Winter 2019

ArcUser

The Magazine for Esri Software Users

Using 3D to Entice Urban Redevelopment 12

The Golden Rule and Citizen Science 58

New Map Projection Meets Cartographic Needs and Desires 38

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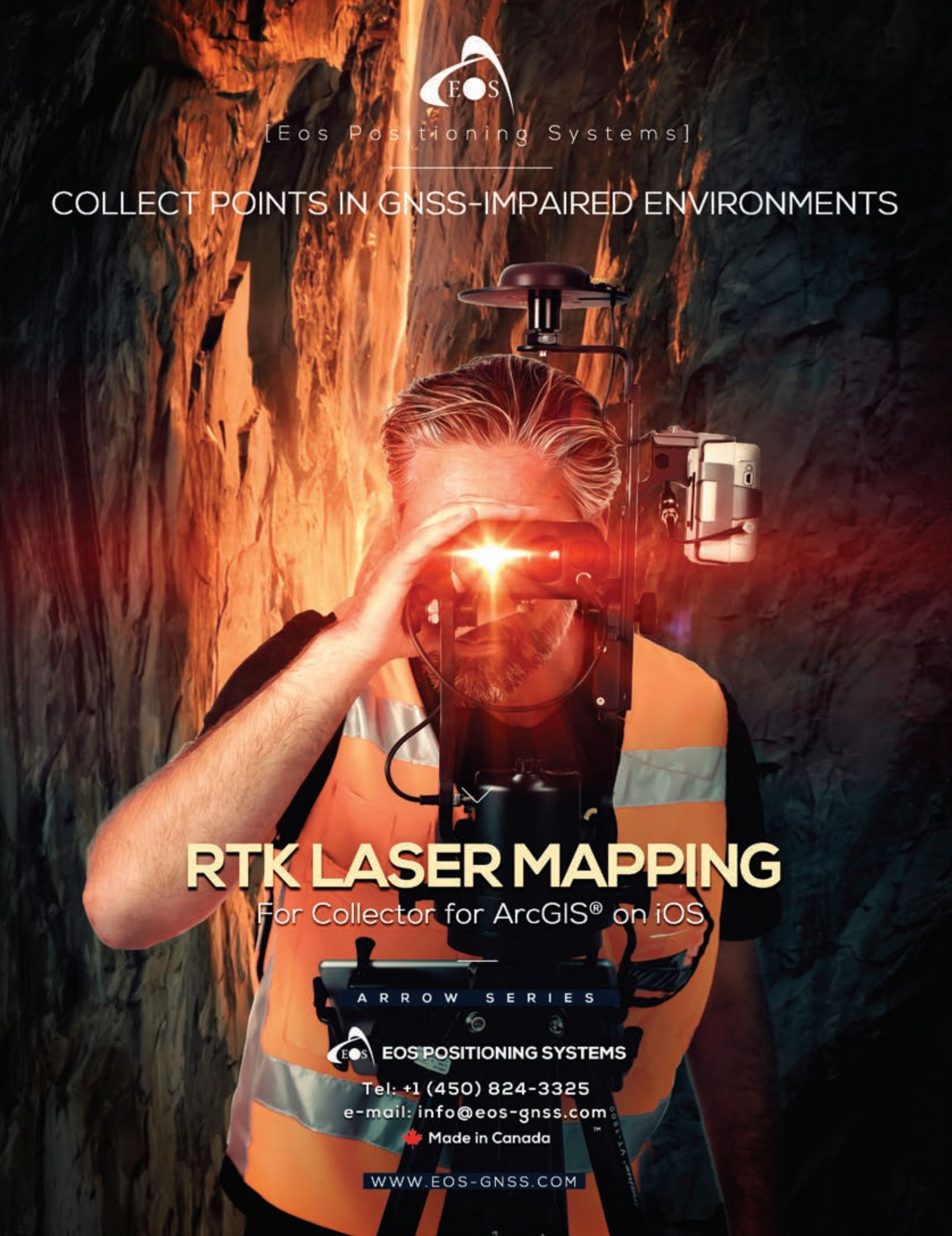
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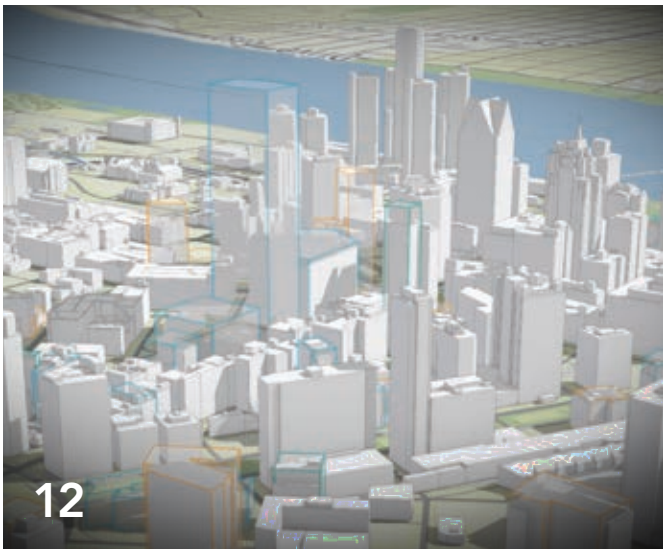

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On the Cover

The image on the cover was captured from an ArcGIS API for JavaScript code sample. The sample demonstrates how to visualize data from downtown San Francisco, California, as a SceneLayer in 3D. Building edges are rendered using SolidEdges3D or SketchEdges3D. Thematic data is visualized by applying a color ramp based on the SceneLayer's attributes using visual variables.

Location Intelligence Makes a Better Future Possible

As business and government organizations move to information systems that are entirely digital, they are also revising and streamlining processes and integrating those systems. In this process, which produces both disruption and opportunity, GIS has emerged as a powerful IT platform.

According to Esri president Jack Dangermond, "GIS can easily integrate with other corporate IT systems and bring together many different kinds of disparate data using the common thread of geography." GIS does this by redefining relationships between data and revealing patterns. This process results in location intelligence, which can coordinate workflows in ways that were not possible before and enable greater collaboration within and between organizations.

The market research firm Forrester recently recognized Esri's leadership in location intelligence by noting,"Esri's vision for location intelligence is to help organizations understand why things happen where and when they happen, with the goal of gaining business advantage through better understanding. By continuing to evolve *[its]* ArcGIS *[platform]*, Esri is pushing beyond the traditional GIS markets that it has long dominated into the location intelligence market."

By integrating on-premises software with cloud-based services, ArcGIS users can extend and expand existing systems. Esri's Geospatial Cloud platform has made location intelligence available across organizations. The geospatial cloud supports a more inclusive and informed decision-making process.

Esri recently launched the Esri Maps for Public Policy website that—through ArcGIS Online and the ArcGIS Living Atlas of the World—provides access to the datasets, analysis tools, and visualization capabilities needed for meaningful policy research that identifies opportunities for intervention.

A broad range of ArcGIS developer tools encapsulate location intelligence in apps so it is available to people who previously would not have experienced the benefits of GIS. Whether using noncoding tools, like configurable apps and app builders, or one of the ArcGIS APIs or SDKs, ArcGIS-based solutions can be created to meet the specific needs of organizational workflows.

These solutions are making palpable differences, as the articles in this issue illustrate. The City of San Diego, California, is integrating Esri and SAP technologies to improve its infrastructure management. The nonprofit organization Winrock International designed an ArcGIS-based tool for decision-makers so they can assess the impacts of forest loss and help preserve Cambodia's fragile ecosystems. These organizations are realizing Esri's vision of enabling location intelligence to support better decisions that make a better future.

Monica Pratt
ArcUser Editor

ArcUser

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Editorial

Editor Monica Pratt
Contributors Jim Baumann, Carla Wheeler, Citabria Stevens
Technical Adviser Paul Dodd
Copyediting Linda Thomas

Design

Creative Director James Hitchcock
Designer Doug Huibregtse
Illustrator Dan Gill
Photographers Eric Laycock, Eric Johnson
Print Coordinator Lilia Arias

Advisory Board

Corporate Marianna Kantor
Products Damian Spangrud
International Dean Angelides
Marketing Communications Jeff Brazil
Industries Damian Spangrud

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Editorial Inquiries

Monica Pratt, *ArcUser* Editor
380 New York Street
Redlands, CA 92373-8100 USA
arcuser_editor@esri.com

Read the article submission guidelines at **esri.com/esri-news/arcuser/writer.**

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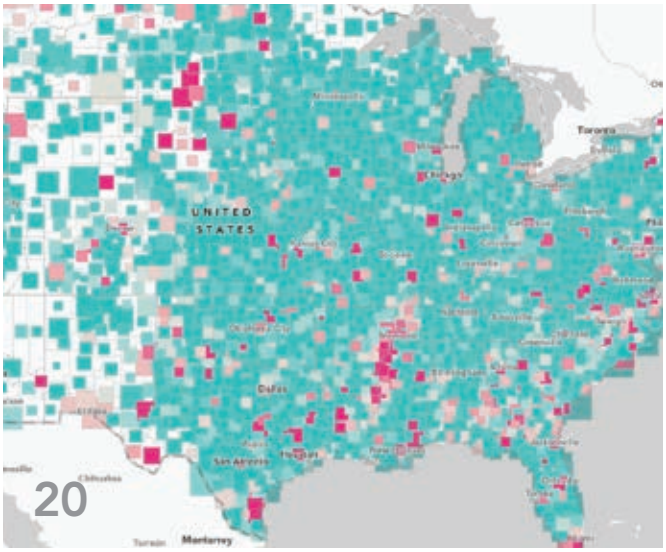

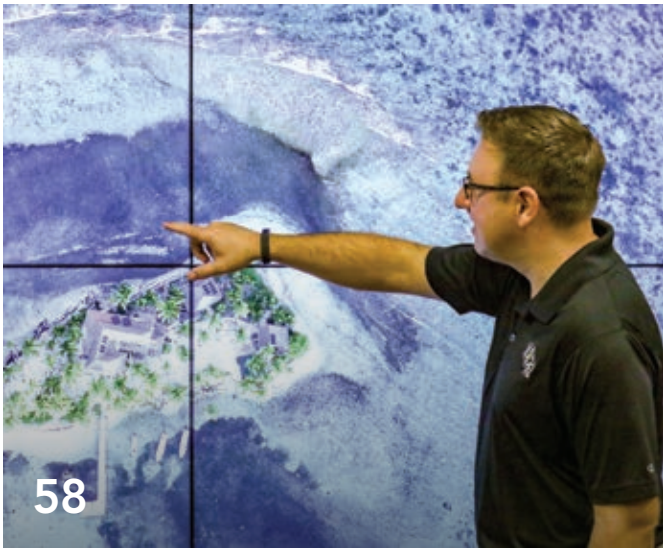

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What's Your User Type?

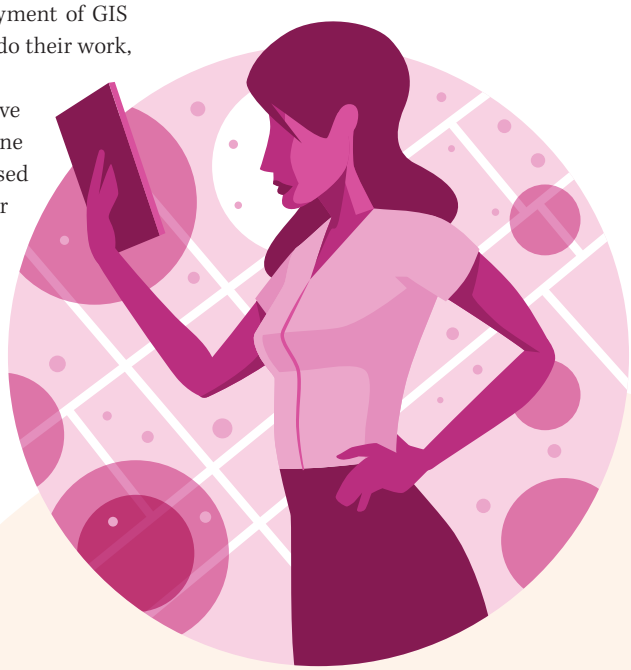
Are you a Creator, Viewer, Field Worker, Editor, or GIS Professional?

With the December 2018 update of ArcGIS Online, Named User levels were transformed into User Types that expand access to functionality in a way that corresponds to the needs of different users in an organization. This change was requested by users through the ArcGIS Ideas section of GeoNet.

New User Types give organizations more granular control over the deployment of GIS tools. User Types let staff members get the capabilities and apps they need to do their work, and organizations have a cost-effective way to manage user accounts.

Although User Types redefine access to apps, administrators can still give members in their organizations access to supplementary apps and further refine specific users' roles. This allows organizations to fine-tune access to apps based on user needs. Administrators can still assign custom roles to specific users or groups of users by refining their permissions.

If you were a Level 2 user, you will become a Creator User. If you were a Level 1 user, you will become a Viewer User. However, you also have three additional User Type options: Field Worker, Editor, and GIS Professional.



Creator

If you are a GIS specialist, asset manager, or data journalist, and you create maps and apps, perform spatial analyses, and share the results with colleagues and clients via ready-to-use apps, Creator is your User Type. As a Creator, you can employ one of three app bundles:

- With the Essential Apps Bundle, you get Esri Story Maps apps, Web AppBuilder for ArcGIS, Operations Dashboard for ArcGIS, configurable apps, Map Viewer, and Scene Viewer.
- With the Field Apps Bundle, you will get Collector for ArcGIS, Survey123 for ArcGIS, and Workforce for ArcGIS.
- With the Office Apps Bundle, you will get ArcGIS Maps for Office and ArcGIS Maps for SharePoint.

Viewer

If you need to view the maps and apps created by others but don't need to build them yourself, then you are a Viewer User Type. Your job title might be that of an executive officer, manager, or sales manager, and you use ArcGIS Online to access your organization's private information to make informed decisions and monitor performance.

Field Worker

If you collect real-time data, manage field assignments, inspect assets, and/or do surveying, you are a Field Worker User Type. You use Collector for ArcGIS, Survey123 for ArcGIS, and Workforce for ArcGIS to do real-time data collection, tasking, and operations to improve the efficiency and productivity of your organization. Your job title might be maintenance foreman, field technician, or volunteer for this User Type.

GIS Professional

If you are a superuser who produces advanced maps, visualizations, and analyses, you are a GIS Professional User Type. The maps you create and the geospatial insights you uncover empower the people in your organization and advance its projects. As a GIS Professional User Type, you will have ArcGIS Pro (Basic, Standard, or Advanced) and have the Essential Apps, Field Apps, and Office Apps bundles. Your job title might be GIS analyst, GIS manager, geodeveloper, or cartographer.

Editor

If you modify and add spatial data to ArcGIS Online to improve how accurate and current your organization's geospatial information is, you are an Editor User Type. You probably review and edit incoming data to ensure that your organization's system of record contains authoritative data. Your job title might be data entry clerk, GIS technician, or data quality engineer.

The March 2019 release of ArcGIS Enterprise 10.7 will include User Types so all organizations that use Web GIS can more efficiently and cost-effectively manage team members by assigning User Types.

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MAKING YOUR ArcGIS ONLINE ORGANIZATIONAL ACCOUNT MORE SECURE

In 2018, an ArcGIS Online update introduced some changes to the security settings available for ArcGIS Online organizational accounts. These settings allow access to the organization only through HTTPS and allow only standard SQL queries.

To help ensure a secure platform for your organization's hosted resources, Esri has made changes to these settings as part of a larger commitment to providing a secure platform:

- If your organization already has these options enabled, you will no longer see them as configurable options in your organization's settings.
- If you have one or both options disabled, you will see a Warning banner with a recommendation that you enable these options for your organization.

To help administrators safeguard ArcGIS Online organizational accounts, Michael Young, Esri's chief information security officer, has provided detailed answers to questions about these enhancements.

WHAT IS HTTPS?

HTTPS, which is an abbreviation for Hypertext Transfer Protocol for secure communication, commonly referred to as Transport Layer Security (TLS) or Secure Sockets Layer (SSL) encryption, provides a layer of security for data transmission over the Internet. When HTTPS is used, incoming and outgoing communication between your browser and the server providing the layer is encrypted. This secures information while it is in transit so that anyone monitoring traffic between you and the layer cannot see the information being transmitted.

One of the main drawbacks of using HTTPS has been that it is not as fast as HTTP. However, advances in web technology have closed the gap, specifically with the introduction of HTTP/2 *[which is defined for both HTTP URIs and HTTPS URIs]*. In many cases, HTTPS is now faster than HTTP. HTTPS has become the Internet standard. Most popular websites use HTTPS. It is recommended that all communication over the Internet use HTTPS.

WHY HTTPS MATTERS FOR YOUR ORGANIZATION

HTTPS helps secure your organization's assets. For instance, when you view data (as part of a layer, map, or app) or collect data (as part of a survey), HTTPS helps ensure that nobody can see the data aside from the people that you share it with. Many government agencies, especially at the federal level, have stringent requirements regarding how data must be secured.

Esri has done a considerable amount of work to meet these requirements, adhering to guidelines from Federal Risk and Authorization Management Program (FedRAMP), Federal Information Security Management Act of 2002 (FISMA), General Data Protection Regulation (GDPR), and other agencies and will continue to enhance security for ArcGIS Online and the ArcGIS platform overall. Visit the ArcGIS Trust Center (trust.arcgis.com) for more information on Esri's compliance with these initiatives.

Encrypting sensitive information is the primary reason to use HTTPS. HTTPS uses TLS or SSL encryption protocols that provide secure communication across networks. The ArcGIS platform uses TLS, which is a more recent and secure encryption protocol than SSL. ArcGIS Online still supports SSL, and you will often see SSL and TLS used interchangeably in documentation.

When you send information over the Internet using HTTPS in your URL address, only the intended recipient can understand the information. This encryption is important because the information you send over the Internet is usually passed between many computers before it gets to the destination server. Any computer between you and the server can see sensitive

information, such as passwords, if the information is not encrypted with a valid TLS or SSL certificate.

With a cloud-based software as a service (SaaS) such as ArcGIS Online, using HTTPS for communication over the Internet is one of the most important steps you can take to secure sensitive information. When the HTTPS only setting is enabled for your organization, your data hosted in ArcGIS Online can only be accessed over HTTPS. HTTP is effectively disabled. Any communication between you (or anyone else) and your ArcGIS Online organization is only over HTTPS, whether that is through a browser, device, or desktop application.

In addition, Google Chrome, Mozilla Firefox, Microsoft Edge/Internet Explorer 11, and Apple Safari are becoming increasingly strict with HTTP traffic. Browser updates frequently introduce tighter controls that either alert you to security issues with websites or block you from visiting websites a browser deems unsafe.

HOW TO UPGRADE YOUR ORGANIZATION TO HTTPS ONLY

To enable the HTTPS only setting for your organization, go to the Settings tab of your ArcGIS Online Organization page and select Security. In the Policies section, you will see Allow access to the organization with HTTPS only under the Warning banner. If you don't see this option, your organization is already enabled for HTTPS only.

Here are a few items to consider when enabling the HTTPS only setting for your organization:

- Layers hosted in ArcGIS Online as well as layers provided by Esri, such as ArcGIS Living Atlas of the World layers or basemaps, are automatically HTTPS ready. For many organizations, transitioning to HTTPS only will be seamless.
- You can update the layers in your maps or scenes to use HTTPS from the item's details page.
- Check your Esri Story Maps apps for HTTPS compatibility using the Check Stories utility at the Story Maps website.
- If you have an ArcGIS Hub site, you can configure your site to enforce HTTPS only. HTTPS is not currently supported with custom domains. HTTPS support for custom domains is coming in the near future. When HTTPS is supported for custom domains, Esri will automatically update your custom domain to support HTTPS (if you have enabled Enforce HTTPS).

Once you've enabled HTTPS only, check any critical apps, maps, or other content hosted in ArcGIS Online. If you've enabled HTTPS only and find an issue, you can revert the setting back to allow HTTP access. Once the issue is resolved, you can reenable HTTPS only. The option will remain available to disable for 60 days. Once 60 days has elapsed without being disabled, the option will no longer be available in your organization's settings.

ALLOW ONLY STANDARD SQL QUERIES

SQL is a scripting language commonly used by developers when working with feature data hosted in ArcGIS Online. Standardized SQL, a specific version of SQL, is generally regarded as more secure. All ArcGIS apps support standardized SQL. Esri recommends that your ArcGIS Online organization allow only standard SQL queries. If this security option is enabled, you will no longer see it as a configurable option. If option is not enabled, you will see the option under the Warning banner in the Security section of your organization's settings.

Visit the ArcGIS Trust Center (trust.arcgis.com) for more information about Esri's commitment to security and compliance.

Briefly Noted

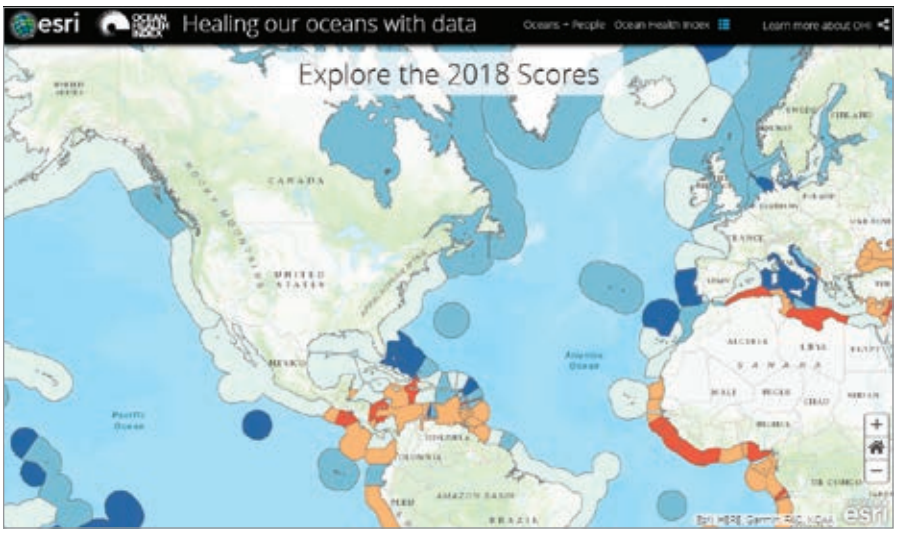
→ Esri Named a Leader in Location Intelligence Platforms

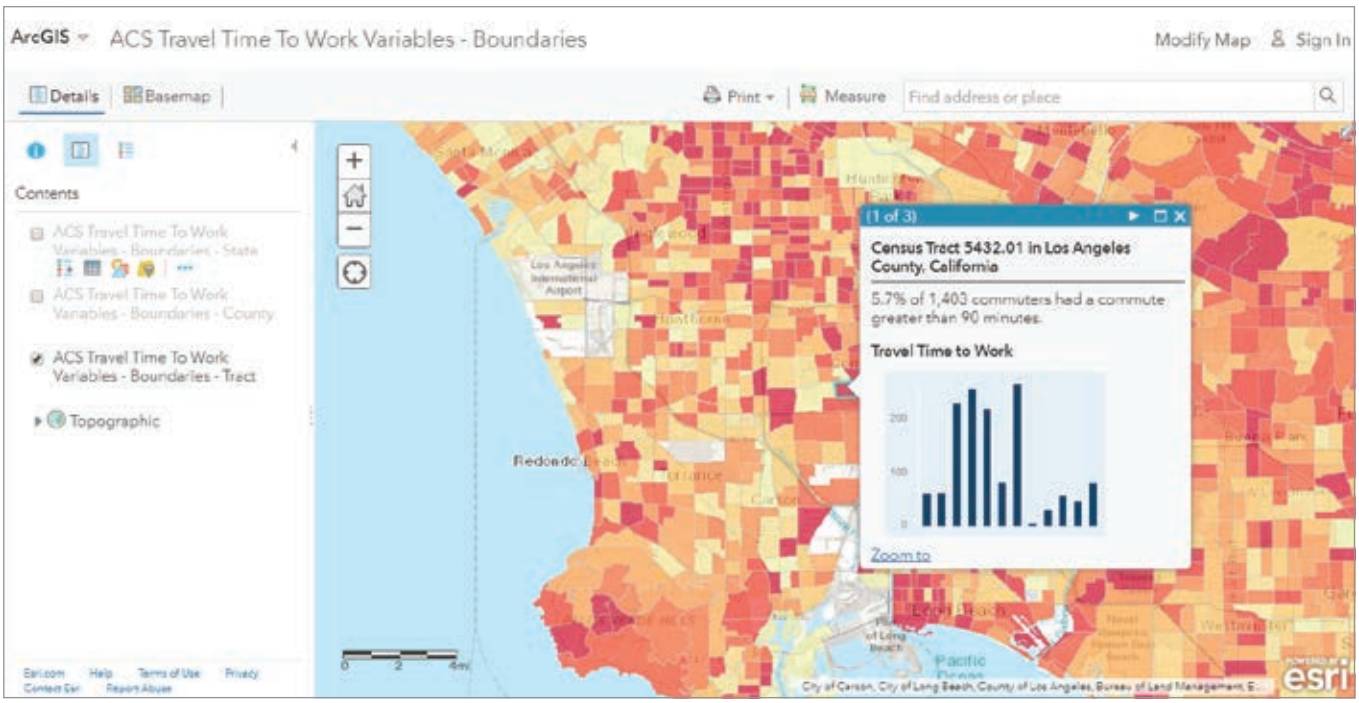
The market research firm Forrester recognized Esri in *The Forrester Wave: Location Intelligence Platforms, Q4 2018 Evaluation*. The Forrester report notes, "Esri's vision for location intelligence is to help organizations understand why things happen where and when they happen, with the goal of gaining business advantage through better understanding. By continuing to evolve *[its]* ArcGIS *[platform]*, Esri is pushing beyond the traditional GIS markets that it has long dominated into the location intelligence market." To learn more about Esri's ranking in the Location Intelligence Platforms Q4 2018 Forrester Wave Evaluation, visit bit.ly/2Gak6WI.

→ New Hubs Show Regional Ocean Health

Esri has partnered with the Ocean Health Index (OHI) team to release new ocean health data. A joint project of Conservation International and the National Center for Ecological Analysis and Synthesis, OHI looks at the social, ecological, and economic benefits that oceans provide to people. Dealing with ocean health data is complex. There are more than 100 global datasets that power OHI's annual assessments, which will serve as the foundation for Ocean Health Hubs. While OHI's ocean health scores are already integrated as a data layer in ArcGIS Living Atlas of the World, Esri and OHI will launch Ocean Health Hubs, powered by ArcGIS Hub, to enable ocean managers to explore data that will help them understand regional ocean health. For more details, visit ohi-science.org/ohi-global/index.

↓ The Ocean Health Index assesses ocean health by looking at the social, ecological, and economic benefits that oceans provide to people.





↑ American Community Survey (ACS) five-year estimates are now available in ArcGIS Living Atlas of the World. ACS helps determine how $675 billion in federal and state monies are spent annually.

→ Get the Latest American Community Survey Maps and Data

Maps and data from the most current American Community Survey (ACS) five-year estimates are now available in ArcGIS Living Atlas of the World. ACS data helps determine how $675 billion in federal and state monies are spent annually, so access to the latest available data is crucial for policy makers, their staff, and GIS analysts. Anyone who uses these layers now has immediate access to the latest census data. The nationwide data (which also covers Puerto Rico) includes state, county, and tract geographies. Each year, the layers are updated in a similar pattern. This essentially eliminates the hours or days normally spent locating, downloading, processing, and doing quality assurance to have this valuable data in a GIS-ready format. Each ACS estimate comes with the associated margin of error. Each feature layer is provided as boundaries and centroids with ready-to-use cartography and pop-ups that can easily be customized or reconfigured for web maps.

→ 2019 ArcGIS User Seminar Series

A series of free, half-day events to help Esri's current customers become more successful in their work will be held at cities throughout the United States, ending in April 2019. These presentations share solutions, highlight new capabilities and products in the latest versions of ArcGIS, demonstrate best practices, and outline ways to engage with the Esri community. Visit go.esri.com/arcgisuserseminar for information on dates and locations.

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Using 3D to Entice Urban Redevelopment

By Rae DeVito

The Downtown Detroit Partnership (DDP), a nonprofit that manages Detroit's Business Improvement Zone and Downtown Detroit Parks, recently turned to 3D mapping to creatively market its metropolitan areas.

The once vibrant and bustling city of Detroit, Michigan, has gone through significant economic and demographic changes due to industrial restructuring. It is working to attract investment by business and lure back residents.

DDP engaged CyberCity 3D, Inc. (CC3D), to create a 3D map of its projects in the downtown area that would show projects that were recently completed, ones that are under construction, and those that are in the development pipeline.

CC3D is a Southern California-based company that creates detailed "smart" 3D city models. For this project, CC3D brought in Garsdale Design 3D (GD3D), its partner in the United Kingdom, to create customized 3D maps using Esri's ArcGIS. Garsdale Design is a longtime Esri partner.

Rae DeVito, the communications director for CC3D, interviewed Joshua Long, DDP's data program manager, about the 3D maps DDP unveiled in September 2018.

↓ The Downtown Detroit Partnership (DDP) engaged CyberCity 3D, Inc. (CC3D), to create a 3D map of its projects in the downtown area.

↑ The 3D maps show the spatial relationship of projects that have recently been completed (green), those that are under construction (blue), and those that are in the development pipeline (orange).

Rae DeVito: What was the project or application undertaken? What problem or issue did it address?

Joshua Long: The Downtown Detroit Partnership creates an annual report highlighting current and future building developments in our downtown. The report has been accompanied by a 2D story map in the past, highlighting locations of projects, together with information about each (expected completion, amount invested, land use, pictures, owner, and a narrative about the project from the developer).

This year, I've made it a priority to start visualizing our downtown business data in three dimensions to make our visualizations more powerful. After CyberCity 3D delivered the downtown models, CC3D's Kevin DeVito arranged a meeting with Elliot Hartley at GD3D to discuss the possibilities in terms of online visualization of 3D data.

It became clear that creating the development update map online in 3D would be a great use of the new data. This application allows people to see how the skyline will be affected by new buildings. In addition, the format of the new tool (online and in 3D) really drives interest and entices more people to interact with the application and share it with colleagues.

RD: What aspects of the project or application are the most successful or unique?

JL: While there are other groups in Detroit that are tracking real estate development, especially downtown, our annual update takes advantage of our relationships with developers by getting information about the projects straight from the source. This information includes a description of the project, history, goals, plans for tenants, and other information that others don't get from news articles. Putting this information online, along with renderings of the projects, links to web pages, and general 3D massings of each project, makes this application really engrossing.

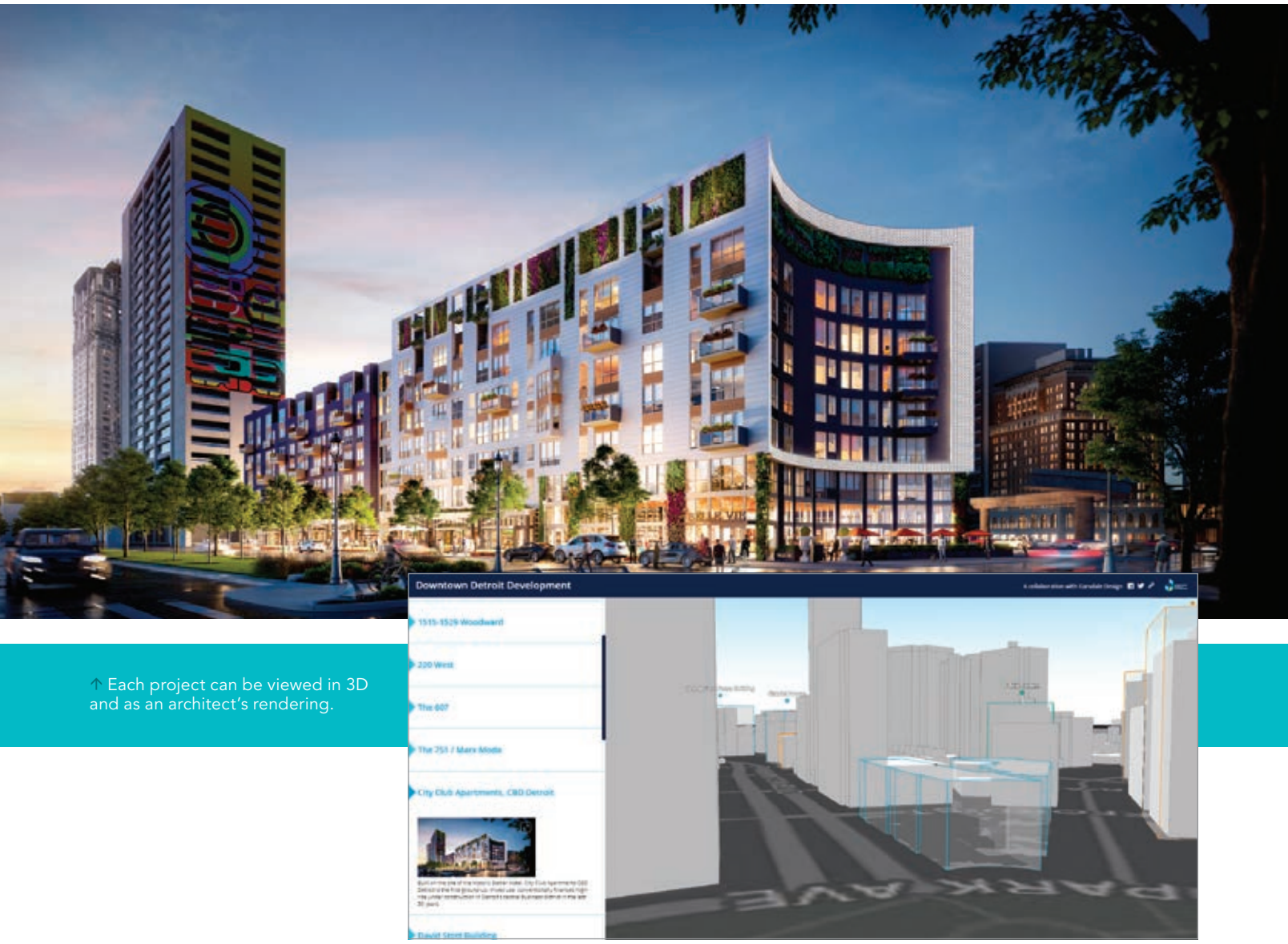
RD: How long did it take to complete, or is it ongoing?

JL: The data took several weeks of full-time work to put together, not to mention the time that CyberCity 3D spent creating the 3D models. Apart from the development of the data, the actual web scene and app development took around 40 hours over two weeks. Part of that time was spent getting up to speed with 3D GIS, 3D web scenes, etc. While I'm experienced using ArcGIS, ArcGIS Online, and ArcGIS Online apps, I have not done much with 3D. If I knew what I was doing, creating this application would have taken half the time.

RD: How was GIS integrated with other technologies in the organization?

JL: The first step for creating the Downtown Detroit Development Update report was to identify which new developments or major renovations were happening downtown. The DDP operates the Downtown Detroit Business Improvement Zone, and we regularly keep track of ownership since we collect an annual special assessment on commercial property.

Our first pass to identify new development was to list the properties that recently changed ownership. Our staff has working knowledge of development plans through our relationships, and that knowledge was also utilized to help flesh out our list of developments.



↑ Each project can be viewed in 3D and as an architect's rendering.

Finally, we cross-referenced with third-party sources, such as CoStar *[a commercial real estate information company]*, newspapers, and online media. After we had our list, we created a survey using Google Forms and sent it to our developers to fill out (and hounded them for months). The spreadsheet generated from that was joined with GIS parcel information, which is kept in Salesforce to keep track of contacts and companies at each parcel.

RD: What is the future of the project or application?

JL: We plan on updating the app annually to coincide with our annual development update. In addition, we are encouraging frequent collaborators and partners to utilize the data and incorporate the web scene in their own applications. Further, we hope that the tool will entice future developers to share even more information about their developments because of the publicity that the application brings and the utility of seeing and sharing their project in the 3D landscape.

RD: Any interesting information about the city's history and the issues it's focusing on?

JL: Downtown Detroit is currently developing at a pace not seen for several generations. In our 1.1-square-mile downtown, the DDP development update listed 21 current developments and another 24 projects in the pipeline. These include new buildings as well as major renovations (most of which were complete gut renovations). Among current projects is the 912-foot Hudson's Site tower, which will be the tallest building in Michigan. For a city like Detroit, which has faced many challenges over several decades and has worried more about population loss than development, the pace of change can be overwhelming. This application really helps to visualize just how drastically our downtown is changing and also draws attention

to developers who are doing the work to transform our city. By making this application publicly available, we are hoping that our partners and the public can utilize the data and share insights about upcoming changes.

RD: What kind of reception is the map receiving?

JL: The application is averaging 240 views a day since inception. It had a huge spike in users right after the OpenStreetMap State of the Map US conference, held in Detroit in October. We did a social media push, *[resulting in usage]* peaking at nearly 2,300 views. It is incredibly useful that this application works well on mobile devices.

About the Author

Rae DeVito is the communications director at CyberCity 3D, Inc. She has been writing about the burgeoning 3D city modeling/mapping market for the past decade. DeVito earned a bachelor's degree in journalism from the University of Texas at Austin.

For more information, contact Andy Yang, CyberCity 3D production manager, at 310.837.1794 or ayang@cybercity3d.com.

View the 3D maps on the Downtown Detroit Partnership's website.

↓ Specific information about a particular project is available directly from the map.

A Spatial Tool for Prioritizing Capital Projects

By Gerard Lonergan, Scott Daeschner, and Jodi Luostarinen

In 2018, the City of San Diego, California, rolled out the first phase of a software solution, the SAP Enterprise Asset Management (EAM) module, to improve its infrastructure management. This tool is used for asset planning, capital asset management (including the Capital Improvements Program), and the city's financial plan for the repair and/or construction of municipal infrastructure.

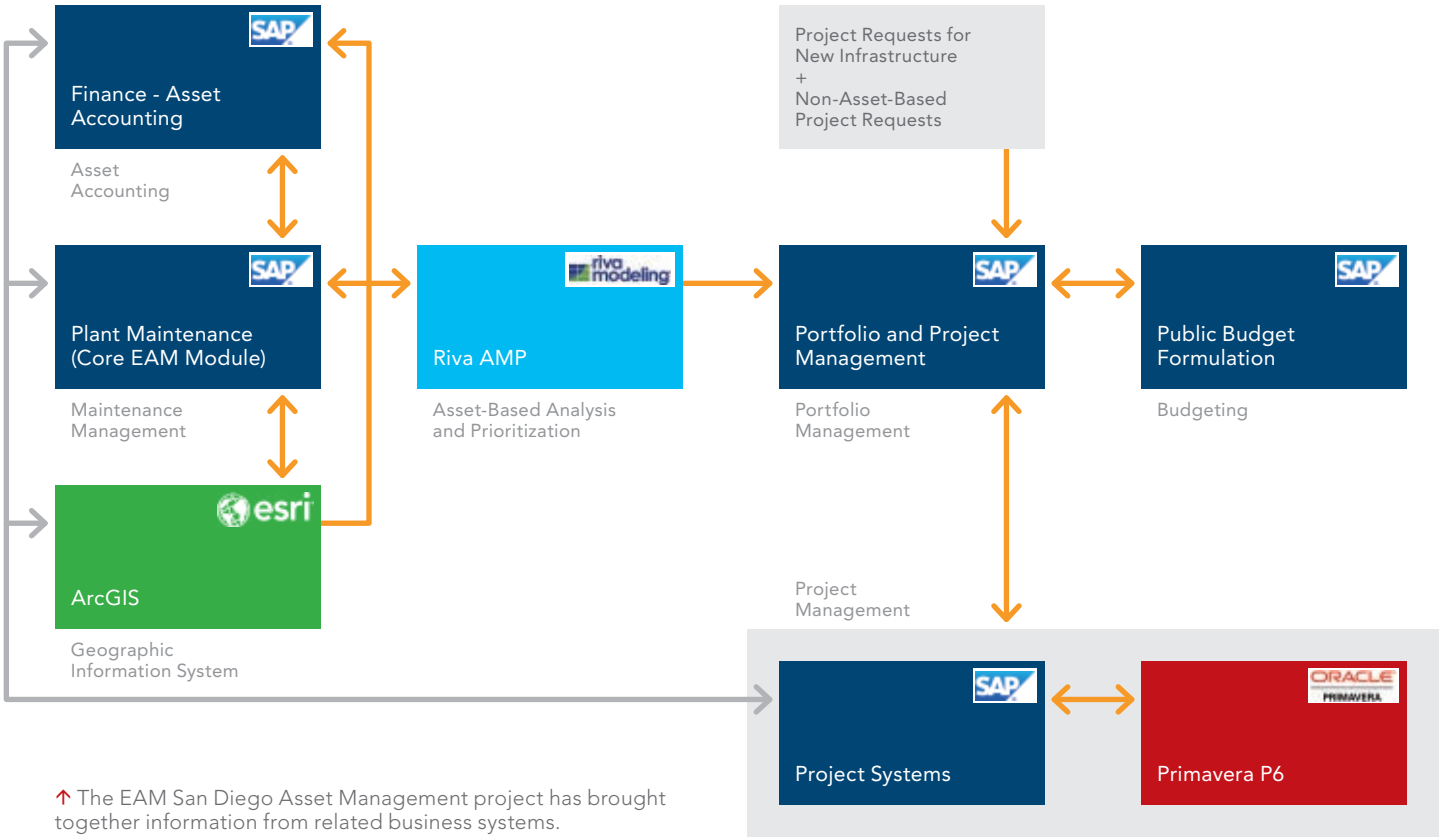
The city, which owns and maintains a large and complex network of infrastructure assets valued in the billions, has aging and deteriorating assets and a backlog of deferred maintenance and capital projects. The EAM San Diego project is an ongoing citywide strategic initiative to develop and implement a software solution.

GIS plays a critical role in asset management by applying spatial data structures, geographic relationships, and location-based functions to traditional database tables. The city has streamlined operations by standardizing on SAP as the work order system for operational asset maintenance and added spatial insight by incorporating Esri GIS technology.

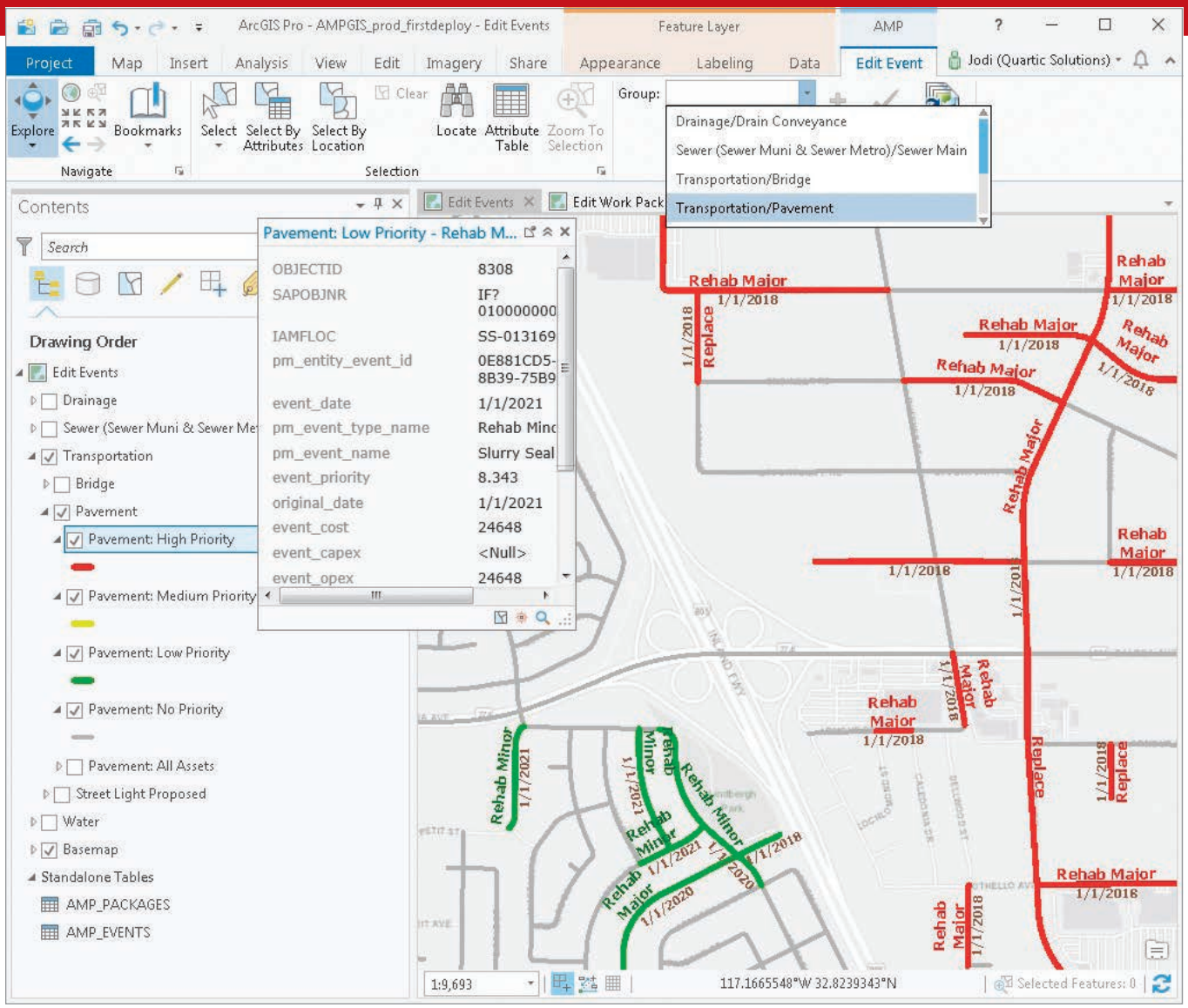
Scott Daeschner, the city's GIS manager, said, "The fusion of familiar GIS interfaces and tools with *[the]* powerful SAP enterprise workflow is making it easier to manage assets across all levels. Our users are familiar with GIS displays and are comfortable using standardized mapping symbols, relationships, and spatial functions."

Esri partner Quartic Solutions LLC, a GIS consulting firm, worked on the project. "One of the coolest things Quartic did was to apply that familiar mapping experience to the life cycle modeling product. Quartic's mapping interface minimized training costs, significantly enhanced *[the tool's]* immediate utility and seamlessly transitioned staff to new tech via a familiar UX," said Daeschner.

The EAM San Diego project required that asset information include the geographic location and user tools that enable staff to identify and answer location-based questions. For example, viewing active work orders on a map allows staff to identify clusters of work and more efficiently



↑ The EAM San Diego Asset Management project has brought together information from related business systems.



↑ The ArcGIS Pro add-in is used for updating priority, location, and assigned groups for work events. (Data is for demo purposes only.)

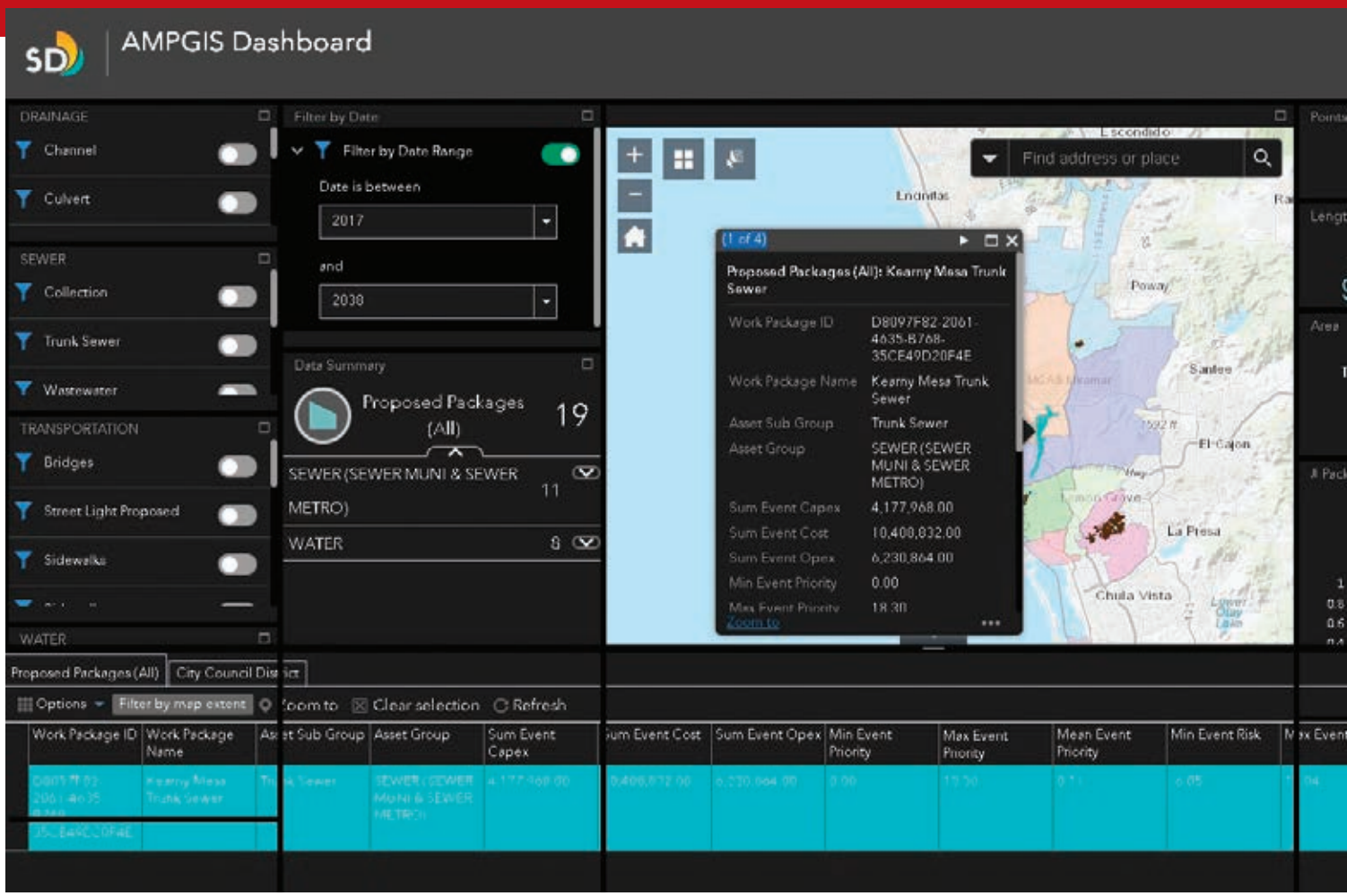
plan and schedule the city's multiyear capital plan. GIS requirements were met by implementing desktop, web, and mobile GIS components.

GIS components enable holistic planning and prioritization of infrastructure investments across departmental lines. Using a systematic approach will increase the long-term stability and sustainability of the city's asset management program. GIS helped institute an objective and transparent process that provides internal and external stakeholders with a clear view of what the city is investing in and why. The bidirectional syncing of SAP and enterprise GIS data allows more dynamic and accurate operational decision-making.

For capital planning, an application named AMPGIS was developed which combines the asset maintenance history and prioritization information stored in the city's SAP and Powerplan Asset Investment Optimization software with the city's Esri-based enterprise GIS system. AMPGIS was implemented using the SAP HANA ODBC *[Open Database Connectivity]* driver with ArcGIS clients and the ArcGIS Pro SDK. These combined technologies enable staff to visualize the distribution and extent of planned rehab and replacement jobs throughout the city.

AMPGIS Desktop is deployed to users as an ArcGIS Pro add-in that consists of an interactive map and specialized tools for grouping identified capital jobs based on geographic proximity to other similar job types, enabling the city to stay within its annual budget targets while working with planning time frames spread across 10 to 15 years.

Using AMPGIS, city engineers can visualize the dispersion, clusters, and extent of the proposed work packages by project type and prioritization ranking. AMPGIS tools enable staff to directly insert a new proposed work event using the map and update an existing prioritization category or package grouping. Also, communication between SAP and GIS is bidirectional. For example, if a user modifies a priority value ranking or group assignment in the



↑ The AMPGIS Dashboard summarizes total cost, total pipe lengths, and asset counts using maps and charts. (Data is for demonstration purposes only.)

SAP client interface, the value will be reread and redrawn on the map when the map refreshes.

This desktop application was designed, developed, and implemented during a six-month time frame. It went live in summer 2018 as the Public Utilities, Transportation and Storm Water, and Public Works departments reengineered processes for identifying and prioritizing rehab and replacement projects.

While the AMPGIS ArcGIS Pro application is primarily used by engineers to schedule and group work packages by time and location, Portal for ArcGIS is used as the underlying technology for a dashboard used by city planners and managers across multiple departments to review the proposed transportation, water, and wastewater capital work locations. The dashboard allows city staff to view where the planned work is, check for conflicts, and identify opportunities for coordination or schedule improvements. The dashboard provides maps and charts summarizing statistics such as total cost, total pipe lengths, and asset counts by work package type and location.

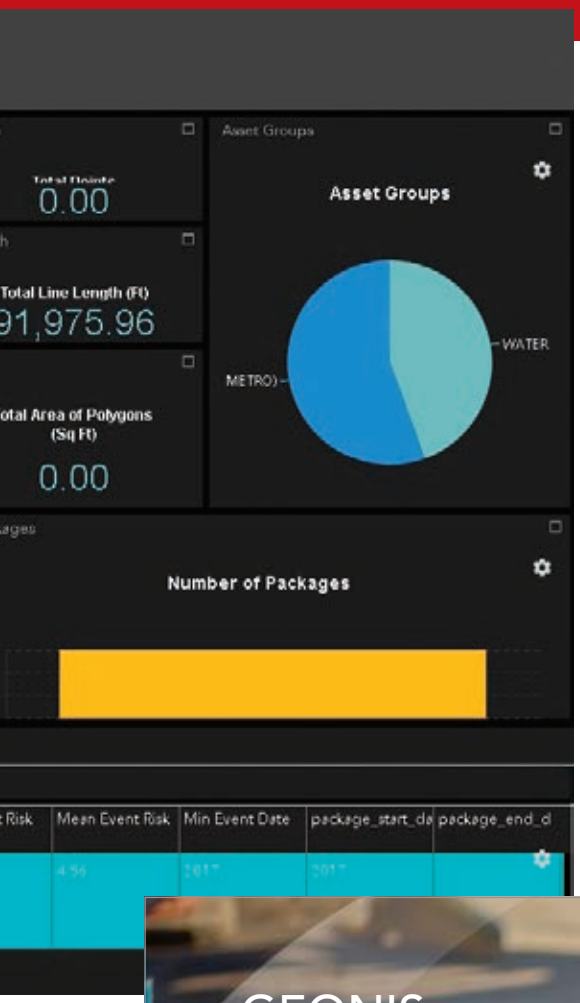
The EAM San Diego project is a critical step toward the full replacement of existing disparate and outdated maintenance management systems that were used by the departments participating in the initial phase of the project. By using current EAM and GIS technology, the capital asset maintenance process has become more systematic and transparent across departments.

The EAM system has helped transform the city's approach to maintenance from a reactive one to a proactive one that is based on life cycle management. Minimizing life cycle costs for assets optimizes the city's limited funds. Tools that enable the city to better prioritize work allow the city to be more proactive. The solution supports predictive and corrective maintenance of asset-intensive operations, inspections, and condition assessments. By effectively managing capital assets, the city minimizes the total cost of owning and operating assets over their life cycle while delivering desired service levels to constituents.

For more information, contact Gerard Lonergan, EAM project manager, Department of Information Technology, City of San Diego, at glonergan@sandiego.gov.

About the Authors

Gerard Lonergan has worked for the City of San Diego for 16 years in various management positions. Recently, he was the business process manager and testing lead during the recent EAM implementation at



the city. He was instrumental in helping the city's business units through their complex processes and mapping them in SAP, especially around GIS. He managed a team of external vendors of Deloitte, SAP, Quartic, and other subcontractors to build this SAP Geographical Enablement Framework (GEF) solution for the implementing city departments. He currently leads the ERP EAM Support Team in the city's Department of Information Technology. Lonergan has an MBA degree with a specialization in organizational leadership.

Scott Daeschner is the GIS manager for the City of San Diego. He has worked with spatial information technologies and remote-sensing systems for 30 years in support of local, state, and federal agencies. He has developed technology solutions for emergency response and coordination, asset management, predictive modeling, community engagement, environmental monitoring, and sustainability. Daeschner worked to implement SAP/Esri geo-enablement at San Diego. He received his bachelor's degree from the University of California, Santa Cruz, and continued research at the University of South Florida and San Diego State University.

Jodi Luostarinen is the CEO of Quartic Solutions, a GIS consulting firm that delivers innovation and leadership to the field of GIS. She has more than 20 years of experience in the management, design, and development of GIS programs and applications. Luostarinen is one of the longest-standing certified GIS professionals (GISCI GISP) still active. She was also the winner of the 2018 first annual SAP and Esri Hackathon held in Palm Springs last spring.

Making a Difference

By Christopher Thomas

When do you know that you are truly making a difference in the world? How do you know that the work you are performing is not simply automating processes?

Don't get me wrong, I see GIS helping governments—large and small—do a better job. The technology is improving processes, opening communications, streamlining workflows, and helping governments move toward digital transformation.

I worked in local government early in my career. My GIS team made maps for meetings and created public information products. As we moved the technology forward, it was truly appreciated by all who touched it, but there was a general feeling that management and elected officials didn't get the full picture. They didn't appreciate how transformational analysis on a map could be.

I finally saw that shift—that realization of the power of GIS—when my team had a problem that needed to be solved but could only be solved using GIS.

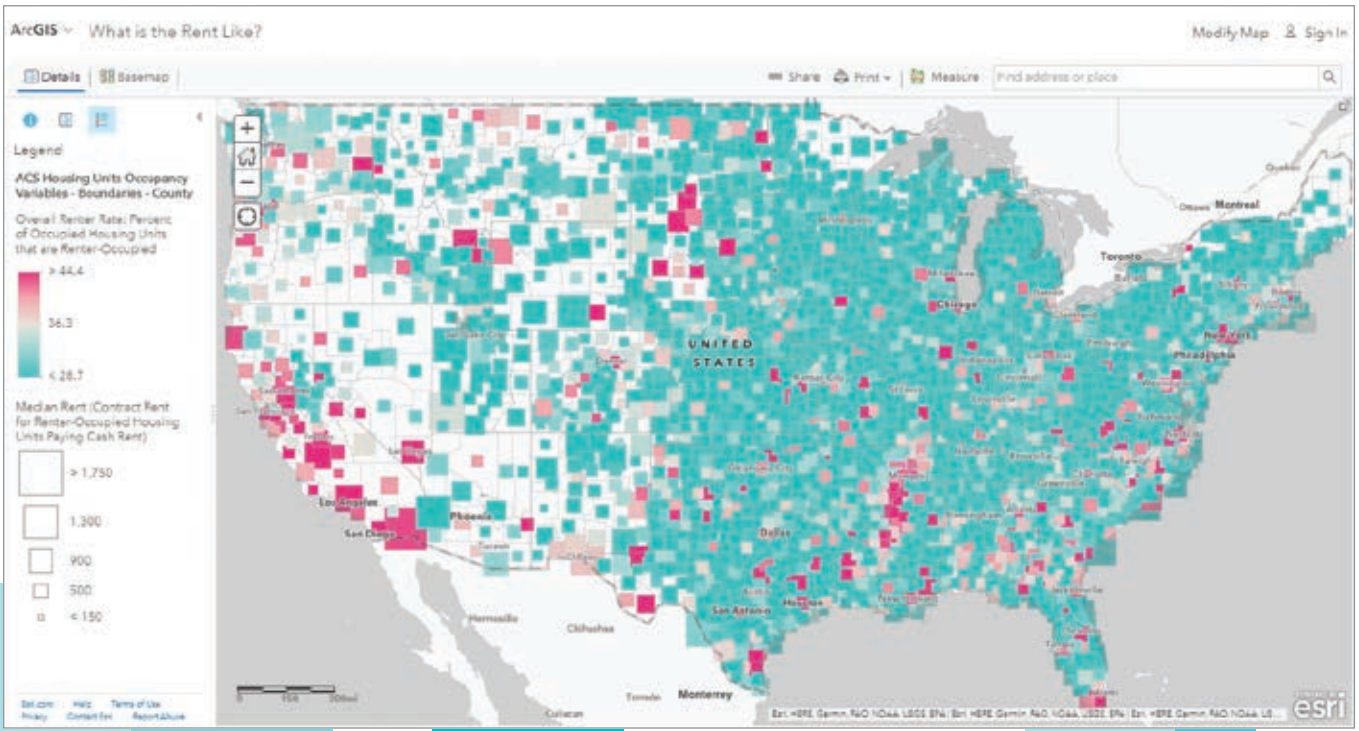
At the time, my city was going through one of the most comprehensive and controversial general plan updates. A massive annexation proposal meant that thousands of properties were being considered for rezoning. Major growth in the entire region was changing the land use at the city limits. Airport, freeway, and rail expansion was changing the mobility of residents. GIS was an integral part of the community meetings held to plan the updates. It let us present new ways of thinking through how the plan would reshape the community.

But a real turning point happened smack dab in the middle of the general plan update process, and it was caused by a major disaster that took place in the county. The rail lines that ran across the county were adjacent to a highly flammable aircraft fueling pipeline. A train derailed, crashing into homes near the track and killing the conductor, a brakeman, and two residents. Seven houses on the street that were immediately adjacent to the tracks were demolished by the wreck.

Surrounding jurisdictions began wondering if they were vulnerable and what they should do. The general plan and rezoning effort we were working on offered the perfect opportunity to intervene and to address the issue head on.

When my city's planning director asked the GIS team if we could help, we said, what do you need? Her first request was for a map depicting the location of railroad tracks and the pipeline in relation to planned development. We envisioned her using the map in a

↓ This map, available from the Esri Maps for Public Policy site, shows the median contract rent (what people pay in existing leases) and the percentage of renters by state, county, and census tract.



↑ In 1989, a disaster caused by a train wreck near pipelines led to an opportunity to use GIS analysis to inform public policy. Photo courtesy of Jeremy A. Greene.

townhall setting to figure out what to do. Frankly we were disappointed because we wanted to provide analysis before the meeting, but we were eager to highlight the value of GIS, so we said yes. We had to scramble to find data and maps of the exact location of the rail lines and, of course, the pipeline itself.

We understood that the planners were thinking of creating a policy requiring 150-foot setbacks from pipelines. Simplifying the study, we performed a quick analysis and depicted a 150-foot setback from the pipeline that showed areas where a building footprint could not be located. The results were a parcel-level land-use map with an estimate of the population located within the setback. We presented the results to the general plan committee immediately.

The committee was impressed and asked if we could perform another analysis. We told them we could do as many as they wanted. We ran four different setback analyses that resulted in a policy for lessening the impact to the public should a similar event take place in our city. That policy was integrated into the planning process.

This was a major turning point, not only in the general plan update, but also in how planners thought about how GIS could be used. Things are much different today. With the availablity of data, stronger data analysis tools, and a more collaborative work environment, forums for sharing policy development work are becoming the norm.

But there is a difference between mapmaking and *policy* mapmaking. Just because data is available doesn't mean we have reached a new level of data literacy. As my family and friends in the teaching profession remind me, there is a difference between reading and comprehension. It's the same with data analysis. According to Steven Goldsmith, "A policy map is a map where the opportunity to intervene is clear." Goldsmith, a former mayor of Indianapolis and former deputy mayor of New York City, is a proponent of policy mapping,

At the National League of Cities conference in November 2018, Esri president Jack Dangermond announced the launch of the Esri Maps for Public Policy site (esri.com/policymaps). Any organization can explore its hundreds of datasets, policies, best practices, and lessons that provide a greater understanding of the difference between a map and a policy map. Esri wants to give every jurisdiction the opportunity to increase its ability to perform meaningful policy research and analysis. Use this site to make policy maps that address pressing issues in your jurisdiction such as the opioid epidemic, housing affordability, or access to health care.

To learn more about policy mapping, read "Mapping the Opportunity to Intervene Clearly" in the Spring 2018 issue of *ArcUser*.

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.

THE IMPORTANCE OF COMMUNICATING YOUR VALUE TO LEADERS

By Adam Carnow

IF YOU WANT a government program or project to be successful, one of the most important factors is securing executive support or sponsorship.

This means constantly establishing and expanding that support. The more sponsors you have, the more support there is for your program. Diversifying your executive support is smart business. Leaders come and go, and their importance ebbs and flows over time.

Many managers of government programs or projects seem to be unaware of the value of executive sponsorship. I work with GIS practitioners in government agencies across the United States, and often, securing executive sponsorship is not prioritized. I believe this stems from the fact that they are unaware of how to best communicate their value to leadership.

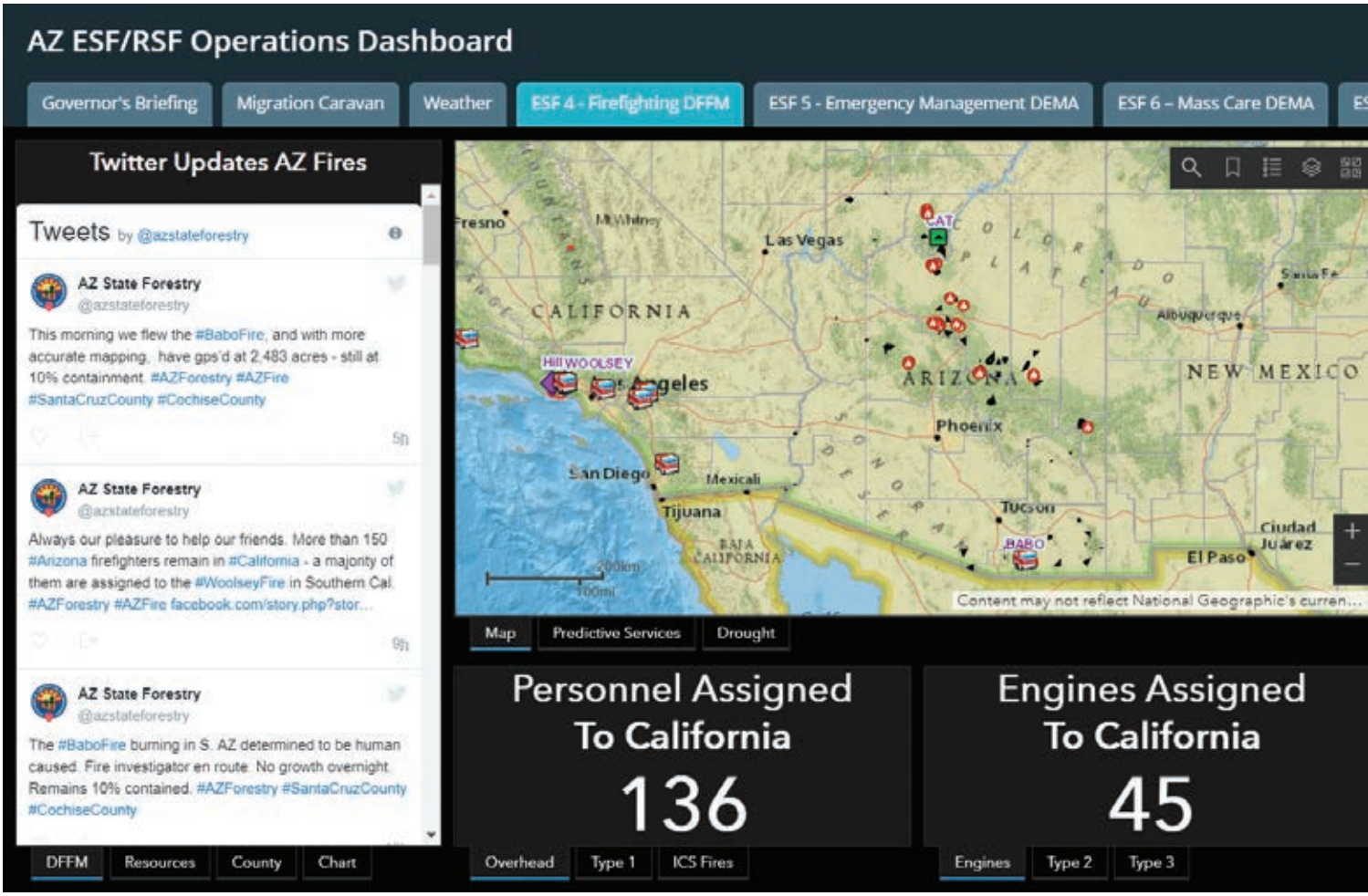
Effectively communicating with leaders takes special skills for three reasons:

1. Leaders usually don't have a lot of spare time.
2. Leaders may seem intimidating.
3. Leaders often do not want or need to understand the details.

However, there are some techniques you can use to help get leaders to understand and support your program or project.

If the project centers on a technology such as GIS, you need to make sure that you do not use overly technical terms when communicating with executives and elected officials. Usually, leaders are not interested in technology. They want to focus more on solutions to problems.

Therefore, it is critical that you learn how to communicate the value of your program



ALIGNING YOUR WORK WITH AN EXECUTIVE'S VISION IS CRITICAL.

or project as a solution to a problem the executive is interested in solving. To do this, it is best to frame your program or project in one of two ways—either in relation to the leader's vision or the leader's pain.

A leader is happy to discuss either vision or pain with you. An executive is always working toward a vision and wants as much assistance as possible in making it a reality. You can usually find out more about a leader's vision by looking at :

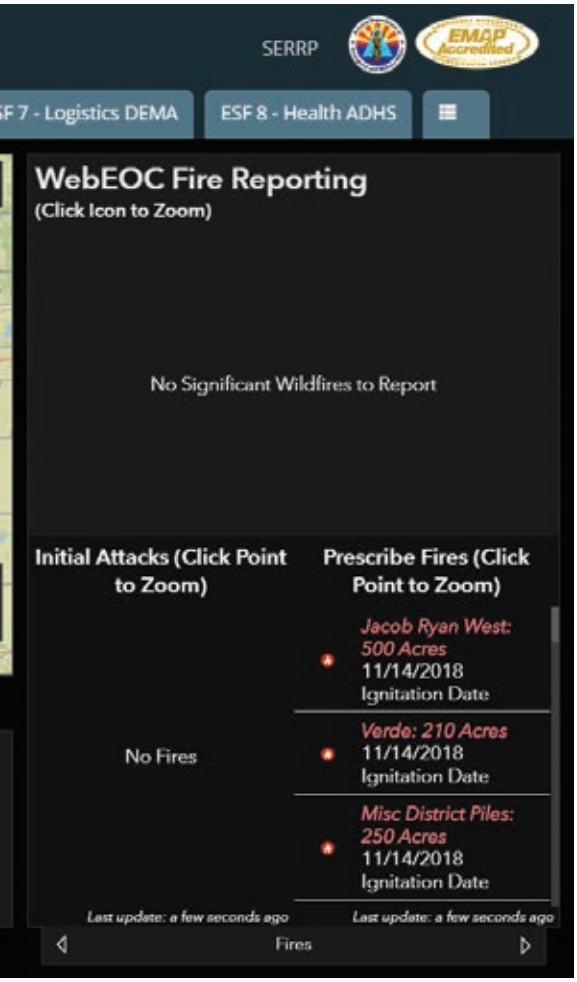
- Strategic plans
- Initiatives
- Goals, objectives, policies
- Key performance indicators (KPIs)

Aligning your work with an executive's vision is critical. It ensures that you are working on what matters most to the organization. If your work helps an executive move closer to realizing his or her vision, more value will be assigned to you and your work. This will lead to requests for more assistance from you. This is also true if your work helps alleviate an executive's pain.

It is important to get your executive involved in your program or project, rather than simply gaining support. By turning a GIS supporter into a GIS user, your leader will appreciate the technology on a personal level and understand that GIS is more than just mapmaking. An executive GIS user is more apt to provide additional GIS resources. The best way to get an executive to use GIS is through dashboards that provide real-time access to valuable data, visualizations, and analytics.

Remember these key points regarding communicating your value to executives.

- Make the most of your work, and make sure it is aligned with what your organization's leaders are focused on.
- You need to be proactive. Don't wait for them to come to you. They usually won't.
- Learn their business, then propose solutions that advance their vision and alleviate their pain.
- When proposing solutions, keep the communication short and direct. State the problem, the cause, and the negative impact, then describe how to solve the problem and describe the positive outcome.
- You should also provide the cost and timeline, and be sure to adhere to both.
- Don't just get their support, get them involved.



← The best way to get an executive to use GIS is through dashboards. This GIS-powered dashboard is used daily by the governor of Arizona to monitor emergency situations.

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. He is a certified urban planner (AICP) and GIS Professional (GISP). Follow Adam Carnow on LinkedIn or on Twitter @SpatialAce.

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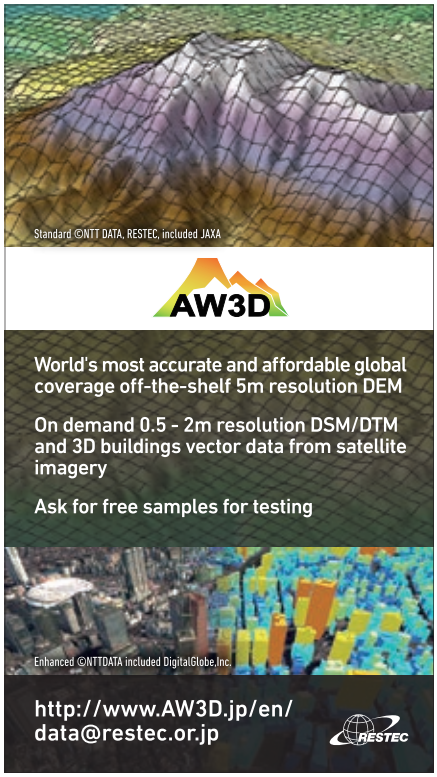


PICTURING PROSPERITY FOR YOUR COMMUNITY

By Helen Thompson

Ninety percent of all information we remember is based on its visual impact, according to a *Forbes* magazine article entitled "Use Infographics to Boost Your Credibility and Traffic."

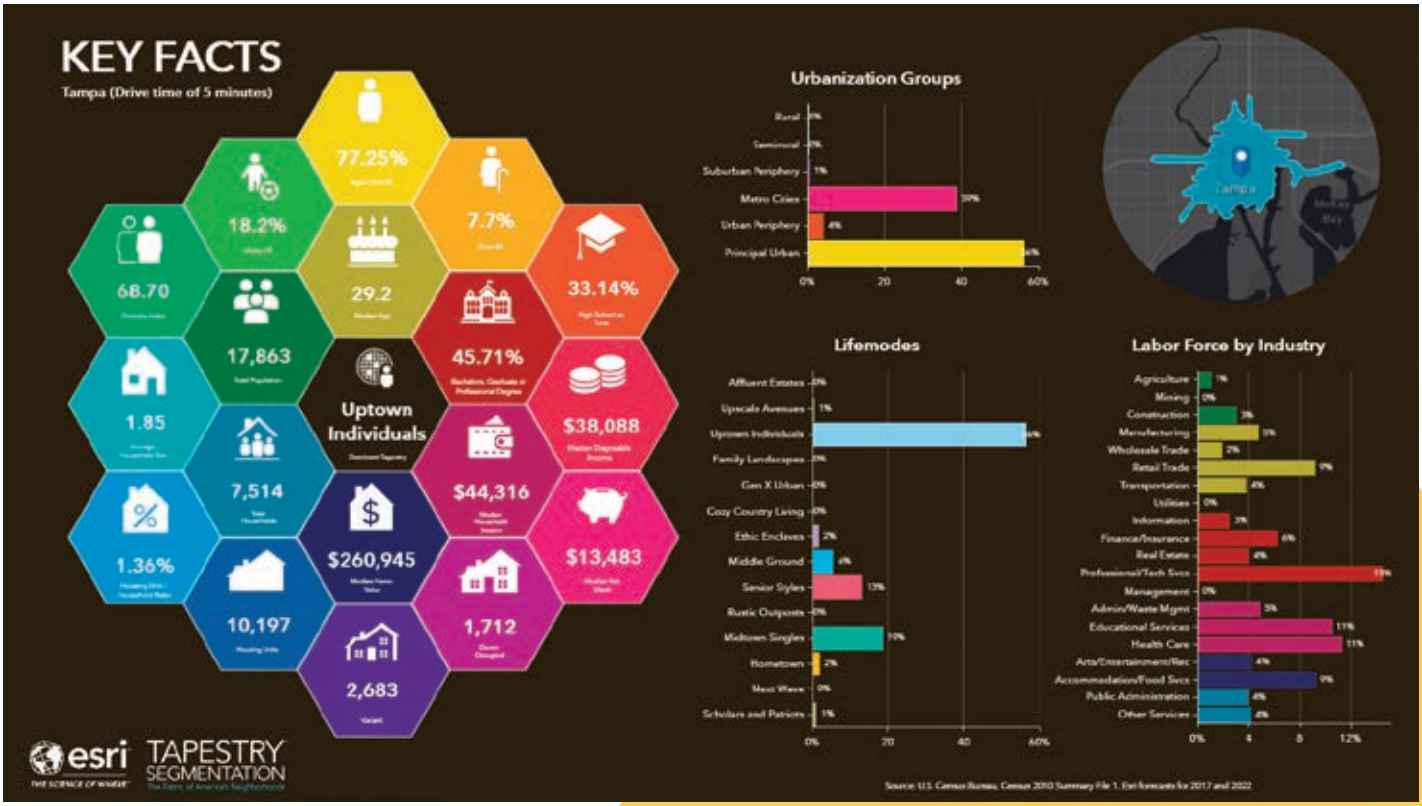
Infographics summarize key facts in a way that is easily digested by the reader and turn hundreds of words into easily understood facts. ArcGIS Community Analyst provides a growing library of professional infographics and templates that improve the way you tell the story of your community.

Although many municipalities still use paper brochures and static websites to attract investment, interactive infographics provide a beautiful, engaging, and easy-to-update user experience that the businesses you want to attract will want to use. Any infographic can be exported as an image or PDF, included in an Esri Story Maps app, or embedded in a community's website as an interactive dashboard.

Economic developers are continually challenged with finding the best strategies for successfully attracting new business—while growing existing business—to make their region a better place to live, work, and play. By employing entrepreneurial strategies that produce jobs for local citizens and increase tax revenues, they create opportunities to improve the community. A data-driven approach to attracting, growing, and retaining quality businesses is essential to realizing those goals.

Community Analyst provides the tools that help you employ three

↓ Use ArcGIS Community Analyst tools to employ three strategies for ensuring economic development success: showing off your community's strengths; bringing your data together; and simplifying communication, both internal and external.



EXISTING BUSINESSES ARE OFTEN YOUR BEST ALLY WHEN ADVOCATING FOR YOUR COMMUNITY.

strategies for ensuring economic development success: showing off your community's strengths; bringing your data together; and simplifying communication, both internal and external.

SHOW OFF YOUR STRENGTHS

All communities have strengths and weaknesses, so it is vital that you understand those of your community. The most successful economic developers emphasize the strengths that differentiate their community from neighboring ones. Those strengths could be an educated and diverse workforce, affordable housing, lower cost of living, or a thriving local economy.

Presentations made by the last 20 communities competing to be chosen for Amazon's new headquarters relied on data and infographics produced by Community Analyst. Easily embedded in Esri Story Maps apps and community websites, infographics provide a mechanism for easily sharing valuable insight with stakeholders in a way that sets you apart from the competition.

BRING ALL YOUR DATA TOGETHER

Community Analyst shortens your market analysis process. The infographics created using it effectively summarize large amounts of data. Infographics help improve the site-selection process and the flow of information from the local government to the stakeholders and entrepreneurs who can best use these visualizations to drive job growth. Employment-centric infographics get the buy-in of start-ups or existing businesses that are looking to locate a new facility. The hyperlocal information presented in infographics helps them choose your region.

A large percentage of new jobs in an economy are created by existing companies. One major role of an economic developer is to reduce a region's overreliance on a single industry sector by improving the diversity of the whole local economy. Community Analyst helps an economic developer support companies that are expanding operations to stay local rather than relocate elsewhere.

Jobs and employment data help a community understand the industries that are best placed to grow and how well local skills and wages match this growth potential. Developing a more detailed understanding of businesses that exist within the community helps deliver services that retain and grow business locally. Growing local businesses tends to encourage wage earners to spend locally. For example, job growth in a manufacturing business will drive the need for other service industries such as retail and health care. Creating new jobs in existing industries has a multiplying effect on unrelated industries and generates new sources of tax revenue because the economic base is diversified.

Better infrastructure and more jobs improve the economy of the region, raising the standard of living for all residents. This creates a virtuous cycle: as the quality of life improves in your community, which becomes more attractive to external organizations as a result, so the growth potential for local companies increases.

SIMPLIFY INTERNAL AND EXTERNAL COMMUNICATION

Data, infographics, reports, and story maps generated using Esri technology improve the way you communicate with existing businesses—usually a community's greatest resource for attracting new jobs and investment. By understanding the needs of businesses and the demographic and socioeconomic trends in your community, you can improve your community's services before other communities can compete for the same jobs. Existing businesses are often your best ally when advocating for your community. Better understanding and communication with them can dramatically increase your chances for job growth and community improvement.

WHAT'S NEXT?

Economic developers want to provide their communities with more and better jobs by attracting companies that will create jobs that are appealing to both current residents and new graduates, and even entice companies that have left the region to return. New investments and the increased presence of existing companies enable the community to thrive. Greater economic prosperity and the growth of tax revenue enable a community to reinvest in local infrastructure such as schools, transit, and parks.

Through understanding the needs of business and the strengths of your community, you can create an environment in which opportunities abound. Workers will move into the area in search of their dream jobs. With the ability to easily discover and communicate your community's differentiating characteristics in comparison to nearby, competing jurisdictions, you will help your community reach its economic potential.

ABOUT THE AUTHOR

Helen Thompson is Esri's global marketing strategy manager for real estate, banking, and insurance. As a recognized thought leader and keynote speaker on spatial theory and location platforms, she has applied her entrepreneurial and technological passion to help advance the understanding and use of spatial technology in business and society. She believes that geographic context is central to creating a better future and solving some of our biggest global challenges while delivering new opportunities for consumers and businesses.

House Hunting the Data Science Way

By Atma Mani

Most of us have spent time hunting for a house to rent or buy. Whether you realized it or not, a lot of the factors you considered were heavily influenced by location.

This article shows how the data wrangling capabilities of the scientific computing tools for Python and the geospatial data visualization and analysis capabilities of the ArcGIS platform can be used to build a model that generates a shortlist of houses in Portland, Oregon, that fit the needs and desires of a house hunter.

Why do this, you ask? There are real estate websites that promise to do the same thing. I hope that by the end of this article, you will be able to answer that question yourself.

The process I used is extensively illustrated in a Jupyter Notebook, available on GitHub at bit.ly/2rXCXub. Open it, examine it, and follow along when reading this article. This example was originally created for a Portland GeoDev talk.

Data Collection

Housing data, collected from a popular real estate website, came in a few CSV files of different sizes. Data was read using pandas as DataFrame objects. These DataFrames form the bedrock of both spatial and attribute analyses. The CSV files were merged to obtain an initial list of about 4,200 properties that were for sale.

Data Cleaning: Missing Value Imputation

An initial and critical step in any data analysis and machine learning project is wrangling and cleaning of the data. In this case, the data suffers from duplicates, illegal characters in column names, and outliers.

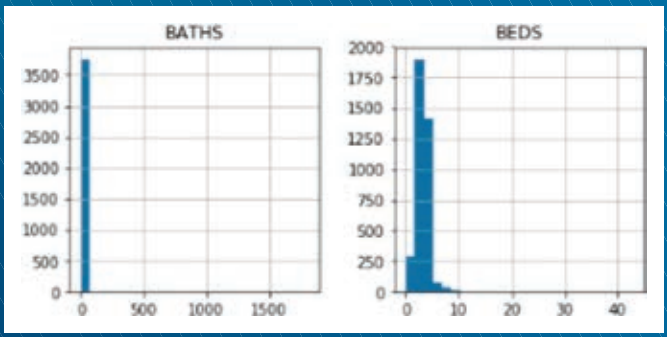
Pandas makes it extremely easy to sanitize tabular data. Different strategies were used to impute for missing values. Centrality measures, such as mean and median, were used to impute for missing values in LOT SIZE, PRICE PER SQ FT, and SQ FT columns, whereas frequency measures like mode were used for columns

such as ZIP. Rows that had missing values in critical columns such as BEDS, BATHS, PRICE, YEAR BUILT, LATITUDE and LONGITUDE were dropped, as there was no reliable way of salvaging these records. After removing these records, 3,652 properties were available for analysis.

Removing Outliers

Outliers in real estate data can be caused by many things such as erroneous data formats, bad default values, and typographical errors during data entry. Histograms of numeric columns can show the presence of these outliers.

In the first two histograms in Figure 1, it appears that all houses have the same number of beds and baths. This is simply not true and a sign that a small number of high values (outliers) are skewing the distribution.

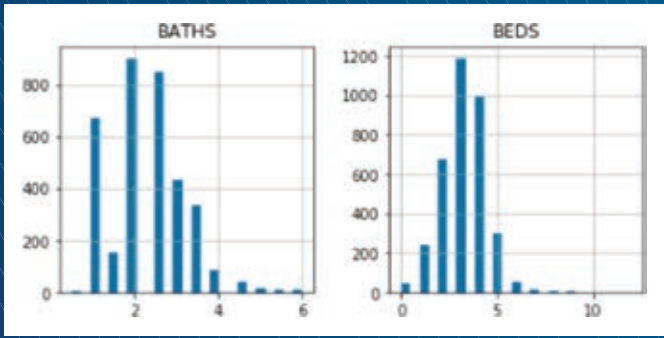


↑ Figure 1: Histograms of the number of baths and bedrooms that show the data has been heavily skewed by outliers.

There are different approaches to filtering outliers. A popular one is a 6 sigma filter, which removes values that are greater than 3 standard deviations from the mean. This filter assumes that the data follows a normal distribution and uses mean as the measure of centrality. However, when data suffers heavily from outliers, as in this case, the mean can get distorted.

An Inter Quartile Range (IQR) filter uses median, which is a more robust measure of centrality. It can filter out outliers that are at a set distance from the median in a more reliable fashion. After removing outliers using the IQR filter, the distribution of numeric columns looks much healthier.

↓ Figure 2: Histograms of the same numeric columns after missing value imputation and removal of outliers are improved.



Exploratory Data Analysis

Pandas provides an efficient API to explore the statistical distribution of the numeric columns. To explore the spatial distribution of this dataset, use the ArcGIS API for Python.

```
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline

from arcgis.gis import GIS
from arcgis.features import GeoAccessor, GeoSeriesAccessor
```

↑ Listing 1

The GeoAccessor and GeoSeriesAccessor classes add spatial capabilities to pandas DataFrame objects. Any regular DataFrame object with location columns can be transformed into a Spatially Enabled DataFrame using these classes.

Similar to plotting a statistical chart out of a DataFrame object, a spatial plot using an interactive map widget can be plotted out of a Spatially Enabled DataFrame. Renderers such as heat maps can be applied to quickly visualize the density of the listings.

Plotting a Spatially Enabled DataFrame with a heat map renderer shows the presence of hot spots. The ArcGIS API for Python comes with an assortment of sophisticated renderers that help visualize the spatial variation in columns such as PROPERTY PRICE, AGE, or SQUARE FOOTAGE. Combining maps with statistical plots yields deeper insights and investigates general assumptions.

↑ Figure 3: Plotting a Spatially Enabled DataFrame with a heat map renderer shows the presence of hotspots.

Running an Initial Shortlist

The rules in Listing 2, based on the houses' intrinsic features, were used to build a shortlist.

```
>>> filtered_df = prop_sdf[(prop_df['BEDS']>=2) &
                           (prop_df['BATHS']>1)&
                           (prop_df['HOA PER MONTH']<=200) &
                           (prop_df['YEAR BUILT']>=2000) &
                           (prop_df['SQUARE FEET'] > 2000) &
                           (prop_df['PRICE']<=700000)]
>>> filtered_df.shape
(331, 23)
```

↑ Listing 2

The shortlist reduces the number of eligible properties from 3,624 to 331. When plotted on a map, these properties are spread across the city of Portland. Histograms of the remaining 331 show that most have four beds and the majority are skewed toward the upper end of the price spectrum.

Quantifying Access

When buying a house, you are looking for proximity to services such as groceries, pharmacies, urgent care facilities, and parks. The geocoding module of the ArcGIS API for Python can be used to search for such facilities within a specified distance around a house, as shown in Listing 3.

```
from arcgis.geocoding import geocode
# search for restaurants in neighborhood
restaurants = geocode('restaurant', search_extent=prop_buffer.extent,
max_locations=200)
# search for hospitals
hospitals = geocode('hospital', search_extent=prop_buffer.extent,
max_locations=50)
```

↑ Listing 3

Another important consideration is the time it takes to commute to work or school. The network module of the ArcGIS API for Python provides tools to compute driving directions and trip duration based on historic traffic information. The snippet in Listing 4 calculates the directions between a house and the Esri Portland R&D office and the time required on a typical Monday morning at 8:00 a.m. You could add multiple stops you make as part of your commute. This information can be turned into a pandas DataFrame and visualized as a table or a bar chart. Thus, houses can be compared against one another based on access to neighborhood facilities.

```
route_result = route_service.solve(stops, return_routes=True,
               return_stops=True, return_directions=True,
               impedance_attribute_name='TravelTime',
               start_time=644511600000)
...
print("route length: {} miles, route duration
      {}".format(round(route_length,3)))
>>>
route length: 10.273 miles, route duration: 27m, 48.39s
```

↑ Listing 4

Access comparisons were run in batch mode against each of the 331 shortlisted properties. Different neighborhood facilities were added as new columns to the dataset. The count of the number of facilities a property has access to (within a specified distance) was added as the column value. If many facilities of the same kind are near a property, they all compete for the same market, keeping prices down and improving service. These houses are more attractive than the rest.

Based on the histogram, many of the 331 houses are near many different services, and the Portland market appears to perform really well when it comes to commute duration and commute length. Through these spatial enrichment steps, you can now consider these location-based attributes in addition to intrinsic property features such as the number of beds, baths, and square footage.

Scoring Properties

Evaluating houses is a deeply personal process. Different buyers look for different characteristics in a house. Not all aspects are considered equally, so assigning different weights for features will let you arrive at a weighted sum (a score) for each house. The higher the score, the more desirable a house is to you.

Listing 5 is a scoring function that reflects the relative importance of each feature in a house. Desirable attributes are weighted positively, while undesirable attributes are weighted negatively.

```
def set_scores(row):
    score = ((row['PRICE']*-1.5) + # penalize by 1.5 times
             (row['BEDS']*1)+
             (row['BATHS']*1)+
             (row['SQUARE FEET']*1)+
             (row['LOT SIZE']*1)+
             (row['YEAR BUILT']*1)+
             (row['HOA PER MONTH']*-1)+  # penalize by 1 times
             (row['grocery_count']*1)+
             (row['restaurant_count']*1)+
             (row['hospitals_count']*1.5)+  # reward by 1.5 times
             (row['coffee_count']*1)+
             (row['bars_count']*1)+
             (row['shops_count']*1)+
             (row['travel_count']*1.5)+  # reward by 1.5 times
             (row['parks_count']*1)+
             (row['edu_count']*1)+
             (row['commute_length']*-1)+  # penalize by 1 times
             (row['commute_duration']*-2)  # penalize by 2 times
            )
    return score
```

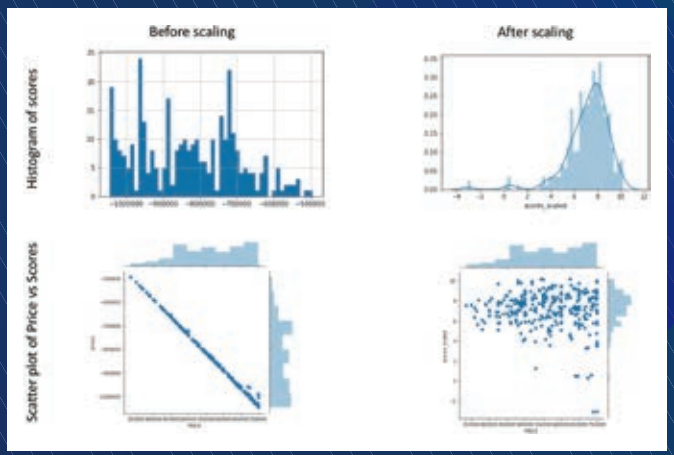
↑ Listing 5

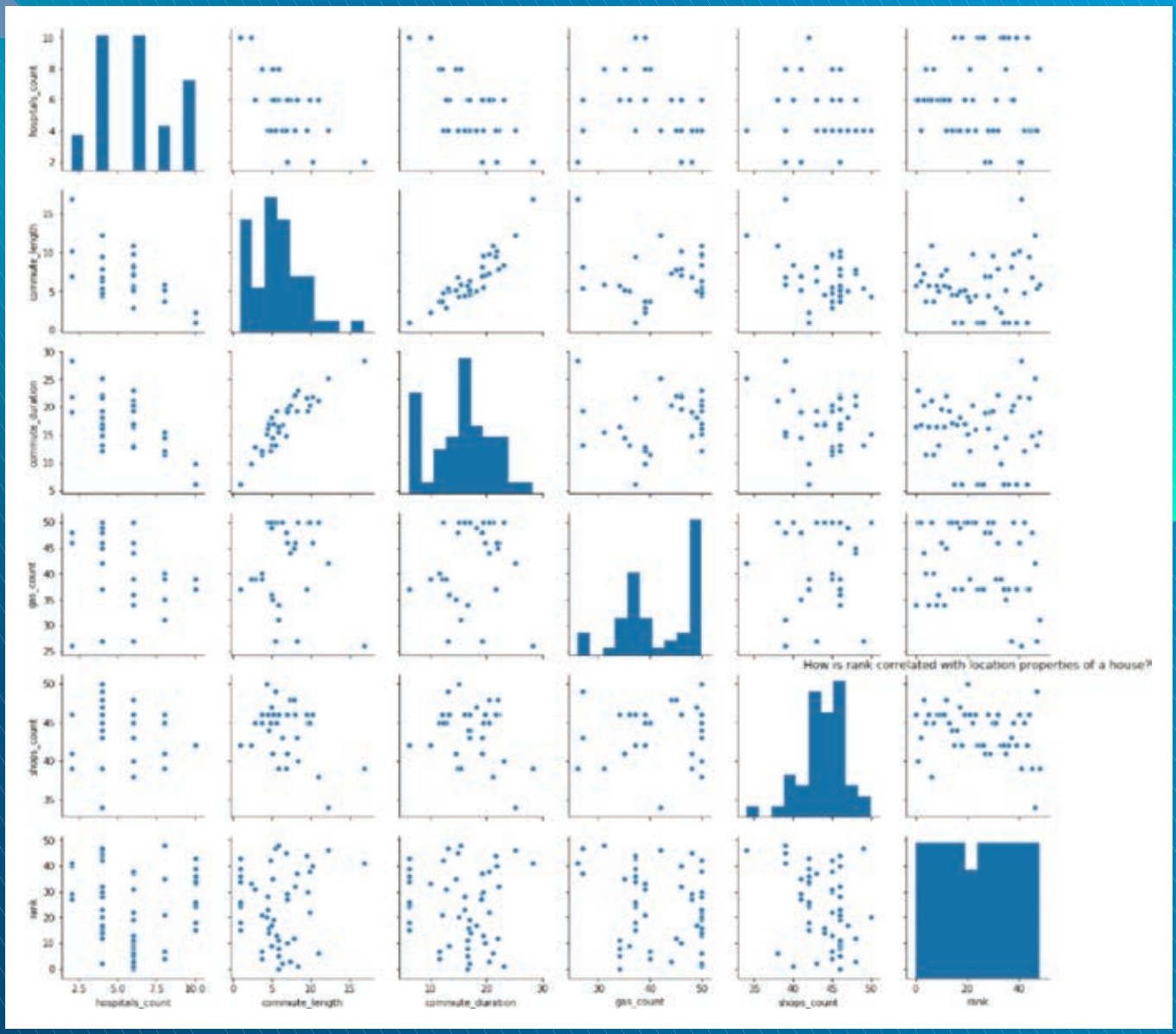
Scaling Your Data

While a scoring function can be extremely handy in comparing the features of shortlisted houses, when applied directly (without any scaling), it returns a set of scores that are heavily influenced by a small number of attributes that have numerically large values. For instance, an attribute such as property price tends to be a large number (hundreds of thousands) compared to the number of bedrooms (which will likely be less than 10). Without scaling, property price will dominate the score beyond its allotted weight. Scores computed without scaling appear extremely correlated with the property price variable. While property price is an important consideration for most buyers, it cannot be the only criteria that determines a property's rank.

To rectify this and compute a new set of scores, all numerical columns were scaled to a uniform range of 0–1 using the MinMaxScaler function from scikit-learn library. In Figure 4, the histogram and scatterplot on the right-hand side show the results of scaling: the scores appear normally distributed, and the scatter between property price and scores shows only a weak correlation.

↓ Figure 4: Property scores plots before and after scaling the numerical columns.





↑ Figure 5: The pairplot()function was used to produce these scatterplots. The diagonals of the matrix represent histograms of the corresponding variable.

Ranking Properties

Once the properties were scored, they were sorted in descending order and assigned a rank, creating a refined shortlist of homes that could be visited. In this example, the top 50 houses are spread across the city of Portland without any strong spatial clustering. Property prices, on the other hand, appear in clusters.

Most houses in the top 50 list have two baths, four beds (although the shortlist criteria was a minimum of two beds), are under 2,500 square feet, and were built in the last four years. Most houses have good access to a large number of services. Most are within 10 miles of the Esri downtown office and can be reached by a 25-minute commute.

The scaling function ensured that there is no single feature that dominates a property's score beyond its allotted weight. However, there may be some features that tend to correlate with scores. To visualize this, the pairplot() function from the seaborn library is used to produce a scatterplot of each variable against each other as shown in Figure 5.

Scatterplots of Rank vs. Spatial Features

In the scatter grid, there is randomness and stratification in the rank variable, except (understandably) between commute_duration and commute_length. In a scatter grid showing rank and various intrinsic features of the properties, the scatter between rank and property price is quite random, meaning it is possible to buy a house with a higher rank for a lower than average price. The scatter between rank and square footage shows an interesting "U" shape, meaning that as property size increases, rank gets better, but after a certain point, it gets worse.

Building a Housing Recommendation Engine

So far, the dataset was feature engineered with intrinsic and spatial attributes. Weights for different features were explicitly defined so properties could be scored and ranked. In reality, the decision-making process for buyers, although logical, is less calculated and a bit fuzzier. Buyers are likely to be content with certain shortcomings (e.g., fewer bedrooms) if they are highly impressed with some other characteristic (e.g., larger square footage). If buyers simply favor some houses and blacklist others, you could let a machine learning model infer their preferences.

Since it is difficult to collect this kind of training data for a large number of properties, a mock dataset was synthesized using the top 50 houses as the favorite group and the remaining 281 as the blacklisted group. This data was fed to a machine learning logistic regression model.

As this model learns from the training data, it attempts to assign weights to each predictor variable (intrinsic and spatial features) and predict whether that house will be preferred by a buyer. As a new property hits the market, this model can predict whether a buyer would like it and present only relevant results.

Listing 6 shows the accuracy of this model on this dataset. *Precision* refers to the model's ability to correctly identify whether a given property is a favorite or not. *Recall* refers to its ability to identify all favorites in the test set. The f1-score computes the harmonic mean of precision and recall to provide a combined score of the model's accuracy.

```
>>> classification_report(y_test, test_predictions,
                          target_names=['blacklist','favorite']);
              precision    recall  f1-score

  blacklist       0.94      0.98      0.96
   favorite       0.88      0.71      0.79
    average       0.93      0.93      0.92
```

↑ Listing 6

The training data used in this case study is small by today's standards and is imbalanced because there are fewer properties that are favorites compared to blacklists (50 vs. 281). Yet the model performs appreciably well with high f1-scores for eliminating properties that are likely to be on the blacklist.

The weights assigned by the regression model are shown on the right side of Figure 6. Based on the training data, the model learned the relative importance of each feature. When compared to the manually assigned weights shown on the left side of Figure 6, the logistic regression model has only mildly penalized property price, commute length, and duration. It has weighted features such as lot size, number of grocery stores, shops, parks, and educational institutions negatively and the rest positively. Features such as hospital counts, coffee shops, bars, and gas stations received a higher weight than when weight was assigned manually.

Conclusion

The type of recommendation engine built in this study is called content-based filtering because it uses only intrinsic and spatial features engineered for prediction. This type of recommendation needs a training set that would be too large to generate manually.

In practice, another type of recommendation engine—community-based filtering—is employed. It uses the features engineered for the properties, combined with favorite and blacklist data, to find similarity between a large number of buyers. It then pools the training set from similar buyers to create a large training set.

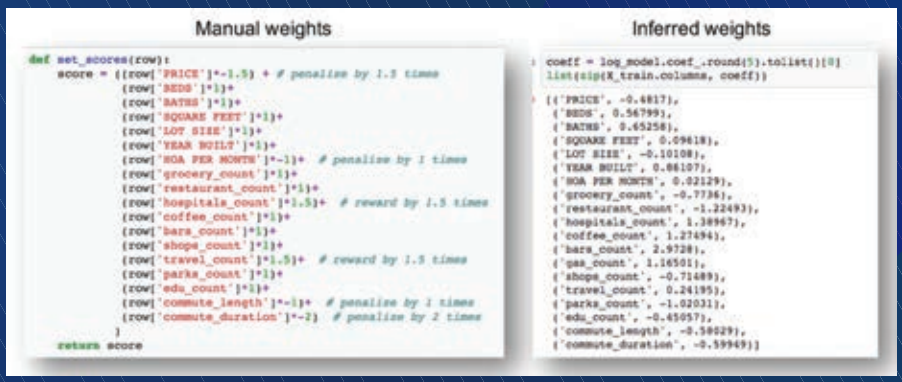
In this case study, the input dataset was spatially enriched with information about access to different facilities. This can be extended further by engineering socioeconomic features such as age, income, education level, and a host of other parameters using the geoenrichment module of the ArcGIS API for Python. Authoritative data shared by local governments under an open data initiative could also be incorporated. For this example, useful spatial layers from the city of Portland's open data site could be used to further enrich this dataset.

This article and its accompanying Jupyter Notebook (bit.ly/2rXCXub) demonstrate how data science and machine learning can be employed. Although buying a home is a personal process, many decisions are heavily influenced by location. Python libraries, such as pandas, can be used for visualization and statistical analysis, and libraries, such as the ArcGIS API for Python, can be used for spatial analysis. You can take the methods demonstrated in this article, apply them to another real estate market, and build a recommendation engine of your own.

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 span 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. 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.

↓ Figure 6: Comparison of weights manually assigned and inferred by the regression model.



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Using React with the ArcGIS API for JavaScript

By Rene Rubalcava

The ArcGIS API for JavaScript is a powerful library that you can use to build applications that leverage the power of the ArcGIS platform. While you can use the ArcGIS API for JavaScript on its own to build compelling web mapping applications, some developers choose to integrate it with other JavaScript libraries and frameworks, especially when building larger web applications.

React is a popular open-source JavaScript library that is used for building reusable UI components for web applications. It is fast and simple and pairs really well with the ArcGIS API for JavaScript, which is why this implementation pattern is becoming popular among many developers.

This article gives you a brief overview of getting started using React with the ArcGIS API for JavaScript by examining a sample application. You may want to also check out the Using Frameworks topic in the online documentation for ArcGIS API for JavaScript to learn more about working with React and other libraries and frameworks.

Getting Started

View the source code for the application on GitHub (github.com/odoe/jsapi-react). For this application, we are going to use the @arcgis/webpack-plugin to help integrate the ArcGIS API for JavaScript into our application. A best practice is to isolate the work of the API from the UI components that you are going to build. This is a nice way to maintain a separation of concerns in your development.

In this example, we are going to do the work of creating our map in data/app.js, shown in Figure 1. Looking at this code snippet, you can see that this is where we create our map and view, but we do not attach our view to the page right away. We export a function called initialize that takes an argument for the container, which is a DOM element where our MapView will be displayed. This DOM element will come from the React component that we will write.

The Component

For the WebMap component, we are going to take advantage of a brand new feature in React called hooks that lets you use state and other React features without writing a class. Hooks are still a React proposal that is scheduled to be finalized in early 2019. I wouldn't recommend using them in production just yet, but I thought it would be fun to use them for this example. There are numerous React hooks you can use, but for our purposes, we are only concerned with two: useEffect and useRef.

```
import WebMap from "esri/WebMap";
import MapView from "esri/views/MapView";
import Search from "esri/widgets/Search";

const noop = () => {};

export const webmap = new WebMap({
  portalItem: {
    id: "974c6641665a42bf8a57da08e607bb6f"
  }
});

export const view = new MapView({
  map: webmap
});

export const search = new Search({ view });
view.ui.add(search, "top-right");

export const initialize = (container) => {
  view.container = container;
  view
    .when()
    .then(_ => {
      console.log("Map and View are ready");
    })
    .catch(noop);
  return () => {
    view.container = null;
  };
};
```

↑ Figure 1: data/app.js

The useEffect hook is run after the React component is rendered. This makes it perfectly suited for dynamically loading our data/app.js module and running the initialize function we created earlier. But how do we get the element for our component? That's where useRef comes in.

The useRef hook creates an object that exists for as long as the component is mounted. In our case, we want to keep track of the DOM element that is going to be created by our React component. We can see what this looks like in components/WebMap.js, shown in Figure 2.

```
import React, { useEffect, useRef } from "react";

export function WebMap() {
  const elementRef = useRef();

  useEffect(_ => {
    // lazy load the module that loads the JSAPI
    // and initialize it
    import("../data/app").then(
      app => app.initialize(elementRef.current)
    );
  });

  // assign elementRef to the ref of our component
  return (
    <div className="viewDiv" ref={elementRef}>
    </div>
  );
}
```

↖ Figure 2: components/WebMap.js

```
import "./config";

import React from "react";
import { render } from "react-dom";

import { WebMap } from "./components/WebMap";

const rootElement = document.getElementById("root");
render(<WebMap />, rootElement);
```

↙ Figure 3: index.js

Looking at this sample, you can see that we use the useEffect hook to lazy load the module that is responsible for handling the mapping portion of our application. This is a useful pattern that you can use in your applications to dynamically load the ArcGIS API for JavaScript in your webpack applications. Now we can render this component like any other React component in our application in index.js, as shown in Figure 3. In your finished application, a React component displays a WebMap, as shown in Figure 4.

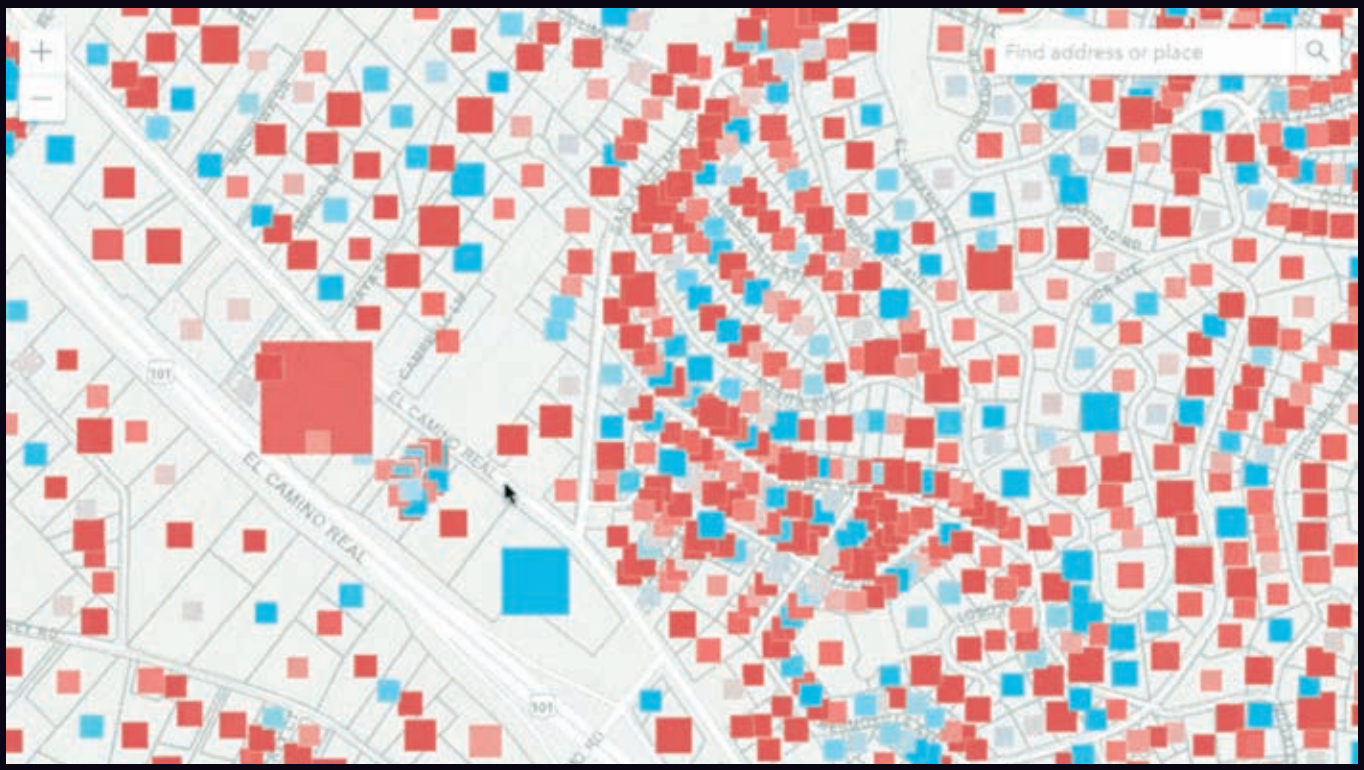
Summary

We looked at how you can isolate the work of the ArcGIS API for JavaScript in its own module in your application and then dynamically load that module in your React components. We also looked at some of the cutting-edge uses of React hooks to help you build your React components with the API.

About the Author

Rene Rubalcava is an Esri software development engineer, blogger, author, geodev, and connoisseur of programming languages and JavaScript frameworks. Follow him on Twitter @odoenet, and read his blog at odoe.net/blog.

↓ Figure 4: In your finished application, a React component displays a WebMap.



Moving from Static Spatial Reference Systems in 2022

By Jim Baumann

In 2008, the National Geodetic Survey (NGS) announced in its 10-year plan the replacement of the country's two national datums: North American Datum of 1983 (NAD 83), the geometric datum used mainly for horizontal positions, and the North American Vertical Datum of 1988 (NAVD 88), the vertical datum used for determining orthometric heights (elevations).

The NGS, the United States federal agency that maintains the country's National Spatial Reference System (NSRS), is part of the National Oceanic and Atmospheric Administration (NOAA). The NSRS is a coordinate system that is the foundation for all national geospatial products and is used for mapping and charting in a wide variety of science and engineering applications.

Datums Briefly Explained

To accurately measure the surface of the earth, surveyors have spent decades creating a complex network of brass disks embedded in the ground, known as reference points or benchmark monuments, and measuring the angles and distances between them. Horizontal benchmarks are determined by latitude and longitude, while vertical benchmarks traditionally represent the height of the reference point in relation to a datum surface (usually one that is close to mean sea level).

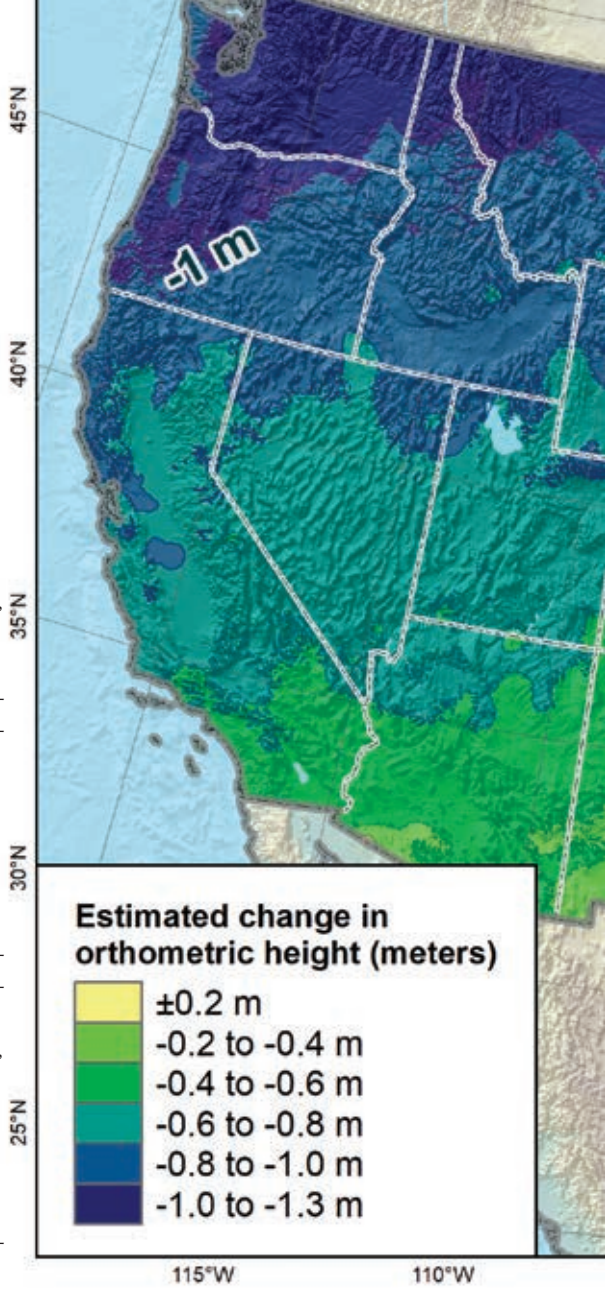
Relating those reference points into a group forms the fundamental dataset for a survey reference frame. Datums (created from such sets of data) are the basis for all geodetic survey work and indeed all types of surveying, mapping, and navigation.

A datum also can provide the basis for an abstract mathematical model of the earth known as an ellipsoid. It defines the relative definition of the size and shape of the ellipsoid and its orientation in space. Ideally, a universal datum that maintains the same level of accuracy throughout the world would be very beneficial. In reality, hundreds of different datums have been developed by individual countries that make use of their system of national reference points established over time. These datums are still in use today. This means that datums are usually most accurate in the country where they were created.

Mean sea level—which is used for the vertical benchmark measurements—is difficult to determine accurately due to coastal effects on tide gauge readings. In addition, mean sea level is not the same throughout the world because sea levels are affected by gravity, and gravitational pull is not uniform. Mountains, valleys, the varying densities of the earth's composition, and groundwater levels, as well as other natural phenomena, such as earthquakes and floods, all affect gravity.

Unfortunately, due to the number of different datums in use, the same location can be referenced by different coordinates, depending on the particular datum used. For example, there is more than a 200-meter difference for some European locations between the European Datum 1950 (ED50) and World Geodetic System 1984 (WGS84).

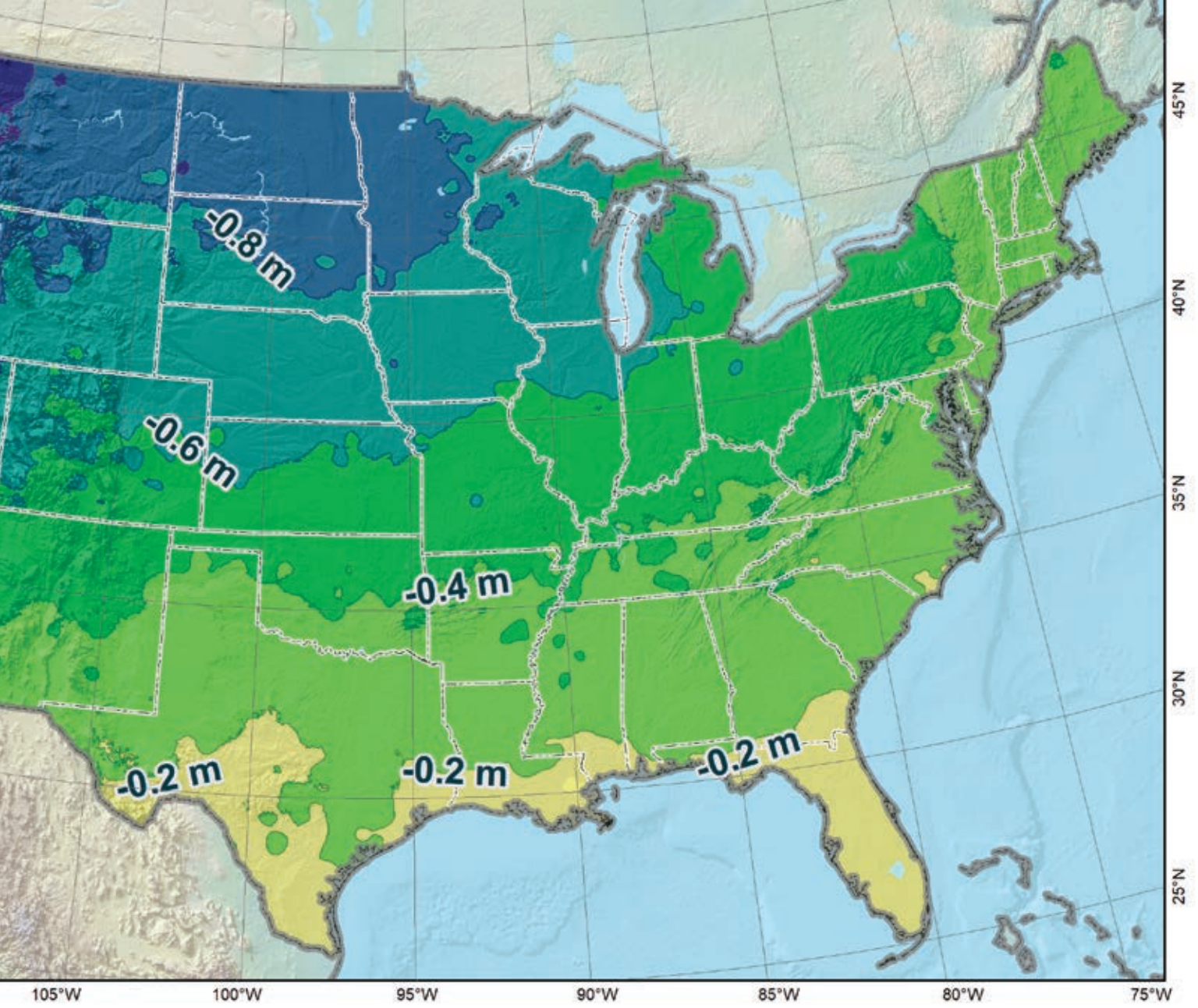
This is due in part because ED50 is based on the Hayford, or International, ellipsoid, which is larger and of a different shape than the WGS84 ellipsoid on which the WGS84 datum is based. But the primary cause is that different survey data was used to position and orient the two ellipsoids with respect to the physical earth. To reduce these differences, there is a movement toward adoption of more uniform global datums. However, such changes will take time.



The Effect of Replacing Datums

Three NGS geodesists—Michael Dennis, Dana Caccamise, and Bill Stone—provide insight into how replacing the country's two national datums—NAD 83 and NAVD 88—will impact the geospatial community.

"The accuracy of the measurements provided by the Global Navigation Satellite System (GNSS) is our primary reason for implementing new reference frames and a new geopotential datum that are consistent with GNSS measurements," said Dennis. This increased accuracy is achieved in part because the GNSS satellites orbit around the earth's center of mass, and the origin of the new reference frames will correspond with that geocenter.



↑ Predicted change in orthometric heights in the conterminous US from the North American Vertical Datum of 1988 to the North American-Pacific Geopotential Datum of 2022.

"The four new horizontal or terrestrial reference frames (TRFs) are each referenced to a specific tectonic plate, as indicated by their names: North American Terrestrial Reference Frame of 2022 (NATRF2022), Pacific Terrestrial Reference Frame of 2022 (PATRF2022), Mariana Terrestrial Reference Frame of 2022 (MATRF2022), and Caribbean Terrestrial Reference Frame of 2022 (CATRF2022). We have selected these tectonic plates because they encompass the US landmass and our territories," said Dennis. "Since tectonic plates are continually moving, the TRFs will move at the same rate (or be "plate fixed") to the rigid portion of their respective plates to maintain the accuracy of each TRF."

The new geopotential datum will be called the North American-Pacific Geopotential Datum of 2022 (NAPGD2022). Unlike the TRFs, there will be only one, and it will be built on a reference geopotential model that is global in extent (but of limited resolution), called the Geopotential Model of 2022 (GM2022). From that global model, higher resolution and more accurate regional products will be built. The three primary regional products will be a model of the geoid surface (GEOID2022), a model of deflection of the vertical (DEFLEC2022), and a model of gravity at the ground surface (GRAV2022). These regional products will be in grids, covering three separate regions. The first, and largest, will span from the equator to the pole, and from 170 to 350 degrees east longitude (10 to 190 degrees west longitude). That doesn't include all US territories, so there will be two additional, smaller regions, one for Guam and the Mariana Islands, and one for American Samoa.

According to Dennis, the data for building the geopotential datum is currently being collected and processed in a massive airborne gravity measurement project under way throughout the US and its territories, called Gravity for the Redefinition of the American Vertical Datum (GRAV-D). The project began in 2009, and the NGS is more than halfway done, but it won't be finished until 2022. Although the NGS can pretty much determine the four new TRFs now, it

decided to make these major changes simultaneously, so everything will be completed and released in 2022.

In addition, these are intended to be highly integrated systems. The historical separation of horizontal and vertical will no longer really apply. It will be a 3D system. Actually, it will be a 4D system, because it explicitly includes time. In addition, the new datums will also be aligned to the International Terrestrial Reference Frame (ITRF), which is geocentric, meaning that the origin of the ITRF is at the true center of the earth. The reference ellipsoid of NAD 83 is about 2.24 meters from the true geocenter.

"It is called a geopotential rather than a vertical datum because the vertical component is only part of the new datum. That's the part used to determine orthometric heights (elevations) and other gravity-based physical heights. It will also provide a model for the deflection of the vertical (the direction of gravity with respect to the TRFs), surface gravity, and other elements of the earth's gravity field," said Dennis.

Greater Datum Accuracy Provides Wide-Ranging Benefits

Organizations that require high accuracy in their mapping applications will likely be early adopters of the new reference frames and geopotential datum. This includes engineering and surveying firms; the transportation, utility, aviation, agriculture, and construction industries; and those agencies monitoring weather forecasts and climate change. Companies involved with autonomous vehicle navigation will also find the new datums very useful.

Because the new reference frames and geopotential datum will be based on highly accurate measurements, the consistency will make spatial analysis and aligning spatial data much easier and more reliable, which is a clear benefit for the GIS professional.

Efficiency will be another big motivator for using the new datums, especially in the vertical. The ability to get accurate elevations from satellite data in mere seconds will be a tremendous benefit. The goal is to provide GNSS-derived orthometric heights at an absolute accuracy of 4 centimeters (at 95 percent confidence).

In addition, those organizations that do business with federal agencies that have adopted the new reference frames and geopotential datum will likely also be required to use them. Most federal agencies should adopt the new reference frames and geopotential datum fairly quickly, since they are required to use the NSRS.

Some Implementation Challenges Are Anticipated

"Geospatial software vendors like Esri will have the defining parameters for the new TRFs and geopotential datum well in advance of our official release," said Caccamise. "So there should be no problem for GIS professionals to select the TRF that is appropriate for their work from preloaded menus.

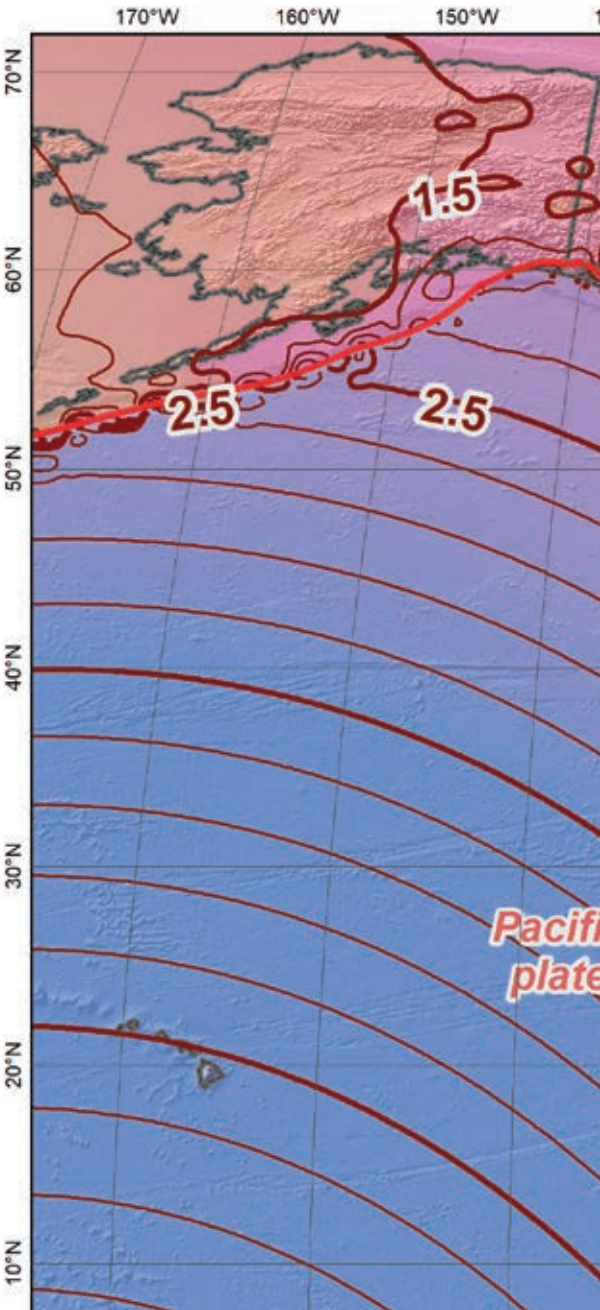
"The hard part will be dealing with the many exabytes of data found in legacy datasets. NGS will provide tools and algorithms for transforming from NAD 83 (2011/PA11/MA11) to the new TRFs, and from NAVD 88 (and the various island datums) to NAPGD2022," said Caccamise. *[NAD 83 (2011/PA11/MA11) refers to the most recent realization of NAD 83 resulting from the National Adjustment of 2011 Project: NAD 83 (2011), NAD 83 (PA11), and NAD 83 (MA11) Epoch 2010.00. The realization names, in parentheses after NAD 83, consist of the datum tag, which indicates the tectonic plate to which the coordinates are referenced and the year in which the realization was completed with the epoch date in decimal years. The datum tag* 2011 *refers to the North America plate,* PA11 *to the Pacific plate, and* MA11 *to the Mariana plate.]*

The hope is that this will satisfy many—if not most—users. However, such transformations may not be sufficiently accurate for some high-accuracy datasets. In such cases, reprocessing or readjusting data within the new TRFs and NAPGD2022 will be necessary to preserve the accuracy of the datasets as originally derived from physical observations. That could prove a major undertaking for certain datasets, and the cost of reprocessing will need to be weighed against the level of improvement in accuracy, as opposed to simply using the transformation tools provided by NGS.

"Another thing that will be new for a lot of GIS professionals is dealing with time-dependence. This also represents a considerable challenge for the software vendors. While it is true that NGS will create new reference frames that move with the tectonic plates, there are areas where the horizontal component of the Intra-Frame Velocities (IFVs) will be too great to ignore (such as the western US and Alaska). And even in areas where the horizontal component of the IFVs is negligible, there could still be significant vertical motion (like the subsidence region along the north coast of the Gulf of Mexico). Don't forget, the IFVs are three-dimensional velocities. No matter how sophisticated the model and software, user education will have to be part of any successful implementation," said Caccamise.

Looking to the Future

"As part of the new 2022 TRFs, NGS will create the State Plane Coordinate System of 2022 (SPCS2022)," said Stone. "We will



seek input from stakeholders throughout the nation on what characteristics they would like to see in SPCS2022. We expect responses will range from keeping the projection zones essentially as they currently are to states that want only a single large zone, while other states will want a large number of small zones. It will be very interesting to see the types of responses we receive and how they will impact SPCS2022."

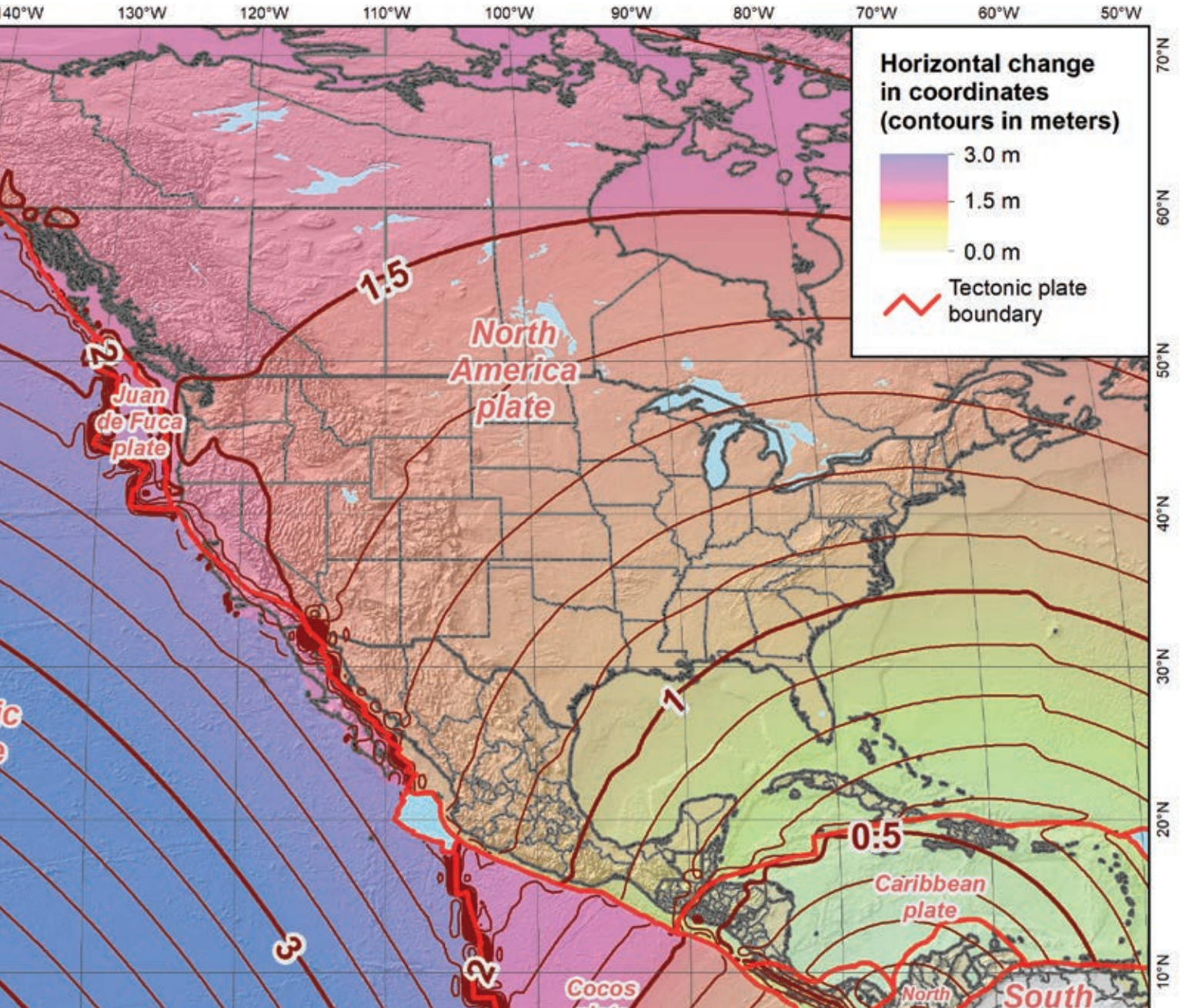
In addition, in most states, NAD 83 is specified as the official geodetic system for surveying and mapping, usually in the context of state plane in state legislation. Obviously, such statutes are not consistent with the new 2022 reference frames and geopotential datum. Last year, NGS, in conjunction with the National Society of Professional Surveyors (NSPS) and the American Association for Geodetic Surveying (AAGS), drafted a model law template for use by states in updating their statutes. The main thrust is to get away from specific names of datums and adopt generic terminology (for example, the National Spatial Reference System or its successor). "Another goal is to remove the defining parameters of state plane from statutes and place them where they can be more easily modified, such as in administrative rules. NSPS will work with states to adopt the new templates," said Stone.

"We are leaving behind forever the idea of static, unchanging spatial reference systems. This has been well-known in the geodetic community for some time. NGS is creating models, tools, and best-practice guidance for transitioning to and using the new reference frames and geopotential datum. But the details of making all of this work for the many applications that exist—and will be created in the future—still need to be dealt with. There is still much to do between now and 2022, for both NGS and our customers and partners," Stone concluded.

About the Author

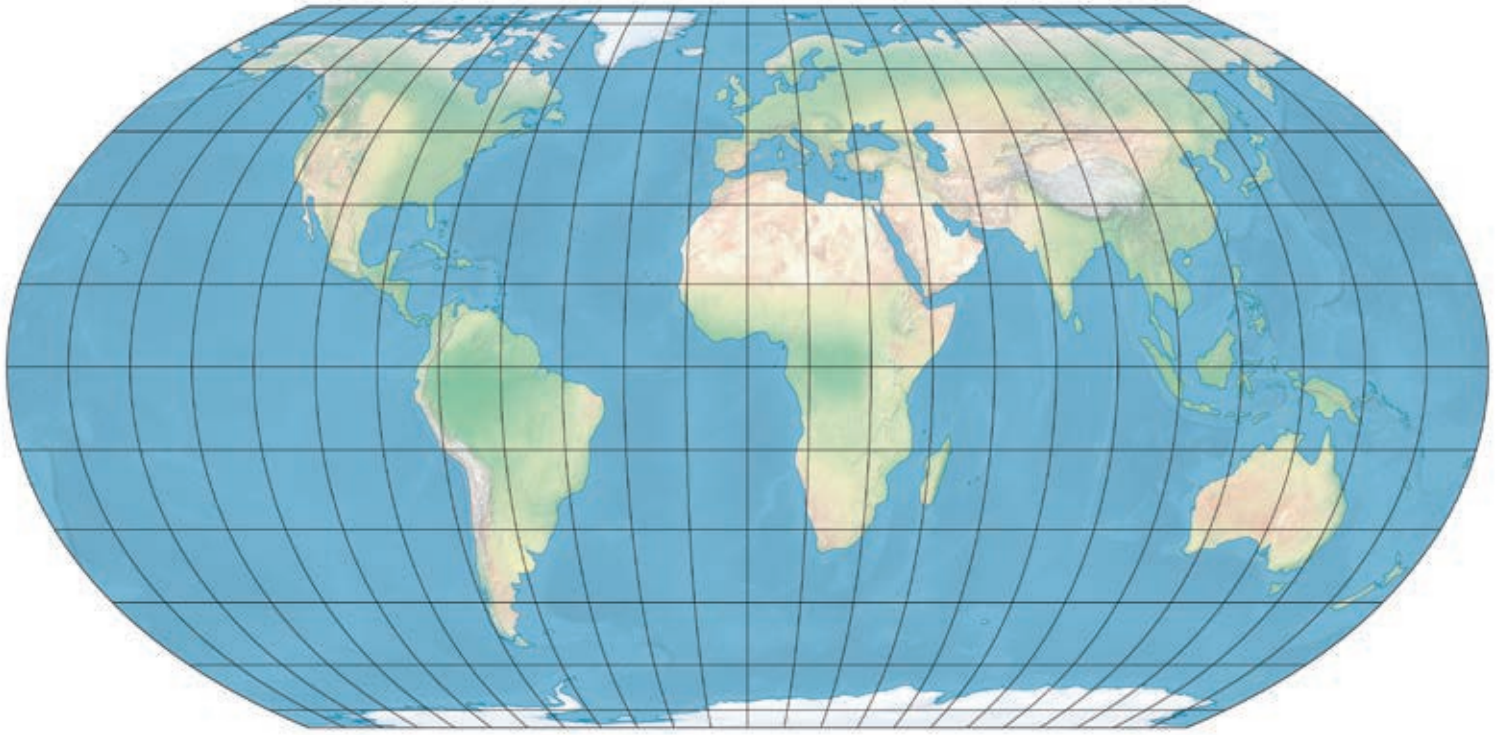
Jim Baumann, who is a longtime employee at Esri, has written articles on GIS technology and the computer graphics industry for more than 30 years.

↓ Predicted change in horizontal coordinates from the North American Datum of 1983 (epoch 2010.00) to the Terrestrial Reference Frames of 2022 for the North American, Pacific, and Caribbean tectonic plates at the initial reference epoch of 2020.00 (January 1, 2020).



New Map Projection Meets Cartographic Needs and Desires

The Equal Earth projection was created in response to a wave of news stories in 2017 following the Boston Public Schools announcement that it was switching to the Gall-Peters projection for all classroom world maps. These articles erroneously asserted that the Gall-Peters projection was the only equal-area projection that shows land features at their true relative sizes, despite the consensus about inappropriateness of this projection for small-scale mapping.



↑ The Equal Earth projection maintains the true relative sizes of the earth's features and is visually pleasing.

About a week after these stories started to appear in the news, Tom Patterson, a cartographer who has since retired from the US National Park Service, began looking at equal-area projections to identify an alternative to Gall-Peters. When he didn't find any good options, he contacted Bernhard Jenny and Bojan Šavrič to find if they would be interested in developing a more visually acceptable equal-area world map for schools and socially conscious organizations. Jenny is an associate professor of immersive visualization at Monash University in Australia. Šavrič is a software development engineer on the Projection Engine team at Esri.

Jenny and Šavrič readily agreed, and all three looked at existing equal-area projections. They liked pseudocylindrical projections because these projections better mimic the earth's spherical form with arcing lateral meridians. Some pseudocylindrical equal-area projections, such as sinusoidal and Mollweide, show the poles as points. While Antarctica retains its circular shape with this projection, the extreme compression in high latitudes where meridians converge means there is not enough room to place labels. Putninš P4′ and Eckert VI have short pole lines instead of pole points—an improvement—but map readers find the outward bulge of the lateral meridians of these projections displeasing. Eckert IV and Wagner IV came closest to meeting the team's design preferences but still had aesthetic issues.

The team decided that a new projection was needed that would have some of the characteristics of these projections. It should have a shape similar to the popular Robinson projection but possess area equivalency.

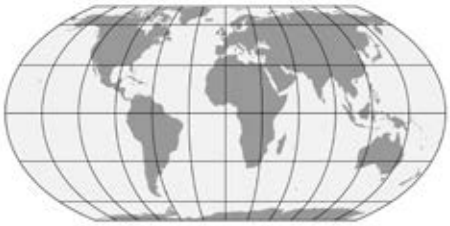
Having adopted a catchy name—Equal Earth projection—they began creating a hybrid that blended traits of Eckert IV and Putniņš P4′ using a web application developed by Jenny for designing the new projection. The team incorporated feedback from the cartographic community on the graphic design of the projection. With the graphic design determined, Šavrič wrote the equations for the Equal Earth projection, and the work of developing the projection was done.

Comparison to the Gall-Peters Projection

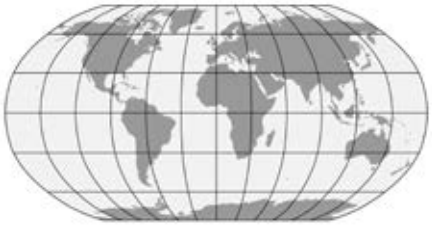
The Gall-Peters projection is cylindrical with straight parallels and straight meridians, while the Equal Earth projection is a pseudocylindrical projection with straight parallels and curved meridians. The rounded outer shape of the Equal Earth projection graticule gives the impression that the planet is a rounded object.

Although both projections maintain true relative sizes, the Gall-Peters projection greatly deforms features on the earth's surface in the tropical and polar regions: Africa is extremely elongated from north to south, and Antarctica is highly compressed and stretched along the bottom of the map. These distortions are significantly reduced in the Equal Earth projection.

Equal Earth



Robinson



↑ Comparison of the Equal Earth and Robinson projections.

Comparison to the Robinson Projection

At first glance, the Equal Earth projection seems similar to the popular Robinson projection. Both projections have a similar graticule shape, but on closer examination, the differences between the two become obvious.

↓ Because this is an equal-area map, less space was available for labeling features in Europe.

All three versions of this map can be downloaded for free at equal-earth.com.

Unlike the Robinson projection, the Equal Earth projection is an equal-area projection. It shows the continental outlines in a visually pleasing and balanced way. The landmasses in the tropical and mid-latitude areas are less elongated, and areas along the poles are less flattened and compressed as they are on similar equal-area world maps.

Slightly wider than the Robinson projection, the Equal Earth projection's meridians are equally spaced along every straight parallel line of latitude. Lateral meridians do not excessively bulge outward, loosely approximating arcs that mimic the overall appearance of a globe. The projected equator is about 2.05 times the length of the projected central meridian of the map. The poles are projected as lines that are 0.59 times the length of the equator.

Its equations are simple to implement, fast to evaluate, and also available for ellipsoidal earth models. These differences are the result of the Equal Earth projection maintaining the true relative sizes of the earth's features, unlike the Robinson projection, which exaggerates areas that are farther away from the equator.

Widely Noted and Quickly Adopted

A paper describing the Equal Earth projection, written by Patterson, Jenny, and Šavrič, was published in the August 2018 issue of the *International Journal of Geographical Information Science*. The Equal Earth map projection became one of the journal's most read papers, with more than 12,000 views. The projection has been featured in numerous science magazines including *New Scientist*, *Popular Mechanics*, *xyHt*, and *National Geographic Magazine*. It was also the subject of news articles in the *Daily Mail*, *Newsweek*, *Metro*, and *CityLab*; and was a trending topic on social media channels.

Patterson and Šavrič also introduced the Equal Earth projection in a presentation at the 2018 annual meeting of the North American Cartographic Information Society (NACIS) in Norfolk, Virginia.

Widespread adoption of the Equal Earth projection started immediately after it was announced. About a week after the projection was published, the NASA Goddard Institute for Space Studies started using the Equal Earth projection for its monthly

↓ Scattered island groups are bounded with soft gray lines for clarity.

↑ Patterson chose bright and appealing colors for the political wall map and included light shaded relief.

maps of global mean temperature anomalies. The International Association of Oil & Gas Producers also included three coordinate reference systems that use the Equal Earth projection in its EPSG Geodetic Parameter Registry just two months after the projection was published.

The Equal Earth projection is already available in various open-source and commercial GIS and mapping software such as Flex Projector, G.Projector, Panoply, GeoServer, QGIS, ArcGIS Pro, MAPublisher, Geocart and code libraries such as PROJ and D3.

Equal Earth Political Wall Map

In addition to publishing a paper about the new projection, Patterson created a political wall map that used the Equal Earth projection and was designed for schools or anyone needing a map that shows countries and continents at their true sizes relative to each other.

Because schools are the target audience for this map, Patterson chose bright and appealing colors. The map includes light shaded relief, labels for major physical features, and select populated places as well as country boundaries and capitals. It makes extensive use of vignettes. Scattered island groups are bounded with soft gray lines for clarity, although these do not represent actual maritime boundaries.

Because this is an equal-area map, less space was available for labeling features in Europe. Getting labels to fit in this area was challenging. Myriad Pro, in condensed and regular type, was used throughout.

Three versions of the map were created: one centered on the Greenwich meridian, one centered on 150 degrees east to shift the focus to east Asia, Australia, and the Pacific, and one centered on 90 degrees west with the focus on the Americas. Copies of all three versions of this map can be downloaded for free at equal-earth.com.

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Mapping Current and Proposed Effective Fire Response

By Mike Price

What You Will Need

- Access to an ArcGIS Pro license
- Sample dataset downloaded from the *ArcUser* website
- Unzipping utility
- PDF reader

In September 2018, Graham Fire & Rescue (GF&R), the fire district for a small but rapidly growing community in Washington, was awarded a grant of more than $3.5 million from the Federal Emergency Management Administration (FEMA). GIS analysis and mapping done by the district was used to support the grant application.

GF&R is a fire protection district for the community of Graham located in Pierce County, Washington, approximately 40 miles southeast of Tacoma. (See the accompanying article "About Graham Fire & Rescue" for more information about GF&R and the SAFER program.)

In this tutorial, you will create several planning and presentation maps similar to the ones used for the GF&R grant application. Although some of the data used in the tutorial is synthetic, it represents conditions in and near Graham, Washington.

Getting Started

Download the sample dataset from esri.com/arcuser and unzip it on a local machine, keeping the root path as short as possible.

Start ArcGIS Pro and open the project, GFR_SAFER_Pro.aprx, and then open the GFR_2018_SAFER_Scenario_A layout. This map layout shows Scenario A, the current GF&R effective response force (ERF), which consists of 15 available responders who travel eight minutes from their assigned stations. Inspect the layout and study data layers, titles, and the current Responders table, sorted in descending order on the Responder field.

It shows the current travel coverage for Scenario A, including five career stations (i.e., stations staffed by nonvolunteers) with current staffing. Areas are colored to represent the number of responding personnel available in eight minutes. The area covered by 1 to 5 responders is shown in pink, and the area covered by 6 to 9 responders is symbolized in blue. The minimum desired number of GF&R personnel for a first alarm is 10 firefighters, and it is shown in green. The Responders Area Sq Mi table summarizes the area covered, listed by responder count.

GF&R encompasses 70 square miles. The total area covered by 10 or more firefighters is 9.74 square miles, or approximately 14 percent of the fire district's area. Notice that the green areas are in the northwest portion of the district. This is where many Graham residents live and work.

Export a presentation PDF showing GF&R's current staffing. With GFR_2018_SAFER_Scenario_A selected, click the Share tab and click Layout Export. Set Resolution to 200 dpi, check Embedded Fonts, select Best Image Quality, and click Export. Keep the layout name GFR_2018_SAFER_Scenario_A, and store the PDF in GFR_SAFER\Graphics. Open the exported PDF in Adobe Acrobat Reader or another PDF viewer.

On the Layout tab, click Activate in the Map section to open the map associated with the GFR_2018_SAFER_Scenario_A layout. The Map tab will be activated. Click Bookmarks and choose the GF&R SAFER 1:80,000 bookmark from the drop-down. Use this bookmark whenever you need to return to the full project extent.

Assessing Staffing Alternatives

This exercise adds up to four additional firefighters to selected career stations and tests the effects of increased coverage. In Scenario B, two personnel are added. In Scenario C, four personnel are added. Mapping and analyzing these scenarios will involve copying and modifying the Scenario A map and layout. Presentation graphics showing the effects of the proposed staffing increases will also be prepared.

Before considering future staffing scenarios, review current assigned station response areas and compare them to optimized travel times that were previously modeled using ArcGIS Network Analyst.

↓ Table 1: Current and proposed staffing for stations

Scenario	Station 91	Station 92	Station 93	Station 94	Station 95	Station 96	Total	Comments
A	4	0	2	3	4	2	**15**	Current Conditions
B	4	0	2	5	4	2	**17**	Initial SAFER Staffing
C	4	0	2	5	4	4	**19**	Optimal SAFER Staffing

In the Contents pane, turn off Scenario A Group and turn on Station Response Areas and Optimized Station Areas layers located farther down the Contents pane. Solid colors shown by the Station Response Areas layer identify current assigned response zones for all six stations. Colored outlines shown by the Optimized Station Areas layer display optimized Network Analyst travel boundaries. Notice the close alignment of assigned zones and optimized travel.

To balance the workload against assigned areas, recent incidents could represent risk and be used to tabulate response load in each station's assigned area.

In the Contents pane, under the Scenario Personnel Group, turn on only Scenario A Personnel, and open its table. Scroll the table to the right and locate the Staff_SA field, which shows the 15 assigned personnel for the current deployment. Keep scrolling right and the Staff_SB field shows staffing for Scenario B, which adds two additional firefighters to Headquarters Station 94 for a total of 17 responders. The Staff_SC field shows staffing for Scenario C, which adds four additional firefighters to Station 96, giving a total of 19 responders. Table 1 summarizes current and proposed staffing for six stations.

Turn off Station Response Areas and Optimized Station Areas layers, and all layers in the Scenario Personnel Group. Save the project.

Modeling Proposed SAFER Staffing Scenarios

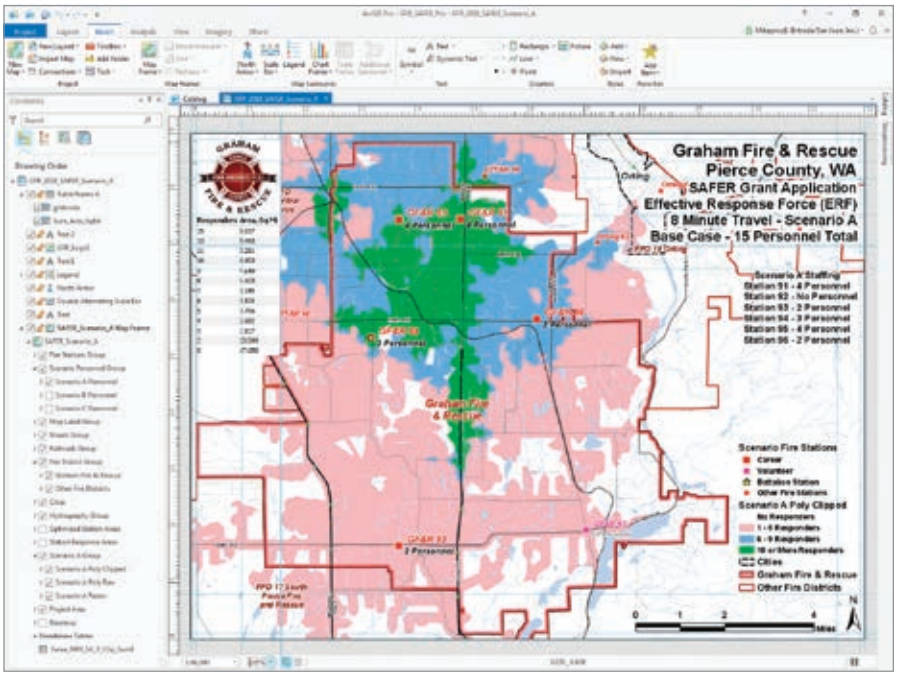
To model the two additional scenarios, create multiple copies of both the Scenario A map and layout. Fortunately, the legend for Scenario A was designed to display as many as 25 responders, so it can readily accommodate increased staffing without modification.

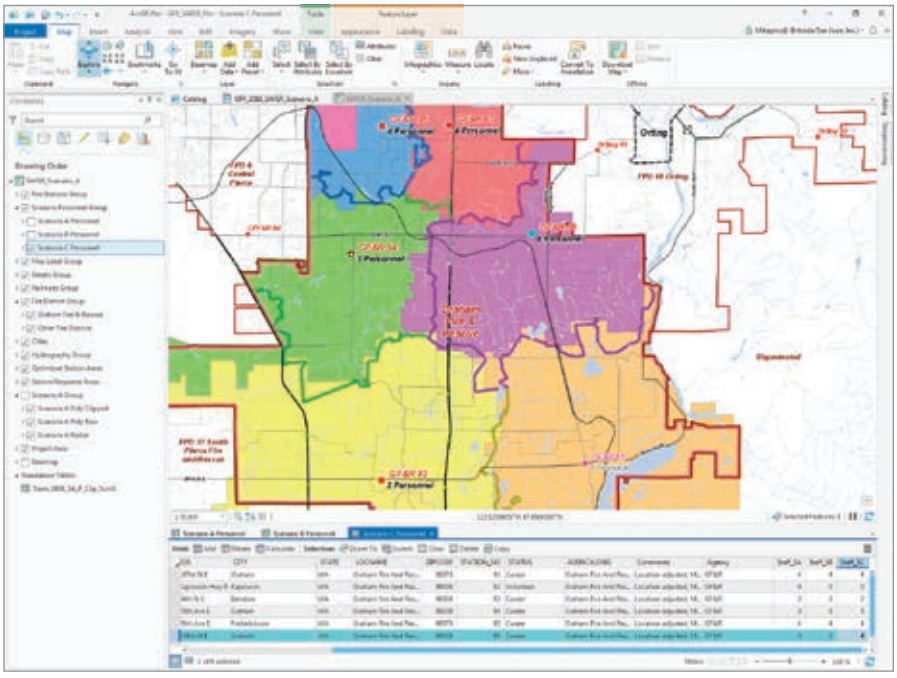
If it is not already visible, turn on the Scenario A Poly Clipped layer (located in the Scenario A Group). It shows the eight-minute responder coverage clipped to the GF&R boundary.

Click the View tab and open the Catalog pane (not the Catalog View), expand Maps, and right-click the SAFER Scenario A map. Choose Copy from the context menu. Right-click Maps and choose Paste to create a copy of the map. Repeat the process to make a second copy.

Expand Layout and repeat the process to make two more copies of the GFR_2018_SAFER_Scenario_A layout.

Rename the copies of the maps as SAFER_Scenario B and SAFER_Scenario C and the layouts as GFR_2018_SAFER_Scenario B and GFR_2018_SAFER_Scenario C. Be sure to rename maps and layouts in alpha order (from A to C). Save the project.





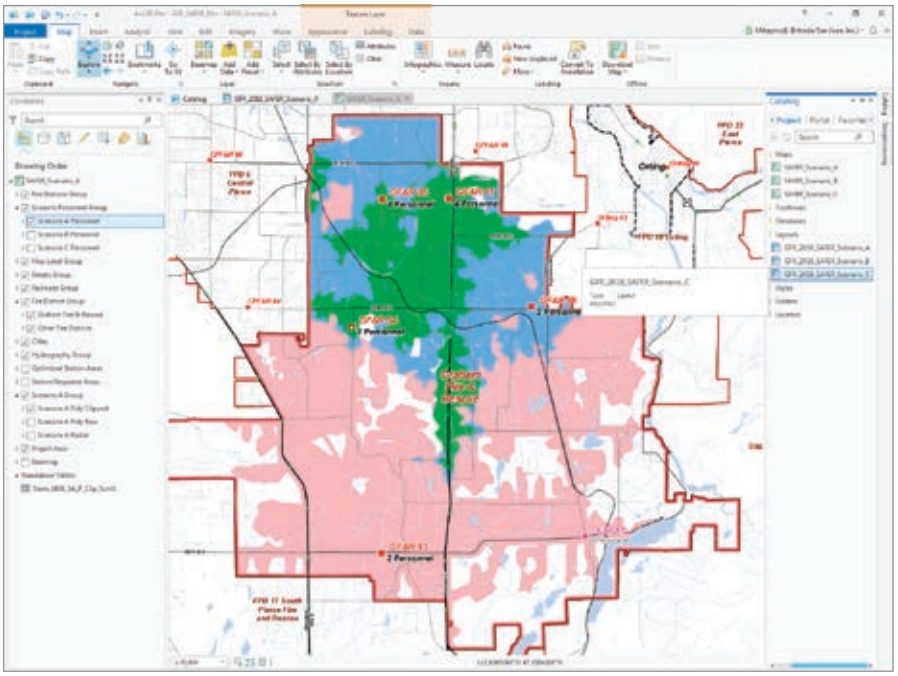
↑↑ The GFR_2018_SAFER_Scenario_A layout shows the current staffing and response for Graham Fire & Rescue.

↑ The staffing levels for the A, B, and C scenarios.

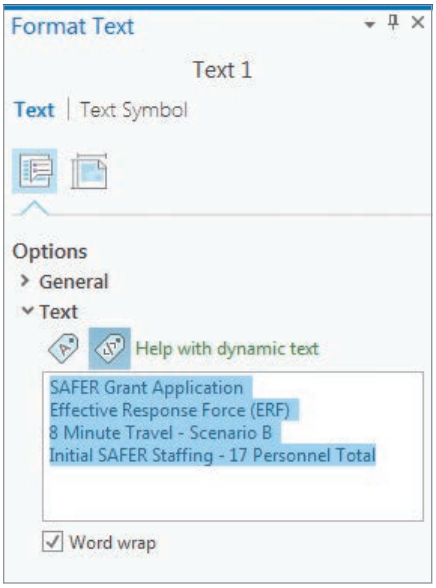
Defining and Refining Scenario B

This tutorial does not teach modeling travel using ArcGIS Network Analyst. The necessary raster and vector travel data has been included in the sample dataset in SAFER.gdb.

In the Catalog pane, under Layouts, right-click GFR_2018_SAFER_Scenario B, and choose Open.



↑ Make two copies of the map and layout for Scenario A, and rename the copies.



↑ Change the layout text for Scenario B.

In the Contents pane, under GFR_2018_SAFER_Scenario B, right-click SAFER_Scenario_A Map Frame, and choose Properties.

In Format Map Frame, click the first icon for Options, and under General, rename it SAFER_Scenario_B Map Frame.

Under Map Frame, click the drop-down and set the data source to Map SAFER_Scenario_B. Save the project.

Return to the Contents pane and double-click Text 1. In the Format Text pane, modify the text label to read 8 Minute Travel—Scenario B, Initial SAFER Staffing—17 Personnel Total.

In the Scenario Personnel Group, turn on Scenario B Personnel to see the proposed staffing of all stations. Open Text 2 and update Station 94 staffing to 5 Personnel. Save the project.

Creating and Updating Scenario B Polygons

In the Contents pane, scroll down and turn off all layers in Scenario A Group, located below the Station Response Areas layer.

Rename Scenario A Group, and the Poly Clipped, Poly Raw, and Raster layers from Scenario A to Scenario B by right-clicking on each, choosing Properties, and modifying the name. Turn on all layers.

Converting a Raster to a Polygon Layer

Right-click Scenario B Raster, and open Properties. Click Source > Set Data Source. Click Folders under Project and choose GFR_SAFER > GDBFiles > WASP83SF > SAFER.gdb, and set the data source to Sarea_0800_SB, a raster. Click OK. Save the project.

In the Catalog pane, expand Maps and open SAFER_Scenario_B. Click the Analysis tab ribbon, and click Tools.

In the Geoprocessing pane, use the Search box to locate and open the Raster to Polygon tool in Conversion Tools.

In the Raster to Polygon tool pane, set Input raster to Scenario B Raster, Field to Value, and set output as Project > Folders > GFR_SAFER > GDBFiles > WASP83SF > SAFER.gdb and name it Sarea_0800_SB_P_Raw. Check Simplify polygons, and click Run to build raw Scenario B 8-minute polygons. Sarea_0800_SB_P_Raw is added to Contents, symbolized as a single color. Turn this layer off.

Make Scenario B Poly Raw visible, and right-click to open its Properties and select Source. Set the new Source to Sarea_0800_SB_P_Raw. The desired response force, shown in green, expands to include an additional area in the central portion of the fire district. Adding two responders to Station 96 helps a lot.

Clipping Polygon to District Boundaries

Return to the Geoprocessing pane and use the Search box to locate the Clip tool in Analysis Tools > Extract).

In the Clip pane, click the drop-down for Input Features and scroll down to choose Scenario B Poly Raw near the bottom of the list.

Set Clip Features to Fire District Group\Graham Fire & Rescue.

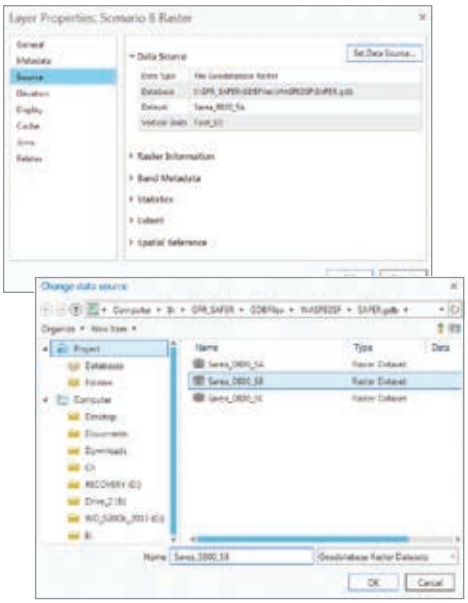
Set the Output Feature Class to Folders > GFR_SAFER > GDBFiles > WASP83SF > SAFER.gdb and name it Sarea_0800_SB_P_Clip, and click Run. It is added to Contents symbolized as a single color. Turn this layer off.

When finished, turn on Scenario B Poly Clipped layer and change its source to Sarea_0800_SB_P_Clip, the clipped raster just created. Save the project.

Calculating and Summarizing Clipped Areas

Open the attribute table for the Scenario B Poly Clipped layer. Right-click the header for the gridcode field, and sort it in descending order. The gridcode field represents the number of available responders. The Shape_Area field gives the area of individual polygons. Notice that there are more than 1,000 polygons in this dataset.

Let's add a new double precision field, calculate each polygon's area in square miles,



↑ Change the data source for Scenario B Raster.

and summarize areas for all gridcode responder values.

With Scenario B Poly Clipped highlighted in the Contents pane, click the Table tab and click Add.

A new field is added at the bottom of this table. Name the field Area_SqMi; make its alias Area, Sq Mi; and set its Data Type to Double. Click in the Number Format, to bring up the Number Format pane and choose Numeric from the drop-down. Set Rounding to three decimal places, set alignment to Left, and check the box next to Pad with zeros. Click OK.

Change the alias for the gridcode field to Responders.

Uncheck Visible for ObjectID, Shape_Length, and Shape_Area. Check visible for gridcode and Area_SqMi, and uncheck Read Only.

On the Fields tab on the ribbon, click Save to update the table. Close the Fields: ScenarioB tab.

In the updated Scenario B Poly Clipped table, right-click the Area, Sq Mi field, and select Calculate Geometry.

Set Input features as Scenario B Poly Clipped; set Target Field to Area, Sq Mi; set Property to Area; and set Area Unit to Square Miles (United States). Set the Coordinate System to the Current Map. Click Run to calculate areas.

Once the Area, Sq Mi field is populated with values, right-click the Responders header, and choose Summarize. In the Geoprocessing pane for Summary Statistics, set the Input Table to Scenario B Poly Clipped, and set output path to Folders > GFR_SAFER > GDBFiles > WASP83SF > SAFER.gdb and name the output table Sarea_0800_SB_P_Clip_Sum1. Set the Statistics Field to Area, Sq Mi; set the Statistic Type to Sum; and verify that the Case field is Responders. Click Run to create the summary table.

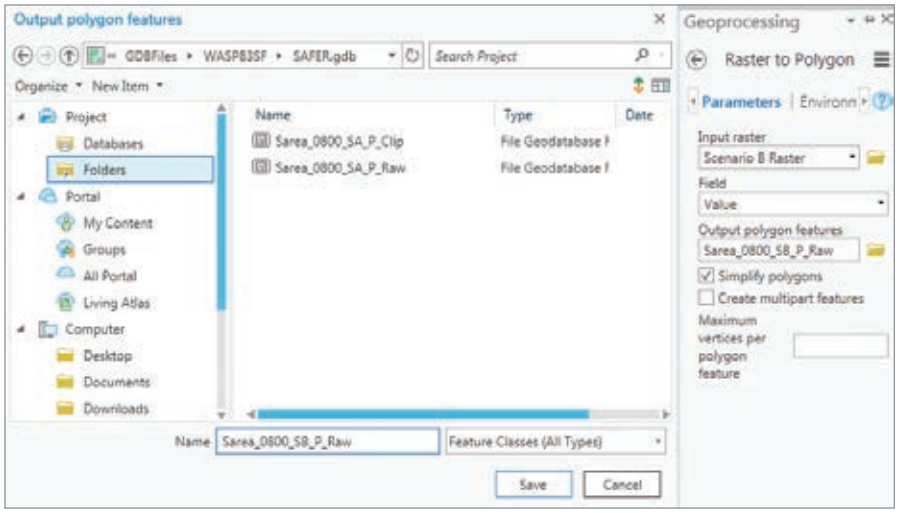
Scroll the Contents pane down, expand Standalone Tables, and open the Sarea_0800_SB_P_Clip_Sum1. Sort gridcode in descending order. Compare the Responders count to the sum of Area_SqMi.

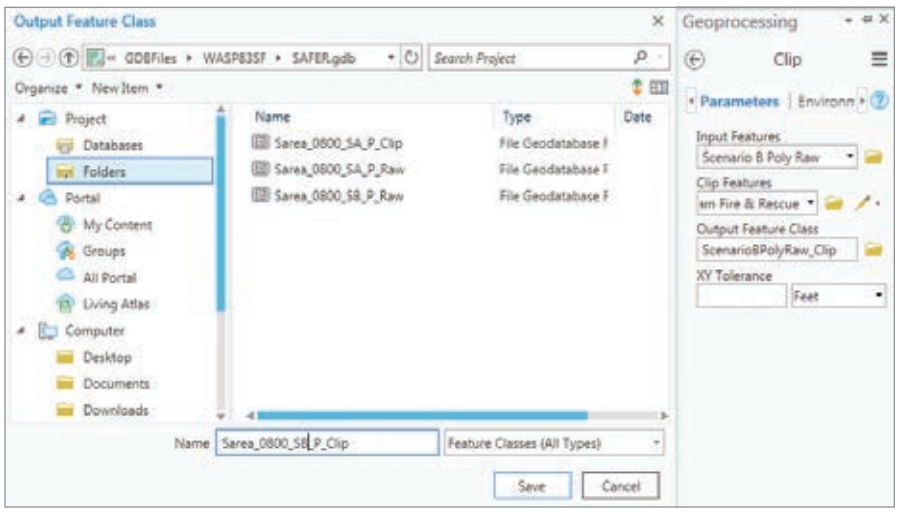
Let's update this table's appearance. Click the Table tab on the ribbon and click Fields. Set Responders as the alias for gridcode. Set Area, Sq Mi as the alias for Sum_Area_SqMi, and click Numeric in the Number Format column to bring up the Number Format pane. Set Rounding to 3 Decimal places, Alignment to Right, and check the box next to Pad with zeros. Turn off visibility for OBJECTID and FREQUENCY. Click Save in the ribbon to update the summary table. Close the Geoprocessing and Catalog panes.

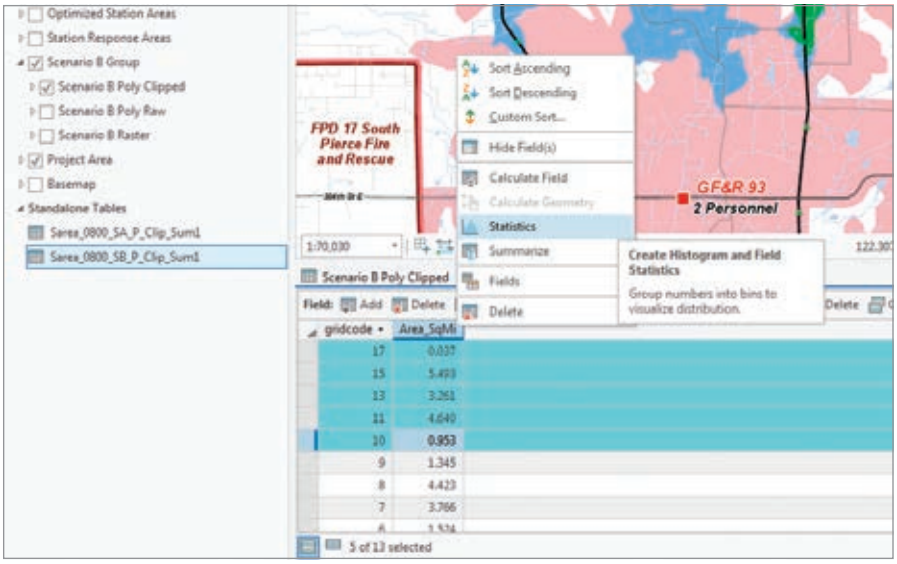
Close Fields: Sarea_0800_FER_Scenario_B). In Sarea_800_SB_P_Clip_Sum1, select all records that have 10 or more responders. Right-click Area, Sq Mi, and select Statistics. Above the chart, click the Selection Filter tab. In the Chart Properties pane, select Sum. It has a value of 14.39 square miles. This is the response area covered by 10 or

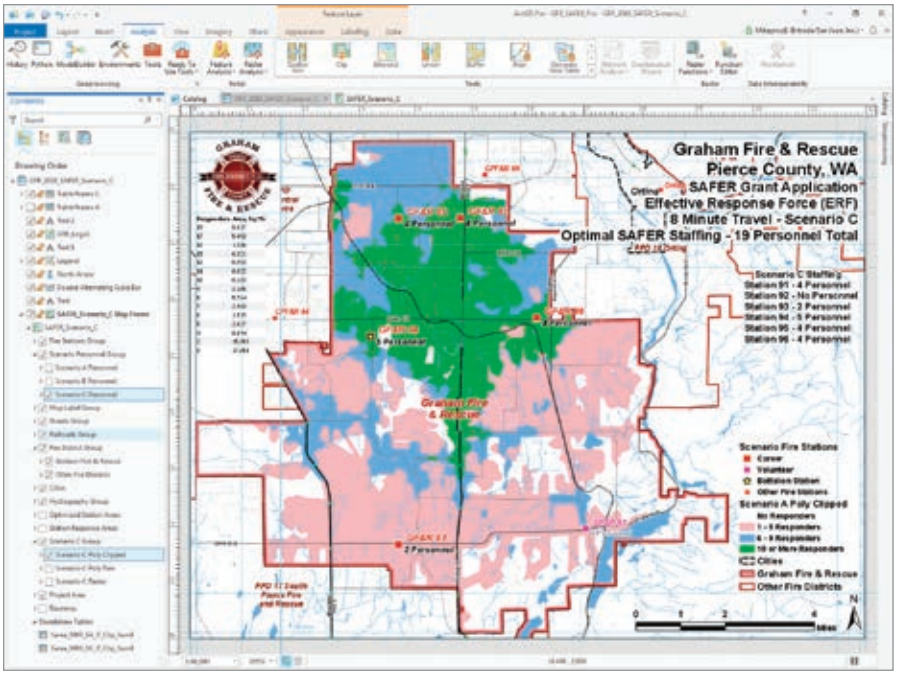
↓ Use the Raster to Polygon tool to create Sarea_0800_SB_P_Raw.

↓↓ Clip Sarea_0800_SB_P_Raw to the boundaries of Graham Fire & Rescue.









↑↑ Summarize and chart Responders (gridcode) in relation to response area in square miles.

↑ Add the summary table to the layout and format it.

more responders in Scenario B compared to Scenario A coverage of 9.74 square miles. Close the Chart Properties pane, tables, and the chart, and save the project.

Placing Tables in a Layout

Let's add the Scenario B table to the Scenario B layout. Activate the layout by clicking the SFR_2018_SAFER_Scenario B tab. Turn off Table Frame A in the Contents pane. In Contents, select Standalone Table Sarea_0800_SB_P_Clip_Sum1.

Click the Insert tab on the ribbon, and click Table Frame. Use your cursor to draw a rectangle to position the table. Outline the rectangle immediately below the GF&R logo and approximately the width of the logo, and extend it to the 5-inch ruler mark. When you release the mouse button, the table will appear.

In the Contents pane, rename the Table Frame to Table Frame B. Next, reformat the table by right-clicking it, and opening its Properties.

On the Format Table Frame pane:

- Click the icon on the far right to reset its placement width to 1.5 and its height to 2.5. Set X to 0.1 and Y to 7.55.
- Click the third icon from the left to set the display. In that pane, scroll to the bottom of the pane and set both Background 1 and Background 2 to white.
- Click the second icon from the left to set alignment. Expand Sorting, click the plus sign and add gridcode, and uncheck ascending. Leave all other settings unchanged, and close the Format Table Frame pane. Inspect the updated table and save the project.

Exporting a Scenario B Map

Now export the completed Scenario B map to a presentation PDF file. Inspect the Scenario B layout and verify that all titles are correct. Turn on Scenario B Personnel and Scenario B Poly Clipped. Open the Catalog pane and expand Layouts. Right-click GRF_SAFER_Scenario_B, and select Export to File. Navigate to GFR_SAFER, and save the file using the Layout's name.

Open the file in a PDF reader and confirm that items have been updated in Scenario B. If you find any items that need to be updated, close the PDF file, move to the project's root directory (to release a possible PDF lock), and return to your project. Make the necessary changes, save your project, and export again.

On Your Own

Now it's your turn to create a Scenario C map using the same workflow described in this tutorial. You will update one map and one layout for Scenario C. Title this map: 8 Minute Travel—Scenario C, Optimal SAFER Staffing—19 Personnel Total. Update Text 2 to reflect that Station 96 staffing has four added personnel for a total of 19 responders.

Remember to closely follow file naming rules to keep the scenarios separate. When finished, verify that the statistical Area, Sq Mi sum for 10 or more responders for Scenario C is approximately 14.59. Notice the moderate extension of area covered by 6 to 9 responders (shown in blue) and the large increase in area covered by 1 to 5 responders (shown in pink). Save the project one last time, and export the Scenario C map to complete the presentation set.

About Graham Fire & Rescue

Founded in 1962, Graham Fire & Rescue (GF&R) covers more than 70 square miles in unincorporated Pierce County, Washington, and it is centered 12 miles southeast of Tacoma. It currently serves more than 65,000 residents, encompassing the community of Graham, a United States Census Designated Area. The district includes a mix of urban, suburban, and rural densities, as defined by the National Fire Protection Association (NFPA).

The fire district is a combination department with full-time, part-time, and volunteer emergency personnel serving the community. The district provides fire and emergency medical services (EMS) response from Stations 91, 93, 95, and 96. Stations 92 and 94 (headquarters) personnel respond to fire and basic life support (BLS) calls that do not require a medical unit.

Since the census in 2000, GF&R has been the fastest-growing large fire district in Washington. Its population, as monitored by the Washington Office of Financial Management, has grown from 38,293 in 2000 to 63,397 in 2017, an increase of 65.6 percent. In 2017, GF&R responded to 6,986 calls for assistance.

Revenue wasn't keeping up with the demand for service. In February 2018, voters approved a four-year maintenance and operations (M&O) levy to increase staffing and start equipment and apparatus replacement programs. The fire district filled four open positions in September, staffing one additional medic unit to respond to emergency medical service calls this year. Currently, 70 percent of all calls received by GF&R are EMS-related.

In April 2018, GF&R applied applied for an award from the Staffing for Adequate Fire and Emergency Response (SAFER) Grants program to accelerate hiring and deal with the growing demand for its services.

The program was created in 2003, and Congress has reauthorized it twice, expanding its scope by increasing the number and type of candidate agencies and extending it through September 20, 2024. The SAFER program is administered by the Federal Emergency Management Agency (FEMA) under the Department of Homeland Security (DHS).

Grants awarded through the program are designed to provide funding directly to career, volunteer, and combination fire departments to help them increase or maintain the number of trained, frontline firefighters available in their communities. SAFER grants are intended to increase the number of firefighters to help communities meet adopted standards and attain 24-hour staffing to provide adequate protection from fire and fire-related hazards. SAFER's goal is enhancement of local fire departments' abilities to comply with NFPA staffing, response, and operational standards established by NFPA 1710 and/or NFPA 1720 standards.

In September 2018, GF&R was awarded more than $3.5 million to more quickly and consistently staff up. Ten new positions are expected to be filled by April 2019 and eight more by September 2019. The district anticipates that this will add one additional medic unit next year and will add needed personnel to fire engines, greatly increasing GF&R's effective response force (ERF) coverage.

Response times for additional staffing were modeled using ArcGIS Pro. Since district policy requires a minimum of three firefighters to enter a burning building, an engine with two responders must wait for a second unit to arrive before it can perform any search and rescue operation. In a medical emergency, additional reliability of units is also important. In a cardiac emergency, as many as 10 firefighters/emergency medical technicans or paramedics are needed for high performance CPR to ensure the best patient outcome. Additional personnel on scene also support the medical care of critical patients while they are transported to area hospitals. The new personnel supported by the SAFER award will reduce response times, improve public safety, and increase the safety and effectiveness of emergency responders.

Chief Pat Dale, who joined GF&R in 2017, noted, "The two concerns I heard when I arrived were response times and staffing levels." Since receiving the grant, GF&R is quickly improving emergency services to residents and the safety of its emergency responders. More information about GF&R can be found at www.grahamfire.com.

Summary

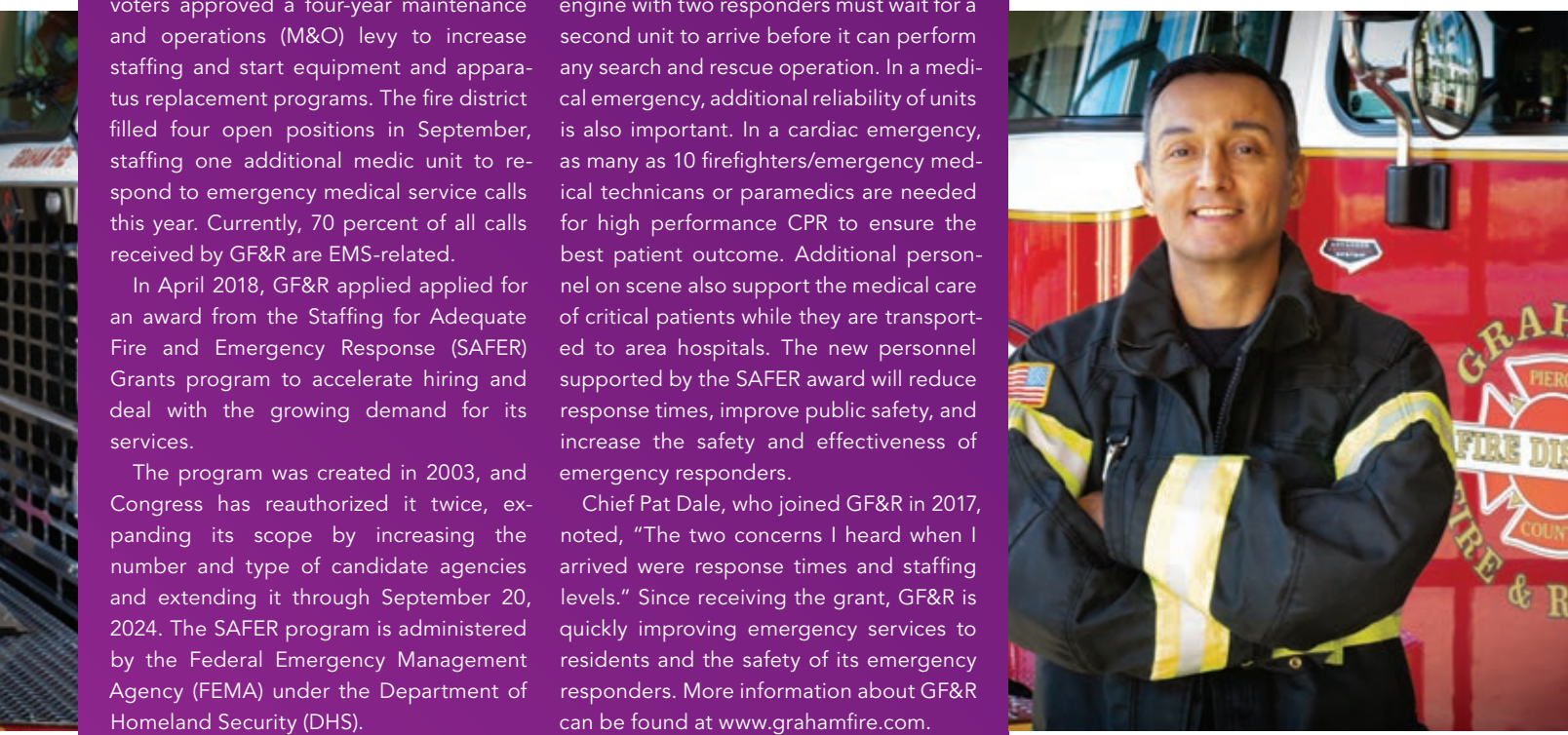
Congratulations. In this tutorial, you created three very persuasive presentation maps that show how GF&R might staff up to meet the needs of the rapidly growing community of Graham, Washington. Remember, although this exercise is strictly hypothetical, it does show how the real the needs of GF&R could be addressed.

Acknowledgments

I commend GF&R for receiving the SAFER grant and the fine service that it provides to this growing jurisdiction. Thanks to assistant chief Oscar Espinosa and the GF&R staff for help with this exercise. Thanks also to the GIS data managers in Pierce County, Washington, for providing datasets that helped represent real-world conditions.

I commend Chief Espinosa for providing planning, data integration, and technological support for the district. I respect his commitment to an ArcGIS Pro deployment "right out of the box," without having prior experience with ArcGIS Desktop. This has truly been a rewarding learning experience. I have certainly developed new workflows and teaching tricks, and I've learned a lot in the process.

↓ Chief Espinosa of Graham Fire & Rescue



Make Living Atlas Layers Work for You with Filters

By Diana Lavery

You can limit the feature layers available from ArcGIS Living Atlas of the World to just the features you need for your analysis by using filters.

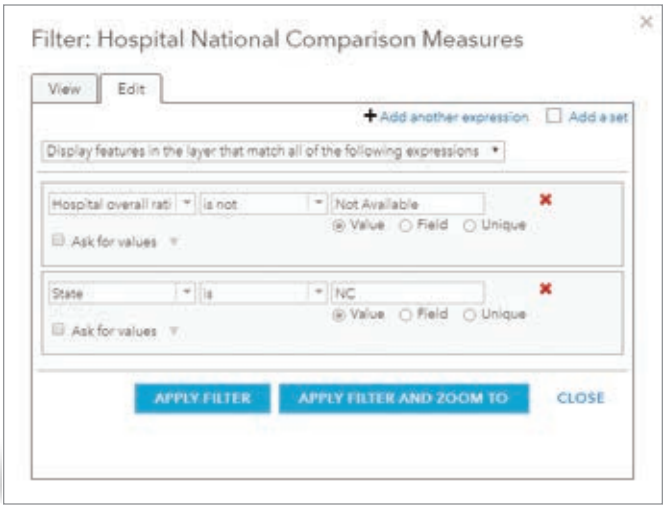
Many feature layers in ArcGIS Living Atlas of the World contain features for a larger region than you need for your analysis. Content items are added to Living Atlas every day. These items may have data for all tracts, counties, schools, hospitals, or parks in the United States, but you may only need to work with features in your immediate area. By applying filters to these national layers, you can work with a subset of these features.

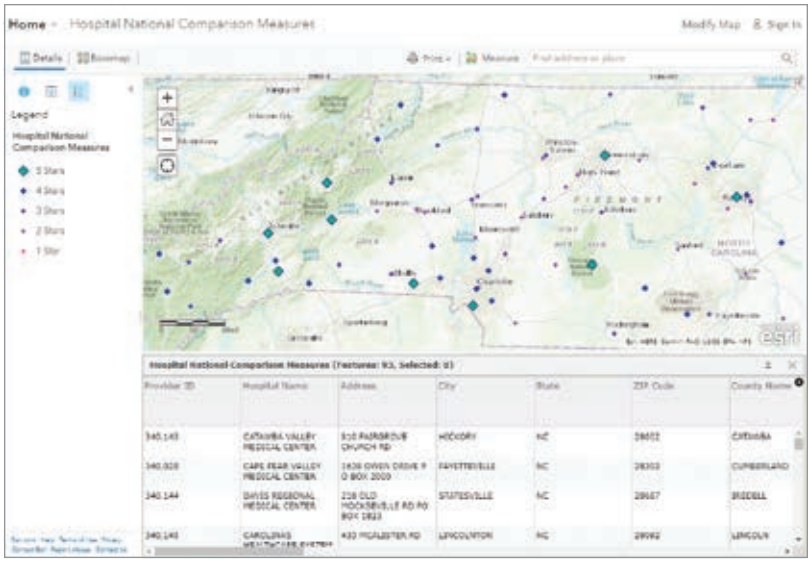
Limit Features with a Filter

For example, the Hospital National Comparison Measures feature layer in the Living Atlas contains 4,798 Medicare-certified hospitals across the United States. If you are examining health care access for Medicare beneficiaries in North Carolina, you will only be interested in the hospitals in that state.

According to this layer's item details page, a filter is applied so that only hospitals with a valid overall quality rating (i.e., hospitals with a quality rating of between one and five stars) will be displayed.

↓ Apply this filter to show only hospitals from North Carolina that have an overall rating.





↑ The results of the filter of North Carolina hospitals with overall ratings.

Any hospitals without an overall rating (i.e., hospitals with a rating Not Available) are filtered out.

To display only North Carolina hospitals, a second filter will need to be added.

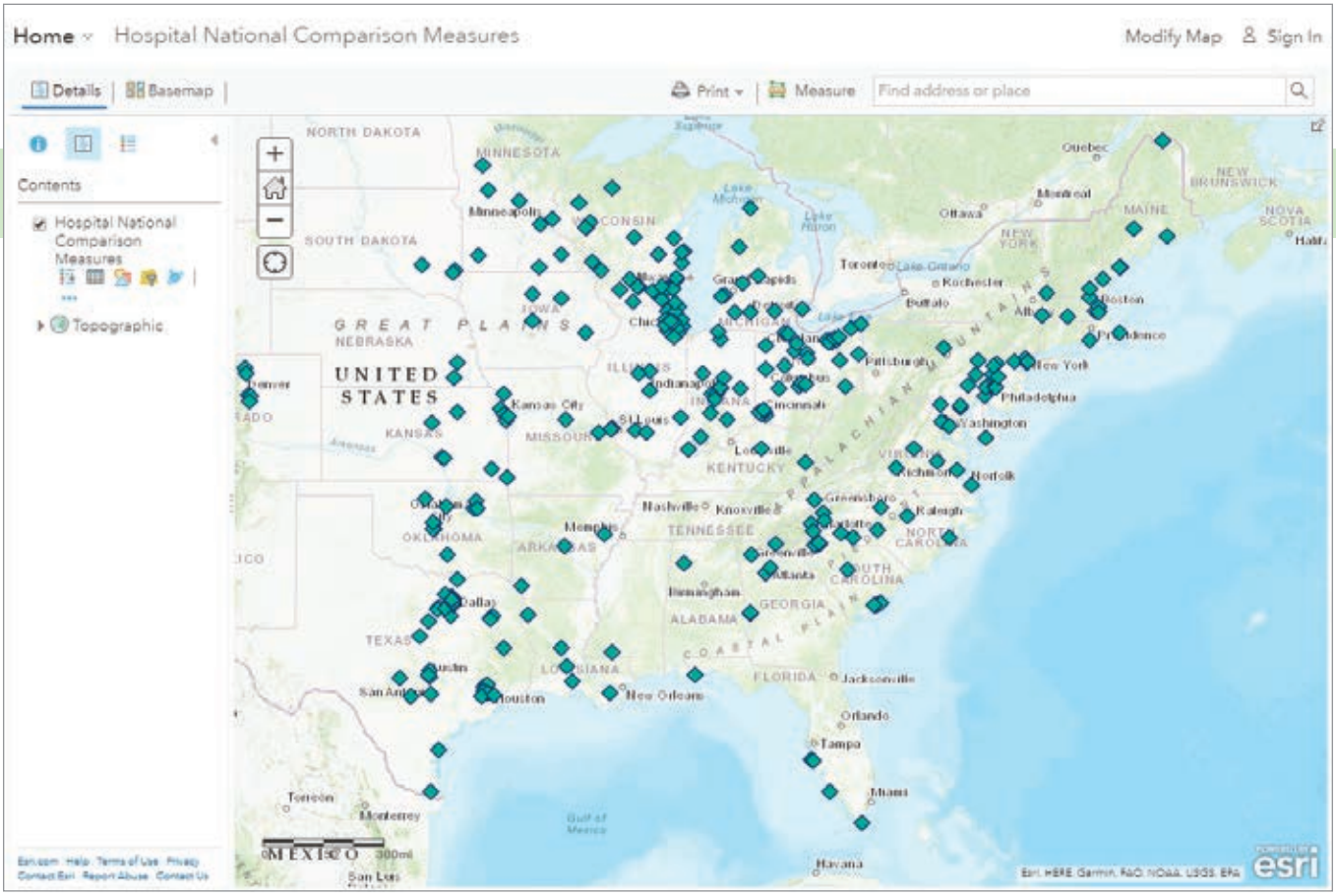
Open the filter and click Add Another Expression.

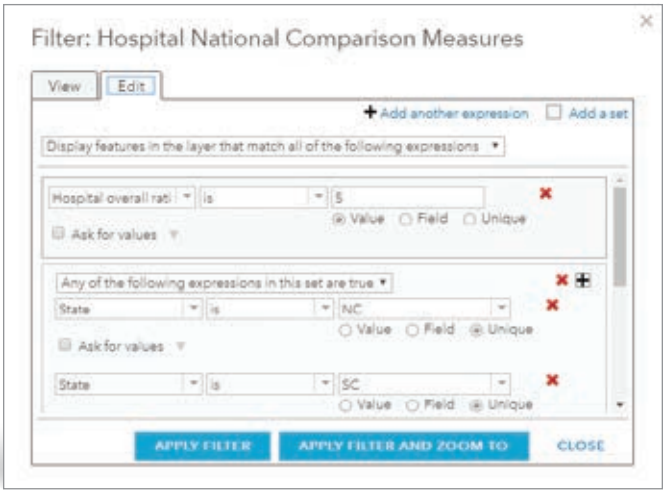
Create the expression State is 'NC'

Make sure "all of the following expressions" is chosen in the top drop-down list, rather than "any of the following expressions."

Apply the filter, and you will see only the hospitals within North Carolina with a valid quality ranking on the map and in the attribute table. Selecting "all of the following expressions" produces features that satisfy both quality and location criteria.

You can change and add to existing filters for your purposes. If you want to find out who is near a 5-star hospital, adjust the filter so that the first expression is no longer Hospital overall rating is not Not Available but Hospital overall rating is 5. Because the overall quality rating is a string field (it contains Not Available values), you will see string expressions in the drop-down (as is, is not, starts with, ends with, contains, does not contain, is blank, is not blank). If this were a numeric field, you would see options applicable to numeric fields (less than, is greater than, is at least, is at most, is between, is not between). Date fields would give you different choices such as





↑ Change the filter to expand it to show all hospitals in the US with an overall rating of 5.

← Use nested filters to display hospitals with an overall rating of 5 that are located in North Carolina, South Carolina, Tennessee, Virginia, or Georgia.

before, after, in the last day, week, month, and five days.

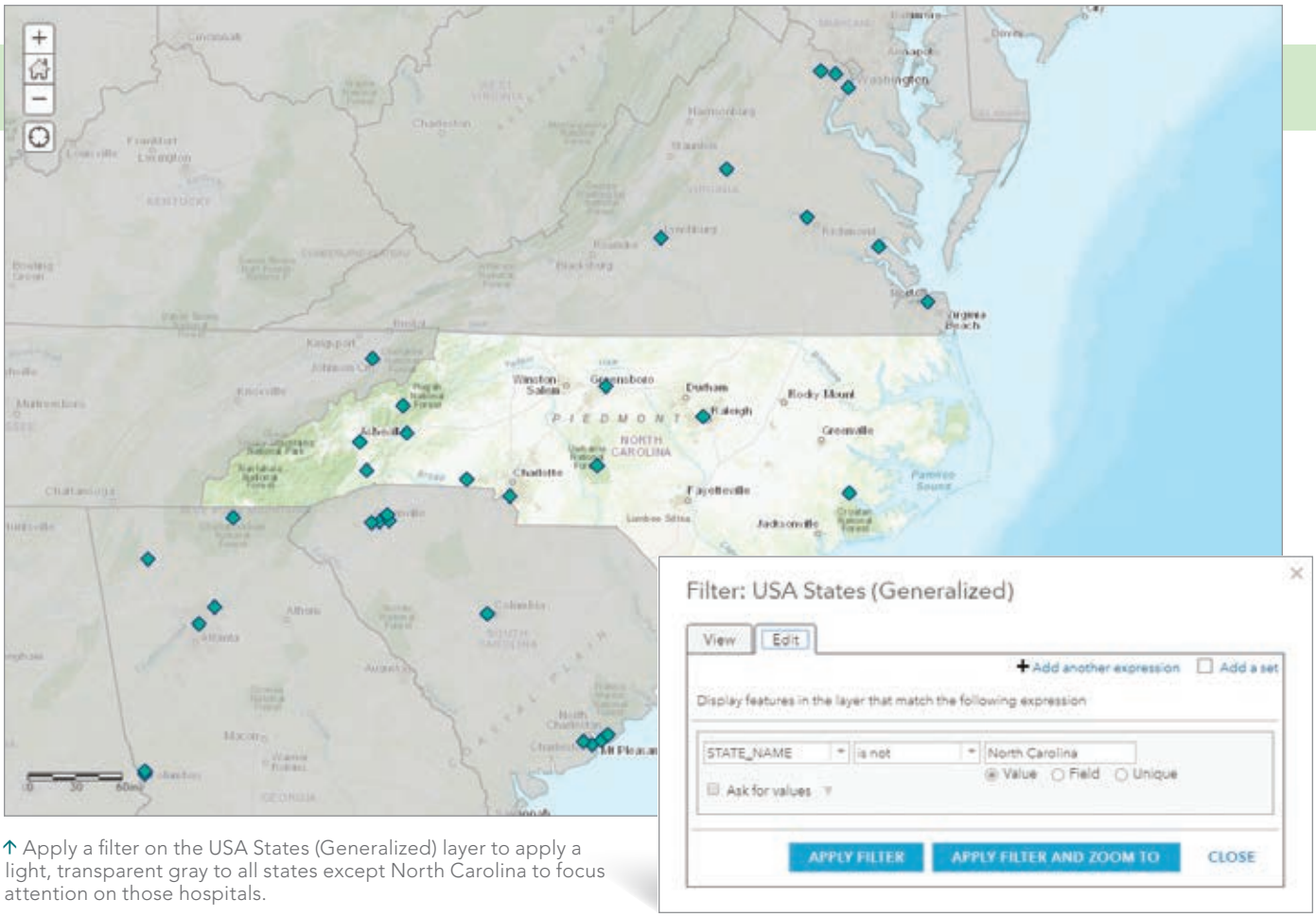
There are radio buttons underneath the third drop-down list labeled Value, Field, or Unique.

If you have a specific value you'd like to filter on, choose Value. If you'd like to compare the value in one field to the value in another field for each record, choose the Field option.

If you'd like to see all the unique values in the field that you're filtering on, choose the Unique option.

For this filter, you could manually type in a value when the radio button is set to Value, or you could select from all the unique values available by setting the radio button to Unique. Either way works.

After clicking APPLY FILTER AND ZOOM TO, the map displays only the 10 hospitals in North Carolina that have an overall quality rating of 5 stars. Make a copy of this layer with the new filter applied, rename it North Carolina 5-Star Hospitals, and save it in My Content. You could use this new layer to create drive-time areas or buffers to use the ArcGIS GeoEnrichment Service, or another type of analysis. You could repeat this process to create layers for 4-star hospitals or 3-star hospitals in North Carolina. The filter allows you to work with only the features that you need.



↑ Apply a filter on the USA States (Generalized) layer to apply a light, transparent gray to all states except North Carolina to focus attention on those hospitals.

More Control with Nested Filters

If you want even more customization, use nested filters. Grouping multiple filter expressions into sets allows for a bit more complexity in defining your subset. Say, instead of showing the 5-star hospitals in the state of North Carolina, you want to show the 5-star hospitals in neighboring states as well. It's possible that these out-of-state hospitals serve people in North Carolina who live close to state lines.

In the filter dialog box, click Add a set, and then add multiple expressions by clicking othe + sign in the new set of expressions. Because these hospitals are in only one state, this time you would select "Any of the following expressions in this set are true" rather than "All of the following expressions in this set are true." When you have added all your desired sets of expressions, click the View tab at the top to see your final filter.

Applying a Filter to Highlight an Area

If you are displaying all the hospitals in the surrounding states, you might want to focus your map clearly on North Carolina. You can do this by adding the USA States (Generalized) layer from the Living Atlas. This is a basic layer containing state boundaries and some basic population fields. To focus your map on North Carolina, you can add a filter displaying all other states and then symbolize this layer in a transparent gray. This will make everything that is not North Carolina fade into the background.

Filtering Improves Your Maps and Simplifies Your Workflows

Filtering is often a great first step in making maps more focused and defining inputs to geoprocessing and spatial analysis. Using filters in ArcGIS Online is a simple way to create a new layer that is a selection based on attributes. By applying filters, you can subset a national dataset in a Living Atlas layer to just the state, city, county, or school district that you need. You can also filter by attribute fields that are not geography based (such as hospital rating in this example) to map only the types of features you need.

Learn even more about filters by reading the ArcGIS Online help topic called Apply Filters. Read the *ArcGIS Blog* (esri.com/arcgis-blog) to learn the latest information about Esri technology.

About the Author

Diana Lavery loves working with data. She has more than a decade of experience as a practitioner of demography, sociology, economics, policy analysis, and GIS—making her a true social science quantoid. Lavery holds a bachelor's degree in quantitative economics and a master's degree in applied demography. She has been with Esri since 2017 as a product engineer on the Living Atlas and Policy Maps teams. She enjoys strong coffee and clean datasets, usually simultaneously.

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TOP 10 BUSINESS ANALYST INFOGRAPHIC FEATURES

By Helen Thompson

With the ArcGIS Business Analyst Web App's extensive library of charts, tables, interactive maps, and easy-to-customize templates, you can present information and communicate the most important facts quickly and clearly using infographics.

The Business Analyst Web App, accessed through an ArcGIS Online organizational account, applies GIS technology to extensive demographic, consumer spending, and business data to deliver on-demand analysis, presentation-ready reports, and maps.

The best infographics are self-contained summaries of what the reader needs or values. They should be designed to display content clearly so complex relationships and patterns can be understood quickly. The Business Analyst Web App has many tools for creating effective and stunning infographics. Here's my top 10 list of key features to make your infographics better.

1 Floating Panels
2 Conditional Images
3 Copy an Element from Another Template
4 Infographic Template Sharing
5 Multi-Area Comparison Table
6 Comparison Geographies
7 Nearby Tables
8 Conditional Style Lists
9 Background/Overlay Images
10 Copy a Cell Style or Conditional Style

Each feature improves your workflow and the reusability of your best infographic elements. I think of my infographics as a reusable library of styles and components that I can use to quickly build a new design to meet the specific needs of my audience. Thinking about infographics in this way and curating my ever-growing collection of design elements has saved me hundreds of hours working on new ideas, concepts, and customer-focused designs. Let's explore my top 10 list in more detail.

↑ Figure 1: This Tapestry Segmentation Profile infographic uses floating panels extensively to align logos and titles to the design, add text such as Household Income/Home Value index over the key facts infographic, and turn a square map into a teardrop shape.

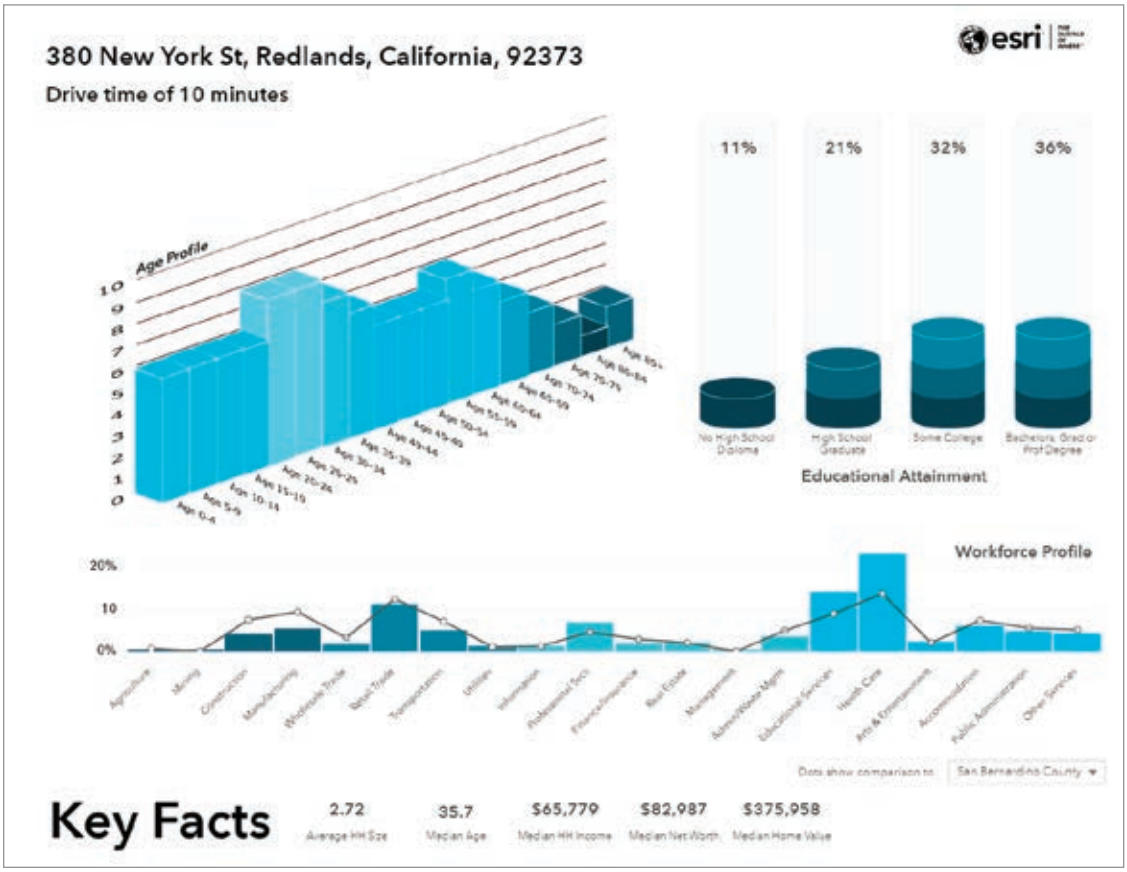
1 Floating Panels

Most of the Esri infographic templates (accessed from Reports > Build Reports > Build Infographics) use a grid design. Each element in the infographic fits into a specific cell on the grid. This makes it very easy to create uniform templates that are aligned both horizontally and vertically. While you can merge and resize individual cells, this has an impact on other cells in the template, so all designs look very rectangular.

Floating panels remove those constraints to allow you to design panels that can be of any size, positioned anywhere, and overlapped. You get pixel perfect control of the size and positioning of each elements. Three other capabilities make this my number one feature: alignment, display order settings, and automatic resizing.

Like Microsoft PowerPoint, you can align elements with other objects on the canvas. You can also change the order of panels to send them backward or forward in the display. This lets you float text boxes as titles in charts, build compound elements, or move infographic "furniture" such as your company logo, copyright information, or data source references. All these noninteractive elements are best moved into the background, allowing you to work more productively on the key charts, tables, and graphics that are the meat of your infographic.

Finally, when you resize a floating panel subelement, such as an image or text, it will automatically resize that subelement, so you can make any individual panels larger or smaller with confidence.



← Figure 2: In this 3D graph, conditional image rules based on the percentage of people in each educational attainment group have been used to create a stacked cylinder graph.

2 Conditional Images

Any attribute can be restyled using conditional text and image formatting. The graphs grow and shrink with the variations in each class, and the graphs are labeled, using a floating panel, within the chart.

In the 3D graph in figure 2, the conditional image rules based on the percentage of people in each educational attainment group has been used to create a stacked cylinder graph. Conditional images and floating panels were used to construct the Age Profile chart as well. Each age band is sliced into 10 categories, with bars of different sizes and colors for each category. This chart uses conditional lists (which is eighth on my top 10 list). I copied the style for each of the 18 bands and aligned and ordered the elements to create the bar graph.

3 Copy an Element from Another Template

I often reuse and restyle elements between infographics. My Home Affordability design uses multiple elements, which were copied from other infographics in my library. The donut chart of educational attainment was restyled from a bar graph in another design, and the workforce profile was reoriented from horizontal to portrait to fit this new design layout.

By using a design theme, I could quickly change the blues in my original to the all-white style of this template. Design themes and infographic styles didn't make my top 10 list, but they are fantastic for adding your corporate branding and quickly restyling infographics. I encourage you to check them out.

↓ Figure 3: This Home Affordability design uses multiple elements, which were copied from other infographics in my library.

4 Infographic Template Sharing

Sharing templates lets you and everyone in your organization get access to the best work, designs, and elements. Esri has provided you with a starter kit. Esri templates are opened by default when you choose Reports > Build Infographics. I copy them all the time. I have shared a couple of my designs—the Executive Summary and Tapestry Profile infographics—with the development team, and those designs have been added to Business Analyst Web App so now you can access them.

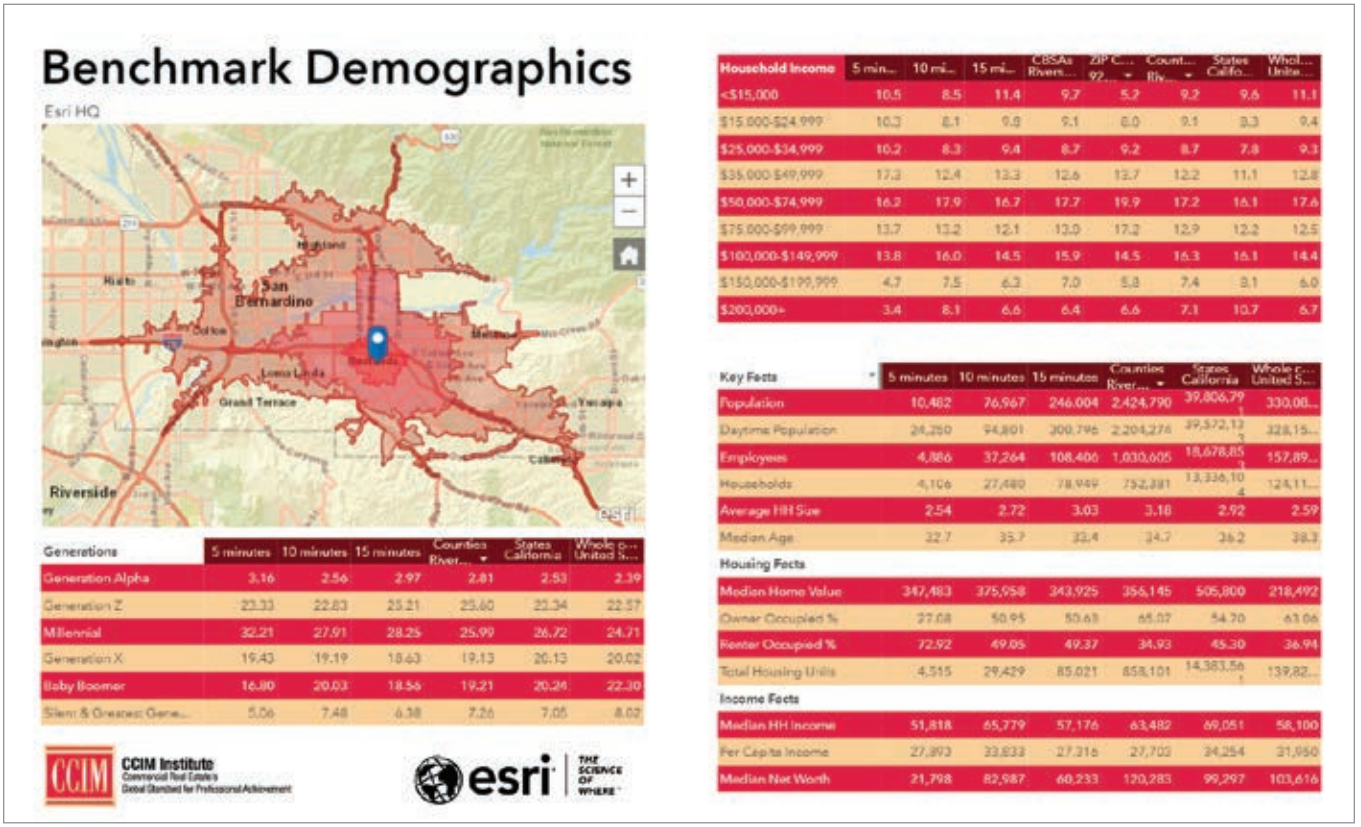
↑ Figure 4: The data summary descriptions in this Chain Link infographic are often copied by my team members to add to their own designs.

5 Multiarea Comparison Table

Typically, infographics are compiled for an individual area. Multiarea comparison tables let you see the demographics or site attributes of multiple areas side by side and compare your functional geographies—such as drive times and rings—with formal geographies like counties, urban areas, or the entire nation.

Multiarea comparison tables also allow you to interactively highlight the characteristics of each area by hovering over the map or a column in the chart. Better still, any column can be sorted or filtered to show which geographies match your leading indicators. For example, if you are looking for areas with income above the national average, use a filter to select just those geographies. All data can be swapped between a table and chart view to provide different visualizations.

↓ Figure 5: Multiarea comparison tables let you see the demographics or site attributes of multiple areas side by side and compare your functional geographies—such as drive times and rings—with formal geographies like counties, urban areas, or the entire nation.



Generations	5 minutes	10 minutes	15 minutes	Counties River...	States California	Whole c... United S...
Generation Alpha	3.16	2.56	2.97	2.81	2.53	2.39
Generation Z	23.33	22.83	25.21	25.60	23.34	22.57
Millennial	32.21	27.91	28.25	25.99	26.72	24.71
Generation X	19.43	19.19	18.63	19.13	20.13	20.02
Baby Boomer	16.80	20.03	18.56	19.21	20.24	22.30
Silent & Greatest Gene...	5.06	7.48	6.38	7.26	7.05	8.02

Household Income	5 min...	10 mi...	15 mi...	CBSAs Rivers...	ZIP C... 92...	Count... Riv...	States Califo...	Whol... Unite...
<$15,000	10.5	8.5	11.4	9.7	5.2	9.2	9.6	11.1
$15,000-$24,999	10.3	8.1	9.8	9.1	8.0	9.1	8.3	9.4
$25,000-$34,999	10.2	8.3	9.4	8.7	9.2	8.7	7.8	9.3
$35,000-$49,999	17.3	12.4	13.3	12.6	13.7	12.2	11.1	12.8
$50,000-$74,999	16.2	17.9	16.7	17.7	19.9	17.2	16.1	17.6
$75,000-$99,999	13.7	13.2	12.1	13.0	17.2	12.9	12.2	12.5
$100,000-$149,999	13.8	16.0	14.5	15.9	14.5	16.3	16.1	14.4
$150,000-$199,999	4.7	7.5	6.3	7.0	5.8	7.4	8.1	6.0
$200,000+	3.4	8.1	6.6	6.4	6.6	7.1	10.7	6.7

Key Facts	5 minutes	10 minutes	15 minutes	Counties River...	States California	Whole c... United S...
Population	10,482	76,967	246,004	2,424,790	39,806,79 1	330,08...
Daytime Population	26,250	94,801	300,796	2,204,276	39,572,13 3	328,15...
Employees	4,886	37,264	108,406	1,030,605	18,678,85 3	157,89...
Households	4,106	27,480	78,949	752,881	13,336,10 4	124,11...
Average HH Size	2.54	2.72	3.03	3.18	2.92	2.59
Median Age	32.7	35.7	32.4	34.7	36.2	38.3
Housing Facts						
Median Home Value	347,483	375,958	343,925	356,145	505,800	218,492
Owner Occupied %	27.08	50.95	50.63	65.07	54.70	63.06
Renter Occupied %	72.92	49.05	49.37	34.93	45.30	36.94
Total Housing Units	4,515	29,429	85,021	858,101	14,383,56 1	139,82...
Income Facts						
Median HH Income	51,818	65,779	57,176	63,482	69,051	58,100
Per Capita Income	27,393	23,833	27,316	27,703	34,254	31,950
Median Net Worth	21,798	82,987	60,233	120,283	99,297	103,616

6 Comparison Geographies

Charts can also be visually compared with different geographies. In the Site Summary infographic in figure 6, graphs, and tables have a drop-down list which allows the user to compare the current area with other formal geographies they cover like ZIP Code, counties, or states. If an area covers multiple formal geographies, they will be shown in the drop-down list, just as they are in multiarea comparison tables. When using comparison geographies in charts, the details of the formal geography will be shown as a line on the chart, so the reader can quickly view differences. Once again, the panels allow you to switch between chart and table view.

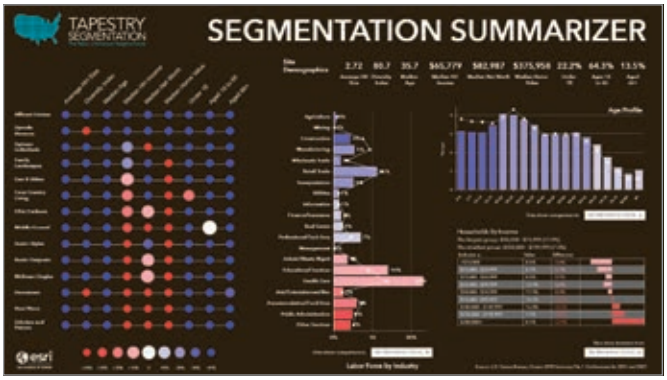
7 Nearby Tables

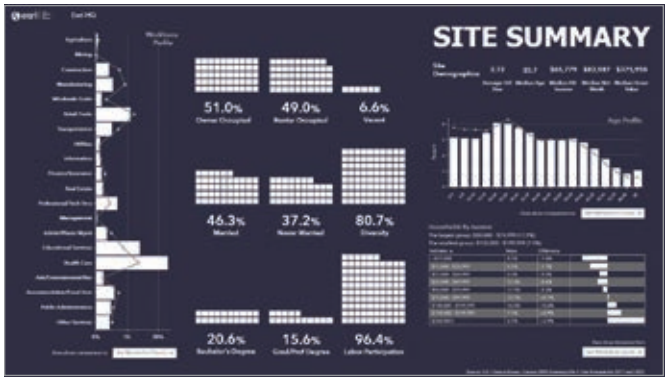
Nearby Tables are another interactive feature that can be added to infographics. Esri has a curated list of businesses by type, which you can automatically add as a table and interactive map. In addition to restaurants, shops, and convenience stores, you can add your own nearby point data using maps from ArcGIS Online. Nearby Tables show which points are in your current trade area and how far away the area is from your site.

In the What's Nearby example in Figure 7, I have added schools, parks, libraries, and other destinations published by the City of Los Angeles into a residential neighborhood infographic. Each table lists the closest facilities, which can be filtered by name, direction, or distance. Schools, hospitals, and parks are shown with different symbols on the map, and hovering over the map pin highlights the feature in the corresponding table.

I particularly like the fact that I can add a data source, like farmers markets, as a table but not show it in the map. This reduces map clutter and improves readability while still providing a dynamic table of points of interest.

↓ Figure 8: Conditional lists let me set up a rule set that I can apply whenever needed.





↑↑ Figure 6: Charts can also be visually compared with different geographies.

↑ Figure 7: In this residential neighborhood infographic, each table lists the closest facilities that can be filtered by name, direction, or distance.

8 Conditional Style Lists

I often need to develop tables that reuse styles and images. In the Segmentation Summarizer infographic in figure 8, I am comparing nine different attributes for each of the 14 Tapestry LifeMode groups. The color and size of each dot in each cell are determined by the average value of the attribute for each segment with nine different conditions for each attribute. That's 1,134 different conditional tests (if I were to hand code each one)!

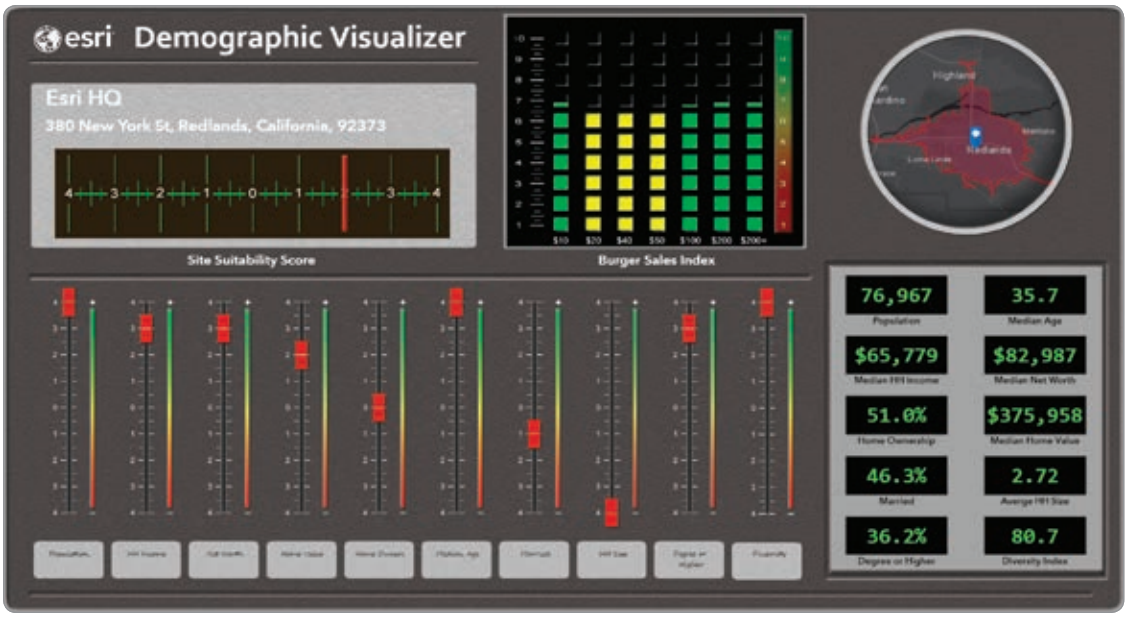
Conditional lists let me set up a rule set that I can apply whenever needed. Each list contains the categorical groupings (greater than/less than XYZ) and the image used for each category. By applying a list, I can quickly slice any variable in different ranges and then style the text using font and background colors or replace the text with an image. If I need to use a different category interval or style, I can simply edit the current styles and rules. This is considerably faster than defining those rules each time. Similarly, if I need fewer or more conditions, I can add or subtract them and be assured that I maintain the same style rules.

Conditional lists are my secret weapon to creating many different visualizations, but there are so many other features I love that it came in at number 8 on my list.

9 Background/Overlay Images

Another secret weapon is using images behind or above other elements to enhance them. In the Key Facts infographic in figure 9, I use floating panels to accurately position, align, and group the 19 different facts into the center of the honeycomb image. Many other infographics use images to enhance the design or provide the reader with more information by using legends and key art. I often use transparent and full-page images to add design effects to infographics such as drop shadows, texture, and brand colors.

↑ Figure 9: Another secret weapon is using images behind or above other elements to enhance them.



← Figure 10: The Demographic Visualizer infographic uses almost all the noninteractive features in the top 10 list: background and overlaid masking images, 3D shadows, conditional lists, and multiple and floating panels. Key to achieving this visualization was the ability to copy and paste styles between cells and data variables.

10 Copy a Cell Style or Conditional Style

Last, but certainly not least, on my top 10 list is cell-based copy and paste. I built the crazy retro Demographic Visualizer infographic using almost every one of the noninteractive features in this list. It uses background and overlaid masking images; 3D shadows; conditional lists to add textures to each cell and multiple; and floating panels to develop the entire effect. Key to achieving the final product was being able to copy and paste styles between cells and data variables.

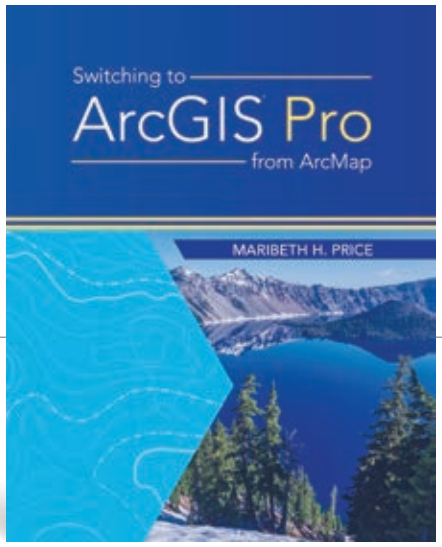
The slider button visualization was created using a conditional style in a table that contained 10 different variables. I wanted each variable to be shown in a position that reflected its variation from a target score. By copying the style of my master cell, I was able to style each column in the table in a consistent way. Using a conditional style meant I only needed to change the ranges for the different variables. I also used this technique to set the text style on the readout displays in the bottom right of the infographic.

Give It a Try Yourself

Creating beautiful, communicative infographic designs in Business Analyst Web App is much easier than most people imagine. Each of these techniques takes just a few minutes to learn and master. With a little creative flair or some inspiration found on the Internet, you'll be well on your way to making infographics that give your reader a better understanding of the demographics in an area.

About the Author

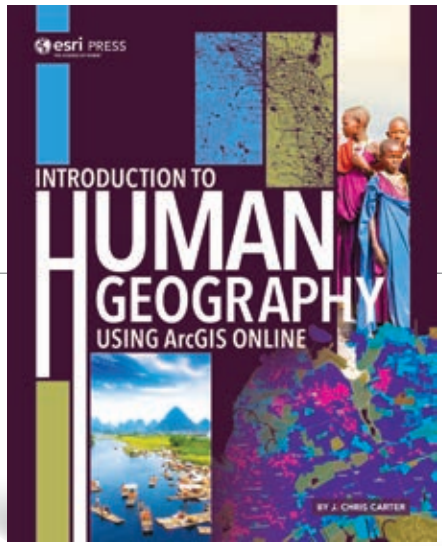
Helen Thompson is Esri's global marketing strategy manager for real estate, banking, and insurance. As a recognized thought leader and keynote speaker on spatial theory and location platforms, she has applied her entrepreneurial and technological passion to help advance the understanding and use of spatial technology in business and society. She believes that geographic context is central to creating a better future and solving some of our biggest global challenges while delivering new opportunities for consumers and businesses.



Switching to ArcGIS Pro from ArcMap

By Maribeth H. Price

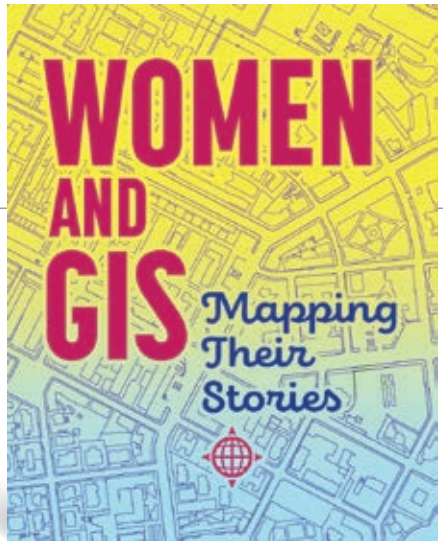
This book helps users migrate more rapidly from ArcMap to ArcGIS Pro by focusing on the differences in approach between the two rather than introducing ArcGIS Pro. It targets an audience of GIS users who are familiar with GIS concepts and ArcMap and who want to transition efficiently to ArcGIS Pro. The new software architecture and layout of ArcGIS Pro can make this transition a bit challenging for experienced users because it requires users to modify existing workflows or adopt new ones. *Switching to ArcGIS Pro from ArcMap* gets users, who are familiar with GIS and ArcMap, working productively in ArcGIS Pro by covering the most common and important workflows required for most GIS work and leveraging their prior expertise so they can more quickly adjust to ArcGIS Pro. The author, Maribeth H. Price, has been teaching GIS at the college level for more than 20 years and using Esri software for nearly 30 years. February 2019, 150 pp. E-book ISBN: 9781589485457 and paperback ISBN: 9781589485440.



Introduction to Human Geography Using ArcGIS Online

By J. Chris Carter

Why are birth rates higher in one country than another? Are there patterns and correlations that help explain this? A new classroom text teaches students how to use GIS tools and data to answer these and other questions. *Introduction to Human Geography Using ArcGIS Online* integrates an examination of human geography with engaging Web GIS activities. Readers learn how to employ sophisticated software and learn new skills so they can actively explore, analyze, and answer questions about human geography by using current data. Instructors can use this book to tailor examples and homework assignments to local geography. Author J. Chris Carter has more than 15 years of experience teaching human geography and GIS as well as world regional geography and economic geography. March 2019, 542 pp. E-book ISBN: 9781589485198 and paperback ISBN: 9781589485181.



Women and GIS: Mapping Their Stories

By The Women of Esri Press

The remarkable women profiled in *Women and GIS: Mapping Their Stories* applied themselves and the power of maps, analysis, and GIS to overcome obstacles in their professions. These stories share the childhood experiences, misstarts, and challenges they faced; the lessons they learned; and their unique paths to achieving success. For example, ecologist Natalia Ocampo-Peñuela discovered through her intensive geography-based research on birds that many more birds are endangered than previously thought. She then parlayed that discovery into a charge to refine areas and species that are deemed threatened. Environmental conservationist Madison Vorva's interests in activism have led her to apply GIS to a range of causes from successfully fighting against practices that put wild animals on the brink of extinction to showing kids—especially girls—how fun and important science and technology are. March 2019, 220 pp. E-book ISBN: 9781589485297 and paperback ISBN: 9781589485280.

The Golden Rule and Citizen Science

By Timothy L. Hawthorne

Do you remember the Golden Rule?

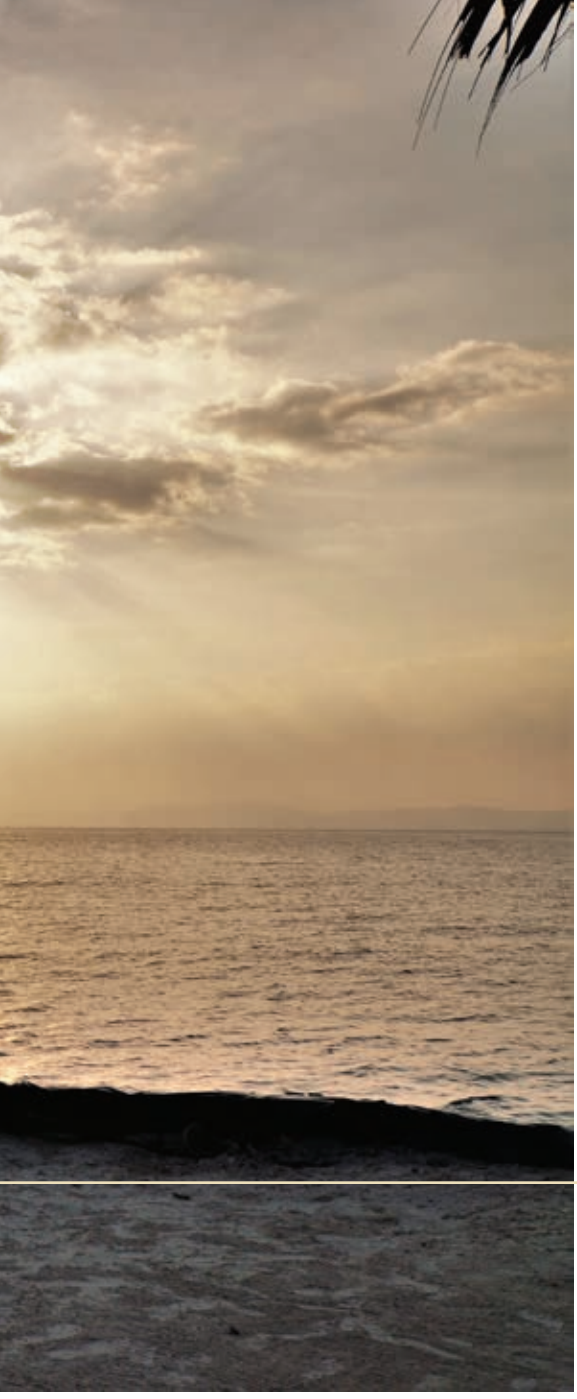
It's a simple premise learned in grade school: "Do unto others as you would have others do unto you." Values like kindness, empathy, hope, and compassion are at the core of the Golden Rule. These principles guide humanity. And believe it or not, they can play a powerful role in the everyday work of geospatial technology researchers, technicians, practitioners, and businesses.

Citizen Science GIS, an international research organization at University of Central Florida, uses spatial thinking, Esri products, and drone technologies in its work with students in the United States and Central America, communities, local governments, and nonprofits. Its goal is to make science more accessible and understandable and ensure that society can inform science and benefit from scientific discoveries.

By implementing the Golden Rule, Citizen Science GIS believes that the geospatial technology user community can become more responsive to and inclusive of members of the general public who are interested in understanding the growing and exciting role of these technologies in their everyday lives. In the process, geospatial datasets can become more contextualized, more accessible, and more representative of local knowledge.

A Guiding Principle

The Golden Rule became a major component of the work of Citizen Science GIS in Hopkins Village, Belize, during the summer of 2016. In this small fishing village of less than 3,000 people, a team of undergraduate students and faculty from the United States and Belize worked alongside community members. They examined flooding, beach debris, and coastal resiliency issues using ArcGIS Online, Esri Story Maps apps,



research in a setting that crosses cultures, values, and languages.

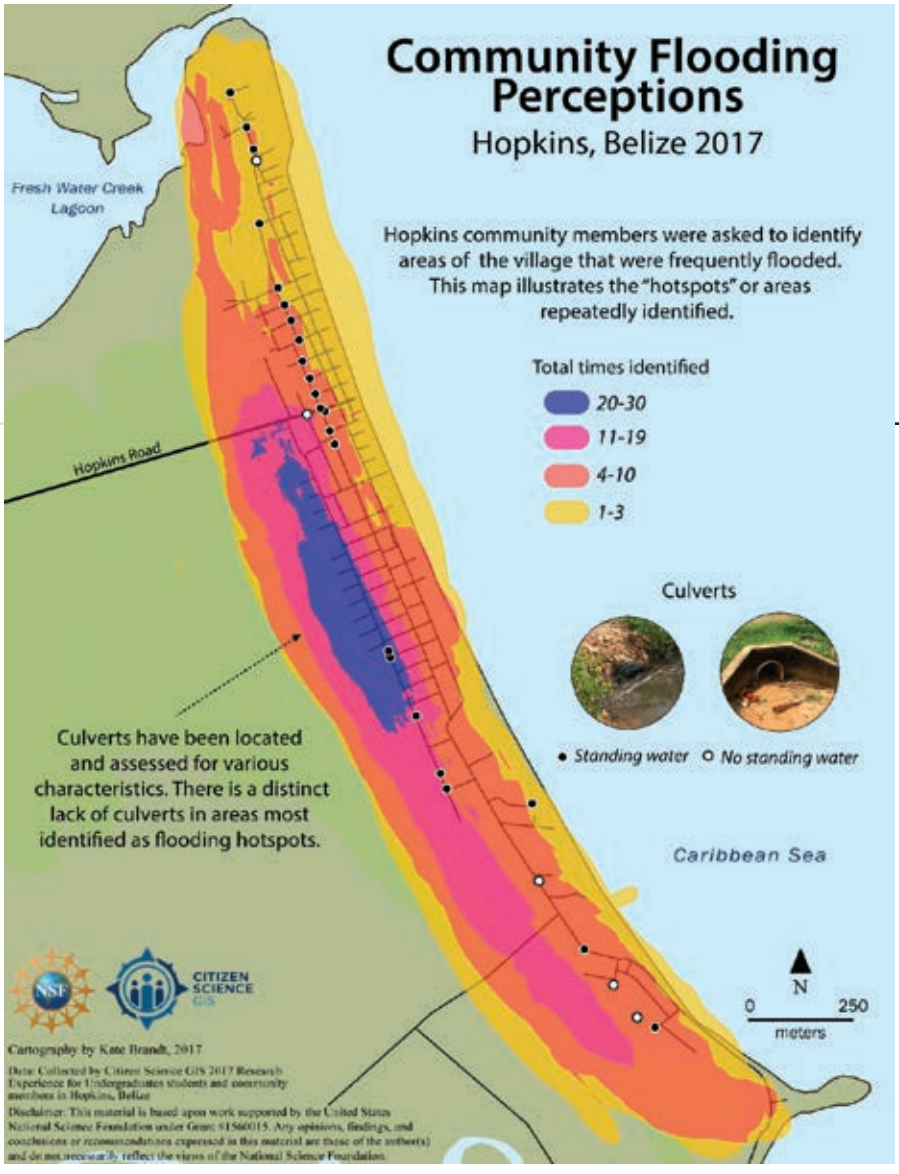
As the work began, it became clear to Citizen Science GIS that the Golden Rule would guide its use of geospatial technologies. The team emphasized the importance of including local, historical knowledge in GIS research about the village and nearby islands in Belize. Basic data about roads, parcels, land use, drainage, and flooding concerns were lacking at the village level. The village had no authoritative data in a GIS format that was accessible to either village council members or the general population.

Open Reef, a Citizen Science GIS project, is a research initiative that seeks to change the way science and society view vulnerable island environments around the world. It promotes exploration of these environments through drone mapping, open data, storytelling, and citizen science.

When the Citizen Science GIS work began in Hopkins, the message from the community members was clear: They wanted access

← Citizen Science GIS emphasizes the importance of including local, historical knowledge in its GIS-based research in the community of Hopkins and nearby islands in Belize.

↓ This map, created using information from interviews with local residents, clearly shows areas of flooding concerns.



Drone2Map for ArcGIS, Collector for ArcGIS, ArcGIS Desktop, and Survey123 for ArcGIS.

With a National Science Foundation grant and additional funding from the University of Central Florida and other supporters, the Citizen Science GIS team developed a community-based agenda to support local needs. The team interviewed community members including fishermen, families, tour guides, business owners, shop owners, resort managers, and government leaders. This work helped undergraduate students gain a glimpse into what it takes to do geospatial technology

to technology and data that supported their needs. They wanted to improve their community by having their knowledge captured using geospatial technologies.

Citizen Science GIS valued the local knowledge that was captured through hands-on experiences with the technology and shared it through spatial storytelling. This approach was applied to the village's first comprehensive study of flooding issues.

Because Hopkins is landlocked—with the Caribbean Sea to the east and a large lagoon to the west—flooding is a major concern for the community. The team went to residents and asked them to help map areas prone to flooding as well as drainage areas in their community using ArcMap, Survey123 for ArcGIS, and Collector for ArcGIS. The maps were created based on interviews with residents and clearly show areas of concern related to flooding and water flow.

Mapping flood data was just the beginning. The Hopkins Village Open Mapping Portal, a public mapping portal, was developed by local government and businesses, nongovernmental organizations (NGOs), and citizens to highlight local knowledge and the concerns expressed by community members.

The portal and the drone imagery captured by Citizen Science GIS are hosted on ArcGIS Online and provide access to basic data about flooding, culverts and drainage, street networks, and imagery for the village. These datasets differ from most of the larger proprietary or government-controlled datasets in that they were created by and with members of the local community, instead of being produced by a research or consulting team.

As Citizen Science GIS shared its science and research processes, something interesting happened. More people wanted to become part of the work and learn more about the power of geospatial technologies to address community challenges. Youth in the village, in particular, began to take a greater interest in the work.

The staff of Citizen Science GIS began working more closely with youth like one 12-year-old boy who woke up at 5 a.m. each day during his summer break to map beach debris and seaweed on the coast near his village. His dedication makes the Citizen Science GIS team hopeful that geospatial technologies can aid communities in addressing plastic pollution in the next few years.

Citizen Science GIS also works with Belizean partners like Dirk Francisco, the local Red Cross representative and a tour operator in the village. Francisco, working with other commmunity residents, has

↓ Over the last two years, Citizen Science GIS and partners in Belize have used affordable drones to completely change the way scientists and locals see the islands and coasts.

and partners in Belize have used affordable drones to completely change the way scientists and locals see more than 175 islands and coasts. This data, available on ArcGIS Online, can be located using the search term "Open Reef Belize."

Getting More People Involved

As interest in the Open Reef project grew, other organizations, researchers, and community members have expressed interest in using drones to understand and document climate change impacts and island development. Beginning in late 2019, Open Reef will sponsor the Amazing Drone Race.

← Drones have been used to map more than 175 islands and coasts in Belize. This data is freely available on ArcGIS Online.

↓ Dirk Francisco of Hopkins Village is learning to fly the drone with Lain Graham, a former Citizen Science GIS staff member and current Esri employee, along with village chairman Ted Mckoy.

flown drones to map the village of Hopkins, vulnerable Mesoamerican reef islands, and coastlines. Their work demonstrates that communities can inform and lead the geospatial technology research needed to address climate change in Belize and share the lessons they learn with others.

Some places in Belize are barely discernible in the satellite imagery that is freely available in online mapping platforms. The work with community members in the coastal village of Hopkins has led to new mapping opportunities in the Belize Barrier Islands, which are located just a boat ride east of the village.

Products like Drone2Map for ArcGIS, coupled with affordable consumer-quality drones, have allowed the team to literally put places back on the map for analysis. Over the last two years, Citizen Science GIS

The race is a 10-day citizen science mapping expedition in which as many as 10 boat teams will simultaneously use drones to map hundreds of islands in Belize over the span of 5 days. Teams will then spend an additional 5 days in Hopkins Village at an imagery summit to process, classify, and host all the imagery online for free in an open data mapping portal.

Why is Citizen Science GIS doing this? Because the team recognizes that collaboration, partnership, and serving humanity should be at the core of geospatial technology practices.

The Golden Rule Drives the Bus

The lessons learned in Belize applying the Golden Rule also drive the work of Citizen Science GIS in its home base in Florida, where it is building the nation's first GeoBus. This 40-foot bus will be decked out with gear that will make it a mobile geospatial technology lab. Starting in 2019, the GeoBus will visit schools around Florida and cultivate a geospatial technology mind-set in more than 15,000 children each year.

As GeoBus drives around Florida, youth will engage in ArcGIS Online GeoInquiry lessons, fly drones and process the resultant imagery, use virtual reality goggles to view drone imagery, learn about topography in an augmented reality sandbox, engage in field data collection using Collector for ArcGIS on tablets, and use ArcGIS Pro to explore 3D drone image scenes captured in Belize and in other parts of the world.

GeoBus will provide a unique educational opportunity by showing children just how valuable they are as geospatial technology users and scientists. The Golden Rule underlies the work of Citizen Science GIS to empower Florida kids just as it does the group's fieldwork in Belize.

↑ A conceptual sketch of the GeoBus

← Hawthorne and a local fisherman discuss drone imagery and island changes in Belize.

A Hopeful Future for Geospatial Technologies

From youth explorers in Florida to fourth-generation fishermen on the Belize Barrier Reef, Citizen Science GIS believes the knowledge of local people is more valuable and accurate than data collected exclusively by nonlocal scientists, hence the organization's emphasis on input by local citizen scientists.

Including the knowledge of everyday, extraordinary citizens represents the greatest growth potential for the geospatial industry and our greatest hope for solving the formidable social and environmental challenges facing society using geospatial technologies. As the geospatial technology industry rapidly expands, Citizen Science GIS will continue to emphasize people and apply the Golden Rule in all it does.

May all geospatial technology users continue to remember the importance of people and the Golden Rule in their work.

About the Author

Timothy L. Hawthorne is an assistant professor of GIS at University of Central Florida. He also serves as the State of Florida Geography Steward with National Geographic. He earned his PhD in geography in 2010 from Ohio State University and is a broadly trained human geographer with deep interests in citizen science, GIS, community geography, qualitative GIS, and critical GIS. *[Critical GIS is a form of GIS that considers the social, human, and ethical implications of GIS technology.]* Hawthorne is also the founding research director of Citizen Science GIS and GeoBus. He is an associate editor for *Journal of Geography* and the *International Journal of Applied Geospatial Research*.

↓ A team of undergraduate students and faculty from the US and Belize work alongside community members on issues such as flooding, beach debris, and coastal resiliency.

Six Ways to Increase Geoliteracy

By Joseph Kerski

All the big issues the world is facing today are fundamentally tied to space and place—they are geographic issues. To grapple with these issues requires a population that can assess and use geographic information to make wise decisions—in short, a geoliterate population.

So how can educators, researchers, and practitioners actively promote the inclusion of geographic knowledge, skills, and perspectives in education and society? I offer the following recommendations.

1 Tie geoawareness to the need for geography education.

A growing awareness of the geographic nature of problems from local to global scales, is evident, yet the realization that these issues can be better understood using the geographic perspective seems lacking. The professional community could take this opportunity to explain to the public what geography really is, why it is important, and how it can help society grapple with these issues. For example, as geographic perspective, content, and skills are becoming more valued by other disciplines on the university campus, geographers can open the dialog to interdisciplinary pathways of research.

2 Emphasize that maps are not just reference documents.

Many still regard maps largely as reference documents that are useful solely for looking up where something is. Our community must demonstrate how maps can be a doorway to discovery about the physical and cultural world and local communities in which we live.

3 Emphasize that digital maps are usually more useful than paper maps.

Paper maps are limited. They cannot be easily updated, modified, embedded, or transported. We must focus on the advantages of digital maps over paper maps.

4 Emphasize that maps are not just for geographers.

Maps are useful to broad sectors of society. They are valuable to epidemiologists studying the spread of diseases, climatologists studying climate change, or businesspeople siting new stores. Maps are essential tools for studying issues and solving real problems.

5 Focus on career skills.

Geotechnologies have been identified by the US Department of Labor as one of three major growth fields for the twenty-first century. The use of GIS and web mapping technologies builds skills not only in technology but also in organization, communication, critical thinking, and other skills needed by government, the private sector, academia, and nonprofit organizations.

6 Help students engage with the tools.

The bulk of geotechnology training at the secondary and university level over the past 20 years has been geared toward educators, rather than students. While this has the advantage of working with professionals who in turn could impact thousands of others, educators must realize that it is even more important for students to learn how to use these tools.

A geoliterate population is one equipped with the skills and perspectives to best deal with the complex issues the world is facing today.

About the Author

Joseph Kerski is a geographer, Esri education manager, and an enthusiastic advocate for all things mapping. His motto: "Maps engage, maps inform, maps inspire." Kerski earned a doctorate in geography from the University of Colorado, Boulder. Follow him on Twitter @josephkerski.

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Helping Cambodia Find Its Way

By Anne Cassidy

Cambodia stands at the crossroads of economic growth and natural resource preservation. It has a vibrant young population, one of the highest rates of deforestation of any country on the planet, and significant development challenges.

Private sector interests in cash crops, timber, and textile mills compete with Cambodia's need to feed its people and protect its natural resources. Government decision-makers must try to balance private investments with sustainable development goals. It has been difficult to compare the potential benefits and costs of development options because decision-makers lacked information.

But three years ago, the nonprofit organization Winrock International stepped in with a digital tool it designed using Esri software. The Watershed Ecosystem Services Tool (WESTool) was carefully conceived with detailed stakeholder feedback and consultation to make a real difference in the health of Cambodia's fragile ecosystems.

The WESTool allows users to explore how ecosystem services, land uses, and socioeconomic factors interact across Cambodia's landscapes. By combining advanced science with intuitive maps and tools, the WESTool offers valuable information at the local, regional, and national scale to support decision-makers and land managers who wish to understand and balance the value of remaining forests with development goals.

Winrock, with more than 100 agriculture, environment, and social development projects in more than 40 countries, has been using Esri software for 20 years. Its

Ecosystems Services unit uses Esri software for all its work.

WESTool grew out of Winrock's Supporting Forests and Biodiversity project, funded by the US Agency for International Development (USAID). Winrock scientists worked with Cambodians to identify their major development challenges and goals, then used Esri software to design a tool that could anticipate changes in water availability, sediment and nutrient loss, water pollution, and greenhouse gas emissions to determine the best policies and practices for agriculture and land management. By bringing together many different types of spatial information, modeling effects, and presenting this information in a nontechnical format, Winrock scientists created a web-based tool that uncovers the impact of widespread land-use change and suggests strategies to stop deforestation.

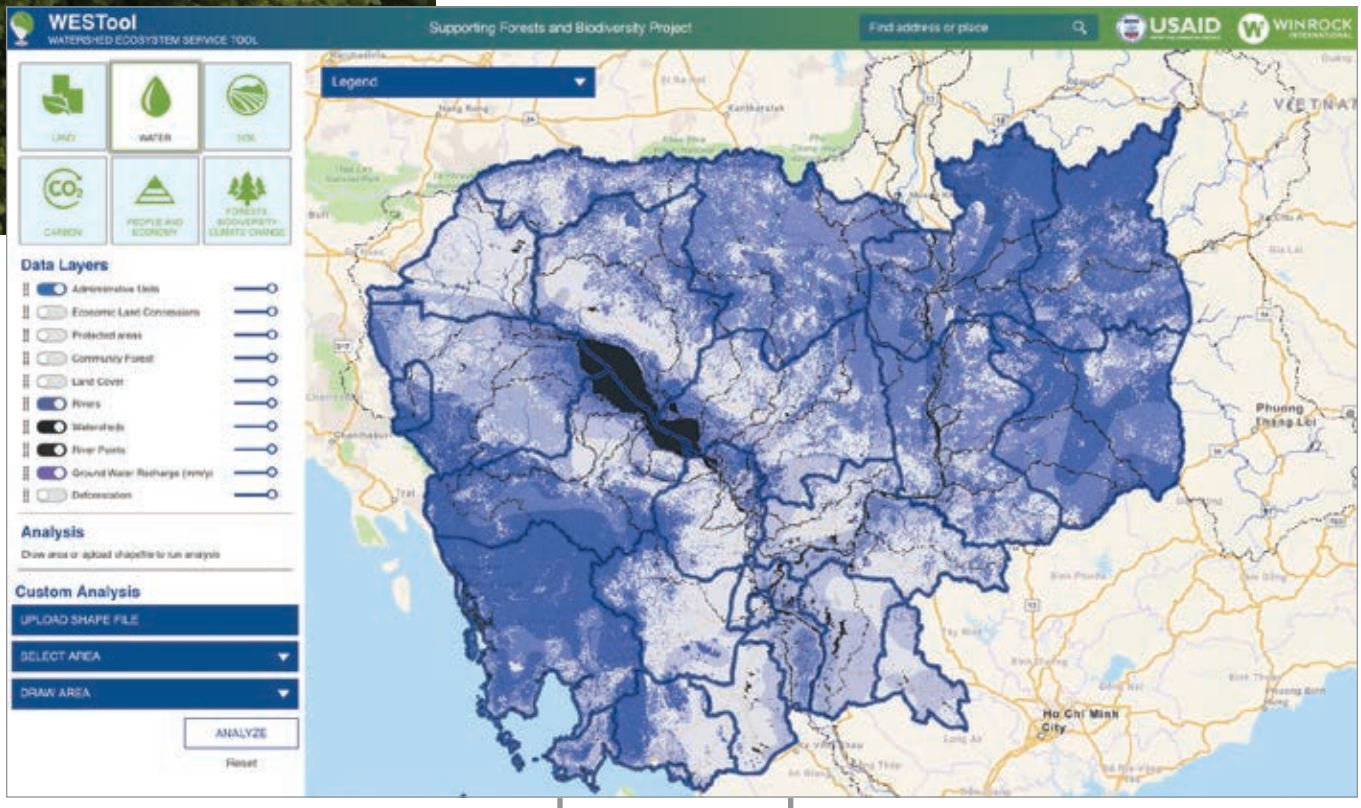
"The application is unique because it provides decision-makers with a tool to assess the impacts of forest loss on ecosystem services," said Mike Netzer, a GIS and remote-sensing analyst with Winrock. "Many decision-makers understand there are environmental risks, but they have never had a tool or any way to quantify them. By combining technological advances with a deep understanding of the challenges facing national and local governments, WESTool helps Cambodians make informed decisions to balance economics and the environment." Netzer helped introduce the tool to Cambodians, and everyone—from government ministers to students—learned to use it.

Seeing Potential Impacts

Three years after Winrock introduced the WESTool, members of Cambodia's Ministry of Environment use it to monitor water pollution and sedimentation in the watersheds that feed the Mekong River, where there are many fisheries. They also use the tool

← Cambodia is one of the most rapidly deforesting countries on the planet. The WESTool uncovers the impact of widespread deforestation and suggests strategies to stop it from continuing.

↓ The WESTool interface allows users to intuitively select and explore data layers and produce analyses of the impact of development scenarios on key ecosystem services.



to predict greenhouse gas emissions from deforestation in the beautiful and protected Prey Lang landscape, where logging is forbidden but still happens.

"The WESTool is a great resource for the Cambodian Ministry of Environment and the Ministry of Natural Resources and Rural Development as we create our state of the environment report," said Vina Touch, director of the Department of Geospatial Information Services of Cambodia's Ministry of Environment. "We plan to use it for environmental reporting and integrate it into the geospatial portal currently under development."

Local communes use the WESTool to create land-use plans and evaluate how dams, roads, and other land-use decisions will affect the landscape. "Just by clicking on the tools in the WESTool home page, we can see potential impacts regarding land use, deforestation, drought, or flood modeling," said Ley Phanna, chief of the Planning and Supporting Communes office in Stung Treng Province, Cambodia.

It's difficult to understand the impact of land management decisions without proper, unbiased, science-based information, said Lara Murray, a low-emission development expert with Winrock's Ecosystems Services team. That's what the WESTool provides.

For example, Cambodia's Tonle Sap Lake, one of the world's largest freshwater fisheries, is surrounded by extensive agriculture but also significant remaining forests. WESTool shows that since 2000, more than 19 percent of the forest in that watershed has been lost. This has caused an increase in sediment and nitrogen loads in the lake. WESTool users can also look at how future changes will affect the lake.

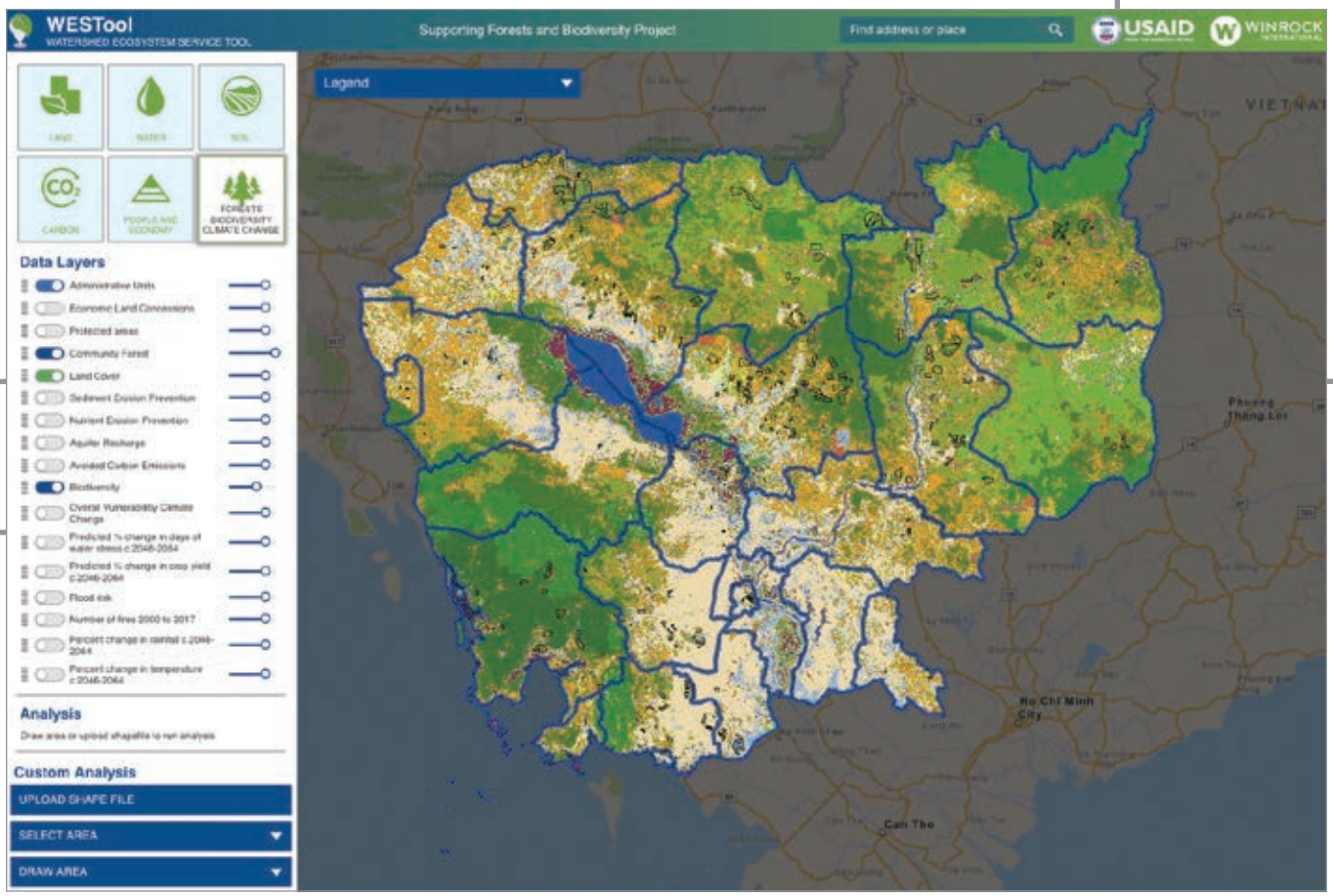
Just a few years ago, if this type of analysis had been done at all, it would have only been done for select locations and select purposes. The results would have only been accessible to scientists and a few government officials. Because it would have required an expensive analysis, likely be localized to a specific area and issue, it would not have taken into account the overall landscape.

Democratizing the Data

"The point of WESTool, originally and always, was to provide an objective platform for Cambodians to evaluate what is happening to their landscape and the impacts of it," said Dr. Sarah M. Walker, director of Winrock's Ecosystems Services team. "We're at a point in history where we have all this amazing data and all this amazing computer power, and that has finally started to reach other countries below the national level, at provincial and local levels."

Walker said that what technologies like WESTool offer developing nations is nothing short of revolutionary. "Often in the past, things were done because some group was advocating for them to be done, not because it was the most pressing problem. WESTool democratizes the data, placing the power of information into the hands

↓ Employees from Cambodia's Ministry of Environment learn how to use WESTool at a training workshop in Phnom Penh.



↑ WESTool lets users explore hotspots in Cambodia by turning layers for erosion prevention, aquifer recharge, avoided carbon emissions, and other metrics.

of all the people of Cambodia."

As countries like Cambodia start to integrate UN Sustainable Development Goals (SDGs) into their development planning, WESTool can also act as a platform to help them plan, implement, and monitor key indicators. The ability to assess SDG baseline conditions and monitor them over time can improve the potential for multilateral SDG financing, which can catalyze sustainable development.

"Developing countries have to prioritize. They can't just say, 'We're stopping all deforestation.' They need to know where the effects of deforestation and degradation are the worst," said Winrock president and CEO Rodney Ferguson. The Cambodian government can use the WESTool to determine that deforestation has altered the water cycle in the southwestern part of the country and that they are not only losing more topsoil through erosion but also seeing less water infiltrate into the aquifer because of decreased tree cover. These changes show decision-makers that forest loss has livelihood and economic impacts. "Then they know that whatever they do, they cannot ignore deforestation and degradation in the southwestern part of Cambodia," Ferguson said.

WESTool has been used to evaluate ecosystem services for 80 percent of Cambodia's land area, home to 8.7 million people. And Winrock continues to improve the tool through its USAID-funded Sustainable Water Partnership, working with Cambodia's Ministry of Environment to promote the tool in environmental impact assessments and commune development plans and to assess water security issues in the Stung Chinit watershed north of Phnom Penh. As users gain experience including WESTool in their planning processes, Winrock is incorporating additional ecosystem services, problem domains, and economic sectors. WESTool is eminently scalable to other countries and terrains.

In 2016, the Cambodian Ministry of Environment honored Winrock with a once-in-a-lifetime award. The Royal Order of Sahametrei—the highest honor the country bestows on foreigners—recognizes outstanding service to the king and people of Cambodia. Winrock was singled out for conserving Cambodia's biodiversity and forest resources, which included its use of WESTool.

What's most exciting about WESTool, say the people who created it, is how it puts a wealth of usable data in the hands of ordinary people. "It brings people science in a way they otherwise might not be able to access," Murray said.

About the Author

Anne Cassidy is a senior writer/editor at Winrock International. She is the former editor of *Georgetown Law* magazine and interim director of communications at Georgetown University Law Center.

Esri Corporate Headquarters

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Business Systems Analyst,
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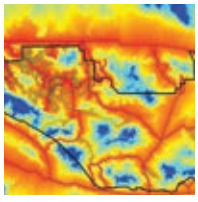

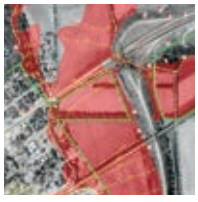

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