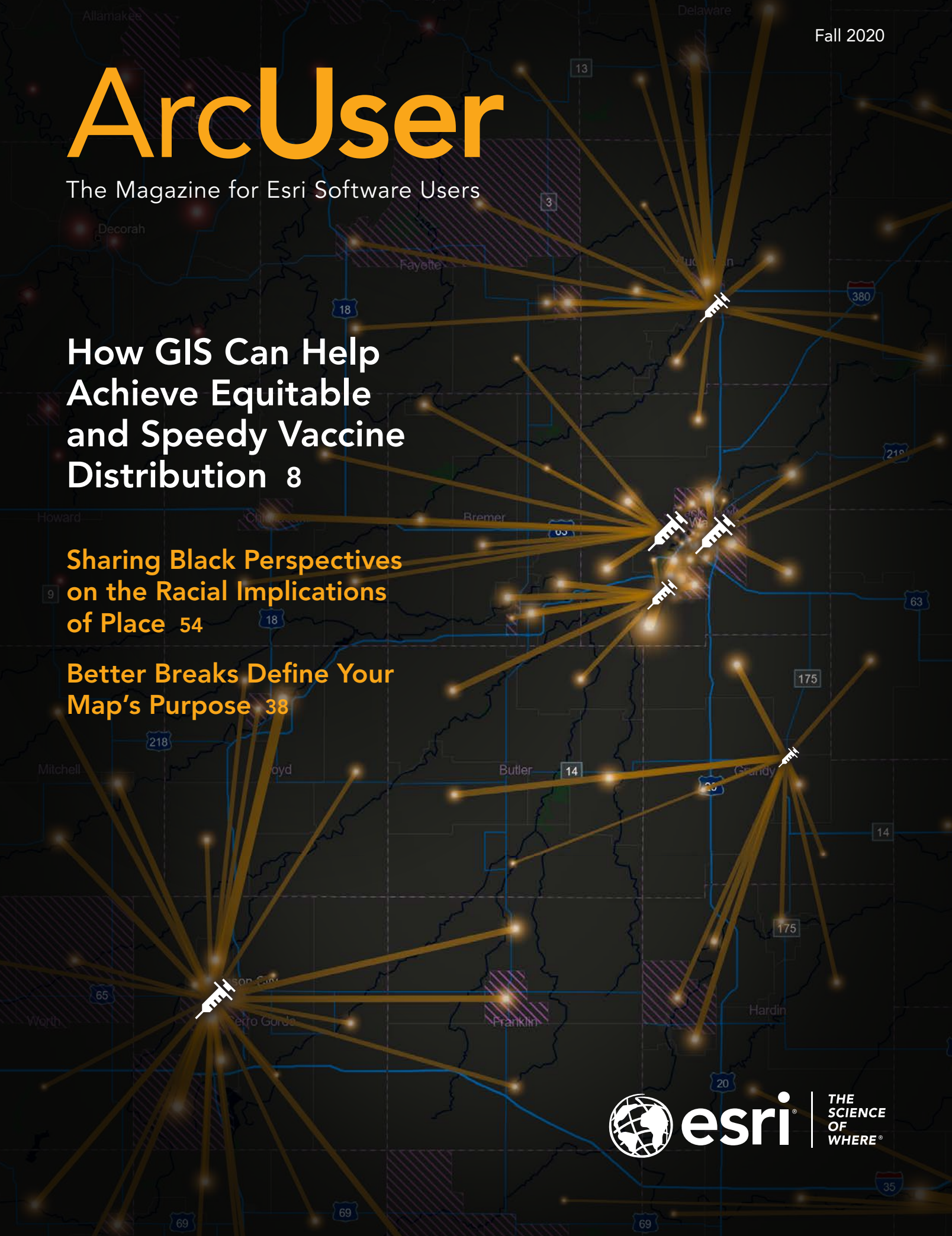
Fall 2020

ArcUser

The Magazine for Esri Software Users



How GIS Can Help Achieve Equitable and Speedy Vaccine Distribution 8

Sharing Black Perspectives on the Racial Implications of Place 54

Better Breaks Define Your Map's Purpose 38

esri THE SCIENCE OF WHERE®


[Eos Positioning Systems]
COLLECT POINTS IN
GNSS-IMPAIRED ENVIRONMENTS
RTK LASER MAPPING
For ArcGIS Collector® and ArcGIS Field Maps® on iOS
ARROW SERIES
EOS POSITIONING SYSTEMS
Tel: +1 (450) 824-3325
e-mail: info@eos-gnss.com
Made in Canada
WWW.EOS-GNSS.COM

Contents

Fall 2020 Vol. 23 No. 4

Focus

Special Section

End Notes

Opportunity in Adversity

The COVID-19 pandemic and the events of 2020 have been a stress-test for our world, bringing widespread social and racial inequities, such as housing, food insecurity, and unequal access to technology, into stark relief and exacerbating the already trying situations of many.

In responding to this public health crisis and its knock-on economic and social effects, GIS has demonstrated the pivotal role geographic technology plays in understanding, responding to, recovering from, and mitigating these threats.

Over the past 40 years, GIS use and the adoption of a holistic, geographic approach have expanded from projects to organizations to countries, furnishing and analyzing data, enhancing understanding, and making more rational decisions and effective action possible.

The creation of a large-scale geospatial infrastructure can improve understanding across the world to meet unprecedented challenges. This is not just automation but insight at a scale and a pace that can let us respond effectively to rapidly changing conditions. From the enhancement of mobile apps to cloud-based analysis tools, geospatially derived knowledge is more readily available than ever.

As both a driver and beneficiary of digital transformation, geospatial infrastructure is also key to renovating the physical infrastructure. The incorporation of SURE technology in ArcGIS will enable the transformation of imagery and lidar into point clouds, photo-textured 3D meshes, and true orthophotos that can be used for creating digital twins. These capabilities are supported by improved field mapping and Site Scan for ArcGIS, which delivers an end-to-end cloud solution for drone imaging projects.

A geospatial approach has been tremendously successful in responding to the COVID-19 pandemic. With a few months, thousands of organizations across the globe adopted it. However, a large-scale geospatial platform requires more than technology. It requires leadership and governance within organizations and across the GIS community. This is the opportunity to use geography to make a lasting change in the way we deal not only with threats to public health but with pressing challenges such as climate change and social inequity.

Monica Pratt
ArcUser Editor

ArcUser

Fall 2020 Vol. 23 No. 4

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

Design
Creative Director James Hitchcock
Designers Doug Huibregtse
Illustrators David Lauruhn
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

Read *ArcUser* Online
Visit the *ArcUser* website (**www.esri.com/arcuser**) to download tutorials, read current and past issues, and access additional resources.

Subscribe to *ArcUser*
Residents of the United States can subscribe to the print edition *of ArcUser* at **go.esri.com/subscribe**

Manage Your *ArcUser* Subscription
Make changes to your subscription information at **go.esri.com/manage-subscriptions.**

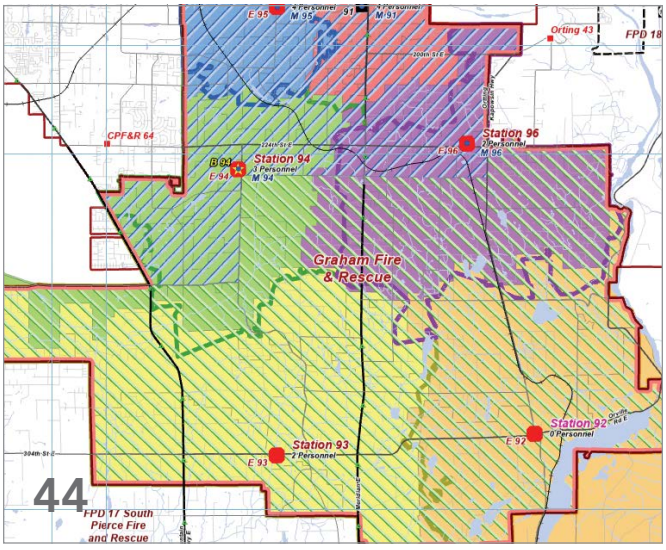
Advertise in *ArcUser*
For information regarding placing an advertisement in *ArcUser* magazine, contact the advertising coordinator at **ads@esri.com**.

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 **https://bit.ly/3mwMRxc**

ISSN 1534-5467
ArcUser is published quarterly by Esri at 380 New York Street, Redlands, CA 92373-8100 USA. *ArcUser* is written for users of Esri software and distributed free of charge to registered users.

Departments



Software and Data

Manager's Corner

Developer's Section

Hands On

Bookshelf

Faces of GIS

Education

Briefly Noted

→ Security Enhancements Meet Government Requirements in US and Europe

New capabilities in Site Scan for ArcGIS will enable governments and critical infrastructure organizations to meet hardware and software regulations in the US and Europe. Site Scan for ArcGIS is an all-in-one, cloud-based drone mapping solution for managing fleets and collecting, processing, analyzing, and sharing data products.

The US government has recently issued advisory warnings and bans on the use of drones that pose security risks, which have adversely impacted federal agencies and private firms that manage critical infrastructure. It has caused the adoption of incongruous drone data capturing and processing workflows using multiple vendor solutions.

Through a partnership with Auterion, creator of the most widely used open-source drone autopilot operating system, security-conscious US organizations will be able to use Site Scan for ArcGIS. Esri can now offer these agencies a single, end-to-end drone solution that integrates Freefly Astro and is fully supported by Site Scan for ArcGIS.

For organizations in Europe with data sovereignty requirements, a new and fully independent instance of Site Scan for ArcGIS has been deployed to European servers, ensuring that organizational data resides within the region.

↑ Esri can now offer governments and critical infrastructure organizations an end-to-end drone solution that meets hardware and software regulations in the US and Europe.

→ ArcGIS Indoors Is Now Online

With the latest release of ArcGIS Online, ArcGIS Indoors is now also available as a software-as-a-service (SaaS) offering in ArcGIS Online. This is an alternative to the on-premises deployment of ArcGIS Indoors with ArcGIS Enterprise. Hosting ArcGIS Indoors in the ArcGIS Online cloud gives users easier access to all the capabilities and benefits of indoor mapping and space planning. This location tracking software helps organizations better manage buildings and improve the safety of employees. SaaS eliminates the need to set up on-site server infrastructure and reduces the cost and effort of getting started with ArcGIS Indoors.

→ Esri and UN-Habitat Partner for More Sustainable Cities

UN-Habitat, the United Nations (UN) program that supports socially and environmentally sustainable urban spaces, will use Esri software to develop cloud-based geospatial technology that can help areas with scarce resources build inclusive, safe, and resilient cities and communities. Through this partnership, UN-Habitat will leverage the geospatial tools and open data capabilities of ArcGIS to improve urban infrastructure and service delivery in regions where development is needed.

→ Pan-African Nonprofit and Esri to Encourage Geospatial Technology Use across Africa

The goal of a new partnership between AfroChampions and Esri is to contribute to sustainable economic development in Africa. The AfroChampions Initiative is a public-private partnership designed to galvanize African resources and institutions to drive Africa's economic integration and transformation. It will promote the benefits of a shared geospatial infrastructure throughout the continent. GIS technology can create new opportunities for growth for Africans, especially in critical fields such as health and telemedicine, land management, agriculture, and mobility. This initiative will offer African governments and other organizations streamlined access to Esri's world-leading GIS technology and expertise, in addition to a broad network of regional partners.

The partnership is part of Esri's ongoing commitment to its users and the broader geospatial community across Africa. It is closely aligned with key continental initiatives such as Africa Continental Free Trade Area (AfCFTA); the African Development Bank Strategy for 2013–2022; the United Nations 2030 Agenda for Sustainable Development; and the African Union Agenda 2063, which emphasizes the need for global Geospatial Information for Sustainable Development (GI4SD) management.

↑ The goal of a new partnership between AfroChampions and Esri is to contribute to sustainable economic development in Africa.

→ Generate High-Res 3D and Imagery Content with SURE

Esri acquired nFrames, the technology company that developed SURE, the industry leading imagery and lidar 3D surface reconstruction software. Integration with ArcGIS adds the capability to seamlessly capture and analyze 3D data from aerial, drone, and ground-based sensors in an automated, end-to-end process and create extremely high-quality 3D data from imagery. This will enhance users' ability to perform highly accurate mapping. Esri anticipates greater use of 3D content in traditional GIS workflows. This will especially benefit users in planning and architecture, engineering, and construction (AEC) industries. The incorporation of SURE technology is part of Esri's commitment to continually enhance ArcGIS and the tools for managing, processing, analyzing, and sharing location information from remotely sensed data.

→ 2020 Esri User Conference Content Available

You can access recordings from the world's largest, virtual GIS event anytime at esri.com/en-us/about/events/uc/login. View hours of recordings that include on-demand learning, user presentations, demonstrations, and technical workshops as well as the Plenary Sessions and the Virtual Map Gallery.

How GIS Can Help Achieve Equitable and Speedy Vaccine Distribution

By Este Geraghty

Reliance on GIS during the COVID-19 disease pandemic response included real-time data sharing, analysis, visualization, and planning. These are capabilities that will be key to equitable and speedy vaccine distribution.

When a COVID-19 vaccine is developed, governments around the globe must be ready to distribute vaccinations on a massive scale. This is an effort that will include meeting sub-zero storage requirements; prioritizing vulnerable communities; communicating between organizations and the public; and ensuring equity across countries, counties, and cities.

Clearly, the work to safely develop and plan immunization in the United States and around the world will require the most complex global vaccination campaign in history. Beginning with the pandemic's onset, government and health-care leaders have relied on Esri's GIS technology for real-time visualization dashboards, data sharing, analysis, and planning.

The same GIS approach will prove crucial for vaccine distribution. Leaders can fine-tune vaccination scenario planning related to prioritization and delivery, assess logistics with public health and emergency management advisers, analyze supply chain capacity and operations, and determine a communication strategy. For all these efforts, GIS will be foundational to helping plan, implement, and manage efficient, equitable vaccine distribution.

In the US, for example, the Department of Health and Human Services (HHS), in coordination with Department of Defense (DoD) and the Centers for Disease Control and Prevention (CDC), provided a strategic vaccine distribution overview along with an interim playbook for state, tribal, territorial, and local public health programs and their partners in September.

[Three new COVID-19 Vaccine Distribution tools available from Esri interpret the CDC COVID-19 Vaccination Program Interim Playbook for Jurisdiction Operations *to determine population phases, allocate resources, and select new sites in a sample region. They can be used to evaluate population phases and select distribution sites.]*

The agencies outline next steps that include engaging with other leaders, stakeholders, and the public; distributing vaccines quickly and with transparency; ensuring safe administration and availability; and monitoring necessary data through an IT system capable of supporting and tracking distribution, administration, and other necessary data.

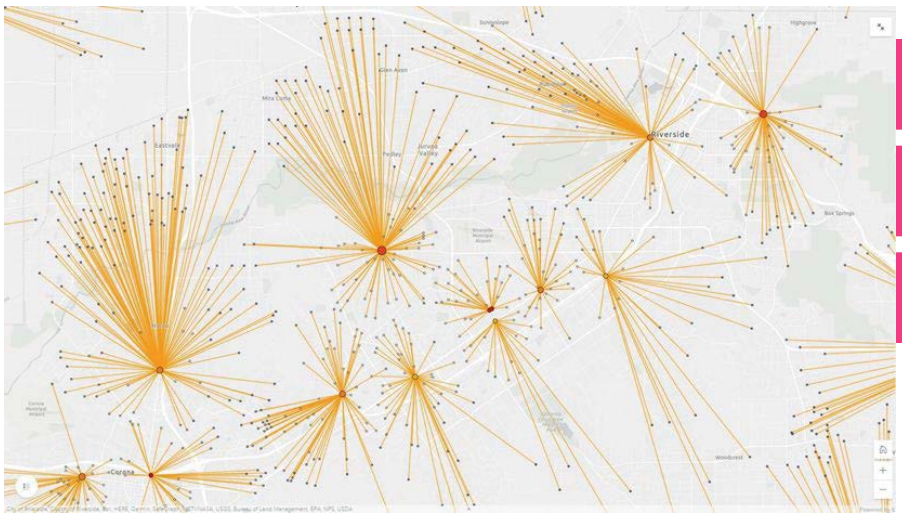
GIS is an integral part of that IT system. It will be central to vaccine distribution efforts, supporting engagement with stakeholders, and the public as well as providing real-time awareness and transparency.

GIS can support COVID-19 vaccine distribution in five key ways that help health agencies and governments execute their plans and end this pandemic as quickly as possible.

↗ This vaccine venue map shows locations with ultracold storage capabilities as red dots and locations with normal cold storage as yellow. Lines represent drive time and distance from population centers to venues.

↘ Dot density mapping, a useful method for showing where various populations cluster, can be used for mapping priority groups for each phase of COVID-19 vaccination.

1 Identify Facilities Capable of Storing and Distributing the Vaccine



1

Both the current leading vaccine candidates require cold storage. One requires ultracold storage at -70 degrees Celsius. Other factors such as parking, accessibility to vulnerable populations, distance from vaccine production facilities, traffic, and overall venue size will also impact which facilities can properly store and distribute a vaccine.

"States are currently surveying their systems to know where their sub-80 (Celsius) freezers are," said Julie Swann, a professor of industrial and systems engineering at North Carolina State University, who was advising the CDC. "I would expect that kind of cold storage to be available at large hospitals, scientific research facilities, and some large pharmacies."

The facilities Swann mentions are likely those that already administering other vaccines in their normal course of business. These larger facilities may be prioritized in phase 1 of the vaccine distribution process. During this phase, vaccines will be limited and focused first on people serving in health-care settings who may have direct exposure to patients infected with COVID-19. Second will be those who work in essential jobs that keep society running (e.g., emergency and law enforcement personnel, food packaging and distribution workers, teachers and school staff, and childcare providers).

A larger vaccine supply is expected to be available to support phase 2 of the distribution process. In that phase, additional facilities will be needed such as private provider offices, work sites, clinics, hospitals, health departments, retail settings, and senior centers. Mapping the breadth of potential facilities in the vaccination process is the first step to ensuring adequate population coverage.

2 Identify and Prioritize Critical Populations

There won't be enough doses of the vaccine immediately, so it's important to be both strategic and ethical with the available resources. The proposed prioritization, as described above, ensures critical infrastructure workers—those most likely to be exposed to COVID-19—are first to be vaccinated.

The next group prioritized are those at increased risk for severe disease or death from COVID-19. This includes people in congregate living situations such as nursing homes and assisted living facilities; those who have underlying medical conditions or risk factors for severe disease like obesity, cancer, and diabetes; and adults age 65 years and older.

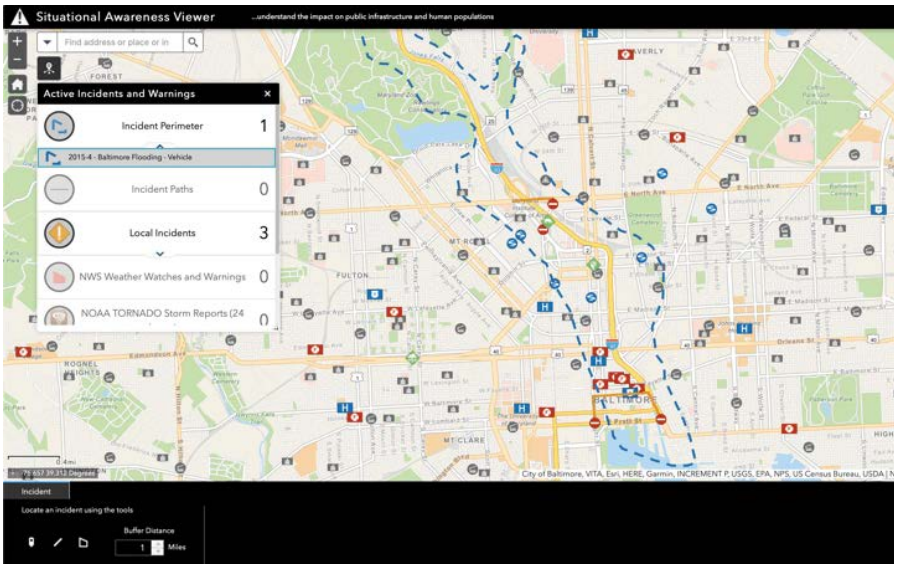
The third group in the prioritization describes people who are at increased risk of contracting and transmitting the virus (e.g., those experiencing homelessness, college students, tribal communities, communities of color, and incarcerated individuals).

Health departments will need to develop a detailed view of the various priority populations across their jurisdictions. At the same time, they will need to assess any additional burdens the priority populations may face in receiving the vaccine, such as lack of transportation or barriers to communication for non-English speakers.

Beyond visualization, health departments will need actual population counts for total population and each priority group. To be most effective, those counts should be available in context—in other words, how much of the population is within one mile, or a 15-minute walk, or a 30-minute drive of a vaccination venue. It will be critical to match facility capacity, vaccine supply, and population groups across locations to that ensure all needs are met.

2

3 Identify Gaps in Access and Formulate Alternative Distribution Options

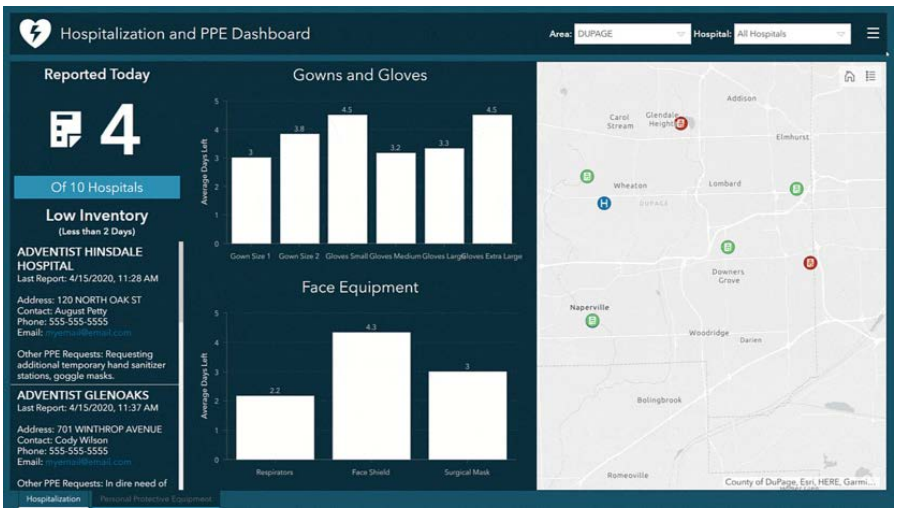


3

After communities have identified potential vaccine distribution facilities along with critical populations to prioritize, they will be able to see potential gaps and evaluate solution scenarios for mitigation.

It is possible and perhaps likely that in phase 2 of the vaccine distribution plan, the general population's desire to be vaccinated will overrun capacity in vaccination venues. Government leaders will have options to increase capacity by engaging new partners in the process and/or by siting points of dispensing (PODs) in strategic locations to meet demand. GIS technology has long been used for various types of site selection and is especially useful when considering complex criteria, such as accessibility, population makeup, ingress and egress, and budget.

There are special populations that should be targeted for more intentional outreach, such as those with limited access to vaccination venues in rural communities, people with disabilities, people experiencing homelessness, people who are underinsured or uninsured, and others who may be less likely to seek out vaccination when available. Mobile vaccination teams may be deployed to fill the gaps. Health organizations, like the Texas Children's Hospital system, use GIS to plan and optimize routes so they can more efficiently serve a larger population.



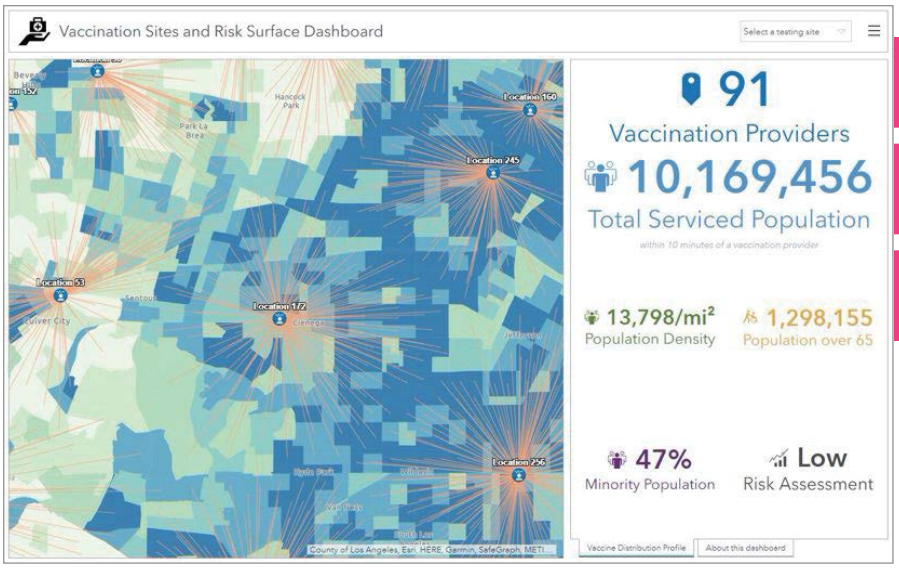
4

4 Implement a Vaccine Management and Inventory System

Both current vaccine candidates require two doses for immunity against COVID-19. However, the time between doses is different for each vaccine candidate, and the vaccines are not interchangeable. Therefore, it will be essential to understand who has received the first dose of a vaccination, which vaccine they received, and when they are due for the second dose.

A digital survey tool can be configured to capture relevant data at the point of vaccine administration or inventory reconciliation. For this, health-care providers and/or governments will need a quick and accurate data capture system that records individual vaccination information along with the bar code identifying the vaccine carton and/or vial. The data capture system will need to keep pace with the fast-moving vaccination process and support tracking of vaccine supply, expiration dates, and any potential adverse events.

In addition to tracking vaccine supply, officials will also need to keep tabs on inventory of personal protective equipment (PPE) for health-care personnel and vaccine kits (needles, syringes, alcohol prep pads). The ArcGIS Survey123 app from Esri offers an easy-to-use option for collecting this data from a smartphone or tablet. Similar to an earlier COVID-19 effort to collect data on hospitalizations and PPE inventories, the app could track vaccines and read 2D bar codes. All collected data can be fed into a web-based dashboard to give decision-makers a real-time view of the constantly changing situation.



5

← Dashboards can also give stakeholders and the public an up-to-date and transparent window into the current status of vaccination efforts.

5 Provide Transparency and Accurate Communication

As vaccines are distributed, states and communities will need to know how well each facility is doing in executing the plan by monitoring whether their populations are experiencing adverse events and tracking the proportion of the community that has been vaccinated.

Early transparency in these efforts will both inspire trust and provide critical information about how and why vaccination resources are allocated in each community. ArcGIS Hub was built specifically as a community engagement platform, offering access to data, maps, and apps related to a designated initiative. For example, the Lake County, Illinois, data hub site provides an excellent account of crucial COVID-19 information for that region.

Another feature jurisdictions should strongly consider adding to their hub site is a vaccination locator service, allowing people to find key information about nearby venues.

Beyond communication to the general public, government leaders will also need to consider targeted outreach to special populations—those with vaccine hesitancy or nontraditional preferences for receiving information. Tapestry Segmentation data from Esri, which goes beyond demographics to offer unique insights into US neighborhoods, can help officials learn more about the needs and communication preferences of their population. By adding Tapestry data to maps, charts, and reports, officials can learn how to deliver relevant and effective messages to their communities.

↖ A configurable situational awareness viewer can support population and facility counts in context.

↙ Collected data can be fed into a dashboard to give decision-makers a real-time view of the constantly changing situation.

Looking Ahead, Planning Now

Governments and responding organizations around the world must consider the aforementioned factors as they develop plans for distributing the vaccine. Communication must be handled with clarity and great transparency to drive an effective vaccination campaign and strengthen public confidence in the vaccine distribution process.

In an August memorandum, the National Governors Association encouraged state leaders to take action. "The challenge of vaccine development is matched by the challenge of vaccine distribution… Although a vaccine is not yet available, lessons learned from the acquisition and distribution of COVID-19 diagnostics and therapeutics suggest that governors may want to begin addressing the challenges of mass distribution before its arrival."

This sentiment is shared and felt around the world, in both government and health care. By relying on a GIS technology platform, leaders will be able to prepare for, implement, and manage COVID-19 vaccine distribution to avoid many of the struggles with capacity and communication encountered at the outset of the pandemic.

About the Author

Dr. Este Geraghty is the chief medical officer and health solutions director at Esri, where she leads business development for the health and human services sector. Formerly the deputy director of the Center for Health Statistics and Informatics with the California Department of Public Health, Geraghty led the state vital records and public health informatics programs. There she engaged in statewide initiatives in meaningful use, health information exchange, open data and interoperability. While serving as an associate professor of clinical internal medicine at the University of California, Davis she conducted research on geographic approaches to influencing health policy and advancing community development programs. A specific area of research focus involved pesticide safety. In addition to degrees in medicine, medical informatics, and public health, Geraghty is also a board-certified public health professional (CPH) and a geographic information system professional (GISP).

GIS Project Helps with Food Insecurity and Waste

By Jim Baumann

According to the United States Department of Agriculture (USDA), Americans throw away 30 to 40 percent of the entire US food supply.

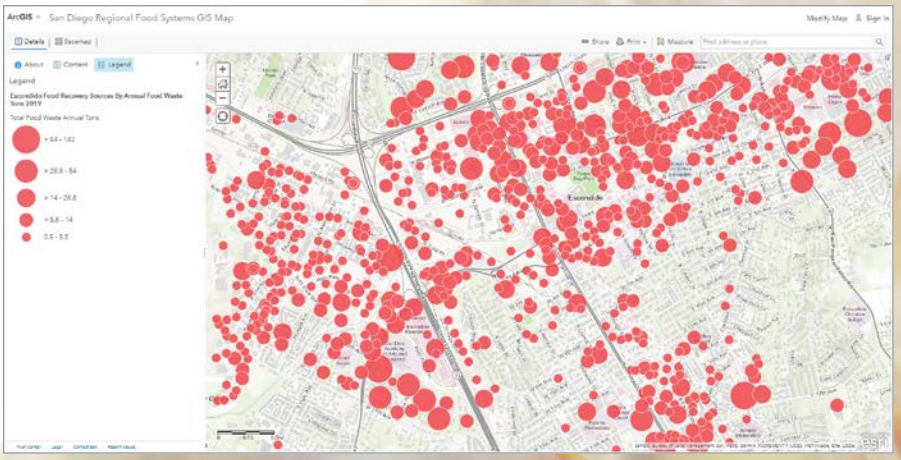
At the same time all this good food is wasted, research conducted by the USDA and released in 2018 estimated that 11.8 percent of Americans struggle with hunger daily and that one in six children live in food insecure households. These numbers represent conditions prior to the massive unemployment caused by the COVID-19 pandemic. With millions more people unemployed, the threat of food insecurity will likely increase.

A geography professor at a Southern California college developed a community-based service-learning project that originally focused on addressing food insecurity. However, the project has expanded and now supports strategies for addressing other social justice and equity issues, implementing state restrictions on solid waste disposal, and mitigating climate change.

In 2014, Wing Cheung, a professor of geography and environmental studies at Palomar College in San Diego, California, met with Craig Jones and Geertje Grootenhuis, representatives of local nonprofit organizations, to discuss how GIS could help solve food insecurity and other equity and social justice issues by developing the community-based service-learning projects that Cheung envisioned for his students. Initially, he discussed using GIS to help minimize food waste.

Jones was instrumental in the founding of the Alliance for Regional Solutions, which coordinates and advocates for communities in the North County region of San Diego County, and the North County Food Policy Council (NCFPC), a member of the Alliance for Regional Solutions that assesses and supports the creation of programs to ensure that residents of North County have adequate food. Grootenhuis is the manager of the Wasted Food Prevention Program at the San Diego Food System Alliance (SDFSA), a network of more than 100 organizations working to make the current food system more equitable, healthy, and sustainable.

↓ Total food waste from 2019 in tons, mapped by location.



"After speaking with Professor Cheung, we realized that GIS could be a very useful tool for the NCFPC," said Jones. "It would allow us to better understand the nature and extent of food insecurity and the resources to address it—both existing and needed."

The State of California recently enacted laws requiring that cities and counties reduce solid waste and reduce or recover food now in the waste stream. Communities are also required to reduce greenhouse gas emissions, which decaying food creates, because of their adverse effect on climate. To ascertain the amount of food wasted locally, the San Diego Food System Alliance established contact with cities in the region to obtain weekly solid waste data for local businesses.

This data is then used to calculate the tons of food waste generated by local businesses on an annual basis. Ultimately, the datasets are provided to GIS students at Palomar College to geocode and analyze. This data is visualized as point data that is categorized based on state land-use codes and the quantity of wasted food generated at that location.

"Having this information in GIS helps our local cities address the state's mandate to plan and reduce/redirect food waste. So far, approximately half of the municipalities in San Diego County have their datasets on our GIS platform and we continue to engage in discussions with other local cities on how they may take advantage of the platform themselves," said Jones.

"The Wasted Food Prevention Program provides technical assistance, consumer education, and network development to raise awareness about the issues of food waste," said Grootenhuis. "Our alliance between SDFSA, NCFPC, and Palomar College has opened up the powerful analytical capabilities of GIS to us. With its custom mapping tools, the technology also allows us to clearly depict the local issues that contribute to food waste, which helps prevent good food

from ending up in the landfill."

The project was fully implemented in the fall semester of 2015. Cheung's students in his introductory GIS class began by geocoding the spreadsheets created by NCFPC that detailed its partners' locations. Semester by semester, both beginning and advanced GIS students at Palomar added data layers and updated existing ones. For example, students mapped the participation rate in free and reduced lunch programs in San Diego County schools.

Over the years, Palomar College students have used ArcMap, ArcGIS Pro, and ArcGIS Online to process, analyze, and share the data they received from community partners. The data is provided by a variety of sources, including local government agencies, school districts, and other community agencies in the region.

Although the project started with data layers that only covered North San Diego County, over time the value of this information attracted the attention of local governments and nonprofits from all over San Diego County, so relevant data layers that include the entire county were created and added.

This is particularly important because the San Diego Food System Alliance has substantial regional connections and the resources to market the value and use of the map throughout the region. The web map has received thousands of views, and has nearly 50 layers, which can be turned on and off by various users. The *San Diego Regional Food Systems GIS Map* can be accessed at https://arcg.is/00a5DK.

Since its beginning, the partnership between NCFPC, Palomar College, and SDFSA has evolved in response to the needs of communities in the region. These service-learning projects demonstrate how GIS can enable educators to build partnerships with community organizations to address many more real-world problems. It began by mapping existing food assistance programs and sociodemographic data to serve those in the region that suffer from food insecurity. Today, the program has expanded to explore opportunities to combat issues such as food waste, climate change, and transportation issues while continuing its focus on food insecurity.

"We have found that using GIS provides us with insight into social services and equity issues far beyond the issue of food insecurity," said Jones.

The Alliance for Regional Solutions is now pursuing a grant from the State of California that will be used for planning transportation systems for disadvantaged populations living in San Diego's North County. Palomar College students have made maps that show the location of disadvantaged communities in relation to their current public transit options. These maps will provide the justification for the grant.

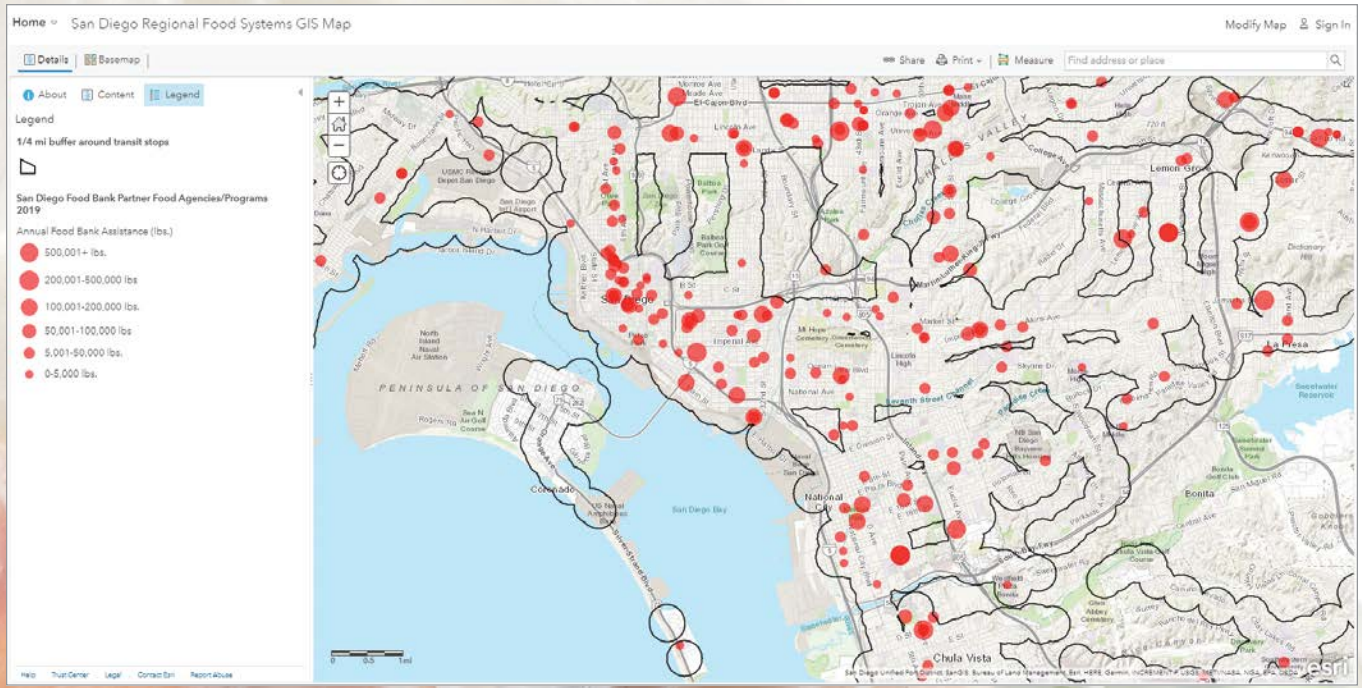
To facilitate the application process, Cheung and his students provided Jones with a data layer of census tracts via ArcGIS Online, which enabled Jones to create custom maps that highlight the transportation needs specified in the grant proposal.

"Those involved in social justice issues in San Diego County are learning that GIS tools can be used to analyze and visualize pressing regional problems," said Cheung. "The projects developed by our partnerships with local agencies require students to apply their classroom knowledge of GIS to research, analyze, and solve real-world problems related to food insecurity and food waste in San Diego County. The program also enhances the students' communication skills, as well as their awareness of social justice and equity issues in the community."

About the Author

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

↓ This map shows the locations of San Diego Food Bank partners, their proximity to transit stops, and the amount of food assistance they provided annually.



Closing the Digital Divide in the World of COVID-19

By Ashley Hitt

Since the outbreak of the COVID-19 pandemic, millions of Americans who now work and school their children at home and online have found that they are more dependent than ever on access to broadband connectivity. This situation has made the technology gap experienced by low-income populations and uneven access to broadband even more pressing issues. Since 2001, Connected Nation, a nonprofit 501(c)(3) organization has been working to bridge this digital divide.

Well before the COVID-19 pandemic, Connected Nation had been working to find innovative solutions for connecting all Americans to high-speed internet and related technologies.

This includes developing and providing tools, resources, and methods to help local communities, states, and federal agencies create and implement solutions to address their broadband and digital technology gaps. Through broadband mapping, community engagement, digital literacy, job placement, education assessments, and telehealth research and development, Connected Nation assesses and plans for the expansion of broadband access, adoption, and use.

When response to the pandemic began shutting things down, all aspects of life became even more tied to broadband. People found they couldn't work from home if their broadband connection was not fast enough. Students who lack a high-speed internet connection and a device of their own couldn't keep up with connected classmates. Quarantined persons without broadband connectivity couldn't stay at home if they couldn't order food, household items, and medications online.

This situation compelled leaders at all levels to seek ways to improve broadband connectivity for residents and businesses immediately. Now, people are paying significantly more attention to the areas of the country that are underserved (i.e., have internet access, but at subpar speeds) or unserved (i.e., lack any internet access). Unfortunately, increased attention to these issues has not led to an immediate resolution of these problems for most people.

GIS and location intelligence can provide key information for fashioning new solutions. It can be leveraged to identify unserved and underserved locations, map broadband service areas, evaluate broadband assets and infrastructure, and provide data visualization applications to policy makers and grant-making agencies that can help enable funding for areas that need the most help getting connected.

Using GIS to Understand Broadband Access

Better and more accurate broadband mapping helps policy makers, city planners, politicians, providers, and others understand where and how to reach families, businesses, farmers, and others who are unserved or underserved by current broadband connections.

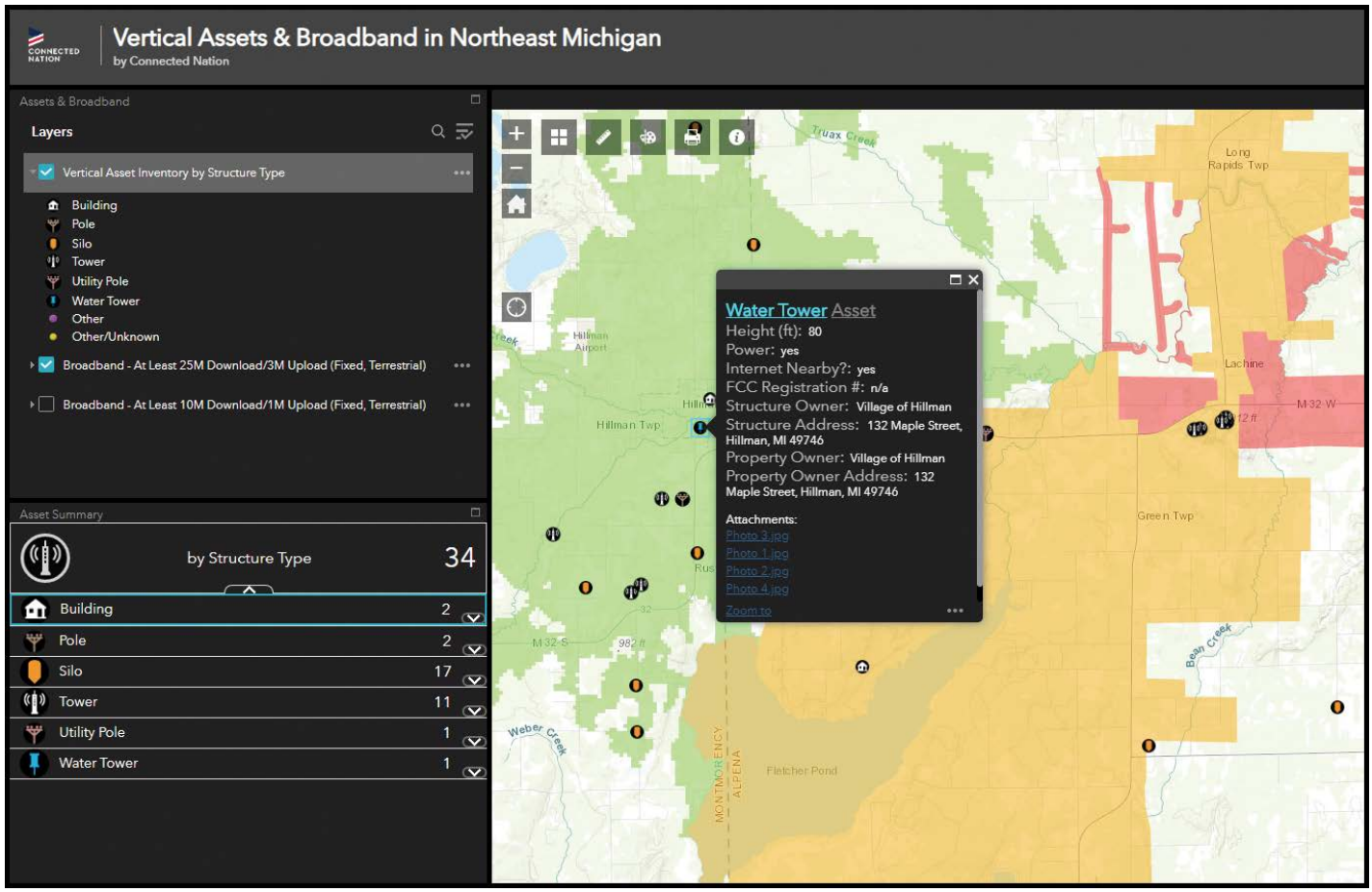
Although there is a federal broadband dataset that is available from the Federal Communications Commission (FCC), known as Form 477, there are several known issues with the data completeness, format, and quality. Not all broadband providers submit broadband service data as required. In addition, not all providers have GIS capabilities or resources to ensure the accuracy of the filings.

Fixed broadband data is filed only as a comma-separated values (.csv) file, which leads to issues when providers aren't able to visualize and confirm the areas being submitted. Fixed wireless services are filed as census block lists instead of propagation models. Also, there is inherent overstatement with data that uses census blocks as the unit of measure when broadband networks are independent of these boundaries. Provider-submitted data is not thoroughly validated to confirm its accuracy.

While the FCC is currently working to implement the Broadband DATA Act passed by Congress on March 23, 2020, to implement a new mapping program, all these issues pertaining to the current federal broadband datasets make them inadequate for the identification of unserved/underserved areas and the local planning efforts that can make a difference to disconnected Americans.

To facilitate more detailed and accurate broadband mapping, Connected Nation carries out four primary tasks:

1. It works directly with broadband providers to understand their networks, service areas, technologies used, and speeds available by collecting information and mapping networks. Because some providers do not have GIS resources data on their broadband service areas, this



↑ Interactive map of vertical assets and broadband service areas in Northeast Michigan.

data cannot be provided in a geospatial format. Connected Nation bridges this resource gap. With participation and feedback from broadband providers, Connected Nation produces those files.

2. It researches and reviews various federal and state databases, provider websites, telecommunications provider associations, and other resources to facilitate discussions with providers on their licenses, spectrum, franchise agreements, and other details that assist in the mapping process.
3. It collects public feedback to identify discrepancies between the mapped service areas and broadband access at each household, identify areas of significant demand where broadband services are not available, and collect firsthand accounts of speed and pricing issues experienced by consumers.
4. It conducts field validation to confirm the presence of broadband services, tests networks, collects additional infrastructure details, refines the boundaries of broadband service areas, and works with providers in the field on other needed information to ensure the accuracy of map representations. Field validation also provides a way to resolve challenges to the broadband maps submitted by local residents, community leaders, and other broadband providers to ensure that the next version of the broadband availability map is more accurate and detailed than the previous iteration.

These tasks work together to develop and update broadband mapping information products that include static maps, interactive maps, household/population availability estimates and statistics, and—most important—the accurate identification of unserved and underserved residents and communities across the country. These communities need the most help, especially during the COVID-19 pandemic when broadband access is a lifeline.

To accomplish these tasks and develop the information products that are essential in closing the digital divide, Connected Nation utilizes several Esri products and solutions and continues to innovate technological offerings to provide resources to identify disconnected areas across the nation.

Custom and responsive interactive maps that show decision-makers the areas most in need, while displaying analysis results on the existing broadband networks, are powerful tools for closing the digital divide.

Connected Nation has also taken advantage of the various mobile work applications, especially the ArcGIS Collector app, so that telecom engineers can track existing or potential broadband assets and infrastructure, review areas challenged as served or unserved, and refine broadband service areas as needed. These location intelligence tools have been instrumental in providing community leaders with the necessary information to make analytics-driven decisions to help the most vulnerable in their communities.

Beyond Data: Connecting People with Pressing Needs

Connected Nation is dedicated to improving lives through the expansion of broadband and technology access, adoption, and use. Connected Nation looks beyond infrastructure when addressing broadband issues because access to infrastructure is only the beginning of an individual's or community's journey to fully leverage technology to improve quality of life and support community and economic development.

Connected Nation recognizes that to fully participate in a digital economy, communities need to address not only the access to broadband (supply), but also the ways in which it is adopted and used (demand). Wires and wireless signals are useless if they are not leveraged to improve civic engagement, improve leadership, and develop local human capital.

Even if broadband access is available, that doesn't mean all households have a computer or other devices for work and/or education. Based on Connected Nation surveys and research, barriers to adoption include cost, lack of digital literacy, and a perceived lack of relevance to the user. That is why Connected Nation uses a holistic approach to understanding the broadband landscape across local communities and states that includes community engagement, education assessments, telehealth, and digital literacy and job placement.

Community Engagement

The Connected Community Engagement program provides a way for local elected officials and community stakeholders to work together and chart a course for accelerating local access, adoption, and use of broadband and related technologies. More information is available at https://connectednation.org/connect-my-community/.

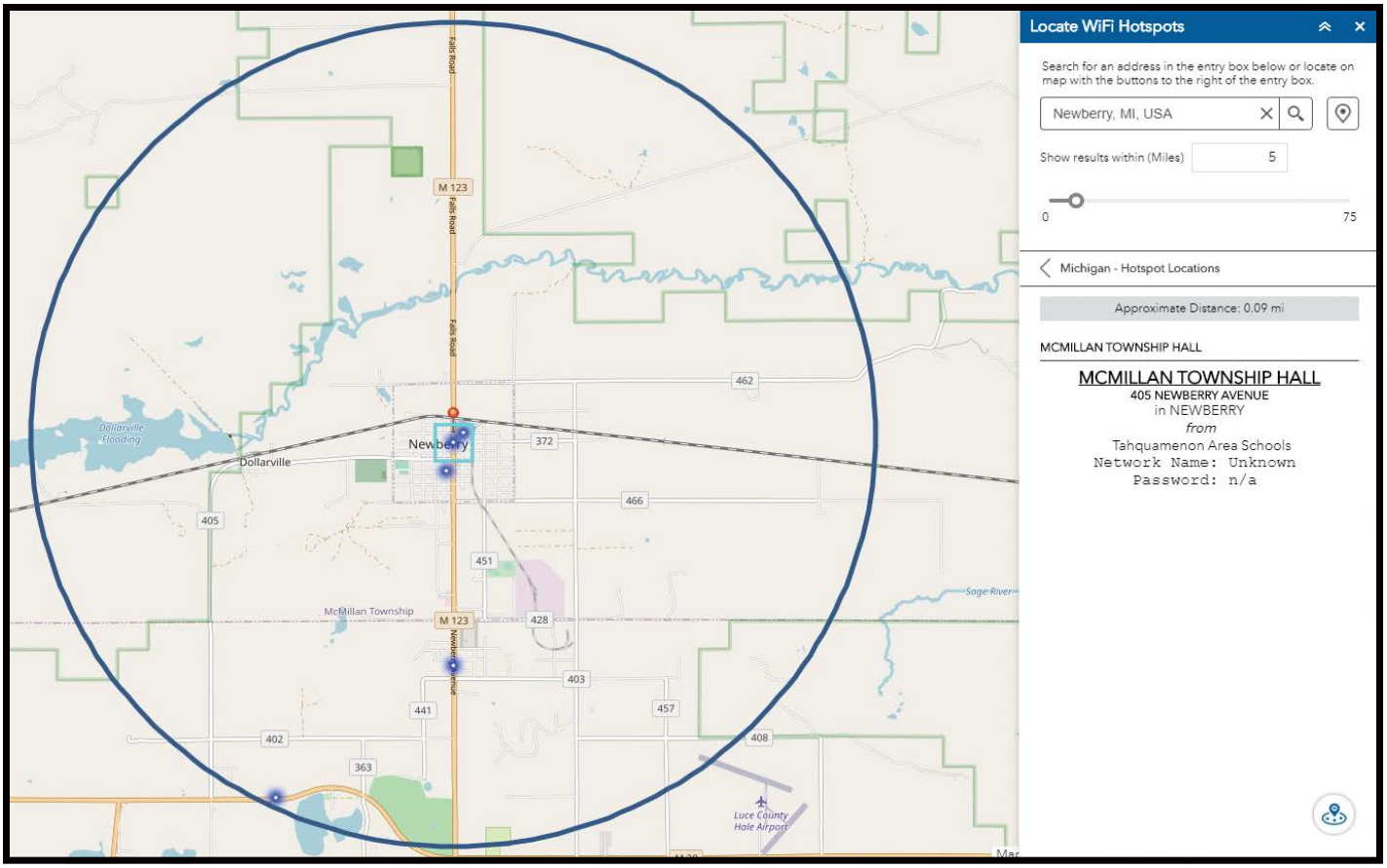
Education Assessments

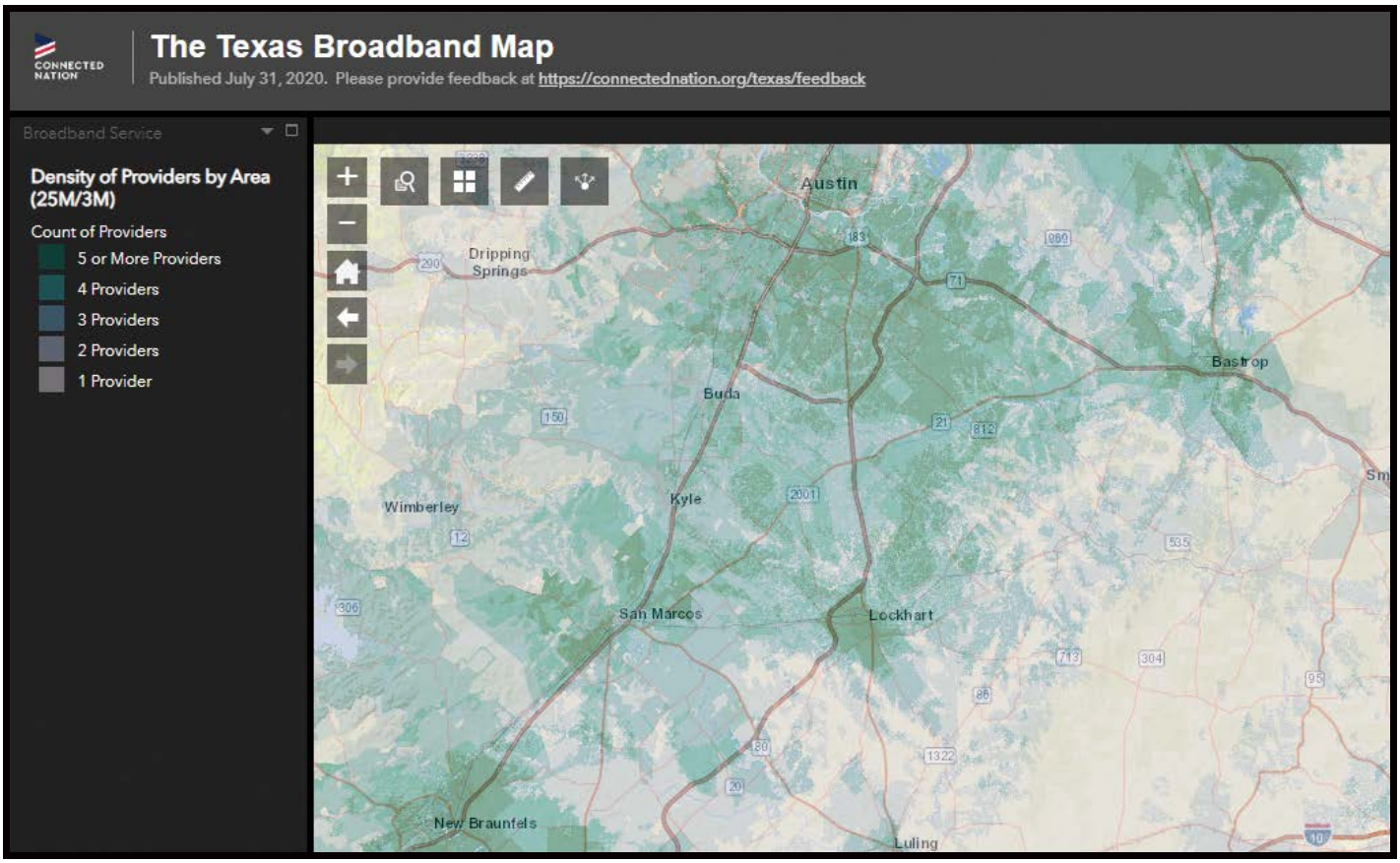
Connected Nation believes that all children should have adequate access to the latest technology in schools. Its work includes school technology assessments, E-rate program assistance *[an FCC program that makes telecommunications and information services more affordable for schools and libraries]*, and closing the homework gap by getting students access to broadband and devices so they have equal educational opportunities. Find more information at https://connectednation.org/transforming-education/.

Telehealth

Connected Nation studies the use of information and telecommunications technology to support long-distance clinical health care, patient and professional health education, public health, and health administration. Find more information at https://connectednation.org/telehealth-research-and-development/.

↓ Interactive map of state grant-funded broadband expansion in Minnesota.





↑ Interactive map of the number of broadband providers by location in Texas.

← Device image of the ArcGIS Collector app for broadband asset and infrastructure field work in Walton County, Florida.

Digital Literacy and Job Placement

Its Digital Works program connects people to leading-edge customer support and IT jobs for global corporations by providing training, mentorship, and job placement assistance, as well as the opportunity for work-at-home and advanced careers. Find more information at https://connectednation.org/digital-training-and-job-placement/.

Residents are voicing their personal needs for improved broadband and technology access across the country. Communities are seeking economic development opportunities to keep and attract residents and businesses with proximity to broadband access. Teachers are advocating for students since the homework gap now starts as early as kindergarten for disconnected children.

The lack of broadband access and its related technologies for all residents has a very real impact on the success, opportunities, and prosperity of students, residents, and communities. Children, the workforce, and the economy are relying on it.

About the Author

Ashley Hitt, GISP, is the vice president of GIS Services at Connected Nation, a national leader in broadband expansion programs. She is responsible for the operation of the GIS Services and Engineering and Technical Services departments. She develops and implements strategic methodologies to promote data visualization solutions using broadband-related datasets and broadband data collection and field validation methodology innovation. Hitt, an active member of the Urban and Regional Information Systems Association (URISA), is the conference chair for GIS-Pro 2020 and an instructor for the URISA GIS Leadership Academy. Previously she served on the URISA Board of Directors. Hitt has a bachelor's degree in geography/meteorology and a master's degree in geoscience from Western Kentucky University. For more information, contact her at ahitt@connectednation.org and follow her on Twitter @AshleyHittGIS.

ArcGIS Solutions Support Pandemic Response and Recovery

ArcGIS solutions provide freely available maps, applications, templates, and widgets that support industry workflows and critical activities by organizations. COVID-19 Solutions (solutions.arcgis.com/#covid19) help organizations maximize their ArcGIS investment in dealing with the COVID-19 disease pandemic.

Business Continuity

Coronavirus Business Continuity maps and apps can be used by businesses, utilities, and government agencies to maintain business operations and share authoritative information with customers and stakeholders during the COVID-19 pandemic. It includes ArcGIS applications for understanding the operational capacity of your workforce, monitoring the status of your facilities, and communicating disruptions to customers and stakeholders. Businesses, utilities, and government agencies can configure and share the entire collection of Coronavirus Business Continuity maps and applications or configure and share only the maps or applications that meet their specific needs.

↑ The Coronavirus Recovery Dashboard can be used to tabulate symptoms, cases, and hospital capacity metrics; monitor key recovery trends and performance targets; and communicate progress made to interested stakeholders.

Site Safety

The maps and apps in the Coronavirus Site Safety collection can be used by businesses, educational institutions, and government agencies to create COVID-19 health safety plans for facilities, sites, and campuses and monitor these plans as locations reopen. Health safety plans address issues such as optimally siting temperature screening locations, handwashing or sanitizer stations, personal protective equipment (PPE) stations, and isolation areas as well as estimating crowd capacities, monitoring social distancing, tracking cleaning and disinfecting, monitoring restocking of PPE stations, and reporting coronavirus-related problems and issues.

Health Screening

Coronavirus Health Screening maps and apps can be used by businesses, utilities, and government agencies to conduct COVID-19 health screenings before employees and visitors are permitted to enter a building, facility, or location to help ensure the safety and public health of all individuals in their facilities. These ArcGIS applications can be used to self-report coronavirus symptoms or contacts, record the result of temperature checks, and track who has been permitted to enter a facility, or location on a given date.

Response

The maps and apps in the Coronavirus Response solution can be used by public health and other emergency response agencies to understand the impact of COVID-19 and share authoritative information about the pandemic with communities. These ArcGIS applications can be used to monitor coronavirus cases and response activities, communicate the impact on public places (e.g., schools, government buildings, common places), inventory meal sites, monitor meal programs, and share information with the public.

Testing Sites

Public health and other emergency response agencies can use maps and apps in the Coronavirus Testing Sites solution to identify at-risk populations, locate optimal testing sites, manage testing site status, and share testing site information with the public.

Coronavirus Recovery Dashboard

The Coronavirus Recovery Dashboard solution provides a series of ArcGIS applications to visualize metrics for an entire state or province and more specific locations within the state or province, such as a region, county, or postal area. It can be used to tabulate

symptoms, cases, and hospital capacity metrics; monitor key recovery trends and performance targets; and communicate progress to interested stakeholders.

Coronavirus Wellness Checks

This solution focuses on monitoring the wellness of vulnerable individuals throughout a community. The Coronavirus Wellness Checks solution provides ArcGIS applications to engage community volunteers, register homebound individuals, conduct regular wellness checks of vulnerable individuals.

Small Business Recovery

Coronavirus Small Business Recovery solution maps and apps can be used by economic development staff to help small businesses operate during the COVID-19 pandemic and understand its impact on small businesses in their community. These ArcGIS applications can be used to engage local business owners, measure the impact of the pandemic on small businesses, report potential health order violations and their resolution, and promote small business recovery.

Force Readiness

State National Guards and other service branches can use Coronavirus Force Readiness to understand the operational capacity of forces, monitor the status of units, and communicate disruptions to commanders and administrative noncommissioned officers (NCOs).

Hospitalization and PPE Inventory

Emergency management staff can use this solution for inventorying the hospital capacity and PPE at local hospitals and acute care centers. In the United States, this solution complements reporting already being done through the National Healthcare and Safety Network (NHSN) and provides emergency management staff timely hospitalization and its inventory of PPE that informs COVID-19 response and recovery efforts. These ArcGIS applications can be used to solicit daily hospitalization and PPE reports, and monitor the capacity of hospitals and their PPE inventory. Government agencies can configure and share the entire collection of Hospitalization and PPE Inventory maps and applications or businesses, utilities, and government agencies can configure and share a survey and dashboard that can be used to understand their inventory of PPE.

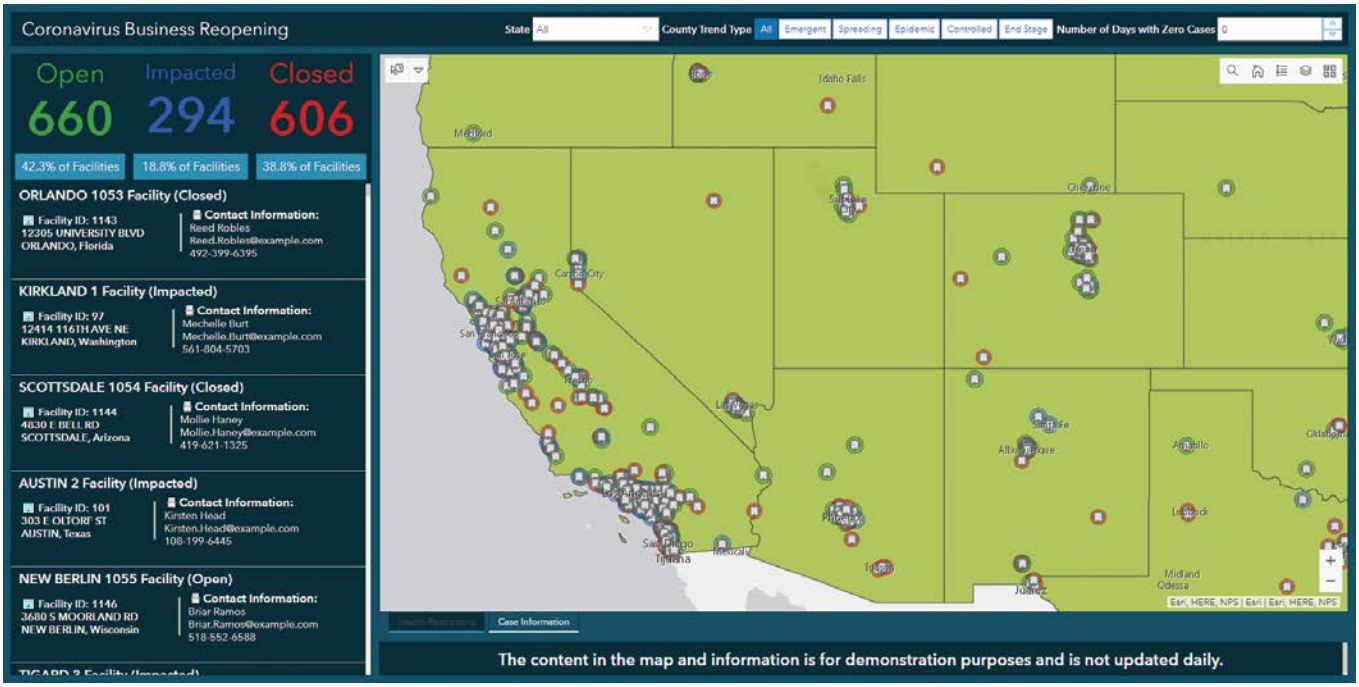
Business Reopening

Businesses reopening during the COVID-19 pandemic can use Coronavirus Business Reopening maps and apps to guide reopening locations that are in multiple jurisdictions. This solution includes ArcGIS Dashboards to evaluate coronavirus case data and health restrictions, understand the impact on business locations that are in many diverse jurisdictions, and share information with key stakeholders. The information gathered guides the decisions to open or close locations. These decisions can be recorded and shared with key internal stakeholders and customers.

Additional Resources

To ask questions and provide feedback, chat on GeoNet or contact Esri Support Services. Esri is providing several resources to help organizations combat the coronavirus. The COVID-19 GIS Hub (coronavirus-resources.esri.com) is the place to access additional resources and to request GIS assistance from Esri.

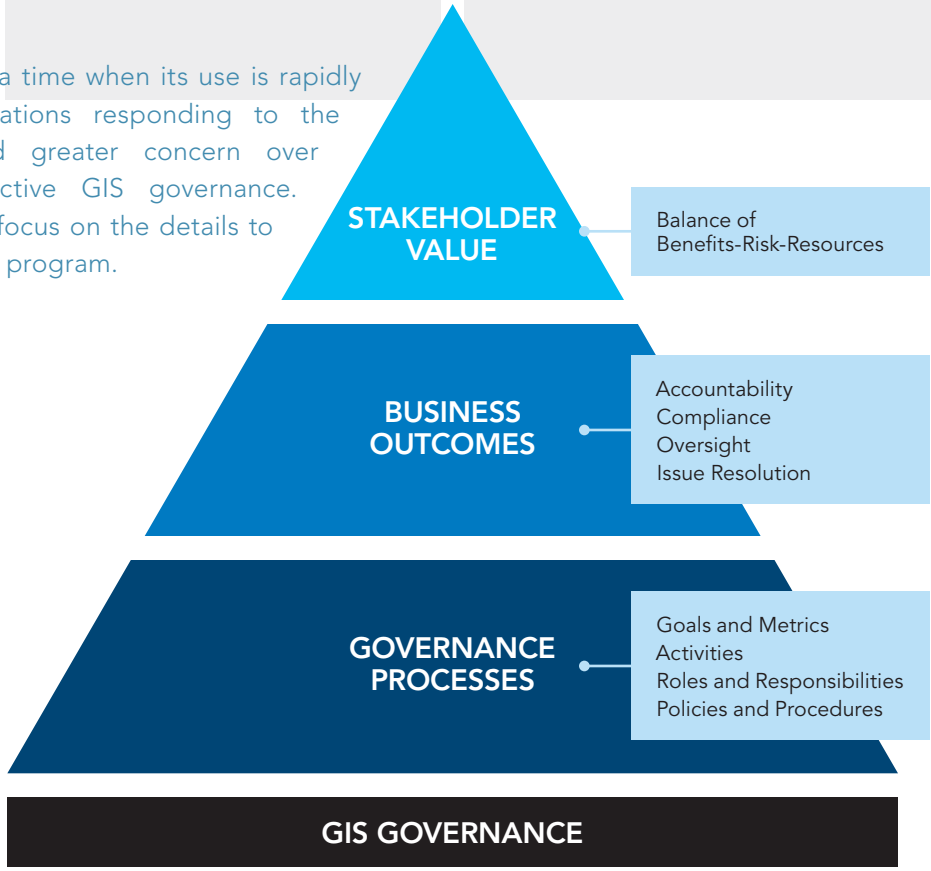
↓ The information gathered by the Coronavirus Business Reopening solution can guide the decisions to open or close business locations.



GOVERNANCE FOR GIS: Decisions and Decision-Making

By Matthew Lewin

The enhanced capabilities of GIS at a time when its use is rapidly expanding—particularly by organizations responding to the COVID-19 pandemic—have caused greater concern over establishing and maintaining effective GIS governance. Organizations need to think big but focus on the details to establish an effective GIS governance program.



↑ GIS Governance Value Pyramid

The CIO of a medium-sized city government was concerned. The city was in the midst of a large-scale digital transformation that promised to reinvent how services were delivered to its residents. The city had committed millions to revamping department systems and investing in critical smart infrastructure.

Early results were promising. The city had enjoyed a high-profile win by integrating road disruption notifications with social media. Notification of planned and unplanned disruptions on a map in real time was a hit with residents. However, the CIO noticed a concerning trend. This win created a demand for new map-based solutions that was stretching his team's ability to deliver.

In the past, GIS was acknowledged as an important system of record for city assets as well as the home for most of the city's mapping information. This new demand had pushed expectations for location-driven applications to new levels. But without a way to manage demand, set expectations, and nurture the development of these apps, the CIO recognized he was facing failure. Without strong GIS governance, how could he deliver on the promise to reinvent the city through digital technology?

This situation is not unusual. Much of the success with GIS comes not from the implementation of the technology but its ability to build a location capability. This means marrying the technology of GIS with the science of geography and ingraining it in the organization's DNA. A well-developed, robust GIS capability is the foundation on which the dreams of a location-based digital transformation are built. To do this, good governance is critical.

By governance, we mean the system of control. This control extends to the applications and infrastructure that drive your location platform, the data at the heart of your maps and information products; the people who build and support the platform, and the capital used to grow and sustain your location capability.

In short, governance is one of the most important factors determining the long-term success of a GIS. Without good governance, plans stall. They are doomed, as the poet W. H. Auden put it, "each to his own mistake." This article discusses some of the reasons why organizations fall short in this regard and looks at a comprehensive framework for GIS governance.

Where Do Organizations Go Wrong?

GIS governance often falls short for several reasons.

First, governance is generally a poorly understood topic in GIS circles. It's not uncommon to hear managers say that they

know they need governance, but they don't know exactly what it means. This speaks to a lack of a shared understanding of why governance exists in the first place. This lack of understanding often results in piecemeal, unstructured attempts at implementing governance in a single area such as data access or application ownership. These are fine starting points but don't constitute a comprehensive approach when considering the range of decisions required to sustain a modern GIS.

Second, GIS governance programs often lack attention to the ongoing job of governing. It's one thing to establish a steering committee and assign responsibilities, but another to keep the program going beyond a semiannual meeting. A well-executed program requires the commitment and energy to govern day-to-day.

Third, governance of GIS relies too much on other, broader levels of governance. To be clear, GIS doesn't exist in isolation. So, it's not surprising to see governance of GIS fall under an organization's IT governance or data governance programs. The problem is that these corporate-wide governance programs are often too general and overlook some of the unique aspects of GIS that require focused attention. These aspects include platform decisions, unique geospatial data considerations (e.g., standards, models), and worker skill sets. Effectively, this speaks to the hierarchical nature of governance—where higher levels dictate broad standards (e.g., corporate data privacy policy) and lower levels shape those standards appropriately (e.g., geospatial asset information access rules).

Last, governance is a cultural shift that requires discipline. For some, this means rules, and rules mean bureaucracy. Organizations that fail in their governance ambitions often fail because the opposition to change was too much to overcome. A systematic and explicit approach to governance is needed so that stakeholders understand the value of taking this on.

↑ GIS Governance Framework

A Comprehensive Definition

To address these challenges, we need to start with a broad definition of governance. Governance is about decisions and decision-making. Specifically, it's about defining the major decisions that need to be made with regard to an organization's GIS (the decisions) and how and by whom those decisions are made (the decision-making). Done correctly, governance creates a system of accountability that defines and enforces the rights of stakeholders.

To be clear, governance is not management. Governance is about setting direction. Management is about executing according to those directions. The distinction is important because much of the GIS conversation has traditionally centered on management topics. While management is vital, we want to draw a clear line between the two to keep the focus on doing the right things (governance) versus doing things right (management).

In practice, governance involves executing a set of processes that are defined based on the major GIS decision area they support (which will be discussed in the next section). Each process is composed of a defined set of goals, key performance indicators (KPIs), structured activities, roles and responsibilities, and policies and procedures.

Collectively, governance processes drive key business outcomes. These include improved accountability, compliance, delivery oversight, and resolution of issues. Effective governance brings structure to decision-making and clarity over responding to change.

Ultimately, governance creates stakeholder value. With greater accountability and control, the organization is positioned to make better decisions with its GIS—decisions that align with and support the organization's strategic mission and work to find an effective balance among the competing constraints of benefits, risk, and resources.

A Structured Framework

With governance defined, consider the specifics of implementing governance for GIS. Based on my experience, I've identified six major decision areas for GIS called domains. Domains are composed of more than 20 governance processes that have been compiled into best practices. Building a successful governance program requires a clear focus and maturity across these areas.

↑ Typical Governance Management Structure

Strategy Domain

Smart organizations have a clear vision of where they want to go with GIS and how to get there. Effective GIS governance means establishing core principles, determining short- and long-term objectives, defining the optimal organizational structure, and monitoring progress against the plan. Governance in the strategy domain supports alignment of the GIS vision with the business vision. Specific governance processes included in this domain are guiding principles, the strategic plan, stakeholder relationships, organizational structure, and innovation.

Platform Domain

Applications and infrastructure are the foundation of GIS. Many decisions must be made that impact the integrity of the technical environment and alignment with strategy, now and in the future. This cuts across the vast world of location-based technology including mapping platforms, geoanalytics solutions, mobile applications, and imagery management. Governance in the platform domain enables a sustainable, flexible, and fit-for-purpose GIS technology architecture. Specific governance processes included in this domain are technology architecture, solution portfolio, platform access, and platform performance.

Data Domain

Data is at the heart of GIS. This is true whether we're talking about geospatial or nongeospatial data, structured or unstructured data. Effective GIS governance establishes consistent GIS data standards, architectural models, data usage, access controls, accountability across the data life cycle, and quality controls. In addition, a key architectural decision relates to the structure of data ownership. This refers to ownership of systems of record versus ownership of derived sources and the business rationale behind decision rights. Specific governance processes included in this domain are data architecture, data usage, data stewardship, and data quality.

Workforce Domain

GIS requires unique skills and competencies across a range of technologies and disciplines. As a broad enabler, GIS is also leveraged by all manner of stakeholders. This means effective GIS governance considers development of the competencies, talents, and external relationships across the entire workforce. Governance in the workforce domain supports sustaining a skilled and informed workforce. Specific governance processes included in this domain are training, development, talent management, and partnerships.

Delivery Domain

An effective GIS is well supported and delivered as a service to the business. Good governance supports practices that promote efficient delivery of GIS as a service including needs capture, delivery, communication, and change management. Governance in the delivery domain establishes an effective GIS operation. Specific governance processes included in this domain are service management, communications, business needs, and change management.

Investment Domain

The end game for GIS governance is an answer to the question, where do we invest our resources? Effective GIS governance provides a mechanism for prioritizing investment decisions and monitoring progress. Governance in the investment domain aligns resources with GIS and business priorities. Specific governance processes included in this domain are budget management and investment prioritization.

Management Structure

To bring it all together, an effective governance program requires a strong management structure. This means organizing stakeholders into meaningful teams and establishing clear reporting relationships. While there is no single management structure that works for all organizations, a three-tiered structure is common. The first tier is a group of influencers (e.g., sponsor, executive champion, IT champion, and stakeholder champion). The second tier is a steering committee. The third tier typically consists of strategy, technical, and operational working groups.

This management structure represents general groupings of key governance roles. In many cases, individuals will play multiple roles and contribute to multiple aspects of governance. This is especially true for smaller organizations.

Influencers

This group is made up of influential and vocal stakeholders who do not make the final decisions on the GIS but whose input is critical to its success. They're generally

interested in business value, risk, and alignment with overall business objectives.

Steering Committee

The steering committee is the primary decision-making body for the organization's GIS. It is tasked with setting the overall direction and approving key GIS decisions.

Strategy Working Group

This group is generally responsible for developing the governance processes supporting the strategy and investment domains. Depending on the size of the organization, these stakeholders might sit on other working groups or be a part of the steering committee.

Technical Working Group

This group is responsible for developing the governance processes supporting the platform and data domains. Stakeholders in this group might also participate in corporate IT governance and data governance programs. They often act as an important conduit to these other, broader governance programs.

Operational Working Group

The operational working group develops the governance processes supporting the workforce and delivery domains. These stakeholders are typically involved closely in the day-to-day operations of providing GIS services. They may also work closely with broader IT service delivery programs.

A Valuable Undertaking

Implementing governance for GIS is a challenging but extremely valuable undertaking. It takes focus and commitment. With a bit of structure, however, any organization can achieve the benefits of good governance. This doesn't mean it happens overnight. By focusing on key problem areas and implementing processes and management structures that will bring these areas under control, organizations can start down a path that will lead to good governance.

About the Author

Matthew Lewin is the practice manager of management consulting for Esri Canada. His efforts are focused on helping management teams optimize and transform their businesses through GIS and location-based strategies. As a seasoned consultant, Lewin has provided organizations in the public and private sectors with practical strategies that enable GIS as an enterprise business capability. His interests lie at the intersection of business and technology and he thrives on helping organizations bridge the gap between the two to achieve their most challenging GIS ambitions.

Intrapreneurship and Geospatial Infrastructure

By Brent Jones

Intrapreneurship

Maybe you've heard this word—maybe not. It simply means having a system that allows employees to act as entrepreneurs within their organization. This doesn't have to be a formal thing. Anyone can be an intrapreneur. They're usually self-motivated, action-oriented innovators who take the initiative within the organization. A lot of GIS professionals are intrapreneurs.

Infrastructure is the basic structure needed to operate an organization. For this discussion, we'll focus on geospatial infrastructure. Geospatial infrastructure is technology, data, and services delivered in modern architected technology. It enables organizations at all levels to share, collaborate, interconnect, and benefit from the capabilities of GIS.

Geospatial infrastructure enables intrapreneurs by delivering data, app builders, configurable dashboards, analytical tools, and a broad range of capabilities designed to address your organizations' workflows and help it meet challenges and capitalize on opportunities. This infrastructure enables the integration of every type of data and format. It makes the organization's data as well as external datasets available in a single, comprehensive view that enables advanced analysis, visualization, and sharing. This improves collaboration, eliminates data duplication, and redundant workflows, and adds capabilities to all levels of an organization.

Back in the old days of custom code, capabilities and workflows had to be built for each organization's needs. There really wasn't a choice. If you wanted a technology solution, you needed to build it yourself. That came with a lot of baggage, particularly as related to the infrastructure needed to support custom software—system upgrades, personnel, documentation, and training—all with costly long-term commitments.

ArcGIS Solutions configurations are now part of the geospatial infrastructure. These solutions furnish maps, apps, hub sites, dashboards, and analytical tools configured to meet the common requirements for specific types of organizations. ArcGIS Solutions for Local Government are focused on planning, land records, elections, transportation, and emergency management. There are solutions for water, electric, gas, telecommunications, business, conservation, and defense and intelligence.

There are also solutions to help organizations respond to specific challenges. There are solutions for the coronavirus pandemic

that assist with site safety, business continuity, health screening, testing sites, and reporting metrics. There is a solution set of maps and apps to help provide insight into patterns of inequality and bring communities together around a common understanding and awareness of social inequities.

Choose solutions that fit the needs of your organization and configure them yourself. Most solutions are supported and being actively developed to evolve with the changing needs of organizations. These solutions include a plethora of datasets found in the ArcGIS Living Atlas of the World including basemaps, demographics, imagery, administrative boundaries, employment, income, and neighborhoods. It also includes live data feeds such as weather and traffic.

These solutions make it easy to be an intrapreneur. You and

others in your organization can easily create efficiencies, reduce redundancies, and add analytical capabilities with dashboards, web maps, and apps. You can configure their look and feel to match your organization's requirements and branding. You still get the same satisfaction of a do-it-yourself project without the necessity of creating custom software with long-term commitments for support, upgrades, and training.

Geospatial infrastructure empowers everyone to be an intrapreneur. We all want to do new things, use new technology, and improve our work. Configurable ArcGIS Solutions, ArcGIS Hub, ArcGIS Dashboards, and ArcGIS Field Apps and workflows make this technology accessible and useful to everyone. It can make us all intrapreneurs.

About the Author

Brent Jones oversees Esri's worldwide strategic planning, business development, and marketing activities for land records, cadastral, surveying, and land administration. As a recognized innovator, Jones specializes in modernizing existing land administration systems and designing new GIS-based cadastral management systems for small and large governments globally. He is president-elect of URISA; past president of the Geospatial Information and Technology Association; and a current member of the United Nations Committee of Experts on Global Geospatial Information Management, sitting on the Expert Group on Land Administration and Management. Esri creates systems that drive all components of land and cadastral administration, including addressing, registration, taxation/valuation, planning, and development.

Pump Up Pop-Ups in Web Apps

By Julie Powell

Pop-ups are often the single most important aspect of a web mapping application because they can enable interactivity with the map. A well-designed pop-up can be the difference between a good app and a great app. This article covers some of the subtle yet powerful capabilities of the pop-up that you can take advantage of as a developer.

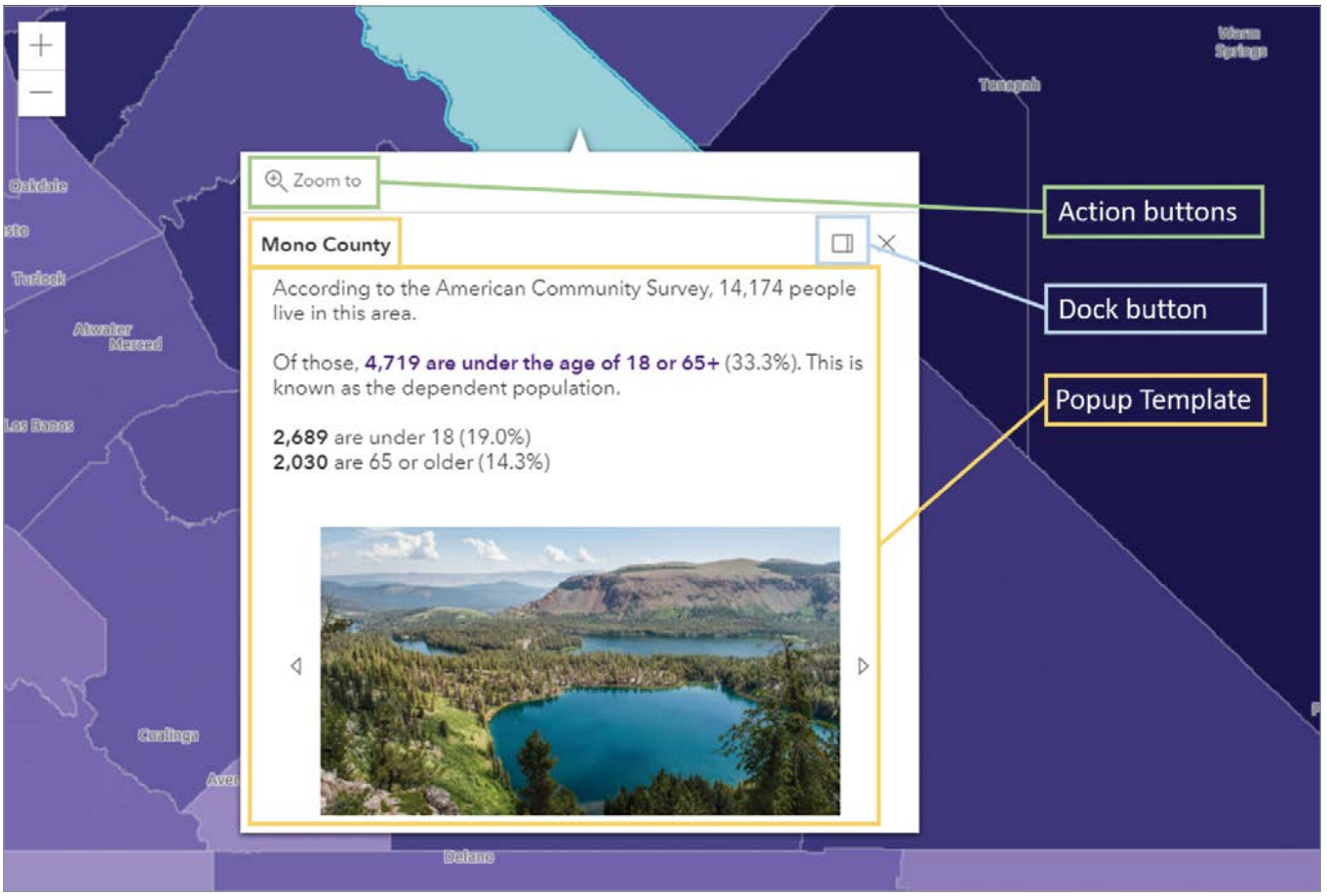
Pop-Up Content Basics

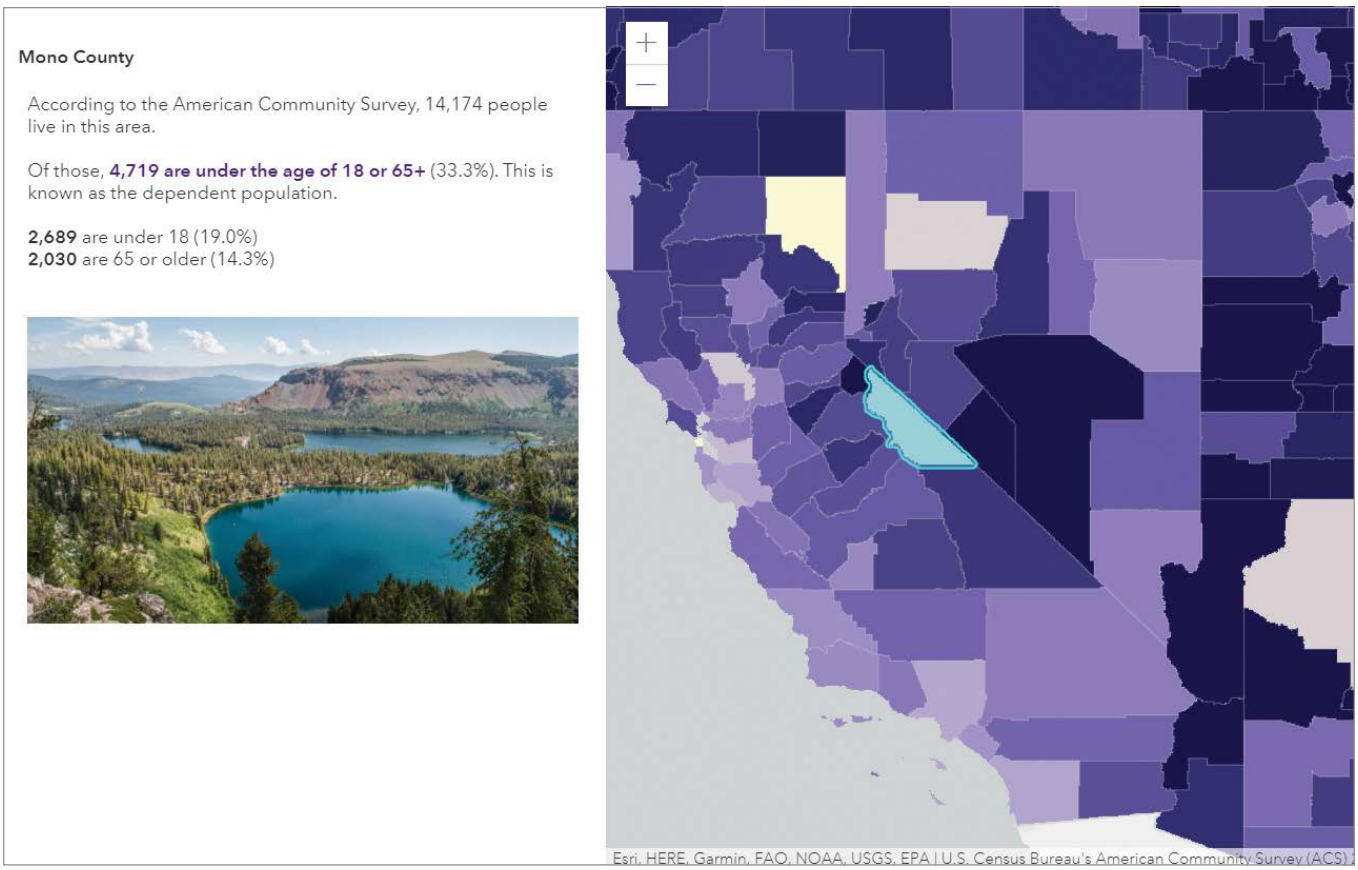
You can define pop-up content for each layer and how it is displayed with little effort using the authoring tools in ArcGIS Online and ArcGIS Enterprise. When these layers are loaded into your map they just work. In the background, the ArcGIS API for JavaScript creates a PopupTemplate for each layer that contains pop-up elements, such as attribute display, media charts, and images, that you've configured as well as any attachments associated with each feature.

Alternatively, you can programmatically define pop-ups using the ArcGIS API for JavaScript PopupTemplate class. It takes a little more work to achieve the same look and feel as pop-ups defined in ArcGIS Online or ArcGIS Enterprise, but you can also do more customization. Search on the *ArcGIS Blog* site and you'll find a large collection of helpful posts covering tips, tricks, and best practices for designing pop-ups.

These are two familiar approaches to creating pop-ups. At this point, many developers would consider their work on pop-ups done. However, you have even more options for tailoring pop-up content and experience. Basically, you can put anything you want inside a pop-up.

↓ The anatomy of a pop-up





↑ Use the Feature widget to place formatted pop-up content in a side panel.

Many More Things to Do with Pop-Ups

The ArcGIS API for JavaScript 4.16 introduced a new content type to the Pop-upTemplate called CustomContent. This content element can be added to the pop-up just like other types such as attribute tables and charts. CustomContent can work with strings, HTML elements, and API widgets. This gives you lots of flexibility regarding what you can place inside a pop-up.

At a high level, you'll create the custom content and create the PopupTemplate, reference the content elements, and configure the layer to use the PopupTemplate. The outFields property is used when creating the PopupTemplate and referencing content elements. For optimum performance, the JavaScript API only requests the feature attributes that it needs for visualization (and for the layer's pop-up definition if the pop-up was preconfigured in ArcGIS Online or ArcGIS Enterprise). If you are customizing, you must specify the attributes that you'll be working with so that they are also downloaded. In addition, you can use the CustomContent destroyer property for cleaning up any custom content when it is no longer needed.

Click a Button, Execute a Function

You can easily configure the pop-up to have one or more buttons that execute a function that you've created. These are called pop-up actions. You may have noticed the zoom-in button that is symbolized by a magnifying glass in the default pop-up. That is an action. When clicked, the map zooms in and centers on the selected feature.

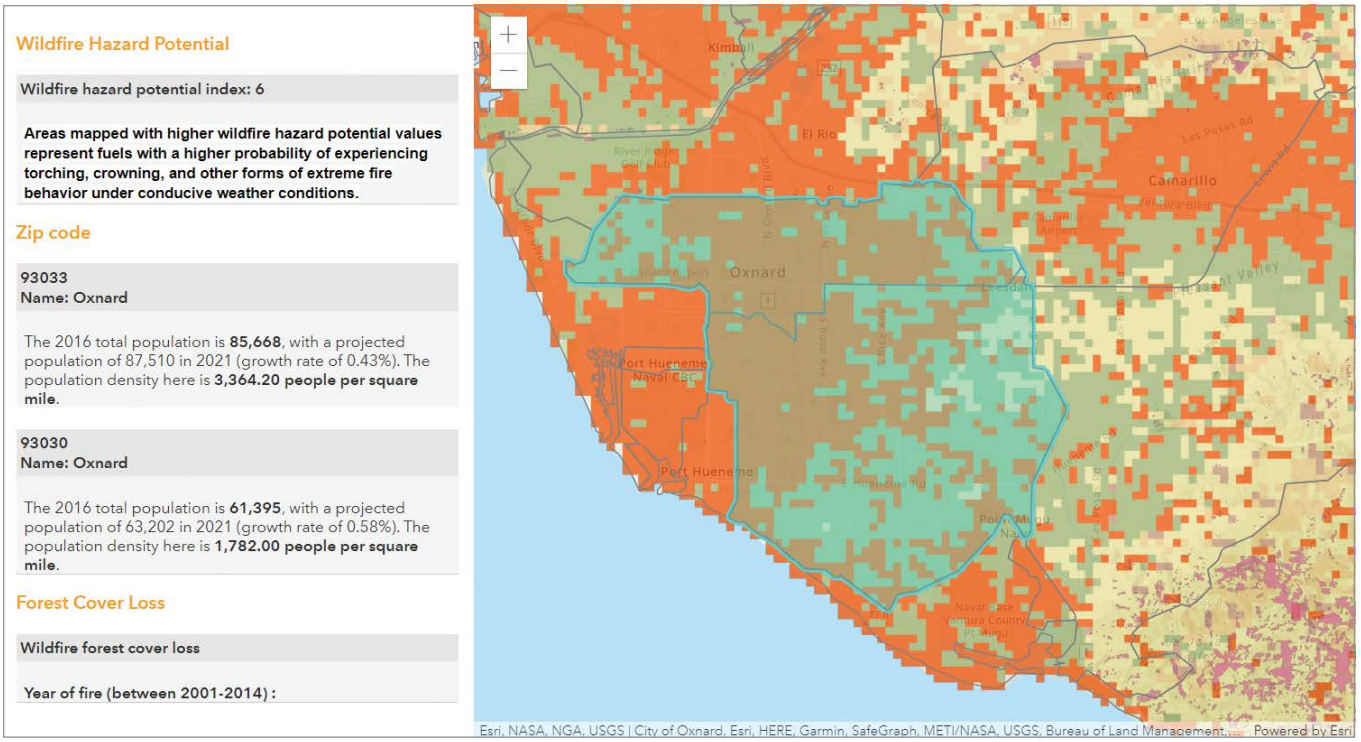
You can add any number of custom actions to the pop-up and control how many are displayed before items are added to the menu accessed by the More Options icon (which is denoted by an ellipsis or "…"). This capability is most often used when you want the user to be able to do something with the selected feature.

For example, if you had a layer containing possible retail locations, you could have an action that, when clicked, calculates a 10-minute drive time around the selected feature and displays demographics for people who live within the drive-time polygon. You could also have a button to intersect the drive time polygon with another layer in the map. You decide exactly what happens when the user clicks on a custom action. Actions were created to give developers an easy way to integrate custom workflows into pop-ups.

Alternatives to the Default Pop-Up

There are some very helpful mechanisms in the JavaScript API for building out your own experience for users. These include formatting content that appears outside the pop-up and displaying more than one pop-up at the same time.

As mentioned earlier, the PopupTemplate is used to display nicely formatted pop-up content. If you'd like to display formatted content somewhere in your application other than inside the pop-up, you can use the Feature widget, which renders information about a feature according to its PopupTemplate. The pop-up uses the Feature widget internally to display content and surrounds it with the pop-up UI (such as the docking control and pagination).



↑ Show feature information from three layers at once using the Feature widget.

The Feature widget can be placed in any container, on top of the map, or completely outside the map. This functionality is commonly used to display the feature's information in a side panel next to the map or in a floating window that is visible when the user hovers over a feature.

If you need to display more than one pop-up at the same time, use multiple instances of the Feature widget, and a pop-up helper method. Rather than showing the information inside a pop-up, which automatically closes when another feature is clicked, it is shown in Feature widgets that are added to the UI. You can display multiple pop-ups next to a selected feature and provide a button for the user to explicitly close each pop-up. You will have to do a little plumbing to get this to work. You will need to set the pop-up's autoOpenEnabled property to false and add a click listener on the view to get all features that were clicked.

You can get the features at a given screen location using the PopupViewModel's fetchFeatures method. (The business logic that powers the pop-up is the PopupViewModel.) You might wonder why you wouldn't just use the map view's hitTest for this. There are two important distinctions with using fetchFeatures. First, you get all the features in all layers from the client and server rather than limiting features to layers that are already loaded on the client. Second, you get the features that have a pop-up enabled and a popupTemplate defined for you to use.

If you don't want to show pop-up information at all, you can disable the pop-up by setting popupEnabled to false for a single layer or disable pop-ups for all layers using this syntax:

```
view.map.layers.forEach( layer => layer.popupEnabled =
false );
```

Fine-Tuning the Experience

There are several configuration options related to the pop-up experience that can be easily overlooked but that you might like to try out.

Customize the feature highlight color. When the user clicks on features, what color would you like used for highlighting? You can customize the color by setting the highlightOptions for the map or scene view.

Remove parts of the pop-up. Using the visibleElements property, you can turn individual elements of the widget's display on and off including the Close button and the navigation controls for cycling through selected features.

Control docking behavior. When a pop-up is dockEnabled, it means the pop-up no longer points to the selected feature or the location assigned to it. Rather, it is placed in one of the corners of the view or at the top or bottom of the view. Docking the pop-up provides a better user experience, particularly when opening pop-ups in apps on mobile devices. You can control various aspects of the docking behavior, including setting the breakpoint property to determine at what screen size the pop-up will be docked. You can also turn off docking completely if you don't want your pop-up to switch to a docked position when the viewport is small.

Pop-Up Styling

Style your pop-up to match the rest of your app and company branding, or change specific elements based on your preferred design. Although it isn't immediately obvious, the pop-up is a widget with the same architecture as other widgets in the JavaScript API, so it

can be styled just like other widgets.

One way to quickly change the style of all widgets in your app at once is to apply a theme. You can pick from light (default), dark, light-dark blue, light-dark green, light-dark purple, and light-dark red. You can also create your own theme and apply it across all widgets, which is more involved. To learn how to do this, read the Styling topic in the JavaScript API Guide.

You can change a handful of properties by overriding the pop-up's CSS. An easy way to figure out what properties you want to change is to use the developer tools in the browser to inspect the CSS to see property settings and test out changes that you want to make.

If you need a scalable approach with more fine-grained control, you may want to consider working with the pop-up's Sass file. *[Sass, which stands for syntactically awesome stylesheet, is an extension to CSS.]* This is the recommended approach for customizing CSS for a pop-up, as it provides a more robust option than manually overriding it. You can find the Sass file for the pop-up on the Esri repo on GitHub (https://bit.ly/3hFgZUY).

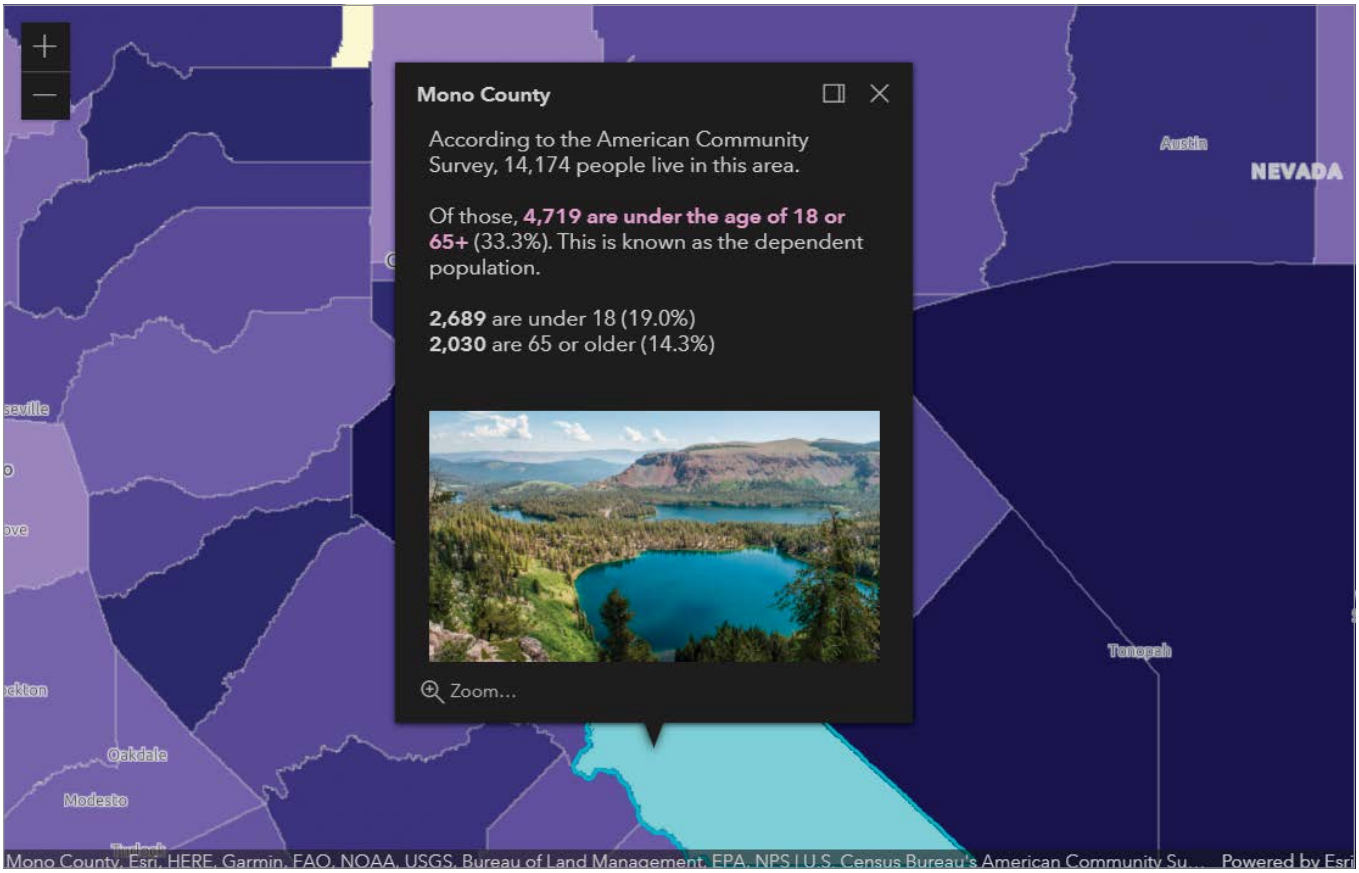
Where to Learn More

This article has shared many ways for you to create beautiful, effective pop-ups. Here are some additional resources on pop-ups. The pop-up is a critical part of web mapping applications, so Esri is continually evolving and improving the pop-up experience and flexibility. Look for information updates to pop-ups in the release notes and release announcement blogs. Just search for *pop-up*. Samples in the JavaScript API documentation cover a wide variety of pop-up topics you might find helpful. Pop-ups are covered at every Esri Developer Summit and Esri User Conference. See the JavaScript API playlist (http://esriurl.com/JSPlaylist) on YouTube to listen to recordings from the last Esri Developer Summit.

About the Author

Julie Powell is a technical product manager at Esri. Her primary focus is the ArcGIS API for JavaScript. She has more than 17 years of experience working with software development, delivering solutions for both enterprise and consumer markets. Powell has worked on a wide range of projects and consulting endeavors, including serving as a technical lead for web mapping solutions for strategic customers. She interfaces with a wide user community to maintain awareness and insight into GIS community needs, meanwhile contributing feedback to development teams to help ensure that users can be successful in building state-of-the-art, purposeful solutions using ArcGIS software.

↓ Applying a theme changes the color of all API widgets in the app, including the pop-up. In this app, the dark theme was used.



ArcGIS Runtime 100.9 Has More Support for Feature Use, Open Data, and Offline Maps

By Rex Hansen and Nick Furness

ArcGIS Runtime 100.9, also known as Update 9, continues to improve support for online workflows with utility networks, but also introduces key enhancements to the use of features, open data, offline maps, and raster capabilities.

Each release since 100.0 in 2016 has targeted a variety of functional areas and industry-specific needs. As this functionality has matured, existing users and partners have migrated from older Esri developer technology to the ArcGIS Runtime, new developers have began using ArcGIS Runtime to add GIS and mapping to native apps, and developers who had been using other development tools have transitioned to ArcGIS Runtime to take advantage of the complete and robust platform available with ArcGIS.

Since 100.6, each release has focused on three tracks: utilities, defense and public safety, and platform (i.e., crosscutting features that support ArcGIS functionality). The industries named in these tracks were the drivers for the development of this functionality, but the applications of those capabilities extend much more broadly to many industries.

Utility Networks

New capabilities enabled for use with online utility networks include two new trace types: loops and shortest path. Loops are areas of a network where resources can flow in either direction. They are expected with mesh networks but usually indicate error conditions in radial networks. Loops can be discovered using a shortest path trace. A shortest path trace identifies the shortest path between two points using a numeric network attribute or weight, such as length or cost.

You can also filter elements returned from a trace to a specific asset type or output condition. If conditions are defined, every feature encountered during a trace is evaluated, and only elements that satisfy the conditions are included in the trace result.

Trace results can now contain a union of all geometries of a type returned from a trace. This provides a more efficient option for displaying trace results on a map instead of iterating through multiple utility elements.

Functions can now be included in a trace configuration and returned with trace results, which allows you to run calculations on network attributes associated with traced features (e.g., the sum of the length of all the wire traced). Several functions can be specified for a trace. The trace function output gives you the trace function definition (e.g., calculation type, network attribute) as well as the function result.

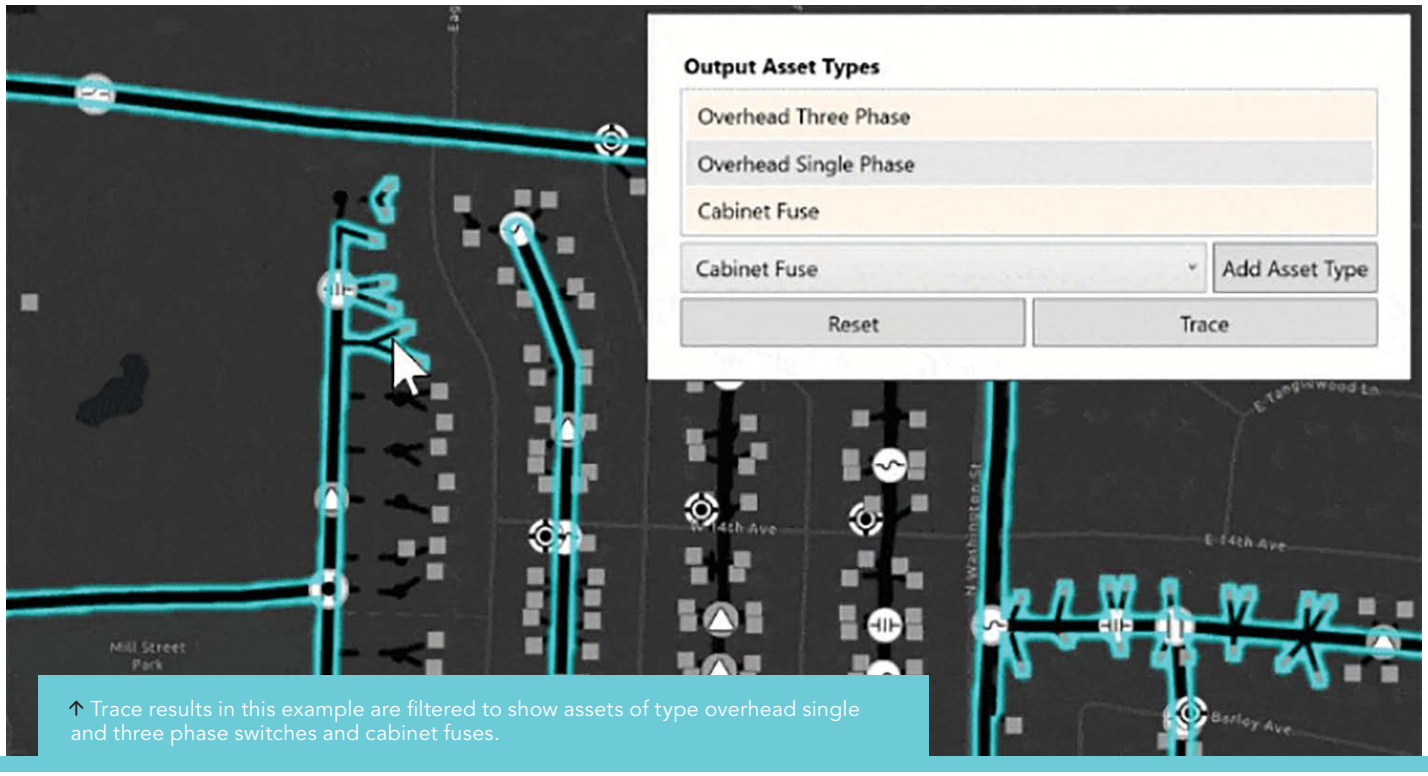
Version 4 of the ArcGIS Utility Network adds nonspatial object support, which enables use with telecom networks and underground electrical utilities. Nonspatial tables are now included with network sources and enumerations.

Feature Tiles

Feature layers now use tile-based requests to fetch and display features in a map when supported by the feature service. Feature tiles enable feature layers in ArcGIS Runtime to load faster and return more features. Feature tiles use a protocol buffer binary format to reduce network latency and advanced HTTP caching semantics to improve performance. At this release, feature tiles are not used to request features for display in a scene (3D).

Branch Versioned Feature Services

Enterprise geodatabases use versioning to accommodate the needs of multiuser editing scenarios and long transactions. Branch versioning uses the Web GIS model to meet those needs via feature services. ArcGIS Runtime now supports branch versioning workflows through feature services. It can



↑ Trace results in this example are filtered to show assets of type overhead single and three phase switches and cabinet fuses.

browse the versions available on a feature service, choose a version to connect to or create a new one, and then display features from that version using feature layers. Edits made to the features in the feature layer are isolated to that version and protected from changes being made to other versions. ArcGIS Pro can be used to reconcile and post changes from different versions at the end of the editing process.

Offline Feature-Linked Annotation

You can now take feature-linked annotation offline from a sync-enabled feature service, add new features, update existing feature geometry and attributes, and view the automatically positioned feature-linked annotation on the map. If you synchronize your changes with the online feature service, the annotation objects will be automatically updated on the server to reflect those changes. Other offline users can then synchronize with the feature service to obtain the updated feature-linked annotation.

OGC API Features

This release introduces support for OGC API Features, a new, open, multipart standard of the Open Geospatial Consortium Inc. (OGC) for sharing feature data on the web. Part 1: Core of this standard describes basic capabilities for enabling read-only access to spatial data. Most of these capabilities are supported in ArcGIS Runtime and are accessible through new classes that represent an OGC feature service and feature service info as well as OGC feature tables and collections. Note that only manual cache mode is supported at this time, which means a developer must use the API to query and populate an OGC feature table with features from an OGC API Feature service.

Offline Maps

In the 100.8 release, Esri delivered support for online layers in mobile map and scene packages. In the 100.9 release, a web map can now be taken offline while retaining layers that reference online services. When network connectivity is available, your app users can utilize these online services, but if there is no connection, users can keep working with their local content.

A few years ago, Esri introduced support for preplanned workflows to optimize and streamline creating and delivering maps and data for offline use. A preplanned workflow relies on map authors who create and publish map areas in ArcGIS Online or ArcGIS Enterprise. Publishing a map area involves generating and storing new files of map content, such as basemaps and features, for download.

Generating and downloading a map area can take some time. With this release, before you download the map area, you can now check whether a map area's publishing process is complete, has failed, or is still in progress.

You can also take a map offline and avoid receiving updates. This will disable data synchronization on the map's geodatabases and prevent associated feature services from creating synchronization replicas. The benefits of this option are that the burden on the feature server is reduced, and you will not need to unregister geodatabases when they are no longer required.

Mosaic Rules

A mosaic rule defines how the individual rasters are combined into a single mosaicked image. With this release, mosaic rules defined in web maps, web scenes, mobile map packages, and mobile

↑ The grid shows tiles defined by a ArcGIS Runtime request for all features of this point feature layer from an ArcGIS feature service. This service represents usage of public transport by census tract in the northeastern United States.

scene packages are honored while rendering image service rasters. You can also override the default mosaic rules to control how overlapping areas in the mosaic are handled. In addition to how it's displayed, the mosaic rules may affect values returned when identifying, computing a histogram, or exporting the image.

Platform Improvements and Changes

New locators were introduced with ArcGIS Pro 2.3 via the Create Locator tool and supported in ArcGIS Runtime 100.5. These locators consist of a *.loc file and *.loz file. These files are smaller, faster, easier to maintain, and offer consistency across the platform. 100.9 will be the last release to support classic geocode locators (that have only a *.loc file), created in ArcGIS Pro using the Create Address Locator tool. This change only pertains to use of local locators. There is no change to ArcGIS Runtime support for ArcGIS geocode services.

For ArcGIS Runtime developers who use ArcGIS Runtime Local Server, Esri has extended the deprecation of ArcGIS Desktop 10.x packages. Version 100.9 will be the last release to support ArcGIS Desktop 10.x packages that were created in ArcMap. The next ArcGIS Runtime Local Server version will require that packages be created with ArcGIS Pro. ArcGIS Runtime Local Server can be used with newer versions of the ArcGIS Runtime SDKs for .NET, Java, and Qt.

Esri has also introduced many more enhancements to group layers, navigation, and scenes; continued to fix issues; improved performance, and enriched integration within the platform. For more details, see the release notes at developers.esri.com for Android, iOS, Qt, .NET, and Java.

Download and Get Started

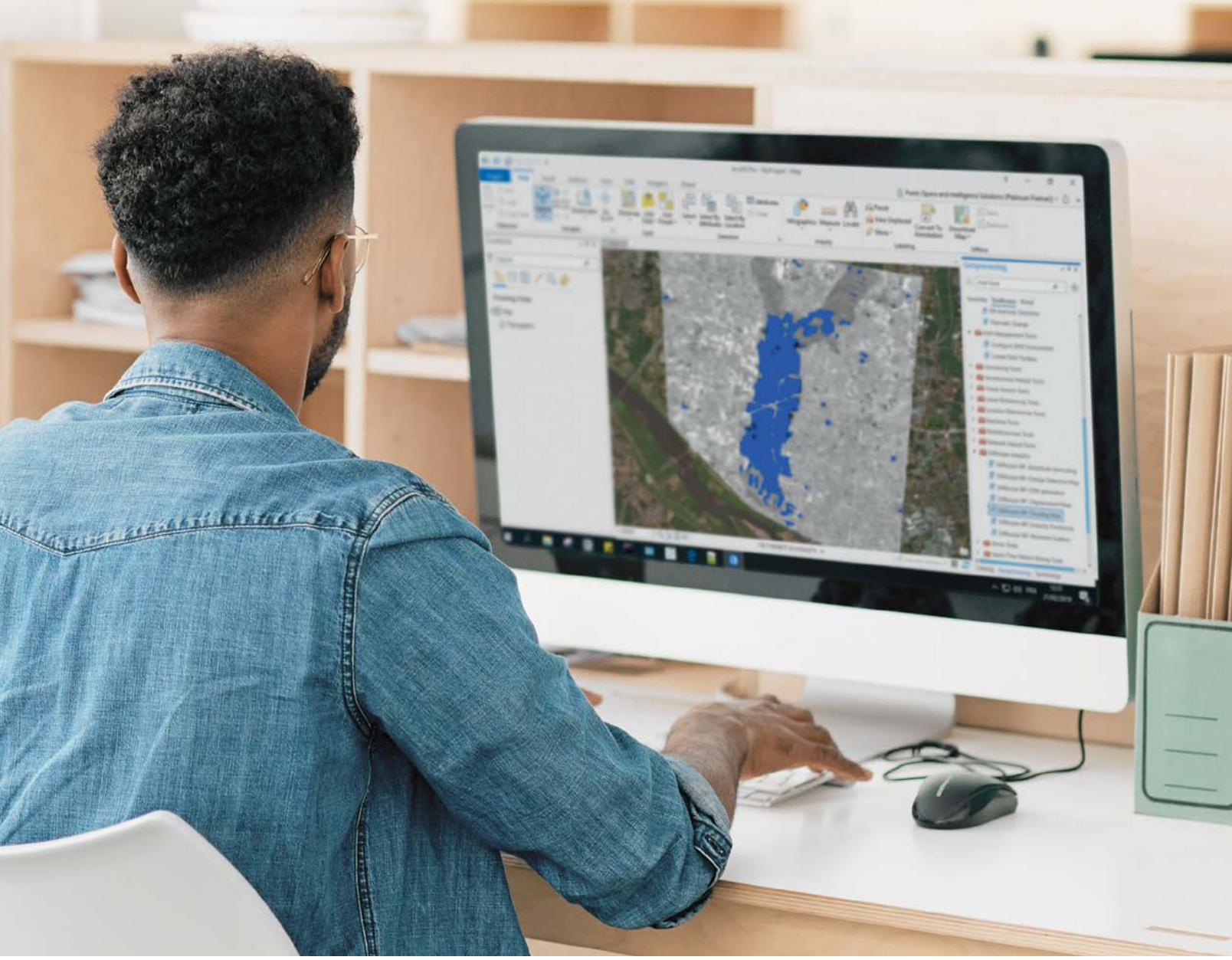
To get 100.9, go to the ArcGIS for Developers website (developers.esri.com), and download the SDK of your choice. You can also reference it through development tools such as NuGet, Gradle, or CocoaPods. If you're new to developing with ArcGIS Runtime and don't have an ArcGIS for Developers subscription, simply sign up for a free account and you'll be able to access everything you need to develop your app.

Sign up for a free account and access everything you need to develop your app.

About the Authors

Rex Hansen is an Esri product manager for ArcGIS Runtime. He has more than 25 years of experience in GIS, spatial analytics, and computer mapping. Recently, he has helped guide the development of native solutions and technologies in the GIS industry that use authoritative geospatial data in immersive, extended reality experiences.

Nick Furness is an Esri technical product manager for ArcGIS Runtime SDKs for iOS and macOS. He has spent more than 20 years working in GIS, building projects that have ranged from small mom-and-pop solutions to enterprise utility and national government deployments. He presents at the Esri Developer Summit, the Esri User Conference, and many other events, mostly on ArcGIS Runtime SDKs.



EASILY PROCESS AND ANALYZE SAR DATA

Get the benefit of SAR analytics
across the ArcGIS® platform

For more information visit www.L3HarrisGeospatial.com/SARscape

L3HARRIS™
FAST. FORWARD.

Providing Actionable Data Aids Earthquake Response

By Alex Rudowski and Rachel Manko

Just after 7:00 a.m. on March 18, 2020, residents of Salt Lake Valley in Utah were shaken awake by a 5.7 magnitude earthquake. Magna, a community a few miles west of Salt Lake City, was at the epicenter of the quake. Although no one was fatally injured, significant property damage was reported across the valley, primarily impacting unreinforced masonry structures.

The Greater Salt Lake Municipal Services District (MSD) oversees planning and development services in Magna, including building inspections. The MSD Operations team quickly created data collection forms in ArcGIS Survey123. The forms helped the public report damage and field inspectors assess structural integrity. MSD building inspectors partnered with Salt Lake County Public Works structural engineers to triage the damage and more effectively direct response efforts throughout the jurisdiction.

"The day of the earthquake, providing timely, relevant, and reliable data quickly became our most important priority," said Lupita McClenning, director of planning and development for MSD.

She noted that the MSD Operations team provided data and analytics to support response initiatives. This data was critical in strengthening efforts by other agencies. The MSD team knew leaders needed to have real-time data and analytics to quickly visualize that data so they could effectively make decisions.

"The end goal of using analytics and GIS technology is to inform decision-making for responders, community leaders, and citizens. Incorporating GIS improved planning, analysis, situational awareness, response times, collaboration, and communication during a challenging time," said McClenning.

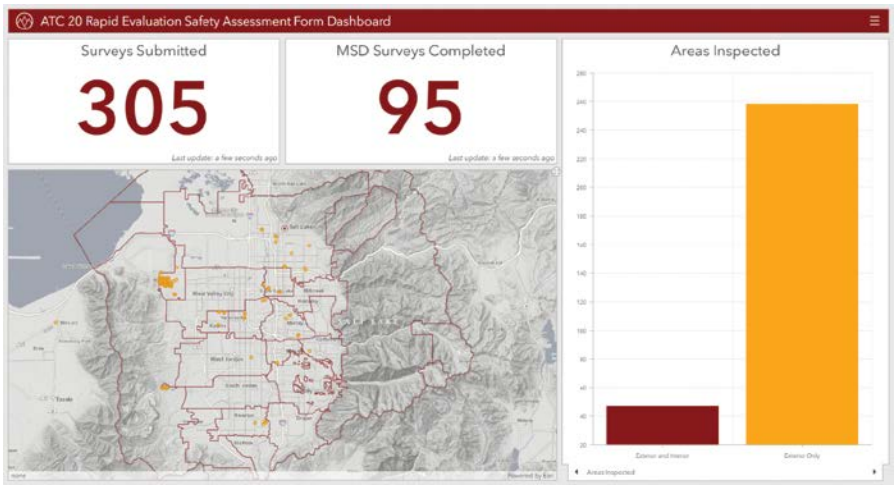
↑ The 5.7 magnitude earthquake centered in Magna, Utah, resulted in significant property damage especially to unreinforced masonry structures like this market.

Earthquake risk is nothing new to those living along Utah's Wasatch Front, a metropolitan region in the north-central portion of the state that stretches from Nephi to Brigham City. Within the region, the Wasatch Fault runs north from the near geographic center of Utah through southern Idaho. This region contains approximately 75 percent of Utah's population, according to estimates by the Kem C. Gardner Policy Institute.

Forecasters at the Working Group on Utah Earthquake Probabilities predict that there is a 43 percent chance that a magnitude 6.75 or greater earthquake will occur along the Wasatch Front within 50 years. The Magna quake was not the "big one," but it did serve as a potent reminder for what lies ahead.

As the municipal service provider for Magna and the other metro townships, the MSD has applied data-driven approaches to serving the population in the past, and the agency's response to the earthquake was no different.

↓ A dashboard provided up-to-date information on the progress being made in assessing damage using ATC-20 Rapid Evaluation Safety Assessment Forms.



Esri tools, such as classic Esri Story Maps templates, ArcGIS StoryMaps, hub sites, custom applications built with ArcGIS Web AppBuilder, and data collection solutions including ArcGIS Survey123 have long been an integral part of regional planning initiatives. They are workhorses for local government.

Forms configured in ArcGIS Survey123 Connect that can be opened in either a web browser or on a mobile device allowed the district to collect residents' input during the emergency response quickly and accurately. These forms also improved field staff productivity by eliminating paper forms and the need to reenter data. Residents and MSD field inspectors could submit surveys while following the safety practices required during the COVID-19 pandemic.

MSD disseminated forms to the public within a few hours via MSD hub sites, social media platforms, news outlets, and municipal websites. These forms helped the MSD gather information quickly and provided better overall service. The Federal Emergency Management Agency (FEMA) requires inspectors to fill out an ACT-20 Rapid Evaluation Safety Assessment for each damaged structure to determine if the public can safely return to homes and businesses. *[ATC-20, developed by the nonprofit hazard mitigation corporation Applied Technology Council, is the standard form for evaluating the safety of buildings after an earthquake.]*

> The day of the earthquake, providing timely, relevant, and reliable data quickly became our most important priority.

Within an hour, the ATC-20 paper form, available from the FEMA website, was converted to a live survey. Using mobile devices, each field officer could assess structures. Local authorities, who viewed real-time monitoring of the damage to buildings in the valley using dashboards, could make data-driven decisions about emergency response.

Izabela Miller, operations manager with MSD, said her team worked with emergency management staff to ensure the information collected was sufficient for determining whether in-person inspections of structures were necessary. Salt Lake Valley residents could submit requests for inspections, no matter where they lived.

"Nature doesn't respect boundaries, and during an emergency, cross-jurisdictional local government cooperation should reflect that in the response," she said. "Using Survey123 and our Damage Assessment Operations Dashboard, we were able not only to reach out to citizens but also to visualize where the damage hot spots were by using the heat map capabilities of ArcGIS Online applications."

On July 9, 2020, FEMA officially declared the Magna quake an active disaster, making individual assistance available for residents in Salt Lake and Davis counties. As of August 2020, the agency had approved 47 applications from individuals that would provide $154,407 in housing assistance. The nationwide COVID-19 emergency has caused FEMA to use remote inspections to assess damage to homes in Salt Lake County.

The unpredictability of earthquakes is part of what makes them so dangerous. The best thing communities can do is to be prepared and have a response plan. MSD prides itself on the level of service it provides to its residents and is confident in its ability to respond to future emergencies in the communities it serves. Effective local government starts and ends with community engagement, and Esri tools like ArcGIS Survey123 and ArcGIS Dashboards grease the gears of this engagement.

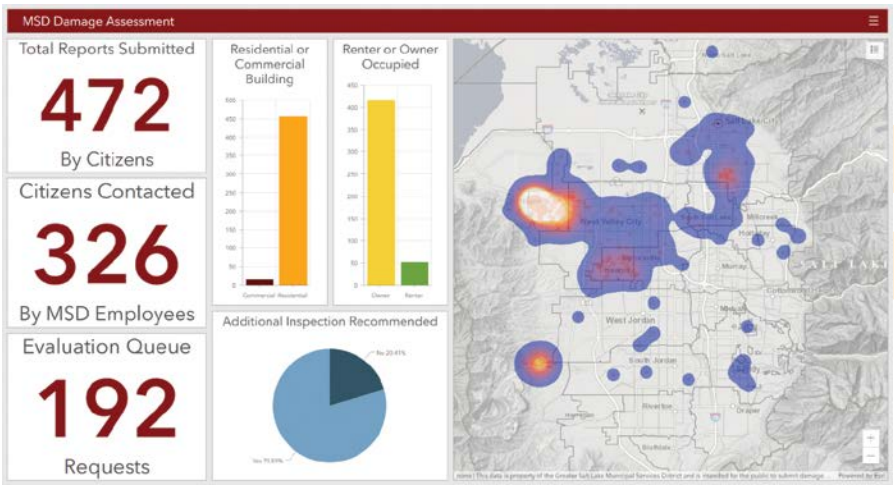
For more information, contact Alex Rudowski at arudowski@msd.utah.gov or Rachel Manko at rmanko@msd.utah.gov.

About the Authors

Alex Rudowski is a GIS analyst and planner who has been with the Greater Salt Lake Municipal Services District for one year. He has eight years of GIS experience in local government and nonprofit environmental conservation. Rudowski has a bachelor's degree in environmental regional planning from Indiana University of Pennsylvania.

Rachel Manko is a business process analyst with the Greater Salt Lake Municipal Services District. She has worked for five years in Utah's GIS community. Manko received a bachelor's degree in urban planning and a GIS certificate from the University of Utah.

↓ Using ArcGIS Survey123 and ArcGIS Dashboards, MSD could reach out to residents and visualize the distribution of damage using the heat map capabilities of ArcGIS Online, displayed in the dashboard.



Adding Traffic Data Using GIS Enhances Commercial Property Valuation

By John Watterson

A Florida county appraiser's office developed a more efficient and less costly method for improving the assessment of commercial properties by more easily incorporating traffic count data using GIS.

Traffic count information is vital in several disciplines that use GIS. Common examples are transportation planning; site selection; and for the topic of this article, commercial real estate appraisal. This article examines how the Martin County Property Appraiser's office (MC PAO) in Stuart, Florida, uses traffic layers to assist in the proper valuation of commercial properties.

Property assessment offices are responsible for developing supportable values of real estate for ad valorem taxation *[i.e., taxation based on the assessed value of an item]* when allocating taxes among property owners.

GIS technology has played an increasingly important role in this task. It is widely understood that location is crucial for a business to succeed. Consequently, road segments with higher traffic counts are more desirable for locating retail businesses.

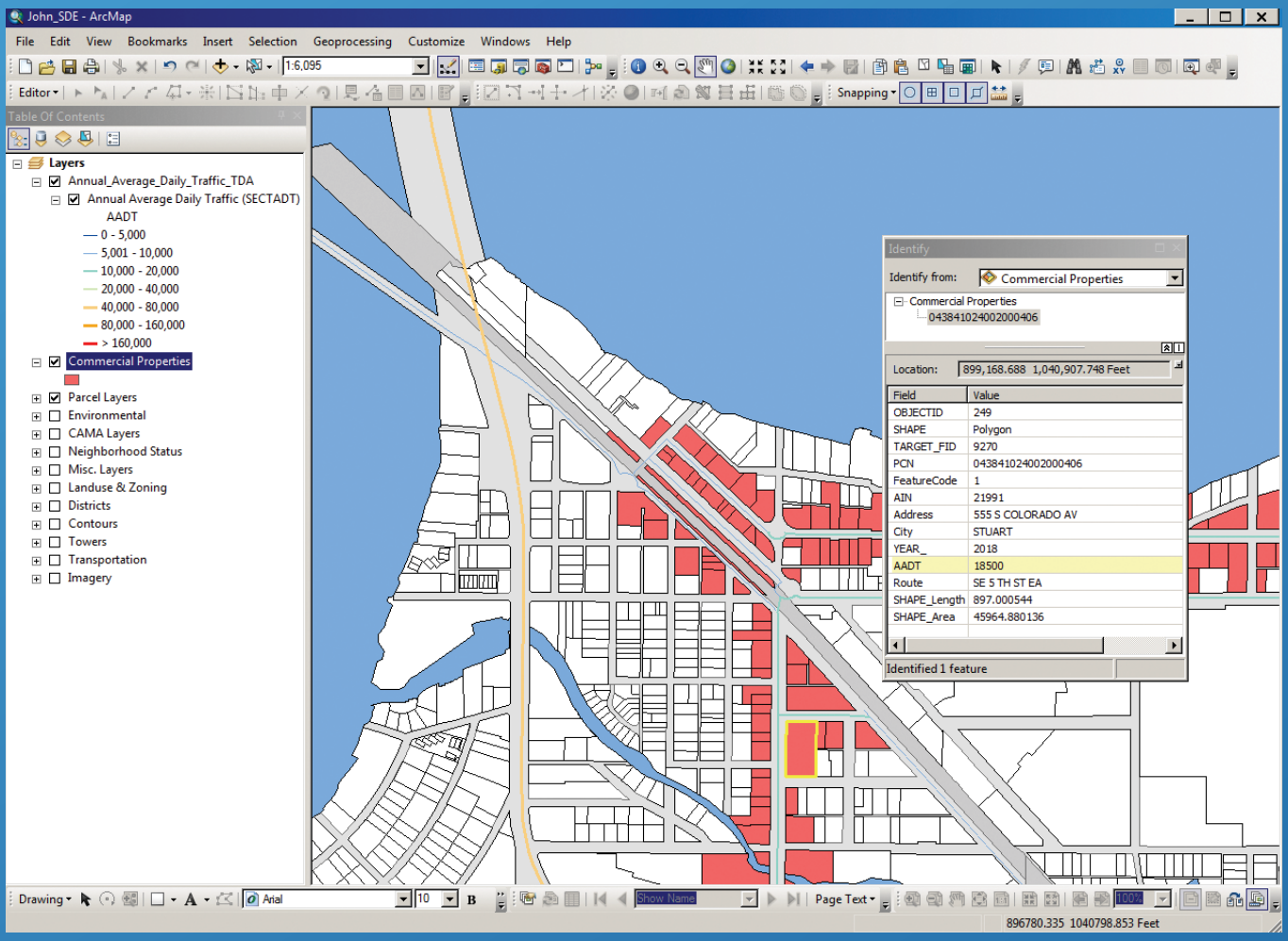
MC PAO uses the term *super-corner* to describe lighted intersections with high traffic volumes. Except for waterfront parcels, these super-corners have land that brings the highest price per square foot of all commercial properties in Martin County.

By integrating traffic count information with GIS, commercial appraisers can better answer questions associated with sales prices and rents when valuing retail commercial properties. Traffic counts can be analyzed in a certain area and then compared to properties with similar zoning and other factors such as water frontage.

In this project, road centerline layers with Annual Average Daily Traffic (AADT) count fields were spatially joined with commercial parcels. The traffic count centerline layers were obtained from the Transportation Data and Analytics Office of the Florida Department of Transportation (FDOT) through the ArcGIS Online portal and the Martin County Board of County Commissioners (MC BOCC) Traffic Division. After gathering the GIS data, the Spatial Join tool was used with a search radius to append surrounding commercial parcels with the AADT field from centerline layers.

Commercial parcels were spatially joined with the AADT field from centerline layers. The target features were in the commercial parcels layer, which was intersected with the join features in the road centerline layers. After running the Spatial Join tool, parcels at intersections required some manual quality control to ensure the correct AADT record was pulled from the proper road. MC PAO commercial appraisers copied traffic information from the layer attribute tables into spreadsheets to conduct further analysis.

As a result of this project, commercial



↑ Commercial properties are shown in red, and traffic centerlines are symbolized by AADT traffic volume. (Traffic centerline data is courtesy of the Florida Department of Transportation.)

appraisers no longer must obtain traffic count information from a separate traffic count map or other private sources. Also, MC PAO no longer pays subscription fees to acquire this information from services.

Unlike residential properties, commercial properties are most often initially grouped by property type, rather than by location. Homogeneous commercial properties are not always located right next to each other but are scattered over large areas, which means that traffic counts vary widely. This project linked traffic volumes to each property regardless of its location.

In the past, commercial appraisers had to search for traffic count information on various websites and then go through the laborious process of linking the information to a parcel. Having all the necessary fields in one layer is very convenient for locating and identifying traffic information for commercial properties.

Another important benefit of this project is that the MC PAO no longer relies on traffic data that is static and becomes outdated. The FDOT centerline layer is dynamically updated once a year through ArcGIS Online, and the traffic centerline layer from the MC BOCC is also updated annually.

Although this project took about a week to complete, it replaced a manual process that previously took at least a month. It has turned out to be a long-term solution for MC PAO.

For more information, contact John Watterson at john.watterson@pa.martin.fl.us.

About the Author

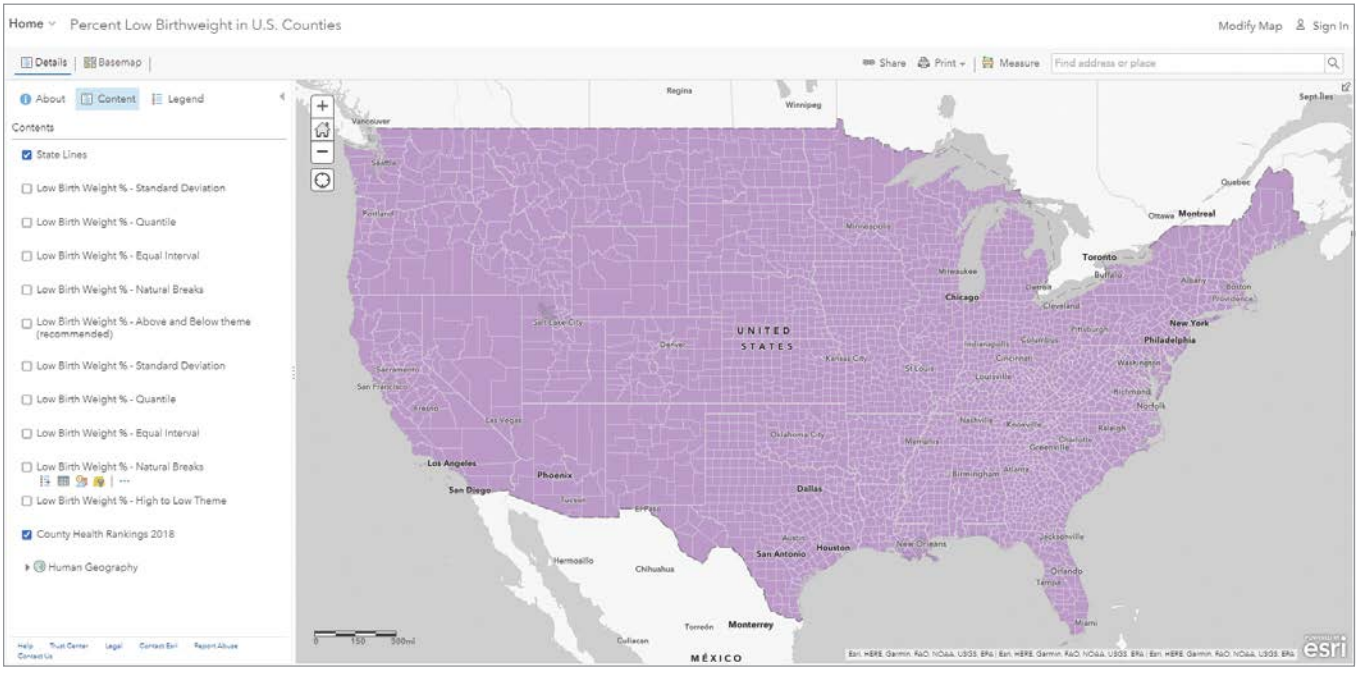
John Watterson is a GIS specialist at the Martin County Property Appraiser's office in Stuart, Florida. He has a bachelor's degree in geography from Florida State University.

Better Breaks

Define Your Map's Purpose

By Jim Herries

Because I am a geographer who makes a lot of thematic maps, over time I've noticed the key moments in the decision-making process that dramatically influence each map. This article discusses how a typical thematic map of a percentage comes into focus and how you give it purpose. The software (in this case, ArcGIS Online) starts the map, but it takes a human to make that data meaningful and give the map purpose.



To start, we need data and an idea of what we want to map. Esri recently hosted County Health Rankings 2018 from the Robert Wood Johnson Foundation and the University of Wisconsin Health Institute. This layer contains dozens of useful measures, each waiting to be turned into useful information on a map.

Let's pick just one subject among the many attributes in this gold mine of data: Percent Low Birth Weight. It represents the percentage of all births in a county that meet the standard of low birth weight. We need an idea for the map. It is easy to imagine a map of the counties, each shaded by its low birth weight percent. Pretty straightforward.

↑ Open the County Health Rankings 2018 map (https://bit.ly/3l2ysb6) from the ArcGIS Living Atlas of the World in ArcGIS Online to follow along with this article.

→ ArcGIS Online saves time and makes you a better mapmaker by suggesting a High to Low theme using a yellow-to-dark blue color ramp, with key breaks set at one standard deviation around the mean.

As always, let's explore the data on the map first to compare what we know about the subject to what's on the map, and then make a thematic map of it. That first step (exploring the data) is key. Unfortunately, a lot of people simply want to get the thematic map done as quickly as possible without thinking critically about the data. They choose a default classification technique, verify that the map shows some variation in colors, and call it a day. That map is unfinished.

How can you tell a thematic map has been rushed? These four characteristics indicate a map that was created without a specific purpose:

- Default colors, outlines, and classification settings were used.
- The breaks used to set the colors have no intrinsic meaning—they are just numbers generated by an algorithm.
- The colors have not been chosen to emphasize the interesting part of the data.
- The legend contains unnecessary levels of precision.

To follow along with this article, open the County Health Rankings 2018 map (https://bit.ly/3l2ysb6) from the ArcGIS Living Atlas of the World in ArcGIS Online. Click Modify in the top right corner of the map.

Click Content and uncheck Low Birth Weight %—Above and Below theme (recommended). Rename the County Health Rankings 2018 to Low Birth Weight. Choose the Change Style button on the layer and choose Percent Low Birthweight for 1. Choose Percent Low Birth Weight as the attribute to explore.

Choose the Counts and Amounts (Color) style of map. This style applies a color to each county, based on the value found in the Percent Low Birthweight attribute for that county. Click Options to explore this data a bit using some settings that decide which counties will be shaded what color.

High to Low Theme

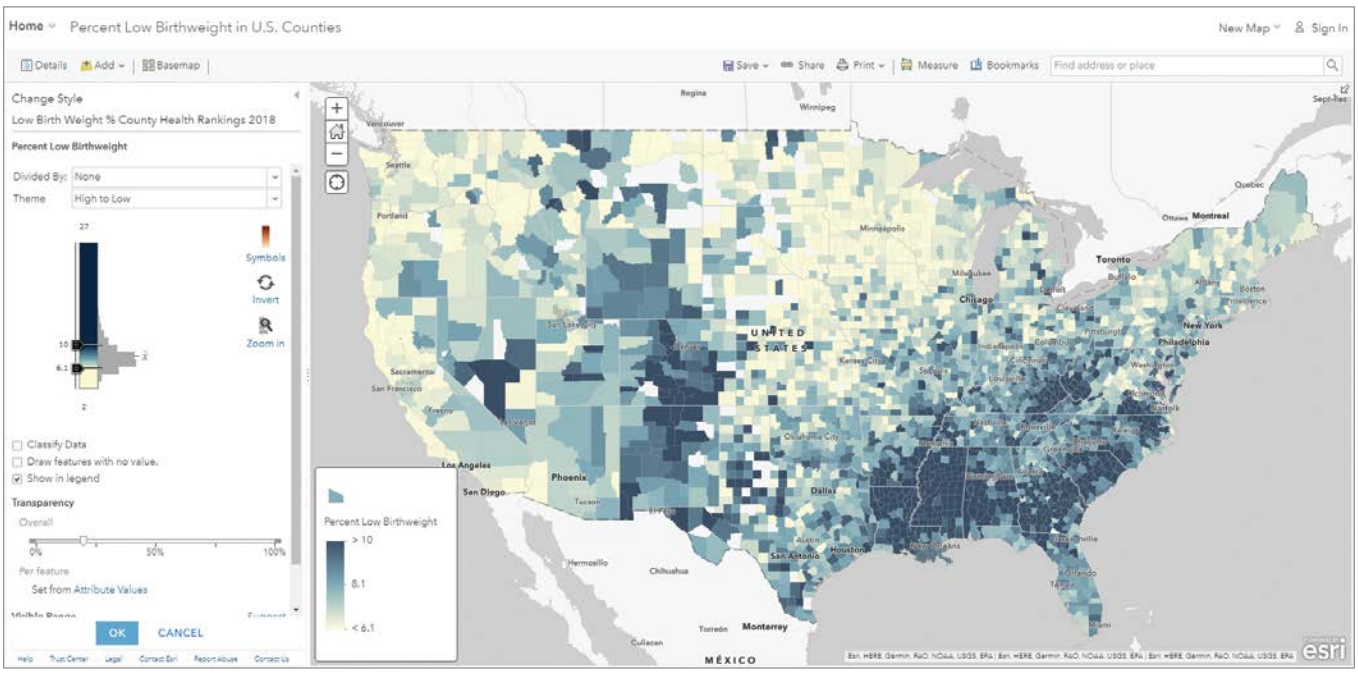
This is where ArcGIS Online saves you time and makes you a better mapmaker. All you did was touch an attribute, and the map lights up with a suggested High to Low theme using a yellow-to-dark blue color ramp, with key breaks set at one standard deviation around the mean. It takes fewer than five clicks to get to this very useful first map.

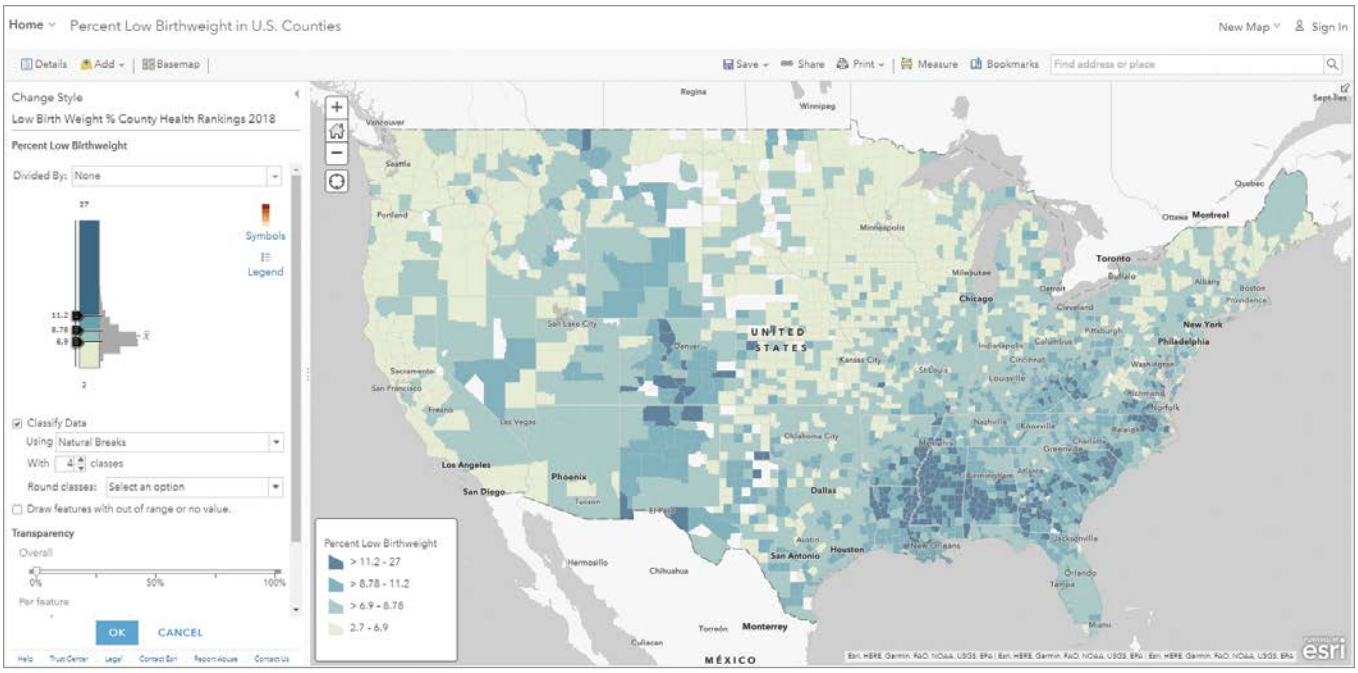
ArcGIS Online shows you the color ramp next to a histogram of the data. For the

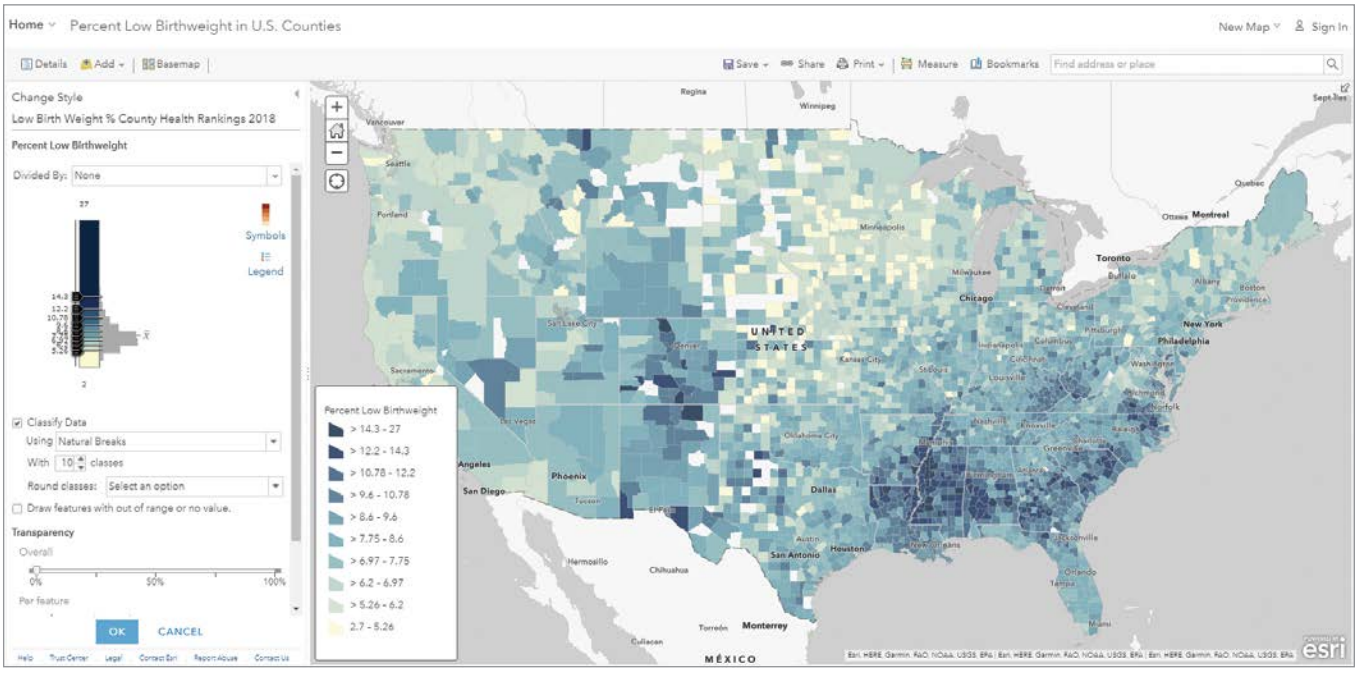
How can you tell a thematic map has been rushed?

High to Low theme, the little handles indicate at what values dark blue or yellow is applied. In this case, counties with 10 percent low birth weight or higher will be given a full dark blue color. Counties with 6.1 percent or lower will be given a full yellow color. These extreme values are not the main story in this map style.

Values between 10.0 and 6.1 are shaded a color somewhere between dark blue and yellow, depending on where the value falls. Sometimes referred to as unclassed or continuous color, its value is that you get an overall pattern on the map, and you can see how neighboring counties vary slightly. I'd call this data-aware color or detailed







color or data-faithful color.

Where did these values come from? They are 1 standard deviation above the mean (10.0) and below the mean (6.1). From the legend or by hovering the cursor over the *x* in the histogram, you can see that the mean is 8.1 for this dataset. (Note: This is the average of the data, not necessarily the true national average, because counties vary widely in population, from hundreds to millions.)

At this point, I always search the documentation or online for what the literature has to say about the subject. In this case, the source data did not provide the national average for percent low birth weight,

↑↑ Natural Beaks is the map default. All this map says is that some places have it worse than others because we have not provided a standard of comparison with which we leverage the use of color.

↑ Increasing the number of natural breaks to 10 produces essentially the same map, but now the legend is harder to read and interpret.

but a broader search found several indications that 8.1 percent is indeed the national average. This is useful information to have as you think about how to style this map.

This default is just a starting point. It is not the one-size-fits-all solution for making maps. It is a great map style for initial exploration of the data, so that you can ask yourself, What part of this data is interesting? From the histogram of the data, we see a pretty normal bell curve with a little skew toward higher values.

A color ramp that has a light color on one end and a dark color on the other end works well. The darker colors are applied to the higher values, but even the middle of the color ramp (near the 8.1 percent national average) is already shading to blue.

If the story needs to focus mainly on areas where low birth weights are a problem, the High to Low theme is a good option. The High to Low theme does not take a national average or mean into account, unless you adjust a break to use such a figure.

High to Low Using Natural Breaks

Let's explore the same data using classification to see where it starts the map. With the same layer, turn on Classify Data. This defaults to a Natural Breaks method. The darkest color is assigned to values at or above 11.2, so the effect is that it is harder for a county to earn that darkest color. The values between 8.78 and 11.2 all get the same color, as do all values between 6.9 and 8.78 and all values below 6.9.

These breaks are where the Natural Breaks algorithm found a mathematical reason to divide the data up into the four breaks it was told to use. There are eight different numbers in this map's legend, with no explanation of their significance. The dark blue color begins at 11.2 percent. Is this to be considered a high rate? Which shade of blue includes the national average of 8.1 percent?

Unless we adjust a break to use 8.1 percent, we can't really speak to that figure effectively on the map. All this map says is that some places have it worse than others. We have not provided a standard of comparison with which we can leverage the use of color.

Increase the number of natural breaks to 10. It's essentially the same map, but now the legend is a little more challenging to read and interpret.

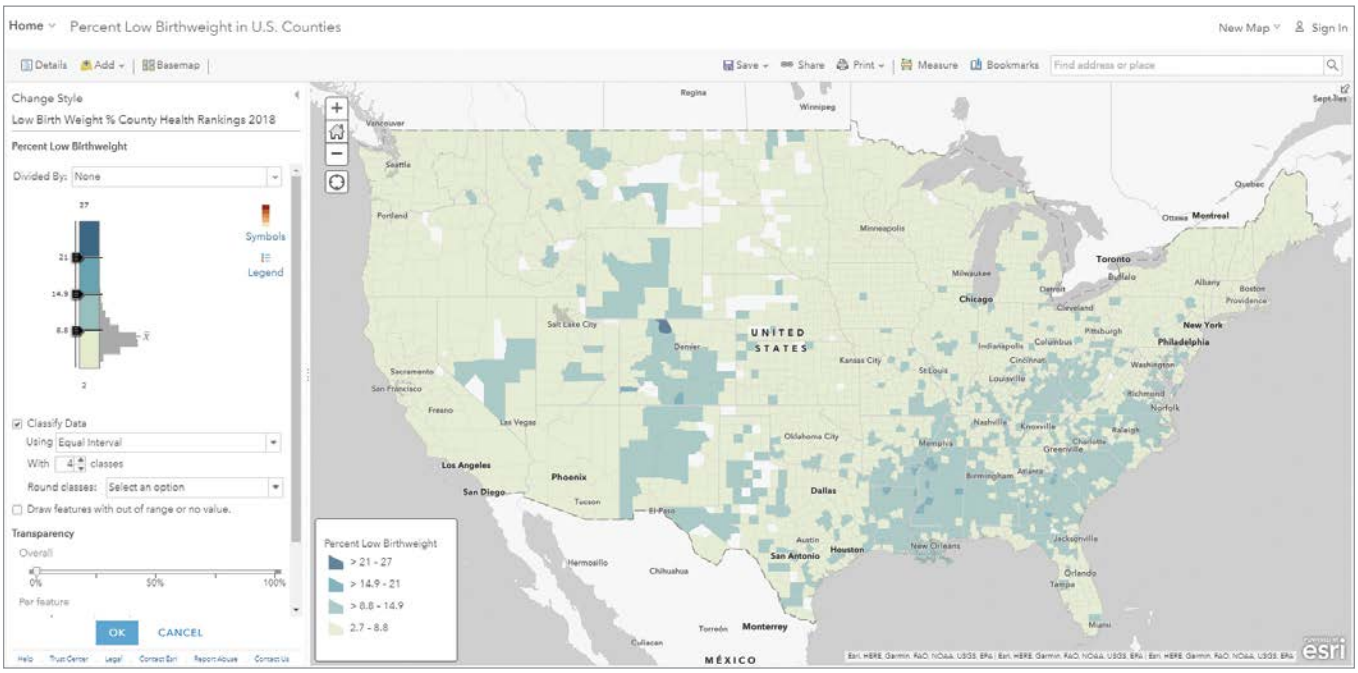
What part of this data is interesting?

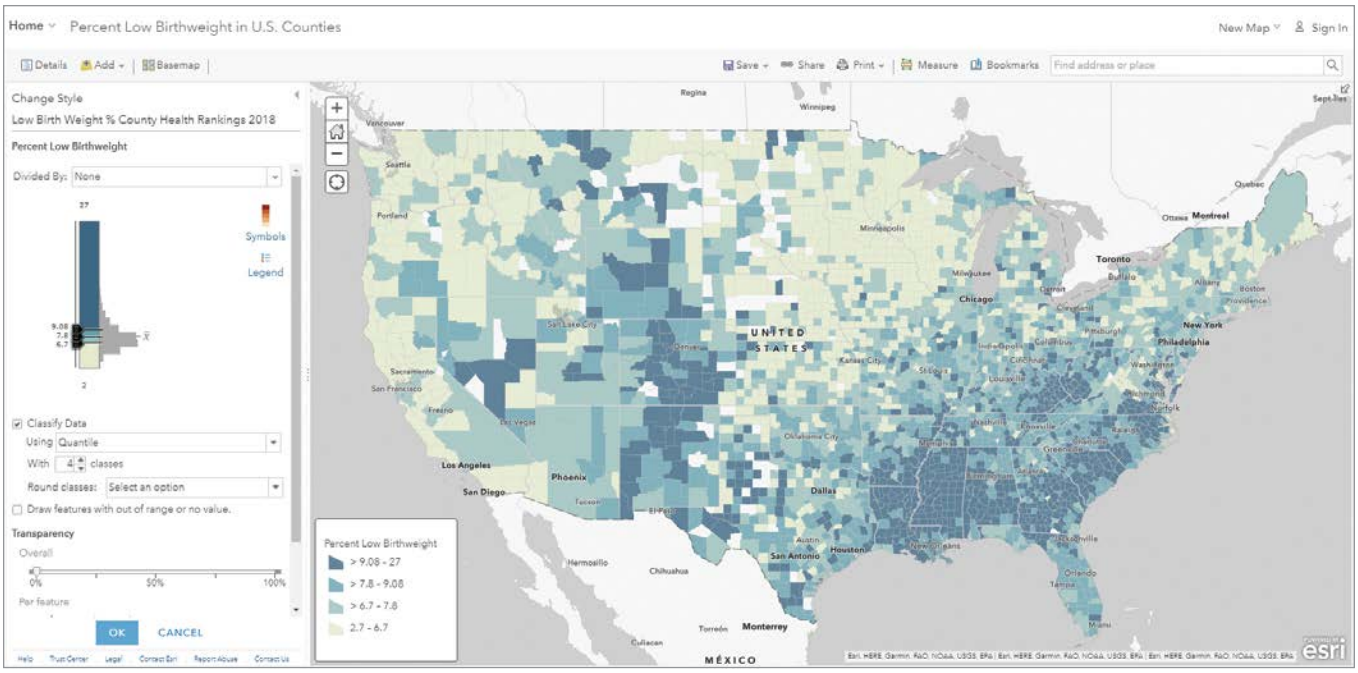
With 10 classes, we can see more detail around those darkest blue counties. But if a legend with 8 numbers for a map author to explain and a map reader to interpret is difficult, a legend with 20 numbers is even more difficult.

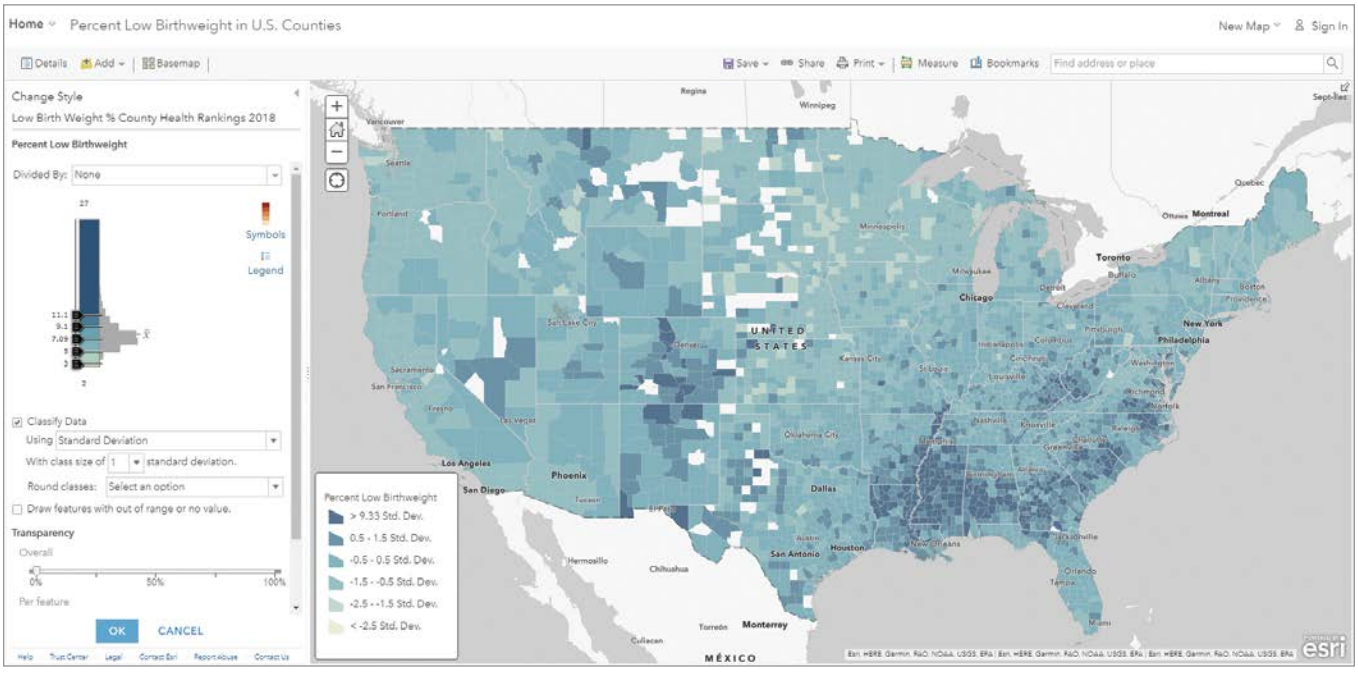
In the legend for the map with 10 breaks, can you find which class would contain the national average of 8.1 percent, and then find a sample county at or near that average? There are nine shades of blue to choose from, and this legend infers that you should be able to distinguish among them.

Whether your map has 4 or 10 classes or is not classified, the legend on a web map is

↓ After applying the Equal Interval classification, the map looks very soft because Equal Interval takes the maximum value minus the minimum value in the data, and divides that by the number of classes to set the interval.







a poor way for someone to understand the actual value in any single county. A label or pop-up can provide the specific value as needed. Because we have not assigned any specific meaning to the classes, such as ">14.3 (Eligible for funding)," the legend is there to simply orient the user about what the color means generally.

High to Low, Using Equal Interval

With Classify Data turned on and the Equal Interval method selected, the darkest color is assigned to values at or above 21, so the effect is that it is very hard for a county to earn that darkest color. The values between 14.9 and 21 all get the same color, as do all values between

↑↑ The Quantile method is the ice cube tray of thematic mapping, in that each cube (class) will be the same size no matter what is going on with the data.

↑ While the Standard Deviation method can help you gain a more fine-grained understanding of how quickly your data deviates from the mean on the map, the legend is unintelligible to most people because it no longer shows the actual percentages.

8.8 and 14.9 and all values below 8.8.

The map now looks very soft, and the histogram and color ramp tell us why. Most counties fall within the lowest category. To many people, this map would suggest that low birth weights are not much of a problem anywhere except that one northern Colorado county.

That's because the Equal Interval method takes the maximum value minus the minimum value in the data, and divides that by the number of classes to set the interval. If the minimum value was 0, the breaks would shift. If the maximum was not 27 but 270, the breaks would shift, dramatically. Outlier values have a big effect on this option. Note that the national average 8.1 percent would fall into the lowest category.

High to Low, Using Quantile

Classify data using the Quantile method, and the map changes noticeably. The Quantile method ensures that each color will have an equal number of features in it when possible. If you have 1,000 features, the Quantile method will stuff 250 into each of the four colors in your ramp. It's the ice cube tray of thematic mapping, in that each cube (class) will be the same size no matter what is going on with the data.

The darkest color is now assigned to values at or above 9.08; the values between 7.8 and 9.08 all get the same color, as do all values between 6.7 and 7.8 and all values below 6.7. The national average of 8.1 is in the second-darkest blue. The Quantile method ensures you'll have lots of colors on the map, but they'll have no intrinsic meaning for this layer.

High to Low, Using Standard Deviation

Changing to Classify Data using the Standard Deviation method assigns the darkest color to values at or above 11.1, and other breaks are introduced in 1 standard deviation intervals. This is a useful method when trying to get a more fine-grained understanding of how quickly your data deviates from the mean on the map. However, the legend is unintelligible to most people because it no longer shows the actual percentages. Consider your audience before showing them a thematic map with this legend. You can manually edit the label of each class to be more meaningful (i.e., >11.1% (Very High) .

You can see from the map that this standard deviation method slices the histogram neatly and applies a color ramp to those slices consistently. The High to Low color ramp spreads the blue color progressively across the classes. The map is mainly blue, because the center of the color ramp is itself a medium blue.

Should You Classify?

Does it matter that a county with a value of 15 is symbolized with the same color as a county with a value of 20.9? In effect this map is saying there is no difference between those two counties.

The person making the map should decide if classification is appropriate. It's not a matter of one being right and another wrong, but it is a matter of knowing how classification tends to eliminate detail, and whether detail is important to the story your map needs to reveal.

All maps in this article take two colors (yellow and blue) and—in effect—smear them across the page based on the breaks you accept or (preferably) set based on your knowledge of the subject. When 4 or 5 or 10 classes let you simplify the world for someone based on a reason they can relate to, then classify! If you can assert why there is no significant difference among features within a given class, that is a reason for that class to exist. It has a meaning, so its use is justified.

Otherwise, give the data a chance to breathe a bit and uncheck that Classify box to let the additional detail drive interest and generate additional questions. Questions raised during the early stages of making a thematic map inevitably lead to better maps.

Questions raised during the early stages of making a thematic map inevitably lead to better maps.

About the Author

Jim Herries is a geographer with Esri in Redlands, California. He serves as a principal product engineer on the team responsible for ArcGIS Living Atlas of the World. Herries is particularly engaged in thematic mapping and map visualizations and wants to help GIS users bring their data to life on the map and stimulate insights. He constantly looks for ways to create clear, focused map information products that incorporate meaningful spatial analysis and evocative visualizations.

Measuring Firefighter Performance with ArcGIS Pro

By Mike Price

What You Will Need

- A licensed copy of ArcGIS Pro (version 2.6 preferred)
- Internet access to ArcGIS Online services
- Sample dataset downloaded from the *ArcUser* website
- Microsoft Excel

Previous tutorials in the 2019 winter and spring issues of *ArcUser* walked through an ArcGIS-based workflow that was used to successfully support a grant request by a district in Pierce County, Washington. This exercise measures the effects of the staffing increases made possible by the grant on the district's response to emergencies.

This exercise uses actual response data, slightly filtered, to analyze more than six years of response activity for Graham Fire & Rescue (GF&R) to document the benefits of a grant it received in 2018.

GF&R provides emergency fire, medical, and other services to Fire District 21 (FD 21), Pierce County, Washington. FD 21 is located in central Pierce County, approximately 20 miles southeast of Tacoma. GF&R protects more than 70 square miles of suburban and rural properties that have a population of more than 67,000.

From 2010 to 2019, the district's population increased by nearly 20 percent, growing 3.4 percent in 2019 alone. FD 21 is one of the four fastest-growing large fire districts in Washington. In 2018, GF&R command staff recognized that the district's growth was quickly challenging GF&R's ability to provide quality essential services from its five staffed and one volunteer station. Planners note that annual emergency responses nearly doubled from 3,658 in 2010 to over 7,250 in 2019.

In April 2018, GF&R prepared and submitted a large request to the Federal Emergency Management Agency's (FEMA) Staffing for Adequate Fire and Emergency Response (SAFER) grant program to expedite hiring of up to 21 line personnel and 5 new 24/7 firefighter positions. The $3.5 million grant, awarded in late summer 2018, provides 75 percent reimbursement for new personnel costs in the first two years and 35 percent reimbursement in the third year. The ArcGIS-based mapping and modeling that supported this grant request was featured in two *ArcUser* articles: "Mapping Current and Proposed Effective Fire Response" in winter 2019 and "Migrating Public Safety Workflows to ArcGIS Pro" in spring 2019.

The second year of the SAFER grant closed on August 31, 2020. As GF&R prepares annual performance reports, staff members have compiled more than six years of apparatus-level response data to support these reports. This data includes response type and travel times and staffing for all responding apparatus.

Getting Started

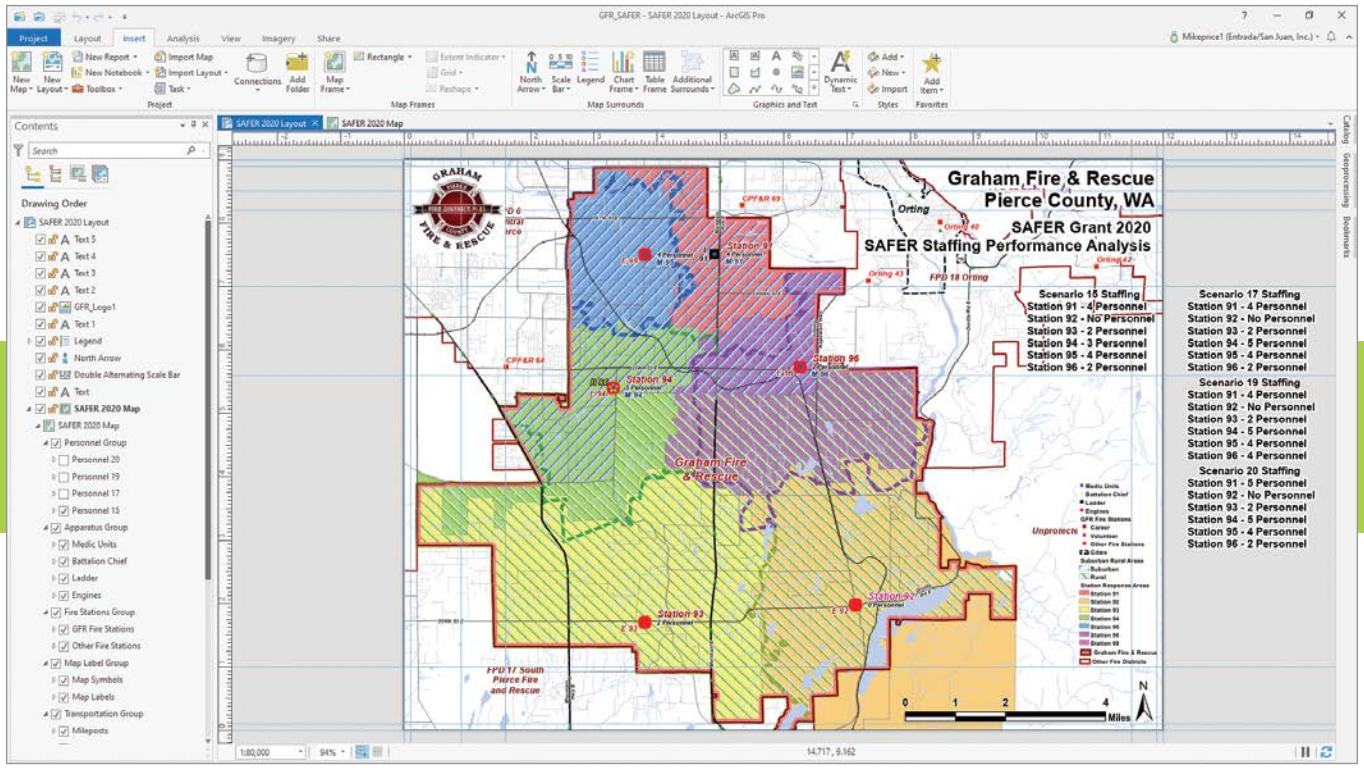
Tasks in this exercise include

- Review the SAFER program map
- Understand computer-aided dispatch (CAD)/record management system (RMS) data
- Import and map apparatus-level CAD/RMS data
- Modify tables to model emergency responder performance
- Create statistical summaries to measure and document performance changes

This tutorial expands on the two *ArcUser* tutorials previously mentioned. Begin by downloading the GFR_Maps sample dataset, unzip it, and store it on a local machine. Start ArcGIS Pro and navigate to \GFR_Maps\GFR_SAFER then locate GFR_SAFER.arpx and open it. This is essentially the same map created in the spring 2019 tutorial to compare the performance of the original fire station staffing and the staffing proposed if grant funds were received.

Study the four scenario staffing title boxes on this map layout to see the incremental changes. The scenario names include the staffing for each hiring interval and will be used to reference them. To measure the performance of these scenarios, you will compile and analyze changes in apparatus-level average travel time and staffing.

Before closing the layout, open the Bookmarks pane to see a single bookmark called GFR SAFER 1:80,000. If you become disoriented at any time in this exercise, use this bookmark to return to the full map extent.



↑ Open the GFR_SAFER project and study the incremental changes for the four staffing scenarios.

Switch from the Layout view to the Map view and study the map layers. Fire Station Group symbols show assigned apparatus and personnel in 2014, before SAFER hiring. The map also shows other important data layers including transportation, hydrography, assigned and optimized Station Response polygons, and Suburban and Rural classification.

Open the GFR Fire Stations attribute table to see all station location, apparatus, and personnel records. Review the current apparatus assignments and the staffing for each staffing interval. You will summarize all personnel and travel times for all responses within each time interval. You will test the premise that as staffing increases, more personnel arrive on scene, often in less time.

Introducing CAD/RMS Data

To perform this analysis, you will import more than six years of apparatus data, captured by the regional dispatch center and modified within GF&R's record management system.

Save the project and minimize ArcGIS Pro. Use your file manager to locate and open APP_2014_2020_XY, the CAD data in a Microsoft Excel spreadsheet that is stored in \GFR_Maps\

↓ Table 1: APP_2014_2020_XY

Columns	Labels	Description
C	Year_Incident_No	This provides a unique code for each incident.
D and E	LonDec83 and LatDec83	These contain geographic NAD 1983 coordinates used to place apparatus responses on a map.
F and G	AppID and App_Crew	These identify each apparatus and provide personnel on board for each call.
H	Arrival_Order	This assigns an integer value to each responding unit, determined from its arrival time.
J and K	EnrouteDT_T2 and ArriveDT_T3	These contain date/time values for all responses used to calculate individual apparatus travel.
R	Staff_Time_Interval	This classifies all apparatus responses by the staffing count for their time intervals.
S	App_Station	This codes each station with its home station number.

GFR_CAD_RMS. Inspect the spreadsheet and study all fields for 60,837 apparatus records from January 1, 2014, to May 5, 2020.

Table 1 includes CAD/RMS field names and a brief explanation of each field. Carefully review the columns in APP_2014_2020_XY as shown in Table 1. You will use many of these fields in this exercise.

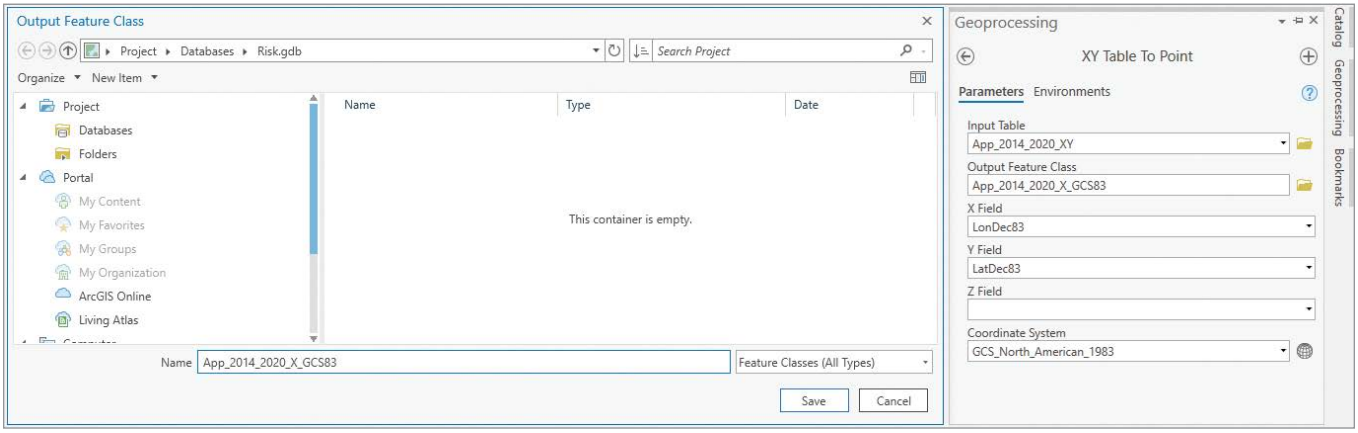
The header names in this spreadsheet are field names that can be imported into ArcGIS because they all start with a letter; do not exceed 64 characters; and contain only letters, numbers, and underscores. All records and fields are formatted to properly import into a file geodatabase table.

Data Development and Management

Many agencies use Microsoft Excel spreadsheets to transfer data from dispatch to and through records management and onto a map. The CAD/RMS data for this exercise has been formatted and standardized to make the import seamless. The only records you will use will be ones with a travel time of 20 minutes or less. Sample data for this exercise has already been filtered to include only those records.

Close the spreadsheet without saving it and return to ArcGIS Pro then click the Analysis tab. In the search box of the Geoprocessing pane, type "table to excel" to locate the Excel To Table tool. Open

↓ In the XY Table To Point geoprocessing tool wizard, select App_2014_2020_XY as the input table and store the Output Feature Class in Risk.gdb, and name it App_2014_2020_X_GCS83.



it. In the wizard, set Input Excel File to GFR_Maps\GFR_CAD_RMS\App_2014_2020_XY.xlsx. Set Output Table to App_2014_2020_XY and save it in GFR_Maps\GFR_Map_Data\Risk.gdb. (There is only one sheet so no need to select one.) Click Run to import the spreadsheet into your project. When the import is finished, open and inspect the table. Close the attribute table and save your project.

Creating and Symbolizing Apparatus Points

Creating apparatus data points in state plane coordinates is a two-step process.

Step 1: On the Map ribbon, click Add Data and select XY Point Data. In the XY Table to Point geoprocessing tool wizard, select App_2014_2020_XY as the input table and store the Output Feature Class in \Risk.gdb, naming it App_2014_2020_X_GCS83. Set X and Y fields to LonDec83 and LatDec83. Click on the globe icon next to Coordinate System and choose Geographic Coordinate System > North America > USA and territories > NAD 1983 to set Coordinate System to GCS_North_American_1983.

In the Geoprocessing pane, click on Environments. Set the Output Coordinate System to GCS_North_American_1983 using the same process as previously described and click Run. Once it is finished importing, open the App_2014_2020_X_GCS83 attribute table and save your project.

Step 2: Export the GCS83 apparatus points to WA State Plane S. In Contents, right-click App_2014_2020_X_GCS83 and select Data > Export Features. In the Export Features wizard, verify App_2014_2020_X_GCS83 as Input Features, set the Output Location to Risk.gdb and Name the Output as App_2014_2020_X. Switch to Environment and use GFR Fire Stations to set the Output Coordinate System to NAD_1983_StatePlane_Washington_South_FIPA_4602_Feet and click OK.

After the apparatus points (i.e., App_2014_2020_X) load, remove App_2014_2020_X_GCS83 and open the new apparatus points attribute table.

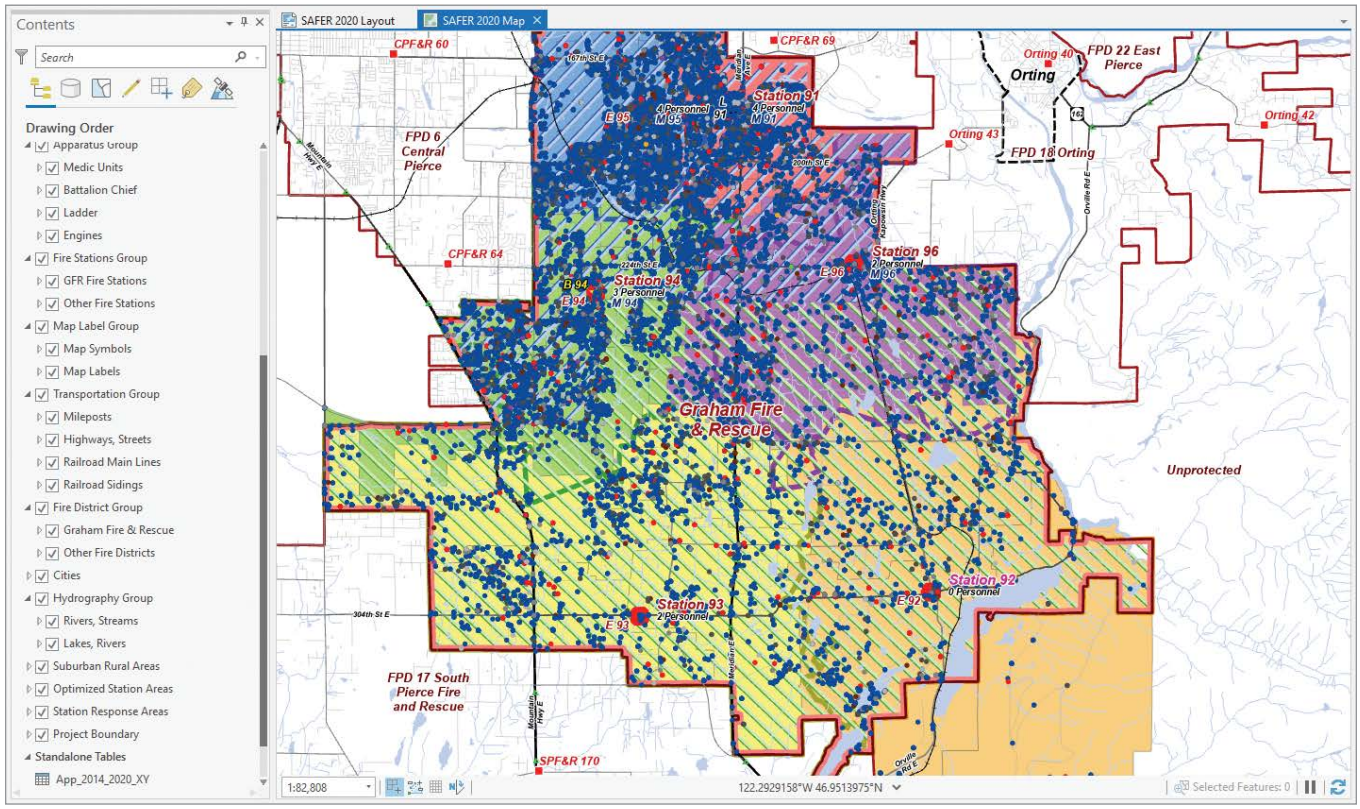
In the Contents pane, right-click on App_2014_2020_X and choose Symbology. Click the three black bars in the upper right corner of the Symbology pane and choose Import Symbology. In the Apply Symbology From Layer tool verify App_2014_2020_X as Input Layer. Click the Symbology Layer browser, navigate to GFR_Map_Data, and select NFIRS All Responses. Set Source and Target fields as IncTypeNo and click Run. Save when the process completes.

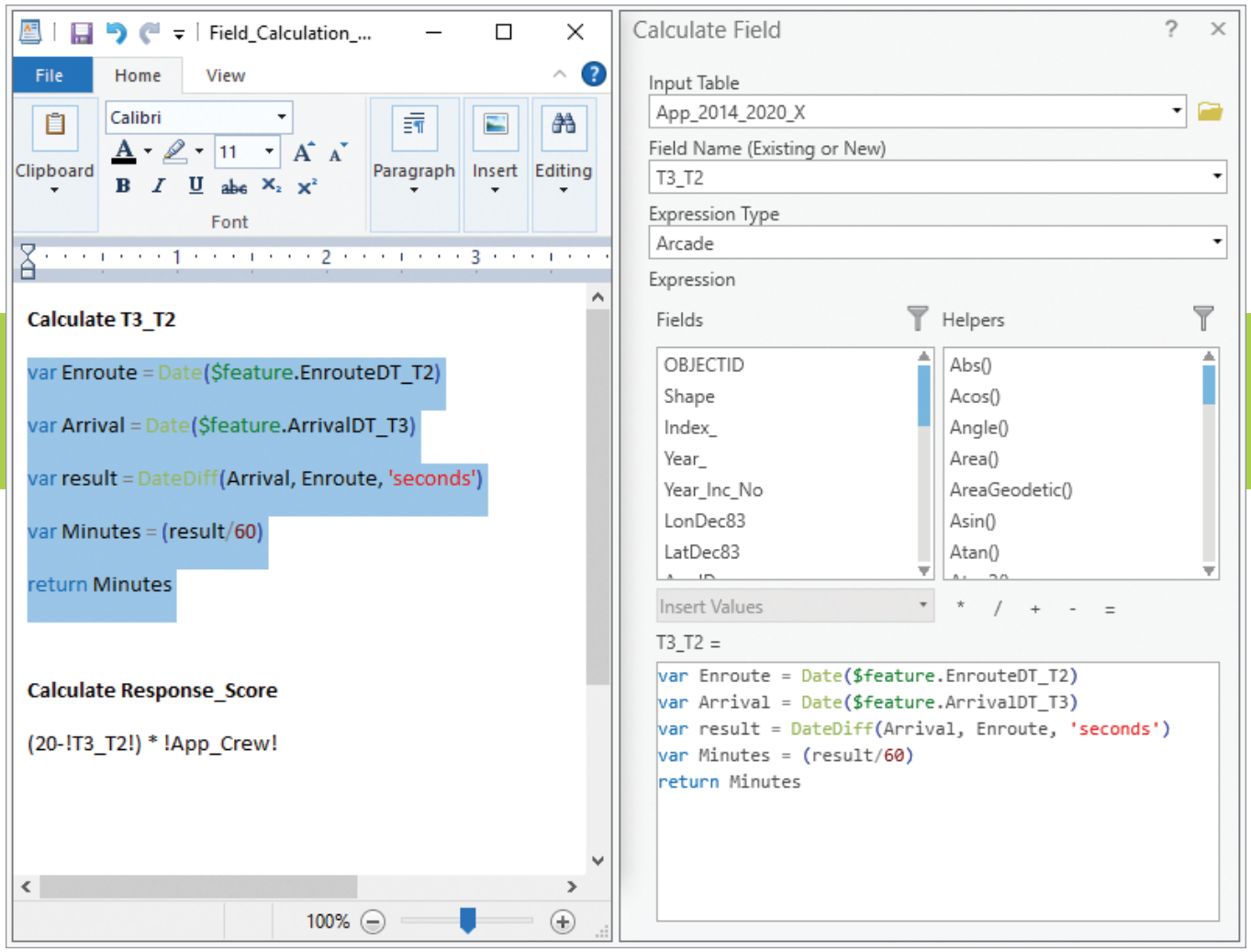
Adding Important Fields

To measure staffing performance, you must add important fields: T3_T2, which will hold the travel time for all apparatus, and Response_Score, which will contain a rating of the response of apparatus. You will use ArcGIS Arcade, a scripting language for the ArcGIS platform, to perform interval time and response scoring calculations.

Inspect the attribute table for App_2014_2020_X and study the EnrouteDT_T2 and ArrivalDT_T3 fields. These fields contain

↓ After importing the apparatus points from Excel, import a layer file to symbolize them.





↑ In Field_Calculation_Scripts, select the portion of the text *under* the heading Calculate T3_T2 and paste it into the formula box of the Calculate Field tool. Click Apply to calculate the travel time for apparatus in decimal minutes.

complete date/time stamps for all apparatus records. You will add a new field and calculate the interval time between Enroute and Arrival times. In the Tables toolbar, select Add and in the Add Field Table, create a new field named T3_T2 and set its data type to Double.

Hint: You can use the Tab and Shift keys in combination to move between fields.

Add a second field named Response_Score and set its format to Double. In the Change area of the Field ribbon, click Save. Verify that your table contains the two new empty fields, close the Fields: App_2014_2020_X table, and save the project.

Calculating Fields Using ArcGIS Arcade

It is standard practice to calculate travel time in decimal minutes by simply subtracting date/time en route values from arrival times and multiplying the difference by 1,440, which is the number of minutes in a 24-hour day. This conversion is incorporated into the Field_Calculation_Scripts that has been included in the sample dataset for this exercise. This RTF file contains an ArcGIS Arcade script for calculating time interval and a Python script for calculating response scoring.

[To learn more about using Arcade for time calculation, see the accompanying article "Scripting Time Calculations in ArcGIS Arcade."]

In a file manager, navigate to GFR_Maps\Support, and open Field_Calculation_Scripts. Open it in Microsoft Word and float the window above or beside your project.

Return to the App_2014_2020_X table, right-click on field T3_T2, and select Calculate Field. In the Calculate Field wizard, verify App_2014_2020_X as the Input Table and T3_T2 as the Field Name, and set Expression to Arcade. In Field_Calculation_Scripts, select the portion of the text *under* the heading Calculate T3_T2 and paste it into the formula box of the Calculate Field tool. Click Apply to calculate the travel time for apparatus in decimal minutes. **Do not close the Calculate Field tool.**

Sort T3_T2 in descending and ascending order and inspect the data. Travel times will range from 0 to almost 20.

Creating One Performance Metric

You don't need to close the Calculate Field tool because ArcGIS Pro supports multiple field calculations in one Calculate Field

session. Now that you have travel times in decimal format, you can score each apparatus response based on the time that it took to arrive on scene. You can also track the personnel on each responding apparatus, so you can score arriving personnel, too.

Low travel numbers and high personnel counts (more firefighters on scene) represent good response. Since these values trend against each other, I decided to use a favorite geophysics trick from my dusty old geology toolbox, and invert one value before combining them. Since travel time is clipped by practice at a 20-minute maximum, I experimented with an inversion calculation of 20 minus travel time. I found that if I multiplied the inverted travel time by numbers of personnel on each arriving apparatus, I could easily quantify and display low response times and high personnel counts with a single value, the Response Score.

To calculate the Response Score, return to the Calculate Field tool and change the Field Name to Response_Score. Make sure that you change the Expression Type to Python 3. Remove the code for Calculate T3_T2 and replace it with one-line Response_Score script from Field_Calculation_Scripts and paste it into the text box under Response_Score =. This script will subtract each travel time from 20 and then multiply the difference by responder count (the value stored in the App_Crew field).

Click OK to run this script and score all apparatus records. When it finishes running, sort Response_Score in ascending and descending order to verify that the field has been populated with values. Save the project.

Modeling Firefighter Performance Statistics

You will use the Response_Score, App_Crew, Time_Staff_Interval, App_Station, and AppID fields to summarize and measure apparatus-level response of four staffing intervals (Time_Staff_Interval). You can prepare multiple summaries for each responding station (App_Station) and for individual apparatus (AppID). This is a ***huge*** benefit because concatenated summarize-only fields are not required. (Also pivot tables are available only in ArcGIS Pro Advanced.)

You will prepare two multifield summary tables from the Response_Score field. ArcGIS Pro summary statistics support complex summaries across multiple fields. *Note: Consistent table names are important.*

To measure station performance, you will create an App_TSI_Station_Response_Score to summarize data by personnel interval (Time_Staff_Interval) and station (App_Station). Return to the App_2014_2020_X table, right-click the Response_Score header and select Summarize. In the Summary Statistics wizard, set the parameters in Table 2 to create the summary table for App_TSI_Station_Response_Score. Be sure to store the Output Table in Risk.gdb. Click OK. The summary table for the stations is added to the bottom of the Contents pane. Save the project.

To measure individual apparatus performance, you will summarize data by personnel interval (Time_Staff_Interval) and apparatus (AppID). Right-click on the Response_Score header and select Summarize then use the parameters in Table 3 to create the summary for App_TSI_Apparatus_Response_Score. Store the Output Table in Risk.gdb. Click OK. The summary table for the apparatus is added to the bottom of the Contents pane. Save the project. Close the Summary Statistics wizard, and save the project.

Measuring the Effects of Staffing Changes

These summary tables will help you see how changes in the staffing of GF&R stations affected their response in terms of time and number of apparatus.

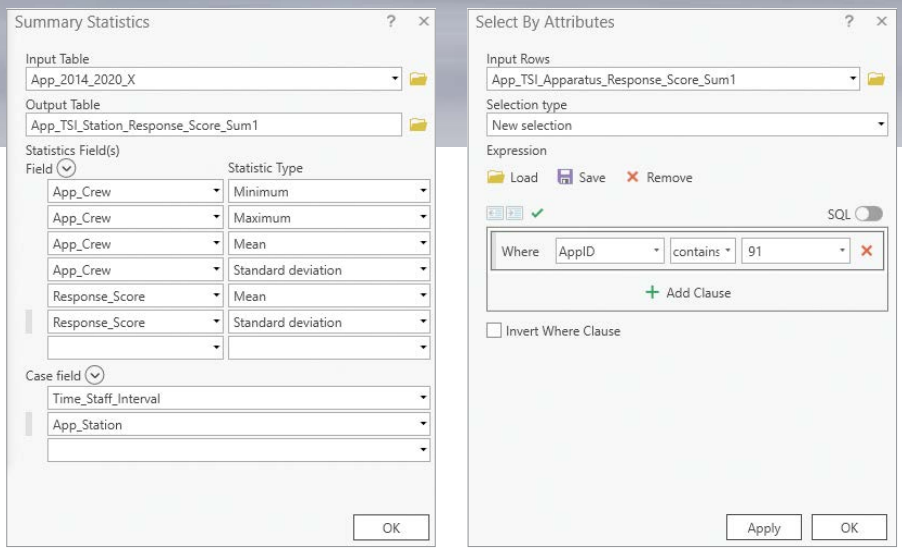
Open both summary tables you just created and stretch them to show at least 24 records. In App_TSI_Station_Response_Score_Sum1, right-click App_Station and select Custom Sort. Define a Custom Sort so that App_Station sorts first and Time_Staff_Interval sorts second, both in ascending order. Click OK.

↓ Table 2: Parameters used to create station response summary

Input Table	App_2014_2020_X
Output Table	App_TSI_Station_Response_Score_Sum1
Statistics Field(s)	
Field	Statistic Type
App_Crew	Minimum
App_Crew	Maximum
App_Crew	Mean
App_Crew	Standard deviation
Response_Score	Mean
Response_Score	Standard deviation
Case Field	
Time_Staff_Interval	
App_Station	

↓ Table 3: Parameters used to create the apparatus response summary table

Input Table	App_2014_2020_X
Output Table	App_TSI_Apparatus_Response_Score_Sum1
Statistics Field(s)	
Field	Statistic Type
App_Crew	Minimum
App_Crew	Maximum
App_Crew	Mean
App_Crew	Standard deviation
Response_Score	Mean
Response_Score	Standard deviation
Case Field	
Time_Staff_Interval	
AppID	



→ Summarize App_TSI_Station_Response_Score by personnel interval (Time_Staff_Interval) and station (App_Station) by setting the parameters in Table 2.

→→ After sorting App_TSI_Apparatus_Response_Score_Sum1, open Select By Attributes from the Table frame and create a new expression that selects all Station 91 apparatus by limiting records to those with AppID containing the text *91*.

Highlight Stations 91, 93, and 95. Look at the values for Mean_App_Crew and Mean_Response_Score. Review all stations and focus on Stations 94, 96, and 91, the three stations that received SAFER personnel.

On September 1, 2018, two new personnel were assigned to Station 94 during Time_Staff_Interval (TSI) 17. Note that its mean App_Crew decreased slightly from Interval 15 to 17, increased during TSI 19, and decreased slightly through TSI 20. Mean_Response_Score increased through TSI 17 and 19, falling slightly during TSI 20. Headquarters/Battalion Station 94 supports operations throughout the district and a moderate increase is not unexpected.

Two SAFER firefighters began service at Station 96 on September 1, 2019 (TSI 19). Mean_App_Crew and Mean_Response_Score increased slightly in TSI 17 and significantly in TSI 19, falling slightly in TSI 20. With two additional crew assigned in TSI 19, Station 96 soon experienced a significant performance improvements during TSI 19.

The fifth SAFER firefighter was assigned to Station 91 on January 1, 2020 (TSI 20). Station 91 is often GF&R's busiest station, housing the district's ladder, a reserve engine, and a medic unit. The SAFER firefighter increased staffing for Station 91 to five, with three firefighters on the ladder and two on the medic unit. The values for Mean_App_Crew and Mean_Response_Score for Station 91 increased during TSI 17 and 19. During TSI 20, the staffing score increased slightly and the response score was flat.

Looking at Selected Summary Apparatus Data

Click App_TSI_Apparatus_Response_Score_Sum1, right-click on AppID, and select Custom Sort. Create a two-field sort referencing AppID, followed by Time_Staff_Interval, both in ascending order. After sorting, open Select By Attributes from the Table

frame. In the Select By Attributes wizard, create a new expression that selects all Station 91 apparatus by limiting records to those with AppID containing the text *91*. Run this query, and now you see all Station 91 apparatus, grouped in ascending Time_Staff_Interval. Check apparatus staffing and response scores for units. Notice that Engine 91 (E91) responds only occasionally, with Ladder 91 (L91) performing most duties. The new firefighter was assigned primarily to L91, so the mean staffing and response scores increase.

Modify your attribute selection to show all equipment responding from Station 94. Both activity and staffing increased slightly for E94 in TSI 17 and 19 but decreased slightly in TSI 20. M94 shows slight continuous increase through all periods. The battalion chief (BC94) typically responds alone and shows a slight score decrease in TSI 20. Note that the Brush unit (BR94) responds only occasionally and typically with a crew of two.

Finally, change the selection query to show only Station 96. This station shows a considerable increase in staffing and performance during TSI 19, with two new SAFER firefighters. Staffing and scores decreased slightly in TSI 20.

Look at station and apparatus summaries for the three other GF&R stations. You may observe some rather unusual trends in TSI 20. For a quick explanation, GF&R initiated a COVID-19 operations plan on March 15, 2020 that included separating the service area into two battalion areas. With some detective work, you can identify and map pre- and post-COVID-19 activities by apparatus and station.

Save your project. You are finished!

Summary and Acknowledgments

In this detailed and comprehensive exercise, you used actual response data from Fire District 21, a quickly growing fire district in suburban Pierce County, Washington, to assess and report improvements that resulted from funds provided by a SAFER grant program. This tutorial tells just part of the story.

Special thanks to the command staff at Graham Fire & Rescue for providing me with the chance to prepare and present this interesting tutorial. Thanks also to Esri Technical Support for introducing me to time-based calculations in ArcGIS Arcade.

About the Author

Mike Price, the president of Entrada/San Juan Inc., was the mining and earth sciences industry manager at Esri between 1997 and 2002. He has been writing tutorials that help *ArcUser* readers understand and use GIS more intelligently since the magazine's founding. He is a geologist and has been a volunteer firefighter in Moab, Utah, for many years.

Scripting Time Calculations in ArcGIS Arcade

By Mike Price

ArcGIS Arcade is a simple, portable scripting language used across the ArcGIS platform. It is included in ArcGIS Pro, ArcGIS Enterprise, the ArcGIS API for JavaScript, and the ArcGIS Runtime SDKs. Arcade supports building custom visualizations, labeling expressions, pop-ups and certain field calculations.

Like other scripting languages, Arcade cannot be used to create stand-alone applications. Arcade differs from other scripting languages because it includes feature and geometry types. In the 1.11 release, geometries can be created and referenced. Field calculations, including areas, lengths, density, date/time, and some trigonometry functions, are available.

Date and Time in Microsoft Excel

In Microsoft Excel, dates and times have been managed as formatted numeric fields. A date/time value is represented as a double precision floating point serial number in which the integer portion is the number of days since December 31, 1899 (January 1, 1900, is value 1), and the decimal portion is the decimal fraction of a 24-hour day.

To calculate the decimal difference between two date/time values, simply subtract the older value from the more recent value to produce a value in decimal days. To convert to decimal minutes, the initial value is divided by 1,440, which is the number of minutes in a 24-hour day.

Date and Time in Arcade

In ArcGIS Pro, date/time formats are managed differently. Arcade is used to calculate the interval time. A multiline script with defined input and output parameters is used to calculate a time interval. Arcade includes several date/time functions, such as DateAdd(), DateDiff(), and Now().

Interval Time Calculation

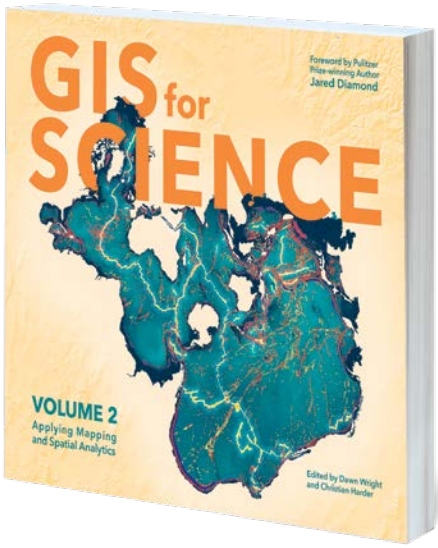
In "Measuring Firefighter Performance with ArcGIS Pro," the Arcade script in Listing 1 was used to calculate the difference between when an apparatus left the station and when it arrived at the site of the emergency to evaluate performance. That script is shown with code comments (denoted by //) explaining what each line of code does. Since Arcade calculates interval time as an integer value, it is important to first calculate the result in seconds, and then divide by 60 (the number of seconds in a minute). This procedure is not as precise as calculating actual decimal minutes, but it is sufficiently precise for emergency response modeling.

```
var Enroute = Date($feature.EnrouteDT_T2)

//Defines a variable named Enroute and sets its
source to EnrouteDT_T2

var Arrival = Date($feature.ArrivalDT_T3)

//Defines a variable named Arrival and
 sets its source to ArrivalDT_T3

var result = DateDiff(Arrival, Enroute,
'seconds')

//Defines a variable named result, calls the
DateDiff function between variables Arrival and
Enroute, and returns an integer value in seconds

var Minutes = (result/60)

//Defines a Minutes variable and
calculates it as result / 60

return Minutes

//Returns the Minutes values inti field as T3-T2
```

↑ Listing 1

GIS for Science, Volume 2: Applying Mapping and Spatial Analytics

By Dawn J. Wright and Christian Harder



GIS for Science, Volume 2: Applying Mapping and Spatial Analytics, is the second collection of articles about science and the scientists who use GIS and spatial data science. It follows the same format as Volume 1, which was published in 2019. These articles, contributed by researchers working for government agencies, academic institutions, and Esri, are organized into four sections: how the Earth works, how the Earth looks, how we look at the Earth, and a final section on outstanding applications.

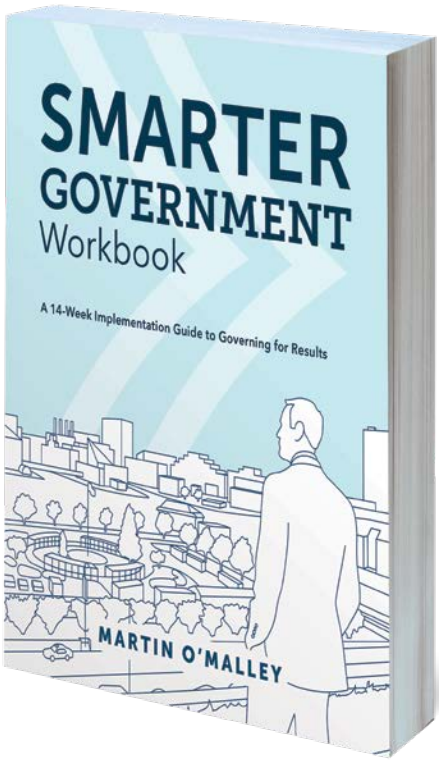
The final section showcases examples of GIS applications for COVID-19 pandemic response, mapping the harmful algal bloom, implementing a map projection that more effectively maps the ocean, modeling the Ebola outbreak in Sierra Leone, and many other examples that demonstrate the value of GIS in the application of science to the world's challenges.

The book was coedited by Esri chief scientist Dawn Wright and Esri technology writer and information designer Christian Harder. It contains a foreword by Jared Diamond, a Pulitzer Prize winner for general nonfiction.

Its audience is made up of professional scientists, citizen scientists, and individuals who are interested in science and geography. To learn more, visit gisforscience.com. This site contains a collection of digital resources related to each chapter including additional maps, videos, web apps, and ArcGIS StoryMaps stories. Esri Press; 205 pp., print edition ISBN: 9781589485877; e-book ISBN: 9781589485884.

Smarter Government Workbook: A 14-Week Implementation Guide to Governing for Results

By Martin O'Malley



This workbook is a companion to *Smarter Government: How to Govern for Results in the Information Age*, the 2019 book by former Maryland governor Martin O'Malley. He provides a practical, interactive 14-week plan that governments can follow to implement a performance measurement and management system modeled on the CitiStat and StateStat systems he developed as mayor of Baltimore and then governor of Maryland.

The StateStat system was modeled after CompStat, a crime management system that New York City launched in the early 1990s. When O'Malley was elected governor in 2007, he implemented the Stat system in state agencies. The workbook walks readers through how to create a framework that will help government leaders:

- Set up a system for gathering and sharing accurate and timely information.
- Deploy resources quickly.
- Build leadership and collaboration.
- Develop and refine effective strategic goals and key performance indicators.
- Assess results.

Esri Press; 2020 80 pp., print edition ISBN: 9781589486027.

SHARING BLACK PERSPECTIVES ON THE RACIAL IMPLICATIONS OF PLACE

By Clinton Johnson

GROWING UP in Philadelphia, everyone in my neighborhood was Black. My elementary school was at the border of all-Black and all-Latinx neighborhoods, and our school makeup reflected that. The only White people I saw in my daily life were teachers at school. I didn't realize this was all by design until several years into my career using GIS.

GIS helped me connect Philadelphia's racially segregated communities to the limits to prosperity for non-White Americans. I learned that beginning in the 1930s, more than 200 cities across the country were redlined, yellowlined, or greenlined by a federal agency. The Home Owners' Loan Corporation (HOLC) created maps guiding efforts promoting systemic racism. A neighborhood ranking system guided real estate developers and appraisers in cities across the US. The neighborhoods deemed hazardous were marked as red on the map. The racial bias of this action is the origin of the term *redlining*, which has become synonymous with government policies that underpin systemic racism.

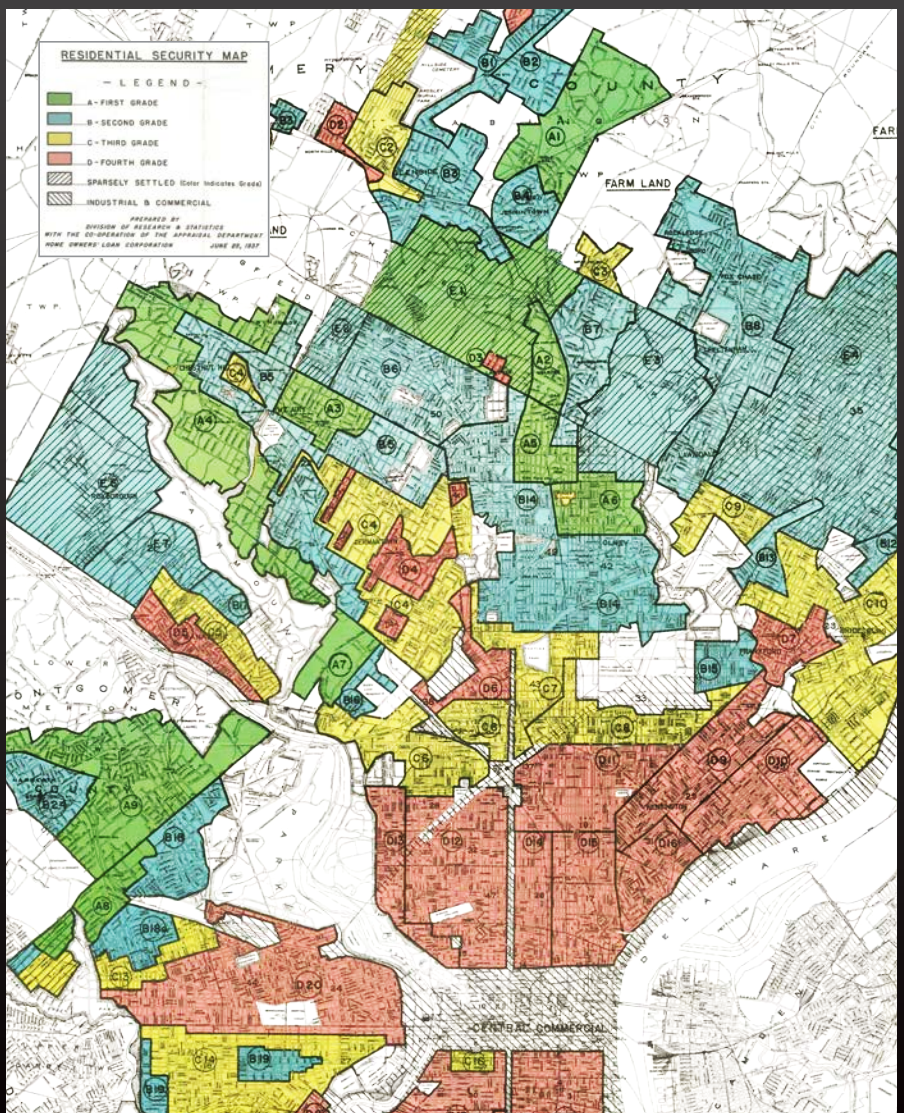
It was clear to me that GIS could be a tool for unraveling racism and designing a better future. I'd heard about redlining as a thing of the past, but my work in GIS for the City of Philadelphia exposed me to continuing patterns. Work to support the city's reinvestment fund got me excited about using GIS as a tool to uncover and eliminate racial injustices that plague my friends, family, and community.

I joined Esri to expand my focus beyond a single city—and leverage my lived experience—by helping cities, counties, and organizations address racial and social inequality. About a year and a half ago, I founded NorthStar to connect students, professionals, and entrepreneurs of African descent to collaborate to increase the representation of Black people in GIS and advocate for the use of GIS to advance equity and social justice.

In the wake of the senseless and horrific killings of George Floyd, Breonna Taylor, and Ahmaud Arbery, Esri launched a Racial Equity initiative, which I lead. This work focuses on the application of GIS and mapping to address racial inequities and involves developing datasets and solutions; creating education materials in the form of demos, videos, webinars, courses, and lessons; and capturing and sharing maps and stories to elevate best practices.

At the recent virtual Esri User Conference, a Homecoming *[a week-long virtual gathering of GIS professionals of African descent was organized by NorthStar and Blacks in GIS]* to provide a place for sharing perspectives. We spoke about equity, inclusivity, unity, and our power to make a difference. During the Homecoming, Adrian Gardner and I spoke about the African continent, what's going on there, and how people of color in different countries have different experiences. The following personal accounts by Adrian Gardner, Valrie Grant, and Jennifer Johnson were related to us. They describe what it means to be a Black GIS user.

↓ Map from work by Robert K. Nelson and Edward L. Ayers, https://dsl.richmond.edu/panorama/redlining/, accessed September 28, 2020. Used under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.



ADRIAN GARDNER

ADRIAN GARDNER

Adrian Gardner was the longest-serving CIO at the United States Federal Emergency Management Agency (FEMA) when he retired two years ago. He since founded SmarTech Nexus, (STN) a nonprofit that uses GIS, data analytics, and artificial intelligence (AI) to empower at-risk and underserved communities.

I've walked through my life very differently than somebody who does not look like me. I was born in Germany, went to high school in the US Virgin Islands and college at Tuskegee Institute, and joined the US Air Force as a second lieutenant straight out of college. I spent four years in Sicily and have done a lot of international travel for work and pleasure.

I have seen and lived how people of color are treated in different countries. Much like life in the US, it doesn't matter how high Black individuals rise in their community or profession; they are still at risk of racial profiling in the street and the boardroom. For the longest time, when I was growing up, the rest of the world wanted to model the US. Now, I see other countries showing the US how to make more equitable decisions.

Some of the GIS work of the United Nations (UN) gives us an opportunity to look at and compare, the capacity of different countries. What are those puts and takes, and how do we get all boats to rise to the same level? Geospatial technology provides the opportunity for storytelling—setting issues in context to make them visible so that we can learn from them and then repeat what worked well.

When I was at FEMA, we used GIS to understand and confirm whether dollars and support for underserved and at-risk communities were equitable. GIS provided us with the tools to look at the agency's decision-making practices, to ensure alignment between the people requiring disaster relief and the people that received it. Often, the data speaks for itself.

GIS is central to the way our organization, SmarTech Nexus, looks at assets within a community. The technology can empower communities to participate in decisions that impact them. STN is focused on two underutilized assets that exist in every community: opportunity youth and faith-based organizations. An opportunity youth is an individual between the ages of 16 and 24 who is not employed and not in school. Faith-based organizations serve as fulfillment centers for goods and services.

We are engaging young people in the practices of mapping their communities and empowering the next generation through GIS to thrive and survive in the skill-based economy. Our goal is to reduce the number of socially disconnected people in underserved communities by 500,000 over five years.

VALRIE GRANT

Valrie Grant, GISP, calls herself a location intelligence strategist. She founded GeoTechVision, an Esri partner, and is the executive chairman of the Marlie Technology Park.

I grew up in the countryside in Jamaica, where I was socialized to think that

VALRIE GRANT

everybody is equal. When I entered the international scene and ventured to other places, I realized that was not the case elsewhere. Black Americans have a different perspective than Caribbean Blacks, probably because we are the majority in our countries, and racism isn't as prevalent.

If you think about society as a body, every part has a different function. The hand may not be as important as the heart, but if you take any of it away, you're just not the same. If society will recognize the value of everyone, we will be so much better for it. At the end of the day, your class or race doesn't matter, and we all make valuable contributions. I operate like that in every sphere.

Doing things together can have an impact, which is the foundation of what geospatial technology has always been for me. It's all about creating opportunities for ethnically diverse communities. GIS shines a light on inequities, and COVID-19 has shown that people are suffering based on where they live and the opportunities they have. It's heartening to come together as a group to collaborate and innovate.

In 2006, I founded the Caribbean chapter of the Urban and Regional Information Systems Association (URISA). We are building on these efforts with the support of the UN-Global Geospatial Information Management (GGIM) Americas Caribbean project, which began in 2014. We now have developed a close-knit geospatial group, with some 16 Caribbean countries participating, and we are having dialogue on the international and regional level.

I lead the UN-GGIM *[Global Geospatial Information Management]* Americas Private Sector Network. I'm also the only Caribbean representative on the World Geospatial Industry Council. You mostly see gray suits, so I'm glad to be there to represent Black women.

One of my passions is youth and education. I think opportunities should be afforded to everyone, not just the people who were born with access. With COVID-19, education has stopped in underserved communities where they don't have access to technology—computers or the internet.

We formed an initiative called EduTech Aid to provide children with tablet computers and enable access to materials so they can continue learning. We recently partnered with the Association of Caribbean States on a series of webinars on equity in education. We're collecting data about broadband access—the location of internet deserts—and we're mapping that to inform policy changes. We're trying to collect as much information as possible to be able to say to the decision-makers, This is the real picture on the ground. What are the solutions?

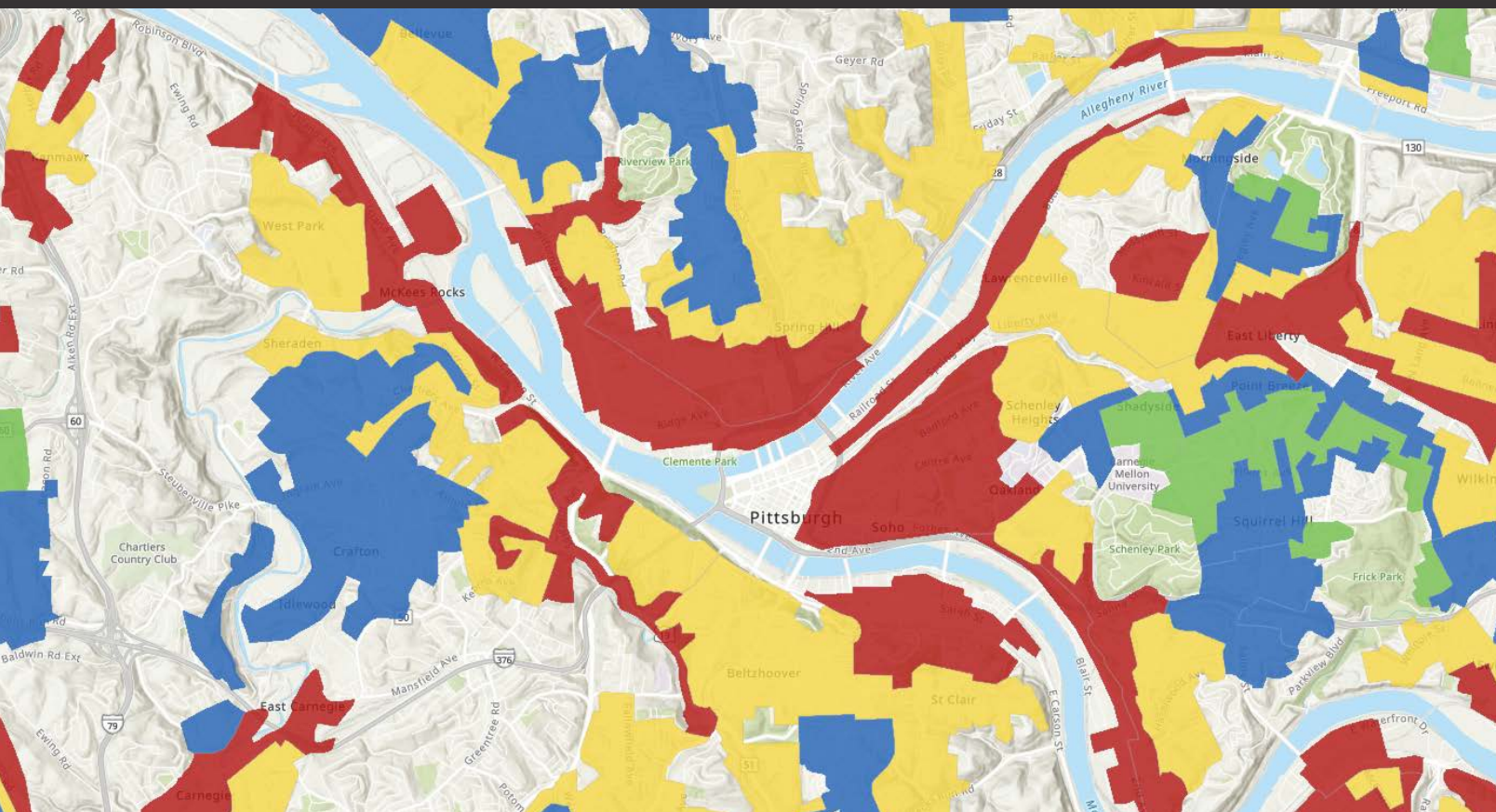
JENNIFER JOHNSON

Jennifer Johnson is a senior GIS analyst at the engineering firm HDR, Inc., a company that prides itself on inclusion and diversity that reflects the communities where it does business.

At HDR, we have a long list of team members on most projects that reflects the diverse communities we serve. Our diversity extends beyond race, age, and gender with a variety of disciplines. The inclusion and representation of different backgrounds are very important for any type of work that serves a wide variety of communities, and I'm proud to have an employer that recognizes that.

The COVID-19 crisis makes us all feel so physically exhausted, mentally overwhelmed and fearful of what's next. It's very important to not only stay positive

↓ The Home Owners' Loan Corporation (HOLC) dataset, available from the ArcGIS Living Atlas of the World, provides historical redlining mapping for 7,148 neighborhoods in 143 cities located across the continental United States.



JENNIFER JOHNSON

and hopeful for the future but also have an understanding that the impact of this virus has been more pronounced in minority communities. The power of GIS has shown us that impact nationwide and allowed us to explore other patterns of the virus worldwide. As individuals, we can use this knowledge to be more compassionate and responsible to prevent the spread of the virus on a daily basis.

COVID-19 has also impacted the way we work. At HDR we are using GIS to provide dynamic tools that track and manage our capacity for staffing our offices responsibly. I personally work from home, but for many, the office is a more productive environment. Our GIS team collaborated with administrative staff, human resources, and office management to provide an Esri mapping solution that supports our goal to make our office a safer environment for colleagues and clients.

Growing up in Philadelphia gave me a unique perspective. What was most astonishing was realizing how maps had historically impacted those communities. Redlining is a perfect example of how a lack of inclusion (when it comes to shaping our society) can be detrimental to generations nationwide. We still see effects today when it comes to commercial investment, landownership, and criminalization.

When I earned my position as a lead GIS analyst for the City of Philadelphia, I worked with a team to build an index of data to identify the impacts of education, drugs, crime, income, housing, accessibility, and many other variables, and provide policy makers with data-driven recommendations. That team has since continued to evolve what's now called the Stress Index, and it is a useful resource for the public to monitor and address important equity issues in Philadelphia.

After a few years with the CityGeo team in Philadelphia, I found myself in Nashville, working as a geodesign specialist for the Metro Planning Department. This position tied in very well with my knowledge of design and my passion for 3D GIS. Moving to Nashville was a professional and cultural adjustment but landing in the planning department meant that a big part of my job was to get to know my new city. I've now been in Nashville for almost four years and have found that everything I've learned along the way has prepared me for my current role as a senior GIS analyst at HDR.

My personal objective has always been to sustain myself doing what I love and be a positive representation of those who have similar backgrounds. As an African-American woman in tech and design, I feel a sense of responsibility to progress and open doors for more inclusivity. Often, if you don't see a representation of yourself in a particular career path, it can seem unattainable, so I'm hoping I can lead by example. As my career progresses, I intend to be the change I want to see in the industry by continuing to provide my unique perspective in future collaborations and uplifting other professionals who also have a passion for GIS. If we can learn from one another, we can overcome challenges more effectively as a team.

RESOURCES FOR ADDRESSING RACIAL EQUITY

To learn how governments, nonprofits, and businesses can address racial inequity, visit Esri's Racial Equity website (esri.com/en-us/racial-equity). The GIS resources on the Racial Equity GIS Hub (gis-for-racialequity.hub.arcgis.com), allow more in-depth analysis of these issues.

GIS-ready historical redlining data for 143 cities is available to help GIS users and policy makers understand how historical inequities continue today because these formerly redlined neighborhoods have fewer resources such as quality schools, access to fresh foods, and health-care facilities. Research by the Science Museum of Virginia has found a link between urban heat islands *[urban areas where temperatures are higher than surrounding rural areas as the result of human activities]* and redlining. These historical data layers can be leveraged to advance equity and social justice in communities. See "Effectively Present Information about race/Ethnicity (or Any Group)" (https://bit.ly/3jfGblC) in the Summer 2020 issue of *ArcUser*.

ABOUT THE AUTHOR

Clinton Johnson helps organizations create geospatial strategies for equitable outcomes. His empathic approach to technology begins with understanding the real-world challenges faced by diverse communities and finding creative ways to implement practical solutions. He leads Esri's racial equity team. He also founded and leads NorthStar, an employee community focused on increasing representation, inclusion, and belonging for people of African descent in GIS. He is an advocate for belonging and equity for people from underrepresented groups in GIS and STEM.

Interns and GIS Improve Campus Transportation

By Sophia Linn and Aaron Fodge

Every university must contend with the daily flow of people commuting to and moving around the campus. How can the students, staff, and faculty of a large university be encouraged to commute safely using alternative and sustainable transportation methods instead of individual cars?

GIS and spatial data can provide campus transportation planners and administrators with a view of the campus community's behavior patterns and transportation dynamics that can help inform decisions.

A long-term and mutually beneficial relationship at Colorado State University (CSU) between Parking and Transportation Services (PTS) and a campus geospatial resource called Geospatial Centroid (the Centroid) has not only improved how the campus functions but also benefited a talented and motivated team of student interns.

Cross-Campus Connections

From his first week on the job in 2013 as the alternative transportation manager at PTS, Aaron Fodge knew he needed the power of GIS to do his work effectively. His role was to expand the options for efficient, convenient, and reliable commuting and communicate how and why the entire campus community could benefit from using other transportation options. To do this, he needed data—specifically, spatial data—and a way to visualize it. Around the same time, the Centroid was established at the Morgan Library at CSU. Fodge, who lacked the necessary GIS capabilities within his own team, immediately tapped the Centroid for help.

Putting Students to Work

As Fodge began this formidable task, the Centroid was grappling with how to ensure it could satisfy the needs of its clients despite having no significant funding to hire professional GIS staff.

Enter the student interns.

The Centroid already welcomed students from across campus to assist in performing small GIS and mapping tasks that complemented their classroom learning and furthered their hands-on GIS experience. However, the work Fodge needed would be substantively different. It would require developing new methodologies, new data management systems, and a vision for long-term maintenance.

These initial efforts in recruiting interns laid the groundwork for a long-term, comprehensive spatial database and delivery system that would significantly influence transportation planning as well as student learning and development.

Building on a Foundation

An initial scope of work outlined tasks the Centroid would perform for PTS. These tasks included gathering data from existing sources and developing maps to show a snapshot of the CSU community and its commuting options. Fodge found that sharing even the most preliminary maps with his colleagues and partners, helped

them see the city differently.

Since these initial activities, the annual scope of work between PTS and the Centroid has been revised and expanded. These activities have built on previous achievements, while looking ahead and utilizing advances in technologies and the increasingly sophisticated skills of Centroid interns.

In addition, data providers from across campus—from the student records office to the police department—have realized the importance of generating accurate and clean spatial data. These providers have improved and streamlined their methods for recording and sharing data with the Centroid.

Where Do Commuters Live?

The first question was to find out where commuters to CSU originated. Each year, CSU collects the addresses of its students, staff, and faculty. This seemingly straightforward geocoding task was confounded by the fact that address fields did not clarify the difference between a local address and a home address. Consequently, some students' home addresses were located beyond a reasonable commuting distance—sometimes outside the state or country.

For the purposes of creating a reasonable commuting reach, the points for home addresses were restricted to a 50-mile buffer from campus or a three-county region. As with other aspects of this project, educating others about the importance of spatial data—gathering it and making it usable—has also evolved. Now the survey for incoming students explicitly asks, "What is your local address while attending CSU?"

Knowing where people commute from enables additional analyses. If this data is consistently collected and mapped over time, observations can be made with respect to where people choose to live and whether patterns emerge when new transportation options are introduced.

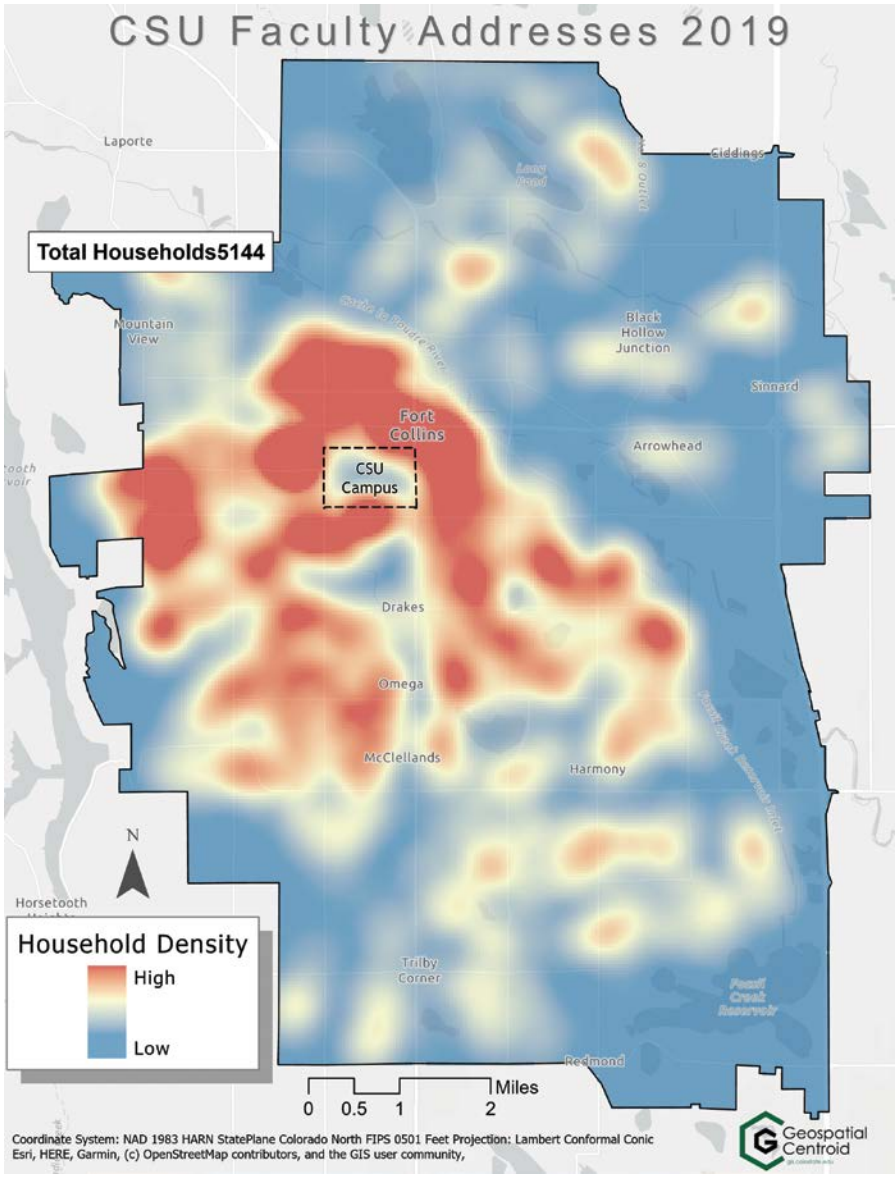
All CSU affiliates can ride buses for free. After the introduction of the MAX, the new north–south bus rapid transit (BRT) line in Fort Collins, there was evidence that some CSU affiliates moved closer to the MAX corridor. Similarly, a buffer analysis around bus stops and routes quantified what percentage of CSU affiliates were being adequately served by these routes and where there were gaps.

Buses, Buffers, and Boardings

Transfort is the transit service in the city of Fort Collins. Because CSU is the largest employer in the city, Transfort is very receptive to the needs of the CSU community. Transfort has been an excellent partner for both PTS and the Centroid and has willingly shared its data. Every year, it provides new bus route shapefiles so that analyses can be kept current and accurate. Every month, Transfort shares bus boarding data, which includes the time, route number, and GPS point location for every CSU affiliate who uses a university ID card to board the bus.

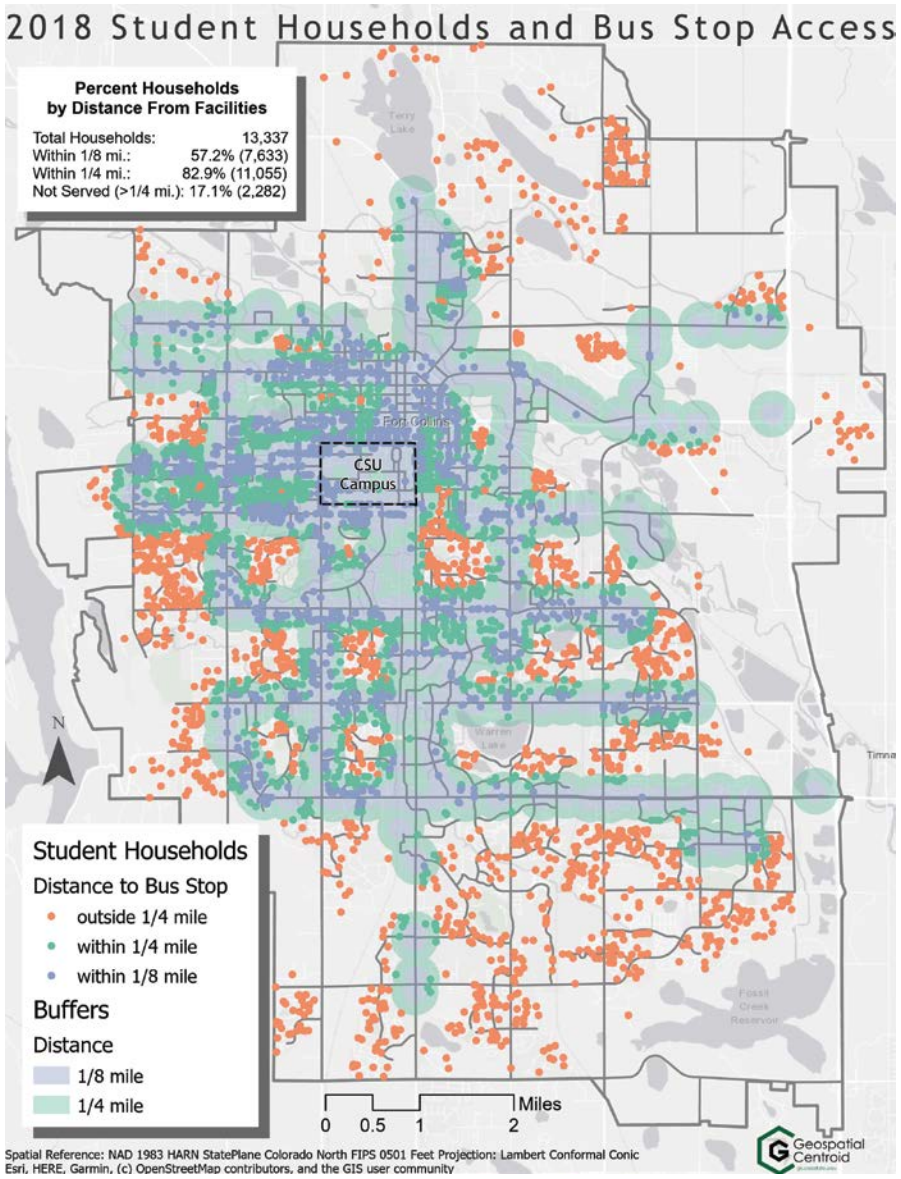
Transfort boarding data is further processed to convert the GPS-generated coordinates into a spatial context and associate the imprecise boarding locations with specific bus stops. Erick Kelly, the first Centroid intern to work on the PTS project, developed protocols that generated buffers around each bus stop so that the number of boardings per bus stop could be calculated. This analysis revealed which stops were heavily used and which were not.

Kelly's efforts provided the basis for building more efficient and accurate methods to show CSU bus ridership across the



↖ Bicycles are widely used at CSU and in Fort Collins.

→ Density of CSU faculty addresses in 2019 (Map by Joshua Reyling)



city. His maps clearly showed gaps where neighborhoods were not being served. Fodge now had concrete evidence so that he could work with Transfort to modify its bus routes to better accommodate CSU commuters. This work helped secure a $1.5-million study to design a second BRT corridor in Fort Collins.

Bikes and More Bikes

Fort Collins and CSU are recognized as being exceptionally bike-friendly places. Bikes are a significant part of the culture. CSU was named a Platinum Bicycle Friendly University by the League of American Bicyclists. The city's annual Tour de Fat bike parade attracts thousands of zany revelers.

However, not all riders ride safely or courteously, particularly on campus. Can data help? By mapping the data, powerful stories can be told. The Centroid's bicycle-related work focuses on plotting the location of tickets and crashes. While the CSU Police Department (CSUPD) records all bicycle incidents, including tickets and crashes, documenting the specific location was historically not a priority. When an officer recorded the location of an incident, it was as a verbal description, such as "south of Lory Student Center" or "on the corner of Plum and Meridian."

By geolocating bicycle incidents and using graduated symbols to display them on a campus map, it became obvious where problems were. PTS could channel resources specifically to these places, adding increased signage, and even providing bike traffic monitors to encourage enforcement of safe policies.

Erica Cirigliano, a nontraditional student with extensive programming skills, volunteered to create a script that could translate these verbal descriptions into consistent point locations. Instead of manually locating bicycle tickets and crashes, this script would be used by interns to automate the process of accurately locating bike incidents.

However, within a few years and with some gentle pressure from the Centroid, CSUPD became cognizant of the extreme value of location information for detecting trouble spots and evolved its data collection methods. Now CSUPD provides data with latitude-longitude points, which has significantly improved accuracy and efficiency.

Online Delivery

After the first few years of data collection and map creation, it became clear that this information needed to be more accessible and widely shared. Every month Fodge meets with other transportation planners in the City of Fort Collins. Having access to these maps and data would enrich the discussions at these meetings and ensure that decisions are based on evidence.

The improvements and accessibility of ArcGIS Online, along with CSU's campus-wide site license, made it the obvious choice. Danielle Davis, a recent geography/GIS graduate from Michigan State University with experience in the transportation sector, coincidently and fortuitously found her way to the Centroid office at just that time. She has since become a graduate student at CSU.

Over the next year, Davis built several web applications that not only visualized existing bicycle and Transfort data, but also allowed for ongoing updates. With these apps, Fodge could see data in near real time, visualize change over time, and

↖ Proximity of CSU student households to Transfort bus stops and routes in 2018. (Map by Joshua Reyling)

→ Web mapping application of bicycle incidents at CSU (Developed by Danielle Davis)

readily share data with other transportation planners.

Retroactive Data Management and More Efficient Processes

After five years, despite a relatively well-functioning system in place, there were data organization and management issues that needed to be addressed. File management and naming conventions were not always as tidy as they should be. That led to inconsistencies and caused frustration when access to historic files was necessary.

Fortunately, Joshua Reyling, a new Centroid intern, could clearly see the issues and set about to clean things up. From ensuring that projections were consistent to automating naming conventions, Reyling worked tirelessly to bring order to the chaos. He created topical geodatabases (e.g., Bicycle Tickets, Bicycle Crashes) with feature datasets for each academic year. These geodatabases contained monthly data processes and outputs. The data is now clearly named, accessible, and easy to find.

In addition, Reyling streamlined and improved the methods for processing the Transfort boarding data by creating a Python script to perform tasks that previously had been accomplished manually. Instead of creating buffers around bus stops and counting the points that intersect, his script relied on referencing Thiessen polygons created between the stops, and then performing a spatial join to associate each boarding with its respective stop. This has increased efficiency and reduced user error.

Like many relationships, there are times of relative calm followed by times of significant change. In a small way, the past seven years have followed this pattern. New systems are created in a disruptive push, which are followed by a period of calm, until a change is needed.

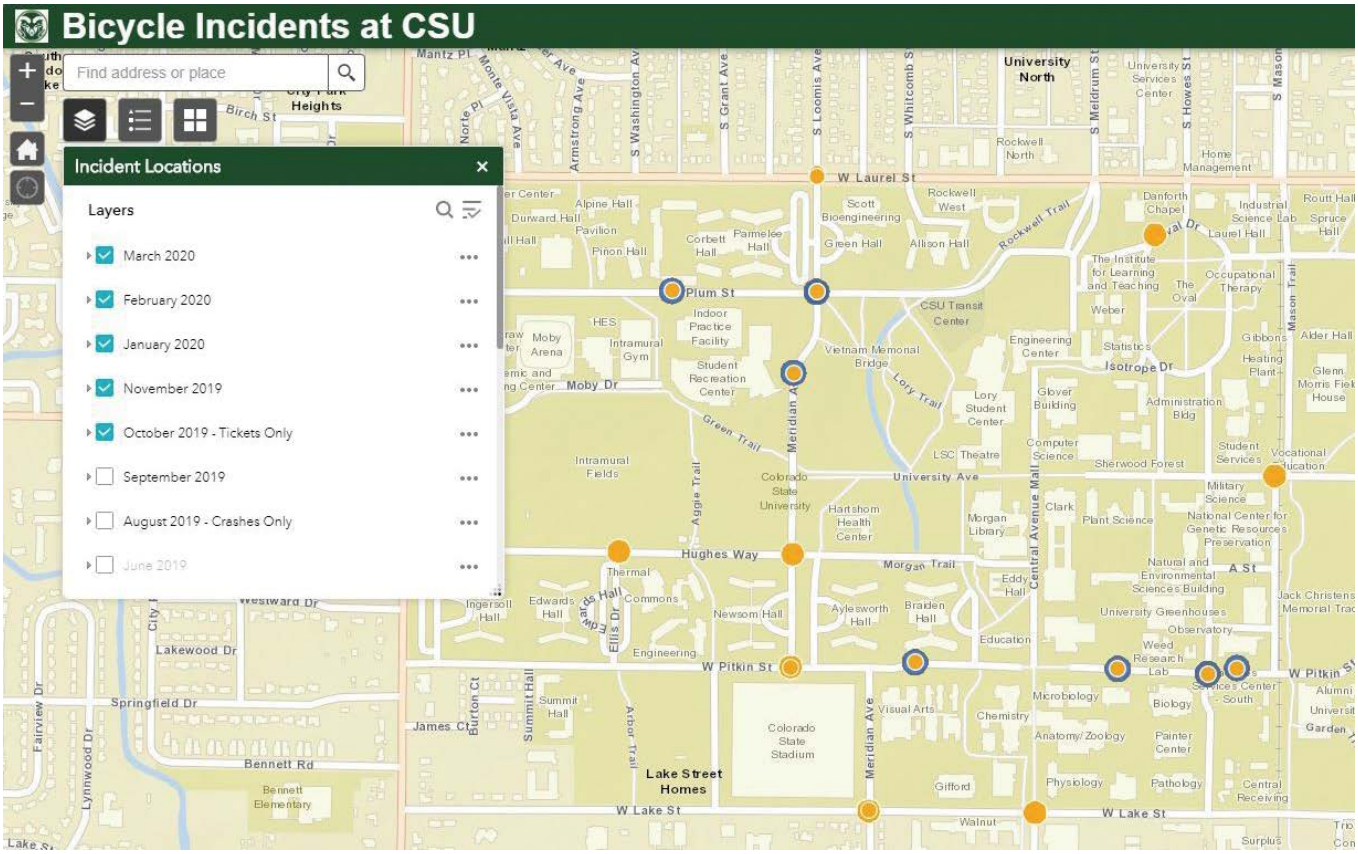
In this case, much depended on the individuals present and the technologies available. Kelly used existing tools to build the initial foundation and Cirigliano increased efficiency while expanding her programming skills. Davis learned to publish services and develop web mapping applications and Reyling learned to write code to wrangle data. Each of these interns contributed their unique skills, influenced the improvement of the local transportation systems, and enriched their own careers at the same time.

Fodge understands and appreciates a geospatial approach. From the start, his instinct was right—he needed spatial data and a competent GIS team to accomplish his mission. He regularly sings the praises of the Centroid and the intern program that enriches student skills while providing him with exactly the kind of evidence he needs. He is often the envy of his colleagues at other institutions who ask themselves Why don't we have a Geospatial Centroid?

For additional information, contact Sophia Linn at Sophia.Linn@colostate.edu or visit the Geospatial Centroid website at gis.colostate.edu.

About the Authors

Sophia E. Linn is the assistant director of the Geospatial Centroid at Colorado State University. **Aaron Fodge** is the manager of Alternative Transportation at Parking and Transportation Services, Colorado State University. Special thanks to the Centroid interns who contributed to this project.



How GIS Is Helping Reinvent Neighborhoods

By Jim Baumann

↑ Bikes can also be attached to racks on public buses and the light rail system will extend the range of bicycle travel to and from transit stops.

The City of Tempe, Arizona, uses GIS and GIS students at a nearby college campus to improve livability by analyzing transportation requirements. The city is reinventing its neighborhoods to encourage the use of walking, biking, and public transportation.

With the promise of an escape from city congestion and a desire for larger, less expensive homes, millions of Americans began moving from cities to suburbs during the 1950s. The migration continues today. Often these communities have been built in areas that lack nearby amenities, necessitating driving for shopping and other common services.

While some established urban neighborhoods include those amenities within walking distance, different approaches are currently being implemented in neighborhoods without nearby services.

Some architectural firms, such as Gensler, design mixed-use communities that include the businesses that sustain them. However, there is a growing movement to improve transportation systems in existing urban and suburban communities that would allow residents to reach amenities such as shopping, schools, restaurants, health-care facilities, parks, libraries, entertainment venues, and other public facilities within a 20-minute travel time.

The phrase *20-minute living*, has been credited to the real estate investment, development, and asset and property management firm of Gerding Edlen in Portland, Oregon. The concept has been championed by transportation planners throughout the world. Its fundamental concept is to build communities that allow residents to locate amenities within a 20-minute travel time that employs walking, biking, and public transit or a combination of these modes.

One of the major themes of the City of Tempe General Plan 2040 is improving the quality of life within the city by enhancing connections for pedestrian, bike, and public transit to produce a 20-minute city.

"Essentially, we want to entice residents out of their automobiles and make use of other methods of transportation, which creates efficiencies in the transportation system and improved quality of life and public health," said Stephanie Deitrick, GIS and data solutions manager for the City of Tempe and program director for the Masters of Advanced Study in GIS at Arizona State University (ASU).

"While there may be some redevelopment involved, we want to work with our existing infrastructure by encouraging residents to adopt a healthier lifestyle by walking or biking to their destinations, combined with public transportation," said Robert Yabes, transportation planning manager in Tempe's Engineering and Transportation Department.

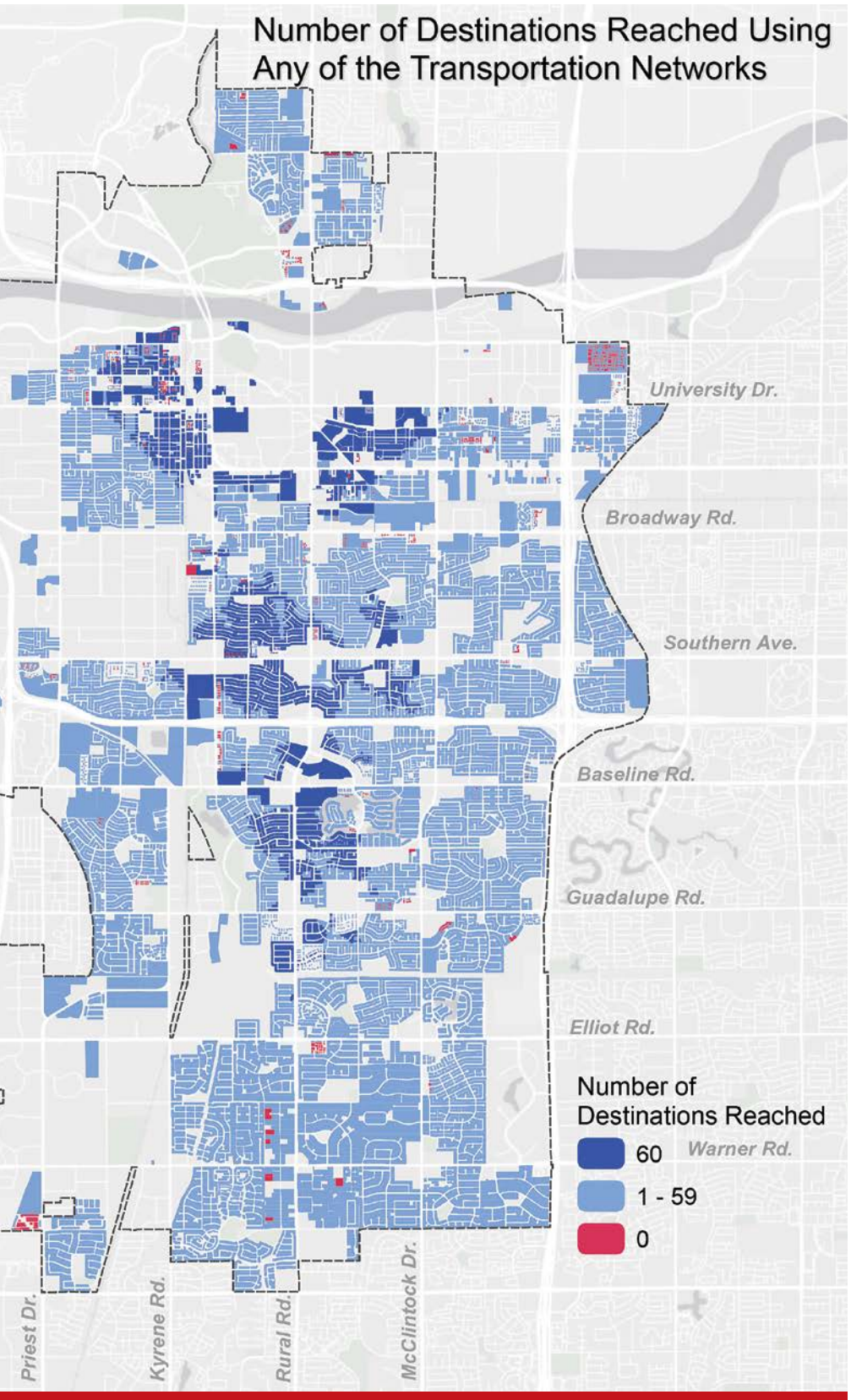
Yabes noted that an added benefit of encouraging alternative transportation is a reduction of air pollution caused by individuals using cars to travel to daily destinations. To help facilitate the 20-minute goal, the city will locate mobility hubs for passenger transfer throughout the city.

Tempe has implemented a bike share system throughout the city for public use. Bikes can also be attached to racks on public buses, and the light rail system will extend the range of bicycle travel to and from transit stops.

The city's Engineering and Transportation Department did the background work and defined what was required to develop the necessary GIS models for the project. The tools in ArcGIS Pro, ArcGIS Network Analyst, and ModelBuilder were used to create, analyze, and run the transportation network models. The models, which included bus, bike, and pedestrian networks, can be tweaked and run again as necessary.

Travel sheds were created using network analysis from key service destinations using Tempe parcel data. These sheds were extended outward with three separate networks for pedestrian, bicycle, and public transit transportation modes. The results represented the distance covered in 20 minutes of travel time: walking (1 mile), biking (4 miles), and public transit (7 miles). These results helped visualize and analyze the number of residential properties that could access services within 20 minutes.

Other factors were also considered in developing the models for Tempe's 20-minute city. These factors—freeways, street intersections, and the lack of sidewalks—can create barriers that people can't easily navigate. The bicycle networks



↑ This map shows the travel sheds created using network analysis from key service destinations using Tempe parcel data. These sheds were extended outward with three separate networks for pedestrian, bicycle, and public transit transportation modes.

created included the assignment of a low-stress network that would provide comfortable riding for bicyclists of all ages and abilities.

Deitrick's unique position as both a Tempe employee and ASU program director has allowed her to include her students in the process of collecting and analyzing data for the 20-minute city performance measure as part of the city's transportation studies. She worked with Trisalyn Nelson, director of the School of Geographical Sciences and Urban Planning; Shea Lemar, GIS project manager at ASU; and David King, an assistant professor in the School of Geographical Sciences and Urban Planning at ASU, to create the City Studio course. This innovative teaching approach allowed students to work more like consultants than interns who were given a project to complete.

"They are working more like experts that make recommendations based on their education and expertise. So, it required a leap of faith by the city to accept this approach, and so far, it has worked out very well," said Deitrick.

This analysis is the foundation of the baseline for Engineering and Transportation's 20-minute city performance measure. Students have determined the percentage of total residential properties in the city that can be reached for each destination type, based on the three modes of travel.

The next step in the project will be looking at those percentages to determine good baseline values for each travel mode and establishing achievable targets for improving them.

"To accomplish this, we would like to do a demand analysis to better understand how to prioritize network improvements," said Vanessa Spartan, a transportation planner in Tempe's Engineering and Transportation Department. "This analysis will include such things as age and health, as well as other demographic and locational factors of our residents that will potentially use the 20-minute transportation networks."

About the Author

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

Trimble | esri Partner Network Silver

Reality Captured

GIS Empowered

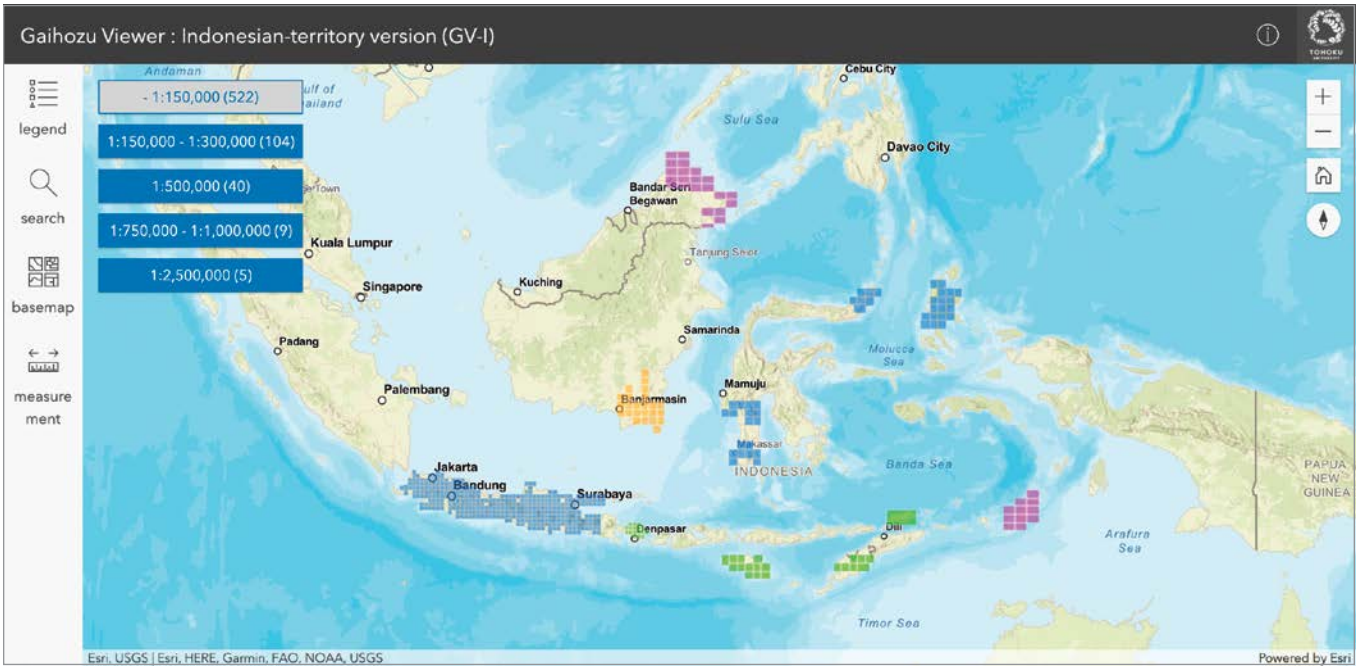
Intelligence Delivered

Geospatial.trimble.com/esri

FINDING *Lost Landscapes* IN SOUTHEAST ASIA

By Yukihisa Hoshida, Tomoki Nakaya, Shohei Nagata, Yuzuru Isoda, and Ryohei Sekine

A web application recently developed by a Japanese university makes a priceless collection of historical maps of East and Southeast Asia and the Pacific Islands available to the public.



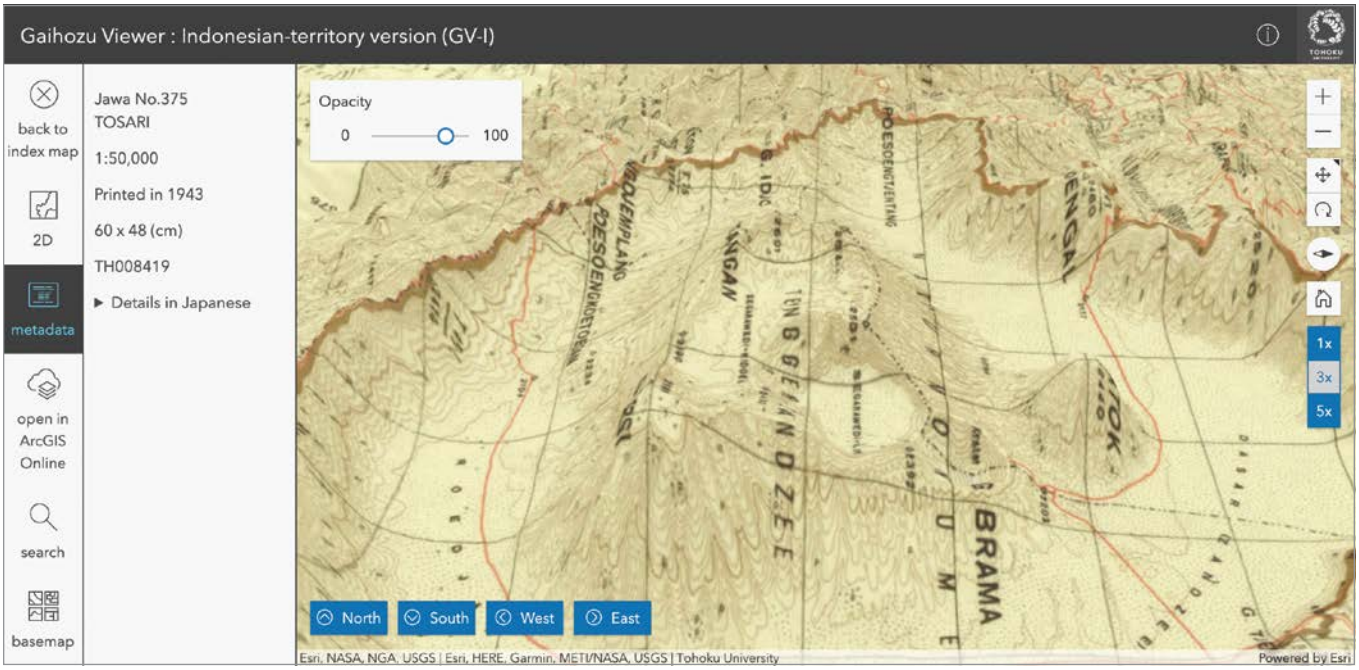
Historical maps tell us a lot. By comparing present land use with past land use, we can identify important changes that have been caused by events, such as natural disasters, or by processes, such as deforestation.

From the beginning of Japanese modernization in the 19th century to the end of World War II, the former Japanese Imperial Army made many topographic maps for military purposes. Maps of areas outside

↑ The Gaihozu Viewer: Indonesian-territory version (GV-I) web application begins with the index map of the area covered by the collection. Each map in the collection has been color-coded by year it was printed and can be filtered by scale.

↗ The app facilitates interactive viewing of 680 georeferenced maps in the Indonesian territory from the Gaihozu collection.

↘ This map from 1943, displayed in 3D, depicts Mount Bromo, located in East Java. Its contour lines align with the elevation of the scene exactly, indicating a high level of surveying technology at that time.



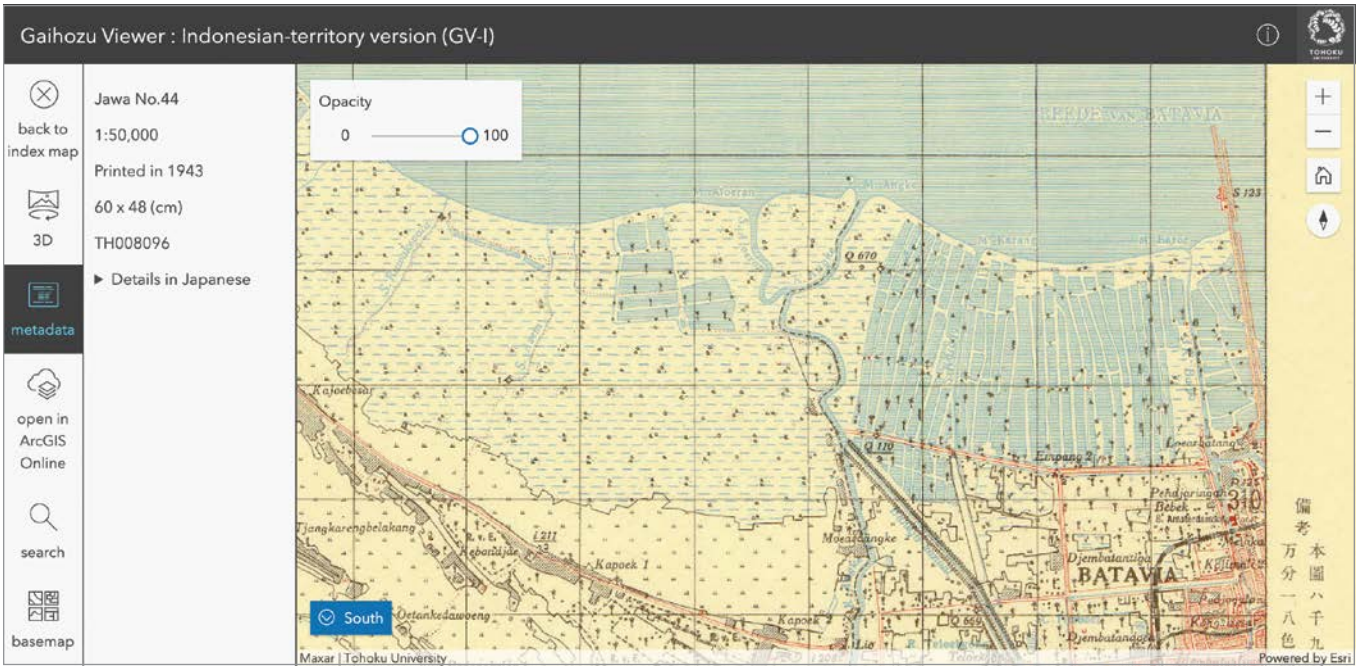
the Japanese islands (inner lands) are called *Gaihozu*, which means *maps of outer lands*. This is where military operations were conducted.

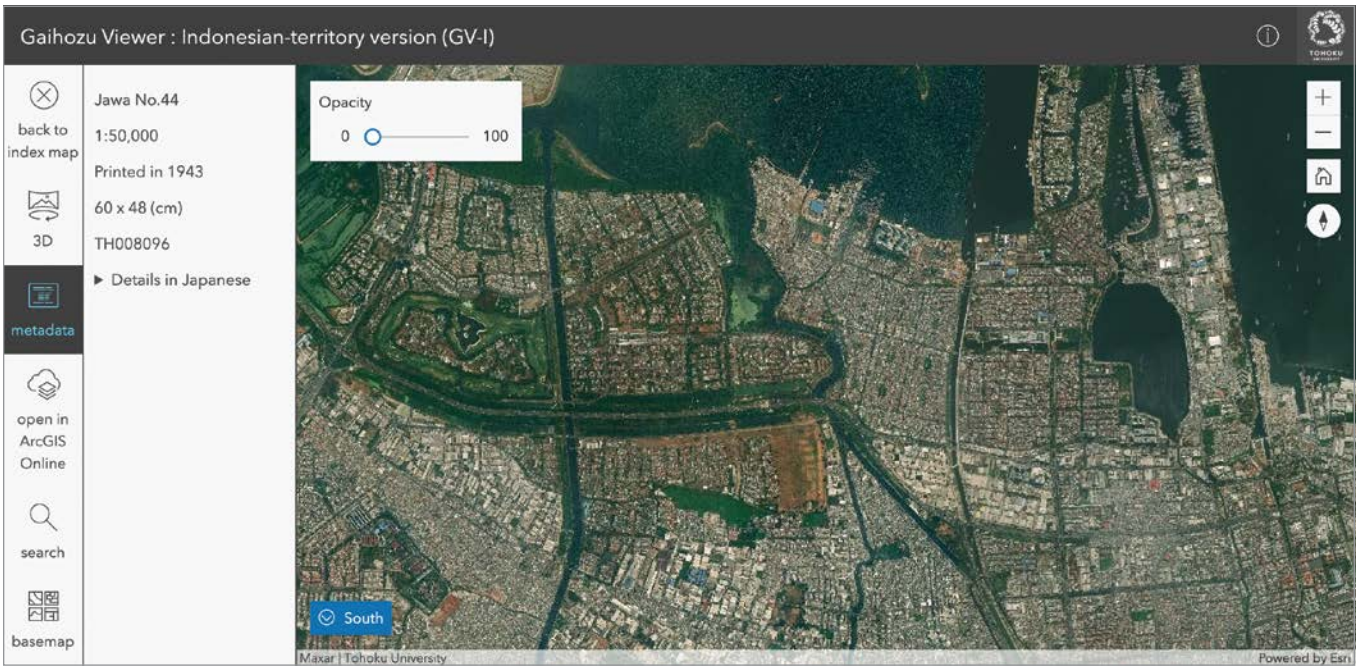
These maps came from many sources: formal surveys by the Japanese surveying department; reproductions of maps made by other countries; and secret surveys carried out under sealed orders. This resulted in huge variations in the style and quality of the cartography.

Nonetheless, the Gaihozu collection contains a valuable record of the detailed landscapes of the past, particularly of the Asian regions where economic development after World War II drastically changed the land use and land cover. These maps may reveal the environmental changes that have occurred.

At the end of World War II, the former imperial army tried to burn the maps as confidential materials. Several sets of maps were confiscated by the United States Army and have been preserved in a collection held at the Stanford University Library called the Gaihozu: Japanese imperial maps.

Other Gaihozu maps were secretly delivered to Japanese academic institutions, such as Tohoku University, where—fortunately—they have been preserved to this day. Previously, Japanese scholars created a large collection of scanned images and metadata for its Gaihozu maps. Tohoku





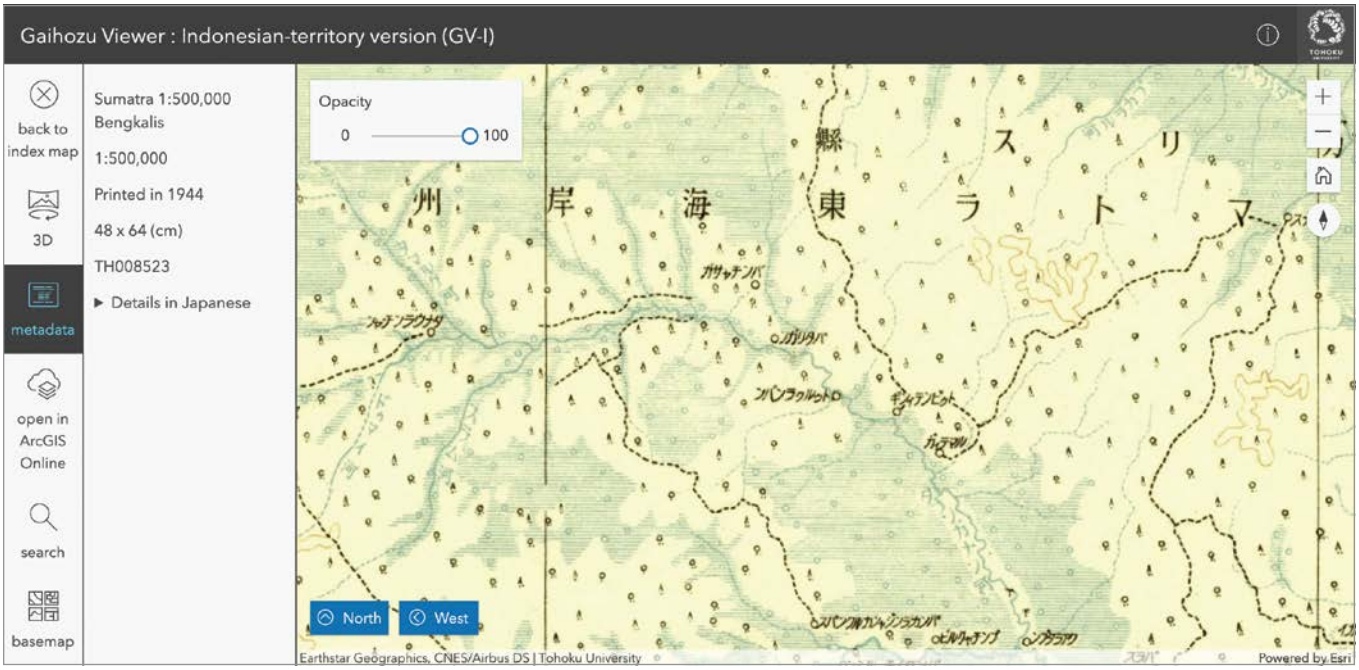
University was looking for a more sophisticated way to furnish the valuable historical maps in the Gaihozu collection to the GIS community.

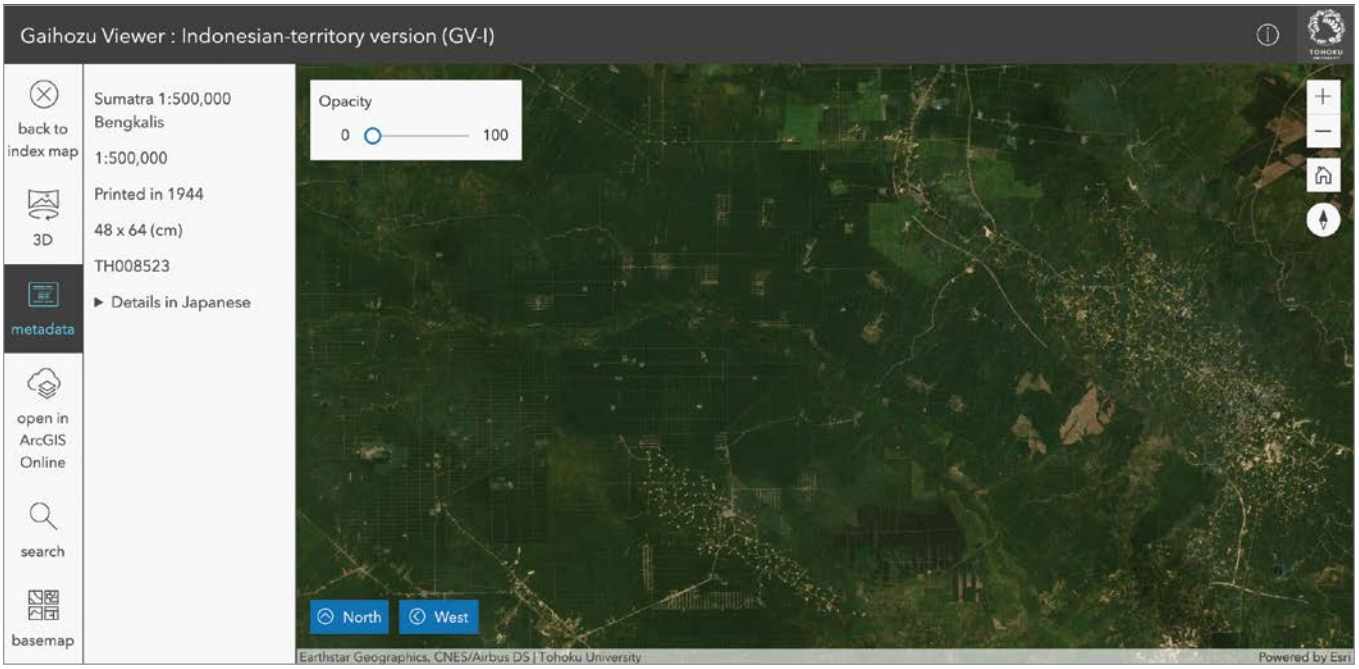
In 2020, Tohoku University released Gaihozu Viewer: Indonesian-territory version (GV-I), a web application that lets the public interactively view 680 georeferenced maps in the Indonesian territory from its collection of Gaihozu maps (https://nakaya-geolab.com/GaihozuV/).

In developing this app, the goal was to realistically create past landscapes that had been captured in these Gaihozu maps to gain a better understanding of world history geographically. Overlaying Gaihozu with contemporary basemaps would allow comparison of the past with the present.

The app delivers a mapcentric experience that lets users locate a specific Gaihozu map image easily. The web application begins with the index map of the area covered by the Gaihozu collection. Each polygon represents the outline of a Gaihozu map extent and is color-coded based on the year it was printed.

The index map can be filtered using the scale to avoid multiple polygons being selected simultaneously. Note that in this region, Gaihozu maps have scales that range from 1:50,000 to 1:2,500,000. Clicking a polygon on the index map enables users to show the corresponding georeferenced





↑↑ This map from 1944 shows Riau, located in the middle part of Sumatra Island, which was covered with mangrove forests at that time.

↑ Present-day satellite imagery of Riau shows that a large part of the mangrove forests has been lost.

↖ This map from 1943 of the northwest side of Jakarta, the biggest city in Indonesia, shows many wetlands and water reservoirs.

↙ This present-day satellite image of the same area shows the area filled with buildings and houses. This may indicate that these former wetlands may be vulnerable to natural disasters such as earthquakes and flooding.

map in both 3D and 2D with metadata, such as map scale and year printed.

Gaihozu map images can be compared with a variety of contemporary basemaps—including satellite images—by changing the opacity of the Gaihozu map image. 3D visualization helps reconstruct the landscape of that time more realistically, and the vertical exaggeration of the surface can be easily changed.

In addition, a web map containing a

georeferenced Gaihozu map image can be created from the application. This functionality helps obtain further insights from historical information by enabling users to overlay any layers they want from the ArcGIS Living Atlas of the World and save the resultant web map in ArcGIS Online.

The project team leveraged ArcGIS products across the desktop and cloud and the ArcGIS SDKs to develop the application. ArcGIS Pro was used to georeference the Gaihozu map images. Tile packages were created using ArcPy. More than 600 tile map services were published to ArcGIS Online using the ArcGIS API for Python. The index polygon feature service is also hosted on ArcGIS Online.

To add functionality to visualize Gaihozu in both 3D and 2D from a single tile map service, the front-end web application was developed using ArcGIS API for JavaScript. Calcite Web and Esri design patterns were used to design UI/UX for desktop, tablet, and mobile window sizes simultaneously.

[Calcite Web is a CSS and JavaScript framework, web style guide, and visual design system for Esri that implements the Esri Brand Guidelines and Calcite design framework for browser-based properties and products. Calcite Web is written in Sass, a CSS extension language.]

The Gaihozu map collections at Tohoku University, numbering more than 1,200, are often used by experts. The team of geographers at Tohoku University is planning to continue georeferencing and publishing other Gaihozu map images to enrich this new map service. The team hopes this application will make valuable modern historical maps more accessible to the public.

For more information on this collection, contact Yukihisa Hoshida at followingmemento@openconcierge.org.

About the Authors

Yukihisa Hoshida is the vice president of OpenConcierge, a nonprofit organization in Japan. He is passionate about geography and GIS and has been working with GIS for more than 13 years. He holds a master's degree in geography from Kyoto University, Japan.

Tomoki Nakaya is a professor of environmental geography in the Department of Frontier Science for Advanced Environment, Graduate School of Environmental Studies at Tohoku University, Japan. Concurrently, he is also an adjunct professor at the Graduate School of Science. His research interests include geographic mathematical modeling, spatial statistics, and geovisualization, including historical materials.

Shohei Nagata is a graduate student of environmental geography in the Department of Frontier Science for Advanced Environment, the Graduate School of Environmental Studies at Tohoku University, Japan. He works on health geographic studies, employing GIS techniques.

Yuzuru Isoda is an associate professor of human geography, Graduate School of Science, Tohoku University. His expertise is in population geography and urban geography, using GIS, and statistical approaches. He is also interested in historical maps and 3D representations of maps.

Ryohei Sekine is currently an assistant professor of environmental geography in the Department of Frontier Science for Advanced Environment, Graduate School of Environmental Studies at Tohoku University, Japan. He conducts geographic research on agriculture in Japan and the Inner Mongolia Autonomous Region of China.

For additional information on Gaihozu collections, visit
The Gaihozu Digital Archive maintained by Tohoku University at http://chiri.es.tohoku.ac.jp/~gaihozu/index.php?lang=en-US.

Esri Resources

Esri Technical Support
esri.com/support

Esri Desktop Order Center and Software Information
T 800 447 9778 (USA only)

Esri Products
esri.com/products

Esri Store
esri.com/store

ArcGIS for Developers
developers.arcgis.com

Customer Care Portal
my.esri.com

Esri US Regional Offices
esri.com/about-esri/usa

Esri Distributors
esri.com/distributors

esri

MASTER THE BUSINESS OF WHERE

DEVELOP SKILLS NEEDED TO ADAPT QUICKLY IN A CHANGING MARKETPLACE

The University of Redlands is a private, nonprofit university located in Redlands, California—close neighbors and partners with geospatial leader, Esri.

All Redlands academic programs enable access to Esri technology, training, people, events, and internships, including classes taught by Esri employees.

Business Location Analytics Certificate

Master the business of "where" with a graduate certificate that focuses on using GIS to achieve business success. Learn how leading organizations deploy location analytics to gain customer insights, expand the business, manage risk, and design effective spatial business strategies. Develop technical skills in location analytics and spatial storytelling that can improve business decision-making and positively impact society.

Online only

3 courses

10 credits

20 weeks

MBA – Location Analytics Concentration

Use the power of location intelligence to lead 21st century businesses and organizations. The MBA with a location analytics concentration equips you to unlock the potential of spatial data, solve real-world problems, and gain a competitive advantage in today's business world.

Online + On campus

9-12 courses

36-48 credits

18-24 months

Learn more
spatial.redlands.edu

UNIVERSITY OF Redlands
SCHOOL OF BUSINESS

380 New York Street
Redlands, California 92373-8100 USA

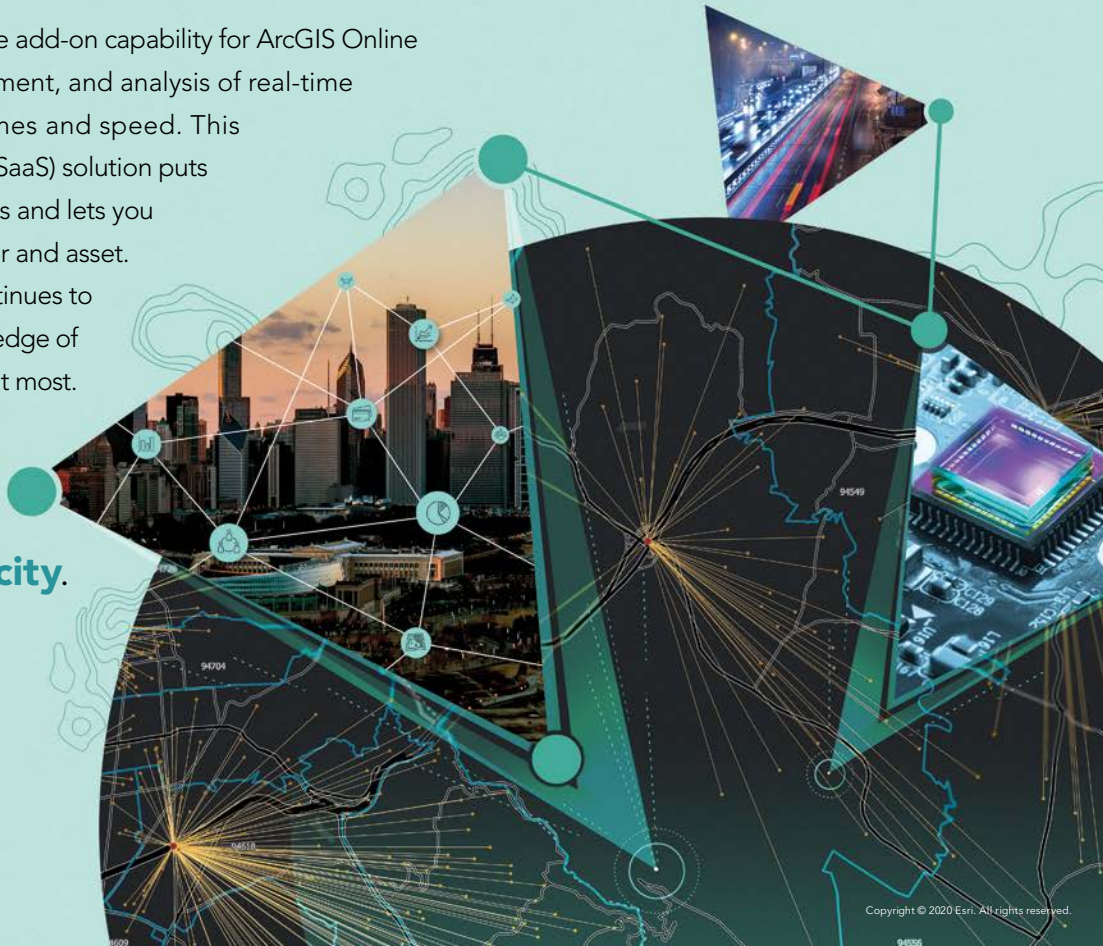
Presorted
Standard
US Postage
Paid
Esri

176458 G1323452

ANALYZING ***REAL-TIME DATA*** *JUST GOT A WHOLE LOT FASTER*

ArcGIS® Velocity℠ is a new, cloud-native add-on capability for ArcGIS Online that enables the collection, management, and analysis of real-time data feeds at unprecedented volumes and speed. This easy-to-deploy software-as-a-service (SaaS) solution puts the Internet of Things at your fingertips and lets you realize the full potential of every sensor and asset. ArcGIS, the leading GIS platform, continues to keep your organization on the cutting edge of digital transformation, when you need it most.

Learn more at
go.esri.com/ArcGISVelocity.



esri THE SCIENCE OF WHERE®