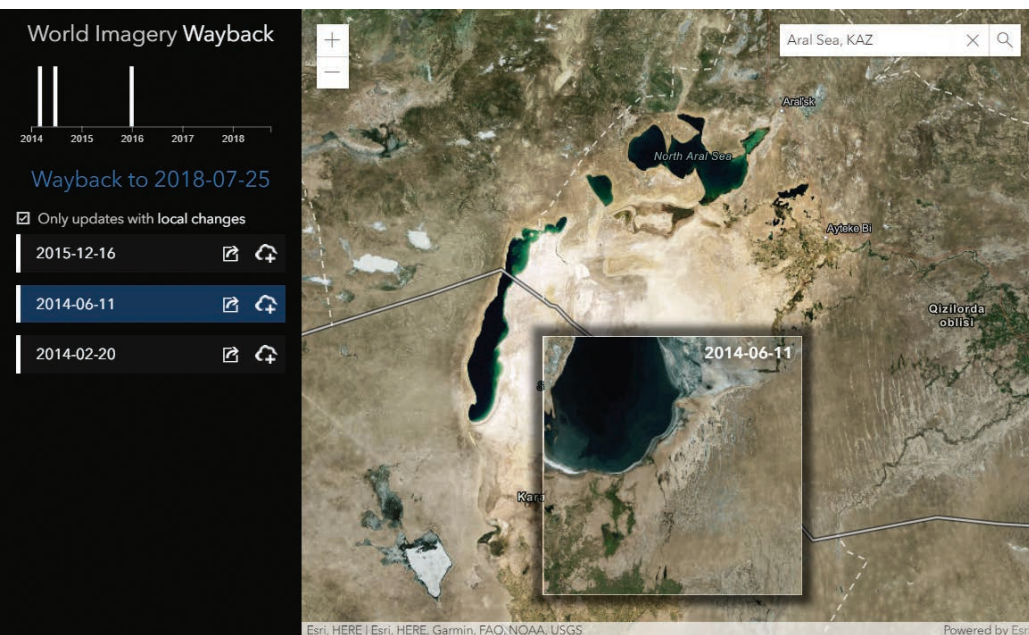
↑ The World Imagery Wayback app allows you to access more than 80 different versions of world imagery that were captured over the past five years.

Analysis Patterns for Multidimensional Scientific Data

By Kevin A. Butler and Deng Ding, Esri

Storing data in multiple dimensions allows earth scientists and GIS analysts to capture and analyze data gathered from under the earth's surface, from its atmosphere, and from its oceans.

GIS workflows have historically been two-dimensional. However, in addition to the familiar x and y spatial dimensions, multidimensional data can have one, and sometimes two, additional dimensions. Three of these dimensions can be visualized as the axes of a cube. The data can be regularly gridded (as a raster) or in point format (with one point at the centroid of each cell in the array). For ocean data, the third dimension contains data on depth (x,y,z). For atmospheric data, the third dimension often contains data on the pressure level in a standard atmosphere (x,y,p). The third dimension is also used to store time (x,y,t).

Four-dimensional datasets store spatial data (x and y dimensions)

at various depths or altitudes (z) at different times (t), yielding an x,y,z,t dataset.

Unlike general relational database or GIS-based formats, scientific data formats are optimized for storing multidimensional scientific data and the associated metadata. To efficiently store multidimensional data, the science community has developed specialized file formats such as Network Common Data Form (netCDF), Hierarchical Data Format (HDF), and Gridded Binary (GRIB).

Support for netCDF was introduced in the ArcGIS platform in version 9.2 through the Multidimensional toolbox. Multidimensional tools support raster, feature (point), and tabular data. Support for

↓ These four analysis patterns embody a high-level abstraction of different approaches to analysis workflows.

Slice by Slice
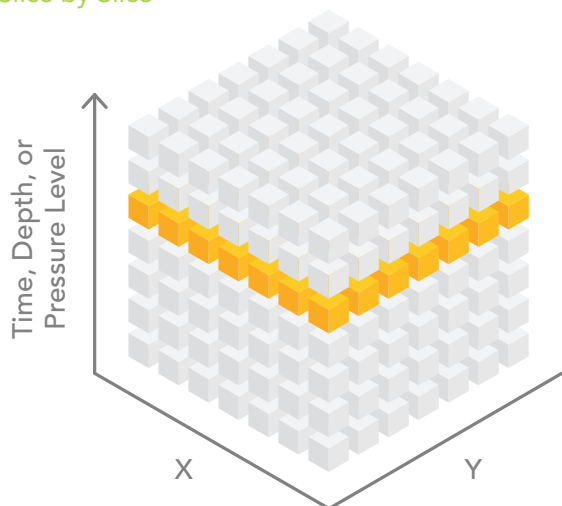
Location by Location
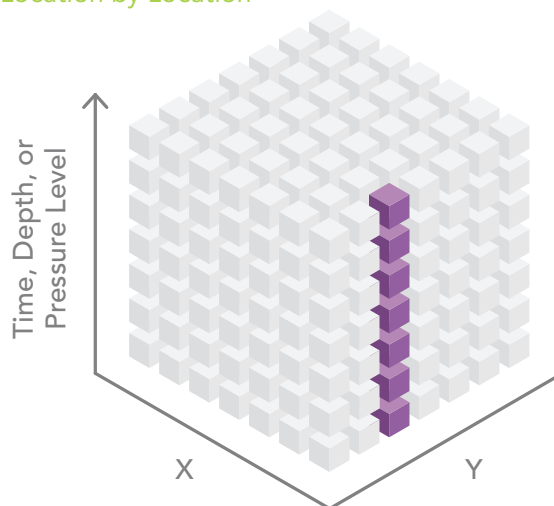
↓ Multidimensional data with three dimensions can be visualized as the axes of a cube.

patterns, and agile software development methodologies, introduced this concept in 1997 to provide a high-level abstraction of an analysis workflow. Slice by slice (within one file or in separate files), location by location, aggregation, and custom are the four main patterns for analyzing multidimensional data. The first three patterns can be accomplished using geoprocessing tools and ModelBuilder in ArcGIS. The last approach—custom—requires some programming.

Slice by Slice

The slice-by-slice analysis pattern works with data in the same file or with data contained in separate files. A common multidimensional data workflow processes the dataset one slice at a time. That one slice can be one depth level, one altitude level, or one time period. Think of the multidimensional dataset as a stack of playing cards. Each card in the deck is peeled off as a two-dimensional slice, and it can be analyzed using some of the hundreds of geoprocessing tools available in ArcGIS. One disadvantage of this analysis approach is that it doesn't include information from any other depth, altitude, or time slice.

To begin slice-by-slice analysis, run one of the Make NetCDF tools from the Multidimension toolbox. This toolbox contains geoprocessing tools that create a netCDF raster layer, feature layer, or table view. Each of these tools has an optional parameter that allows the user to select the dimension (slice) that will be used to create the netCDF layer. The dimension value can be expressed as either a value (mm/dd/yyyy) or as an index.

The first-dimension value in a netCDF file has an index of zero. The

raster data stored in HDF and GRIB was introduced through the mosaic dataset in version 10.3. ArcGIS support of these multidimensional formats enables the integration of scientific data into GIS workflows and allows ArcGIS to serve as a platform for scientific data management and analysis.

Analysis Patterns

According to Martin Fowler, analysis patterns are a way of documenting "an idea that has been useful in one practical context and will probably be useful in others." Fowler, a British software developer who has specialized in object-oriented analysis and design, UML,

Aggregation

Custom Analysis

t_3

Z

X   Y
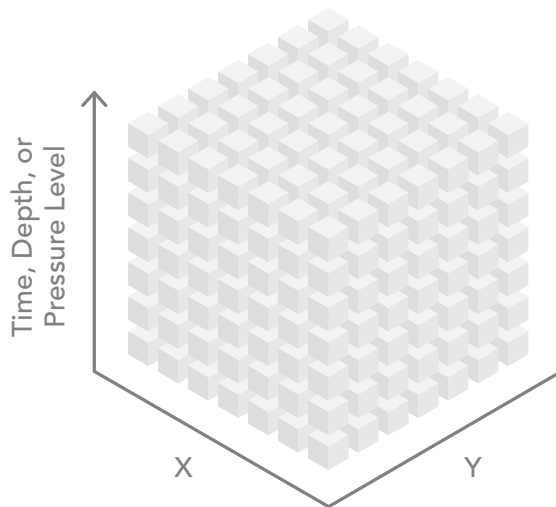
t_n

Z

X   Y
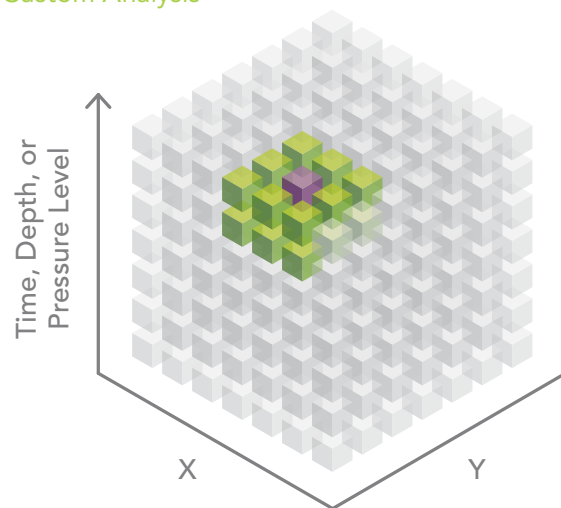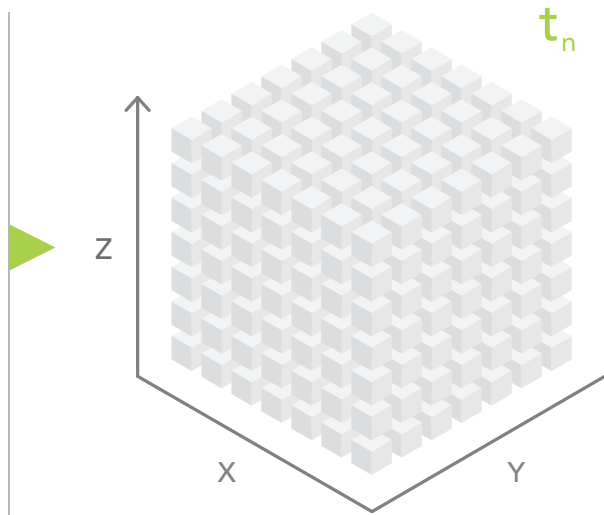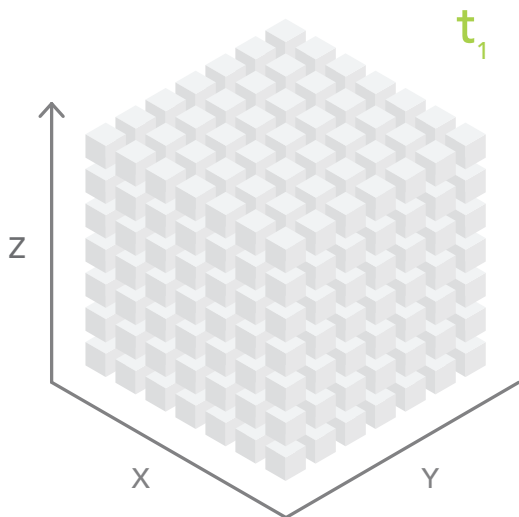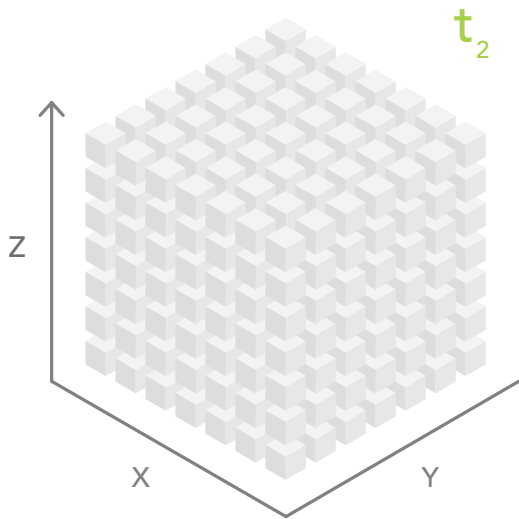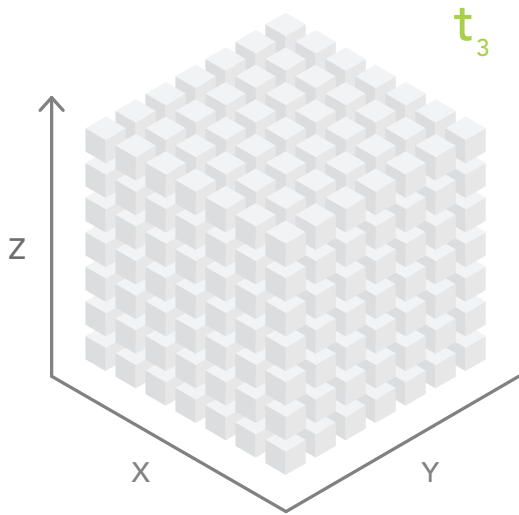
↑ Four-dimensional datasets store spatial data (x,y dimensions) at various depths or altitudes (z) at different times (z), yielding an x,y,z,t dataset.

t_2

Z

X   Y

t_1

Z

X   Y

dimension index is increased by one for each slice. For example, a netCDF file containing five time slices might have dimension values of 2001, 2002, 2003, 2004, and 2005. The same time slices could be referenced using the dimension indexes 0, 1, 2, 3, and 4.

When iterating through the slices of a netCDF file, it is often easier to use dimension indexes especially when using ModelBuilder with an iterator. The iterator starts with zero (the first slice of the netCDF file) and loops through the model until the last slice of the netCDF file is processed. The user must specify the end value of the iterator.

While netCDF files are designed to contain multiple slices of data, sometimes processing constraints, such as file size, rapid update cycles, or the need to move files quickly over the web, prohibit creating large netCDF files with many slices. This is often the case when netCDF files must pass through security firewalls or are the output of models that produce new time slices frequently.

To circumvent these constraints, data providers can create a new netCDF file for each slice. It is then the responsibility of the user to analyze these files one by one or aggregate them into a new file. The workflow to analyze the files one by one is very similar to the slice-by-slice method within a single file.

Location by Location

Raster-based multidimensional data can be thought of as a series of regularly spaced grids stacked on top of each other. Each slice in the stack represents a different depth, pressure level, or time. For some analyses, the analyst needs to process each raster cell (location) across depths or across time. Conceptually, this is like sticking a skewer through the cube at each location and performing some operation on all the cells the skewer touches. This workflow can be accomplished by stacking the slices of the multidimensional data into a multiband raster. Some geoprocessing tools, such as Cell Statistics and Band Collection Statistics, automatically know how to process multiband rasters.

Spatial and/or Temporal Aggregation of Point or Tabular Data

The multidimensional mosaic dataset is the preferred solution for spatially and temporally aggregating multidimensional raster data. However, geoprocessing-based workflows are required to aggregate feature or tabular data. File size, rapid update cycles, or other constraints often cause scientific data to be organized so that each year of data is in a separate file. A common pattern is to aggregate data into a single file and then perform analysis. An example could be creating monthly means for a number of years.

Custom Analysis Using Python

The Make NetCDF Raster Layer, Feature Layer, and Table View geoprocessing tools, along with the powerful capabilities of the multidimensional mosaic dataset, enable a wide range of workflows for analyzing multidimensional data. In some instances, however, the slice-by-slice or location-by-location approaches may not be sufficient. Fortunately, with the 10.3 release of ArcGIS, the new netCDF4 Python library began shipping as part of the ArcGIS platform.

The netCDF4 library allows you to easily inspect, read, aggregate, and write netCDF files. When data is read by the netCDF4 module, it is stored as a numPy array, allowing access to the powerful slicing syntax of numPy arrays. Data can be sliced by specifying indexes. For example, the variable tmin has three dimensions: year, latitude, and longitude. By specifying an index (or a range of indexes), the three-dimensional data cube can be sliced into a smaller cube.

Conclusion

The ArcGIS platform provides many ways to analyze the multidimensional scientific data, enabling modeling and greater understanding of earth phenomena. Esri continually develops and enhances tools and workflows for acquiring, managing, analyzing, visualizing, and sharing multidimensional data.

About the Authors

Kevin A. Butler is a product engineer on the Esri spatial statistics team and a member of Esri's virtual science team. He holds a doctorate in geography from Kent State University, Ohio.
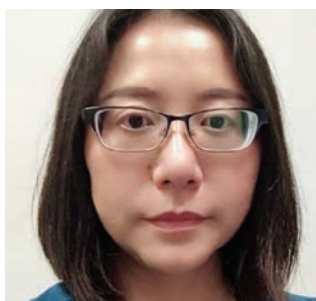
Deng Ding is a product engineer on the Esri raster team. She holds a doctorate in geography from University of Iowa.
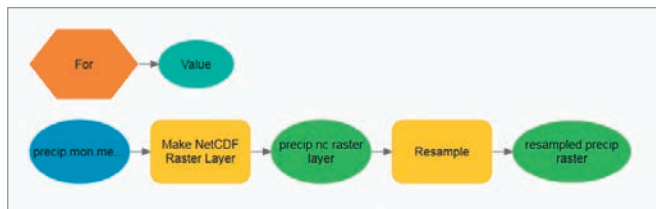
↑ ModelBuilder can be used to perform a slice-by-slice analysis of data in a single file. Each time the model loops (iterates), the value generated by the iterator will be substituted. Note that the same inline variable substitution is used to ensure that a unique output name is used for the output of the Resample tool.
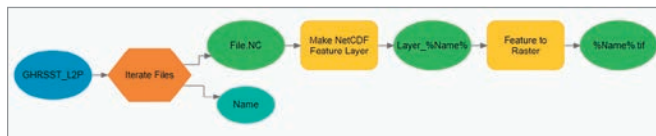
↑ In this workflow, several netCDF files are contained in a single file directory, and a File Iterator—instead of the For Iterator—is used. The File Iterator scans the specified file location and creates a list of files to process. Through inline variable substitution, the name of the file (%Name%) is passed to the Make NetCDF Feature Layer tool, and the resultant netCDF feature layer is passed to the Kernel Density tool to interpolate a raster surface.
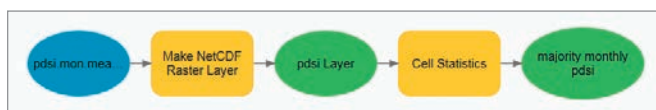
↑ This workflow uses the Band Dimension parameter of the Make NetCDF Raster Layer tool to translate netCDF dimensions, such as depths or time steps, into bands in the output raster.
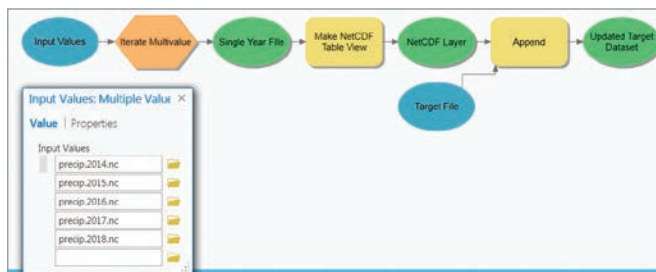
↑ This example aggregates temperature data by having the model iterate through a list of files containing daily precipitation data covering four years. The table created for each year using the Make NetCDF Table View tool is appended to a target file, which is passed into various analysis workflows when the process is finished.

↑ This Python code snippet extracts the first five years of data for the variable tmin and prints summary statistics. The resultant numPy arrays can be passed to any number of Python modules for custom analysis.

The GIS Solution

That's Changing Traditional Emergency Response and Recovery

By Mark Wallace

As one of the largest disaster recovery organizations in the world, the American Red Cross responds to an emergency every eight minutes.

From small house fires to multistate natural disasters, the organization partners with hundreds of government authorities to understand where it is needed before dispatching a volunteer army of more than 40,000 to provide affected communities with clean water, safe shelter, and meals.

The organization recently completed a digital transformation strategy aimed at optimizing its service delivery. Central to this program was establishing a world-class geospatial solution to guide its operations and generate new efficiencies.

RC View, its award-winning GIS solution, synthesizes thousands of federal, state, and local data sources into one dynamic picture that informs the decisions and actions of its workforce of more than 80,000 as well as an extended network of government agencies and community partners.

The insights derived from this GIS solution are vital during large-scale national disaster relief operations, in everyday response to home fires, and in preparedness efforts for local communities throughout the United States.

American Red Cross senior director Brian Keenum gave Mark Wallace of Esri Australia a behind-the-scenes look at the organization's revolutionary approach to disaster response and recovery.

Mark Wallace: When embarking on your digital transformation strategy, what role did you see for GIS technology at American Red Cross?

Brian Keenum: American Red Cross has been using GIS technology tools to support its operations through creating maps of territories and providing situational awareness for around 20 years, but it was only around three years ago that the organization made a concerted effort to digitally transform its GIS. We set out to create a truly dynamic and modern system that could inform all of operations, by ensuring we were making the right decisions and providing absolute operational transparency to our various stakeholders.

We've been successful in achieving that and were humbled to receive the Esri President's Award from Jack Dangermond *[at the 2018 Esri User Conference in San Diego, California]*. But it's not just a testament of the hard work the folks here have done. It's a reflection of the hard work of our extended network of partners—including government departments, community organizations, and technology providers—who provide us with the additional data, content, and capabilities we need to make a difference.

Wallace: Tell us about your flagship GIS solution, RC View.

Keenum: RC View is an enterprise portal that provides broad access to GIS technology to people across our organization and volunteer network, from directors to operations to volunteers. It is our key platform for managing and analyzing our own data, as well

↑ Esri president Jack Dangermond presents the 2018 President's Award to the American Red Cross, represented at the Esri User Conference ceremony by Harvey E. Johnson Jr. and Brian C. Keenum.

as data from other government agencies like the National Oceanic and Atmospheric Administration *[NOAA]* and Federal Emergency Management Agency *[FEMA]*.

The insights the technology generates are absolutely critical to our operations on the ground, as well as for our key strategic decision-makers.

We run several programs that are centered around this technology, but from the perspective of a day-to-day basis, we use our GIS solution to provide mapping and analytics capabilities for our service delivery teams. This includes planning and executing service delivery during crises and in response to natural disasters. It's a critical system for understanding in real time what the potential impact of

a crisis may be, who will be affected, how we should respond—and how we can send resources to the right place as quickly and efficiently as possible.

Wallace: How has the technology strengthened your ability to mobilize your workforce during response and recovery?

Keenum: Mobile GIS—and being able to capture and share data and analysis on the fly—has been a very powerful enabler for Red Cross. For example, at our evacuation shelters, we developed a program called RC Collect, which uses Survey123 for ArcGIS, to give our

workers the ability to electronically check in people and record their details as they arrive. This feeds into our RC View system so we can record and look back on the data, too. This gives us more visibility as to the demographics of who we are helping and reasons they may be staying at the shelter, and unable to get back to their homes.

This was all paper based previously, so the efficiencies gained have been huge. Also, just having that information available in a dynamic, map-based view makes it easier to connect the dots. For example, if we can clearly see there is a large percentage of elderly people at a shelter, then we may need to organize geriatric services, certain medications, or disability services. If there's a significant number of kids present who are typically at school or day care, then we need to arrange suitable entertainment and activities for them. The RC Collect app has already been a game changer—and down the track, we're also investigating extending this capability to enable self check-in.

Wallace: From an efficiency perspective, how has the technology enabled Red Cross to work smarter?

Keenum: We can clearly see it's taking fewer people to perform our service delivery now we have the right technology in place, and we are reacting a lot more quickly. We also have a detailed understanding of exactly what resources are required to perform a task. This, of course, translates to less wasted time and money because we can deploy the right number of people from the outset, instead of just deploying everyone and realizing later that it was too many people.

The great thing with this technology is we are constantly capturing insights into how we operate to ensure we continually optimize our operations. For example, we are now collecting metrics on how long people may be spending in shelters and making inferences as to why this may be, which helps us determine strategies for getting them back on their feet sooner. These kinds of insights are so valuable—and only made possible by capturing and analyzing this data as we receive it.

Wallace: Aside from response and recovery, how do you use GIS technology for preparedness and mitigation?

Keenum: We have a number of evolving programs in place to support our preparedness activities. For example, there is our home fire campaign, which involves us installing smoke alarms and helping families plan and respond to evacuation alerts.

Our GIS solution provides critical insights into where we need to go to install alarms or run fire safety awareness programs. It does this by capturing and mapping our own home fire data records as to where we have previously installed alarms or responded to an incident, as well as data provided from other fire departments or community groups.

Then we have social vulnerability indexes to identify areas most at risk of fire incidents. By viewing and analyzing this data through a geographic filter, we can clearly understand neighborhoods that require education through awareness campaigns or even door knocking.

Beyond understanding where we need to install smoke alarms, it also helps our disaster action teams respond to every home fire in the US. Where appropriate, we offer financial assistance to folks who can't be in their homes due to damage and who need help getting back on their feet.

Wallace: You have hundreds of thousands of volunteers and staff to manage—how do you ensure they gain value from your GIS?

Keenum: We have 80,000 people in our core RC View GIS portal and 40,000 disaster relief volunteers who could each potentially access our GIS solution. The challenge is *[that]* there are different use cases for each of these users. Some people may just use RC View to visualize where key resources are located, whereas others use RC Collect for disaster assessment or shelter registrations.

Therefore, educating our teams and building capacity is a core priority. Increasing user adoption is key to the success of the entire program. We've innovated to create this game-changing solution, but now it's about building our capacity to use the system to its full potential.

To do this, we established the RC View Academy, which is a program with three tiers for learning: beginner, intermediate, and advanced. Beginner *[level]* is very self-guided, such as educating yourself on how to get into the system and make a map. The intermediate level includes more self-development as well as live online training to take them to the next level on the tools we use. And then there's advanced, where we train the high performers. This is a lot more hands-on. For example, we recently sent 15 folks to Esri headquarters for an intensive four-day course on Insights for ArcGIS and

ArcGIS Pro. Fostering their advanced skills is critical to helping us engage our workforce and build innovation and strength.

Wallace: I understand the next focus for the American Red Cross is making its GIS solution more accessible, not only to its partner agencies and organizations but also to the public. Can you tell us a bit about this initiative?

Keenum: Yes, we're currently working on a project called American Red Cross Hub, which is all about establishing a two-way communication platform between us and our many stakeholders. It draws on the new capabilities and frameworks Esri has recently launched with ArcGIS Hub to take our foundational GIS work to the broader community, so we can collaborate on projects and amplify the effects of the work we do. It really is the next step in evolving our data-driven decision-making capability to increase readiness and to better meet our mission of alleviating human suffering in the face of emergencies. It's a way for us to give those incredibly valuable GIS insights and capabilities back to the folks we work with all the time. We know how critical the technology is to supporting our decision-making capability, so we want to ensure others have access to those abilities too.

Wallace: Can you take us through how American Red Cross Hub may be used to improve interoperability between government organizations responding to a crisis?

Keenum: Providing visibility on joint operations is a key element—such as highlighting where Emergency Services Management (ESM) assets are and where are our assets are to give a common operating picture and ensure we don't duplicate efforts and waste precious time. It incorporates data from not only the fire departments but also our service delivery partners like the Salvation Army. For example, using the map, we can determine where the Salvation Army fixed feeding sites may be so we can determine where to deploy our mobile feeding sites. It really going to be key to optimizing our operations. We also collaborate closely with a number of technology partners, with groups like Noggin, and Esri *[is]* helping us develop the Disaster Action Team Dispatch system, which manages how people get deployed to an incident.

Wallace: How will the portal be used to keep the public informed?

Keenum: I recently read a statistic from the Pew Research Center that 65 percent of Americans search online for information about their government, but less than 10 percent report finding what they need. When it's launched in the coming months, the *[American Red Cross]* Hub will help address this problem and allow us to inform the public and shape our message with them early on in disasters. We need to let the public know what we're doing in a disaster response as early as possible, and this portal will enable that. Initially, we'll start out with sharing where the nearest shelter is, evacuation routes, and any other critical other resources that may be required. Then after the storm, it's about providing updates on our ongoing service delivery—such as listing emergency supplies that have been distributed.

About the Author

Mark Wallace is the manager for business development (QLD, NT & PNG) for Esri Australia, Brisbane. He is an authority in the Australian public safety sector who is passionate about helping government bodies and private agencies leverage an interoperable, collaborative approach to GIS technology. During more than 25 years in the industry, Wallace has worked at both local and state government levels, specializing in emergency management and GIS. As Queensland Fire and Rescue Service GIS manager, he helped his team win the Surveying and Spatial Sciences Institute (SSSI) Industry Award for its efforts during the 2011 Queensland floods and Cyclone Yasi. Wallace applies his skill and knowledge to help organizations find solutions that leverage data effectively to drive smarter decision-making and achieve more effective outcomes.

Use of Damage Assessment Configuration Speeds Rescues and Damage Reports

By Citabria Stevens, *ArcNews* Editor

When Hurricane Florence made landfall in North Carolina on Friday, September 14, 2018, the City of New Bern was as ready as it could have been.

Located near the coast at the confluence of two rivers, New Bern was about 90 miles from the hurricane's point of impact. The city had prepared for big storms before. Two years ago, when Hurricane Matthew—initially a category 5 storm—was forecasted to roll through the Carolinas, the city set up Esri's Damage Assessment configuration of Collector for ArcGIS to help emergency responders keep tabs on field resources and conduct damage assessments. But Hurricane Matthew turned back into the Atlantic Ocean after making brief landfall as a category 1 storm in South Carolina, and New Bern was spared.

"We only had 10 houses that were damaged by trees," said Alice Wilson, the city's GIS manager. "We lucked out."

As Hurricane Florence billowed and roared across the Atlantic in early September 2018, it became clear that New Bern wouldn't be so lucky this time.

"When we heard that Florence was coming and we knew how bad it was going to be, our first thought was to evacuate," said Wilson. "But then we knew some of us had to stay here to help the people who stay behind. [...] We knew there would be significant impact and we'd have to go out into the field as soon as possible."

City officials set up an emergency operations center (EOC) the day before the storm hit. Wilson and her team tested all their geospatial tools ahead of time, including the Damage Assessment configuration that emergency responders would use out in the field and the dashboard that teams in the EOC would employ to oversee operations. They also wanted to be able to provide the Federal Emergency Management Agency (FEMA) with as much information as possible as quickly as possible.

"They had me, as the GIS manager, in a central position in the EOC," said Wilson. "I had utilities on one side, public works on one side, and fire and police across from me."

Initially, Wilson and her colleagues looked for areas they knew would incur the most damage so they could turn off utilities. This would also help them be ready to deploy fieldworkers to fix downed power lines and burst water and sewer pipes after the storm was over.

"We knew, based on our elevation data, [which] areas would be affected," said Wilson.

City officials also knew from Hurricane Irene in 2011 that the Neuse and Trent Rivers that surround New Bern could swell up to seven feet, if not more. Wilson pulled stream gauge data into ArcGIS Desktop so staff in the EOC could monitor the rising rivers. They readied for water rescues.

"We'd put a mandatory evacuation in place, but people stayed for one reason or another," said Wilson.

When Florence hit on Friday afternoon, its impact was immediate. The rivers swelled by 10 feet.

"We were getting call after call for water rescues," she said. "People were calling, telling us they were in their attics and needed to be rescued."

By 11:30 p.m. that night, staff at the EOC were aware that about 150 people needed to be rescued, according to the City of New Bern's Twitter account. But that was only half of what was to come.

"We got through our stuff and then got a call Sunday morning at 1:00 that [the neighboring town of] Pollocksville needed water rescues," said Wilson.

Rescue teams from New Bern weren't familiar with Pollocksville. At one point, the fireman in the EOC said his water rescue crew

↑ City officials set up an emergency operations center (EOC) the day before Hurricane Florence hit. (Photo courtesy of the City of New Bern.)

← The Neuse and Trent Rivers that hem in New Bern swelled by 10 feet. (Photo courtesy of the City of New Bern.)

couldn't find high ground, so Wilson used GIS data from North Carolina's statewide GIS advisory group and found contour lines for Pollocksville. She then employed ArcGIS Desktop to map where that crew was and where it needed to go to get to higher ground.

"We conducted over 300 water evacuations," said Wilson, "and not even just in our city."

Using data from ArcGIS Living Atlas of the World and local information, such as where street closures and shelters were located, Wilson and her team created online, public-facing maps as well. They posted a tabbed story map on the city's website that showed stream gauges, wind velocity, and more information about Florence's sheer potency. They also have a live app that displays all the power outages in New Bern in real time, which proved crucial during the storm, saving city staff an untold amount of time answering phone calls from residents asking about outages.

The whole time, Wilson manned two computers: one that showed a map of New Bern in ArcGIS Desktop and one that pulled the online maps and apps she and her team had built into a dashboard that everyone in the EOC could see on a big monitor.

"It was pretty chaotic, but we tried to make sure we had as much information as possible as Florence came in," said Wilson.

The storm passed through on Sunday, September 16, and the City of New Bern immediately began doing damage assessments using the Damage Assessment configuration it had set up in Collector. Utility workers, firefighters, and inspectors—from both New Bern and outside cities—jumped in to help.

Some of them had never used Collector before, let alone the Damage Assessment configuration, so Wilson and her colleagues got them trained quickly and sent them into the field. There were seven teams in all. Utility workers went first to the houses they knew had been completely inundated by water to see what they would

↓ The city conducted more than 300 water evacuations in New Bern and the neighboring town of Pollocksville.

need to do to restore service. Firefighters and inspectors went out in pairs to examine any fire concerns and record all the destruction using the app.

"We had significant damage," said Wilson. "The storm surge affected us the most."
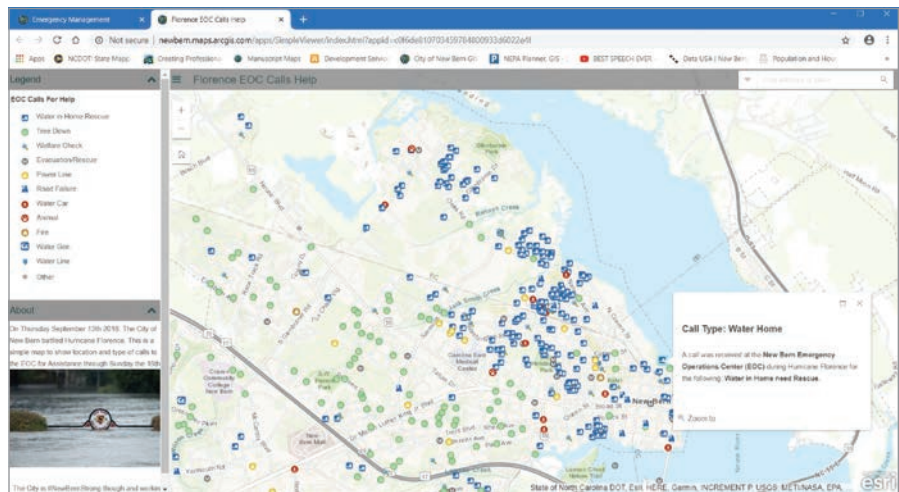
In addition to the 10-foot floods that deluged some parts of town, New Bern had four feet of water inside its historic downtown buildings. Big bear statues that usually stand outside certain businesses were floating down the street. And a few yachts ended up land bound, stranded next to houses and a hotel.

By the following Friday—just seven days after Hurricane Florence hit—New Bern had finished its damage assessments.

"All the houses that were really damaged fell right where we thought they would," said Wilson. "So we knew our data was good."

Inspectors recorded an estimated $100 million of losses to both commercial and residential properties. Although that number is breathtaking—especially for a city of 30,000 residents—Wilson was impressed by how fast New Bern recorded this much damage.

"I was here when we had Hurricane Irene, [which] was probably the worst hurricane that I've been a part of," said Wilson. "Back then, inspectors would use these forms that were FEMA-generated, and they would go handwrite all this information. They would bring it back to me, and I would have to enter it all. It was so time-consuming. You were trying to read somebody's handwriting,

Lines On
Predicted Lines Out
Confirmed Lines Out
Lines Under Maintenace
Device Out Affecting 1-50 Meters
Device Out Affecting 50-350 Meters
Device Out Affecting 350+ Meters
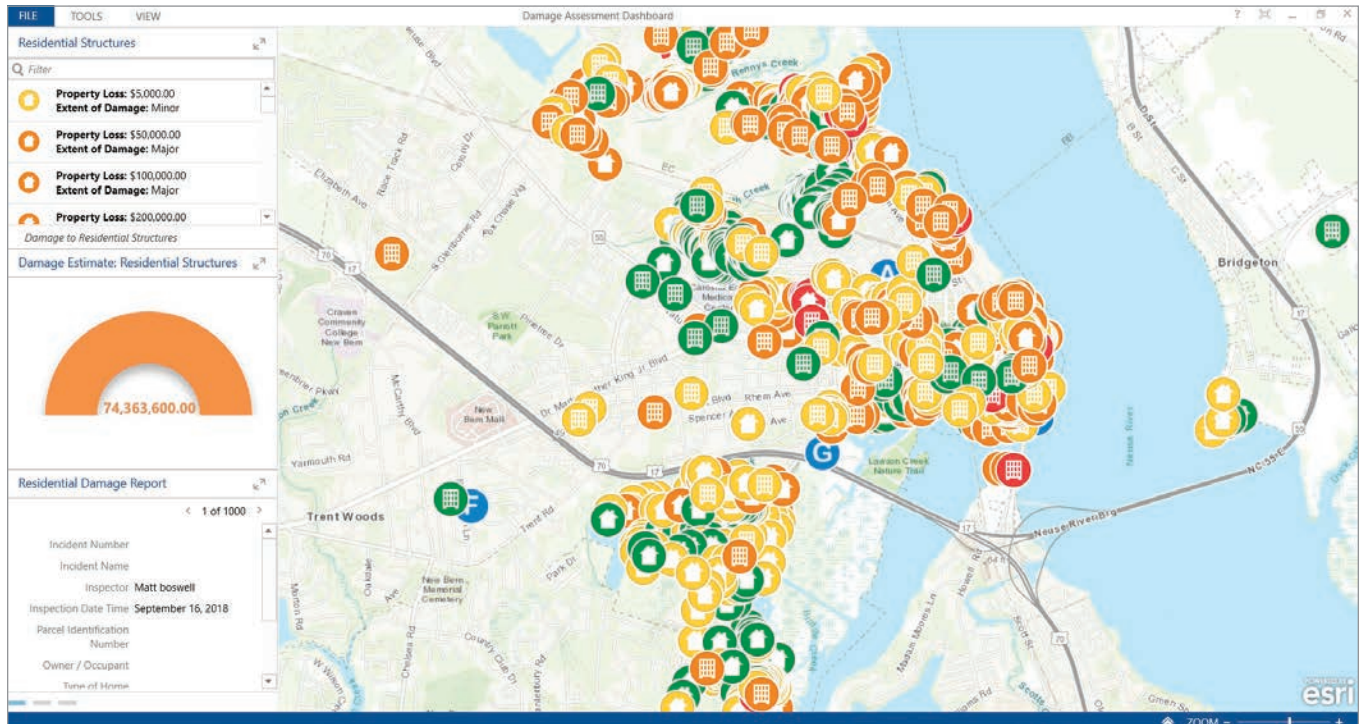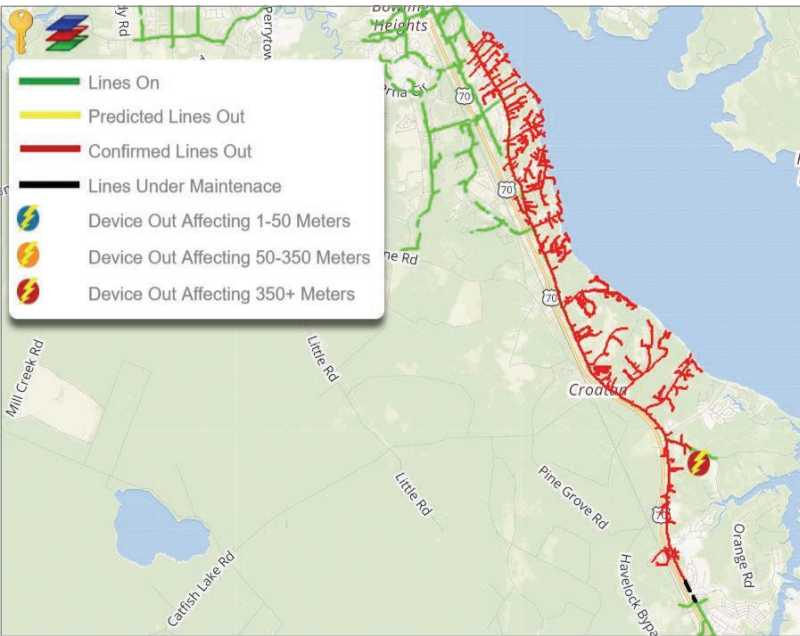
← The City of New Bern has a live app that displays power outages in real time. This map, which the city posted on Twitter and Facebook, shows how many lines were out on September 13—the day before the storm hit.

↓ City manager Mark Stephens (left) and fire-rescue chief Robert Boyd look at a base flood map of New Bern in the emergency operations center. (Photo courtesy of the City of New Bern.)

landfall, FEMA was already aware of New Bern's damage assessment values.

"I can't even think of the amount of time we've saved," said Wilson. "Esri tools…have been instrumental in getting us back on our feet."

With only a few injuries and no deaths recorded in New Bern due to Hurricane Florence, Wilson said she has never been prouder of her community.

"Without question, we just knocked it out of the ballpark and not only helped this city but also helped neighboring cities that didn't have what we have," said Wilson. "Hopefully now we can plan a little better when we rebuild."

About the Author

Citabria Stevens is the senior editor of *ArcNews* magazine. She helps users from all over the world tell compelling stories about how they employ Esri technology in innovative ways and ensures that readers stay well informed about ArcGIS solutions. Citabria began her career as a journalist at CNN before moving into the fields of international development and geopolitics. She holds a BS in communications and journalism from New York University and a dual MA/MSc in international history from Columbia University and the London School of Economics.

and after a while, they would just scribble something because they were so tired."

The Damage Assessment configuration, which works on both Collector and Survey123 for ArcGIS, is so much faster, according to Wilson.

"Because it's spatially located, I don't have to do anything," she said. "We were sharing this live. We *[didn't]* have to process it and turn it around."

As of September 21, just a week after Hurricane Florence made

Leveraging Web 3D for Street-Level Flood Forecasts

By J. Derek Loftis and Geoff Taylor

The StormSense project is an innovative and award-winning inundation forecasting research initiative. It uses ArcGIS mapping to visualize the data from a network of Internet of Things (IoT)-enabled water level sensors and information from the hydrodynamic flood modeling and forecasting capabilities of the Virginia Institute of Marine Science (VIMS) at the College of William & Mary and its VIMS TideWatch network.

This smart city project's objective is to enhance the capability of communities to prepare for and respond to the disastrous impacts of sea level rise and coastal flooding in ways that are replicable, scalable, measurable, and can make a comparable difference.

As tidal flooding is becoming an increasingly pervasive problem for coastal communities, these tidal forecasts are quickly becoming a mainstay for traffic advisories and emergency management.

Additionally, the new sensors densify the previously sparse sensor network to provide additional points of validation for the VIMS street-level hydrodynamic model to aid in guiding improvement for future forecasts.

The project's objective is in the spirit of the National Institute of Standards and Technology (NIST) Global City Teams Challenge. StormSense was awarded its initial funding by NIST through a Replicable Smart City Technologies project grant in 2016. StormSense's goal is to enhance the field of emergency preparedness by advancing research to help predict flooding resulting from storm surge, rain, and tides.

This is translated in a meaningful way by informing map viewers where, when, and for how long flooding will occur. The depth of floodwaters is depicted in 3D.

The project's scope encompasses the interests of coastal local governments in Hampton Roads, Virginia, including the cities of Virginia Beach, Newport News, Norfolk, Chesapeake, Portsmouth, Hampton, Williamsburg, Poquoson, Suffolk, and York and Gloucester Counties. StormSense has installed or ingested existing sensors in these communities into its network.
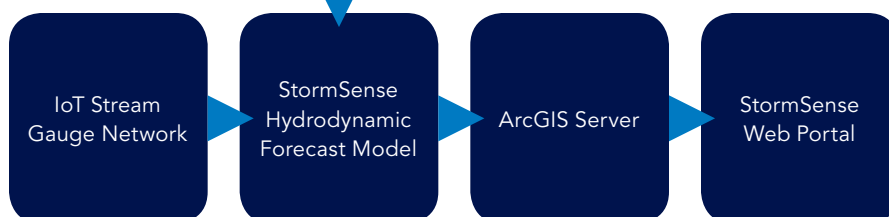
These sensors, located throughout the Tidewater region of Virginia, inform the VIMS' Tidewatch tidal prediction model by ingesting data from a handful of federally owned sensors that were previously installed and data from 28 new water level sensors installed in 2017 by StormSense. The data from these sensors is reported in near real time on the StormSense.com website.

A Proactive Approach to Risk

While being proactive about assessing flood risk is an emergency management mantra, GIS tools are typically funded in response to a specific event. The Flood Inundation Mapping and Alert Network (FIMAN), a component of North Carolina Floodplain Mapping Program (NCFMP), was developed in response to Hurricane Floyd in 1999. *[See "A Real-Time Flood Warning System" in the Winter 2016 issue of* ArcUser.*]* Similarly, the Iowa Flood Center (IFC) was started after a nearly statewide flooding event in 2008.

For FIMAN, the defining event was Hurricane Floyd in 1999; for the Iowa Flood Center, it was a nearly statewide rainfall-driven flooding event in 2008. In Virginia, impetus for developing GIS tools for StormSense was Hurricane Matthew. In 2016, the state legislature established the Commonwealth Center for Recurrent Flooding Resiliency (CCRFR) as a virtual flood center between the Virginia Institute

Observations and Predictions

6-min Automated Retrieval Script

IoT Stream Gauge Network → StormSense Hydrodynamic Forecast Model → ArcGIS Server → StormSense Web Portal
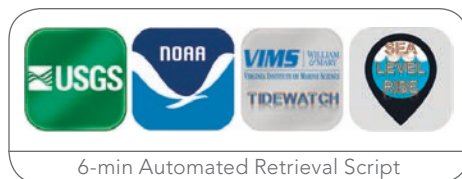
← StormSense workflow for real-time sensor map data
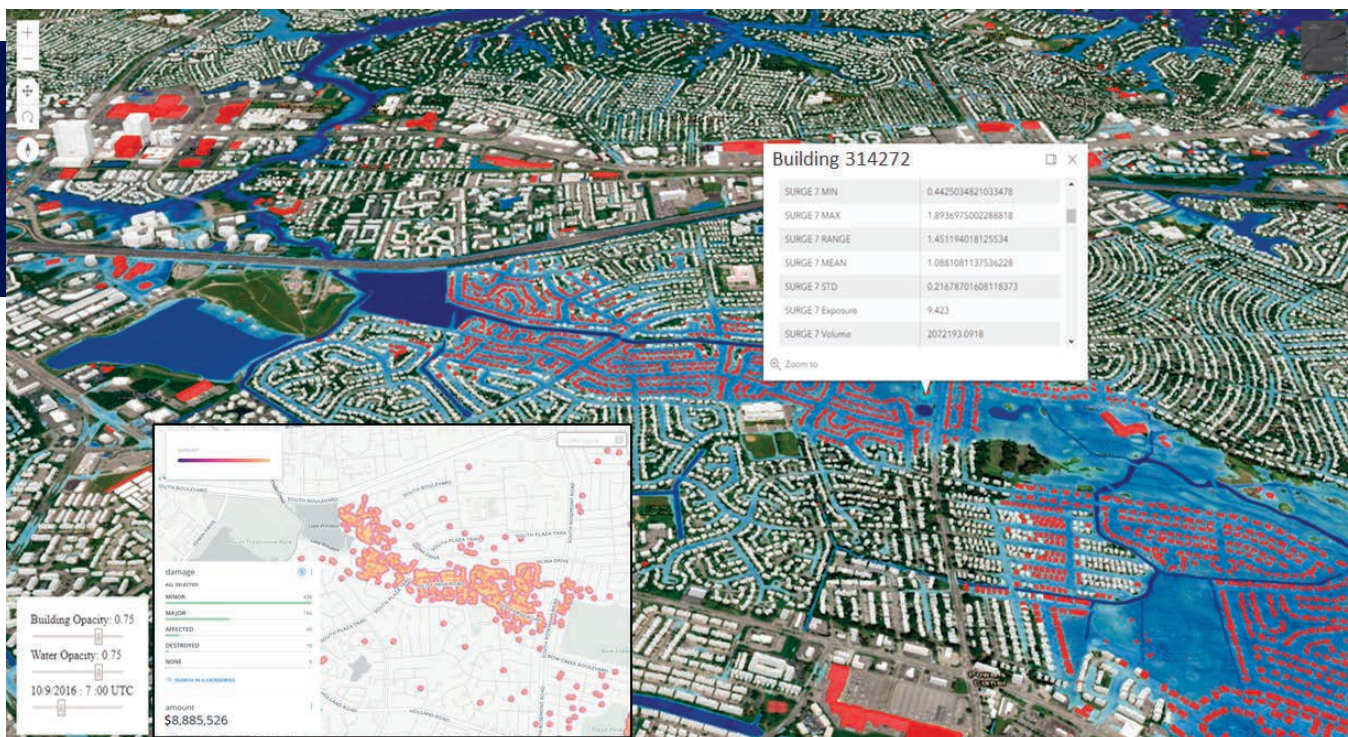
↑ Building-level inundation model during 2016 Hurricane Matthew in Virginia Beach, Virginia. The inset images show the crowdsourced flood damage information that was used to validate the model.

of Marine Science, Old Dominion University, and the Virginia Coastal Policy Center at William & Mary Law School.

Because it was preceded by tropical storm Julia, which left many storm drainage systems at nearly maximum capacity, Hurricane Matthew caused multiple dam breaks in South Carolina and caused soil above an already high water table in North Carolina and Virginia to reach its saturation point.

In response, the Virginia state legislature established the CCRFR as a virtual flood center between the Virginia Institute of Marine Science, Old Dominion University, and the Virginia Coastal Policy Center at William & Mary Law School. CCRFR functions as a one-stop shop for supporting the commonwealth, state agencies, localities, and other entities with scientific and technical support in furtherance of recurrent flooding resiliency.

Methods for Predicting Flooding

StormSense's workflow bears some similarities to North Carolina's FINMAN network with the key distinction of its use of hydrodynamic modeling to drive flood forecasts versus interpolated elevations from nearby sensors. The main difference between the two networks is that StormSense adds hydrodynamic modeling to rectify flood forecasts in the coastal zone up to 36 hours in advance. This is also in contrast to the National Water
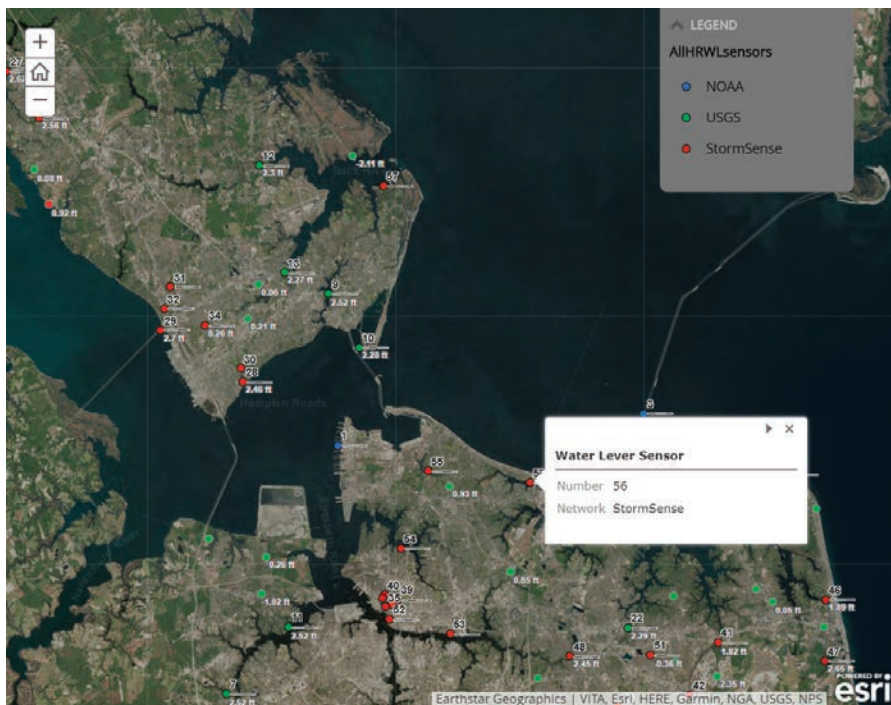
← The project's scope encompasses the interests of coastal local governments in Hampton Roads, Virginia. StormSense has installed or ingested existing sensors in these communities into its network.

Source: USGS, NGA, NASA, CGIAR, GEBCO, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen and the GIS User Community   Powered by Esri
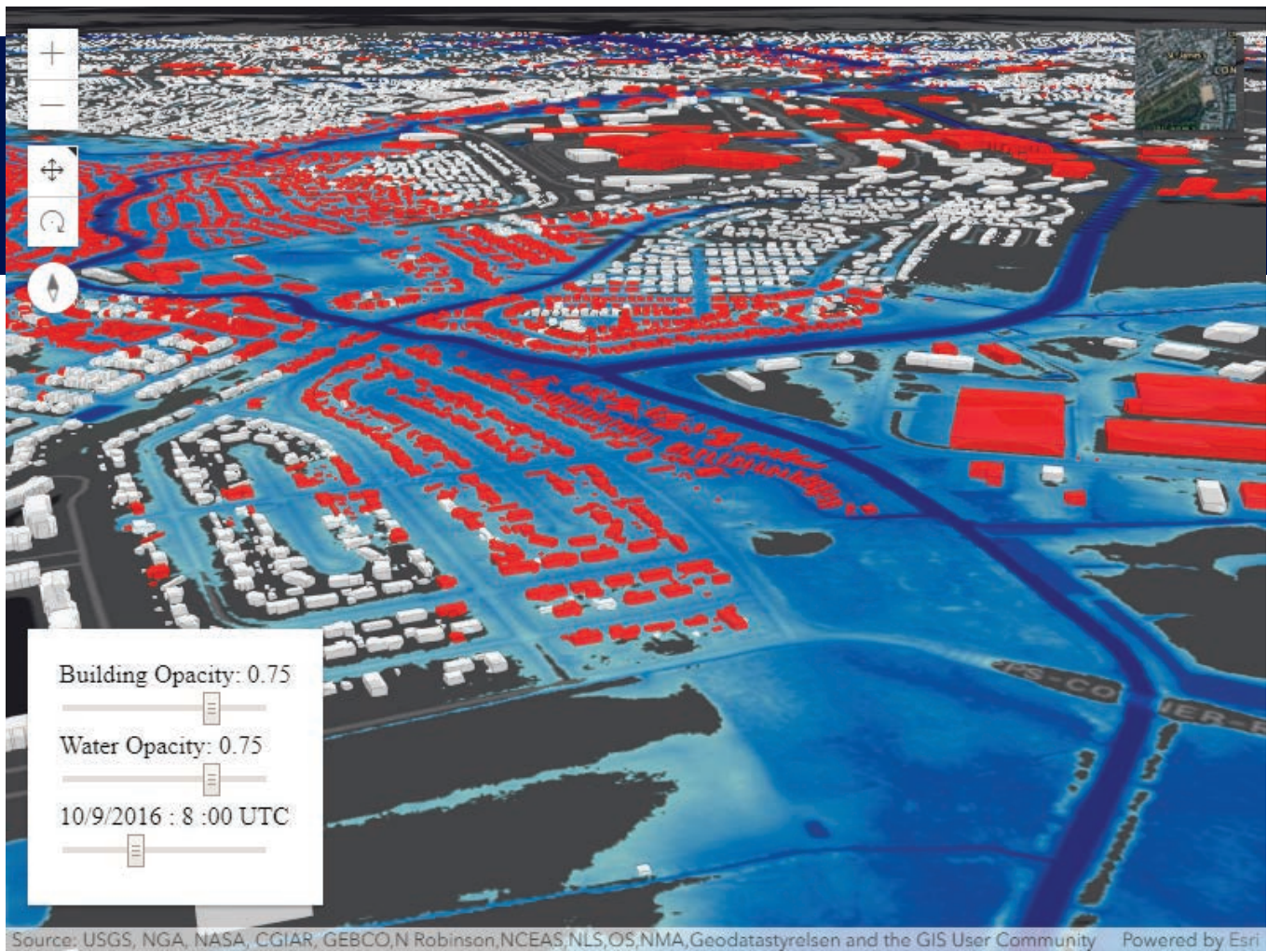
↑ A 3D subgrid model simulation of building-level flood exposure during Hurricane Matthew was developed by the authors. Building-level flood exposure is indicated in red. This simulation can be viewed on the VIMS website at https://bit.ly/2pU8SuF.

Model (NWM) forecasts, which employ a stream reach algorithm to interpolate United States Geological Survey (USGS) stream flow values and interpret flow accumulation paths downstream. The NWM method is relatively effective in rivers with a one-way gravity-driven flow, but in tidal estuaries the approach is greatly complicated. This is where the NWM and FIMAN have a difficult time interpolating between sensors alone to accurately characterize multidirectional flow regimes in tidal areas for stream flow and inundation applications, respectively.

Programs like the one at IFC have successfully employed the riverine approach to predict flooding in riverine conditions. These programs have done this by aggregating water level, stream flow, and data from its rain gauges and those of federal entities such as the National Weather Service (NWS)

and USGS to provide a useful statewide resource for calculating impending flood risk and estimating downstream flood inundation using precached flood raster layers at defined vertical intervals corresponding with real-time water levels at sensors.

StormSense is employing a similar approach using precached flood layers for real-time tidal flood mapping at sensors. However, substantial flood forecasts require the use of a physics-based hydrodynamic model to capture wind-driven storm surges and characterize the influence of the Gulf Stream.

Visualizing Flooding from Hurricane Matthew

The flood impact of Hurricane Matthew was visualized using a dynamic series of flood layers in inland Virginia Beach, Virginia, driven by VIMS Street Level Hydrodynamic

Model using 24 tiled flood rasters that were generated hourly on October 9, 2016, between 00:00–23:00 UTC.

The 3D building layers featured were developed from 2013 raw aerial lidar LAS files that were collected by Dewberry and processed by Geoff Taylor of Esri to extract building vertices and faces for optimal flood data presentation in web 3D.

Building-level flood exposure was illustrated by highlighting buildings in red according to the selected time. Selecting a highlighted 3D building displayed the flood height adjacent to the structure in feet.

Successful simulation of 2016 Hurricane Matthew involved spatially varying the rainfall inputs supplied by 21 rain gauges—12 from the Hampton Roads Sanitation District and 9 from the City of Virginia Beach. (These gauges are slated to

Time Aware Flood Depths Animation from 2016 Hurricane Matthew in Central Virginia Beach, VA
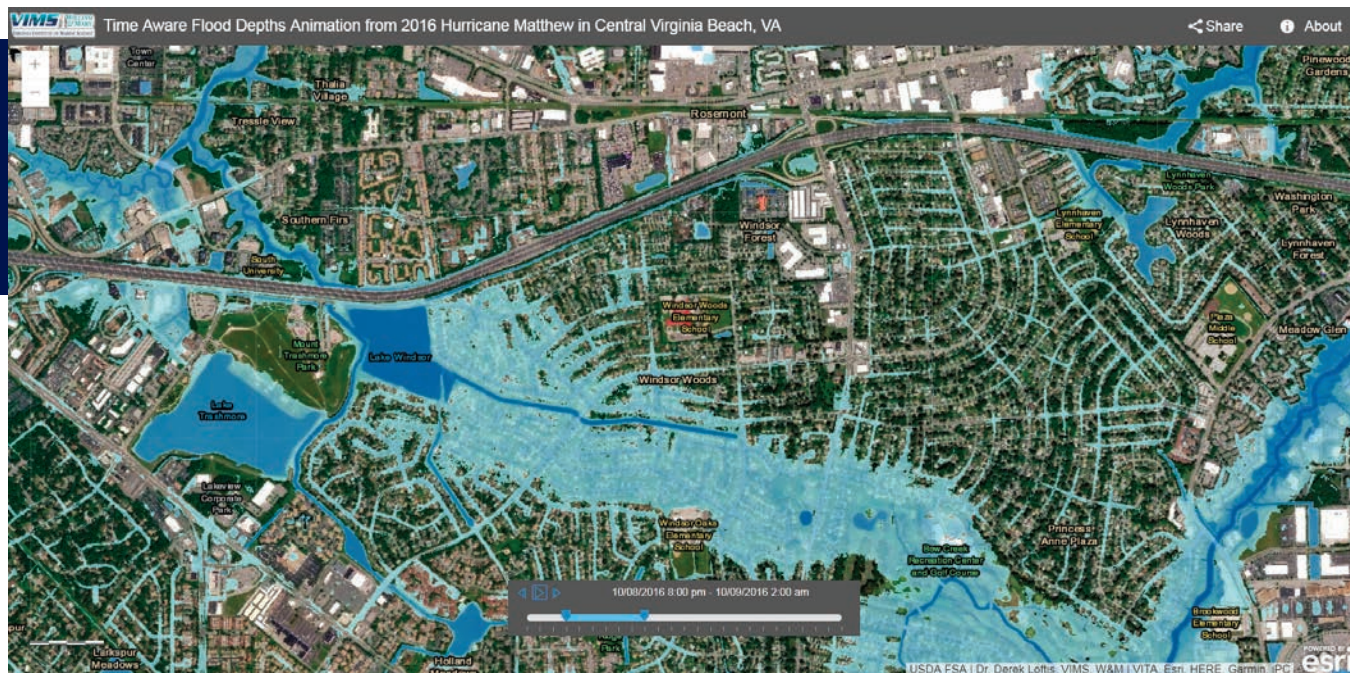
↑ The simulation of building-level flood exposure during Hurricane Matthew can also be viewed as time-aware 2D layers accessed by link at https://bit.ly/2pU8SuF.

be operationally ingested into StormSense by the end of 2018.)

Precipitation inputs were counterbalanced by incorporating various factors. One factor was soil infiltration. The StormSense model allows water to percolate through the bottom of the hydrodynamic grid mesh at spatially varying rates determined by translating surface types of varying porosity to coefficients in Richards' equation, as defined by 1-meter resolution land -cover data. *[Richards' equation, formulated by Lorenzo A. Richards in 1931, represents the movement of water in unsaturated soils.]* Six USGS groundwater wells are used to ascertain current depth of the water table as an inversely proportional estimation of the hydraulic conductivity in Richards' equation.

The locations of storm water drainage infrastructure pipelines and outflow were incorporated from the City of Virginia Beach Open GIS Data portal to best represent guided subterranean fluid transport not accounted for by soil infiltration.

The physics-based hydrodynamic model for Hurricane Matthew is driven with 36-hour forecast water levels from Tidewatch at the map boundaries using three nearby USGS tide gauges ingested into StormSense in Virginia Beach. These three USGS tide gauges (along with seven others, which were permanently installed by the USGS in 2016) and 10 StormSense gauges installed in Virginia City in 2017 have been incorporated into StormSense by Virginia Beach's chief data scientist Sridhar Katragadda, GIS manager and coordinator Robert Jessen, and their colleagues at Virginia Beach and into the Tidewatch network by Dr. David Forrest at VIMS.

Water levels may also be queried through smart devices that can use Amazon's virtual voice assistant Alexa via the StormSense Alexa skill that is available from Amazon.

Flood extents were validated by citizen-reported flood maps and water-level sensors in central Virginia Beach, by city street closure maps provided by the City of Virginia Beach, and aerial drone footage from the City of Virginia Beach's official YouTube channel.

Web 3D brings a realistic and additional dimension to 2D web maps in a way that is powerful and more easily understood. Leveraging GIS time-aware rasters advised by street-level hydrodynamic models can aid in assessing the flood risks of an impending threat in a meaningful way for citizens, first responders, and key decision-makers.

For more information, contact J. Derek Loftis at jdloftis@email.wm.edu or Geoff Taylor at GTaylor@esri.com.

About the Authors

Jon Derek Loftis, a research scientist, works in the Center for Coastal Resources Management at the VIMS. He received his doctorate in marine science in 2014 from at the College of William & Mary. His dissertation focused on street-level flood forecasting in New York City during Hurricane Sandy in 2012. As project lead and a developer, he adapted the hydrodynamic model from his dissertation for use with the StormSense Project in the Greater Hampton Roads Region of Tidewater, Virginia. Loftis also teaches remote sensing GIS classes at the College of William & Mary.

Geoff Taylor, a 3D solution engineer at Esri, supports the spatial technology needs of local governments; AEC; commercial; defense/intel; and other industries. Implementing geospatial, 3D, and geodesign (planning) solutions, he is constantly bridging Esri's technology with emerging technologies that include augmented reality (AR), virtual reality (VR), and mixed reality (MR) to most efficiently connect 2D maps to the 3D world. Taylor received master's and bachelor's degrees in landscape architecture from Clemson University in South Carolina.

One Thing to Rule Them All:
LOCATION

By Adam Carnow

The Internet of Things (IoT) has gained deep traction across the globe in all levels of government and industries. IoT is commonly considered to encompass the billions of physical devices around the world that are connected to the Internet, collecting and sharing data.

IoT gives organizations the ability to collect, process, and analyze vast amounts of real-time data that can reveal real, actionable intelligence. Like other trends in IT, its potential is tempting, but the reality of realizing its value presents certain challenges. With all these devices constantly generating data, this not only creates a data management issue but also the necessity of getting data into a format that allows for the extraction of actionable intelligence.

Context is a critical component that turns IoT data into actionable intelligence. IoT devices are all around us in things such as smartphones, cars, city streetlights, and thermostats. All these connected physical devices share a characteristic: location.

Using GIS to map the location of each device, it can be put into context with its surroundings in the physical world, so we can use spatial analytics to extract actionable intelligence from this context. We can see things that aren't clear using any other type of technology.

Since many of these devices are in motion, location may change over time. By tracking that location over time, the GIS can analyze the historical track of a device, revealing its continually changing spatial context so we know where and when data was collected. The GIS also lets us integrate IoT data with other spatial data to place that data with what is around it.

Many government agencies are embracing IoT to improve everything from traffic flow to public safety. IoT provides values to government agencies through

- Real-time operational awareness.
- Faster and more efficient response.
- Improved government services.

To realize these benefits, location must be part of the IoT solution. That means integrating the IoT systems with an enterprise GIS.

One example of this is the Waze Connected Citizens Program (CCP). Waze is the world's largest community-based traffic and navigation app. CCP is a free, two-way data exchange program between government agencies and Waze that can produce impressive benefits for both. By sharing live road closure data from your city directly with Waze so it can be consumed by Waze and Google users, drivers using those services can be automatically routed around road closures.

This is much better than posting closures on your website, because most drivers won't check it before getting in their cars. Boston, Massachusetts, realized an 18 percent reduction in traffic congestion the first month that its data sharing went live with Waze. *[Read about Johns Creek, Georgia, the first city to join CCP, in "An Open Data Strategy Pays Off for Johns Creek" in the Summer 2018 issue of* ArcUser.*]*

Other government agencies are seeing a four- to seven-minute reduction in emergency response times as emergencies are reported on Waze before witnesses report them via 9-1-1. Waze users don't just report traffic incidents—they also report potholes. By monitoring the pothole reports, government agencies can more quickly respond, patching potholes before they enlarge. This saves money on the patches and saves drivers potential damage to their vehicles.

After the Boston Marathon bombing in 2013, first responders across the city lacked the connectivity and real-time data necessary to coordinate effectively. Without a real-time IoT and GIS platform, it was impossible to relay critical updates and orders among thousands of individual first responders, race participants, volunteers, and spectators.

By the 2014 Boston Marathon, things had changed significantly. Public-facing, IoT-enhanced web maps showed live event details such as the race route and the locations of medical facilities and law enforcement staging areas. Integrating data streams from
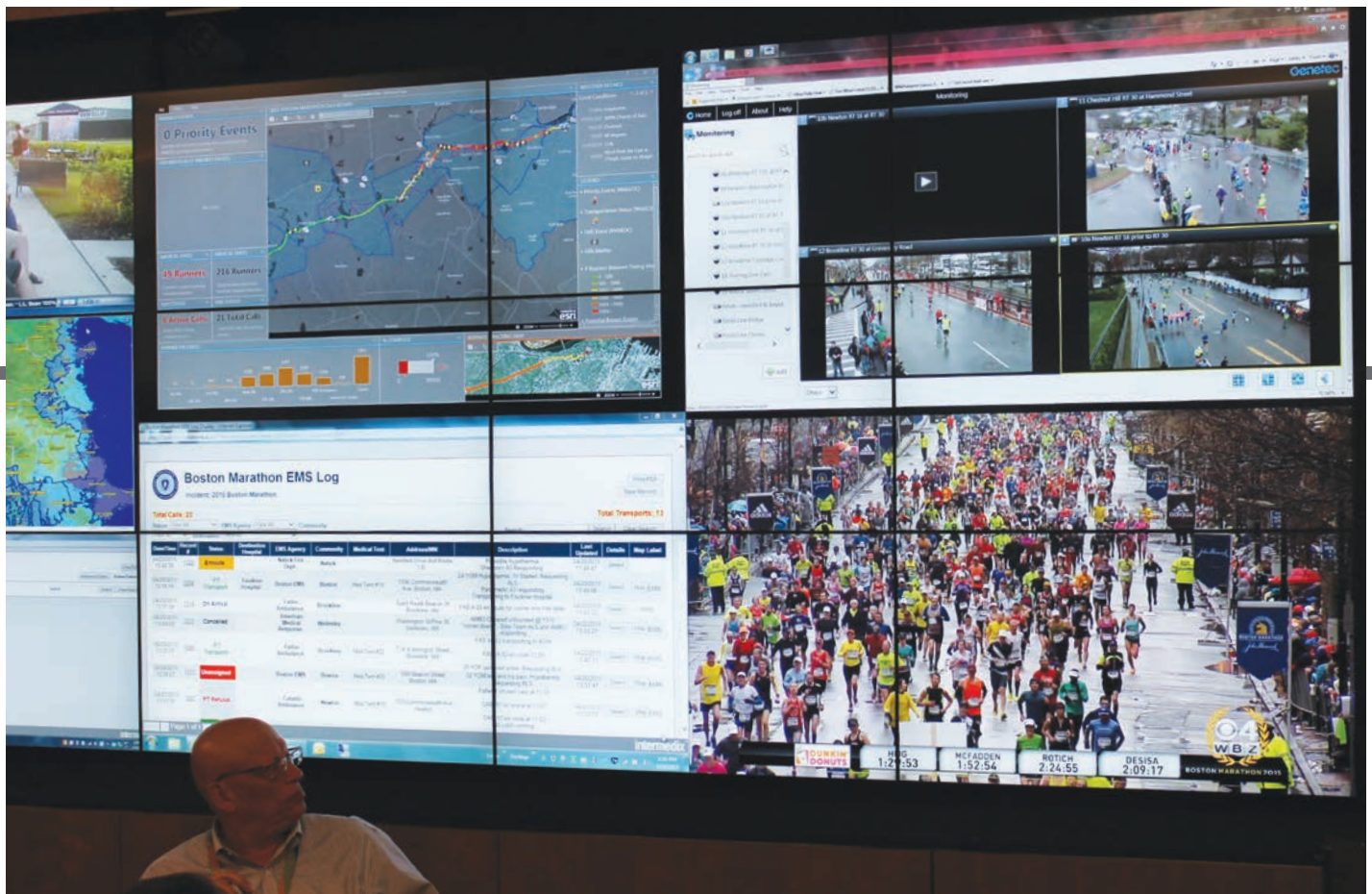
↑ The dashboard featured dynamic web map layers, including live weather and traffic and real-time tracking of runners and emergency vehicles. Photo courtesy of the Massachusetts Emergency Management Agency.

thousands of sensors, devices, video feeds, and locations enabled Boston officials to better address critical aspects of the race, including tracking personnel and resources in real time and shifting public safety assets where needed.

The runners were outfitted with data-producing sensors. This allowed officials to keep track of how many active racers were in the field, as well as how many people were in each section of the course, enabling security and medical resources to be reallocated accordingly.

Not only does IoT and GIS integration support marathon officials in accounting for all participants in motion, but it also serves as the foundation for information being shared quickly and easily among the public, event security, and emergency responders. This benefit proves essential on race day, where 60 different agencies use a common operating picture powered by GIS-based location technology to orchestrate an event that draws a worldwide audience and more than half a million spectators. *[Read "ArcGIS Online Runs Security at Boston Marathon" in the Spring 2016 issue of* ArcNews *to learn more about the use of GIS to enhance security and operations.]*

If your organization has an IoT initiative, include plans to integrate it with your GIS. The benefits of both technologies will be much more substantial.

About the Author

Adam Carnow is an account executive with Esri who manages large local government GIS customers in Florida, Georgia, and North Carolina. For more than 20 years, he has been applying GIS and related spatial technologies to complex, award-winning projects across the globe in the realms of planning, transportation, and environmental sciences for both the public and private sectors. He holds a bachelor's degree in geography and a master's degree in urban and regional planning from the University of Florida, and he is a certified urban planner (AICP) and GIS Professional (GISP).

This article originally appeared September 19, 2018, in *GovLoop.*

What Did My Uncle Wally Really Know about
Public Works?

By Christopher Thomas

My Uncle Wally passed away recently at the age of 87. He was unquestionably one of the best storytellers I have ever met. He was always quick with a one-liner and was current on the latest jokes. Uncle Wally was one of those pivotal people that helped funny things go viral. In fact, he would tell a joke to hundreds of people in one week. And of course, everyone would pass it on, as his or her own. (Yes kids, this is an accurate example of the pre-Internet era.)

As a young kid, I vividly remember one joke that he told about public works. It went something like this:

"Did you hear about those guys down at the city's public works department? They are worried about their jobs. It seems the someone invented a shovel that can stand up all by itself."

Oh, how we laughed. But honestly, it was a long time ago. I am not sure I knew what a public works department did. But I still remember the joke all the same.

I guess you could say he was perpetuating a stereotype that some people had about what a public works department does. Certainly, it was an incomplete picture of the work engineering and public works departments actually perform.

Fast-forward to my time spent working with engineering and public works departments in state, county, and municipal government. I have witnessed firsthand their advocacy of the use of technology and GIS. It seems Uncle Wally may have been misguided in thinking that a new shovel was the closest public works professionals get to embracing new tools.

Public works disciplines have advanced computerized modeling, enterprise resource planning (ERP), computer-aided drafting, GPS, and automated field data collection.

In hindsight, it seems that my Uncle Wally's joke pointed to the need to highlight the important work public works performs in building and maintaining our critical infrastructure.

Public works professionals have always recognized that technology improves service to the community, from the first traffic signal to computerized modeling of infrastructure to being one of the first departments to embrace modern civic engagement through graffiti and pothole reporting applications.

From where I sit, I can honestly say that public works professionals have always pushed the envelope of technology.

Now that we are seeing a rise of tech-savvy professionals across all departments, coupled with the rise of smart communities, how can public works disciplines continue to stay ahead of the pack?

There are five trends I would suggest public works professionals immediately look at to stay on top:
- Shift to real-time operations.
- Embrace the new era of field mobility.

- Evolve civic engagement.
- Lead through advanced data and analytics.
- Achieve success through performance management.

If you follow these trends, you will help your organization move through its next digital transformation, helping you rise to the new expectations of citizens, IT-savvy community leaders, and neighboring organizations.

For example, drones are improving inspections of roads, bridges, and water infrastructure. Sensors and artificial intelligence are altering traffic patterns in real time. Operations dashboards are integrating real-time data from sensors, staff, and citizens to improve performance.

There is more than enough evidence that these trends are moving past the stage of early adoption and are becoming integrated into mainstream operations. GIS is evolving with these trends, resulting in solid solutions that improve day-to-day management, enhance decision-making, and streamline workflows. In fact, you'll find that GIS is the foundation for creating constantly connected and proactive operations.

About the Author

Chris Thomas is the director of government markets at Esri and a founding team member of the Industry Marketing Department. Prior to joining Esri in 1997, he was the first GIS coordinator for the City of Ontario, California. Thomas frequently writes articles on the use of GIS by government. Follow him on Twitter @GIS_Advocate.

Feel free to pass on the joke.
Uncle Wally would have loved it.

LEARNING PLANS FOR YOU AND BY YOU

By Suzanne Boden

Esri learning plans have evolved into an open tool that you can use to chart a course of study that will lead to the mastery of an aspect of GIS that you define.

Initially, learning plans were a set of learning resources on a focused topic designed to accomplish defined learning goals. These learning plans were (and still are) created by Esri's team of curriculum specialists. In addition to these plans, you can now create your own learning plan.

If you have an Esri account, you can go to the Esri Academy website and create a learning plan tailored to your professional needs or personal interests. That learning plan can be shared with friends and colleagues, published so others can find and use it, and assigned to others so you can monitor their progress through the plan.

This article describes how you can use these additional capabilities, added at the request of users, to achieve your goals.

STEP 1
Create a Learning Plan

There are two ways to create your own learning plan. You can copy an existing plan and modify it, or you can build a plan from scratch by adding resources from the catalog and/or your wish list.

Suppose you're a GIS professional who works with ArcGIS Pro and wants to learn how to create Python scripts, but you've been putting it off because projects have been coming fast and furious lately. You know scripts will save you time, but you have no idea how to go about learning Python code and syntax. A learning plan can rescue you.

It's always a good idea to start by exploring what's already available, so go to the Esri Academy site (esri.com/training) and click the Learning Plans button. Type python in the search box. Although Esri ArcGIS Desktop Professional Certification 10.5 comes up (because the plan includes "Introduction to Geoprocessing Scripts Using Python"), there are no existing plans just on Python.

Go to the Course Catalog (esri.com/training/catalog/) and search for Python. There are many resources that can help you learn Python scripting, but because you are working with ArcGIS Pro, you can narrow the search results further by clicking the Products drop-down list and choosing ArcGIS Pro.

Now there are fewer results. After viewing the details of each resource, you decide to create a learning plan that includes all of

them. To do that, you click the plus sign on the card for one of the items and click Add to Learning Plan. If you aren't already signed in, the site will ask you to sign in with your Esri account. In the Add to Learning Plan dialog, click Select a Plan, then click Add course to new plan.

Each learning plan must have a title and (optionally) a description. If you publicly share the plan, its title must be unique and it must have a description. The description should provide enough information to help other users understand the plan's purpose and content so that they decide whether they want to enroll in it.

After adding a title and description, click Create New Plan, then close the dialog box. Click the plus sign on each card and click Add to Learning Plan to add the other four resources to the new plan. Your new learning plan is accessible from your My Learning Plans page.

At any time, you can click the View Courses tab to open a resource and start learning right away. As you work through the resources in the plan, your progress (percent completed) will update. One of the resources has a dashed circle rather than a solid circle next to the resource title because it requires you to self-report its completion. Just click inside the circle after completing it. The Training site tracks completion of instructor-led courses, web courses, training seminars, videos, and massive open online courses (MOOCs) but currently cannot automatically track completions of tutorials, story maps, documents, and teacher resources.

STEP 2
Edit a Learning Plan

Learning plans are intended to be dynamic. Esri constantly adds new resources. As the plan creator, you can add or remove items at any time. Suppose you visit the Course Catalog a week later and see that another Python resource has been added. You can easily add it to your learning plan.

In the Course Catalog, click the resource's card and choose Add to Learning Plan. Choose your learning plan title in the dialog's drop-down list. Click Add to Plan, and that's it. Alternatively, if you know the title, you can add a catalog resource directly from

your learning plan by clicking the Edit Plan tab. Start typing the title of the resource in the box under Add Courses and click the title of the resource you want to add when it appears, then click Add to Plan. Click Save Plan.

STEP 3
Share a Learning Plan

After talking with you, a coworker has expressed interest in learning Python too. To help him out, you can share your learning plan just by finding the learning plan on your My Learning Plans page and clicking Share Plan under its title. This will generate a URL for the plan. Using the Share dialog, you can copy and paste it into an email, or share it through Facebook or Twitter using an @ mention with the person's name.

STEP 4
Assign a Learning Plan

During the six months since you created your Python learning plan, you've been promoted and are now a supervisor. Although you no longer perform data management tasks yourself, you want your direct reports to also learn Python so they can realize the same significant time savings you did by scripting tasks. The scripts you created will probably need to be updated at some point, and new ones created.

From your My Learning Plans page, find the plan and click Assign Plan under its title. In the Assign Plan dialog box, insert the email addresses of your direct reports, separated by a space or comma.

You can enter as many email addresses as you want when assigning learning plans. To save time, you can copy/paste email addresses from a text file or from a Microsoft Excel spreadsheet if they are stored in one column with no header row. Add a personal note to the boilerplate email text and preview it before clicking Send Invitation.

Your direct reports will receive this email from GIStraining@esri.com with a link to enroll in the plan. After clicking the link, they will need to log in with their Esri account and accept the terms acknowledging that you will be able to see the name and email address associated with their Esri

account and their plan progress.

To monitor your reports' progress in the learning plan, locate the plan on your My Learning Plans page and click the View Assignments tab below the title.

Not Accepted in the Status column indicates a person has not clicked the link in the invitation email. You can resend the email if needed. When enrollees start working through the learning plan, you will see their progress through each resource and the date each resource was completed.

Plan for Success

It's easy to customize learning plans for your own professional development, share custom learning plans with others, and assign learning plans to others in your organization to increase their geospatial skills and knowledge.

↓ Each learning plan must have a title and (optionally) a description. If you publicly share the plan, its title must be unique and it must have a description.

↓↓ Your learning plan can be shared with friends and colleagues, published so others can find and use it, and assigned to others so you can monitor their progress through the plan.
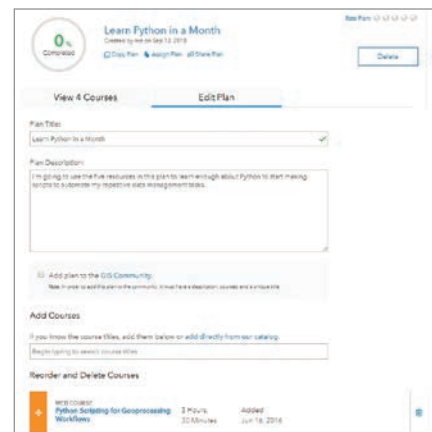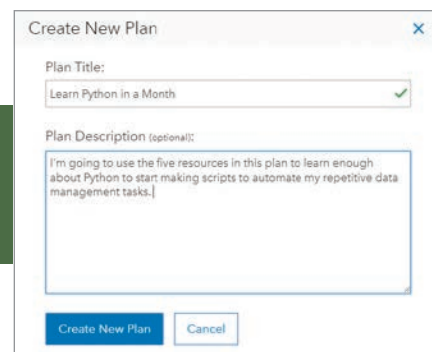
Build Mobile Web Apps with a Great 3D Experience Using the ArcGIS API for JavaScript

By Raluca Nicola and Julie Powell

Web-enabled mobile devices are so ubiquitous that they generate almost half of all Internet traffic. To reach a wide audience, web applications need to provide a good user experience whether the browser is on a mobile device or a desktop machine.

However, 3D web applications that work well on mobile devices are not so common. In the past, it wasn't possible to visualize a point cloud layer or a 3D model of some city buildings on a smartphone. But with the ArcGIS API for JavaScript, developers can now create 3D experiences that work well in both mobile and desktop browsers.

This article highlights several apps that showcase the value of web 3D on mobile devices and gives best practices for building user-friendly 3D web mobile apps that have optimal performance. The first sample app gives information on hiking trails, the second app helps a city planning department share project proposals with citizens, and the third app lets a newspaper tell a story more effectively with interactive graphics. Use the accompanying URLs to explore the capabilities and design of these apps.

1 Take-Along Hiking App

The hiking trails app lets visitors to the Swiss National Park plan trips by providing information about the park's hiking trails that can be viewed on a desktop or a mobile device. Visitors use the mobile web app to view their progress along a trail whenever they have connectivity during their hikes.

2 Gathering Community Feedback

The planning department of a city created a 3D web application to present several new project proposals to its citizens. To get community feedback, the department shared the app on social media platforms. Since most people access social media on mobile devices, the web app had to be mobile friendly.

3 Telling the Story with Interactive Graphics

The world population count app was created to visualize data from the Socioeconomic Data and Applications Center (SEDAC). Newspapers often have online versions of articles that use interactive graphics to tell more of the story. Because many readers look at online articles on smartphones while waiting or commuting to work, any graphics used in online versions must display well on a phone.

Best Practices for 3D Performance

These apps are examples of mobile web apps that provide good performance despite hardware and bandwidth constraints. Complex rendering requires more memory and processing power, so it's important to consider how to optimize how resources are used.

Some of these best practices include

- Efficiently managing layers.
- Employing a lower rendering quality profile.
- Using lower-resolution textures for rendered objects.
- Optimizing how features are displayed on terrain.
- Simplifying the geometry of rendered objects.
- Minimizing initial load time.

Efficiently Manage Layers

ArcGIS API for JavaScript visualizes data in 3D by loading the layers that have been defined as part of a web scene. Web scenes can be authored with ArcGIS Pro, ArcGIS Online, or programmatically with the ArcGIS API for JavaScript. To optimize performance, limit the number of layers in a scene to less than 12 because each layer must reserve memory. Consider merging

1 ralucanicola.github.io/hiking-app

2 ralucanicola.github.io/JSAPI_demos/urban-development

3 ralucanicola.github.io/JSAPI_demos/world-population

or combining two or more layers that are logically similar and share the same geometry type. Reducing the number of visible layers minimizes the CPU and GPU overhead. Only make visible the layers that are needed. Last but certainly not least, add scale dependency to web scene layers. This can have a significant positive effect on display performance.

Employing a Lower Rendering Quality Profile

Profile settings incorporate a variety of graphic options such as map resolution, scene detail level, and anti-aliasing. Using a lower-quality rendering profile can maximize performance. The ArcGIS API for JavaScript automatically detects mobile browsers and will use a low-quality profile by default unless configured otherwise.

Using Lower-Resolution Textures for Rendered Objects

Most city visualizations have a scene layer with 3D building models. Building models can be memory intensive, so avoiding high-resolution textures will allow for better performance on mobile devices. Consider omitting textures altogether if they do not contribute to the objective of the web application.

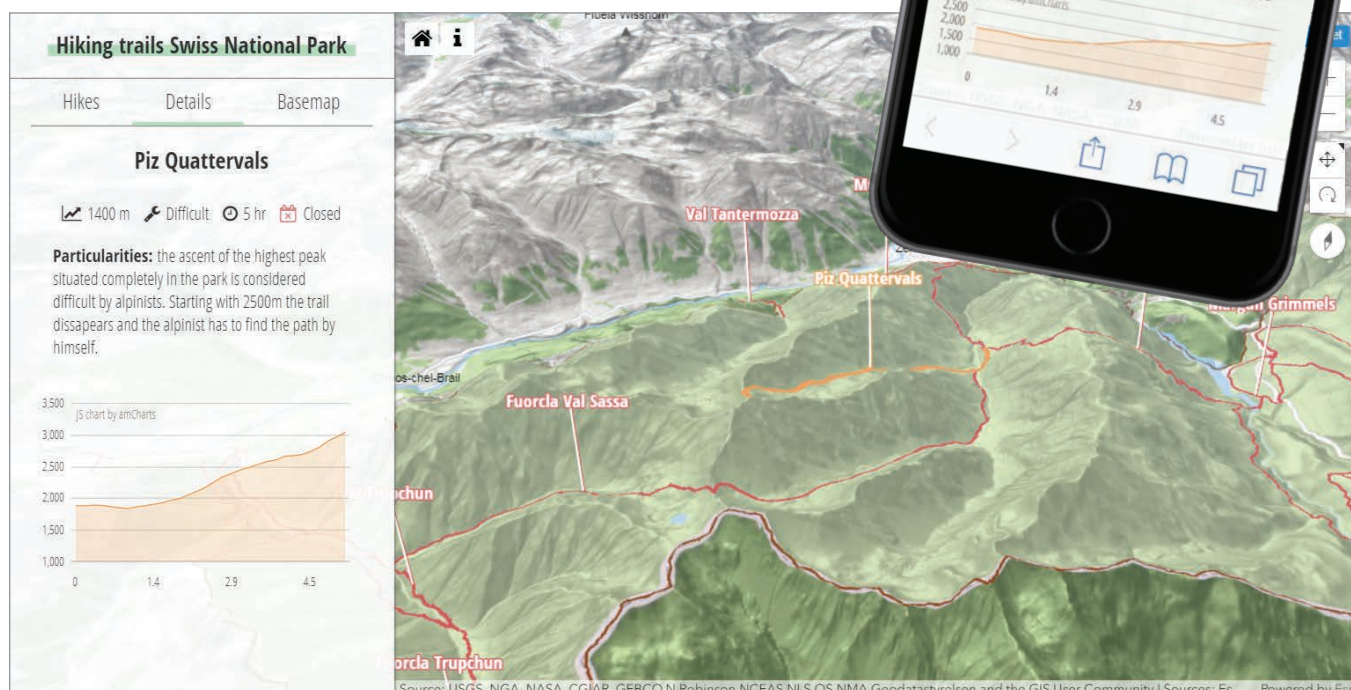## Optimizing How Features Display on Terrain

For apps like the hiking one, aligning features to terrain is important since elevation plays a key role in understanding the trail. There are multiple elevation modes in 3D that will align features to the ground in different ways. The on-the-ground elevation mode turns the feature layer into a texture and drapes it on the ground. The relative-to-ground elevation mode will display the line as a vector, but it will align the geometry to the elevation surface. Using relative-to-ground is more resource intensive because it computes the elevation at each vertex of the geometry to align it to the terrain. The hiking app used on-the-ground because it displays well and requires fewer computations.
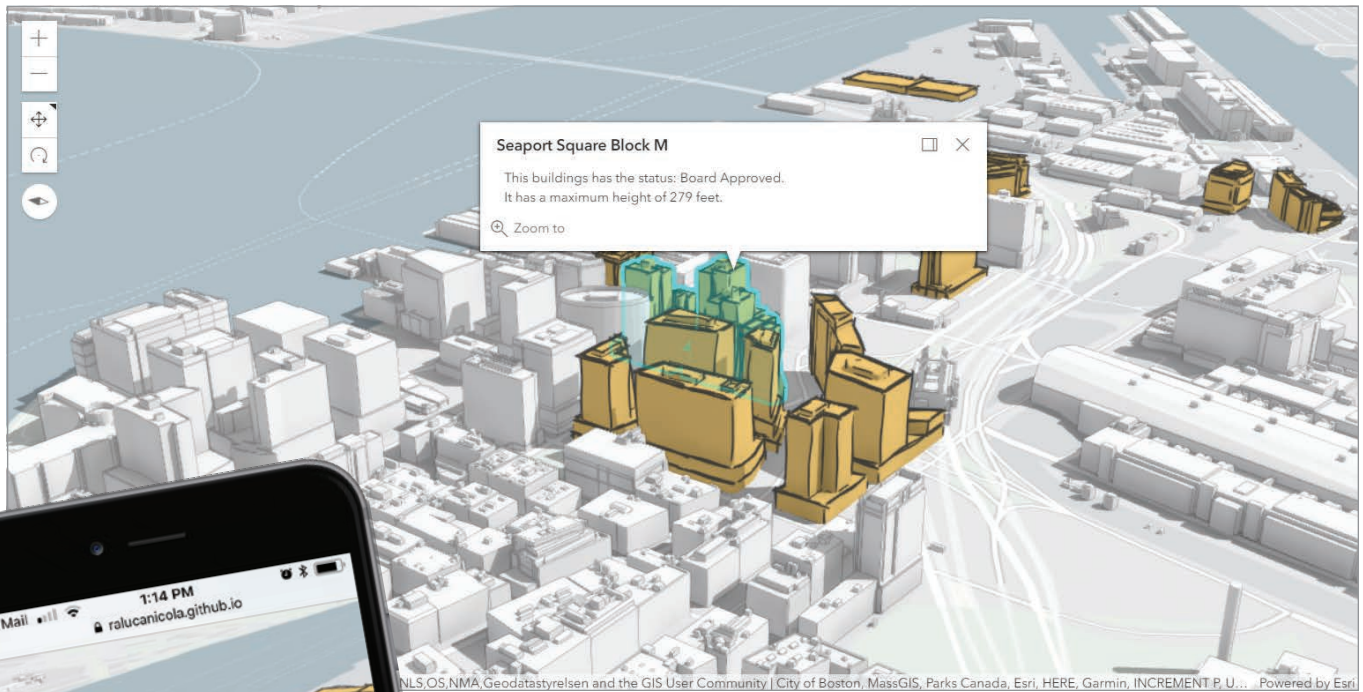
Reducing Feature Complexity

Simpler shapes with fewer vertices render more quickly. Data can often be more complex than necessary. See whether the level of feature complexity can be reduced by thinning out dense data and reducing the number of vertices. This is accomplished by simplifying or dissolving lines and polygons in ArcGIS Pro. When visualizing lines, 2D lines render faster than 3D tubes. Optimal performance can be achieved

by ensuring that building geometry is not too complex: the fewer vertices, the better.

Shadows and ambient occlusion are great ways to enhance the perception of the third dimension in urban visualizations, but they can be very resource intensive for mobile devices. [*Ambient occlusion is a lighting model that calculates the brightness of a pixel in relation to nearby objects in the scene.*] Turn off shadows and ambient occlusion on mobile devices. Use these effects only when the app is run on a desktop.

Seaport Square Block M

This buildings has the status: Board Approved.
It has a maximum height of 279 feet.

Zoom to

NLS,OS,NMA,Geodatastyrelsen and the GIS User Community | City of Boston, MassGIS, Parks Canada, Esri, HERE, Garmin, INCREMENT P, U...   Powered by Esri

2

Visualizing Data at a Global Scale

When visualizing data at a global scale, the terrain is often unimportant, so you can simply remove the ground from the web scene. While flat symbols perform the best in a 3D scene, volumetric symbols can be much more compelling. For example, in the case of the world population app, it is better to use volumetric symbols with fewer faces. Because spheres and cylinders are complex objects, it is better to use cuboids or tetrahedrons for thematic visualizations.

On-Demand Data Loading

Because network bandwidth can be limited, it's important to consider optimizing your app's initial load time by lazy-loading data. Rather than loading everything during the initial app load, the app makes several requests on demand. The Swiss National Park hiking app uses this approach, making several requests on demand after the user selects a hiking trail. Elevation data is requested to create the elevation profile. The geo-referenced Flickr images are queried using the Flickr API. If the user clicks on the same trail a second time, the data is already cached in the browser and the application only needs to display it.

Performance Testing and Mobile Devices

Important enhancements have been added to the ArcGIS API for JavaScript in the last year that improve overall performance in mobile browsers. These updates, combined with the best practices outlined in this article, will help you provide a rich 3D experience for users of your web apps. The following mobile devices are officially supported: Apple iPhone 8, Apple iPad Pro 2, Samsung Galaxy S8, Samsung Galaxy S9, Samsung Galaxy Tab S3. However, web apps created with the API are being used on a range of devices.

Performance testing of your app is critical. The more devices you can test on, the better. If you don't have access to all the device types your end users will be using,there are some great software tools for measuring performance. For example, in the Audits panel in Google Chrome Developer tools, you can select either Mobile or Desktop to run performance tests on your app and rate compliance with Progressive Web App (PWA) standards, accessibility, and best practices.

Providing a Better User Experience

In addition to best practices that are specific to designing 3D apps, more mobile-first and PWA approaches yield superior results when designing any mobile app.

Instead of initially designing a full-size desktop app and then creating a mobile version of that design, start by designing for mobile. The mobile-first design approach considers the mobile user interface requirements and then adjusts those requirements to accommodate the desktop version. Mobile-first design assumes a responsive interface. The UI automatically adjusts as

needed based on the user's screen dimensions, so the user experience is good regardless of the screen size.

The ArcGIS API for JavaScript supports responsive design with the widthBreakpoint property. This property defines the breakpoints of a SceneView for screen sizes. All UI components that are attached to the view, such as the legend, will be placed based on the current view width and how the widthBreakpoint property was set.

Widgets are designed to be responsive. For example, when the width of the view is smaller than the API's defined threshold, the pop-up will be automatically placed at the bottom of the view and will be adjusted to the view's width.

PWA design takes advantage of new features supported by modern browsers to make web apps even more mobile friendly by making them behave more like native applications—reliable, fast, and engaging.

A browser service worker is used to cache the required data and make the application load quickly and independently of the quality of the network connection. A manifest file is also created to provide all the necessary metadata so that users can install the web application on a phone's home screen.

The Swiss National Park hiking app uses PWA. It can be installed on the home screen of a phone, and it doesn't break if the network connection is briefly lost. Note that this app is designed for intermittent connectivity. For a fully offline experience, the ArcGIS Runtime SDKs would be a better choice.

Conclusion

Using the ArcGIS API for JavaScript and following the best practices outlined in this article will help you build useful and effective 3D apps that work well on mobile devices as well as desktops.

- Read more on best practices for scene performance at doc.arcgis.com/en/arcgis-online/reference/best-practices-scene-performance.htm.
- To access the API guide and reference and look at code samples, visit the ArcGIS API for JavaScript section of the ArcGIS for Developers site (developers.arcgis.com/javascript).
- Interact with other JavaScript developers on the ArcGIS API for JavaScript GeoNet section (community.esri.com/community/developers/web-developers/arcgis-api-for-javascript).
- Learn more about PWA at developers.google.com/web/progressive-web-apps.

About the Authors

Raluca Nicola is a cartographer at Esri who has strong interest in 3D web cartography. She works as a product engineer for ArcGIS API for JavaScript, makes demos, writes documentation, and performs testing.

Julie Powell is a technical product manager at Esri. Her primary focus is the ArcGIS API for JavaScript. She has more than 17 years of experience working with software development,

delivering solutions for both enterprise and consumer markets. Powell has worked on a wide range of projects and consulting endeavors, including serving as a technical lead for web mapping solutions for strategic customers. She interfaces with a wide user community to maintain awareness and insight into GIS community needs, meanwhile contributing feedback to development teams to help ensure users can be successful in building state-of-the-art, purposeful solutions using ArcGIS software.
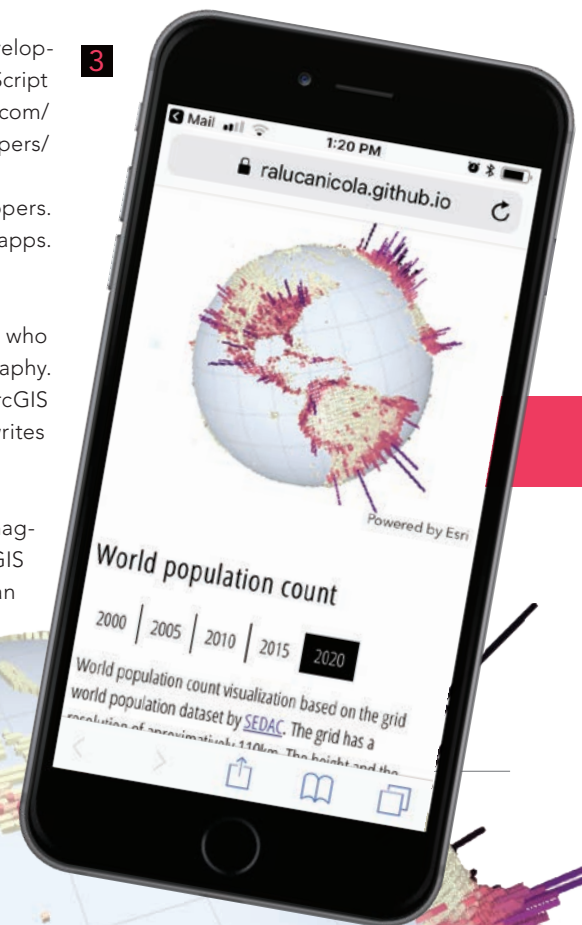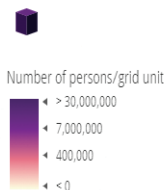

World population count

2000 | 2005 | 2010 | **2015** | **2020**

World population count visualization based on the grid world population dataset by SEDAC. The grid has a resolution of aproximatively 110km. The height and the color of the bars represent the number of persons per grid unit.

Number of persons/grid unit
- > 30,000,000
- 7,000,000
- 400,000
- < 0

Coding Standards for Jupyter Notebook

By Atma Mani

Jupyter Notebook has become incredibly popular among data scientists and general users of Python and R. While the Jupyter framework is liberal and lets you be creative, it would benefit you, your team, and your readers if you define a structure and follow it. Based on my experience as developer evangelist and the author of public-facing notebooks for the last three years, I share in this article the patterns I recommend for writing data science samples using Jupyter Notebook.

Use Headings and Markdown Lavishly

Start your notebook with Heading level 1 and give it a title. Follow with a narrative explaining what the notebook aims to do, where the data is sourced, and what the user can expect.

Break down your notebook into smaller parts and use Heading levels 2, 3, 4, and so on for the hierarchy of topics and subtopics. A notebook should ideally have just one Heading level 1, under which multiple Heading levels of 2, 3, 4, and so on are nested. To enhance your notebook, embed images and use different typography such as bold or italic, or insert code to enliven text.

Use LaTeX for Equations

LaTeX is a document preparation system that uses the TeX macro language. A cheat sheet from the New York University website is linked to the online version of this article. Insert LaTeX equations inline within two dollar signs $...$.

Break Longer Segments of Code into Multiple Cells

Try to keep your code cells as short as possible. Break them up by adding markdown cells in between and add explanatory text. A cell for a single line of code is too short. A cell with more than 15 lines of code is too long.

Finding suitable spots for placing heart defibrillator equipments in public

In this sample, we will observe how site suitability analyses can be performed using the ArcGIS API for Python. The objective of this sample is to find locations in the city of Philadelphia that are suitable for placing AED (Automated External Defibrillator) for public emergencies.

The criteria for a suitable place are those that have high incidence of OHCA (Out of Hospital Cardiac Arrests) and be accessible to public, such as commercial areas.

As inputs, we start with geocoded OCHA (Out-of-Hospital Cardiac Arrest) point data, along with a few base layers for the city of Pittsburgh published as feature layers. As output, we need to generate a list of locations that have a high incidence of heart-attacks and located within commercial areas, allowing easy access at times of emergencies.

↑ This is a good example of a title and a narrative for a notebook.

Plot Profusely

Matplotlib, a Python 2D plotting library, is great, but check out higher-level plotting libraries such as Seaborn *Pandas.DataFrame. plot()* before you settle for Matplotlib. Use *plt. tight_layout()* to autosize your plots to fit the notebook. Use subplots when you want to show a grid of plots. And finally, ensure that your plots have a legend, title, axes names, and discernible symbols.

Coding Standards for Your Python Snippets

For variable and function names, use underscores to separate words—in other words, snake_name_your_variables—instead of separating words with cases or camelCasingYourVariables. The exception is class names, which should use camel casing and start with the capital case.

Do all imports at the top of the notebook. This way, the reader knows what libraries are used and can ensure that their environment is ready.

Name variables so that they don't clobber built-ins. For instance, call your map object map1 and map2 instead of map, which will hide built-in *map()* function. Don't call variables as dict or list, which will hide built-in data structures with the same names.

For enhanced performance, use the Spatially Enabled DataFrame (available since version 1.5 of ArcGIS API for Python) in place of SpatialDataFrame objects.

Use Round Numbers for Display Purposes

Quickly round your DataFrames during

↓ This is an example of how headings render in notebooks.


```
# Heading 1
## Heading 2
### Heading 3 ...
```

display by calling the DataFrame_obj. *round()* method. For instance: *usa_house_scaled.describe().round(3)* will display numeric columns in your DataFrame rounded to three decimal digits.

Be Explicit about Uncommon Libraries

It is generally a good practice to import all your dependencies at the beginning of your script. However, in the notebook medium, you might prefer to import them as and when necessary to better explain your work. This is especially true if you import a lot of dependencies at the function level. If you use a library that is not shipped with base anaconda, then the user must run installation steps and relaunch the notebook. Make this explicit at the beginning of the notebook.

Structure of Your Data Science Notebook

By and large, use headings to structure your notebook as you would a paper for a scientific journal.

Heading 1: Title: Cover the narrative or abstract and include a TOC.
Heading 2: Get data—Import libraries and search for and get required datasets.
Heading 2: Exploratory data analysis: Use maps and charts lavishly to show different aspects of the data.
Heading 2: Feature engineering
Use pandas and other libraries to prepare your data for training. After each significant transformation, show previews of your data by printing the first three or five records of your DataFrame.

Heading 2: Analysis
Perform analysis and build and train models.
Heading 3: Evaluation
Evaluate model and note if assumptions are met by using both charts and metrics. Run predictions, evaluate results using both charts and metrics. Use more than one metric for evaluation.
Heading 2: Act on the analysis
Persist the results, either by writing to disk or publishing them to the web. Elucidate with maps and charts as applicable. If you built a prediction model, publish it as a web tool (REST API). If you built an explanatory notebook, publish it as an article or report.
Heading 2: Conclusion
Summarize your work by starting from your problem statement, moving to the approach you followed, and describing the results you obtained.

About the Author

Atma Mani is the lead product engineer for ArcGIS API for Python at Esri. He has more than 11 years of experience in different facets of the geospatial industry ranging from advanced remote sensing to GIS modeling to software development. His interests spans data science, analytics, and all things geospatial. He has worked in government and academia and for private companies. He likes to connect with users from these communities to understand the latest trends and apply them to his work at Esri by translating them to requirements and development goals. He received a bachelor's degree in engineering, majoring in geoinformatics, from Guindy Engineering College in India, and a master's degree in geography from University of Northern Iowa.

```
##### embedding images
![`'alt text'`]('https://path_to_img.png')

**bold**
*italic*
`variable_names_in_code_format`

```python
# put your block of code here
cluster_results = arcgis.features.analysis.cluster()
```
```

```
##### in line equations
If A and B are mutually exclusive, then $P(A \cap B) = 0$

##### multiline equations
$$
P(A_i | B_j) = \frac{P(B_j | A_i)P(A_i)}{P(B_j | A_1)P(A_1) + P(B_j | A_2)P(A_2) + ... + P(B_j | A_k)P(A_k)}
$$
```

in line equations

If A and B are mutually exclusive, then $P(A \cap B) = 0$

multiline equations

$$P(A_i|B_j) = \frac{P(B_j|A_i)P(A_i)}{P(B_j|A_1)P(A_1) + P(B_j|A_2)P(A_2) + \ldots + P(B_j|A_k)P(A_k)}$$

Note: to run this sample, you need a few extra libraries in your conda environment. If you don't have the libraries, install them by running the following commands from cmd.exe or your shell

```
conda install scipy
conda install matplotlib
conda install scikit-image
```

↖ Master markdown to enrich your notebooks with rich typography and multimedia.

← An example showing how LaTeX equations are rendered in Jupyter Notebook.

↙ Explicitly state uncommon libraries that you use at the beginning.

APPLYING GIS TO "EVERYBODY'S PROBLEM"

By Monica Pratt, *ArcUser* Editor

The number of homeless people in the United States—nearly 554,000, according to the US Department of Housing and Urban Development (HUD) annual Point-in-Time (PIT) count released in December 2017—rose for the first time since the onset of the Great Recession in 2007. HUD secretary Ben Carson said in a statement released with the report that, "This is not a federal problem—it's everybody's problem."

The substantial and increasing number of homeless people, especially in urban areas in California, Oregon, and Washington, is far more than a nuisance. Homeless populations that often congregate in encampments impact the infrastructure and economic viability of cities. This phenomenon threatens public health, taxes public works departments, discourages business, and burdens law enforcement agencies.

Like a natural disaster, this situation requires a rapid and coordinated response. Local governments have had to deal with growing homeless populations. In 2017, the City of Anaheim, California, declared an emergency over the hundreds of homeless people on its streets and encamped along a popular trail.

A complex problem with many underlying causes, contributing factors, and impacts that require the coordination of several government departments, the homeless problem can greatly benefit from the use of GIS. Using a geographic framework to integrate data, GIS makes relationships and dependencies apparent.

The City of San Diego, California, declared a state of emergency in 2017 when faced not only with a shortage of available shelter housing but also an outbreak of hepatitis A that caused 20 deaths and more than 400 hospitalizations. Because the outbreak was occurring predominately in the homeless population, the county, a longtime user of GIS, geotagged data on homeless populations to identify and deal with the outbreak.

Governments are adopting a life cycle approach similar to the one used for emergency management to address the homeless crisis. This approach employs GIS to use repeatable, successful patterns for the four phases of this cycle: plan, respond, mitigate, and recover. These phases encompass activities such as assessing the problem, understanding contributing factors, gathering and analyzing data, communicating with the public and decision-makers, planning and implementing strategies, and monitoring the progress and success of strategies. These activities can all be more effectively carried out using GIS.

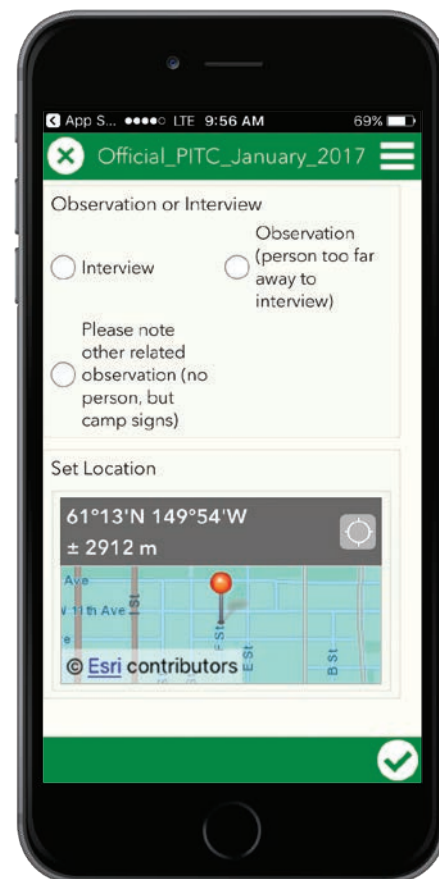## DEALING WITH THE CHANGING FACE OF THE HOMELESS

There have always been homeless people, but that population has grown significantly and changed in composition. Underlying factors, such as lack of savings, lagging wages, the scarcity of affordable housing, inadequate public transportation, and the absence of health insurance, have both increased and diversified the homeless population. For at risk populations, these factors mean that life on the streets may only be a couple of missed paychecks away.

Consequently, according to the HUD PIP count, the homeless stereotype of the middle-aged, unemployed man has given way to a larger swath of demographic types: entire families, some employed but unable to afford a permanent home; victims of domestic violence; abused children; disabled or mentally ill people; substance abusers; and veterans. These are some of the new face of the homeless.

← Homeless encampments threaten public health, tax public works departments, discourage business, and burden law enforcement agencies.

→ OECD built a Survey123 for ArcGIS app that makes the annual PIT count for Anchorage easier to conduct and allows volunteers from the community to participate. Courtesy of the Municipality of Anchorage

GIS helps cities and counties better understand the differing needs of this population, track its locations, and predict its movements and impacts. With a better understanding of who is homeless and where they are, local government can work on providing services and shelter for homeless and clean up camps.

USING A DATA-DRIVEN APPROACH

In the Municipality of Anchorage, Alaska, when homeless people set up campsites along Anchorage's 250 miles of trails and 223 parks and greenbelts, they cause sanitation problems, discourage use of these areas by other residents, and attract crime. These campsites are also dangerous for the homeless people who inhabit them.

Anchorage's Office of Economic and Community Development (OECD) is the agency responsible for improving the community's economic vitality and enhancing the quality of life for residents. OECD worked with the coordinator for Housing and Homeless

Services on Mayor Ethan Berkowitz's staff to develop a comprehensive approach to solving the problem of camp identification and resource allocation to help people move from these locations to safe shelter and housing. The agency used ArcGIS to take a more holistic approach that incorporated the legal requirements of an abatement process, enhanced communication between agencies, and aided collaboration with the community's nonprofit and private sector to begin addressing this serious problem.

Initially, there were two efforts to increase data and understanding. The first effort involved increasing community participation and reliable input of data on where homeless camps were located to save police and cleanup time. The second effort was designed to increase coordination internally for agencies responding from the municipality to ensure that departments understood the workflow and activities. This resulted in more effective coordination with

the community for homeless resource allocation. Collecting camp data and making it available in a dashboard was beneficial because it increased the ability to identify the likely locations of homeless persons to aid required homelessness count activities.
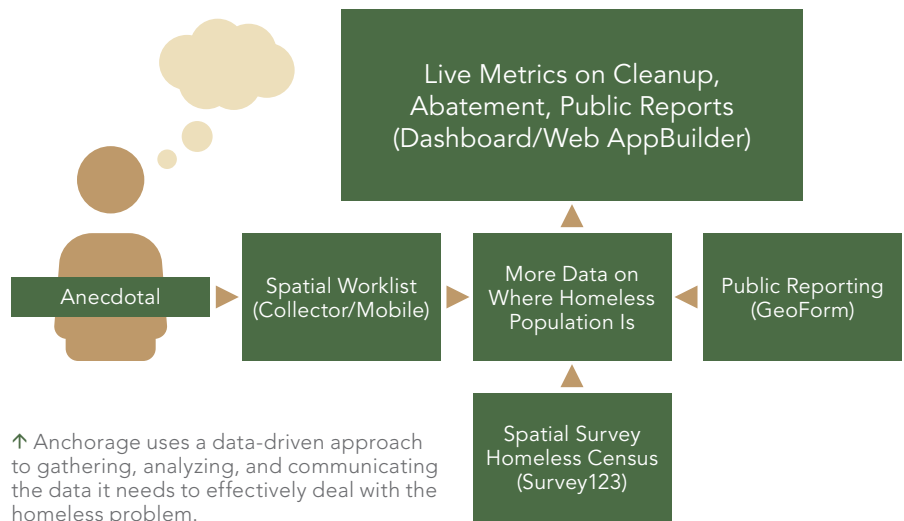
After fielding complaints about homeless camps in 2015, Mayor Berkowitz was looking for a way to increase public participation by providing a method for reporting homeless camps. An ArcGIS-based solution that used GeoForm replaced an initial and less useful address-based system. GeoForm let people reporting a camp drop a pin on a map so it could be easily located by Anchorage Police Department, Anchorage Parks and Recreation staff, and social services agencies. The result was #AncWorks, an interactive online tool for reporting homeless camps and other concerns.

The next enhancement was the development of a work process to help parks and recreation staff handle reports of camp debris, not only the increasing number of these reports but also the backlog.

According to Tina Miller, the geographic information officer for OECD's Geographic Data and Information Center, OECD developed a Collector for ArcGIS app as a better way to handle this backlog of homeless camp cleanup requests.

Camp abatement is a process, not an event. Challenges such as determining ownership of land—private, state, or municipal—and appropriate follow-up response is made easier with a dashboard. If the camp is on private land, the owner can be notified of the camp for follow-up. If the camp is on public land, the municipality proceeds with the legal process to give notice and remove the camp. Operations Dashboard for ArcGIS serves as an organizing tool for the legal proceedings and follow up coordination for social services resources. Instead of a stream of emails batted between departments, Collector and Dashboard allow Anchorage's staff to track the status of camps throughout the abatement process.

This has aided communication between the police and parks and recreation staff who are involved in the abatement process. Using Collector has saved staff substantial time when locating camps and monitoring the abatement process. The data produced

↑ Anchorage uses a data-driven approach to gathering, analyzing, and communicating the data it needs to effectively deal with the homeless problem.

by these efforts has made both staff and the public more spatially aware and understanding of the abatement process. As the data has been fed back into the system, it has continually improved processes.

Taking an infrastructure management approach to solving one aspect of broader issues related to homelessness allows for a more refined approach. Combining tools and a multidisciplinary team allows Anchorage to evolve the questions it asks

and produce additional results. Using Survey123 for ArcGIS, it has refined camp location information for the PIT counts in subsequent years, making those surveys more effective. The use of tools and increased cooperation provided the right environment for Anchorage Police Department Community Action Policing team to add two new positions in the unit for mental health and social services coordination. These positions now help lead community homeless outreach

↓ The AncWorks Camps Dashboard lets staff in the various departments involved in the camp abatement process know the current status of all camps. Courtesy of the Municipality of Anchorage

and provide support for persons with mental illness and disabling conditions in the homeless services systems. This resource allows police to become more effective in engaging people who are homeless in a way that helps them move to needed resources.

An additional benefit came from an increased ability to locate places where homeless persons may be encountered across the community. Anchorage participates in the HUD PIT count. By providing demographics on the homeless population to the federal government, it can apply for federal housing grants to fill gaps in housing capacity and social services needs. In 2016, OECD built a Survey123 app to make the PIT count easier to conduct. When Anchorage invited volunteers to participate that year, 190 residents responded. The app was so simple to use that these volunteers required virtually no training. After temporarily adding them to Anchorage's ArcGIS Online account, volunteers were sent out to areas where camps had been reported.

According to Miller, much of the success of Anchorage's approach has been due to its focus on the data needed to answer questions instead of application development. Now that Anchorage can assess the unsheltered homeless population and more efficiently handle cleanup, it can use the information generated to address other aspects of the problem such as the number of emergency shelter spaces, needed housing programs, and additional support and resources for homeless people to connect with housing.

"We have been able to take an agile approach using GIS, allowing us to change from our original direction without wasting any time or resources," said Miller. By using a multiagency approach with police and parks and recreation departments, with policy support from the directors of these agencies and the mayor's office, Anchorage has been able to begin implementation of a robust system of municipal land-use management paired with social services and opportunities for homeless people to move to safe locations and housing.

DECREASING CALLS FOR SERVICE

A county in Southern California also combines enforcement and support in a program enabled by GIS. The San Bernardino County Sheriff's Department's Homeless
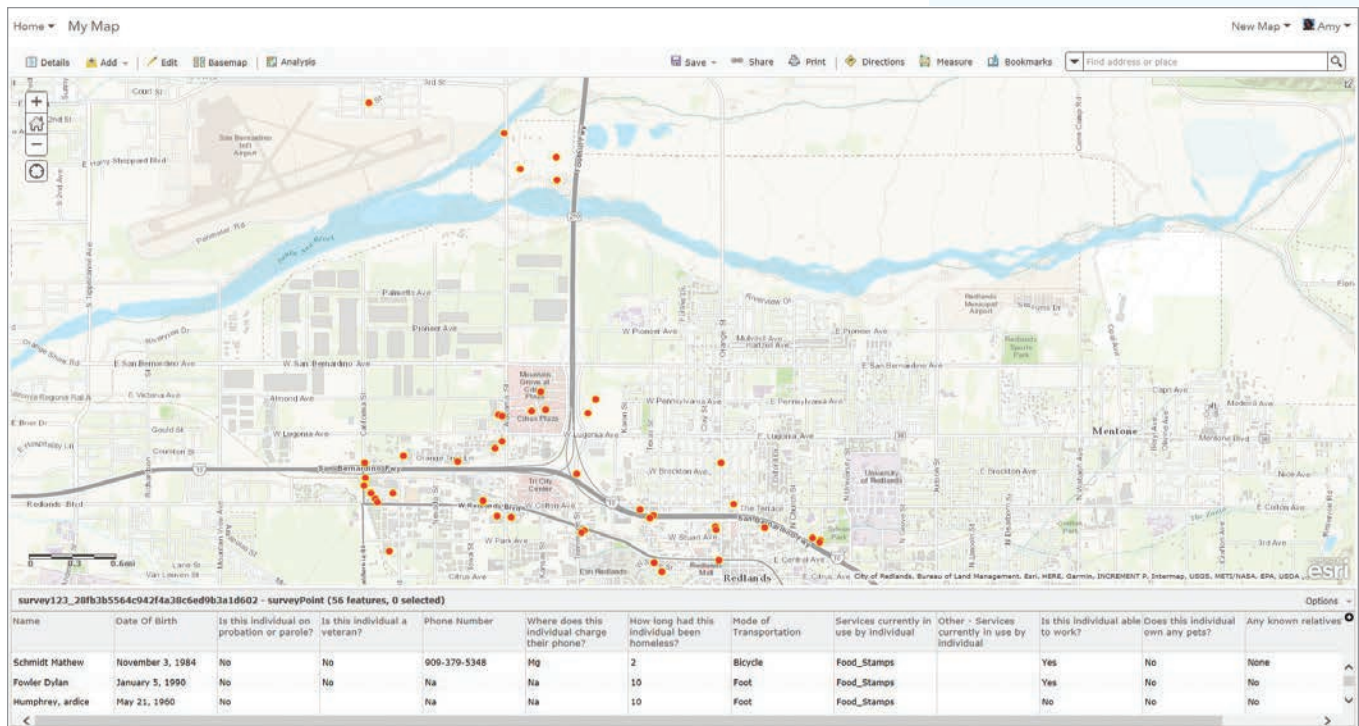

↑ Anchorage residents can use this simple form to report a homeless camp.

Outreach and Proactive Enforcement (H.O.P.E.) program, started in 2014, uses a proactive approach that is intended to ultimately reduce calls for service and other resources required to deal with the county's homeless population. By linking homeless people, especially chronically homeless, with resources and service providers throughout the county, the program is designed to break the cycle of arrest, incarceration, and release.

By reducing the rate of recidivism and the costs associated with homeless-related crime, the program's goal is to improve the quality of life for all San Bernardino County citizens, decreasing crime, saving taxpayer money, and helping the homeless transition from life on the streets.

The H.O.P.E. team, headed by Deputy Mike Jones, uses ArcGIS Online to share information in a controlled manner with other officers in the county sheriff's 20 patrol

Using the Homeless Contact Reporting app, officers can easily record encounters with the homeless individuals or families and any services they may be receiving. The information can be securely shared using ArcGIS Online.

stations and 11 police departments. Information sharing can be challenging in any jurisdiction that encompasses multiple law enforcement agencies, but it is unusually so because San Bernardino County is the largest county in the United States. Its more than 20,000 square miles are handled by the three members of the H.O.P.E team. The county has approximately 1,800 homeless persons according to the county's PIT count for 2017. By creating the Homeless Contact Reporting Group, an ArcGIS Online group, H.O.P.E. has a platform that will allow it to securely share data between law enforcement agencies in the county.

Documenting contacts between law enforcement and homeless persons and any services provided to those persons is an important aspect of dealing with the homeless problem. ArcGIS Solutions for Local Government, which includes several solutions for the homeless problem, is available for free to organizations with ArcGIS Online subscriptions. The homeless solutions are maps and configurable apps that can help agencies count and monitor homeless populations, inventory homeless resources, and locate homeless services. These apps work with the ArcGIS platform

including ArcGIS Pro, Survey123 for ArcGIS, Operations Dashboard for ArcGIS, and Collector for ArcGIS.

Before H.O.P.E. implemented the Homeless Contact Reporting app, this information was managed through a labor-intensive, manual process. Officers filled out information cards in the field for each contact. When they returned to the office, they then entered the data into one of about 30 different spreadsheets.

The Homeless Contact Reporting app, a configuration of Survey123 for ArcGIS, can be used to create a context-sensitive form for easily recording encounters with homeless persons. Not only does it aid in recording information about an individual or family and any services they may be receiving, but it also lists nearby available resources based on the current location. Photos and documents can be attached and uploaded with the survey form. The app is available for use on Android and iOS devices or in a web browser. Completed surveys can be sent if connectivity is available or sent later. The location where the survey was taken is mapped.

The app helps officers collect the data needed for funding, reporting, and

response requirements and makes the data collected immediately available to other ArcGIS apps. The data can be queried using Homeless Contact Query and Data Download, a Web AppBuilder for ArcGIS app. Analytics can be run on this data using the Homeless Contact Analytics page.

For mapping homeless encampments, a Collector for ArcGIS configuration called the Homeless Encampment Reporting app can map where the homeless are congregating. This information can be used for locating and assisting people during disasters. Camps are symbolized by size and automatically geolocated, and text boxes are provided for descriptions of the area to aid the code enforcement and public works staff involved in camp cleanup. Any hazardous materials, biohazards, or pets present can be noted for other county staff coming to the site. The app can be used offline. Data can be uploaded when connectivity is available.

Homeless Contact Mobile Search will bring up a list of all matching contacts based on a name or partial name, furnishing location, contact, and survey information. The Homeless Contacts Dashboard accesses all data acquired from Survey123 or Collector apps. It is used by H.O.P.E. to provide an overview of contact with homeless over time and space. It can be searched by individual name, age range, timeline, location, or other characteristics. Once the data is queried out, it can be exported to a CSV file for use in other applications.

USING GIS TO COLLABORATE ON EVERYONE'S PROBLEM

Addressing the homeless problem requires efforts across and between local governments and coordination with other government agencies and private organizations. It benefits from the kind of holistic approach enabled by ArcGIS.

Using GIS to address homelessness will help cities work together to mitigate the health and economic impacts of homeless populations and help these vulnerable people get connected with services that help get them off the streets.

The homeless solutions and other ArcGIS Solutions for Local Government are configurable apps and maps. Available at no additional cost with a named user that is part of a ArcGIS Online subscription, they make collecting, organizing, analyzing, and accessing data on homeless populations simple but secure, since only the creator of a record can edit it.

For more information on these solutions and how to implement them, contact John Beck at JBeck@esri.com or Chris Fox at chris_fox@esri.com.

ABOUT THE AUTHOR

Monica Pratt is the founding and current editor of *ArcUser* magazine, the executive editor of *ArcNews* magazine, and the editor of *Esri Globe* and leads the publications team at Esri. She has been writing on technology topics, specializing in GIS, for more than 25 years. Before joining Esri in 1997, she worked for newspapers and in the financial industry.

↓ The H.O.P.E. team works with officers in the county's sheriff's 20 patrol stations and 11 police departments in a collaborative manner to deal with San Bernardino County's homeless population.

3D Modeling with ArcGIS Pro

By Mike Price, Entrada/San Juan, Inc.

What you will need

- Access to an ArcGIS Pro license
- Sample dataset downloaded from *ArcUser* website
- Unzipping utilty

In this tutorial, 2D and 3D data will be combined in an ArcGIS Pro Local Scene to visualize the topography, imagery, and cultural features of a region in the state of Washington. Mapping and modeling in 3D makes it easier to understand and communicate the effects of natural events such as volcanic mudflow (lahar).

For this tutorial and in the three previous ones in this series, the area mapped was the site of an international emergency planning and response exercise that was conducted in November 2017. That exercise, the fifth Canada-United States Enhanced Resiliency Experiment (CAUSE V) exercise, was conducted in Whatcom County, Washington, and southern British Columbia, Canada.

The data captured during that exercise has been the basis for four tutorials in *ArcUser*. The first tutorial, "Modeling Volcanic Mudflow Travel Time with ArcGIS Pro and ArcGIS Network Analyst," appeared in the Fall 2017 issue of *ArcUser*. It introduced a special use of ArcGIS Network Analyst, an ArcGIS Pro extension, to model lahar as it ran down the Nooksack River, through several communities, and into Puget Sound as the result of a hypothetical seismic event—the crater collapse on Mount Baker.

The second tutorial, "Georeferencing Drone-Captured Imagery," in the Winter 2018 issue, showed a simple imagery georeferencing workflow that imported an ArcMap document (MXD) into ArcGIS Pro. In that exercise, two images were georeferenced by interactively connecting the ground control targets on the raster with vector control points.

"Test Georeferencing Transformations," which ran in the Spring 2018 issue, showed how to georeference an image by importing a file containing ground control points and explored the effects of all the transformations available in ArcGIS Pro.

"Mapping and Modeling Lidar Data with ArcGIS Pro," the most recent tutorial, which appeared the summer 2018 issue of *ArcUser*, showed how to compare bare earth and first return lidar rasters to explore natural and cultural features in ArcGIS Pro.

← The Drone_4_Everson in ArcGIS Pro layout mode contains a new feature class, HWY 544 Bridge.

↗ Make Topo_LiDAR_BE visible, the bare earth lidar data layer. Define a Pop-up (Identify) rule by clicking the drop-down arrow at the bottom of the Explore tool and choosing Selected in Contents.

↘ Use the pop-up to check the elevation values for the bare earth raster.

Monitoring the Exercise with Drones

One of the critical tests conducted during CAUSE V was capturing high-resolution and real-time data transmitted from the field to the CAUSE V Emergency Operations Center. On the second day of the exercise, drones were deployed along the Nooksack River to assess, capture, and relay event status to headquarters for follow-up mapping, incident management, and response planning.

One of those drones, Drone 4, was stationed on the north side of the Nooksack River, just above the Washington State Route 544 (WA Hwy) bridge. This bridge bisects the town of Everson and is the only means of crossing the Nooksack River at that point. Drone 4 was assigned to assess the bridge's condition, monitor traffic flow, and identify threats to the structure and the surrounding community. The drone was also tasked with monitoring anticipated debris flow from the Nooksack River, over a low divide into Johnson Creek, and into the Sumas River, flowing toward Canada.

Getting Started

Although this exercise uses essentially the same data as was provided for the previous tutorial, **use the sample dataset that accompanies the online version of this article**. Several vector datasets have been modified and filtered to support 3D modeling, although the lidar data used to create hillshades, feature heights, and contours is unchanged. After you complete this tutorial, you could re-create those derivative products and add them to the final 3D scene.

Download the sample dataset, CAUSE_V_Drone_v21n4, for this tutorial from esri.com/arcuser and unzip it on a local machine. It should contain slightly more than 61 MB of data.

Start an ArcGIS Pro session, browse to CAUSE_V_Drone_v21n4\Drone_4_Everson

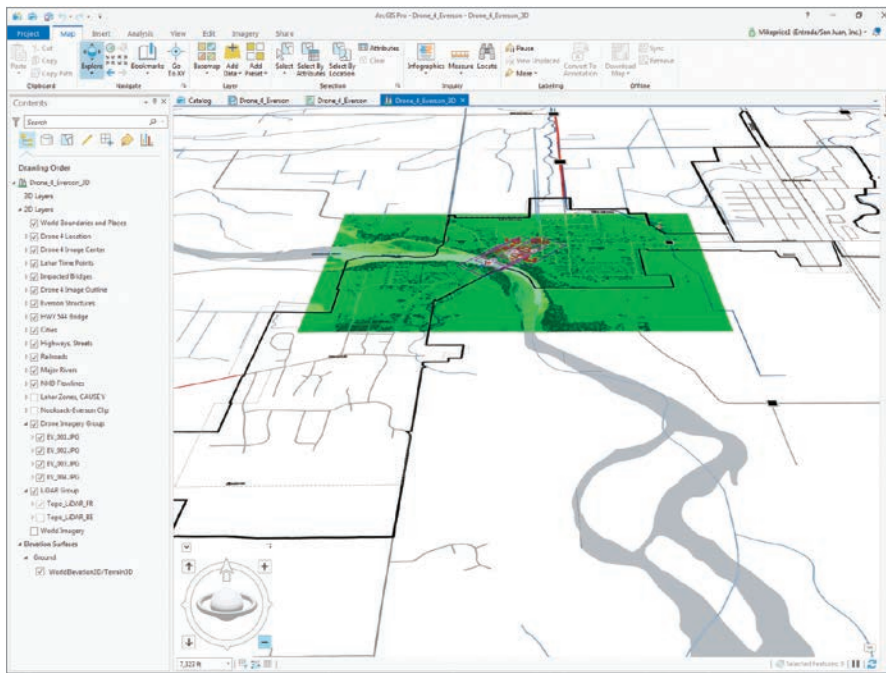and open the new Drone_4_Everson.aprx. *[Do not open a project from a previous tutorial in this series.]*

Drone_4_Everson is in ArcGIS Pro layout mode. It contains a new feature class, HWY 544 Bridge. Switch from layout to map view, open Bookmarks, and zoom to Everson 1:2,500.

All data layers posted in this map—except World Imagery and World Boundaries and Places—are projected in the same coordinate

system—Zone 10 N, universal transverse Mercator (UTM) using the North American Datum 1983 (NAD83) and metric units.

Reviewing Vector and Raster Data

Click the tab to switch the view to map view. In the Contents pane, right-click the Everson Structures layer and open its attribute table. In the table, inspect the fields and note two numeric fields, Height_M and

Contents pane, select Topo_LiDAR_BE, and click any area near the center of the HWY 544 Bridge (which is outlined in blue). The elevation value displayed in the pop-up should be 24 meters or less.

Click in adjacent areas to check other pixels in this bare earth raster to check the elevation values. As you click, you may notice that other visible raster layers may flash, but they are not selected, so no pop-up data is returned.

Return to the Contents pane, uncheck Topo_LiDAR_BE, make Topo_LiDAR_FR visible, and click on pixels in this layer located on the bridge. The elevation values on the bridge should be clustered around 30.8 meters. To query both bare earth and first return rasters, make them both visible *and* select both and click an area inside the HWY 544 Bridge polygon to display values from both rasters. In the next step, the Drone_4_Everson map will be converted to a 3D scene, and both lidar rasters will be used for data display and visualization. Save the project.

Everson in Three Dimensions

There are two viewing modes for scenes: global and local. Global is used for content that covers a large area and for which the curvature of the earth is an important element. Local is used for extents that are smaller and are in a projected coordinate system or for applications when the curvature of the earth isn't needed.

Because this is a small area and it is in a projected coordinate system, convert this map to a Local Scene. Click the View tab and open the Catalog pane and expand the Maps item. Right-click Drone_4_Everson, open Convert, and choose To Local Scene.

Wait patiently as the 3D scene builds. Drone_4_Everson_3D appears on a tab to the right of the Drone_4_Everson map. Verify that Drone_4_Everson_3D is active.

Click the Map tab and click Bookmarks to see bookmarks for both 2D and 3D maps.

Elev_M. The attributes in these fields will be used to place structures and a bridge in 3D space. Close the attribute table.

Return to the Contents pane and open the attributes table for HWY 544 Bridge. This layer now displays a single polygon and has been separated from other polygons in the Everson Structures layer by applying a definition query. Notice that its height is zero and its elevation is 30.5 meters. Close the attribute table.

Scroll to the bottom of the Contents pane and make Topo_LiDAR_BE visible. This is the same bare earth lidar data that was used to create a hillshade and contours in the previous tutorial.

To better understand how this layer might behave in 3D, define a Pop-up (Identify) rule for a single Contents item by clicking the Map tab, then click the drop-down arrow at the bottom of the Explore tool and choose Selected in Contents. Return to the

Select the 3D Everson 1:2,500 bookmark. All four image outline polygons that will be used for georeferencing will be visible.

Displaying and Navigating in 3D

In the Contents pane, note the 3D layer group in Drone_4_Everson_3D does not contain any layers. As 2D objects are placed in 3D space, layers will be automatically generated and moved into the 3D group.

At the bottom of the Contents pane, in the Elevation Surfaces group layer, is a subgroup called Ground. This subgroup contains the WorldElevation3D/Terrain3D layer. This default surface, registered in World Geodetic System (WGS) 1984 Web Mercator (auxiliary sphere), initially posts the 2D vector and eventually raster data in 3D. *Using this layer successfully requires a reasonably fast Internet connection.*

Click the 3D Everson 1:25,000 bookmark to zoom out to the full project extent. ArcGIS Pro Navigator appears in the lower left side of the scene. Even though the map still looks flat, the navigator can be used to explore Everson in 3D.

Click the up-facing caret in the navigator control's upper-left corner to show the navigator in full control mode. Experiment with navigator. If you are not familiar with the navigator, read the accompanying article, "Navigating in ArcGIS Pro" and the ArcGIS Pro help for more information.

Adding Local Lidar Surfaces

Use the 3D Everson 1:2,500 bookmark to zoom in. Angle the view point using navigator. Go to the bottom of the Contents pane. Under Elevation Surfaces, right-click the Ground subgroup. In the context menu, choose Add an Elevation Layer. Navigate to GDBFiles\UTM83Z10\Topo_LiDAR.gdb and add Topo_LiDAR_BE. Watch as the bare earth lidar raster loads and notice the increased resolution provided by the draped vectors.

Use the same process to add Topo_LiDAR_FR. Watch as the first return surface pushes vector data to higher elevations. Notice that all 2D vector feature classes are suspended on the highest visible ground elevation surface.

Initially, all vector data drapes on the WorldElevation3D ground surface. Now the forest canopy, approximate shape of structures, and the HWY 544 bridge are

visible. Because these surfaces have one-meter pixels, the level of topographic detail is very high. Save the project.
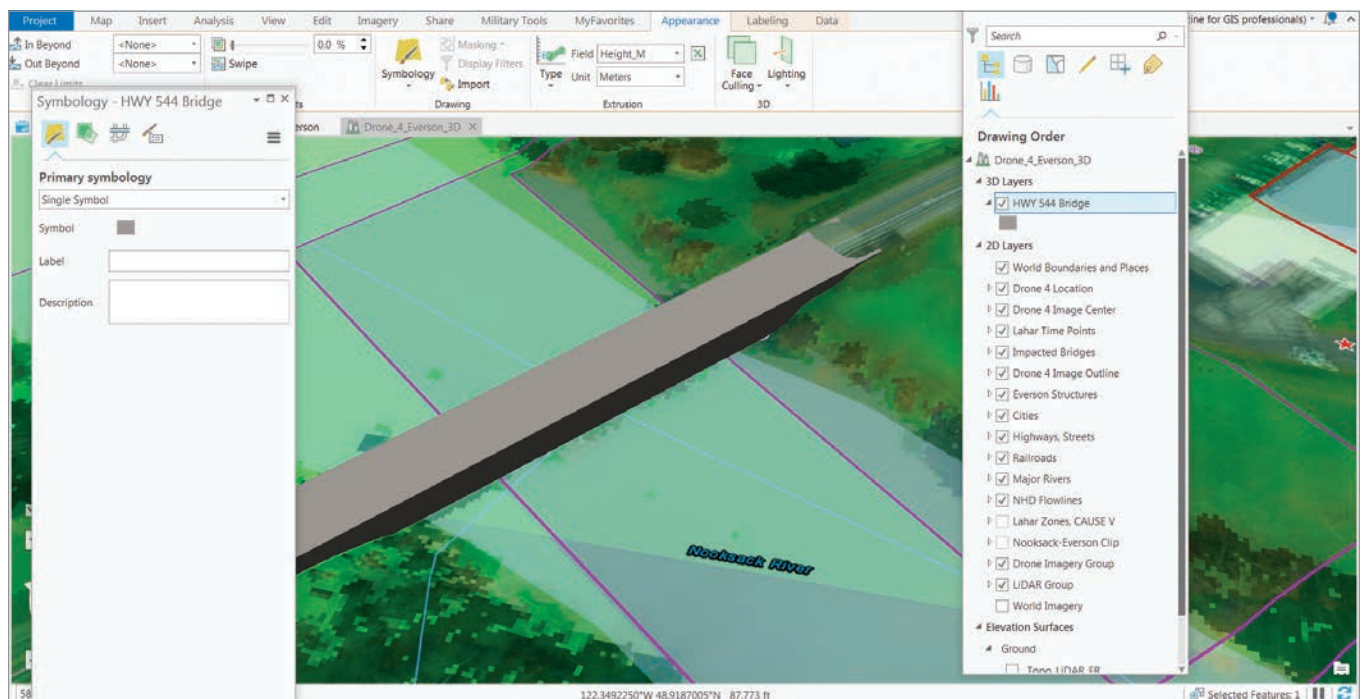
Enhancing Vector Polygon Surfaces

In the Ground subgroup, turn off Topo_LiDAR_FR and WorldElevation3D, but leave Topo_LiDAR_BE on. Zoom in to show all image outlines.

In the Contents pane, select HWY 544 Bridge and click the Appearance tab. In the Extrusion group, click the drop-down below Type and study the extrusion types. The default is None. The other choices are Min Height, Max Height, Base Height, and Absolute Height. Since the bridge is essentially flat, click Absolute Height to place it in 3D space.

In the Extrusion area, set the Field to Elev_M (to use the field values previously previewed in the attribute table for this layer) and confirm units as Meters. Zoom in to the bridge. Click Save to apply these updates. Notice that the bridge is now in the 3D Layers group.

The bridge symbology is a blue outline, which does not display well in 3D.

↓ Apply Concrete symbology to the HWY 544 Bridge polygon to make it display better.

Navigating in ArcGIS Pro

Right-click the HWY 544 Bridge layer and select Symbology. In the Symbology pane, double-click the symbol to open the Gallery tab, move down to ArcGIS 3D, and double-click Concrete to apply it.
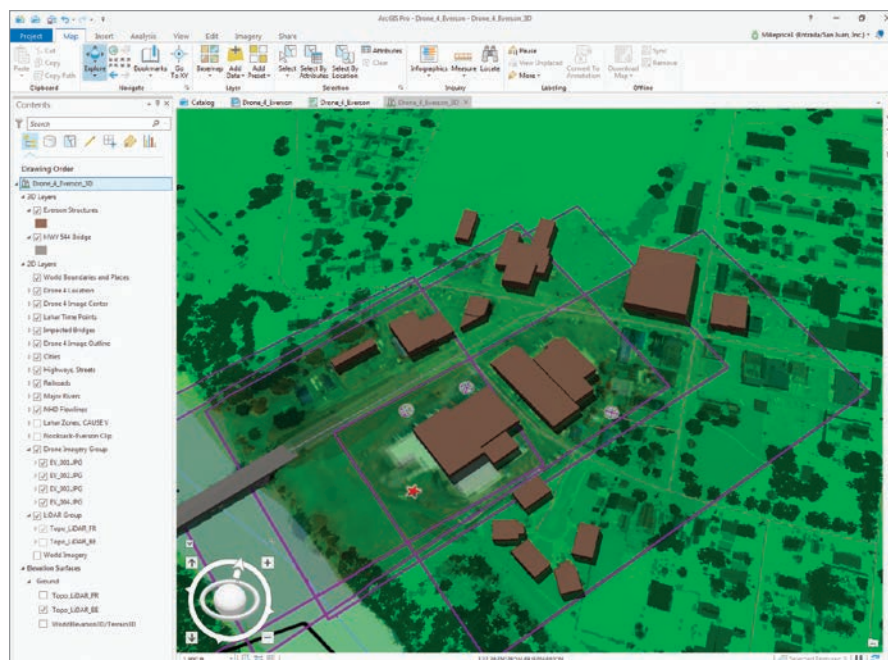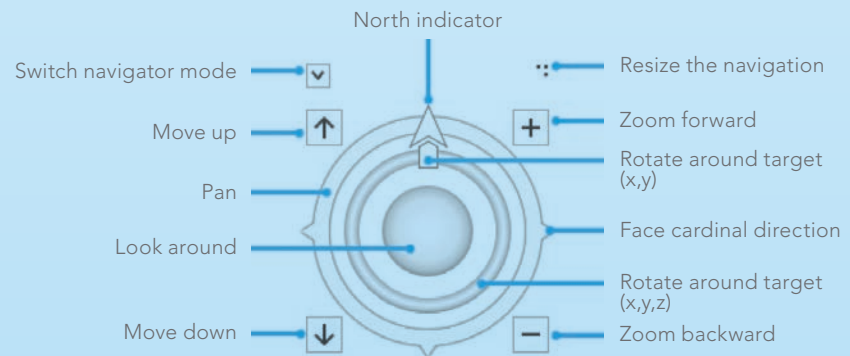
Select the Everson Structures layer and zoom to its extent. On the Appearance tab, in the Extrusion group, click the drop-down below Type and select Base Height, using the Height_M field to define the extrusion. Open Everson Structure's Symbology pane and select a 3D Brick. From the Face Culling drop-down, choose Back.

The bridge needs shadows. In the Contents pane, right-click Drone_4_Everson_3D and select Properties. In Map Properties, select Illumination. Notice that the sun's altitude is 90 degrees, straight down. Change this value to 45 and verify that Contrast is set to 30. Check Display shadows in 3D and click OK. Now note the shadows under the bridge and on the southeast side of buildings. Save the project again.

Studying Lahar Effects

Click the 3D Everson 1:25,000 bookmark to zoom out to the full project extent. With the Drone_4_Everson scene in 3D, some of the impacts of the lahar (volcanic mudflow)

Click the upward arrow in the control's upper-left corner to show Full Control. In Full Control, the 3D navigation icon expands to show several new features, including an enhanced Pan and Rotate around target (x,y) ring, a 3D Rotate around target (x,y,x) ring, and a central Look around ball. Two Move and two Zoom buttons frame the Navigator. If you become disoriented, use the Previous Extent arrow on the ribbon to back up, or use 3D Bookmarks to return to a home position. Experiment with these controls until they become second nature to you.
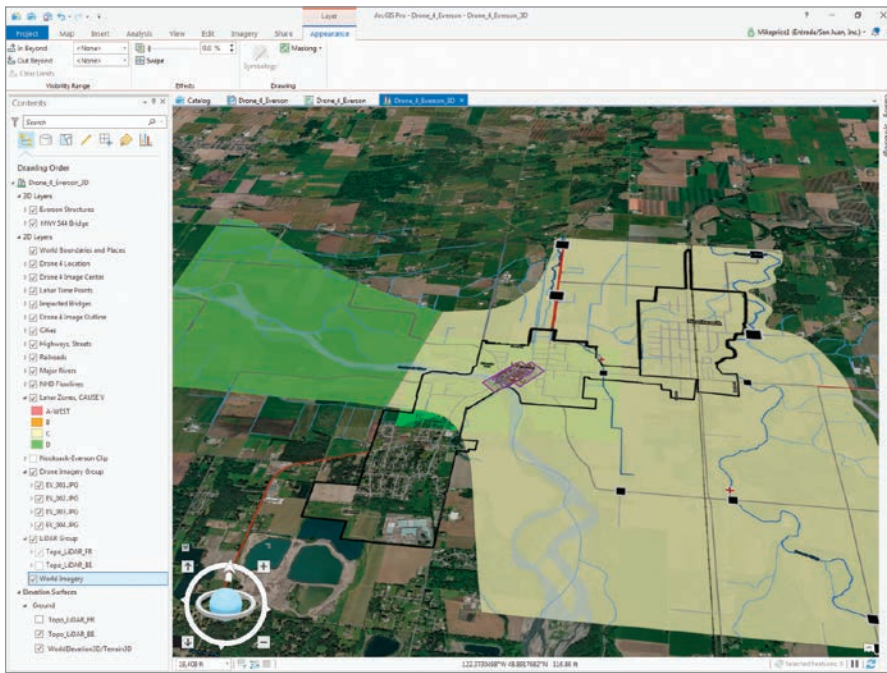

that was modeled in earlier exercises can be viewed. You will need a fast and stable Internet connection and some patience to do this portion of this tutorial.

In the Contents pane, turn off the Topo_LiDAR_FR. Expand the Lahar Zones, CAUSE V layer and turn it on. Once it appears, turn on WorldElevation3D/Terrain3D layers. Save the project. Watch the performance monitor in the lower right corner as the scene rebuilds. You will likely have to be patient to wait for WorldElevation3D/Terrain3D layer to display.

On the Appearance tab, use the transparency slider in the Effects, reduce the

←Make buildings more realistic by using the Height_M field to define the extrusion for the Everson Structures layer, and select 3D Brick symbology.

↖ Turn on the Lahar Zones, CAUSE V layer and change its transparency to 20 percent.

↙ Select Impacted Bridges and use the attribute table to select the Johnson Cr - E Main St bridge. View the bridge from the east and west, along the direction of traffic flow.

inundate a considerable length of its roadway as it is diverted toward Canada. During an actual Nooksack River flood, the inundated area can be up to 400 meters wide.

If you become disoriented when navigating through the scene, reopen the Impacted Bridges table and use the selected record to pan to the selected feature. Progress slowly, allowing the scene to fully rebuild before continuing to navigate. Save the project.

Challenge Exercises

In the most recent tutorial, "Mapping and Modeling Lidar Data with ArcGIS Pro," hillshades were generated from bare earth and first return lidar rasters. Those rasters were also used to create contours. You can refer to the instructions in that tutorial to create those layers for this project. As you become more comfortable with ArcGIS Pro 3D capabilities, you can use your own local terrain, vector data, and images to create new scenes.

Summary

This is the final article in the CAUSE V series that started by modeling lahar travel in ArcGIS Network Analyst. Then high-resolution drone imagery was georeferenced in local coordinate space. The various transformations available in ArcGIS Pro were explored using the georeferenced lidar imagery. Next, lidar data was modeled to show detailed topography and calculate vegetation and structure heights. In this final tutorial, a 2D map of the area was converted to a 3D scene to better visualize and understand the extent and effects of the simulated mudflow.

Acknowledgments

transparency of the Lahar Zones, CAUSE V layer to 20 percent. You can use the navigator to explore the area. North Everson and all of Nooksack are in an area designated as Zone C in the Lahar Zones, CAUSE V layer. Notice that lahar flow divides south of Everson and flows northward down Johnson Creek into the Sumas River and on to Canada.

Select Impacted Bridges in the Content pane and open the attribute table. The bridges in this table are located in the modeled lahar zone and are subject to failure. To show the impact on a smaller bridge, select the Johnson Cr - E Main St bridge. Use the selected record in the table to zoom to this bridge and navigate slowly around it.

Close the attribute table. Try to view the bridge from the east and west, along the direction of traffic flow. This small bridge is a major crossing point on a Washington state highway. Nooksack floodwater may

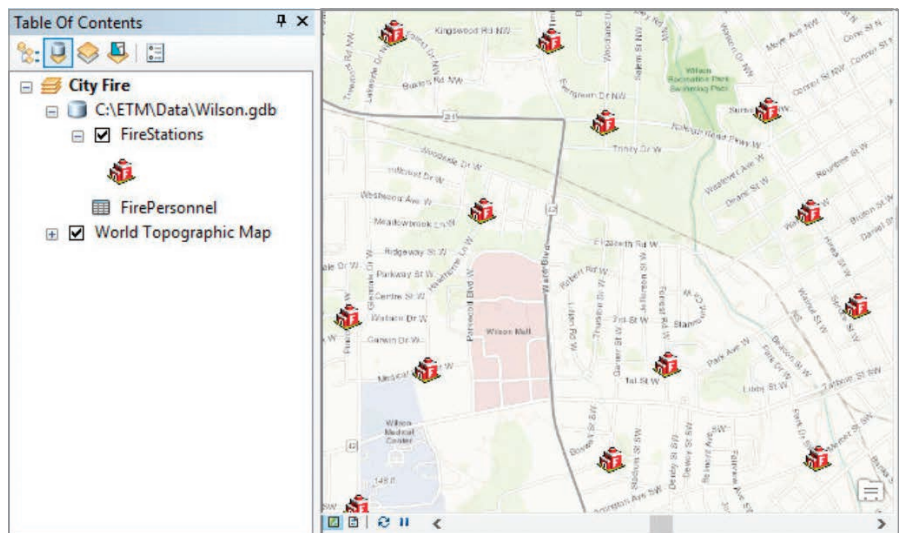# Relates and Relationship Classes Explained

By Suzanne Boden

The difference between relates (often called table relates) and relationship classes is a source of much confusion, especially for new ArcGIS users.

Though the terms sound similar, they refer to different things. There are reasons to use each one.

A relate exists in a map or layer file. Relates are great because they allow you to select features in a layer, then easily see related features in a different layer or related records in a nonspatial table.

A relationship class is an object in a geodatabase. Relationship classes enable smart behavior. You can set up rules for how the participating feature classes or tables behave when something happens. For example, with a relationship class in place, if a feature is deleted, then its associated record in the other feature class or table will be automatically deleted.

Both relates and relationship classes rely on cardinality, which describes how records in two different tables are related to one another. Cardinality can be

↑ A relate exists in a map or layer file and allows you to select features in a layer, then easily see related features in a different layer or related records in a nonspatial table.

one-to-one, one-to-many, many-to-one, or many-to-many.

Relates support only one-to-many and many-to-one cardinalities, while relationship classes support all four cardinalities.

Feature classes and tables that participate in a relate or a relationship class must have a field of the same data type (e.g., text, short integer, long integer, ObjectID). That field will be the connection point or key field between
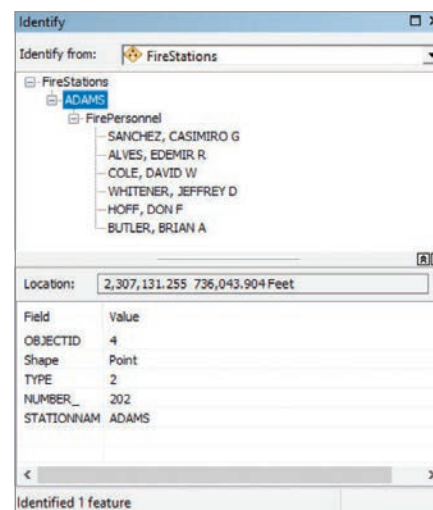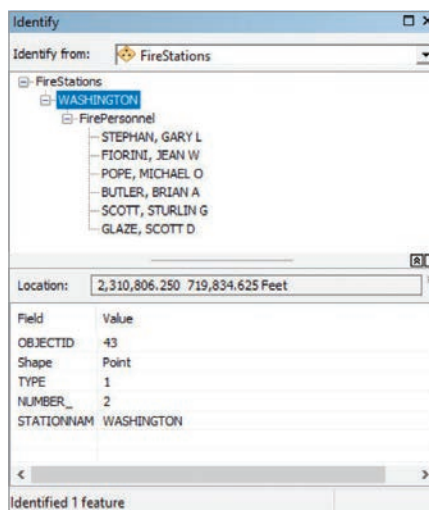
→ When Brian Butler transferred from the Washington station to the Adams station, his record in the FirePersonnel table was edited, replacing the Washington station number (which is 2) with the Adams station number (which is 202) so the data shown in the Identify window reflected his new assignment.

the two feature classes or tables participating in the realate or the relationship class.

Example of a Relate

The map below contains a layer of fire stations and a nonspatial table that stores data about the city's fire department personnel. A relate was created between the layer and the nonspatial table, which has a many-to-one cardinality because every fire station has multiple personnel. The relate is based on a short integer field in both tables that stores a fire station ID number. The fields have different names, but that doesn't matter.

Relates make it easy to find out which personnel are assigned to any given fire station just by using the Identify tool and clicking a fire station symbol on the map. In the Identify window, the related table name displays below the fire station feature name. Expanding the table shows the records associated with that station. In this example,

An Example of a Relationship Class

Table relates are super useful for quickly viewing feature data stored in separate tables for efficient data management. Relationship classes give you the ability to do more than view data easily. With a relationship class, you can set rules and properties that control what happens when data in either table is edited. You can also ensure that only valid edits are made.

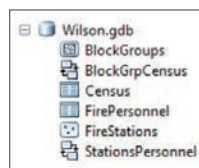| One-to-one | Every feature has exactly one related record in the other table. |
One-to-many	Features in one table may have more than one related record in the other table.
Many-to-one	Multiple features in one table have one related record in the other table.
Many-to-many	Multiple features in one table have multiple records in the other table.

↑ Cardinality Relationships

the Washington station has six assigned personnel.

Suppose Brian Butler is transferred from the Washington station to the Adams station. His record in the FirePersonnel table is edited to replace the Washington station number (which is 2) with the Adams station number (which is 202). When the edit is saved, the data shown in the Identify window will reflect his new assignment. The Washington station now has only five assigned personnel, and the Identify window will now reflect that fact. Clicking the location of the Adams station will now show Butler in its list of personnel.

Using the previous example, suppose a relationship class named StationsPersonnel has been created between the FireStations feature class and FirePersonnel table. Also suppose the city requires that all stations have a minimum of five assigned firefighters and a maximum of 15 assigned firefighters. A rule has been created in the relationship class to enforce this requirement.

With Butler's transfer to the Adams station, Washington is left with five assigned

firefighters. Jean Fiorini, assigned to the Washington station, has requested a transfer. Her request was approved. The GIS technician responsible for maintaining the fire department's GIS data tried to update Fiorini's record in the personnel table with her new station number, but she got a message that the edit cannot be made.

The database would not allow the edit because without Fiorini, Washington will have fewer than five assigned personnel. To comply with the relationship class rule, a firefighter must be added to the Washington station before Fiorini's record can be edited to reflect her new station assignment.

In this example, the relationship class ensures that data edits are valid and that the city's GIS database reflects and supports the real-world needs reflected in the rule in the relationship class. If the person who approved Fiorini's transfer didn't realize that Washington would be left with only four firefighters, the relationship class rule surfaced that piece of key information, and may have prevented loss of property or lives caused by insufficient staffing of the Washington station.

Both relates and relationship classes can help you work more efficiently, and now that you understand them, you can use them effectively.
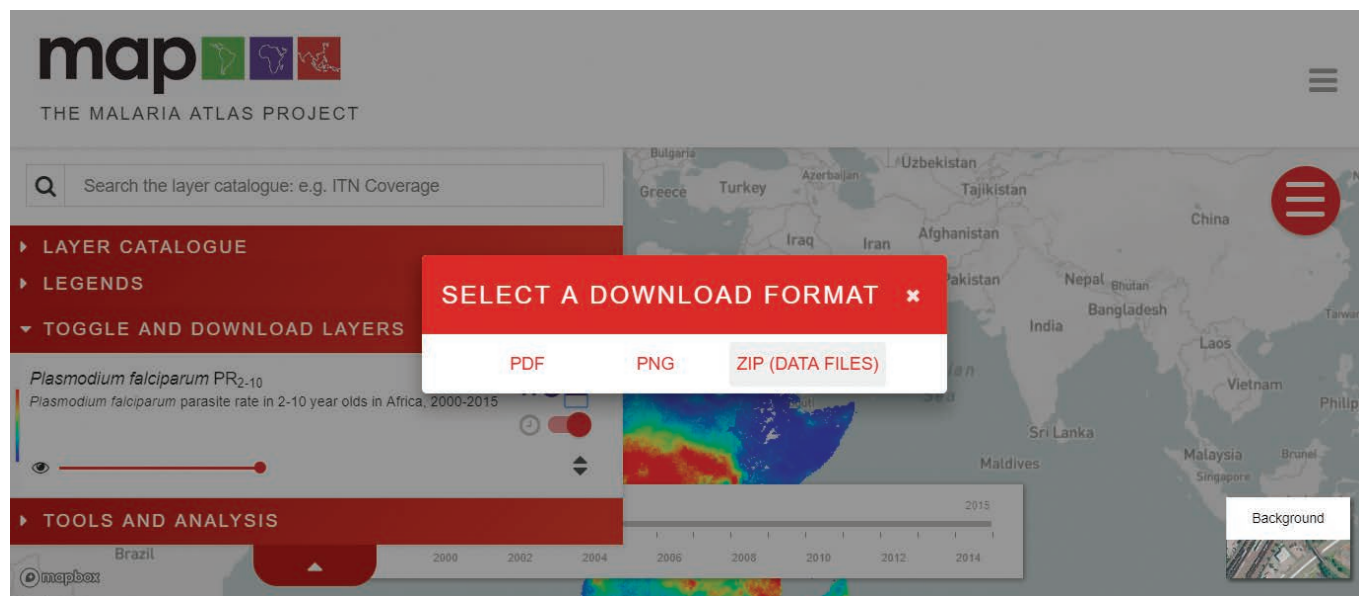
← A relationship class named StationsPersonnel, created between the FireStations feature class and FirePersonnel table, enforces a city requirement that all stations have a minimum of five and a maximum of 15 assigned firefighters per station.

Visualize Malaria Rates in Africa

By Kathy Cappelli

What you will need

- ArcGIS Pro
- ArcGIS Image Analyst extension or the ArcGIS Spatial Analyst extension
  (If you don't have ArcGIS Pro or an ArcGIS account, you can sign up for an ArcGIS free trial at esri.com/en-us/arcgis/trial.)
- An Internet connection to download data

↑ Go to the Malaria Atlas Project website (https://map.ox.ac.uk/). Under TOGGLE AND DOWNLOAD LAYERS (on the left side of the screen), click the Download button and choose ZIP (DATA FILES).

Malaria is a life-threatening disease that is both preventable and treatable. Transmitted by mosquitoes, it affects millions of people worldwide, especially young children in sub-Saharan Africa. But there's good news. Due to treatment and prevention efforts, such as insecticide-treated mosquito nets and rapid diagnostic tests, incidence rates have been shrinking.

This tutorial shows you an adaptable workflow that will let you quickly analyze and visualize raster data so you can find out how much malaria rates have decreased. Using data from the nonprofit Malaria At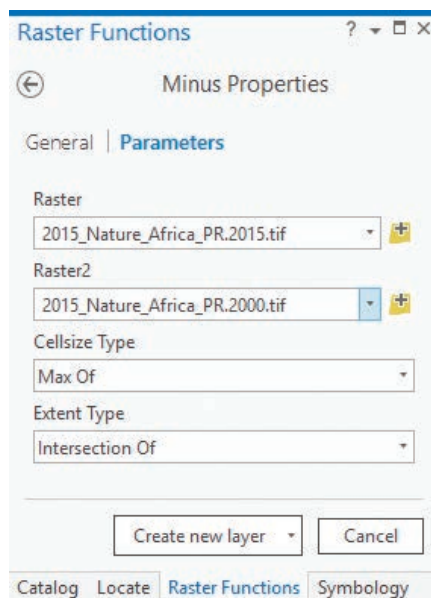las Project, you will analyze how malaria rates for children aged 2 to 10 in sub-Saharan Africa have changed since 2000. After downloading the data, you'll use the Raster Functions analysis tool in ArcGIS Pro to calculate the change in malaria prevalence from 2000 to 2015. Then, you will visualize malaria rates over time in sub-Saharan Africa. (You also will need the ArcGIS Image Analyst extension or the ArcGIS Spatial Analyst extension to complete this tutorial.)

Step 1

Download Data from the Malaria Atlas Project

1. Go to the Malaria Atlas Project website (https://map.ox.ac.uk/).
2. Under TOGGLE AND DOWNLOAD LAYERS (on the left side of the screen), click the Download button and choose ZIP (DATA FILES). Download the data on a local machine. The download may take a few minutes.
3. Extract and unzip the files.
4. Start ArcGIS Pro. Make sure that either the Image Analyst or Spatial Analyst extensions are available. Under Create a new project, click Blank. Name your project Malaria.
5. Add a New Map. In the Catalog window, navigate to the folder where you saved the unzipped malaria data. Use Add Data to add 2015_Nature_Africa_PR.2000.tif and 2015_Nature_Africa_PR.2015.tif to the map.

A map will open that displays the data with a black–white ramp. These two layers

↑ To calculate the change in malaria rates, you'll subtract the value of overlapping cells using the raster functions in ArcGIS Pro.

show malaria rates among children aged 2 to 10 in sub-Saharan Africa in 2000 and 2015. White pixels represent higher malaria rates, while darker pixels represent lower rates.

↓ The Minus layer shows the difference between the two TIFFs. White areas represent positive values, or an increase in malaria rates, while darker areas represent negative values, or a decrease in malaria rates.

Step 2

Calculate Change

Next, you'll analyze the change in malaria rates from 2000 to 2015. Because the data is in raster format, it is represented as pixels, or cells. Each cell shows the average value of the area it covers. To calculate the change in malaria rates, you'll subtract the value of overlapping cells using the raster functions in ArcGIS Pro. The resultant layer will be calculated on the fly as a temporary layer instead of being saved to your computer, which would take up storage space.

1. On the ribbon, click the Analysis tab. In the Raster group, click Raster Functions.
2. In the Raster Functions pane, type Minus in the Find Raster Functions Search box and click the Minus tool. The Minus tool subtracts the value of the second input from the value of the first input on a cell-by-cell basis.
3. In the Minus Properties pane, click the menu for Raster. For Raster1, select the 2015_Nature_Africa_PR.2015.tif layer from the drop-down. For Raster2, select the 2015_Nature_Africa_PR.2000.tif layer. Accept the defaults for Cellsize Type and Extent of Type. Click Create new layer. Save the project.
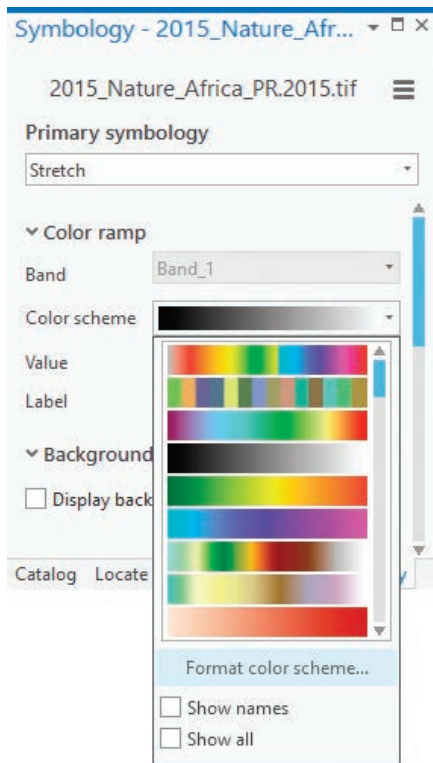
The result is added to the Contents pane. White areas represent positive values, or an increase in malaria rates, while darker areas represent negative values, or a decrease in malaria rates. It is clear from this map that there were significant decreases in malaria rates in the Congo, Burundi, Uganda, and Tanzania. Increases occurred in Mali and Guinea, but most of the other shades of gray do not show a clear visual pattern.

Step 3

Visualize Your Results

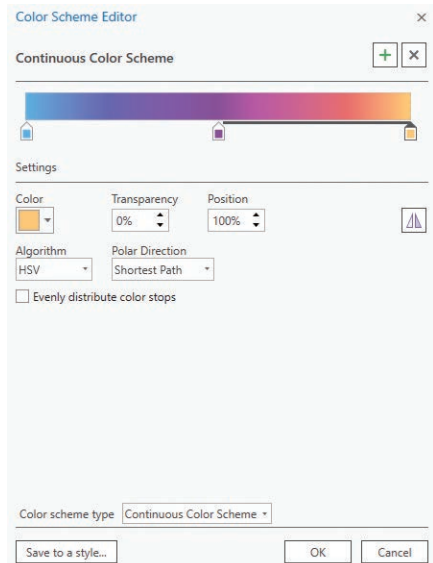To better visualize where malaria rates increased or decreased, change the colors of the layers.

1. On the ribbon, click the Map tab. In the Layer group, click Basemap and choose Dark Gray Canvas. Changing the basemap to a simple one like Dark Gray Canvas helps your data stand out because it removes distracting details like topography and river features.

↑ In the Symbology pane, under Color scheme, click the black–white color ramp. A drop-down opens and shows a color scheme choices menu. On the Color scheme menu, click Format color scheme.
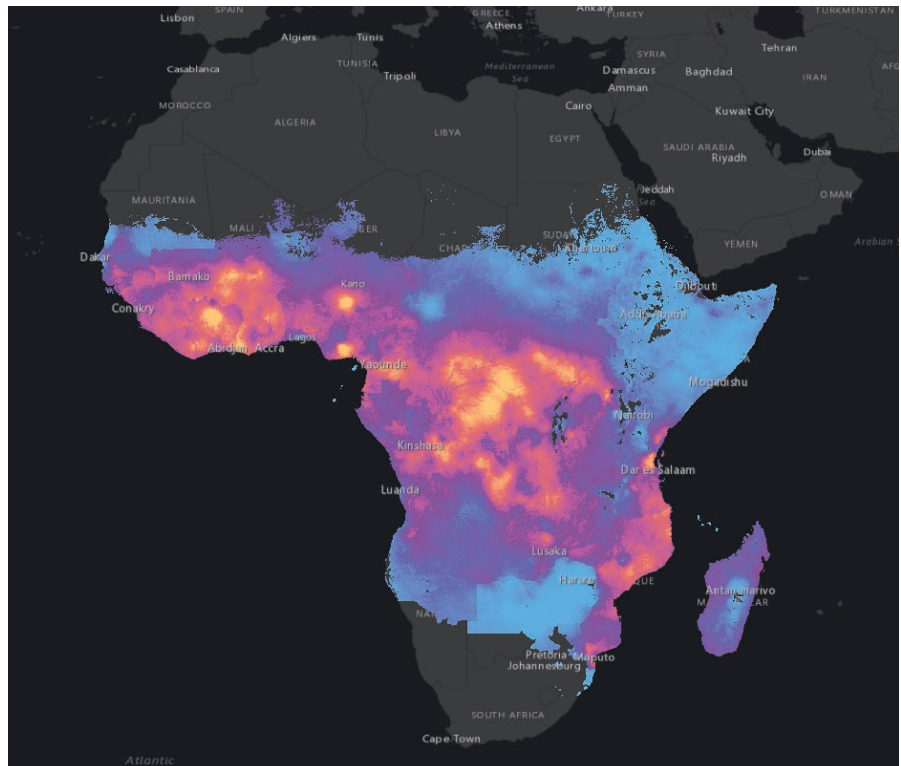
Now, you'll symbolize the 2015 data for malaria.

2. In the Contents pane, turn off the new Minus layer, and click the color ramp for the 2015_Nature_Africa_PR.2015.tif layer. The Symbology pane opens for the 2015 data layer.

3. In the Symbology pane, under Color scheme, click the black–white color ramp. A drop-down opens and shows a color scheme choices menu. On the Color scheme menu, click Format color scheme. The Color Scheme Editor opens. This window allows you to create custom color schemes by specifying color values for each stop, or relative percentage of the data.

4. On the top right of the Color Scheme Editor, click the plus sign to add a color stop. There are now three stops, at 0 percent, 50 percent, and 100 percent.

5. Click the 0 percent stop (black, on left). Under Settings, click Color, then click Color Properties to invoke the Color Editor.

6. In the Color Editor, make sure the Color Model is set to HSV. Look for the text box next to HEX # and change the HEX
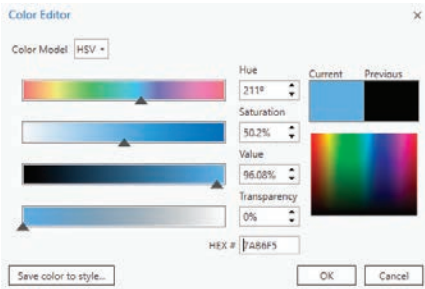
value to #7AB6F5. Click OK.

7. Repeat the same process to change the middle value to #805499, and the right-most value to #F5CA7A.

8. Click OK to return to the map and view your symbology changes. Save the project.

9. Repeat steps 4 through 8 to apply the same symbology to the 2000 imagery.

10. In the Contents pane, turn off the 2015 and 2000 imagery layers, and turn on the Minus layer. Save the project. The Minus layer opens in the Symbology pane.

11. Immediately under Primary symbology in the Symbology pane, click the Stretch type drop-down and choose Classify. Choosing Classify breaks the data into defined categories instead of being symbolized along a single ramp, as the 2000 and 2015 layers are. The color scheme also changes to a default color ramp, such as red to yellow.

12. In the Class breaks section, change the numbers in the Upper value column to -0.3, -0.1, 01, 0.3, and 0.4. Save the project. Negative values represent areas that had a decrease in malaria
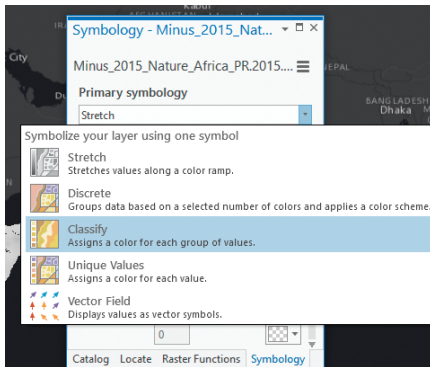

↑ The Color Scheme Editor opens. This window allows you to create custom color schemes by specifying color values for each stop, or relative percentage of the data.
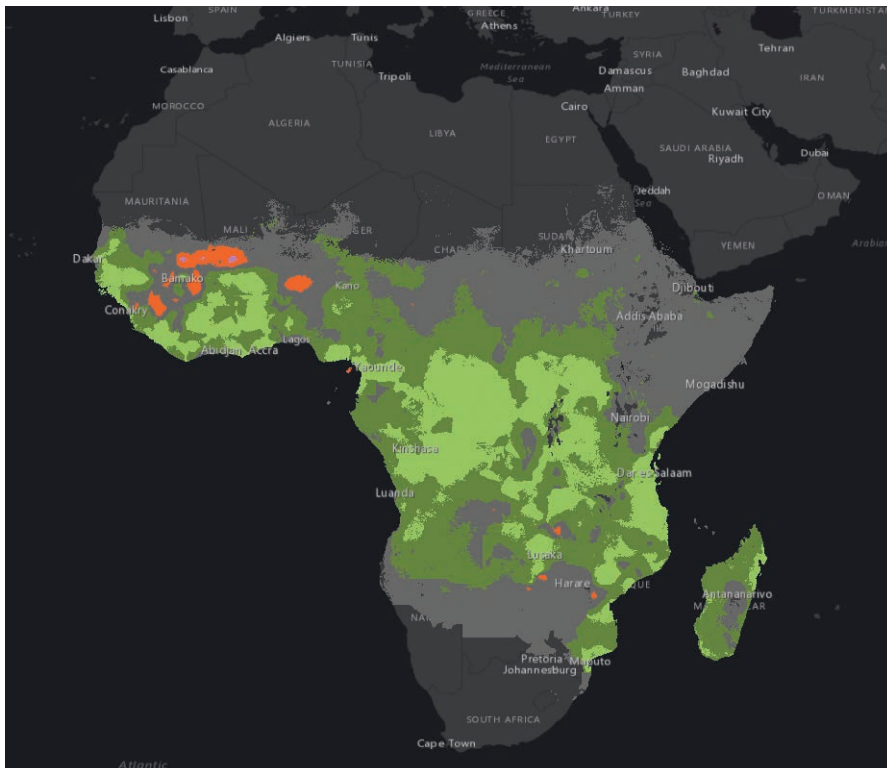
↓ Symbolized 2000 data for malaria

↑ In the Color Editor, make sure the Color Model is set to HSV. Look for the text box next to HEX # and change the HEX value to #7AB6F5.

↑ Turn on the Minus layer and classify it.

rates, while positive values indicate an increase in malaria rates. For example, 0.1 indicates that there was a 10 percent increase in malaria among children from 2000 to 2015. Because this data has a clear and important midpoint (0), it calls for a divergent color scheme. By showing positive change in one color and negative change in another color with a neutral middle color, the change is clear.

13. In the Color column, click the color symbol next to ≤ -0.3, and in the Color picker, click Color Properties. In the Color Editor, make sure the Color Model is set to HSV. Change the HEX value to #AACC68. Use the same process to change the rest of the color symbology as shown in Table 1.

This workflow for visualizing data can be applied to most raster datasets. Raster functions require little processing time, making them ideal for quick analysis and visualization. The most difficult part of the workflow is deciding which of the hundreds of visualization techniques you'll apply to your data.

For more ideas on raster data visualization, check out John Nelson's posts on the

ArcGIS Blog. Learn more about the ArcGIS Pro cartographic capabilities by doing the Learn ArcGIS lesson called Cartographic Creations in ArcGIS Pro.

Malaria data used in this tutorial belongs to the Malaria Atlas Project and is publicly available.

About the Author

Kathy Cappelli is a product engineer on the Learn ArcGIS team. A Penn State-trained geographer and journalist, she enjoys mapping in ArcGIS Pro, keeping up-to-date on the Esri Story Maps apps gallery, and appending the prefix *geo* to unsuspecting words.

Class	HEX Value
≤ -0.1	#718845
≤ 0.1	#686868
≤ 0.3	#704488
≤ 0.4	#CA7AF3

↑ Table 1

↓ Because this data has a clear and important midpoint (0), it calls for a divergent color scheme.
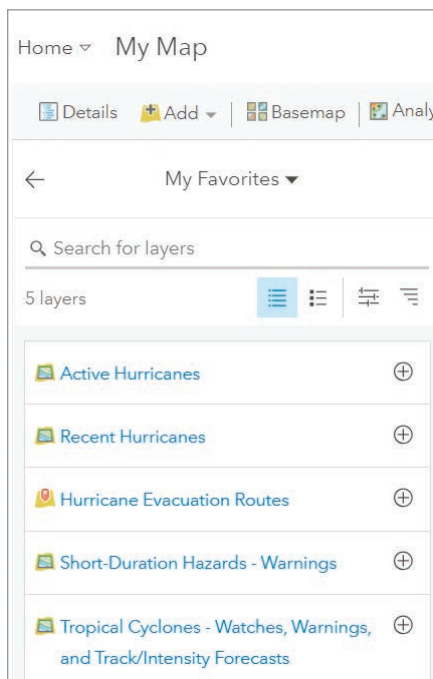
Organize Your Online Life Using Favorites

By Bern Szukalski

There are many ways that you can organize the content you frequently use or gather together the maps and layers you are using for a project so they are readily accessible. In addition to groups, categories, and tags, favorites are an even easier way to keep tabs on those frequently used items. Think of favorites as a way to earmark your most useful or most used items for easy access.
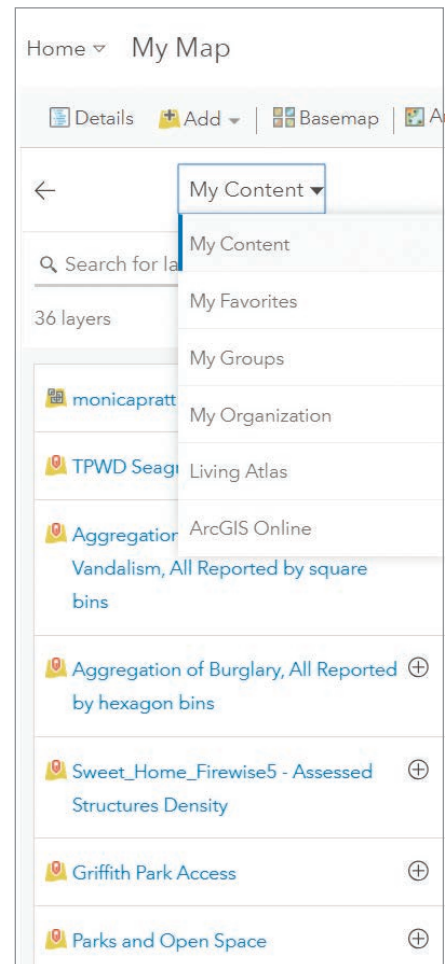

My Favorites is your favorite collection of content. After you sign in to ArcGIS Online, find My Favorites by clicking Content, then click My Favorites to show your current favorite items.

If you haven't added any favorites, you will see an empty gallery with instructions. To add to My Favorites, go to Content or use Search to locate items you want to add. In the table, list, or grid view of those items, look for the star icon and click it to add the item to My Favorites. All item types are supported: maps, layers, apps, scenes, tools, and files. To remove an item, go to My Favorites and click the star icon to remove it. You can also add favorite items you find via the ArcGIS Living Atlas of the World website. Just click the star icon on the item to add it to My Favorites.

You can use content in My Favorites to streamline your workflow when authoring maps. Add the layers you frequently use or ones you are using for a specific project to My Favorites so you can easily find them. While authoring a map using Map Viewer, click Add, then Search for Layers, then choose My Favorite to see a handy list of layers that are just a click away from being added to your map.
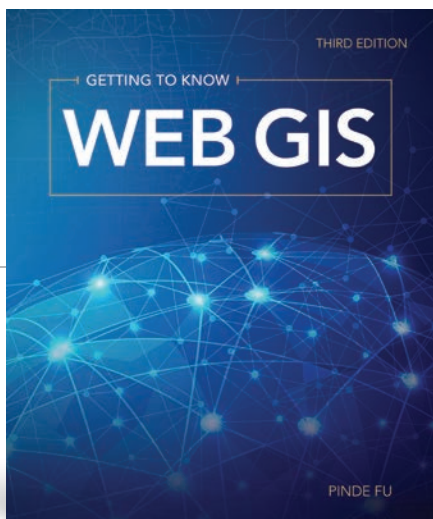
For more information on working with content in ArcGIS Online, see the topics "Search for layers" and "Find and work with content" in the ArcGIS Online help.

About the Author

Bern Szukalski is a tech evangelist and product strategist at Esri. He focuses on ways to broaden access to geographic information and help users succeed with the ArcGIS platform. On a good day, he is making a map. On a great day, he is on one. Follow him on Twitter at @bernszukalski or contact him at bszukalski@esri.com.

Updated and Expanded Introduction to Web GIS

By Pinde Fu

Getting to Know Web GIS, Third Edition, by Pinde Fu, integrates fundamental principles with step-by-step exercises. It gives readers a thorough grounding in the latest advances of the rapidly growing field of Web GIS. It meets the needs of professors as a lab book for teaching Web GIS and can be used by professionals already in the field who must remain current on this technology.

Like previous editions, this book provides a comprehensive view of Web GIS technologies from the server to the browser and covers mobile and desktop applications. *Getting to Know Web GIS* includes assignments based on relatable, real-life scenarios that show how to create web maps, web apps, and Esri Story Maps apps as well as how to use web apps to collect data in the field, author an operations dashboard, conduct spatial analysis, and incorporate real-time data feeds. Assignments include creating a points-of-interest city tour, determining the best site to open a new restaurant, and building an app for reporting potholes or other street maintenance issues.

Tutorials that were done in previous editions in ArcMap are now done in ArcGIS Pro. Many tutorials use ArcGIS Online or ArcGIS Enterprise. An optional tutorial, performs big data analysis using ArcGIS GeoAnalytics Server.

Each chapter includes a conceptual discussion that places the information in context and explains the underlying principles followed by a step-by-step tutorial. Common questions are answered. Chapter assignments put the concepts and information presented to work. The chapter concludes with online resources such as blog posts, videos, and articles. System requirements are listed for each exercise to help instructors set up labs.

The third edition has a new chapter on image services and raster analysis. This chapter, contributed by Esri software engineer Dr. Jie Chang, shows readers how to publish image services and make large volumes of imagery and remote-sensing datasets available online for fast visualization and spatial analysis.

Tutorials for migrating existing workflows from ArcMap to ArcGIS Pro will give readers access to new, more powerful tools. Topics covered include big data analysis, the Internet of Things (IoT), virtual reality (VR), augmented reality (AR), and artificial intelligence. ArcGIS Arcade, Survey123 for ArcGIS, Workforce for ArcGIS, Operations Dashboard for ArcGIS, Drone2Map for ArcGIS, and Insights for ArcGIS are some of the new products discussed.

Separate chapters now give more extensive information on mobile GIS and using real-time GIS data. One chapter is devoted to 3D GIS and introduces the use of VR and AR to visualize GIS data.

"With VR, users are immersed inside maps. This will be useful in architecture and urban planning to see, for example, how a building will look in 3D before it is constructed," Fu said. He also noted that AR can enhance our understanding of the world by letting us see underground pipes or wires in a wall, for example.

Fu, the book's author, realized the possibilities that Web GIS would bring as early as the mid-1990s when he built his first web application using Esri technology. Fu is a software developer who leads the ArcGIS platform engineering team at Esri Professional Services in Redlands, California. He teaches GIS at the University of Redlands in California and the Harvard Extension School and writes extensively about Web GIS.

"I hope this book sparks *[the]* imagination and encourages creative uses of Web GIS," Fu said.

Getting to Know Web GIS, Third Edition, is available in print (ISBN: 9781589485211, 486 pages) and as an e-book (ISBN: 9781589485228, 486 pages). Both the print edition and the e-book can be purchased from most online retailers.

More Than Capitals, Rivers, and Climate Maps

How GIS is making geography more meaningful for both students and teachers

By Chris Bunin

"I love maps!" is a common response when I tell people I teach geography and geospatial technologies.

When most of us think of K–12 geography, we probably think of memorizing capitals and rivers, coloring and labeling climate maps, and taking map quizzes. It may surprise you to know that my students use GIS to create digitized spatial layers, x,y data based on coordinate systems, and make dynamic maps to analyze and answer complex questions.

This isn't just happening in GIS classes. My students in humanities classes regularly plot and analyze data, compare differences between data layers, and learn the basics of GIScience.

From Cumbersome to Awesome

My personal shift to using GIS in my social studies classrooms began in 2005 when I joined Project GRASP (Geospatial Related Activities for Student Progress), a professional development course at James Madison University (JMU) in Harrisonburg, Virginia. In that class, I was exposed for the first time to the power of GIS and all its possibilities for teachers and students. Though I was jazzed about the technology's potential, afterward I found myself essentially on an instructional island when it came to finding colleagues ready to take the GIS plunge.

Back then, GIS was a hard sell to teachers. The software was cumbersome, difficult to install, and had a steep learning curve. Lesson plans and datasets were limited. Today, the practicality of using GIS in the classroom is at an all-time high, as a result of the work done by JMU, the Virginia Geographic Alliance, and Esri. Under the direction of Dr. Bob Kolvoord, dean of the College of Integrated Science and Engineering, JMU held national summits on geospatial technologies in K–12 education from 2008 to 2011. At these events, teachers and education and industry leaders met to identify the resources needed to make serious inroads into Virginia's classrooms.

At the same time, Esri made GIS software more accessible to schools. Today, the company provides free cloud-based and desktop GIS technologies to any school in the US. As a result, Virginia has become a leader in classroom GIS use.

A Culminating Experience for High School Students

As part of its outreach to Virginia's high schools, JMU launched a program called Geospatial Semester (GSS) in 2005. It offers high school juniors and seniors a culminating experience steeped in authentic engagement, workforce preparedness, and problem-based learning.

Students from 25 high schools participate in the program and earn dual-enrollment credit. While learning about a cutting-edge technology, they gain valuable workplace skills. These students are also taught spatial thinking skills that are key to STEM careers and not taught elsewhere in the high school curriculum. They study how GIS is applied in fields such as emergency management, environmental science, public policy, and community and business analytics.

At the end of the course, students complete capstone projects that are assessed by JMU professors. The titles of recent projects have included

- "An Analysis of the Change in the Amount of Ground-Level Ozone for the Metropolitan Region from 2013–2016"—Washington Lee High School, Arlington.
- "Proposal for Realignment and Placement of Heavy Rescues in Loudoun County, Virginia"—Briar Woods High School, Ashburn.
- "Setting Up a Volleyball Defense"—Shenandoah Valley Governor's School, Fishersville.
- "An Interactive Guide to Nelson County Hiking Trails"–Nelson County High School, Lovingston.

> "Knowing that I can answer my own inquiries and represent my findings in a way that is presentable to others is empowering."
>
> Claire King
> Albemarle High School Student

- "An Analysis of EMS Calls within Albemarle County"—Albemarle High School, Charlottesville.
- "Refugee Camp Site Selection in Jordan"—South Lakes High School, Reston.
- "Rerouting the Iditarod"—Dominion High School, Sterling.

These and other projects can be seen at www.isat.jmu.edu/geospatialsemester/recognition.html.

"When I began using GIS, I viewed it as a tool to make pictures," said Albemarle High School student Claire King. "As I gained more experience, its functionality seemed to multiply. I began to view it as an investigative tool to explore, visualize, and model data rather than simply as an image creator. Understanding how to use GIS has made me more curious about the world around me. Having the ability to satisfy my curiosities through GIS has been surprisingly rewarding. Knowing that I can answer my own inquiries and represent my findings in a way that is presentable to others is empowering. Learning to use GIS in school brought me the opportunity to have an internship with the University of Virginia, which allowed me to have my work published as a junior in high school."

She's not alone. Many students have parlayed GSS into summer internships and gained work experience, according to Kolvoord, who helps supervise the GSS program. "It's also introduced geography as a potential area of study for many students. In fact, JMU geography enrollments are at an all-time high, in part due to a steady flow of students from the GSS," said Kolvoord.

Interdisciplinary GIS: The iSTEM Framework

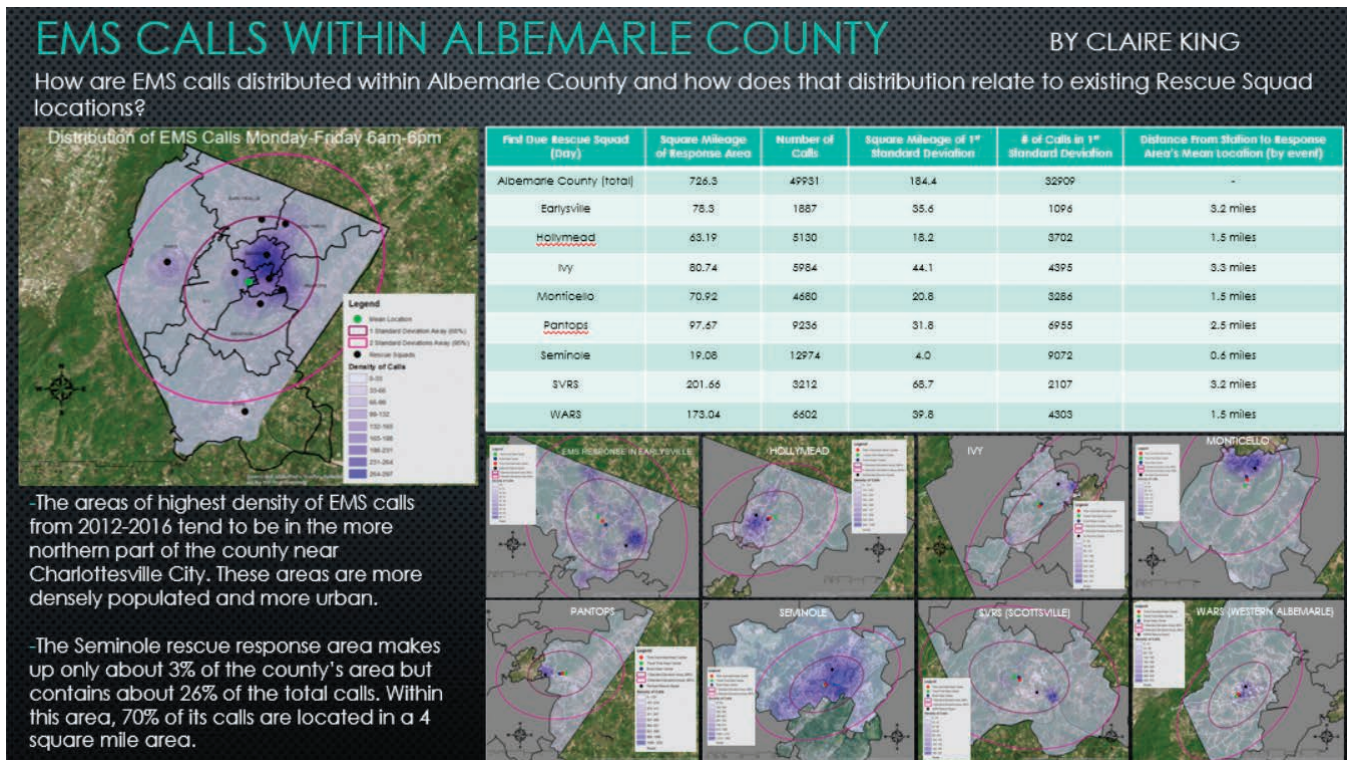Albemarle middle school teacher Julie Stavitski learned about

"By providing students with skills in GIS, I have been able to give them the type of independent learning environment that fuels curiosity and growth. Students use the software to explore and analyze all sorts of topics that transcend disciplines."

Andy Dojack
William Monroe High School Teacher

↘ Entry by Claire King in the Geospatial Semester Map Contest Project

You Can Map That

↑ The #YouCanMapThat! curriculum has been used to train more than 250 teachers how to use GIS and iSTEM GIS activities in their classrooms. It is available in iBook format and is free to the public.

the power of geospatial technologies through the iSTEM Teacher Scholars program. "Ten minutes of seeing GIS in action in my classroom was enough to convince me of the power of this technology," she said. "I was surprised at how quickly I became comfortable with it. In one training session, Kathryn Kernanen, a GSS cofounder, sensed our hesitance and shared a perspective that gave me permission to explore using GIS in classroom. The scale of our first activity doesn't matter as long as we just did something to get the kids using the technology."

The iSTEM Teacher Scholars program, founded in 2014, focuses on workforce preparedness and GIS as an interdisciplinary bridge. Not designed as a hypothetical exercise, the program helps classroom teachers develop practical and transferable approaches to GIS classroom use.

GIS offers a way to meet the difficult challenge of incorporating STEM skills and strategies into the humanities. In most academic situations, core science and social science subjects are taught in isolation, which limits opportunities for teachers and students to engage in integrated STEM learning. GIS can be a way to combat a general lack of interest in STEM fields among students if we can develop ways to inspire and extend these skills, tools, and concepts beyond the silos of science, technology, engineering, and mathematics.

One excellent way to do this is to use #YouCanMapThat!, a flexible curriculum that contains best-practice GIS activities for multiple grade levels and disciplines. It has been published in iBook format and is free to the public, available for download at http://bit.ly/YCMT. Some examples of iSTEM lesson titles include "Exploring

> ## "Ten minutes of seeing GIS in action in my classroom was enough to convince me of the power of this technology."
>
> Julie Stavitski
> Jack Jouett Middle School tTeacher

the Fate of the Titanic," "Mapping the First Five Presidents," and "Querying the Reach of Jim Crow."

"Participating in the iSTEM Teacher Scholars program brought into focus the notion that teachers teach students and not content," said Andy Dojack, a teacher at William Monroe High School in Greene County. "By providing students with skills in GIS, I have been able to give them the type of independent learning environment that fuels curiosity and growth. Students use the software to explore and analyze all sorts of topics that transcend disciplines. This provides a deeper understanding of subject matter when compared to teaching with traditional resources. Put simply, the iSTEM method empowers students through the use of twenty-first-century technology."

#YouCanMapThat! is funded through partnerships with Esri; the Virginia Geographic Alliance; Battelle, a nonprofit applied science and technology development company; The National Council on Social Studies; and an Eastern Regional grant from the Teaching with Primary Sources program of the US Library of Congress. The #YouCanMapThat! curriculum has been used to train more than 250 teachers how to use GIS and iSTEM GIS activities in their classrooms. It has also created an online professional learning community so that once teachers have completed their training, they aren't isolated and suffering from limited support.

"The iSTEM Teacher Scholars program has been instrumental in showing teachers the value of including GIS in their teaching," said Dojack. "Most teachers are willing to try new methods, but many are hindered by a limited amount of professional development time. This program provides a convenient, straightforward set of lessons and activities."

About the Author

Chris Bunin is a member of the Albemarle Education Association who teaches advanced placement human geography, world history, and geospatial technologies at Albermarle High School. He is also an assistant professor of geography at Piedmont Virginia Community College and serves as the Geospatial Technologies chairperson for the Virginia Geographic Alliance. He was named the 2016 Secondary Social Studies Teacher of the Year by the National Council for the Social Studies and received the 2017 Brunn Creativity Award for the Outstanding Teaching of Geography from the National Council for Geographic Education. You can follow him on Twitter at @ahsgeo.

How to Get Started Using GIS in Your Classroom

This article first appeared in the October 2018 issue of the *Virginia Journal of Education* and is used with permission.

Here are a few ways you can immediately begin integrating GIS into your teaching practices:

1. Download the #YouCanMapThat! iSTEM iBook at http://bit.ly/YCMT to introduce yourself to GIS and gain access to best practices.
2. Check out the Geospatial Semester at www.isat.jmu.edu/geospatialsemester/.
3. Register your school for the free Esri ArcGIS Online organizational account. There is no catch. Register at Esri's website and gain access to a lot of GIS bells and whistles, including an organizational account that allows you to enroll and manage 500 student accounts; the ability to create customized classroom or student maps; and access to the advanced functions of ArcGIS Online, such as density analysis and interpolation. With these accounts, you can have students become digital historians who research, design, and create their own story maps. It is a great option for your tech-savvy students. You can register for an account at https://bit.ly/2MwwRZm.
4. Explore and use GeoInquiries (https://bit.ly/2Ao32Yn). GeoInquiries are 15-minute activities, each with a teacher's guide with questions and answers and a professionally designed Web GIS map. No installation, fees, or logins are necessary. The more than 100 activities include ones specific to earth science, English/language Aarts, mathematics, human geography, US history, and world history.
5. Go to Esri's Story Maps Gallery (http://storymaps.arcgis.com/en/) and click Gallery to browse the ready-made interactive maps.
6. Attend a workshop on using GIS in the classroom. There are many options available. For example, the Virginia Geographic Alliance has a five-week online asynchronous course, "Putting Social Studies in iIts Place," that covers beginner and intermediate skills and ways to seamlessly integrate GIS into the K–12 classroom. If you're interested in taking the course, fill out the online form at http://bit.ly/VGAGIS.

Helping Students
Learn with GIS

Teaching with GIS employs an inquiry-based, problem-solving approach to learning that also promotes valuable spatial thinking skills.

According to Joseph Kerski, a manager on the Esri education team, "Today, spatial thinking is more relevant than ever before as issues such as climate change, economic globalization, urban sprawl, biodiversity loss, sustainable agriculture, water quality and quantity, crime, cultural diversity, energy, tourism, political instability, and natural hazards grow in importance on a global scale but also increasingly affect our everyday lives."

This approach not only benefits the teaching of geography but also science, technology, engineering, and mathematics (STEM) as well as the humanities. Because Esri strongly believes in the value of GIS in education, it has continually provided schools, teachers, and students with many resources.

Esri has a longstanding commitment to supporting the use of GIS to enhance learning. Dating from Esri's earliest years, this support initially came in the form of software discounts and donations, a continually expanding inventory of teaching materials, the Education User Conference, and the founding of the GeoMentor Program.

The advent of ArcGIS Online in 2012 removed many barriers to using GIS as a teaching tool. In May 2014, Esri joined US President Barack Obama's ConnectED initiative. ConnectED was an initiative to make American schools more technologically savvy. Esri offered a free ArcGIS Online subscription to every public, private, and home school in the United States.

After having invested more than $40 million in ConnectED software donations, curriculum solutions, training, and support for K–12 teachers in the United States, Esri president Jack Dangermond pledged in 2017 to continue participating

in ConnectED through 2019.

Following the success of ConnectED in the United States, Esri joined the Digital Skills and Jobs Coalition, an initiative of the European Union (EU), EU member states, and other stakeholders, which is committed to reducing the digital skills gaps in Europe. In December 2016, Esri pledged to participate in the GIS School Program, which offered free access to ArcGIS Online to primary and secondary schools and vocational institutions in 10 EU member countries.

ArcGIS software is available directly from Esri for instructional use by individual K–12 schools, school districts, and states in the United States at no cost through the ArcGIS for Schools Bundle program. Currently there are more than 6,500 schools participating in the program. In August 2017, the ArcGIS for Schools Bundle became available for instructional use worldwide through Esri's network of international distributors. Every public, private, home school, and youth-serving club is eligible.

The ArcGIS for Schools Bundle program includes ArcGIS Online organizational and user accounts, ready-to-use web and mobile apps, ArcGIS Community Analyst licenses, and ArcGIS Desktop licenses.

ArcGIS Online organizational and user accounts require only an Internet connection and provide access to web mapping, app creation, spatial analysis and mapping tools, and data resources from the ArcGIS Living Atlas of the World. The availability of low-cost Wi-Fi-only laptops and tablets and access to an ArcGIS Online subscription means teachers and students can do GIS, anytime, anywhere, on any connected device.

Giving teachers access to specialized web and mobile apps, such as Collector for ArcGIS, Survey123 for ArcGIS, and ArcGIS Maps for Office, expands the kinds of projects that can be undertaken. ArcGIS Community Analyst provides access to extensive demographic, census, health, crime, and business data that gives student research added dimension. ArcGIS Desktop software, which includes both ArcMap and ArcGIS Pro, can be used for more extensive spatial analysis and visualization.

The use of GIS in schools, supported by Esri, continues to grow worldwide. In the United Kingdom, more than 1,000 schools signed up for the ArcGIS for Schools Bundle during 2017–2018. Canada also has more than 1,500 secondary and 200 primary schools connected and teaching with ArcGIS. Spain has connected 56 schools and has another 50 in process. Schools in Lebanon, United Arab Emirates, Colombia, India, Japan, Rwanda, South Africa, and Lithuania all have successful programs of teaching with GIS. Schools in Greece, Austria, and many other countries across Europe have taken advantage of this offer.

Over the years, Esri has developed different types of materials for teaching with GIS. GeoInquiries complement ArcGIS Online capabilities. They are short, standards-based inquiry activities that can be used for teaching the map-based content found in commonly used textbooks in study areas that include American literature, earth science, environmental science, government, human geography, mathematics, cross-curricular social studies, United States history, and world history. Each GeoInquiry focuses on an activity that can be presented quickly from a single computer and projector or modified for students' hands-on engagement.

Esri also supports teaching with GIS through Learn ArcGIS (learn.arcgis.com). The website hosts individual Learn ArcGIS lessons that link to data resources and are constantly added, and often include topical subjects. The site allows filtering by level of proficiency, geospatial capabilities taught, subject area, and software requirements. Implementation guides for teachers, schools, and school districts that are available on the site provide road maps for integrating mapping and location analytics into schools.

To learn more about the resources and opportunities available to schools from Esri, visit the GeoNet group at community.esri.com/community/education.
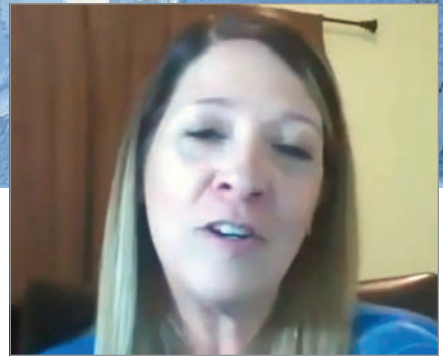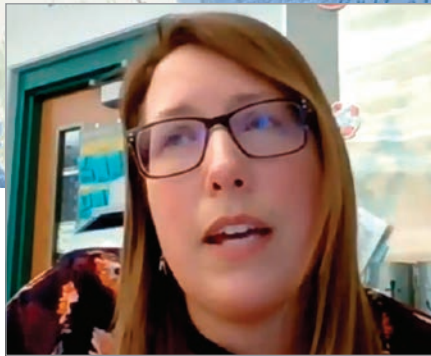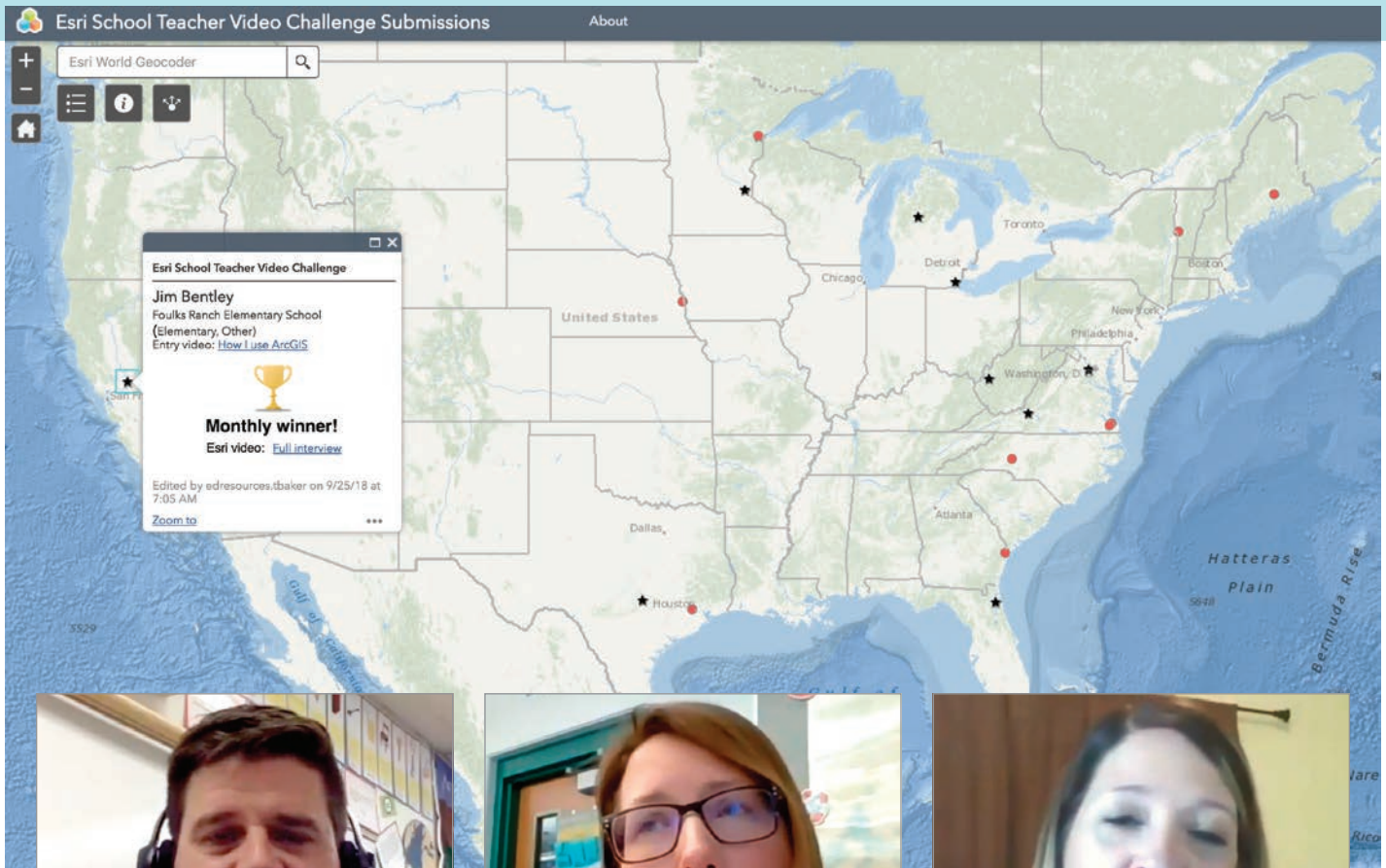
The use of GIS in schools, supported by Esri, continues to grow worldwide.

↓ Learn ArcGIS lessons provide teaching resources. New lessons are constantly added and often include topical subjects.

How Are You Using ArcGIS in the Classroom?

Jim Bentley, who teaches at an elementary school in Elk Grove, California, uses ArcGIS Online and Survey123 for ArcGIS to help his fifth and sixth grade students explore issues in their community based on data they collect and analyze themselves.

Erika Klose, a middle school science teacher in Winfield, West Virginia, uses ArcGIS Online with her seventh grade science students as often as she can in as many ways as she can to add a spatial component to the content in her teaching plans. She notes that her students see the value of real data. "They would much rather engage with real data in the real world."

Maribel Ramos, a geography teacher at Akins High School in Austin, Texas, uses ArcGIS to increase the rigor of her classes and teach physical geography and current events. "I want my students to think like geographers. I want them to be able to do analysis and project-based learning modules. I think my job as a teacher is to prepare my students to meet future demands. I give students the opportunity to treat information scientifically and come up with solutions."

These teachers were all monthly winners in the Esri K–12 Teacher Video Challenge. This contest gives teachers an opportunity to share the innovative ways they are using their school's ArcGIS Online subscription to more effectively teach not only geography but STEM and the humanities. Esri will award ten $500 prizes between September and June for the most compelling video.

Through the ArcGIS for Schools Mapping Software Bundle, ArcGIS Online subscriptions are available to every public, private, and home school across the United States. Outside the United States, the bundle is available worldwide through Esri's network of international distributors. If you are not already using ArcGIS, apply for an ArcGIS for Schools Mapping Software Bundle at https://bit.ly/2MwwRZm.

Because the bundle includes an ArcGIS Online subscription with licensing for many students, from dozens to thousands, it helps schools take full advantage of one-to-one student computing. This is a growing trend in K–12 education in the United States and elsewhere to provide every student with a laptop or tablet device. The goal of one-to-one programs is improvement of students' technology skills and support of inquiry-based teaching methods.

Any K–12 school teacher in the United States, (including districts and territories)who is using ArcGIS Online technologies or Esri instructional materials can enter. No purchase is required to enter or win. Simply create a testimonial video of 60 seconds or less in which you describe how you use ArcGIS Online, GeoInquiries, Survey123 for ArcGIS, or other ArcGIS software to teach your students. You can enter only twice during each challenge period (September and June). You should be the only identifiable person in the video, and it should not contain trademarked or copyrighted material.

Fill out the form at https://bit.ly/2Oz60Cd and provide a link to where your video can be publicly viewed (i.e., no login required). Entries for each monthly contest close on the last business day of that month at 5:00 p.m. Pacific Daylight Time. Videos not chosen for the month submitted may win in a succeeding month during the challenge. To win the prize, each monthly winner will work with Esri to produce a three-minute video about how they use ArcGIS.

Accepted videos can be viewed on the map at esriurl.com/TeacherVideos. Visit this site to learn how other teachers are using ArcGIS in the classroom.

Making the World
More Accessible

By Christina Ingoglia

When David Nykodym and Christina Ingoglia need to change their daughter Lilly's diaper, they typically must choose between putting her on a dirty bathroom floor or cleaning her in the trunk of their SUV.

Lilly has a condition known as Mowat-Wilson syndrome. She will likely be in diapers for years to come. Now that she is almost four years old, she is too large for baby changing tables, and she must lie down to be changed.

Her parents tried to remember locations in their home state of Missouri that work better for changing Lilly. Nykodym said, "We kept mental maps of these locations, but it wasn't always easy to remember all of them." Trying to remember which rest stop had the best restroom for Lilly became especially difficult when traveling across Missouri on Interstate 70 because rest stops are often

difficult to distinguish from each other.

Because of their experience with Lilly, Ingoglia and Nykodym helped form Missouri Disability Empowerment (MoDE), a nonprofit advocacy group. Through MoDE, they met other families who are also dealing with similar restroom challenges.

Robyn Schelp is the president of MoDE and Ingoglia's good friend. Schelp shared her struggles with her 11-year-old son, Nathan, who still needs supervision and assistance in the restroom.

"I'm used to getting weird looks when I bring Nathan into women's restrooms," Schelp said. "People don't understand that

↓ MoDE launched RestroomMap.com (www.restroommap.com) to serve all 50 states in September 2018.

A map that finds a restroom for ALL

MoDE's Restroom Map ● Unisex ◆ Family ★ Family with Adult Sized Changing Table ● Other 560 Visits

Restroom: Independence Center

Restroom: Independence Center

Name of Location	Independence Center
Restroom Address	18801 E 39th St S, Independence, Missouri, 64057
Accessibility Level of Restroom	Family Bathroom
Comments (Ex. Please note if there is anything obstructing the path to the restroom.)	Large family restroom in food court

Edited by dnykodym86 on 8/2/18 at 7:46 PM

↑ Instead of trying to remember which rest stop had the best restroom for Lilly, Ingoglia and Nykodym devised on RestroomMap.com, which helps locate accessible restrooms.

you can't see all disabilities, and I imagine they're judging me as a parent. They don't realize that when it comes to restrooms, I usually don't have other options, and Nathan is not able to go to the bathroom by himself."

A Real Map for Real Needs

After meeting other MoDE members and hearing their stories, Ingoglia had an idea: a map that would be the "Waze of accessible restrooms." She said, "I thought, wouldn't it be cool if we could share information with other families and people like us, who are not served by a typical single-sex restroom with a wide stall?"

Nykodym is a GIS analyst who works for the State of Missouri and a graduate student who is studying geography and urban planning. He knew that he could create that map with Crowdsource Reporter, an ArcGIS for Local Government application that could be configured in and hosted by ArcGIS Online as well as with ArcGIS Enterprise. "Really, once I played around with it, it didn't take me too long to figure out how to build the map to get it up and running."

The map launched on August 6, 2018. In just four weeks, the map had more than 200,000 views, and 64 restroom locations were verified and pinned on it. "We verify all restrooms that are submitted because it is important for people needing an accessible restroom to get accurate information from a reliable map," said Ingoglia.

Crowdsource Reporter at Work

The map is now embedded in RestroomMap.com, a site owned and operated by MoDE. Building the map with Crowdsource Reporter through ArcGIS Online required a lot of preplanning to generate a feature class that would represent the data accurately and make

the map as user-friendly as possible.

To minimize confusion and ensure data quality when someone was submitting an accessible restroom location, Nykodym created a simple submission form that utilizes drop-down values for fields and makes some fields required. The web app has two maps: the

Crowdsource Reporter map that people use to find facilities and submit suitable restroom locations for verification and another map for reviewing the submitted restroom location points.

Data for the public-facing map is filtered so only restrooms that have met MoDE's criteria are displayed. To protect the information provided by submitters, users of this crowdsourced map get the information they need but cannot see all the map's fields. Nykodym wrote a Python script that extracts submitted data to ArcGIS Pro. He transfers the unverified locations to a shared Google Sheet that volunteers can use to contact facilities and verify restroom information.

Mapping Missouri and the Nation

After garnering some media attention in Missouri, the Associated Press ran a story on MoDE's restroom reporter map. People began to reach out to MoDE to see if the map's coverage could be extended to other regions of the country. Schelp said her sister in North Carolina was practically begging to have her state included. She has a child with medical needs that require privacy and a bathroom where her daughter can lie down. MoDE also heard from people in Virginia and New York making similar requests.

Functionally, the map was designed to work anywhere, but MoDE did not initially advertise and limited submissions to Missouri to test out the map and the restroom verification processes.

"I work full time as a GIS analyst, and Christina is a full-time college professor," said Nykodym. "We needed the map and our processes to be efficient while maintaining our standards for data collection."

The couple and MoDE launched RestroomMap.com (www.restroommap.com) to serve all 50 states on September 4, 2018. In addition to going national, MoDE hopes to raise funds to turn the web app into a mobile app. "We know that mobile apps are where it's at right now," said Ingoglia, "and as someone who uses the map, a mobile app would be even easier to access."

The Ideal Restroom for Everyone

"The benefits of this map keep unfolding," said Nykodym. "We've heard from parents of children who are transgender or nonbinary. These families are so thankful they can find restrooms that are not gender specific. We can also imagine the map helping older couples who care for each other and so much more."

If asked about their ideal changing spot, Ingoglia and Nykodym will tell you about the St. Louis Children's Hospital. The couple often makes the two-hour trip from their home to the hospital for Lilly's numerous medical appointments. The hospital has family restrooms with adult-size changing tables that Lilly can lie on safely and with privacy.

These single-occupancy restrooms with large changing tables are rare—and, consequently, memorable for this family. "I never thought I could get so excited about a well-designed bathroom, but now that we have Lilly, this is a basic need that rarely gets met. When it does, we're ecstatic," said Ingoglia.

MoDE has also worked with Missouri state legislator Martha Stevens to convince facilities administrators at the state Capitol in

↑ Nykodym created a simple submission form for people to submit accessible restroom locations.

> "We see RestroomMap.com as a tool for self-empowerment."

↑ Dave Nykodym and Christina Ingoglia at the MoDE kickoff, when it was launched as a 501(c)(4) organization. Photo courtesy of Mary Ingoglia.

→ Robyn Schelp is the president of MoDE.

possible, and now that we're covering the entire nation, we hope others will take up this cause in their own states and hometowns too," said Schelp. "We see RestroomMap.com as a tool for self-empowerment. We hope people will use it to do good."

About the Author

Christina Ingoglia is an associate professor of English at Columbia College in Missouri.

n Jefferson City to install a family restroom with an adult-sized changing table. Because of MoDE's advocacy and the media attention over RestroomMap.com, more of these facilities, like the ones at the University of Missouri Women's and Children's Hospital, are being built in Columbia.

"The one thing this map can't do is build accessible single-occupancy restrooms," said Schelp. MoDE plans to use the map as a tool to drive people to businesses, organizations, and locations where people are planning for all needs. Similarly, MoDE hopes to point out what it calls "restroom deserts" to businesses and local governments. These deserts are areas that lack publicly accessible restrooms that serve needs beyond those required by law.

"We plan to use this map to make Missouri as accessible as

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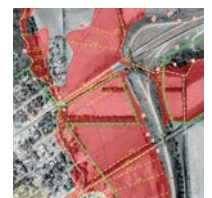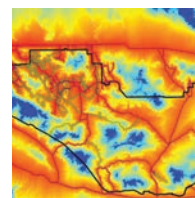
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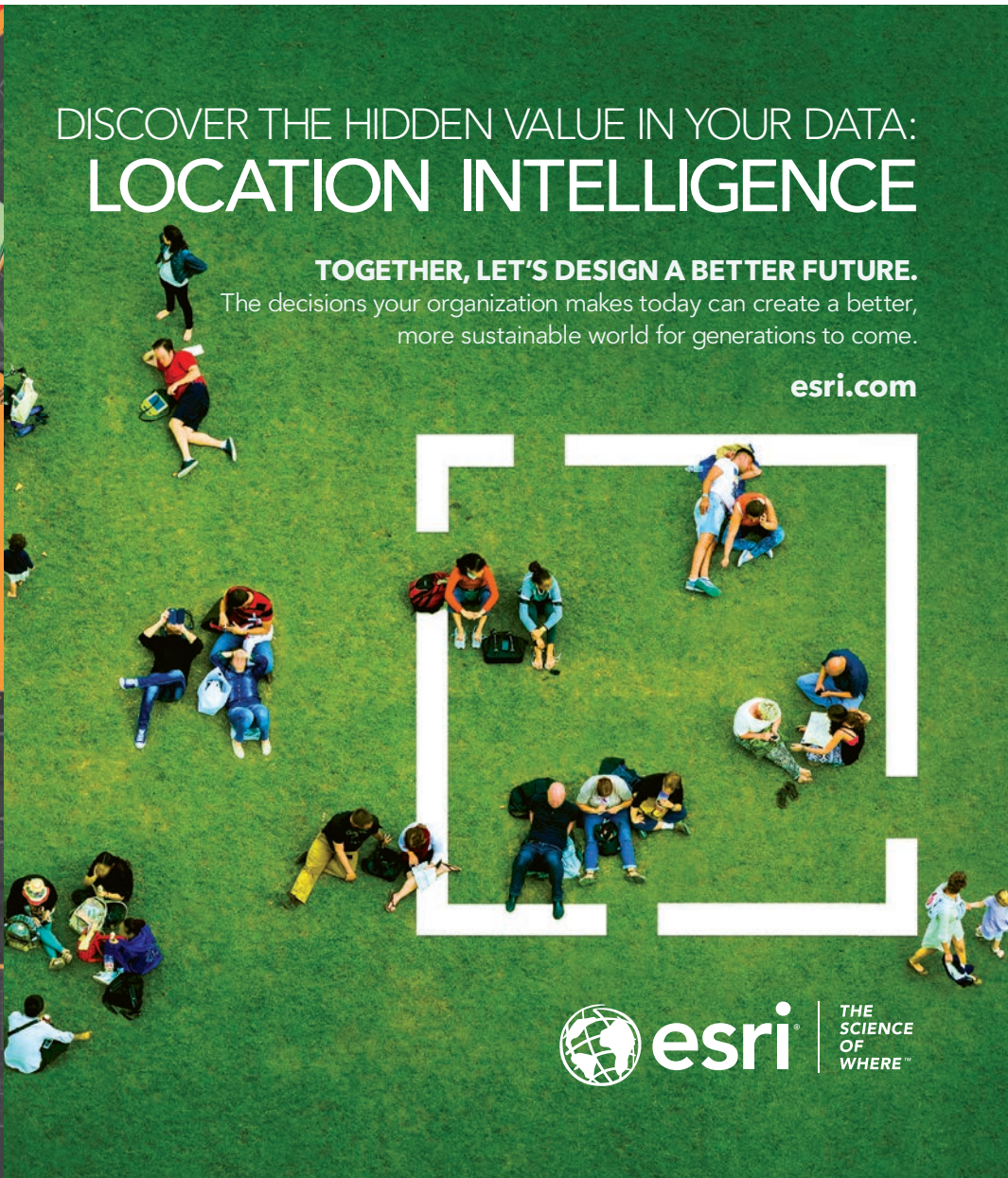**Redlands**

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