Fall 2022

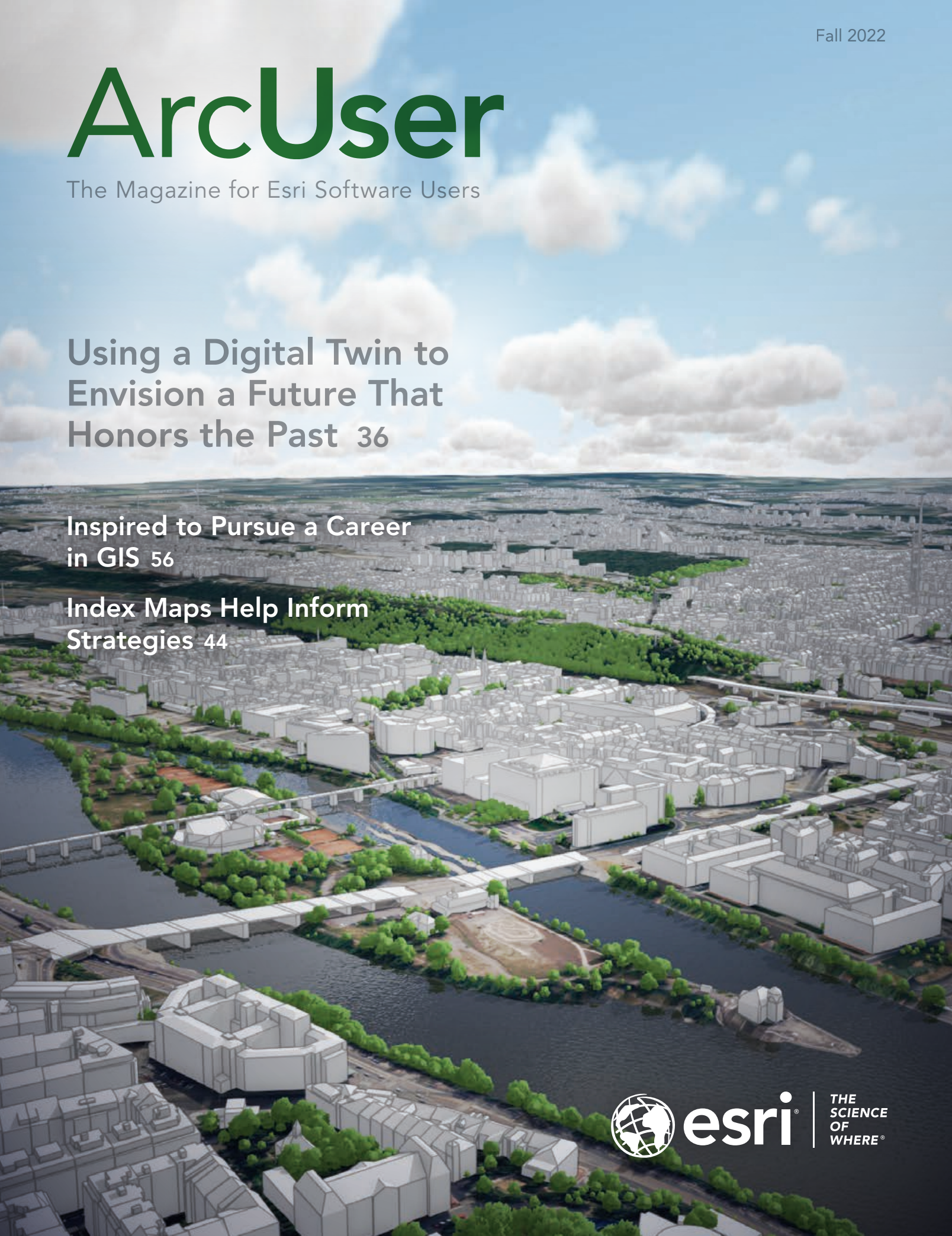
ArcUser

The Magazine for Esri Software Users

Using a Digital Twin to Envision a Future That Honors the Past 36

Inspired to Pursue a Career in GIS 56

Index Maps Help Inform Strategies 44



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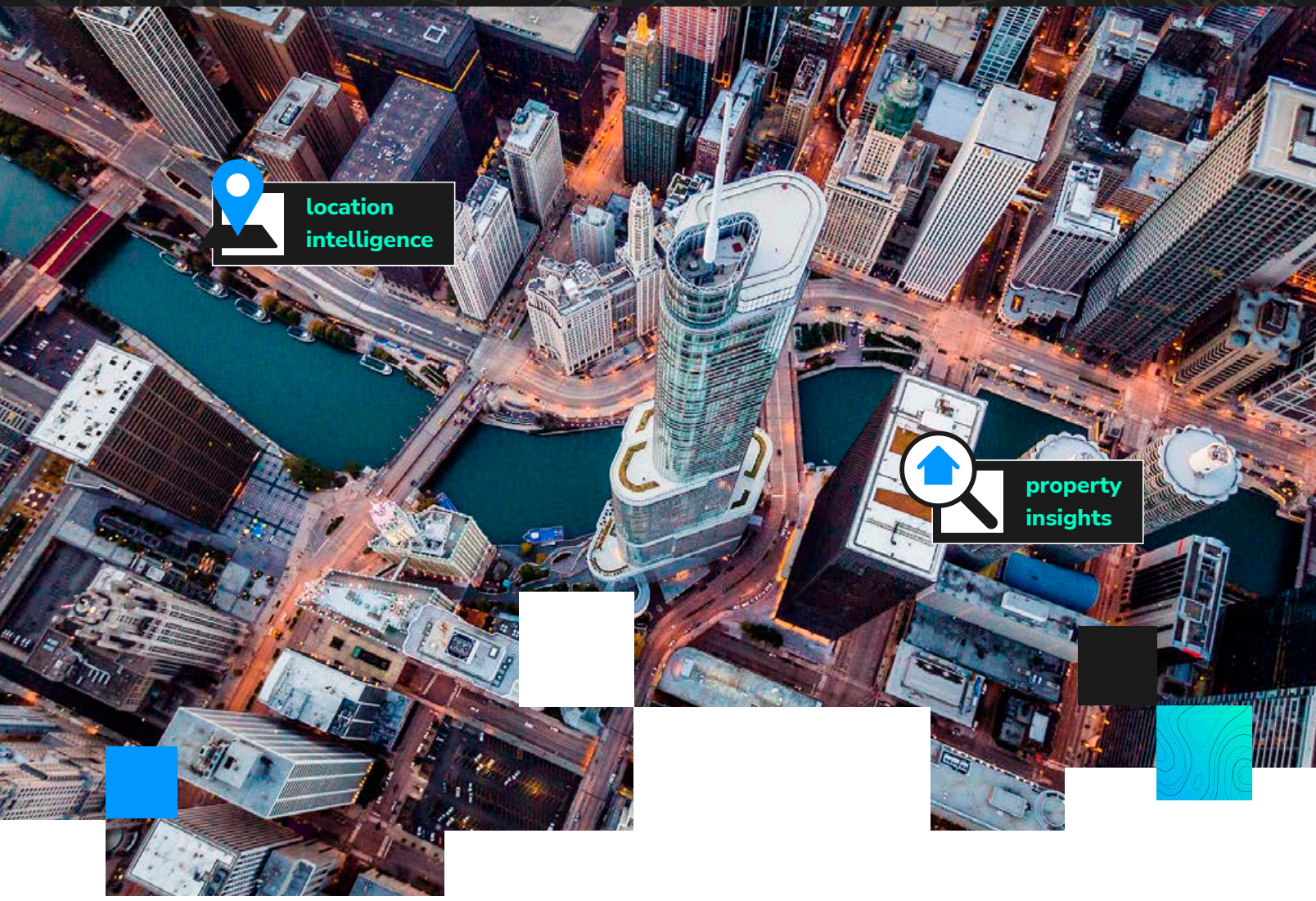

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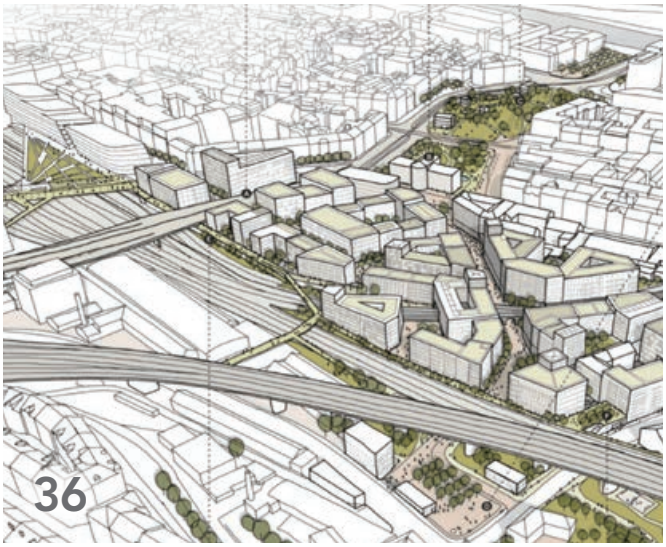
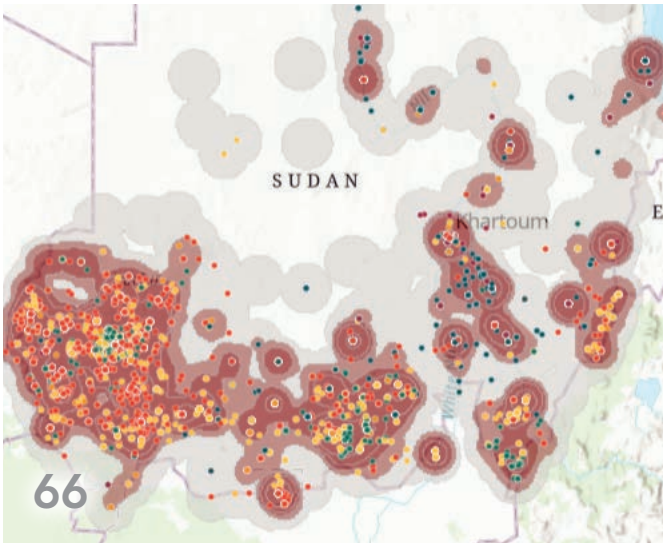
Contents

Fall 2022 Vol. 25 No. 4

Focus



Special Section



End Notes

On the Cover

The Prague Institute of Planning and Development (IPR Prague), the main policy making unit for urban architecture, planning, development, design, and administration for the city, employs a digital twin of Prague that lives in the city's GIS. The finalists in a design contest to revive Florenc were able to blend their plans into the digital twin so that it could be used for decision-making.

The Rise of Geospatial Analytics

According to global market research and consulting firm MarketsandMarkets, the geospatial analytics market is projected to grow from US$67.4 billion in 2022 to US$119.9 billion by 2027. It reports, "Governments and corporate organizations can now use geospatial data as a critical information source to make decisions about risk assessment and mitigation, disaster management, and urban development as well."

GIS has always been the premier technology for bringing data from many sources into a geospatial framework and applying the geographic approach to understanding the world on many levels. Through modeling, analyzing, and interpreting data, GIS can yield a deeper understanding of the world that supports better decisions and real-world action.

With the integration of rapidly expanding technologies—machine learning, imagery analysis, cloud computing, 3D visualization, and predictive modeling—the expanding capabilities of GIS are being applied to better understand how the world is, how it could be, and how it should be. Articles in this issue highlight examples of these robust applications of GIS.

Using ArcGIS Knowledge, the Kansas Water Office (KWO) integrates large amounts of nonspatial and spatial data and applies spatial and graph analytics. With the information produced, KWO communicates more effectively with stakeholders through interactive charts and graphs so that they can make more informed decisions.

The visualization tools in GIS not only reveal the current situation but can also model the future. Built using GIS, digital twins are more than 3D visualizations. They can contain a wealth of information on buildings, neighborhoods, and cities that can be queried. Digital twins can be used to develop, model, and test proposed solutions in the context of existing conditions. The City of Prague in the Czech Republic is employing its digital twin not only to optimize city operations but also to design solutions to connectivity problems within the city's infrastructure.

Missing Maps, which provides free mapping services to humanitarian organizations, is working to aid at-risk populations in Sudan. It analyzes data on hazards such as drought, flooding, and areas of conflict and social stressors such as food insecurity and the displacement of populations. Using results of this analysis with predictive models, Missing Maps can anticipate where aid will be needed and proactively stage resources to speed response.

As ArcGIS continues to expand the analytical capabilities in GIS and incorporate information technologies such as cloud computing, its scalability will aid in tackling challenges such as the effects of climate change, declining biodiversity, and the need for sustainable urban design.

Monica Pratt

Monica Pratt
ArcUser Editor

ArcUser

Fall 2022 Vol. 25 No. 4

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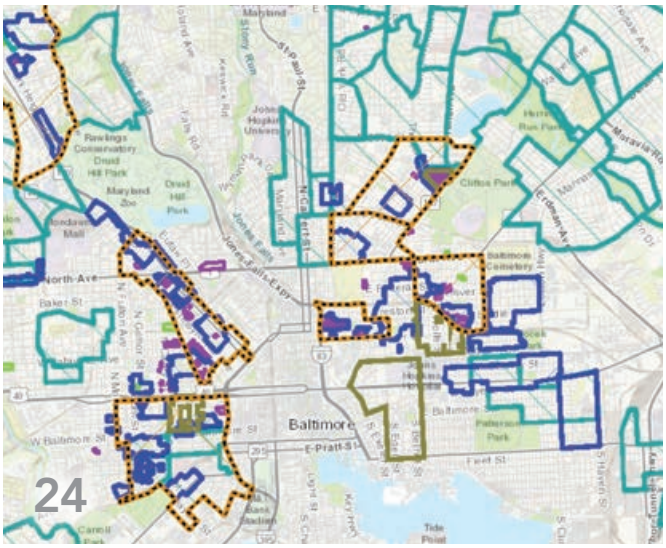
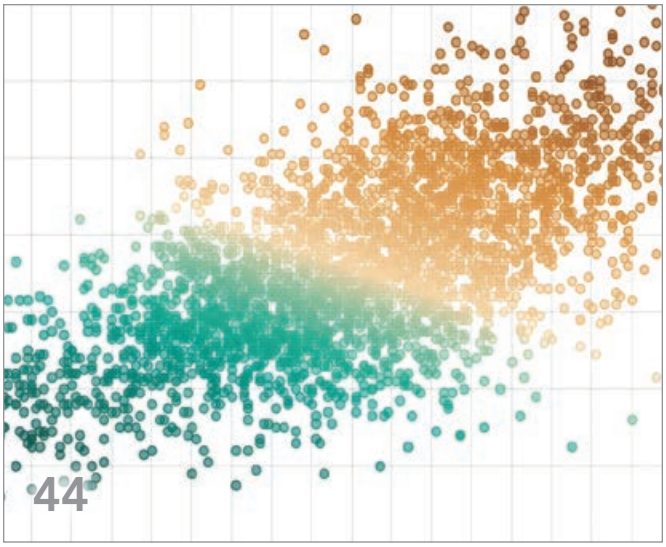
ISSN 1534-5467
ArcUser is published quarterly by Esri at 380 New York Street, Redlands, CA 92373-8100 USA.
ArcUser is written for users of Esri software and distributed free of charge to registered users.

Departments





Briefly Noted

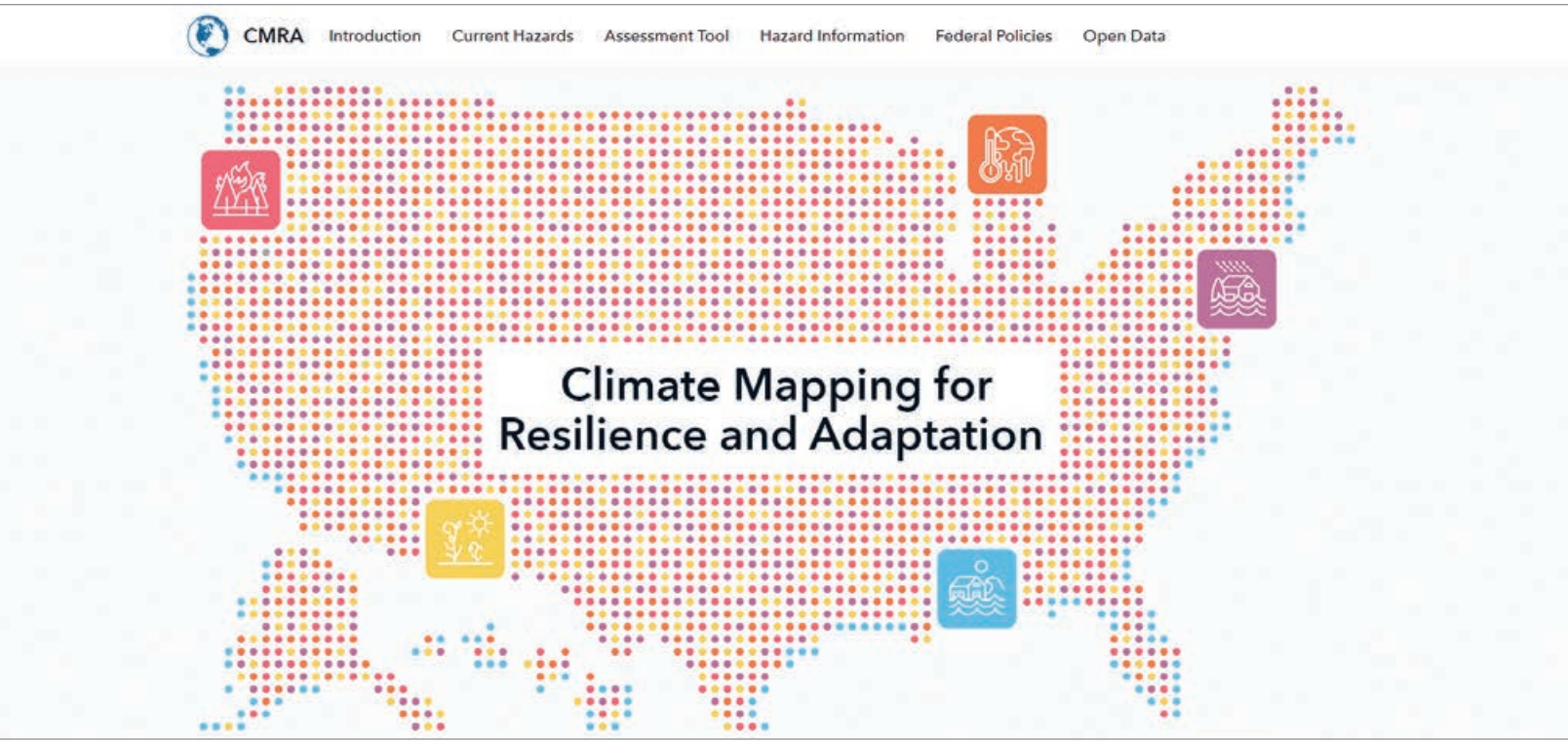
White House Releases New Climate Data Portal

In September 2022, the White House debuted the Climate Mapping for Resilience and Adaptation (CMRA) portal. This portal brings together critical climate data in one place where it is easy to find and visualize on maps, in charts, and in reports. Anyone can access the data, from city planners and resilience officers to tribal leaders and residents.

Built through a collaboration between the White House and Esri, this portal can help cities, counties, states, tribes, and territories make better decisions about where and how to take action. A dashboard monitors the climate-related hazards that affect communities each day. Site visitors can see where there are extreme heat advisories, active wildfires, coastal flooding warnings, and other threats.

The CMRA Assessment Tool lets users explore scenarios based on current and projected climate conditions in locations across the United States. CMRA can be used to learn how to prioritize resilience-building actions and find programs that offer compatible funding. CMRA provides links to federal funding resources, federal climate policies, and proven solutions from other communities. The portal also displays a curated collection of open datasets related to extreme heat, drought, wildfires, flooding, and coastal inundation. Users can combine this data with local geospatial data or incorporate it into their assessment tools to configure new maps and apps that address local needs.

To start exploring CMRA, go to resilience.climate.gov.



↓ The Climate Mapping for Resilience and Adaptation (CMRA) portal (resilience.climate.gov) brings together critical climate data in one place.

Location Intelligence to Inform Rebuilding of US Infrastructure

To support the goals of the $1.2 trillion Bipartisan Infrastructure Law to rebuild aging infrastructure in the United States, Esri has renewed a joint venture partnership with the US Department of Commerce's National Technical Information Service (NTIS). The agreement supports innovative joint venture projects throughout the federal government to make data more accessible and transparent.

NTIS helps federal agencies make better decisions by providing the support and structure that helps partners securely store, analyze, sort, and aggregate data. Through the Joint Venture Partnership (JVP) program, NTIS leverages its private sector partners' knowledge to create new ways of using data to solve problems. Esri technology is helping government organizations take a geographic approach to solving complex issues that often reach a national and global scale.

↑ Esri has renewed a joint venture partnership with the NTIS to support the goals of the $1.2 trillion Bipartisan Infrastructure Law to rebuild aging infrastructure in the United States.

Building a Sustainable Rail Infrastructure in the European Union

Esri and RB Rail AS, a joint venture, signed an enterprise agreement to integrate GIS software across all Rail Baltica project units. Rail Baltica is a rail transport infrastructure project that will include five European Union (EU) countries—Poland, Lithuania, Latvia, Estonia, and (indirectly) Finland. The project's purpose is to provide sustainable passenger and freight service between participating countries and improve rail connections between central and northern Europe. GIS will be used to help engineers plan, construct, and manage maintenance tasks to make improvements. ArcGIS will be used as a connection hub, and all asset data will be stored and handled in a unified spatial database.

The system will also serve as a foundation for implementing the Rail Baltica digital twin, a virtual model of the railway's entire operational infrastructure. The holistic geographic approach that the new GIS will bring also allows railway personnel to make necessary adjustments in near real time and plan routes to be less environmentally impactful. Creating this digital twin will help build a sustainable European infrastructure network.

Building Stronger Communities with Nonprofits

By Christopher Thomas

Charitable giving and volunteering have always seemed personal to me. My support of nonprofits probably started in grade school. The nuns made us give our change to poor children in faraway lands, pick up trash on the side of the road, or volunteer at school. Later, I gave to United Way through payroll deductions and donated blood to LifeStream. Frankly, these were easy ways of giving.

As I grew older, my causes became more personal: dropping off a bag of food and supplies for a homeless person or paying for a disabled youth's summer camp that uses horses as therapy. When a friend's son came down with arterial tortuosity syndrome (ATS), I supported research on this rare disease. I responded to needs that tugged at my heart.

My career in government and GIS shifted my thinking and I began seeing how I could promote charitable works by supporting nonprofits. One of the first ways I applied GIS was helping organizations fill out their Community Development Block Grant (CDBG) requests. The CDBG program led to me adopting the public library and providing access to maps and data via a rudimentary app so that nonprofits could find their census tracks to obtain data and maps about low- and moderate-income populations. I began to see how nonprofits could use GIS to help them apply for grants and communicate their missions.

This spring I had an eye-opening experience. I watched two of my Esri coworkers, Pat Dolan and Amanda Stanko, rally several small nonprofits to raise awareness of those affected by amyotrophic lateral sclerosis (ALS). Pat is living with ALS. He and Amanda used GIS to help ALS nonprofits secure funding from Congress for the first time. Their efforts were inspirational and a model for how GIS professionals and nonprofits can work together. *[See the article "Using GIS to Effect Change for the ALS Community" in the fall 2021 issue of* ArcUser *(https://bit.ly/3QiV72o.)]*

Adopt a Nonprofit: It Will Do Your Heart Some Good

The world needs more people like Pat and Amanda. This is an open call to you, a GIS professional—or a professional who uses GIS—to adopt a local nonprofit. Pick a cause that tugs at your heartstrings and tell the people at that nonprofit about the power of GIS. More specifically, pick a smaller nonprofit. Pick one that works at the state, region, county, or city level. Did you know that small nonprofits—those with 25 employees or fewer—make up the bulk of the 1.6 million organizations that help augment or supplement government services?

Introduce the people at that nonprofit to the advantages of spatial thinking and GIS. You can assure the leaders and volunteers that thousands of nonprofits already use GIS to advance their efforts. The wide range of organizations that use spatial technology include the following:

- Donate Life California uses maps to help communicate its causes and educate potential organ donors.
- San Jose Mothers' Milk Bank uses ArcGIS Business Analyst to reach women who might like to donate breast milk.
- The Surfrider Foundation volunteers use ArcGIS Survey123 and ArcGIS QuickCapture in their beach cleanup activities.

Make a Difference

Esri has made adopting a nonprofit easier with the Esri Small Nonprofit Organization Grant Initiative, which will waive the first year's fees and provide data, software, and resources to nonprofits. GIS is a tool that helps nonprofits become more data-driven organizations, identify opportunities to connect with donors and volunteers, and communicate their mission and successes more effectively. The initiative's goal is to assist small nonprofits that would benefit from the value GIS brings to their business functions. A secondary goal is introducing smaller nonprofits to the larger academic, commercial, and government communities.

Esri is asking you, as a GIS professional, to become a GIS ambassador. Your support can come from joint county and nonprofit projects; through extending local data; by providing cross-training on the software; or by keeping an open line of communication with a nonprofit. Even though your

passions may focus on a specific nonprofit, Esri hopes you will consider helping all the nonprofits in your community.

As you know, nonprofit organizations are driven by a desire to make a difference. But having a great mission is not enough. Having the tools to collect and analyze data and the storytelling tools to communicate the mission will let nonprofits target the donors and volunteers who will help build strong business operations. You can help nonprofit leaders understand the business value of GIS and direct them to Esri nonprofit community resources.

Those resources will help nonprofits use the geographic approach to identify communities in need, allocate resources, communicate purpose, improve advocacy, and increase the overall effectiveness and efficiency of their organization operations. The organizations that thrive are those that plan, measure, and manage their programs and operations through one common language—location.

Who Is Eligible?

The Esri Small Nonprofit Organization Grant Initiative assists small nonprofit organizations that are new to using GIS technology. Esri is investing $1 million in a grant initiative that will provide software and training to 150 nonprofit organizations that meet the requirements of a 501(c)(3) public charity and have 25 or fewer employees who are not currently using Esri's ArcGIS software. Esri has designed a special grant package that includes software, data, and training for up to five people in an organization.

Apply Now

The grant program was launched on August 17, 2022, National Nonprofit Day. To apply for the Esri Small Nonprofit Organization Grant Initiative, visit esri.com/nonprofitgrant. The application process is simple.

Applicants fill out the short online grant request and justification form. They confirm their 501(c)(3) status via the Esri Nonprofit Organization Program form. This helps make a nonprofit a sustainable member of the Esri nonprofit community.

Once both steps are completed, Esri will confirm a nonprofit's 501(c)(3) status and then review the grant application. Grant recipients will be announced in two groups on November 17, 2022, and February 28, 2023.

About the Author

Christopher Thomas, director of government markets on the industry solutions team at Esri, focuses on state and local disciplines. He has worked in and with national, state, and local governments implementing GIS technology for more than 30 years. As a strategist and subject matter expert, Thomas works to identify emerging trends GIS can support.

↑ Download a free ebook on using GIS for nonprofits at https://bit.ly/3rTXLBQ.

What's in the Esri Small Nonprofit Organization Grant

This special grant package is designed for small nonprofits based in the United States. Grants include ArcGIS Online, ArcGIS Pro, and ArcGIS Business Analyst; maps, data, and apps; and training and support.

With ArcGIS Online, organizations can create and share web-based interactive maps. The subscription also includes essential apps such as ArcGIS StoryMaps, ArcGIS Hub, ArcGIS Survey123, ArcGIS Dashboards, and ArcGIS Instant Apps.

ArcGIS Pro is desktop GIS that supports advanced data visualization and analysis. Its scientific analytical tools can be used to identify patterns, make predictions, and answer questions.

ArcGIS Business Analyst is the premier tool for site selection, customer segmentation, and territory design. It combines access to proprietary data on locations and property costs with data about prospective customers, clients, and patients. The results of analysis can be shared as customizable infographics.

The grant gives access to the constantly growing collection of curated data layers, maps, and apps available in ArcGIS Living Atlas of the World. This constantly updated data source can be used to better understand communities, as input to analysis, and included in reports and presentations.

ArcGIS Living Atlas provides access to maps that use 2020 decennial census data on topics such as race/ethnicity, group quarters populations, and vacant housing; and maps of the most recent American Community Survey data on social, economic, demographic, and housing topics.

ArcGIS Living Atlas also includes maps on health topics that visualize data from the Centers for Disease Control and Prevention (CDC). It has apps that use real-time data feeds on natural disasters and air quality and can identify populations that could be adversely affected.

Of special interest to many nonprofits, ArcGIS Living Atlas has maps of communities that have been identified by the Council on Environmental Quality as disadvantaged according to Justice40 Initiative criteria and maps of historical redlining for neighborhoods in 143 US cities. These maps can be used in dashboards and instant apps.

The grant also provides unlimited access to self-paced e-learning courses. Discounts on instructor-led or private classes are available through the program. Resource websites and forums let members of nonprofit organizations connect and collaborate with other GIS users. To learn more about the Esri Small Nonprofit Organization Grant Initiative, visit esri.com/nonprofitgrant.

Optimizing Bird Migration Tracking with ArcGIS

By Jon Rice, James Whitacre, and Bryce Stouffer

A network of research partners is using GIS to more effectively site tracking stations that gather data on migratory birds to help reverse decreases in their numbers.

According to "Decline of the North American avifauna," an article published in the September 19, 2019, issue of *Science* magazine, there has been a net loss of nearly 3 billion birds since 1970, which is a 29 percent reduction in total bird abundance, and more than 83 percent of those birds are migratory species.

Migratory animals perform some of the most astounding journeys on the planet. These extraordinary animals travel hundreds—if not thousands—of miles every year. Migratory birds, some weighing as little as a AAA battery, can perform nonstop flights of 2,500 kilometers over open ocean. Their ability to make such incredible journeys depends on many factors, especially the location of suitable stopover sites and destinations.

Most migratory bird research has focused on European and North American breeding grounds, with less emphasis on migratory routes, stopover sites, and nonbreeding grounds, which are most often located closer to the equator.

What factors are contributing to the steep decline, general ecology, and complex life histories of migratory bird species? While global climate change and habitat loss are certainly factors, understanding key elements of migration, such as changes in migration distance, timing, duration, and persistence of stopover site locations, can help researchers recommend habitat conservation solutions for greater yearly success. Integrating animal tracking technologies with GIS revolutionizes the investigation of climate change and habitat loss impacts on declining migratory bird species.

Tracking Animal Movements

Radio tracking wildlife has been a core technique used for decades. Traditional very high frequency (VHF) radio transmitters are still in use today. However, they require much additional work by researchers ,who must pinpoint a species location with a mobile VHF receiver. Recently, satellite-based technology has increased the spatial precision of tracking animal movements. However, satellite tags can cost up to 10 times more than radio tags. In addition,

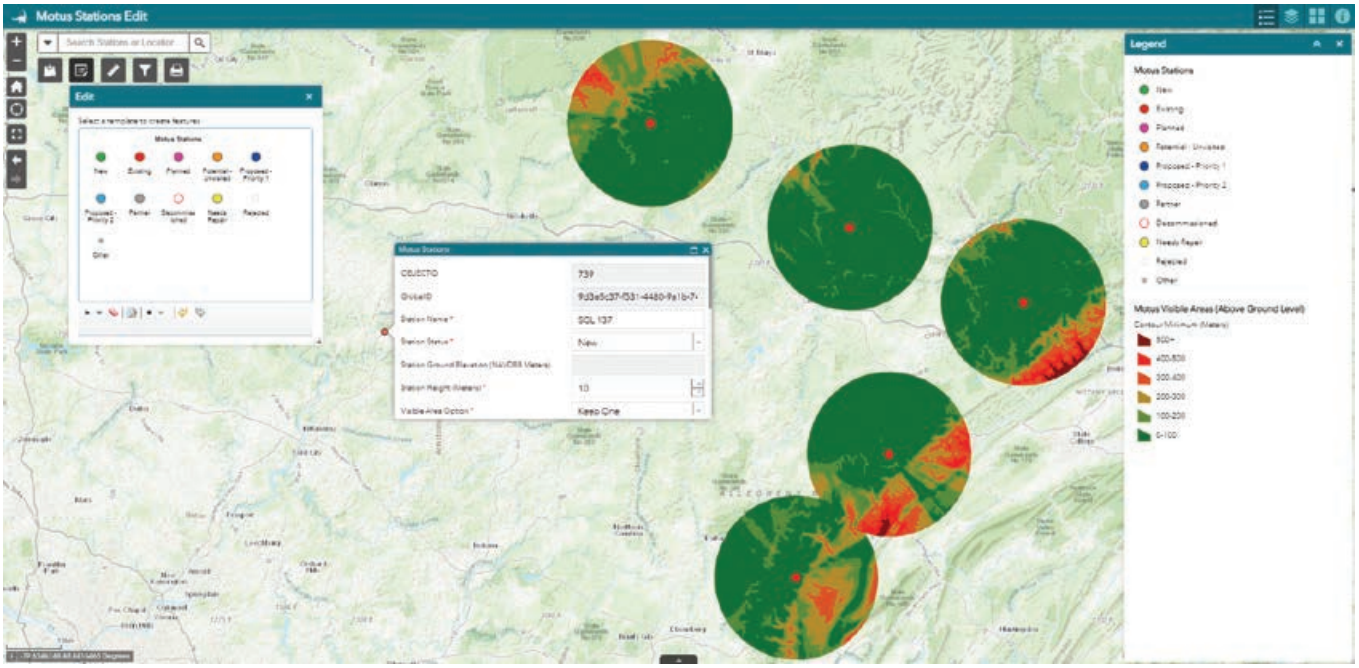
most radio tags are suitable for larger birds that can handle the additional weight, such as raptors and large waterfowl. Although there are satellite tags designed for smaller birds, they require recapturing the birds to extract and access the data.

A new radio tracking approach that uses nanotags weighing a fraction of a gram allow tracking animals as small as individual insects. Nanotags transmit radio signals on the same frequency but with a unique, digitally coded micropulse that individualizes each tag. These pulses can be detected by automated receiving stations. These stations are elevated structures with multiple antennae that are oriented in different directions and listen at a set frequency.

Motus Wildlife Tracking System

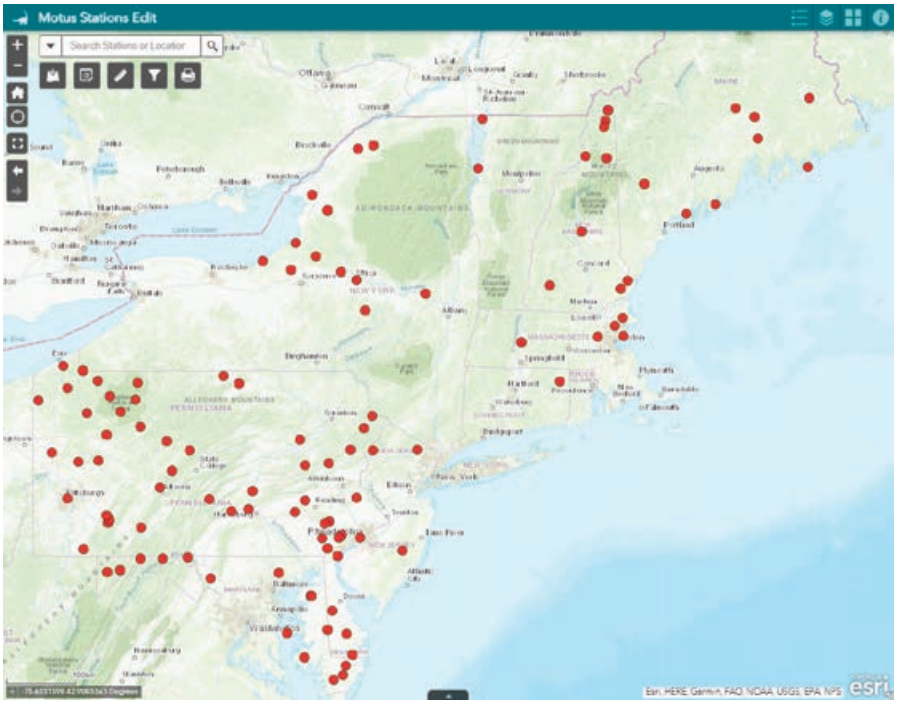
In 2008, Bird Studies Canada began the Motus Wildlife Tracking Network (Motus). *[Bird Studies Canada, a nonprofit, is Canada's national bird conservation organization.]* Motus now includes more than 1,200 research partners deploying automated receiving stations (Motus stations) in 31 countries.

↓ Northeast Motus Collaboration avian researchers use the Motus Stations Edit web application to strategically plan new Motus stations.



Motus station antennae are oriented in specific directions. Depending on visibility, they can detect nanotags up to 15 kilometers (km) away. By strategically installing Motus stations, researchers can create a fence line or grid that tracks nanotagged animals over time. When a Motus station detects a nanotag, it records a time stamp, the radio signal strength, and which antenna detected the signal. When combined with geographic location and antenna orientation, researchers can determine approximate migratory paths and movements.

For five years, the Northeast Motus Collaboration (NEMC) has worked to create an interior network of more than 100 Motus stations in the mid-Atlantic and New England states of the US. Before installing a Motus station, site analysis is necessary for each potential station location.



↑ The Northeast Motus Collaboration has installed and maintains more than 100 Motus automated receiver stations across the northeast US.

Geospatial Problems Solved with Geospatial Tools

Initially, Google Earth and site visits were used to manually analyze each station location. However, a more analytical and informative tool was necessary to maximize nanotag detection by ensuring optimal Motus station coverage across the landscape. ArcGIS was adopted so that researchers could share Motus station data, site analysis results, and resources with collaborators.

As the NEMC network continued to grow throughout the northeast US, researchers at Powdermill Nature Reserve, the environmental research center of the Carnegie Museum of Natural History, saw a need to centralize data collected by NEMC and other Motus station locations into a single dataset. Powdermill staff started by creating a feature service and web mapping application in ArcGIS Online that was shared with Willistown Conservation Trust and other collaborators.

This enabled edits to existing and potential Motus station sites. In addition, Powdermill staff created a publicly shared feature layer view and web map without editing capabilities. While this allowed greater control over Motus station data by each organization, existing data could still be shared with outside stakeholders and potential partners who might not have access to ArcGIS Online.

Centralizing Motus data in a shared feature service simplified geospatial analysis for regional planning, so Motus stations could be deployed strategically and efficiently. Since Motus station antennae require good line of sight to the horizon with minimal obstruction, viewshed tools in ArcGIS Pro help optimize antenna coverage to maximize the probability of nanotag detection.

ArcGIS provides several tools for analyzing viewsheds. The Geodesic Viewshed tool (formerly called Viewshed 2) in ArcGIS Pro was chosen for two reasons: its ability to input a vertical observer offset value to account for antenna height and the option to create an aboveground level raster to

↓ This Evening Grosbeak has a small, solar-powered nanotag made by Cellular Tracking Technologies affixed to its wing.

↑ By strategically installing Motus stations, researchers can create a fence line or grid that tracks nanotagged animals over time.

account for local topography and avian flyways.

To enhance the geospatial analysis planning workflow, Powdermill opted to use Python scripting and ArcPy to generate a custom script tool in ArcGIS Pro. The custom script tool digests new Motus data from the hosted feature service, performs several data management tasks, and outputs viewsheds classified by the required aboveground height for each new Motus feature in a 15 km radius.

With Python as the workflow's core, Powdermill could extend the customization and functionality of the script tool with other Python modules. For example, the Requests Python package automates the download of additional digital elevation models (DEMs) from US Geological Survey or Natural Resource Canada (NRCan), if they are needed by a new Motus station. Powdermill developed a robust geospatial tool that can be shared with other Motus researchers via an ArcGIS Pro project package.

A Keystone for Motus Research

Since implementation of the script tool, evaluation of potential station locations has resulted in more than 100 Motus station installations. The ArcGIS Online feature service web mapping application is used in semiweekly regional planning meetings for ongoing grants funding Motus work.

Using ArcGIS for data sharing and analysis has become mission critical for building the Motus network in the northeast US. Managing and sharing data on ArcGIS Online ensures simple and high-quality data collection. By analyzing Motus data in conjunction with other environmental and climatic variables, scientists can better understand why migratory birds are declining. This will improve habitat conservation and restoration efforts along migratory paths, and geospatial tools will continue to play a significant role in future research with Motus data.

For more information, contact Bryce Stouffer at stoufferb@carnegiemnh.org.

About the Authors

Jon Rice is the urban bird conservation coordinator at Carnegie Museum of Natural History.

James Whitacre is the chief of the GIS Services Division at the Pennsylvania Game Commission.

Bryce Stouffer is the GIS research scientist at Carnegie Museum of Natural History.

Seeing Data in Context Enables Better Decisions

The Kansas Water Office (KWO) adopted ArcGIS, which enabled the analysis, display, and clear communication of complex information about the state's water plan to its many stakeholders.

In devising strategic plans that sustainably and equitably manage and develop water resources, state water agencies must deal with the challenges of climate change, the increasing demands of human populations, and the depletion and degradation of ground and surface water stores.

KWO is a state-run agency that communicates, coordinates, and provides marketing resources to support the Kansas Water Plan. The statewide water plan is the primary source document developed by Kansas officials to address the availability of water supplies and plan for a sustainable future.

The plan's objectives include conserving and extending aquifer water levels, protecting reservoirs, improving overall water quality, reducing vulnerabilities to extreme weather events, and increasing awareness of water resource needs through public education. The plan is also used by residents, advocacy groups, and local governments to enhance awareness of water needs in the state.

> "We're able to provide a visual, interactive display that allows users to see a more complete picture to make more informed decisions."
>
> Katie Goff
> GIS Coordinator
> Kansas Water Office

Meeting the Needs of Many Stakeholders

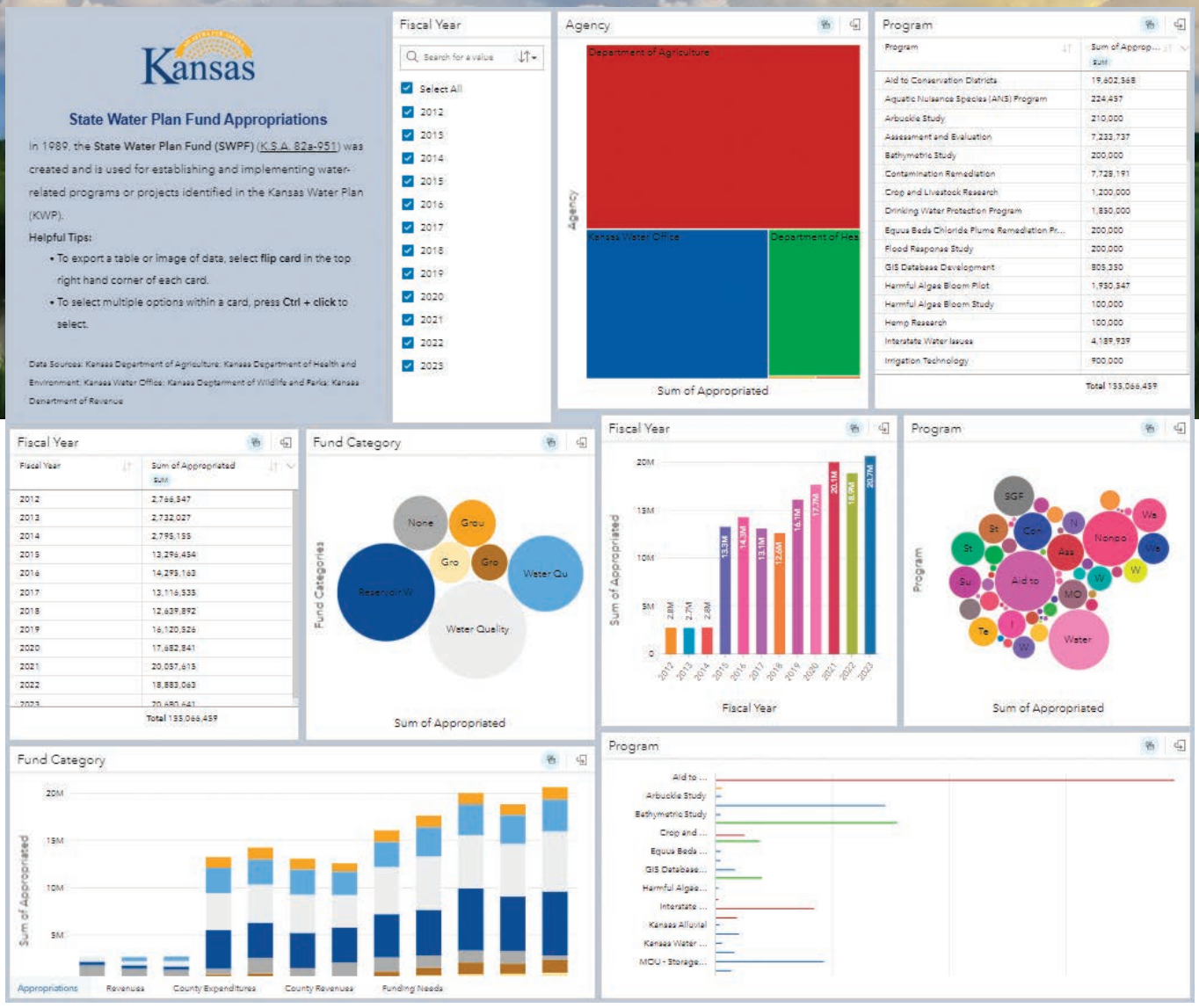
KWO has multiple stakeholder groups that need access to information at various levels of detail. The agency needed an efficient solution that would explain and easily display the State Water Plan Fund (SWPF), which is created to implement the state water plan.

Projects are funded by water user fees and general tax contributions to the state. Annually, funds are distributed to multiple state government agencies for projects including watershed dam construction, irrigation technology, basin management practices, water use studies, crop and livestock water research, water education, public water supply support, and flood response.

The distribution of funding is guided by considerations relating to conservation, sustainability, and education. Programs being considered for funding are reviewed by KWO and other state agencies involved in creating the annual budget. Then recommendations are made to the governor and state legislature to ensure that water policies and programs equitably address the unique needs of residents and supports the state's water resource goals.

Previously, KWO used spreadsheets and narrative reports to share this data, but this did not share the SWPF information in a meaningful and impactful way. For example, fully appreciating the current year's appropriations required seeing data for funded categories in the context of funding for those categories over recent fiscal years. That was difficult or impossible using those methods.

With the need for effective communication with stakeholder groups and the requirement to implement the state water



↑ The State Water Plan Fund Appropriations page, created using ArcGIS Insights, enables queries about allocations for multiple fiscal years.

plan in conjunction with the SWPF, leaders at KWO saw an opportunity to be innovative and efficient in their data sharing approach.

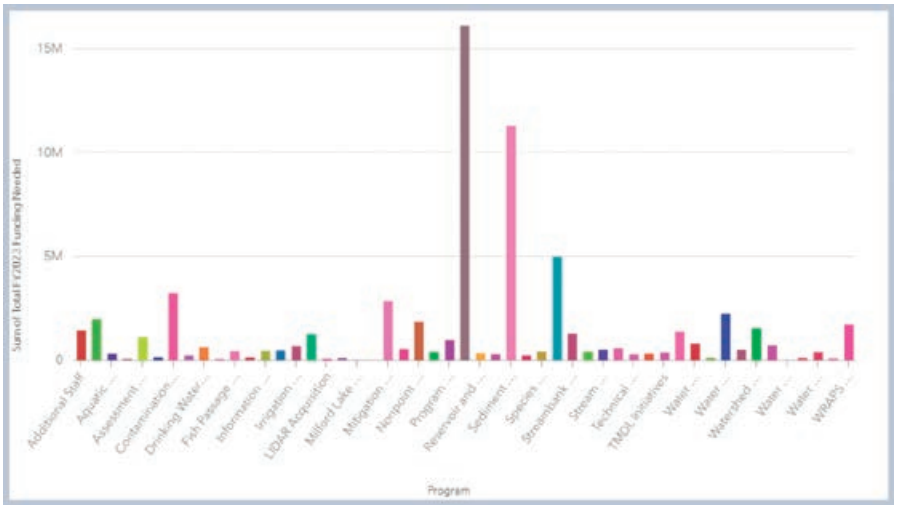
Interactively Providing Information

KWO realized a GIS solution could create efficiencies in its data sharing processes. The agency chose ArcGIS Insights, a self-service location analytics application that allows users to explore data and cross-filter results. With ArcGIS Insights, it was also easier for KWO staff members to provide stakeholders with more detailed information to answer specific questions.

KWO also uses GIS to show past areas of focus and identify the need for future funding requests. This leads to faster, better-informed budgetary decisions. Kansas residents can access the interactive charts, graphs, and tables to better understand and advocate for their needs. The data in those charts can be exported in a comma-separated value (CSV) file for further analysis. Using the data and tools in ArcGIS Knowledge, past public budget data can be analyzed, and project funding reviewed. The detail provided helps residents understand how specific water needs fit into budgetary decisions made by elected officials.

Making Water Data More Accessible

KWO has a lot of information to share, and it now has a simple way to do that using a single access point. A hub site (https://bit.ly/3DvlvTN), created using ArcGIS Hub, shares information about appropriations that are based on priorities in the Kansas



Water Plan and revenue generated from fees, fines, and fund transfers. This site also lets users interact with data using interactive graphs and charts and contains links to background information and relevant statutes before diving into the information.

"*[Using the ArcGIS Insights and the hub site]* regional planners have been conducting informational sessions to ask questions of stakeholders, and this information loop helps us to understand what is important to regional users through facilitated discussions. We are also more efficient by not replicating multiple regional static maps. With an easy upload of data, next year's fiscal data can be easily viewed," sais Katie Goff, GIS coordinator at KWO.

Building in time-saving measures for KWO staff has also streamlined communications with stakeholders. "Internal staff *[have]* found the solution incredibly helpful. When they are asked questions by residents or regional members, they now have a better understanding of the data. This helps facilitate better conversations and decision-making processes," Goff said.

↖ ArcGIS Insights displays allocations to each funding category for each fiscal year.

← Using the interactive display, residents can isolate specific categories to view more detailed information.

↙ Data charts also show funding needs for programs.

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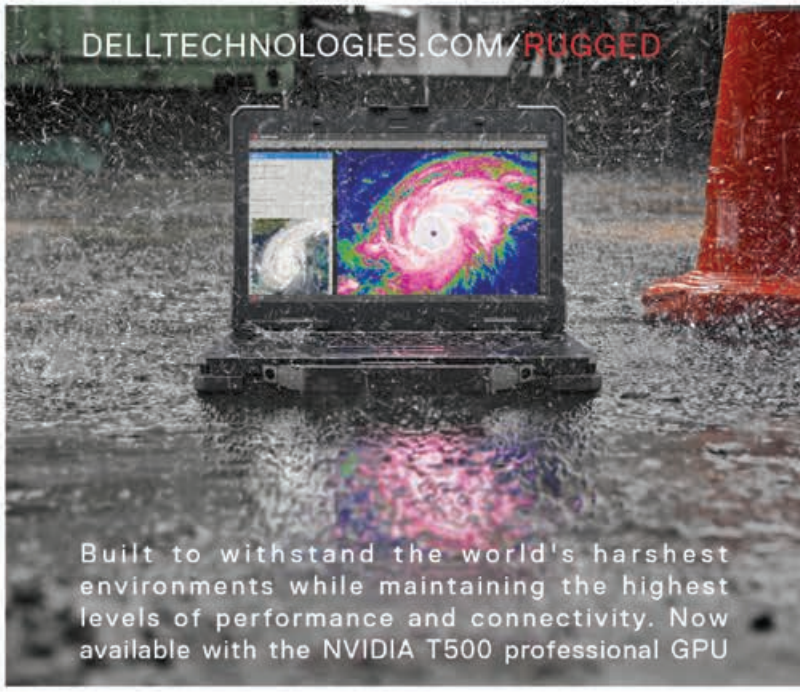

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[1]Based on IDC Quarterly Workstation Tracker, CY2021 (units)

3D MAPPING HELPS EPA PRESERVE FRESHWATER RESOURCES

The United States Environmental Protection Agency (EPA), which plays a critical role in protecting and improving water quality and making decisions regarding how water resources are used, is replacing paper-based maps and aerial photography prints with GIS and imagery.

The demands of climate change and population growth are affecting the lakes, rivers, streams, and underground aquifers that supply fresh water. Across the United States, communities of all sizes are facing the need for increased, sustainable access to freshwater resources. A 2014 report by the US Government Accountability Office, *Freshwater: Supply Concerns Continue, and Uncertainties Complicate Planning*, noted that water managers in 40 of 50 states expect shortages of fresh water to continue to increase in the next decade.

Although analog methods served EPA well in the past, they are no longer efficient and are being replaced with digital ones. EPA employs a variety of geospatial tools to complement its standard photogrammetry practices. Photogrammetry is the science of obtaining reliable measurements from photographs and digital imagery to produce products such as orthomosaic maps, GIS data layers, or 3D models of real-world objects.

EPA has established a unique, iterative process to develop information that supports enforcement of its cases. Once EPA embraced the power of remote sensing and digital mapping, it realized these tools can help with its investigations. GIS helps EPA answer questions about how wetlands have changed over time and understand the impacts of its decisions on commerce.

Bringing Orthomapping and Digital Maps Together

EPA recently began exploring the use of orthomapping in ArcGIS Pro. More advanced image analysis capabilities, provided by the Esri orthomapping suite, are available in the ArcGIS Image Analyst extension.

With orthomapping, historical information augments current data to make better decisions that support EPA's work enforcing the Clean Water Act (CWA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA provides federal funding to clean up uncontrolled or abandoned hazardous-waste sites.

Orthomapping capabilities in ArcGIS Pro

provide critical support for EPA studies by accurately placing raw historical photos into the same view with existing datasets and maps. Before transitioning to ArcGIS Pro, paper maps and photographic transparencies were viewed on a light table with traditional optical devices. It was a slow and tedious process that involved manually positioning film or prints that could easily get out of alignment.

Changes over Time

Peter Stokely has worked as an environmental scientist at EPA for more than 30 years. His work for the EPA water enforcement division in Washington, DC, has focused on using imagery analysis and GIS to provide accurate analyses of water resource sites.

"My focus has been *[on]* helping compile the facts to support enforcement cases for Section 404 of the Clean Water Act, which is the part that protects our nation's wetlands and streams and rivers from being filled with solid material. We are working to protect the environment," said Stokely.

Stokely uses GIS and photogrammetry to support advanced spatial analytics. He looks at current and historical imagery to digitize changes over time. His work helps answer critical questions about the location of wetlands under federal jurisdiction and whether those lands are being managed in compliance with the law. His work combines imagery and mapping with field data.

Historical imagery is useful for more than understanding landscapes. It helps in evaluating the historical impacts to a local water resource. This imagery is necessary when studying a property that is subject to pollution to determine the source and timing of contamination and provides the EPA with context for Clean Water Act enforcement. Asking critical questions about an area's past can help guide decisions and identify possible future implications.

"You can make a lot of interpretive mistakes by just viewing two-dimensional imagery," Stokely said. "ArcGIS provides the ability to incorporate other geospatial data layers, such as contour lines and digital elevation models, to inform imagery interpretation. With orthomapping, the ability to view and pan around three-dimensional images on a computer screen is amazing. You know how crisp the imagery can be and then how the three-dimensional image can be so realistic."

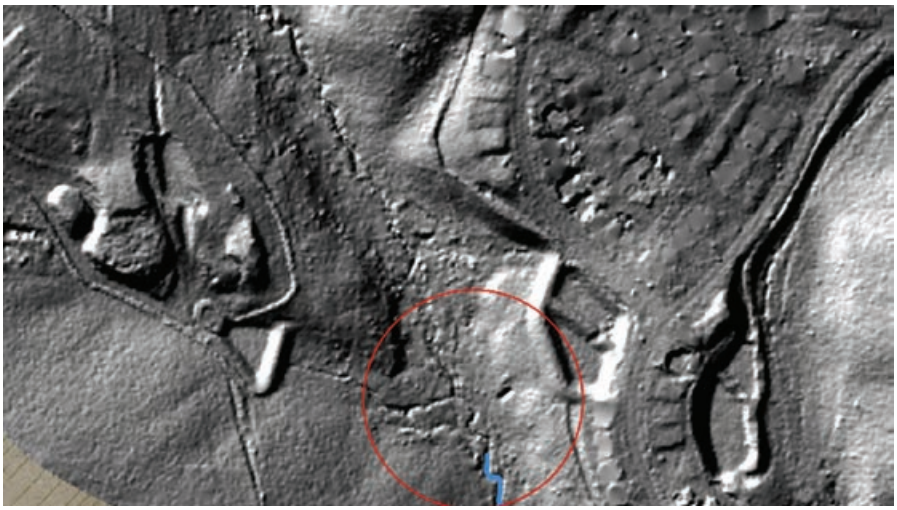
Making Decisions in 3D Context

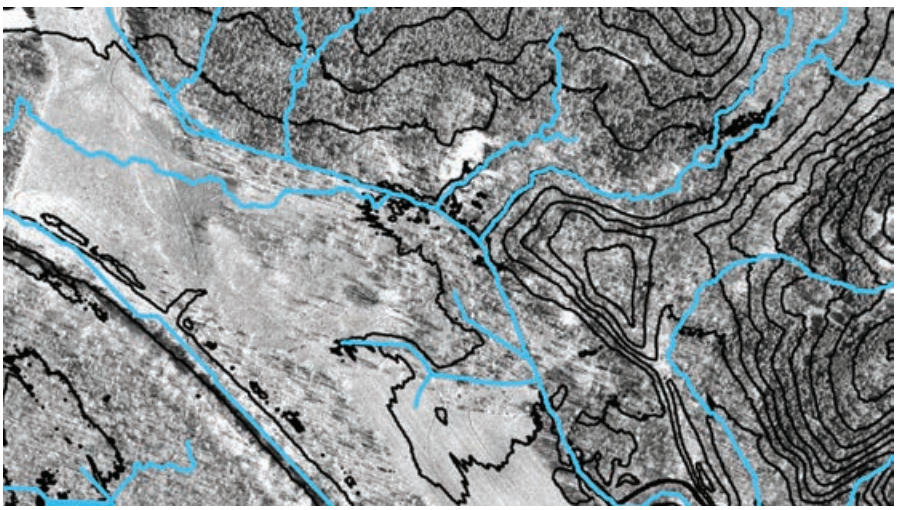
In addition to producing more accurate images that are faster to review, aerial photography in a 3D format helps decision-makers see original imagery in a mapping context and identify relevant facts about authenticity.

Updated digital maps enhance but do not replace historical data. They create a new level of rigor and analysis. Compiling detailed information about a specific site for one or many time periods can be critical to understanding and documenting the site's current state and guide decisions about its future.

In the future, there will likely be continued enforcement actions under CWA. In addition, there is an increasing need to understand the impacts of climate change and human activities on natural landscapes. ArcGIS Pro provides EPA with GIS capabilities in a powerful, single desktop application that supports data visualization, analysis, and authoritative data maintenance.

Stokely believes that there are more applications for GIS in the future. "There are still things to discover in historical imagery about past pollution events where three-dimensional viewing is helpful," Stokely said.





↖ USGS stream data (blue line) is compared with stream channel characteristics expressed by hillshade elevation data derived from lidar.

↙ Contours and stream network data that was derived from digital elevation data using ArcGIS Pro tools is overlaid on historical aerial photography.

GIS Governance Distilled

By Matthew Lewin

Governance is among the primary levers used by GIS managers in their never-ending quest to improve the quality of geospatial data, content, and solutions provided to their organizations.

GIS governance offers a formal structure for making and managing decisions about the long-term direction of a geospatial program and a mechanism to handle the day-to-day issues that inevitably arise when managing a complex enterprise system. When done well, governance empowers managers with the oversight and authority required to ensure their organization's geospatial program meets its mandate.

Over the past several years, my colleagues at Esri Canada and I have worked with various organizations on their geospatial governance models—including local and regional government agencies and organizations from heavy industry and the private sector. The lessons from those engagements have proved invaluable in helping us formulate and refine our thinking on the topic. We've taken steps to synthesize this knowledge into frameworks that help others with their governance endeavors. I'm confident that these efforts have helped bring greater awareness to the topic of governance and its relevance to the geospatial industry.

However, despite those efforts—or perhaps because of them—governance remains a difficult topic. Conceptually, governance is challenging because of the complexity and sheer scope of processes to consider when attempting to devise an appropriate governance model. In practice, it's even more difficult because those with a stake in the geospatial program must be aligned and agreeable whether they are stakeholders in data or systems ownership or in the long-term direction of the program itself.

Studies have shown that organizations often leave geospatial governance to other domains like IT governance (if they do it at all). However—for better or worse—you need geospatial governance. A geospatial program of any significant size, at some point, will need clarity about who has rights to what and who makes those decisions. The trick is to figure out what aspects of your program to focus on and which controls you need to implement.

To help make this process easier, we've taken our previous frameworks and put together a simplified version that distills geogovernance into a set of generalized components. The goal is to provide a tool that helps you identify what you're missing and where you need to focus on to develop a governance model that works for you.

The framework covers six foundational domains, each representing a defining aspect of your geospatial program. These are areas requiring focused attention and careful decision-making. I've discussed these domains at length in previous articles. In summary, these domains cover areas, as categorized in Table 1, that relate to direction setting and funding (Strategy and Investment), geospatial technology and content (Technology and Data), and services and human resources (Delivery and Workforce).

The purpose of your governance model is to establish a sufficient level of oversight across each domain to ensure your geospatial program reaches its objectives. That means determining who is accountable for the critical decisions across each domain and the controls, processes, and measures that create the desired system of control. In our framework, this system of control is divided into four major components: structure, controls, processes, and performance.

Structure

The structure of your governance model determines the division of authority across each of the six domains. The purpose is to assign oversight responsibilities to individuals and teams that have the primary stake in that domain. Usually, no single person has authority over a specific domain, so the decision structure typically manifests as a network of committees, subcommittees, and working groups. The trick is figuring out the right mix of stakeholders to serve on the committees in a way that creates oversight but also respects your organization's decision-making style and culture.

In the framework, we've identified a selection of governance roles and committees that organizations routinely implement. It's not an exhaustive list or the only way to structure your governance model by any means, but it serves as a common starting point. In practice, you'd assign individuals to roles and create groups that

Geospatial Governance Framework

Roles, processes and control mechanisms used by organizations to govern geospatial programs

Governance Component	Strategy Direction and approach	Technology Apps and infrastructure	Data Content and maps	Delivery Services and operations	Workforce People and skills	Investment Budget and resources
Structure Roles, committees and division of authority	• Strategy owner • Executive sponsor • Program steering committee • Innovation sub-committee	• Application owners • Portfolio owners • Vendor representatives • Technology sub-committee	• Data owners • Data stewards • Data custodians • Data sub-committee	• Service line owners • Project owners • Services sub-committee	• Practice leads • Partner representatives • Community of practice	• Budget owners • Project portfolio sub-committee • Budget approval board
Controls Policies, procedures, standards, plans and guidelines	• Geospatial vision • Guiding principles • Geospatial strategic plan • Governance charter • Stakeholder matrix	• Target architecture • Integration standards • Technical Roadmap • Security policy • Upgrade principles	• Spatial data inventory • Data lifecycle plan • Cartographic standards • Metadata standards • Open data guidelines • Access and usage policy • Privacy policy	• Service catalogue • Service level agreements • Operational agreements • Project charters • Business continuity plan • Communication protocol	• Professional development guidelines • Geospatial skills matrix • Recruitment plan • Succession plan • Role definitions	• Business case template • Benefits register • Project prioritization framework
Processes Management activities and administrative functions	• Long-range planning • Strategic communications • Risk mitigation • Approval processes	• Business capability mapping • Access approvals • Architectural approvals • Upgrade process	• Data publishing • Data collection • Quality control • Data model management	• Service request process • Project forecast • Project health checks • Project status reporting • Change management plan • Maintenance calendar • Service communications	• Performance reviews • Mentorship process • Talent outreach	• Budgeting process • Funding approval process • Out of budget review process
Performance Measures and monitoring systems	• Goal achievement • Stakeholder engagement • Benefits realization • Business/IT alignment • Strategic goal dashboard	• Security compliance • Solution availability • Unplanned incidents • Adoption rate • Capabilities supported • Total cost of ownership • Technology performance dashboard	• Standards compliance • Confidence in data • Data in use • Open data distribution • Defined stewards & custodians • Data performance dashboard	• Project delivery time • Service delivery time • Service level compliance • Service satisfaction • Service performance dashboard	• Training completed • Skills competency • Partner effectiveness • Staff satisfaction • Workforce performance dashboard	• Annual investment • Project return on investment • Innovation spend • Benefits realized • Investment dashboard

↑ Table 1: Geospatial Governance Framework: Roles, processes, and control mechanisms are used by organizations to govern geospatial programs.

align with your situation. But in all cases, your job is to identify the critical roles; outline the responsibilities and key decision rights for each role; arrange roles into groups; define a group-level mandate; and articulate the relationships and interdependencies among the groups.

Controls

Decisions made by stakeholders are typically compiled into documents that formalize governance decisions into standard practice. This includes policies, procedures, strategic plans, standards, and operating guidelines. These controlling artifacts enshrine key decisions into an agreed-upon set of rules and regulations that govern day-to-day operations as well as plans. The intention is to encourage behavior among people and systems involved in your geospatial program that aligns with your program's objectives.

Examples of controls for the strategy and investment domains include strategic plans, governance charters, and project prioritization frameworks. On the technology and data side, there are reference technology architectures, data usage policies, and cartographic standards. Possible governance controls for the workforce and services domains include a geospatial skills matrix, mentorship guidelines, service catalogs, and service-level agreements. Your governance controls form an operational bounding box within which your geospatial program functions.

Processes

Governance is an ongoing activity, so having clearly defined processes is essential to ensuring your program remains a going concern. For geospatial programs, we're primarily concerned with domain-specific processes that maintain and enforce matters like system performance, spatial data integrity, and service quality, as well as processes that cut across multiple domains for things like change communication and issue escalation.

Typically, organizations initially focus on efforts that smooth out their decision-making process. This often involves processes for recommending and approving new solutions or technology investments. These kinds of processes help overcome issues related to funding decisions. Beyond this, many organizations focus on establishing methods for dealing with critical service disruptions. For example, a midsize city organization we worked with developed a process to provide manual backfill support when its

Geospatial Governance Framework: Maturity Scorecard

Use the governance framework to assess the maturity of your organization's geospatial governance capabilities and plan targeted improvements

Governance Component	Strategy Direction and approach	Technology Apps and infrastructure	Data Content and maps	Delivery Services and operations	Workforce People and skills	Investment Budget and resources
Structure Roles, committees and division of authority	● Strategy owner ● Executive sponsor ● Program steering committee • Innovation sub-committee	● Application owners • Portfolio owners • Vendor representatives ● Technology sub-committee	● Data owners ● Data stewards ● Data custodians ● Data sub-committee	• Service line owners ● Project owners ● Services sub-committee	• Practice leads • Partner representatives ● Community of practice	● Budget owners ● Project portfolio sub-committee ● Budget approval board
Controls Policies, procedures, standards, plans and guidelines	● Geospatial vision • Guiding principles ● Geospatial strategic plan ● Governance charter • Stakeholder matrix	• Target architecture • Integration standards ● Technical Roadmap ● Security policy ● Upgrade principles	● Spatial data inventory • Data lifecycle plan ● Cartographic standards ● Metadata standards • Open data guidelines ● Access and usage policy • Privacy policy	● Service catalogue • Service level agreements • Operational agreements ● Project charters • Business continuity plan ● Communication protocol	● Professional development guidelines ● Geospatial skills matrix • Recruitment plan • Succession plan • Role definitions	• Business case template ● Benefits register ● Project prioritization framework
Processes Management activities and administrative functions	● Long-range planning • Strategic communications ● Risk mitigation • Approval processes	• Business capability mapping ● Access approvals • Architectural approvals ● Upgrade process	• Data publishing ● Data collection ● Quality control • Data model management	● Service request process • Project forecast ● Project health checks • Project status reporting ● Change management plan • Maintenance calendar • Service communications	● Performance reviews • Mentorship process ● Talent outreach	● Budgeting process ● Funding approval process ● Out of budget review process
Performance Measures and monitoring systems	● Goal achievement ● Stakeholder engagement • Benefits realization • Business/IT alignment ● Strategic goal dashboard	● Security compliance • Solution availability • Unplanned incidents ● Adoption rate ● Capabilities supported ● Total cost of ownership • Technology performance dashboard	● Standards compliance • Confidence in data ● Data usage • Open data distribution ● Defined stewards & custodians ● Data performance dashboard	● Project delivery time • Service delivery time • Service level compliance ● Service satisfaction ● Service performance dashboard	● Training completed • Skills competency • Partner effectiveness ● Staff satisfaction • Workforce performance dashboard	● Annual investment • Project return on investment • Innovation spend ● Benefits realized • Investment dashboard

● Well-defined, effectively implemented
● Partially defined, moderate implementation
● Poorly defined, limited implementation

↑ Table 2: Use the Geospatial Governance Framework as a way to score your organization's maturity and performance.

mapping platform failed to meet uptime requirements. This is a nice example of a process that supports a control (uptime standard) implemented through the governance structure.

Keep in mind, a governance process is different from a functional workflow. A workflow simply illustrates steps to complete a task. For example, you might define a workflow for publishing a new production map to an external corporate site. If there are steps in the process that enforce rules defined via the governance controls, then this could be construed as an important governance process. But if it's just about describing a series of steps to make it easier for people to complete a task, then I'd classify this as more of a functional workflow than a critical governance process.

Performance

The purpose of your governance model is to ensure your geospatial investment delivers business results. That means that users and stakeholders derive real value from the solutions and services offered through your program, and the constraints of risk and resource utilization are understood and well-managed. In short, governance is about performance. How will you know if your geospatial program is delivering acceptable performance? You need to measure it.

The key here is to select performance indicators that demonstrate that your governance controls are working. An example of a strategic performance measure could be the percentage of funded projects that are aligned with the geospatial program's strategic objectives. Platform access measures might consist of the number of users accessing a particular solution or map service. A data stewardship measure could be the percentage of data assets with an identified owner. The point is, the metrics you select indicate your geospatial program's performance against a specified standard.

I'd also include systems you use to track and monitor performance measures as part of this governance component. The City of Calgary, for example, developed a dashboard to monitor system health of the city's geospatial environment. The dashboard tracks metrics like service availability and database access requests and serves as an excellent governance tool for tracking platform technical performance. You can create dashboards such as this to track any performance measure, whether technical or nontechnical.

Using the Governance Framework

To use the framework, don't attempt to tackle every item in the list. Instead, use it as a simple scorecard to help you prioritize your program's most important governance items; consider the maturity of each item; and develop a plan to address the gaps.

Prioritize

Look at the six governance domains and decide which of these areas are a priority for you. Usually, these are the areas of greatest concern or areas in which you have a significant, potentially disruptive issue. Narrow the list down to the top one or two domains that will serve as a starting point.

From my experience, most organizations start by focusing on data governance. Many focus particularly on establishing controls concerning data usage and quality. Other organizations sprinkle in some aspects of strategy and investment governance, such as establishing a strategic plan and formalizing funding guidelines.

Once you've sorted out your focus areas, run through the four governance component categories (i.e., Structure, Controls, Processes, and Performance) and flag the components you currently have in place and the components you're missing that you feel are acutely needed. This will tease out the critical pieces of the framework that will be the basis of your initial governance model.

Evaluate

The next step is to consider the relative maturity of each priority governance component. You don't need to develop a rigorous maturity scale to do this. All you're doing is identifying areas of strength and weakness. Table 2 shows an example of a scorecard that rates maturity using red, yellow, and green dots. The areas with red dots are key. These are components with a low level of control that may lack set decision rights and may have ad hoc processes and limited performance measures. Addressing these gaps is the highest priority.

Plan

Once you've completed the evaluation, you build out your action plan. Usually, this is done by packaging similar governance components into projects that you execute sequentially. Most organizations start with structural components first. There's often a significant amount of interdependency between the roles and committees involved in your decision structure, so a single project to establish an overall working structure is a prudent starting point.

After that, focus on higher risk controls or processes. This could include the development of data security or privacy policies or escalation processes for resolving disputes over data or application access. Finally, develop performance metrics and implement performance monitoring systems to instantiate measurable management within your governance model.

Governance is a complex and multilayered topic. It is too broad to be covered by a single article. However, the intention of this distilled Geospatial Governance Framework is to provide you with a starting point for establishing key components of your geospatial program's governance model. Work through the framework systematically, and don't be afraid to augment the framework by adding your own controls or processes.

The author thanks Allen Williams, senior management consultant at Esri Canada, for his valuable contributions to the governance framework.

Resources

- "Implementing governance for GIS (Part 1): Design Approach" https://bit.ly/3OheecS
- "Implementing governance for GIS (Part 2): Structure and processes" https://bit.ly/3HIc2bX
- "7 practical steps for improving your organization's spatial data governance" https://bit.ly/3ncltqo

About the Author

Matthew Lewin is the director 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.

Work through the framework systematically, and don't be afraid to augment it with your own controls or processes.

Data-Driven Zoning Reform

By Keith Cooke

One of the fastest-emerging trends among community planners is zoning reform. This has been gathering momentum for the last three to five years. Three federal funding vehicles have been proposed to primarily fund this initiative. There are several reasons why zoning reform has quickly moved to the forefront of priorities for hundreds of counties.

The Need for Zoning Reform

It all starts with the fact that many zoning codes are antiquated. They were initially developed several decades ago to meet the needs of residents. At that time, many counties may have made patchwork changes, such as adjustments to floor area ratio; increases in setbacks and the proximity of development to wetlands; and changes made to fit demands from residents, administrators, and developers. But these were only temporary fixes and didn't address the need for reforming codes to meet modern expectations of residents.

Consequently, this makes it difficult (at best) for counties to provide the kinds of housing options that existing and prospective residents need. Single-family housing was in greater demand in the 1970s and '80s than it is today because the size of the average household has been decreasing. Many residents, particularly those who are young and single, either aren't looking for or cannot afford these types of homes and would prefer more walkable communities with denser concentrations of housing and better access to stores, restaurants, and transit.

Finally, dated ordinances with restrictions on newer types of housing directly impact housing affordability, as has already been seen in communities of all sizes across the United States. These ordinances severely limit housing options for low- and middle-income households and, by extension, adversely affect economic mobility. People who cannot live close to their work or the services they need may be forced to move farther away to afford housing. This, in turn, increases commuter traffic and limits opportunities for economic growth.

Geographic Approach to Zoning Reform

There is little doubt that changing development parameters is going to be a sensitive topic for residents, developers, and county leaders, so zoning reform requires a data-driven approach. It will be essential for planning professionals and county leaders to embrace a geographic approach to zoning, which includes understanding neighborhood characteristics.

The main drivers for neighborhood zoning reform have changed over the last several decades. Consequently, having a detailed understanding of the current characteristics of these neighborhoods is essential.

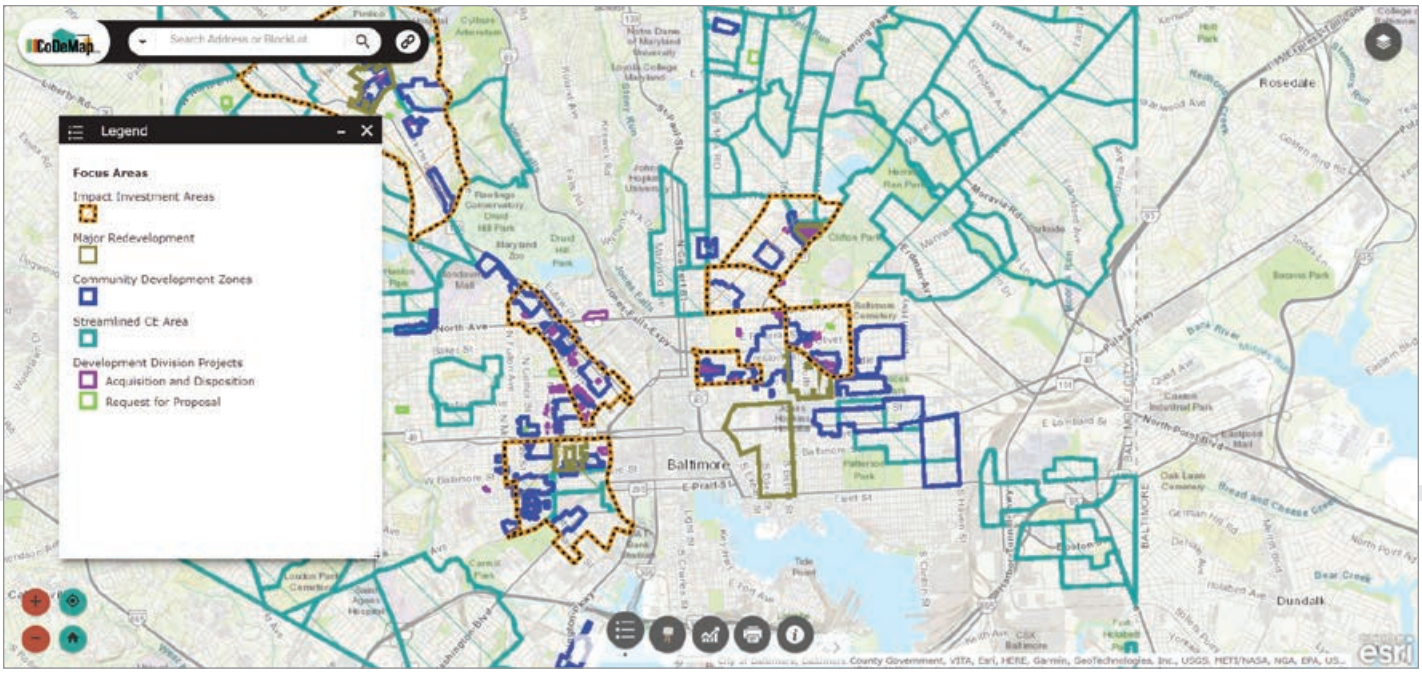
ArcGIS Business Analyst Web App provides access to about 2,000 demographic, socioeconomic, workforce, and business variables that deliver detailed insight into the characteristics, market trends, and needs of neighborhoods down to the block group level.

Deriving intelligence from business systems can benefit zoning reform. Nearly every county leverages one or more business systems to record and monitor developments, most often a permitting system. While not everyone in a county directly uses this system, planners and county administrators need at least an overview of the data that it holds.

ArcGIS Insights generates business intelligence from existing community development systems, such as permitting systems, to identify trends and patterns in development over time to show where the greatest need for reform exists. ArcGIS Insights acts as a complement to—not a replacement for— these systems.

Leaders in county government are expected to create, promote, and drive sustainable zoning and development policies that benefit their residents by meeting their needs. More than ever, this requires a data-driven approach. Sometimes knowing where to start for this process can be challenging in and of itself.

A free resource in ArcGIS Living Atlas of the World, *Esri Maps for Public Policy*



↑ Staff at Baltimore's Department of Housing and Community Development (DHCD) built CoDeMap, a mapping application that visualizes and analyzes housing needs in the city, neighborhood by neighborhood.

(https://livingatlas.arcgis.com/policy/overview/), includes curated content focused on policy initiatives, such as housing, economic mobility, and disadvantaged neighborhoods.

Zoning reform is likely to spawn some heated debate. You need to be sure that all your residents have a way to learn and provide feedback about proposed zoning changes is more essential than ever. Simply relying on public hearings and town hall meetings to provide civic inclusion won't create the inclusivity and feedback that leaders need.

ArcGIS Hub opens the door to all residents and stakeholders so that they will be better informed about specific initiatives. It can also provide direct feedback about plans, using maps, surveys, and videos.

Empowering Scenario Planning and Design

The geographic approach to zoning reform will require creating, analyzing, and comparing multiple scenarios. In the past, this would have required costly outsourcing to a consulting firm. Today, planners can use GIS to create and measure these scenarios to find the optimal zoning changes down to a fine level of detail, including setbacks, building height, dwelling unit density, and housing affordability.

ArcGIS Urban is a web-based tool that enables planners to play out different scenarios for proposed zoning changes. Planners can instantly see the potential impact of a zoning change, including changes in population, increases in jobs, effects on traffic and utilities, and financial impacts. These plans can be compared with others to identify the path forward that best meets the needs of the community.

Reforming a zoning ordinance can be a daunting, time-consuming task. GIS provides the essential tools that planners, residents, and county leaders need to take a data-driven approach to zoning and create a more sustainable, equitable, and thriving county.

About the Author

Keith Cooke is the global industry manager for community development at Esri. A graduate of Auburn University, he has been a GIS professional since 1994 and has worked for planning and community development agencies at the regional and municipal levels in Alabama and North Carolina. Prior to this role, he was an account executive at Esri for 15 years, working with more than 100 local governments.

A Comprehensive Approach to *GIS Management*

The GIS Management Handbook, Third Edition, by Peter L. Croswell, provides specific practical advice that can help GIS managers be more successful.

This book reflects how the use of GIS has expanded since it was developed in the late 1960s for managing projects. As GIS and IT have evolved, the scope of GIS has also grown to encompass the management of programs and portfolios of programs. The range of topics handled in the book also goes beyond simply technical ones and tackles organizational structure and governance, human resources, financial management, legal and contract issues, and operations and service delivery.

Although GIS management professionals are the obvious target audience for this book, it is also valuable for senior executives and policy makers who oversee GIS programs; IT personnel involved in GIS integration and the coordination of GIS with overall IT programs; and those who teach and are studying GIS management at the university level.

This book has a wider audience than typical GIS management books because it addresses not just management issues that are common to GIS but also those problems common to other types of IT systems in a variety of organizations. It differs from more generic management books in that topics are approached from a GIS perspective and offers strategies and approaches that address the specific challenges GIS managers face.

A unique strength of this book is that it includes access to supplemental digital files that are real-world examples of agreements, evaluations, plans, and other materials from more than 130 organizations.

First published in 2009, this third edition of *The GIS Management Handbook* has been updated to reflect changes not only in GIS and IT technology but also the evolution of management methodologies and the increase in the resources available to support GIS implementation. This edition includes references to books, papers, websites, and other resources that will be useful to GIS managers.

Dr. John Morgan, assistant professor of GIS at the University of West Florida, recommends its use as a text for university courses on GIS management. Morgan said, "As an academic, *The GIS Management Handbook* is the best textbook I have found on the topic."

With the third edition, *The GIS Management Handbook* is available in Spanish. More than a simple translation from English to Spanish, this edition cites GIS sources and programs in Spain and Latin America and has numerous bibliographic additions for Spanish-language references and publications.

The author, Peter Croswell, has more than 40 years of experience in IT and GIS and has worked on GIS planning and implementation projects throughout North America and in Europe, Asia, the Caribbean region, and the Middle East. Croswell is a certified project management professional (PMP), an American Society for Photogrammetry and remote sensing (ASPRS) certified mapping scientist, and a GIS professional (GISP). A former board member and president of URISA, he has authored several books and numerous professional papers and publications. He is the president of Croswell-Schulte Information Technology Consultants, a firm specializing in GIS and IT assessment, planning, design, and management support.

This book is published by Kessey Dewitt Publications in association with URISA, and is available in print and digital editions.

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Five Reasons Every Data Science Team Needs a Geographer

By Lauren Bennett and Trisalyn Nelson

The authors, Lauren Bennett and Trisalyn Nelson, are both trained geographers. Bennett is the program manager for spatial analysis and data science at Esri. Nelson holds the Jack and Laura Dangermond Endowed Chair of Geography at the University of California, Santa Barbara. The authors combine their perspectives from industry and academia to consider the role of geography and GIS in data science. They hope that data scientists and geographers alike will gain perspectives about the unique contributions a geographic approach brings to the field of data science.

There is little doubt we are in the age of data science. While there was a time when saying we studied spatial statistics made us unpopular party guests, today being a spatial data scientist carries cachet. People are interested. There is an intuitive understanding that society is generating massive amounts of data that—in the right hands—has power.

Recently, we were panelists for a spatial data science webinar. An audience member asked us to comment if GIS was still relevant in the age of data science. Another asked if data science should be taught in geography programs or left to computer science and statistics programs. We found these questions both surprising and not surprising.

Despite the success of GIS, geographers wrestle with their identities. This makes sense. Geography can be difficult to define. In many ways, geography is everywhere—in our cars and smartphones and in the media we consume. If it is all around us, what makes geography—and geographers—special? How many times have we explained we are not geologists or been diminished as scientists because don't all the rivers already have names?

As both geographers and spatial data scientists, we have wrestled with our identities. Our skill sets sit at the intersection of a Venn diagram of the fields of geography, statistics, and computer science. When we are struggling with spatial analyses and our code keeps crashing, it is easy to wonder why we didn't learn more computer science. We can envy the deep skills of colleagues in computer science and statistics. Yet, as we have advanced in our careers, our geographic training has been a powerful asset.

Geographers are trained in interdisciplinary thinking. They are trained to identify questions and pose solutions. In addition to bringing a spatial perspective to data science, they also bring the ability to link methods and solutions to applications. They are the people who connect all the threads, using geography's interdisciplinary approach to link problems to solutions and data science to decisions.

Interestingly, we have found the benefits of our geographic training have amplified over the course of our careers. As we have moved into roles leading teams, our geographer's secret sauce has been critical in helping us accelerate science and pose solutions to pressing environmental and societal problems. This article highlights five reasons why data science teams should include a geographer.

1 Data science is (mostly) spatial science.

The current era of big data is an era of big spatial data. Eighty percent of big data is spatial. It contains geographic coordinates that can be mapped, according to *Big spatial data for urban and environmental sustainability*, a 2020 paper by Bo Huang and Jionghua Wang.

The importance of spatial data is evidenced by the growing prevalence of maps in every form of communication, from media outlets to public health briefings to social media. The spatial dimension of data provides additional information on how phenomena vary across space and relate to location.

This means that if you're analyzing data, you could already be doing spatial data science. If you're not already taking advantage of the spatial characteristics of your data, you may be missing key information. But to take advantage of spatial information, you need to treat your data right.

If you are not a geographer, you should call one before you dig into the time-consuming, persnickety task of data formatting to make sure you are handling the spatial aspects of the data correctly. Geographers can make informed decisions about whether to use raster or vector representations and which resolution, extents, and spatial units to employ.

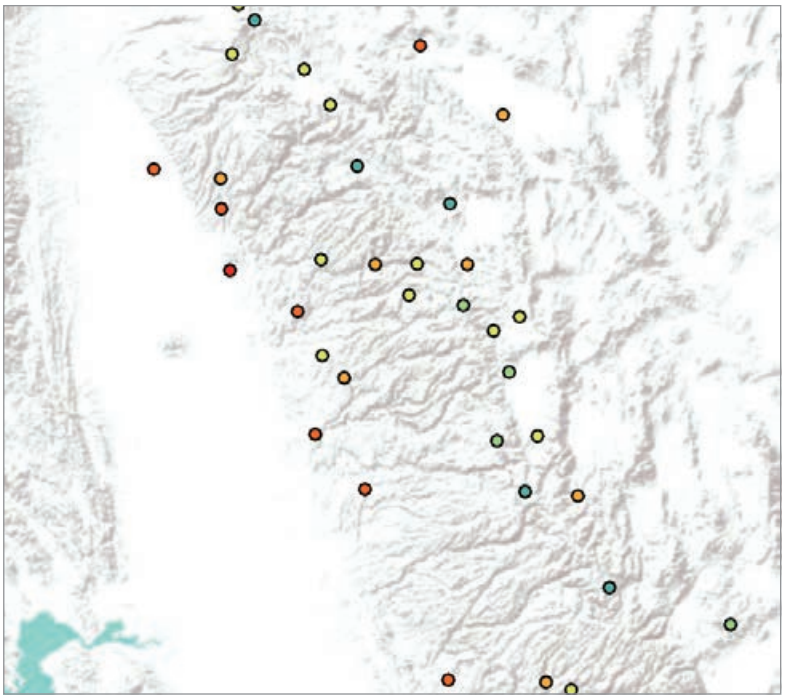
2 Spatial relationships can inexpensively provide information.

Mapping data can yield useful information that is hidden in spatial relationships. By leveraging Waldo Tobler's first law of geography, "All things are related and near things are more related than distant things," geographers can use spatial queries and analysis to uncover gems of information buried in the data.

Temperature Readings

Field: Add Calculate Selecti

	OBJECTID *	Shape *	temperature
1	2	Point Z	99
2	3	Point Z	96
3	4	Point Z	94
4	5	Point Z	95
5	6	Point Z	83
6	9	Point Z	92
7	10	Point Z	96
8	11	Point Z	82
9	14	Point Z	76
10	15	Point Z	82
11	16	Point Z	83
12	17	Point Z	89
13	18	Point Z	80
14	20	Point Z	87
15	22	Point Z	90
16	24	Point Z	95



←← These sampled temperature values in a table provide limited information.

← Mapping the same temperature values based on where samples were acquired and symbolizing by temperature range provides more context, but GIS tools can provide more information.

As trained sleuths, geographers can uncover spatial relationships to better understand natural and human processes. Predictive models can pull in hundreds, if not thousands, of variables to try to make sense of complex phenomena but ignore the value that spatial relationships can bring to the table. Often those relationships incorporate the characteristics of places that are difficult to measure or quantify but can dramatically improve models. For example, if you are modeling data at the ZIP code level in your state, you know that ZIP codes that are closer together are more related than ZIP codes that are more distant from each other.

Geographers can model this simple truth and it will pay huge dividends. For a model that ignores geography and is given enough data, a relationship between two nearby ZIP codes may be uncovered based on their similarity. Including spatial relationships can cut down on the number of variables required and still get to the same conclusion more quickly and efficiently. Data can be expensive to purchase or time-consuming to organize. Often models can be improved when reality is more accurately represented. Why not include a geographer to make the most of your spatial information?

3 Geographers know how to communicate with maps.

There are few tools as effective as maps at communicating complex concepts in tangible, approachable ways. Maps can make even the most abstract academic concept evident and illustrate its importance. For example, it's much harder to ignore the results of analysis if they show your house will be directly affected.

However, it is easy to make cartographic mistakes, intentionally or unintentionally. Books have been written about how to lie with maps. If you don't produce correct results from your analysis, it can mean losing money or resources or credibility. Sometimes, it can even be a matter of life or death.

You might want to call a geographer if you want to display your results on a map. Better yet, get help from a geographer who specializes in the art and science of mapmaking: a cartographer. While anyone can display data on a map, a cartographer is trained in map communication and will help you communicate the right message, using appropriate colors, shades, symbols, labels, and scales. ArcGIS Dashboards and ArcGIS StoryMaps can bring your maps and message to life.

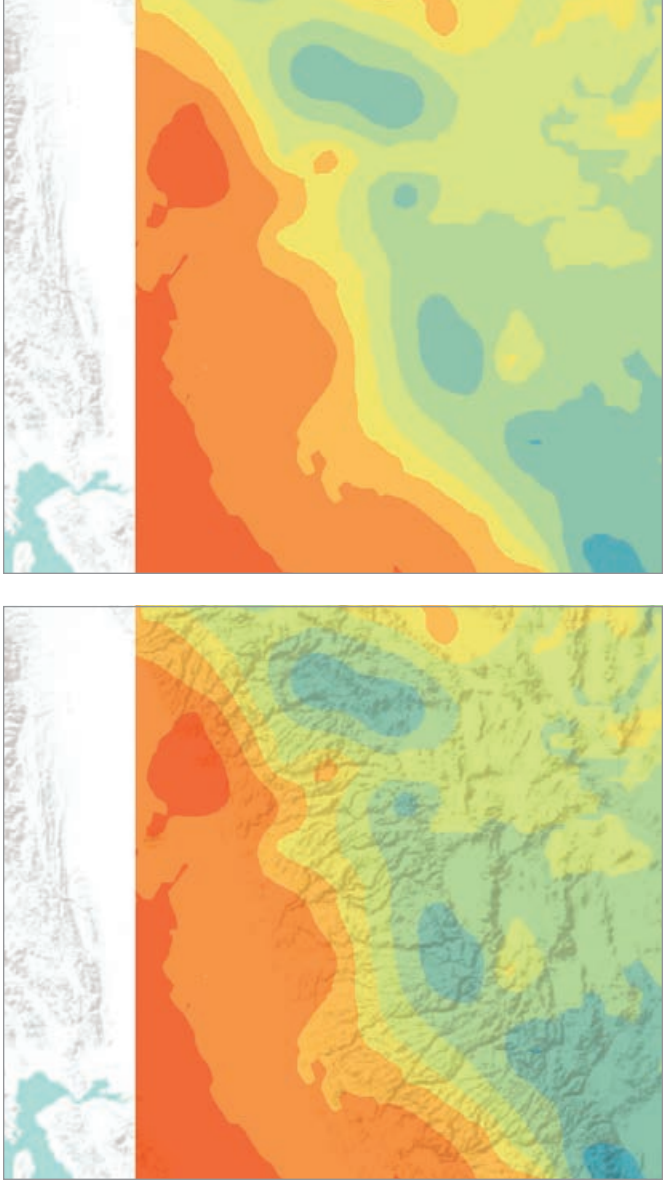
4 Geographers link science to the real world.

While data science seems to be resonating broadly with society, there is a growing subset of society that does not trust science. Effective scientific communication is critical as more decisions are made using the results of increasingly complex algorithms.

Communication needs to reach even those who are unfamiliar with data science. Because data analytics is used to manipulate perspectives and increase sales as well as create knowledge, the public can be suspicious when the same methods are used to do things that are ethically questionable or just plain wrong.

Geographers have a critical role in science communication because they are trained in linking science to real-world problems. They know how to work with data, but they also understand the nuances of the phenomena that are represented by the data.

Geographers can make a good analysis great by adding the



↑↑ Using geostatistical tools to interpolate a surface from the temperature values and relate them spatially provides more information.

↑ Combining the interpolated temperature surface with elevation data can yield useful information hidden in spatial relationships.

perspective of real-world problems and making it actionable. They can bridge the gap between analysis and action. As a result, geographers should be able to turn data into a truthful narrative and answer the critical questions required to build trust in their findings.

5 Geographers are interdisciplinary.

If your data science team is having trouble finding common ground or struggling to communicate with subject matter experts, you may have forgotten to add a geographer.

Very few geographers arrive at university knowing they want to be a geographer. Geography is often a called a "found" major. Students from a variety of fields stumble across geography and find a fit because it overlaps a huge variety of fields, from the humanities to engineering. People who like to connect problems and solutions often find a home in geography.

Some geographers are purely qualitative and others are purely quantitative, but a good geographer can work with teams that include various perspectives, approaches, and kinds of expertise. The interdisciplinary perspective of geography is a strength when it comes to building and leading teams because geographers are trained to integrate perspectives, ideas, and skills. Geographers learn that complex problems are rarely solved using approaches from a single discipline or field. Success is the product of carefully examining the problem and combining complementary and, at times, even seemingly contradictory approaches.

Call to Action

The problems that we are trying to tackle—with the best and brightest minds in data science—are formidable. Solutions addressing climate change, racial equity, and environmental justice are complex. It is important to remember that effective data science solutions need to resonate with decision-makers, politicians, and public opinion.

That doesn't mean that everyone has to like your results. Rather, people need the best information to make the best decisions. Geographers can help get the best information out of spatial data and create pathways to communicate their findings through maps and by translating science for decision-makers and the public.

Although there have been times in our careers when we wished for deeper knowledge in one field, as we have progressed into leadership roles, we have been grateful for the breadth and approach of our training.

We are grateful that data scientists have deep and diverse skills. The geographic approach of spatial scientists includes the ability to integrate diverse disciplines, connect problems and action, and lead in developing solutions to address many of our world's greatest challenges.

If you're a geographer, lean into your unique skill set. If you're leading a data science team or project and haven't yet brought a geographer into the mix, what are you waiting for?

About the Authors

Dr. Lauren Bennett leads the spatial analysis and data science product engineering team at Esri. In this role, she oversees research and development of the ArcGIS geoprocessing framework, which includes spatial and spatiotemporal statistics, raster and multidimensional analysis, machine learning, and big data analytics. Bennett is passionate about the power of spatial data science to make an impact on the world in many areas including racial equity, social justice, public health, and climate change.

Dr. Trisalyn Nelson holds the Jack and Laura Dangermond Endowed Chair of Geography at University of California, Santa Barbara, and is the chair of the Department of Geography. Nelson and her team develop and apply spatial and spatiotemporal analyses to address applied questions in a wide range of fields ranging from ecology to health. Currently, her research focuses on active transportation and the use of big data and analytics to better plan cities.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Create Heat Maps That Work at All Scales

By Kristian Ekenes

ArcGIS API for JavaScript at version 4.24 adds a referenceScale property to the HeatmapRenderer. (The HeatmapRenderer renders point features in FeatureLayers, CSVLayers, GeoJSONLayers, and OGCFeatureLayers as a raster surface.) The referenceScale property allows you to fix the configuration settings for a heat map at a specific scale level, making the density appear consistent at all scales.

HeatmapRenderer dynamically updates surface density as the user zooms in and out, which makes it hypersensitive to scale. The way you configure a heat map at one scale may result in a misleading visualization at other scales.

By default, heat maps appear denser as they are zoomed out, which sharply contrasts with the density at the original scale. This is jarring and may confuse the viewer. Conversely, heat maps appear to disappear as they are zoomed in, which may cause the viewer to ask where the data went.

While the effect can be confusing for the end user, it makes sense when you consider that points generally appear more dispersed at large scales and dense at small scales. Let's take a look at a few ways for configuring a heat map to work well at various scales starting with the new referenceScale property.

The referenceScale Property

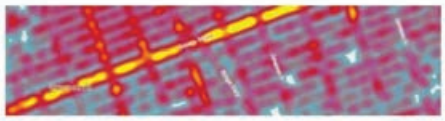
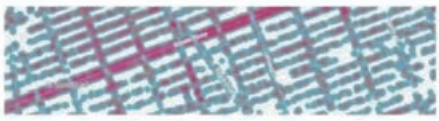
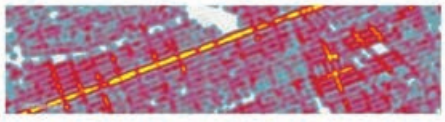
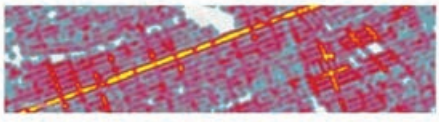
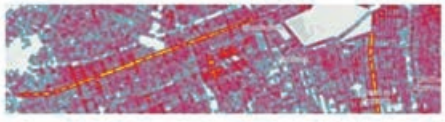
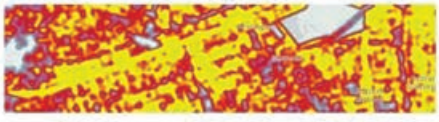
This property allows you to lock the visualization to a specific scale. This makes the heat map static, so the density surface remains consistent as the map is zoomed in and out.

Table 1 shows the differences in a map configured with and without a reference scale when zoomed in and out. To enable this behavior, simply set the referenceScale property to the view scale at which the heat map is authored, as shown in Listing 1.

```
const renderer = {
  type: "heatmap",
  colorStops: [
    { color: [133, 193, 200, 0], ratio: 0 },
    // ... more color stops here ...
    { color: [255, 255, 0, 255], ratio: 1 }
  ],
  maxDensity: 0.319,
  minDensity: 0,
  radius: 6,
  // settings for heatmap apply only to this scale
  // so renderer will look consistent without
  // dynamically updating on zoom
  referenceScale: 36111
};
```

↑ Listing 1: Setting Reference Scale

The sample heat map in Figure 1 (https://bit.ly/3SmQzdb) showing New York City tree census data demonstrates how the same

Zoom Offset from Reference Scale	Static (Reference Scale)	Dynamic (No Reference Scale)
+1 LOD		
Reference Scale		
-1 LOD		

→ Table 1: Comparison of static and dynamic (default) heat maps at the reference scale and level of detail (LOD) above (+LOD) and below (-LOD) the reference scale

↑ Figure 1: This sample heat map shows New York City tree census data. It lets the user toggle the reference scale off and on.

```
layer.renderer = {
  type: "heatmap"
  // additional heatmap properties
}

const view = new MapView({
  container: "viewDiv",
  map: new Map({
    layers: [layer]
  }),
  constraints: {
    // prevents the user from zooming in
    // beyond a scale value
    maxScale: 33003,
    minScale: 250000
  }
});
```

↑ Listing 2: Constraining Navigation

```
const layer = new FeatureLayer({
  title: "Motor vehicle crashes (2020)",
  // ...other layer properties
  renderer: {
    type: "heatmap",
    // ...other heatmap properties
  },
  // layer is only visible in this scale range
  maxScale: 60494,
  minScale: 196253
});
```

↑ Listing 3: Setting Visible Range

heat map looks with and without a reference scale. The reference scale can be toggled off and on. Zooming in and out will demonstrate how the density remains constant in the initial view. View the code for this app at https://bit.ly/3LAAwFI.

Setting a reference scale works great when the user is naturally inclined to zoom out from hot spots to see more context. It is not as useful if the user attempts to zoom to large scales at which heat map patterns are no longer visible. For that reason, it is best to always set the referenceScale property in combination with one of these techniques:

- Navigation constraints
- Visible scale range
- Scale-dependent renders

Navigation Contraints

Constraining the maxScale value of the view prevents the user from zooming in past a specific scale level as shown in Listing 2.

The app in Figure 2 (https://bit.ly/3DIhL1n) shows data on motor vehicle crashes in New York City for 2020. Adding view constraints ensures that the user will never zoom to the point at which the heat map appears either too cold or too hot. On the app, click the Toggle view max scale button in order to see how constraining view navigation affects the user experience when zooming in and out. View the code at https://bit.ly/3R0DTal.

Keep in mind that setting a view constraint applies globally to the view and only works well when there is no other data to view at larger scales. If the user is required to view other datasets at other scale ranges beyond the constraints, you should set a visible scale range or use scale-dependent renderers.

Visible Scale Range

Setting a maxScale value on the layer itself will cause the layer's visibility to toggle off when the user zooms beyond a specific scale

↑↑ Figure 2: This app, with view constraints, shows data on motor vehicle crashes in New York City for 2020.
↑ Figure 3: This view of motor vehicle crash data for 2020 includes a visible scale range constraint.

value. Listing 3 provides an example of how it is set.

The app in Figure 3 (https://bit.ly/3BvnlkY) shows motor vehicle crashes in New York City for 2020 and includes a visible scale range, set using the ScaleRangeSlider widget. Zooming in and out demonstrates how setting the visible scale range affects the user experience. View the code at https://bit.ly/3r1D4n0.

This technique works well if the data becomes irrelevant at larger scale levels. If the end user also needs to see data from the heat map at large scales, consider toggling from a HeatmapRenderer to a renderer showing discrete points.

Scale-Dependent Renderers

When the user zooms in so far that points largely appear dispersed, then it may make sense to switch the layer renderer to one that shows discrete locations for each point such as SimpleRenderer, UniqueValueRenderer, ClassBreaksRenderer, or any renderer that also uses visual variables to visualize the data.

To implement this behavior, set a watch on the view's scale property and toggle between the renderers when the threshold is crossed in either direction, as shown in Listing 4.

When zoomed in, the app in Figure 4 (https://bit.ly/3UuXjHb) changes the renderer and instead of showing a heat map of streets,

```
const heatmapRenderer = {
  type: "heatmap",
  // ...other heat map properties
};

const healthRenderer = {
  type: "unique-value",
  field: "health",
  // ...other unique value properties
}

// Switch layer's renderer to a unique value
renderer
// to view individual points when the user zooms in
// beyond the scale threshold. Use heatmap when
zooming out
view.watch("scale", (scale) => {
  layer.renderer = scale <= 9027 ? healthRenderer :
heatmapRenderer;
});
```

↑ Listing 4: Set a watch property on view to switch to a unique value renderer.

it shows individual tree locations. View the code at https://bit.ly/3By5GsS.

Conclusion

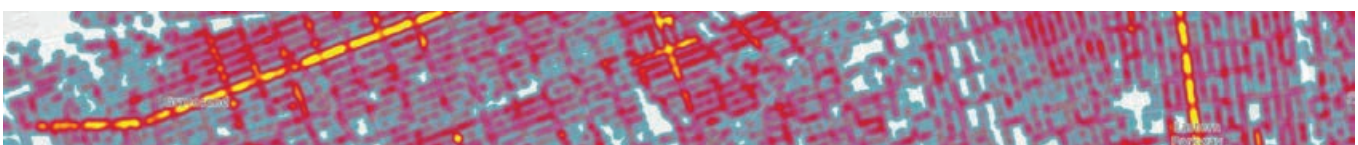
Because HeatmapRenderer is so sensitive to scale, always ask the following questions:

- At which scale range should the heat map render?
- How should the heat map behave on zoom? Should it be locked to a reference scale?
- What should be the behavior as the map is zoomed to large scales? Should navigation be constrained? Should layer visibility toggle off? Should individual points be rendered?

The new reference scale gives you one more tool that allows you to improve how a heat map appears at various scales. I recommend applying all the techniques described in this article.

About the Author

Kristian Ekenes is a senior product engineer at Esri. He works on smart mapping, data visualization, clustering, and ArcGIS Arcade integration in ArcGIS API for JavaScript. His goal is to help developers be successful, efficient, and confident in building web mapping applications with ArcGIS API for JavaScript, especially apps for visualizing data. Prior to joining Esri, he worked as a GIS specialist for an environmental consulting company. He enjoys cartography, GIS analysis, and building GIS applications for genealogy.



Using a Digital Twin to Envision a Future That Honors the Past

By Brooks Patrick

An urban design competition focused on turning an area that had heavy industrial and extensive transportation infrastructure development into a vibrant neighborhood that would restore the connectivity of its historic past, ensure its climate resilience, and preserve it as a UNESCO World Heritage Site.

Prague, one of Europe's fastest-growing cities, faces an ongoing struggle to reconcile dynamism and preservation. Urban development trends in the Czech Republic's capital evince a clear desire to return to a city that is more accessible to pedestrians—not for the sake of nostalgia, but because it will improve the city's livability.

Much of this activity is occurring in brownfields that were once home to rail terminals and other transportation infrastructure. One of the largest brownfields is Florenc. Near the historic center of Prague, it is a neighborhood on the edge of New Town, which was established in the 14th century.

Prague's Institute of Planning and Development (IPR Prague), a public benefit corporation that is the main policy making unit for urban architecture, planning, development, design, and administration for the city, employs a digital twin of Prague that lives in the city's GIS. Planners use the digital twin to design outcomes that are then tested.

Many planning projects focus on reducing the rift that was created by the city's main rail lines nearly 200 years ago. Rail lines destroyed surface connections between neighborhoods while opening connections to the rest of Europe.

In recent years, IPR Prague has taken a special interest in determining how climate change will affect and alter the city. The city's digital twin helps new development strike the right balance between efforts to address climate pressures and changes that improve the lives of residents. Using GIS, city planners have constructed

↑ Prague, one of Europe's fastest-growing cities, is using a digital twin to restore connectivity of Florenc, a historic neighborhood, with the surrounding area and preserve its world heritage status.

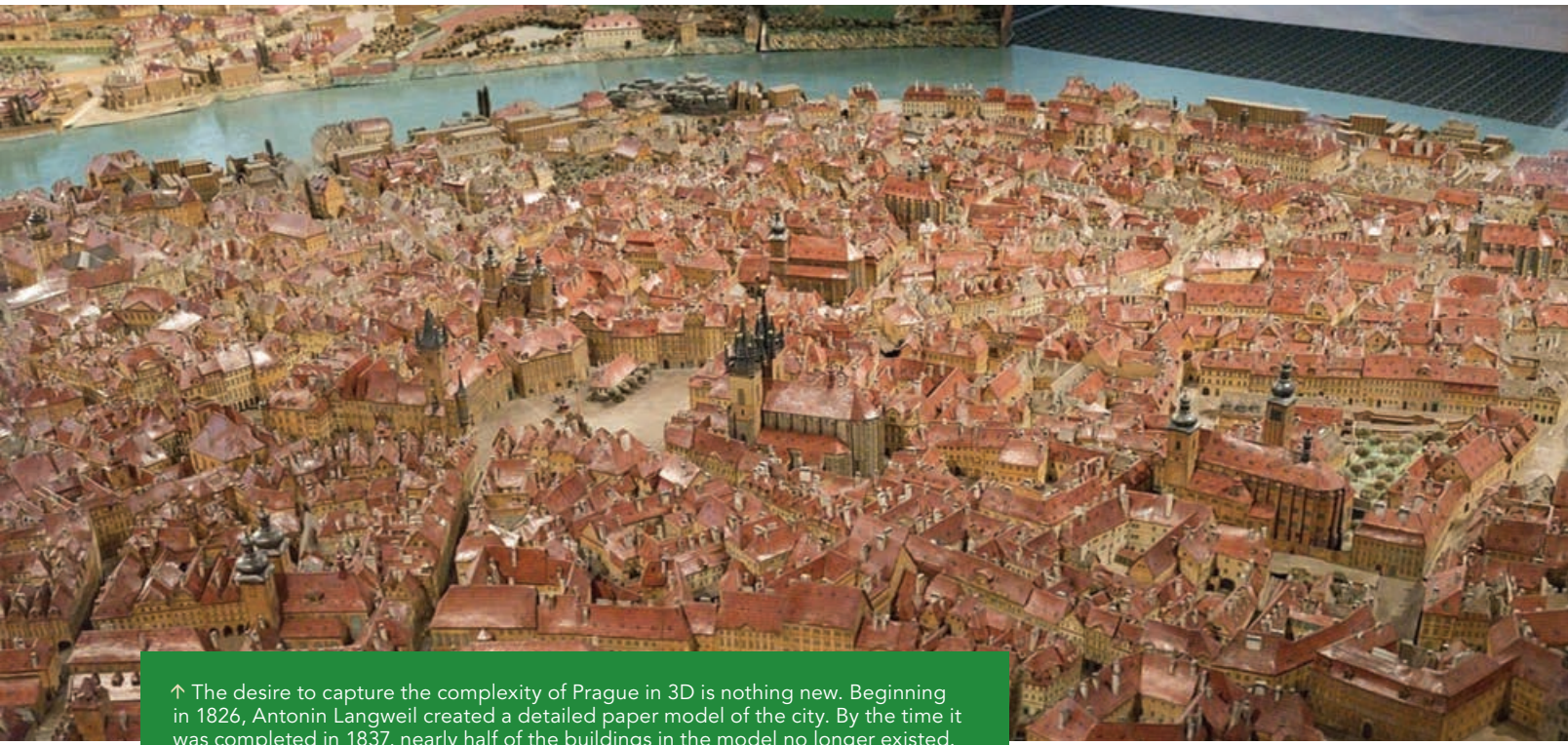
↑ The complexity of the Masaryk train station discourages pedestrian travel in the area.

3D models of Prague's microclimates. These models provide a way to simulate the effect of mitigation strategies before they are implemented.

The Future of Florenc

The modern character of Florenc was formed half a millennium after the founding of New Town when rail disrupted the old patterns of the city. "It's basically a 19th-century development, an old industrial and residential quarter," said Jiří Čtyroký, IPR Prague's director of spatial information.

Čtyroký noted that Florenc is one of Prague's largest brownfields. It's a contaminated remnant of the area's industrial past and evidence of the modern transportation infrastructure that now dominates the locale. A nest of rail lines; a large bus station; a major subway transfer point; a clogged arterial road; and the Negrelli Viaduct, which carries trains over the Vltava River, have made Florenc less a neighborhood to live in and more a place to travel through.



↑ The desire to capture the complexity of Prague in 3D is nothing new. Beginning in 1826, Antonin Langweil created a detailed paper model of the city. By the time it was completed in 1837, nearly half of the buildings in the model no longer existed. Instead of a physical model, the Florenc 21 contest opted to use a digital twin as a more equitable way to compare entries. (Public domain image accessed from Wikimedia Commons)

Over the next few years, the Florenc brownfield will be replaced with housing for 1,600 new residents and business development that will create 3,200 job opportunities. IPR Prague models show that this development risks creating heat islands and intense warming in Florenc.

"That's exactly the kind of place where it's worth implementing the microclimate modeling, because it's a place where massive change will occur, and we want to see how it will work," Čtyroký said.

International Teams Ponder Florenc's Future

Last year, IPR Prague helped organize Florenc 21, an architectural competition that attracted 57 teams of architects and urban designers from around the world. Each team submitted ideas for how to reorient Florenc around the coming changes.

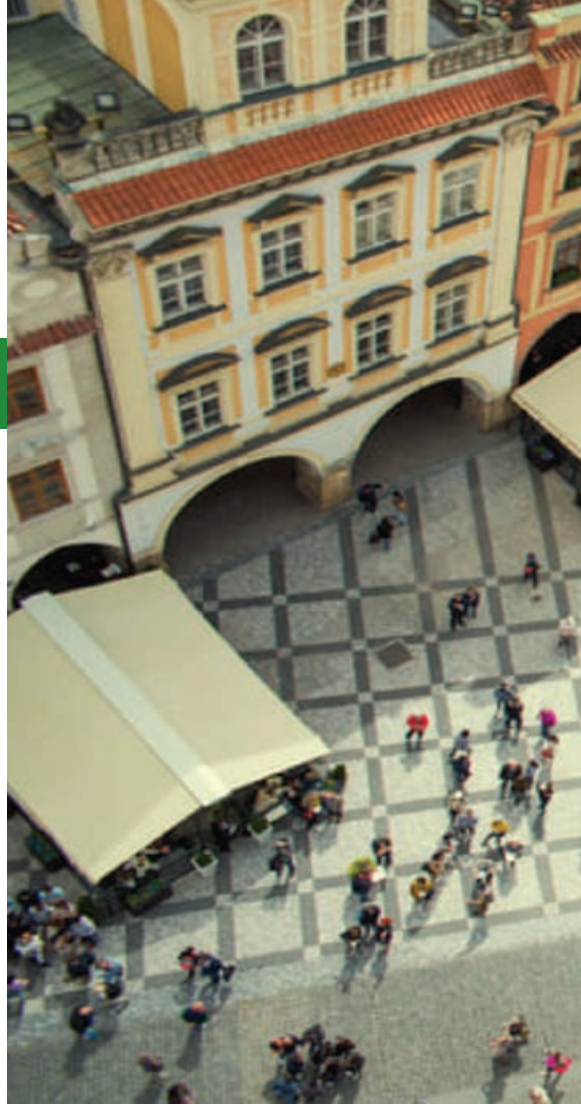
"We thought about creating a physical model of the competition area, where all participants could input physical models of their proposals," said Luboš Križan, an urban planner with IPR Prague's Office of Territorial Support. "But it would've been extremely expensive and complicated for us to make the whole model available to all five competitors, and it would take a lot of time to do so."

"So, we thought, Why not use a digital twin and web app to share the model of the neighborhood?" Čtyroký said. "It would be cheaper and more flexible."

Sam Blanár, an IPR Prague developer, pulled the 3D model for Florenc, and used GIS to create an app that all participants could explore. Using the app, the finalists were able to blend their plans into the digital twin. The five contest finalists developed their designs into overall plans and received access to IPR Prague's digital twin of the city to use for their presentations.

In the past, Čtyroký explained, IPR Prague would sometimes augment finalized design proposals by asking the winning bidder for data. "Then we'd put it into the digital twin," he said. "But this was the first time the 3D model was used in real decision-making during a competition."

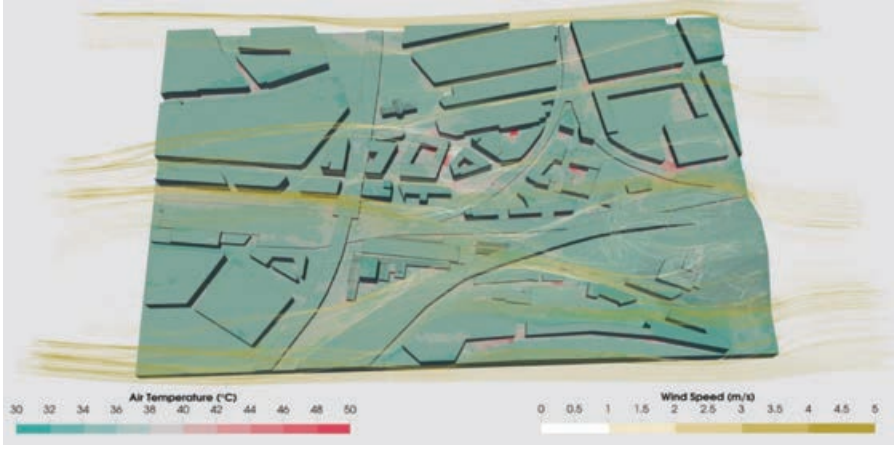
This provided a standardized view that enabled the Florenc 21 judges to compare the entries. It also allowed them to make



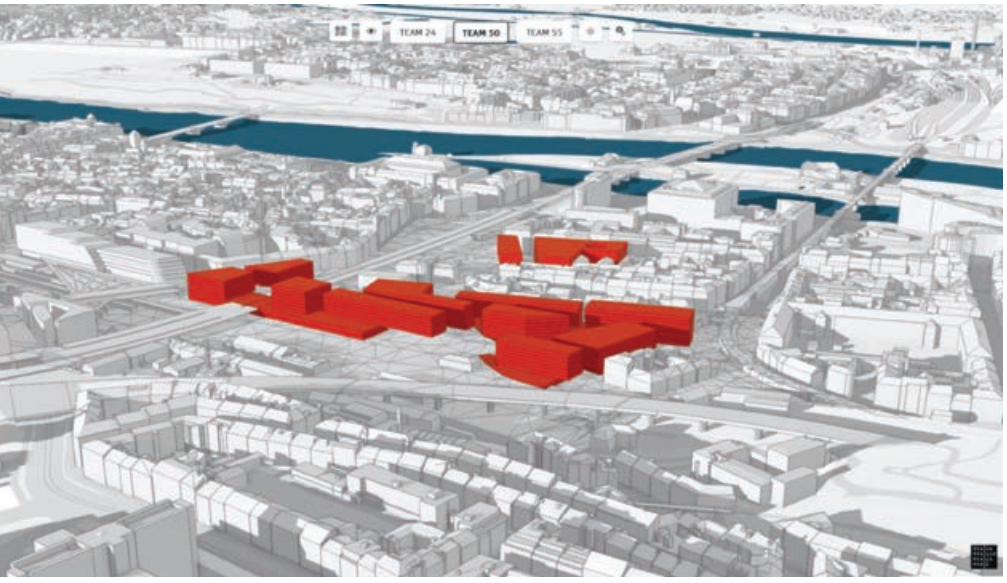
↑ Prague's Old Town promotes pedestrian travel.

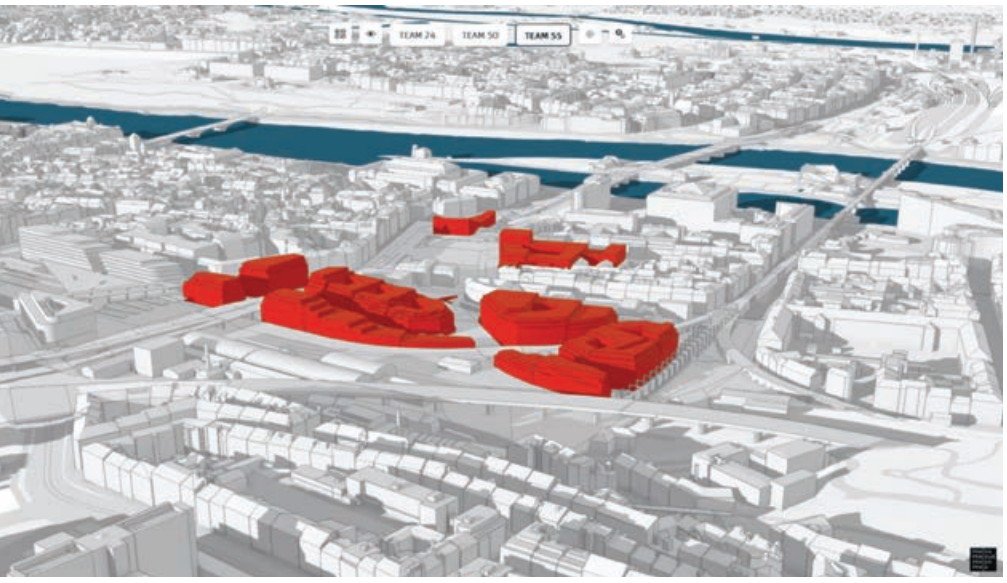
→ The Prague 3D map allows users to view the city from any angle, filter the city by building floors and other parameters, and see the city's land-use plan.

↓ The microclimate model of Florenc shows specific areas of concern.



> "So, we thought, Why not use a digital twin and web app to share the model of the neighborhood?"
>
> Jiří Čtyroký
> Director of Spatial Information
> IPR Prague





informed judgments about massing *[an architectural term that describes how a building design fits into its surroundings]* with a level of detail not possible with either standard two-dimensional plans and images or visualizations that are aesthetically pleasing but contain little useful information.

The winning proposal came from Team 24, composed of UNIT architekti, A69–architekti, and Marko&Placemakers. Filip Tittl of UNIT architekti described the unique infrastructural and topographical constraints that made reimagining Florenc a challenge: the arterial road, railway bridge, subway tunnels, rights-of-way for future subway lines, and land that rises as one moves away from the riverbank. "All of this creates one of the most complex places in Central Europe," Tittl said.

Climate and Connectivity

In keeping with IPR Prague's interest in how Florenc will fare in an era of climate change, the winning team integrated sustainable energy sources and microclimate research into its design. Vegetation is strategically placed to mitigate heat islands, and a ventilated street design should maximize the cooling effect of the predominant winds.

Climate change is not the only issue that affects the rethinking around Florenc. The process also reflects a return to certain values that were once basic to how people thought about cities.

New Town existed for 500 years before the establishment of the Masaryk train station brought rail transit to Prague. The station cut off Florenc from New Town and

← Viewing the designs of the different teams (shown in red) within the model allowed judges to compare plans within the context of the surrounding city. (Screenshots courtesy of IPR Prague)

↑ Team 24 won the design competition, with input from Unit architekti, A69–architekti, Marko&Placemakers. (Image courtesy of Team 24.)

began the area's shift away from an intimate neighborhood in which everything residents needed was within walking distance to an area oriented around mechanized travel and industry.

The result was a region of diminished connectivity. Walkability and pedestrian flows were increasingly narrowed and blocked. A major renovation of the Masaryk station, that began as part of another urban architecture competition in 2009, has sought to restore that connectivity.

The Florenc 21 website noted that, "At the time of its establishment, the station was proof of the modernization of the city and its economic progress." However, the winning proposal works with the demands of the 21st century for jobs in new economy sectors, strategically locating the transport hub, and supporting pedestrian links.

Among the changes to improve connectivity is the reestablishment of pedestrian and cycling interconnections among three major streets that the station once blocked. Gardens that were once replaced by tracks have reemerged as part of the station's roofing.

Florenc 21 has further refined the values of connectivity and livability so that Florenc the transport hub is now subsumed into Florenc the neighborhood and is no longer an island. The winning proposal included multifunctional buildings, an urban market, and retail stalls under the viaduct's arches. IPR Prague praised the winning team's vision of a "highly permeable neighborhood that connects all the surrounding neighborhoods and heals the wounds left behind by the construction of transport infrastructure in Florenc."

International Recognition

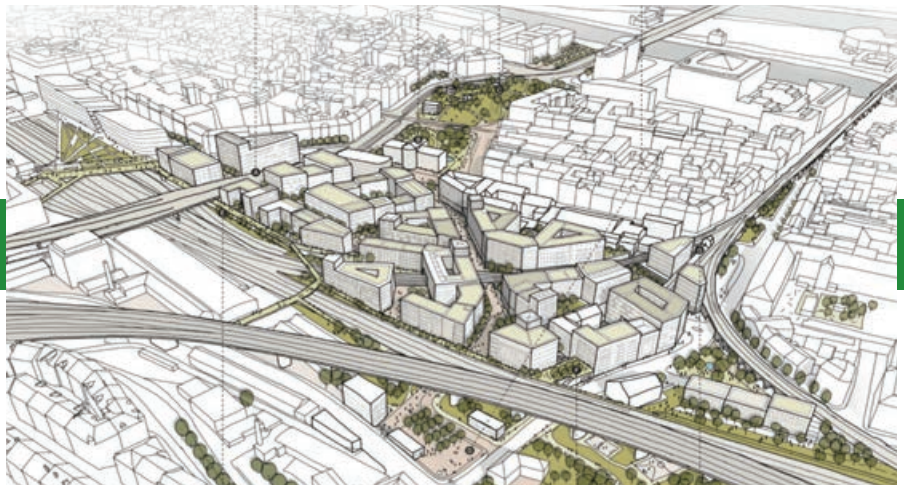
In 1992, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) designated Prague's Historic Center, an area that includes part of Florenc, as a World Heritage Site.

When UNESCO granted the area world heritage status, it noted how the region "admirably illustrates the process of

The winning proposal included multifunctional buildings, an urban market, and retail stalls under the viaduct's arches.

continuous urban growth from the Middle Ages to the present day." Nearly two decades later, Prague's post-Cold War expansion caused UNESCO to reconsider, noting in 2019 that the integrity of the area is "threatened by the pressure of developers wishing to build oversized new buildings."

UNESCO made it clear that, should unchecked growth continue, the Historic Center could lose its world heritage status. Florenc 21 is a signal to UNESCO that the city is serious about smartly managing these development pressures.



↑ Viewing the winning project design in 3D reveals the complexity of the site, and demonstrates how the design works around barriers. (Image courtesy of Team 24.)

"For the people from UNESCO and Prague's heritage office, it's extremely important to look at panoramic views, to see how structures would work with surroundings," Križan said. The digital twin allowed designers to consider these values throughout the design process. UNESCO lauded the winner's potential to better reveal the exceptional value of this part of Prague.

↑ The future look of the Florenc bus depot and metro stop will revitalize an industrial area that's just one kilometer from Prague's Old Town Square. (Image courtesy of Team 24.)

The web app made it easy to understand the effect a proposal would have by it displaying it realistically. Blanár preloaded perspectives of noteworthy locations in the app such as the view from the Prague Castle, which dates back to the ninth century.

"The judges could check it out using the 3D model," he explained. "We had prechosen a few spots that showed some of the most beautiful and panoramic scenes of Prague, and there was a tool to click on them, which rotated the scene into the proper position so that everyone could look and instantly compare the spots on the proposals."

The next step will be a feasibility study for the proposal. IPR Prague is optimistic that the plan will withstand the scrutiny. "Florenc is a scar on the city of Prague," Ondřej Boháč, IPR Prague's director, bluntly noted, "which will finally be healed, thanks to this competition."

About the Author

Brooks Patrick is a global business development manager for smart cities at Esri who helps both local government and private sector users and partners understand and implement Esri software and solutions.

Index Maps Help Inform Strategies

By Jim Herries

When people plan a weekend trip, a single number helps them plan what they will do: the forecast high (or low) temperature. The predicted temperature is the number they use to decide what clothing to pack.

That number—temperature—is defined and expressed as a value on a scale defined hundreds of years ago. Specific numbers on that scale have a significant meaning in the real world. For example, in the case of temperature, the value of 32 degrees on the Fahrenheit scale is the temperature at which water freezes. Whether people use Fahrenheit or Celsius, they most likely do not know the actual scientific definition of temperature or its scales. Instead, they know how to use temperature in everyday life. Use is sufficient.

It wasn't until 1945 that scientists thought to try to measure the effect of wind and temperature on how fast water freezes and how human skin reacts. From these two independent measures—temperature and wind—comes a new measure: wind chill. Side note: the wind chill you grew up with is not the same as today's wind chill, which was last adjusted in 2001.

Wind chill is an index. Smart travelers also factor in the wind. Wind combines with temperature to make us feel colder, faster, so we check the wind chill information if available. Well, some of us do anyway.

Broadly speaking, an index is a thoughtful combination of two or more numbers that give us a single measure to use.

For many of us, wind chill has been an index longer than we have been alive. At some point in our lives, we were introduced to wind chill. If it resonated with our experience, we began to trust it. Today, we take it at face value and plan a strategy independent of the science behind wind chill calculation.

A wind chill chart helps visualize how the two measures of wind and temperature combine to let you know what it will feel like when you are out in those conditions.

Can an Index Be Mapped?

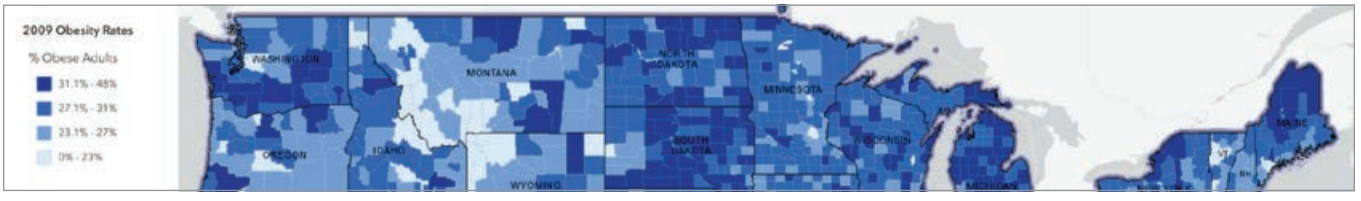
A good index can make a great map. Chances are good that you have seen a wind chill map. A wind chill map is how people use wind chill to plan. The science behind wind chill is available to anyone interested, but the pragmatic value of an index is found in how it is used and how people react to the information it brings.

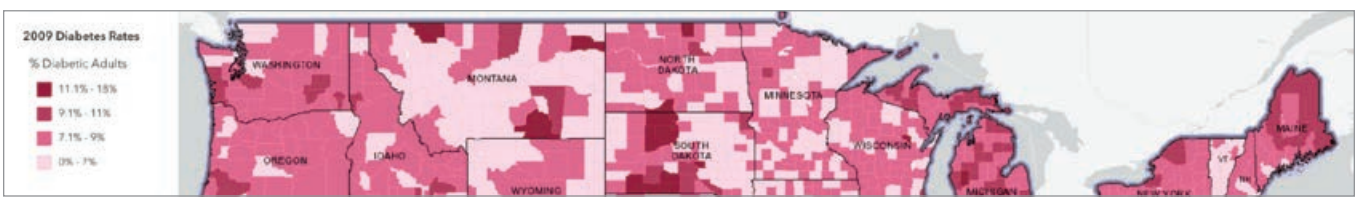
Perhaps you are a GIS analyst or someone who works with one. How can you bring a similar pragmatic index or composite score to bear on the topics you're looking into?

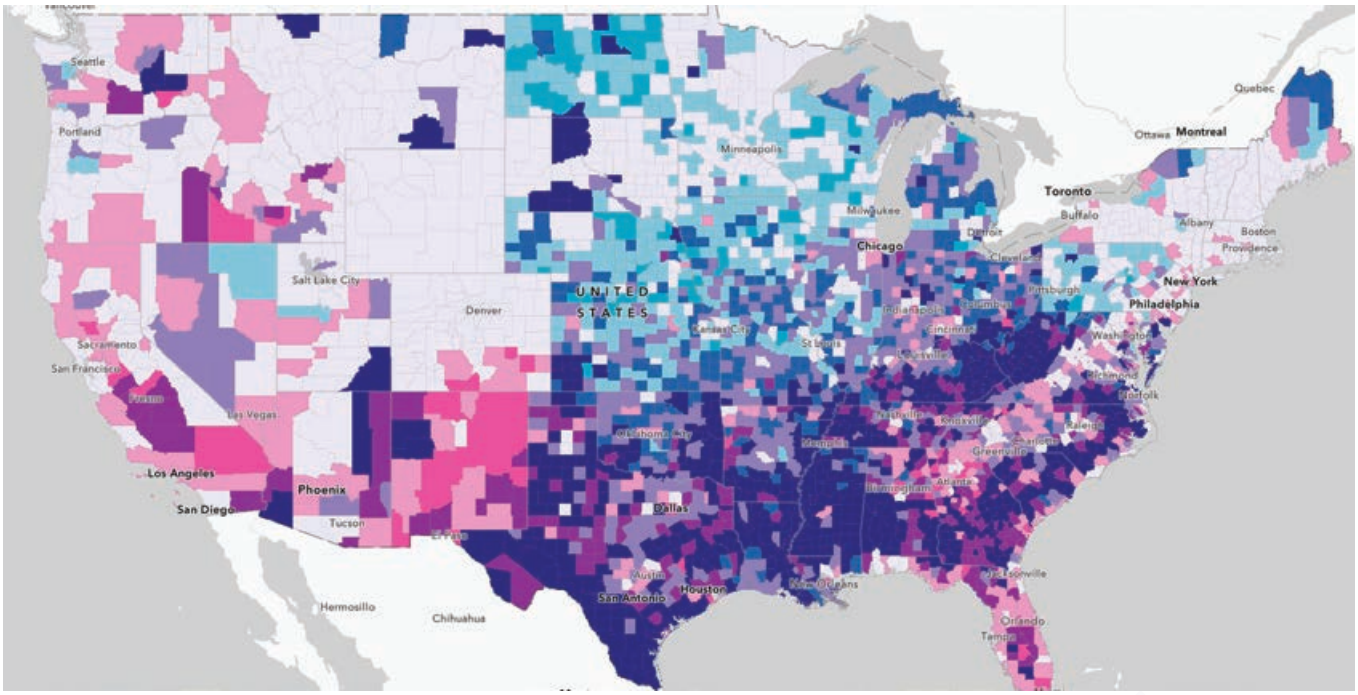
In my daily work, I frequently make maps of individual measures relating to populations. I also make maps of indexes (or, if you prefer, indices). One memorable example involved mapping obesity and diabetes measures. I used Map Viewer in ArcGIS Online to map obesity rate data

↓ Data on obesity rates mapped by county.

↓↓ Data on diabetes rates mapped by county.







↑ Bivariate map of obesity and diabetes uses a single map to capture the relationship between these two attributes.

from the Centers for Disease Control and Prevention (CDC) for US counties based on the percentage of the adult population designated as obese. I made a second map showing the percentage of the adult population diagnosed as diabetic. Given that obesity is a proven contributor to higher diabetes rates, I expected to see similar patterns in the two map layers when viewed independently.

You can interpret either map successfully at a glance if you understand that darker colors mean higher rates of obesity (blue) or diabetes (magenta). Focus on a single county in each map. As your eye goes back and forth between the two maps, your brain does the interpretation. If you are just looking at a single county, it's not too much to ask.

To better understand how these two measures (obesity and diabetes) interact, you might add a swipe tool in the map to provide an easy user experience for someone interactively comparing large areas. I really like the interactivity that the swipe tool brings to the two maps. It helps the reader compare more than one county at a time and start to see the pattern in a larger area. It's the same two maps, but that ability to swipe engages the brain a little differently than just staring at two separate maps.

There is another way to engage the brain using a single map to capture the relationship between these two attributes. A bivariate map shows a blend of the two colors to give a clearer picture of where both rates are high. On a bivariate map of obesity (blue) and diabetes (magenta), an area in which both are high is dark purple. Equally interesting are the areas with high obesity yet low diabetes rates, which is light blue on this map.

With this map, you have gone from asking the reader to look at two maps and mentally blend two colors to blending the colors on a single map. Can you do even better?

Make an Index Map

Remember the wind chill example, where the wind is combined with temperature to produce a new number you can use to think about your plan of action? Let's do the same thing with obesity and diabetes. I chose this map in Map Viewer in ArcGIS Online to work up a simple weighted index of obesity and diabetes for each county in the US. I used the ArcGIS Arcade expression shown in Listing 1 to calculate an index (or composite score) for these two factors.

For each county, the obesity rate needs to be compared to a standard of comparison. I chose the national rate for obesity (32.1 percent) to show how the rate in each county relates to the national rate. For diabetes, the national rate (11.1 percent) is again used. The Arcade expression in Listing 1 does the math and returns an index value of 100 if a county's rates exactly match the national rates. Values below 100 indicate one or both county rates are lower than the national average, and values above 100 indicate one or both county

rates are higher than the national average.

The result of this calculation for every county in the US happens to produce a nice bell curve, which always makes a good, expressive map. The color ramp colors are anchored around the 100 index value, which represents the national average. A histogram of this map shows the actual mean value for counties and one standard deviation around that mean. The histogram handles are set to theoretical bell curve standard deviation values of 134 and 66 for an index that has a mean of 100.

```
// get the attributes

var obesity = $feature["Obesity_Percent"];
var diabetes = $feature["Diabetes_Percent"];

// set the standard of comparison for the index to be based upon
var national_obesity = 31.2;
var national_diabetes = 11.1;

//calculate the simple index, equally weighted
var obesity_index = 100 * (obesity / national_obesity);
var diabetes_index = 100 * (diabetes / national_diabetes);
var weighted_index = (obesity_index + diabetes_index) / 2;
return weighted_index;
```

↑ Listing 1

Histogram of the County Index

Counties with higher rates of obesity and diabetes are shown in progressively darker shades of brown. Counties with lower rates of both are shown in progressively darker shades of green. It is easy to see what the data looks like in a scatterplot using the colors from the index map. I think it took me all of one minute to construct this chart in Map Viewer because the scatterplot chart automatically chooses the colors already being used in the map.

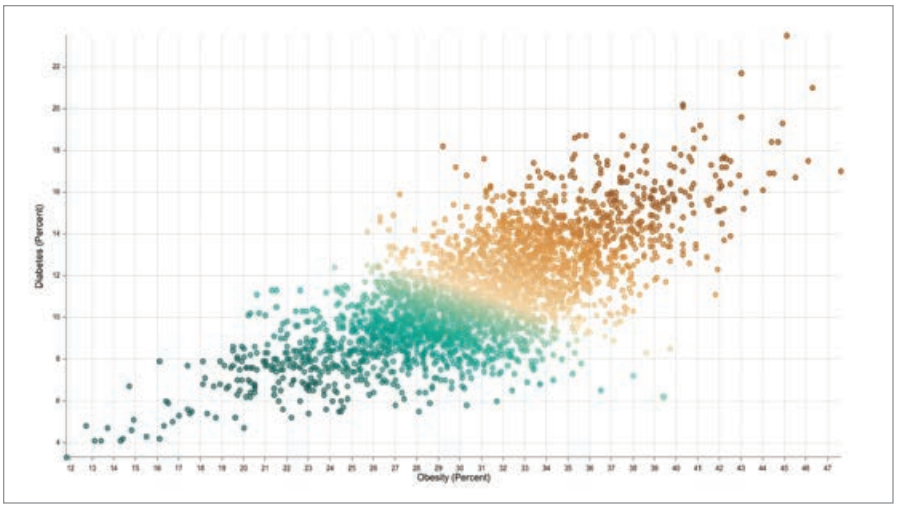
The general trend shown is that as obesity rates go up, diabetes rates go up too. However, the trends away from that pattern are equally interesting, and the colors show them.

Let's say you were interested in setting a policy that would make counties with obesity rates of 30 percent or higher eligible for special funding for efforts to help curtail diabetes. A glance at the scatterplot below reveals that, at the 30 percent obesity rate, there are an equal number of counties with diabetes rates above and below the national diabetes rate of 11 percent. This means that some counties are already experiencing lower rates, so the policy may need to account for that in its method.

The resultant map begins to suggest that different strategies may be needed to tackle the related issues of obesity and diabetes rates. It shows a pattern that is very similar to the bivariate relationship map, but the Arcade expression gives much greater control over what is visualized on the map and why. I chose values of 134 and 66 in the legend because those scores are one standard deviation around the mean (100). That choice more clearly illustrates which counties are truly abnormally high or low on this scale while preserving the variation between 66 and 134. I value the variation because every county official will likely want to know how their county is doing relative to surrounding counties. The pockets of green within otherwise brown areas stand out in this two-color map.

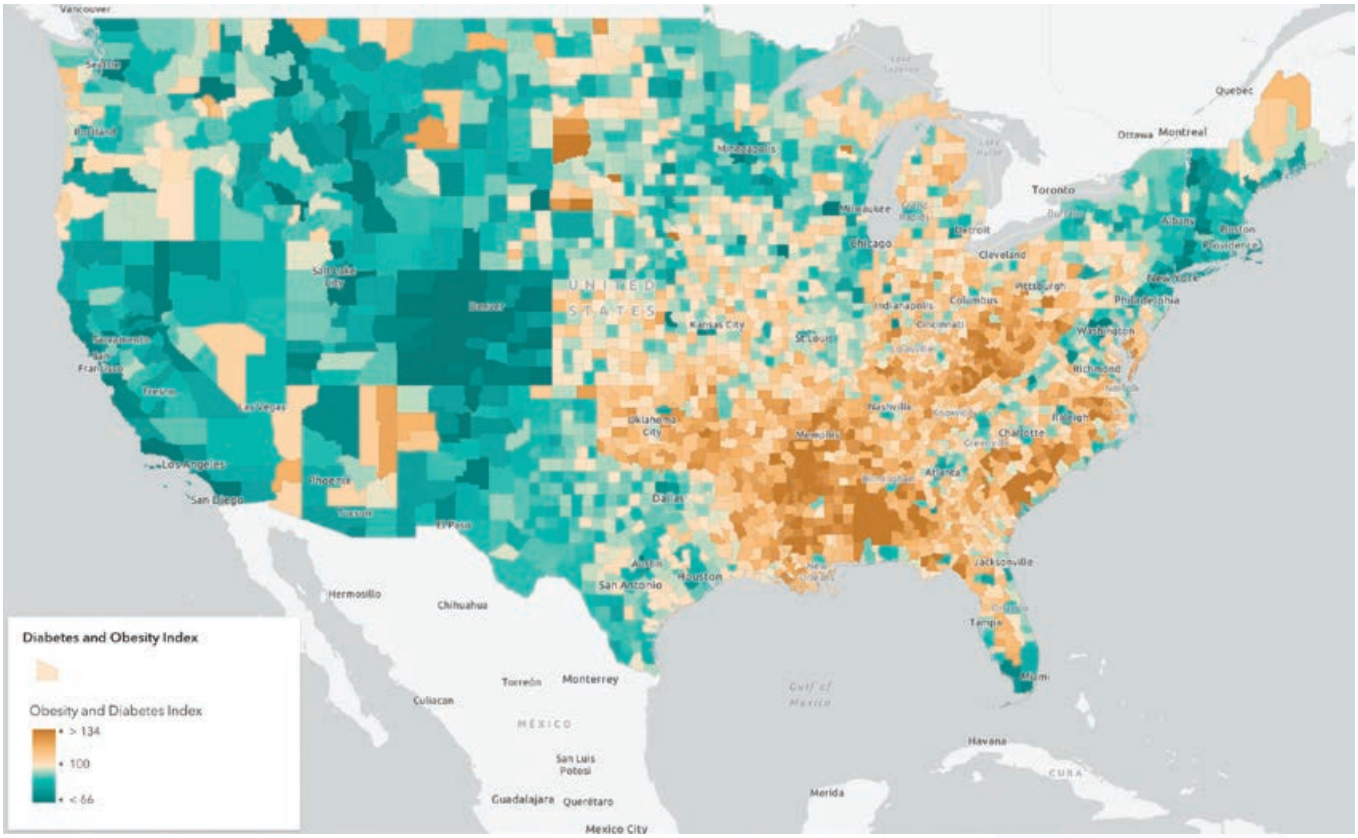
To improve this index and the resultant map, a subject matter expert on obesity and diabetes is needed to help refine how the index is defined in the Arcade expression. The GIS analyst who created the index map can guide the development of a better equation, which might better capture how these two rates are related. For example, if the subject matter expert indicates that health-care costs for diabetic patients are 10 times higher than for obese patients, the Arcade expression could be modified to more heavily weight the diabetes rate.

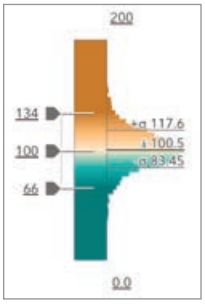
↓ In ArcGIS Online, making a scatterplot map of obesity and diabetes rates from the index map is easy.



Ask More Questions

For decades, mapmakers have made maps of individual but related topics like obesity and diabetes. They have dutifully shown a map for each topic and expected the reader to mentally synthesize both to get the full picture. As a mapmaker or someone who directs which maps are made, you have an opportunity to break through that limitation by making an index map that explores the patterns in each topic. Amplify





↑ *Obesity and Diabetes Index Map*

← Histogram of the county index

one topic or another to see if they cancel each other out. A region with high obesity rates but very low diabetes rates is as interesting as a region where both rates are very high. What would explain the differences?

An index map allows you to ask more questions about the intersection of topics and encourages further statistical analysis of the relationships at work. As you can see, using Arcade expressions means that the level of effort needed for these types of analysis is low, and the value of the discussion that index maps trigger is high.

Look at the Maps Online

- *The linked burdens of obesity and diabetes* (https://bit.ly/3AepulT)
- Swipe tool for *The linked burdens of obesity and diabetes* map (https://bit.ly/3NxmEf5)
- *Obesity and Diabetes in the US* map (https://bit.ly/3ugqger)
- *Obesity and Diabetes Index Map* (https://bit.ly/3Ac875p)

Resources

- "An Improved Histogram Experience in Map Viewer" (https://bit.ly/3IbJSpR)
- "Your Arcade Questions Answered" (https://bit.ly/3NyAmhy)

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. He is particularly engaged in thematic mapping and map visualizations, reflecting a drive 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.

Designing Effective Dashboards

By David Nyenhuis

Are you a dashboard user who has struggled to get useful information from a dashboard? Are you a dashboard author suffering from information paralysis who simply doesn't know where to begin to create your dashboard? Do you have disagreements over how a dashboard should look and work? If any of these questions resonate with you, this article will help you.

Why is there so much debate over what constitutes a good dashboard? For one thing, dashboard is a loose term. Many think that a dashboard is simply a single screen of information or a display with charts on it.

With such a generic term, it is difficult to draw any conclusions and recommendations, but there are some core principles that apply to all dashboards. A good dashboard:

- Communicates important and critical information.
- Draws attention to where it's needed.
- Conveys the information clearly and at a glance.

Divide and Conquer Dashboard Design

By classifying dashboards into different types, the best practices and design guidelines for each become clearer. Dashboards can be divided into two primary groups: snapshot dashboards and monitoring dashboards.

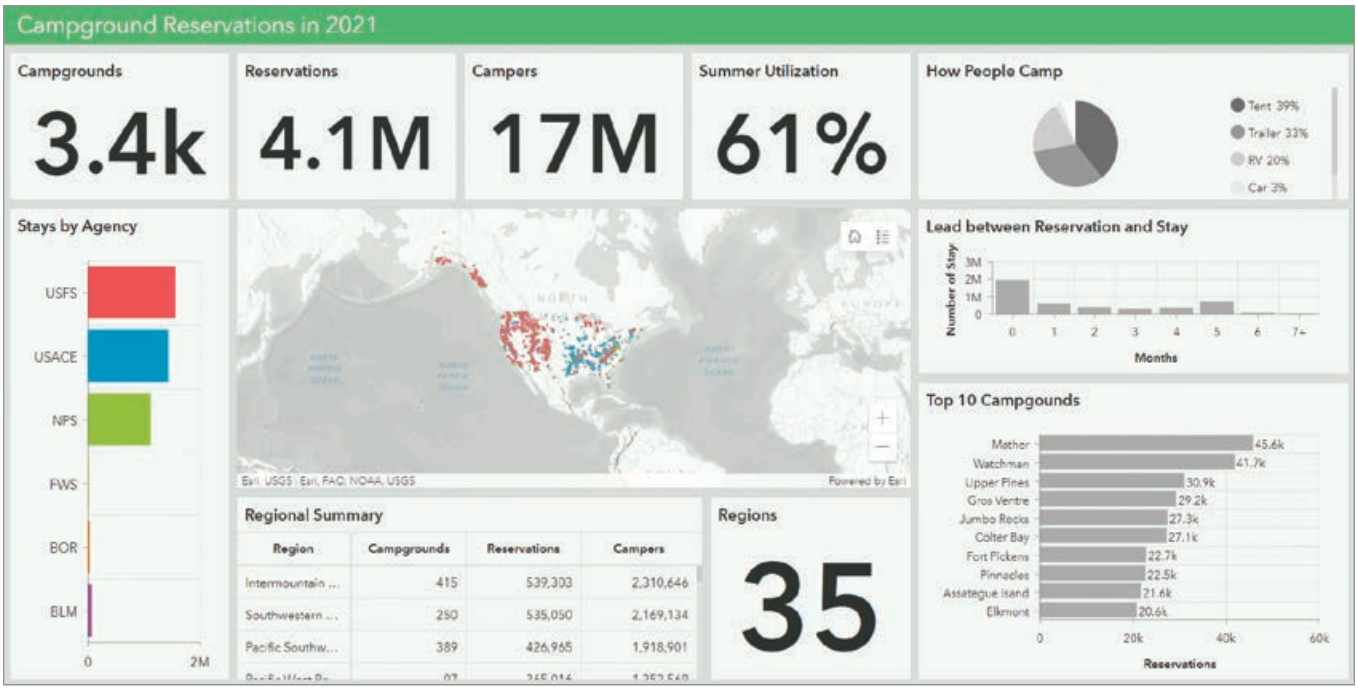
A snapshot dashboard summarizes a dataset that does not change and therefore represents a snapshot in time. This type of dashboard can be used to tell a story or make a claim.

A monitoring dashboard provides updates on data that is dynamic, whether it changes intermittently or regularly. With continually changing data, this type of dashboard has quite a different role. Although it can't often be used to tell a story, it can be used to draw attention to values of interest or concern through highlighting them. Table 1 summarizes the key attributes of each type of dashboard.

As you can see, these types differ considerably. Knowing your dashboard type can help you make creative design decisions and support those decisions if they are questioned by a user or manager. Let's dig a bit deeper into each group.

↓ Table 1: Key attributes of snapshot and monitoring dashboards

Attribute	Snapshot	Monitoring
Data	Static—point in time such as a census count	Fluctuating—updates intermittently or regularly
Viewing Frequency	Once	Often
Purpose	• Information • Explanation • Persuasion • Analysis	• Information • Status • Performance • Progress • Analysis
Style	Colors can be used to support branding or storytelling. This type of dashboard can be embedded to add context.	A muted color scheme that reserves bold colors for highlighting data of interest or concern on both maps and charts works best.



↑↑ Figure 1: This snapshot information dashboard shows a neutral summary of data.

↑ Figure 2: This snapshot explanation dashboard shows why it can be hard to make summer camping reservations.

Snapshot Dashboards

A snapshot dashboard summarizes a static dataset to communicate some information such as census data or analysis results. Charts can often complement a map in visualizing data temporally or categorically in addition to spatially. Once the information is communicated and understood, users may be done viewing it.

These dashboards can serve several purposes:

- Inform
- Explain
- Persuade
- Analyze

Information Dashboard

Knowing the purpose of and audience for the dashboard is key to making it effective. Let's look at an example that uses data about camping in national parks in the US. After analyzing camping reservation data, I wanted to show some key results that were discovered. If I simply wanted to provide a general, neutral summary of the information, the dashboard might look like the one in Figure 1.

Note: *This analysis was done for demonstration purposes.*

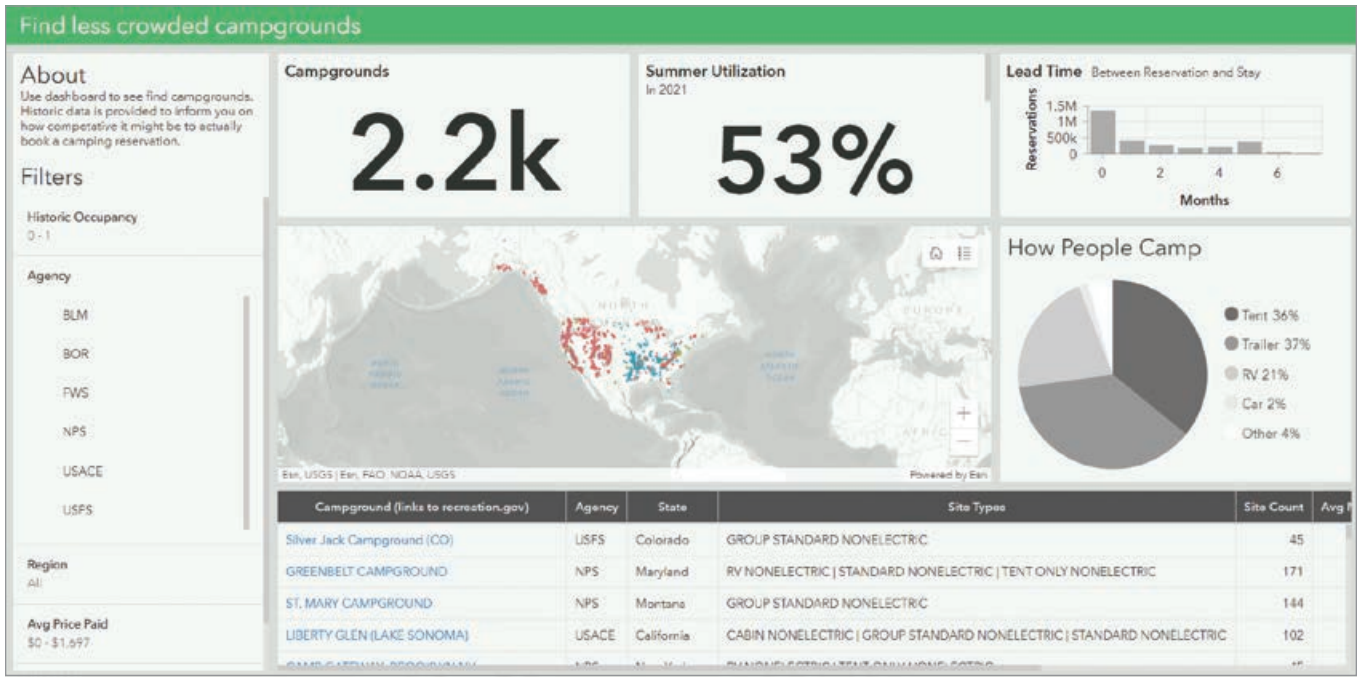
Explanation Dashboard

However, if I want to explain something I found in the data, I may want to design the dashboard differently. Because I had failed to secure camping reservations several times, I wondered how many campgrounds were full all summer. I wanted to explain why it is difficult to plan a summer visit to a national park. In analyzing the data, I discovered that nearly half of National Park Service (NPS) campgrounds were at or over 80 percent occupancy during the summer, which makes it difficult to secure camping reservations for a typical stay.

Showing bits of information on a bunch of metrics isn't necessary and can be distracting. To explain this finding, I made the dashboard shown in Figure 2 that focuses exclusively on the NPS campground summer occupancy. Since the data is not changing, I can describe the methodology used and provide a written summary too.

Persuasion Dashboard

This analysis might also inspire me to make a dashboard and a related ArcGIS



↑↑ Figure 3: A snapshot persuasion dashboard can persuade viewers that there are not enough camping sites.

↑ Figure 4: This snapshot interactive analysis dashboard can help people find less crowded parks and make reservations.

StoryMaps story to persuade others that there are not enough NPS campsites. The dashboard, shown in Figure 3, could be embedded in the ArcGIS StoryMap story.

Analysis Dashboard

A related dashboard could help people find less crowded campground options. An interactive analysis dashboard would let people filter the data to find campgrounds with historically lower summer occupancy and provide attribute information and a link to the booking platform. This dashboard is shown in Figure 4.

As you can see, snapshot dashboards can look quite different, depending on what I want to focus viewers' attention on. Whatever the focus of a dashboard, users should find the important information at a glance and understand what they are seeing.

Monitoring Dashboards

Instead of showing data for a point in time, monitoring dashboards summarize data that is changing. This could be data that changes many times per minute, daily, or even monthly. In each case, the dashboard provides always-current data to viewers.

What information do viewers need to know? Well, that's for you to decide, but the purpose of a monitoring dashboard will likely fall under one of the following categories:

- Inform
- Provide status
- Evaluate performance
- Convey progress
- Analyze

For example, let's say I wanted to monitor pothole repair requests. How I designed that dashboard depends on what information I want viewers to see. Sometimes a general, unbiased summary of the data for a recent time frame is what is needed for a public resource or open data site. For this type of dashboard, neutral colors and a variety of summary information, like the dashboard in Figure 5, can work well.

Information Dashboard

This dashboard provides the number of requests for the last 30 days along with the percentage broken down by status and origin (i.e., how it was submitted). On the right, graphs show district-level counts and how daily counts have fluctuated.

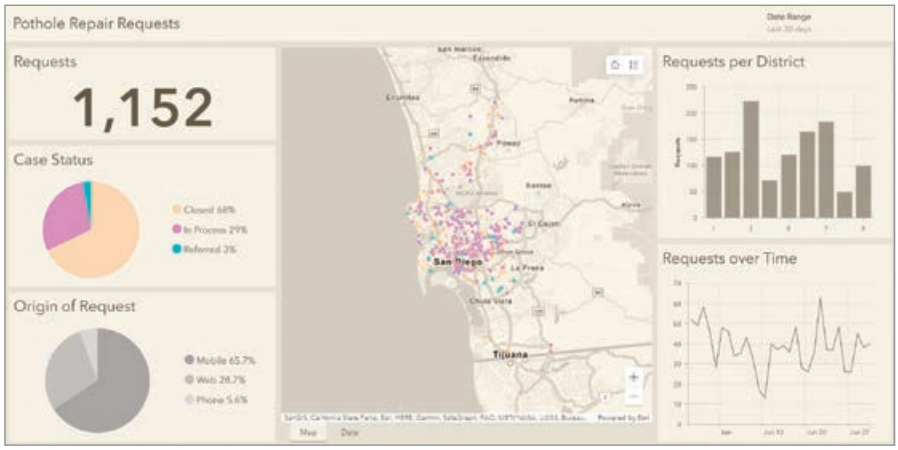
Although this approach works for some scenarios, it won't provide an operations manager with the current data needed to know if there is anything concerning that needs to be investigated. This scenario requires a dashboard designed to provide situational status at a glance, like the one in Figure 6.

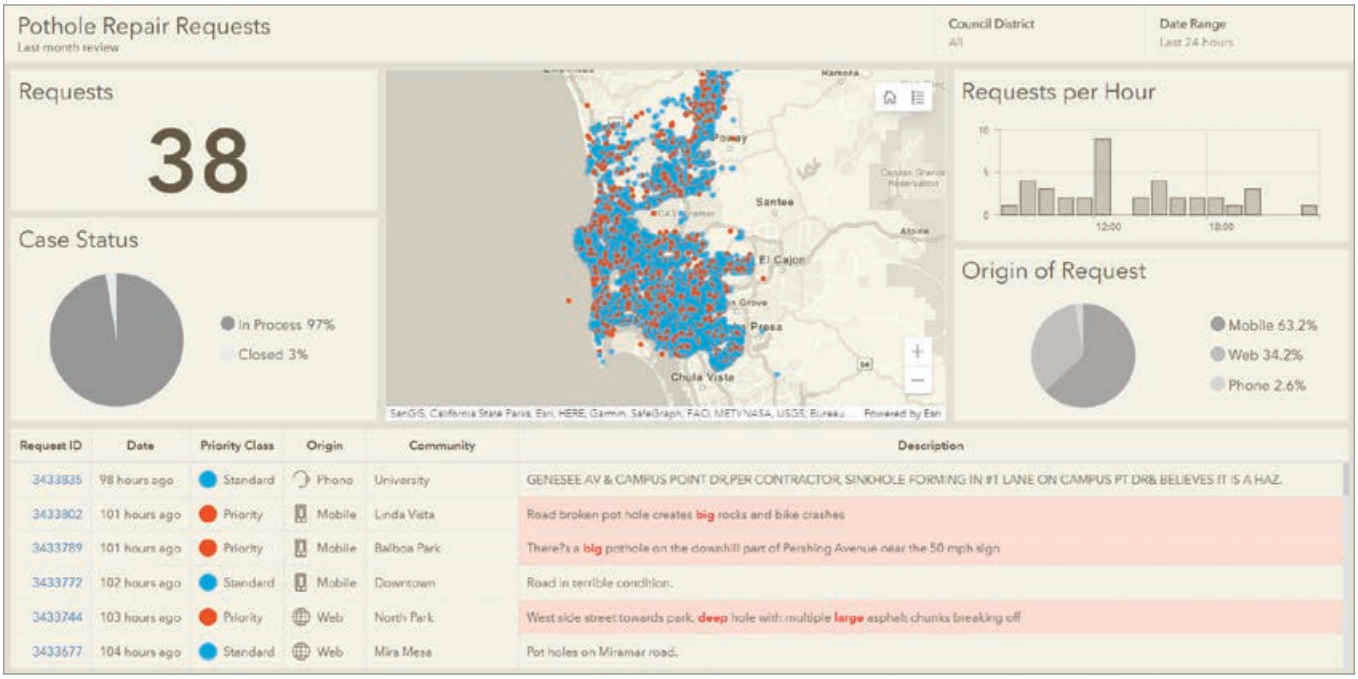
Status Dashboard

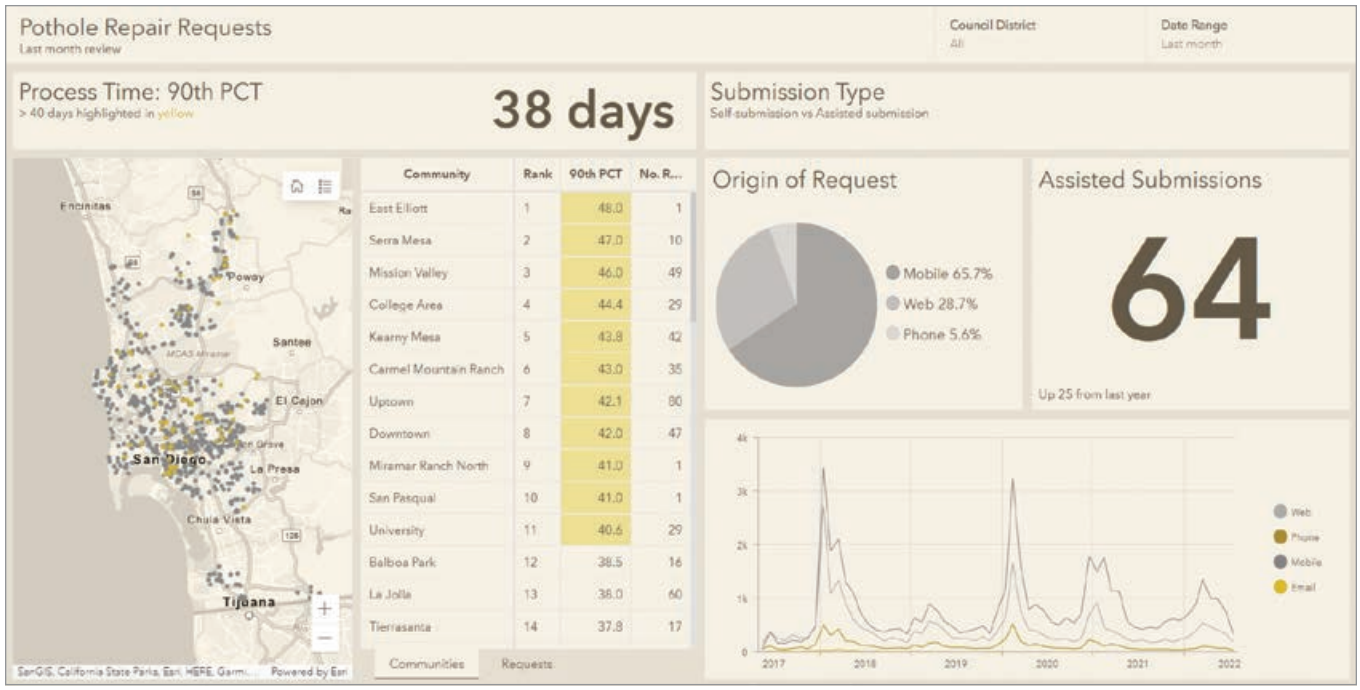
The dashboard in Figure 6 distinguishes priority requests that need immediate review based on descriptions containing one or more concerning keywords. Red dots on the map and in the table highlight potentially dangerous road conditions. The right column of the table highlights the keywords for which it was flagged, making review quick and effortless. For details on how the table in this dashboard was made, see the blog post "Arcade tips for tables in ArcGIS Dashboards" (https://bit.ly/3e3MJX7).

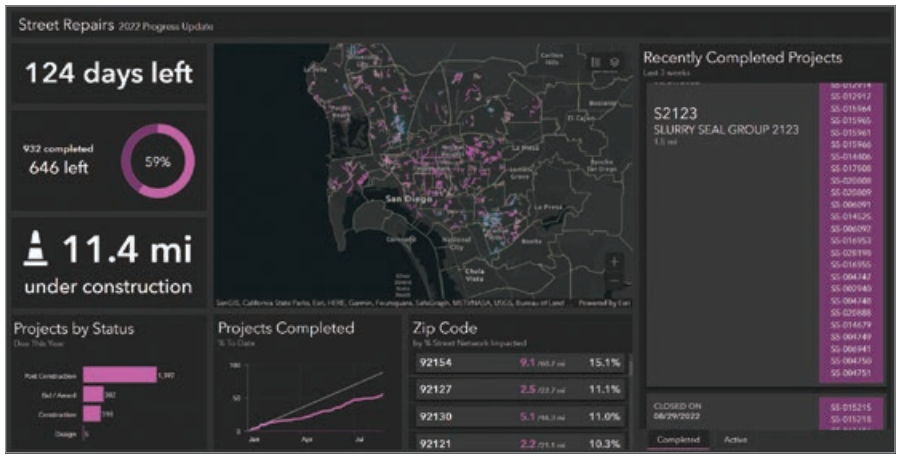
↓ Figure 5: This monitoring information dashboard displays public data.

↓↓ Figure 6: This monitoring status dashboard provides situational status at a glance.









↑↑ Figure 7: This monitoring performance dashboard measures key performance indicators (KPIs).

↑ Figure 8: This monitoring progress dashboard shows how projects are progressing to completion.

Now, say in this scenario that the department of transportation has implemented two initiatives that require all requests to be processed within 40 days, and all submissions must be made digitally. Submissions that are called in or emailed will be phased out. To evaluate the key performance indicators (KPIs) associated with these initiatives, I could make the performance dashboard as shown in Figure 7.

Performance Dashboard

In the dashboard shown in Figure 7, an overall 90th percentile process time is displayed along with this metric for each community. The communities exceeding 40 days are highlighted. The right side of the dashboard provides an overview of submission types. By reviewing the indicator and line chart, viewers can quickly get a picture of how both assisted (nondigital) submissions are trending.

Progress Dashboard

The dashboard in Figure 8 provides information on repair projects to learn what's being done to fix things. Each year, the department of transportation plans large and small projects. Each project has planned start and end dates to ensure projects stay on schedule.

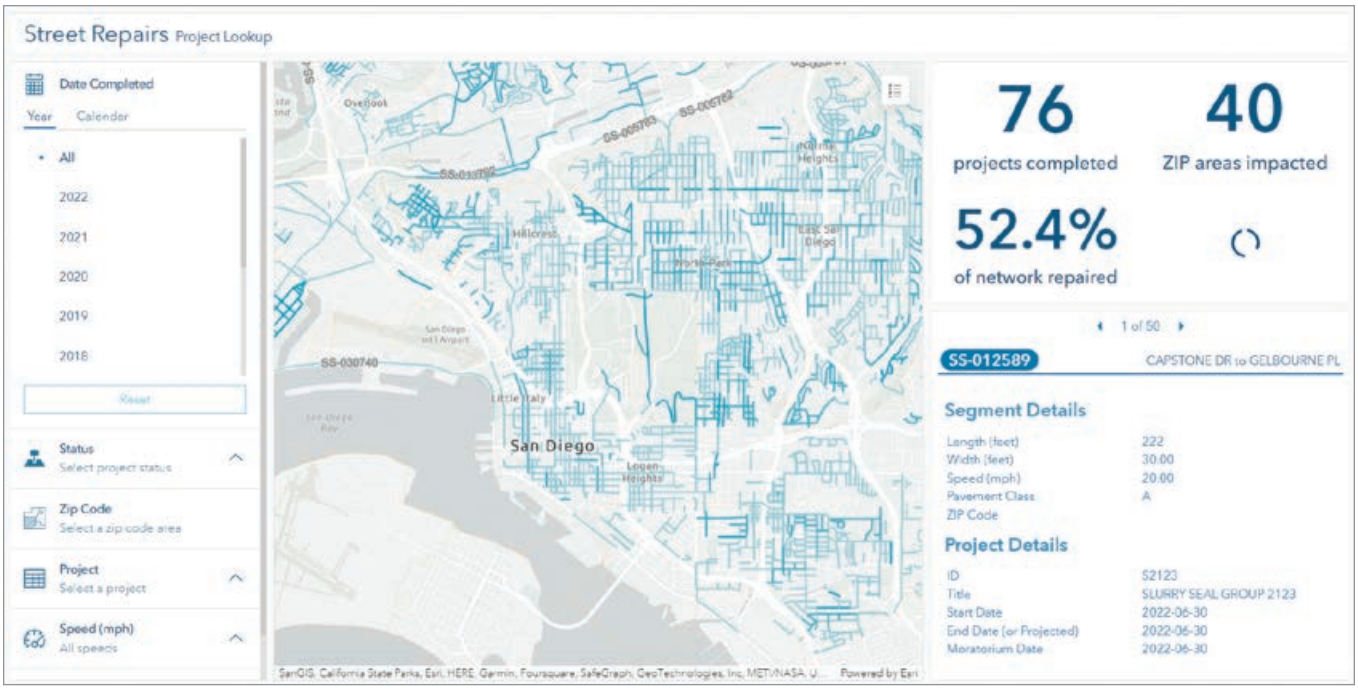
For projects that have a clearly defined start and end date, a dashboard can be a useful way to communicate progress, or percentage of project completion. To monitor projects, the dashboard shown in Figure 8 summarizes active projects and shows whether things are on schedule to be completed by year-end.

The upper left area of the dashboard shows how many days are left in the period and the percentage of completion. Under that, the number of miles currently under construction for all projects is displayed. The line chart at the bottom shows whether projects are on track.

Analysis Dashboard

As project managers review the details in the dashboard, they will almost certainly have questions such as:

- Which projects are currently active?
- Which communities are impacted by extended construction times?
- How does current performance compare with previous years?



↑ Figure 9: This monitoring analysis dashboard compares current projects to ones from previous years.

To answer these types of questions, I created the analysis dashboard in Figure 9 to filter data by certain criteria. With a series of selectors to look up data for a particular time frame, status, and geographic region, this dashboard can provide quick answers. In addition to visualizations, filtered data can be downloaded in CSV format for easy dissemination or further review.

Dashboards can be used for many different purposes. Knowing the purpose informs design decisions. Each type of monitoring dashboard displays and elevates different information. By having a clear understanding of what you want to communicate, you can design your dashboard to be effective.

If your dashboard contains a lot of data, consider splitting it into multiple dashboards. If you need a single resource from which your dashboards can be accessed, consider embedding them in an app.

Additional Considerations

Here are a few more things you may want to consider: designing for mobile devices, making color choices that account for color-blind individuals and cultural sensitivities, planning modifications to dashboards or charts when data accumulates or the relevancy of metrics change, and making dashboards that can scale.

See the following resources:

- "Strategies & Best Practices for Using Dashboards on Your Smartphone" (https://bit.ly/2KtwN0D)
- "Choosing the right colors for your dashboard" (https://bit.ly/3KqE3WT)
- "Build highly scalable dashboards" (https://bit.ly/3KokKgC)

By having a clear understanding of what you want to communicate, you can design your dashboard to be effective.

About the Author

Dave Nyenhuis is a product engineer and UX designer at Esri who is on the ArcGIS Dashboards team. He enjoys geeking out on data visualization, advancing real-time GIS, and sketching new dashboard features on whiteboards.

GIS Bookshelf

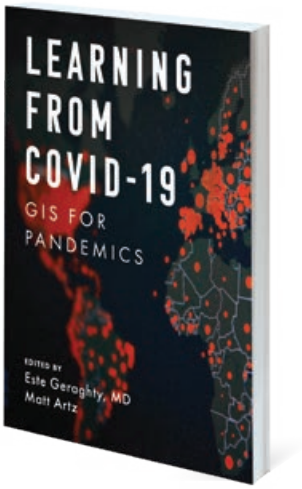
Designing Our Future: GIS for Architecture, Engineering & Construction

Edited by Kathleen Kewley, Micah Callough, and Keith Mann

Location intelligence is changing how land development and large infrastructure projects take shape. This book provides an overview of why and how architecture, engineering, and construction (AEC) firms worldwide are using GIS and location intelligence to strengthen their design practices; realize greater operational efficiency; improve the livability of cities, workplaces, and campuses; and share information throughout the life cycle of the building. Whether building a new residential complex or planning a high-speed rail system, taking a geographic approach generates better, more sustainable designs. *Designing Our Future: GIS for Architecture, Engineering & Construction* shows how architects, engineers, and construction professionals implement GIS to improve workflows; bring context to large projects; and increase collaboration among governments, contractors, partners, and the public. Esri Press, 2022, 120 pp. Ebook ISBN: 9781589487246 and paperback ISBN: 9781589487239.

Learning from COVID-19: GIS for Pandemics

Edited by Este Geraghty and Matt Artz



As the health community examines the worldwide response to the COVID-19 pandemic, part of this process includes improving the level of preparedness for the next public health emergency. Coedited by Esri chief medical officer Dr. Este Geraghty, this book highlights best practices, key GIS capabilities, and lessons learned during the COVID-19 response that can help communities prepare for the next crisis. *Learning from COVID-19: GIS for Pandemics* gives real examples of how spatial thinking became invaluable for both local and full-scale outbreaks of COVID-19. Answering the question of "where" was paramount, and when civic leaders and public health agencies used GIS to do real-time disease surveillance, it transformed overwhelming amounts of data into valuable and actionable intelligence. Esri Press, 2022, 204 pp., Ebook ISBN: 9781589487123 and paperback ISBN: 9781589487116.

Protecting the People: GIS for Law Enforcement

Edited by John Beck and Matt Artz

This is a collection of real-world stories from law enforcement agencies across the United States that are using GIS to improve crime analysis, streamline operations, increase citizen engagement, and enhance field mobility. Through these accounts, *Protecting the People: GIS for Law Enforcement* illustrates how police departments and law enforcement organizations employ GIS to drive decision-making in everyday operations. Esri Press, 2022, 114 pp. Ebook ISBN: 9781589487307 and paperback ISBN: 9781589487291.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INSPIRED TO PURSUE A CAREER IN GIS

By Rosemary Boone, Alexa Vlahakis, and Raquel Perez

↑ YoLani Martin, a geospatial analyst for Esri partner Dewberry Engineering, is passionate about humanitarian initiatives.

YoLani Martin is passionate about applying GIS to humanitarian initiatives. She has participated in initiatives for the Humanitarian OpenStreetMap Team, YouthMappers, and the Healing Yemen project. A geospatial analyst for Esri partner Dewberry Engineering, she produces datasets used in emergency management analysis and runs machine learning models to predict damage to buildings. Members of Esri's industry marketing team interviewed her about the path that led to her career.

Q: WHAT DO YOU LOVE ABOUT GIS?

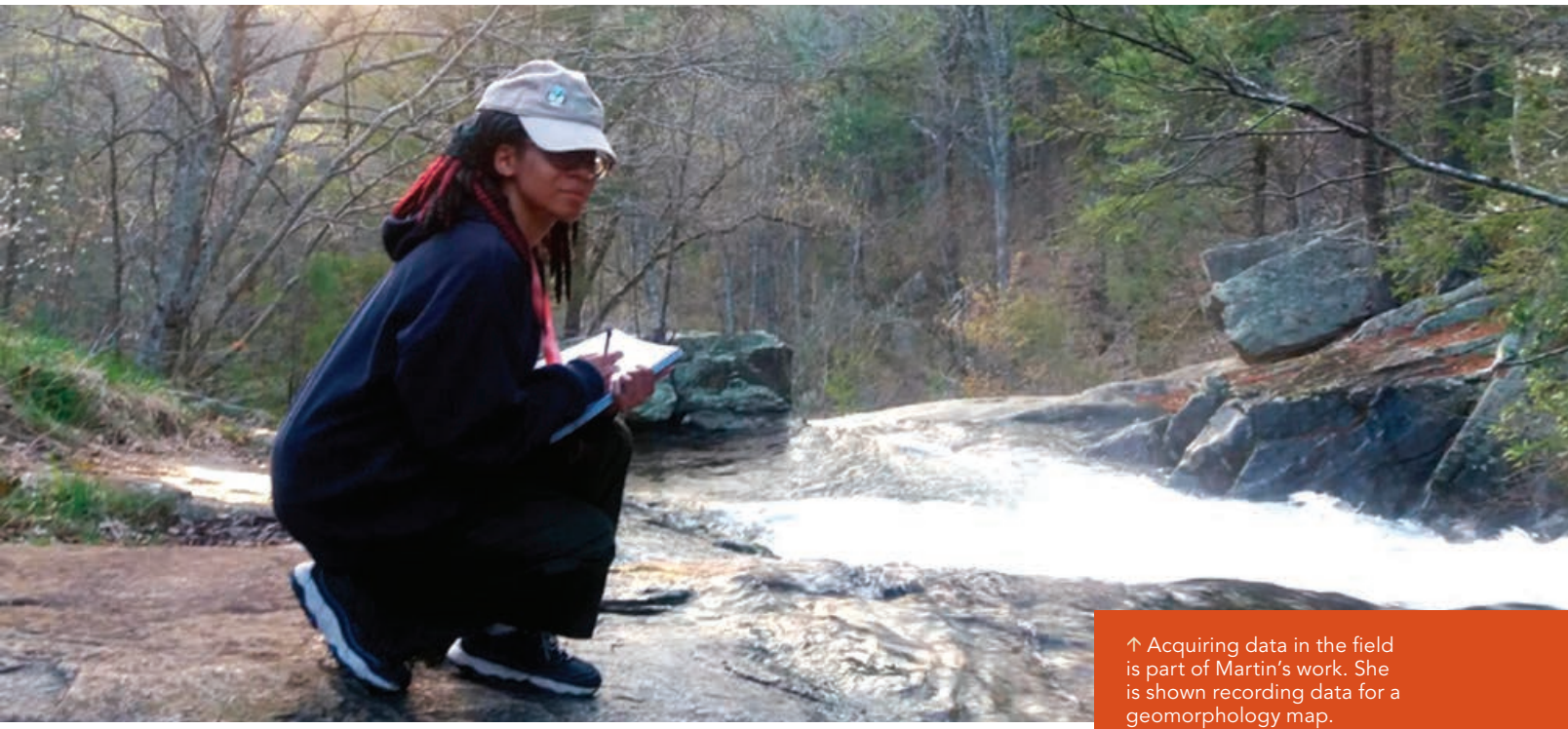
A: What I love about GIS is that it gives people a better understanding of their communities and can encourage them to shape their surroundings for the better. GIS is a tool that not only helps one share stories but rather makes them think critically about how they're telling the story.

Throughout my career and education, GIS has been a versatile tool in many fields. I've had the pleasure of applying GIS to geological mapping, historical archiving, web apps, graphic design, and so much more. One of its greatest applications is to humanitarian initiatives. Despite all the data that is discussed in news, there is still so much spatial data that communities lack.

I've participated in many initiatives to collect and edit critical data for remote communities through the Humanitarian OpenStreetMap Team; collaborated and developed training workshops with YouthMappers; and have even started my own projects to bring awareness to issues, such as the Healing Yemen project *[a website project with resources dedicated to discussing the civil war in Yemen and how to get involved in awareness]*.

Q: HOW DID YOU GET YOUR START IN GIS?

A: I was first introduced to GIS when I was a senior in high school. I had a science teacher *[who thought that GIS would]* be a good fit for me. It was a course that really challenged me because I usually get things right off the bat. We had some freedom in the projects



↑ Acquiring data in the field is part of Martin's work. She is shown recording data for a geomorphology map.

we got to research, and through the course of that, I was able to see the many humanitarian applications that GIS had. It was very inspiring to see *[that]* maps and data can really make an impact—especially *[in]* remote and rural communities. That sparked an interest, and I carried that throughout college and *[now]* find different ways to bridge GIS wherever I can. I double majored in geography and geology and did a GIS internship in college. Now I am mapping away at Dewberry.

Q: HOW ARE YOU USING GIS IN YOUR CURRENT ROLE?

A: I wear many hats. One of my responsibilities is remote sensing. Through a remote sensing lens, a lot of my duties involve performing quality assurance and performing quality control over orthoimagery the imagery we receive from different clients. One of which is the Pennsylvania Emergency Management team. We review their imagery so they have up-to-date images for next generation 911 emergency management.

We also use imagery for our lidar projects. Through those projects, we do a lot of lidar editing and cleaning up of data that we acquire from in the field. We might edit point cloud data, collecting break lines and editing them to ensure we develop bare earth digital elevation models.

I also helped develop web application tools for clients who need another way to manage their projects. Some of this is through ArcGIS Experience Builder and ArcGIS StoryMaps to better communicate some of the data quality that we control through lidar. I also help develop internal cartographic materials as well, on a request basis.

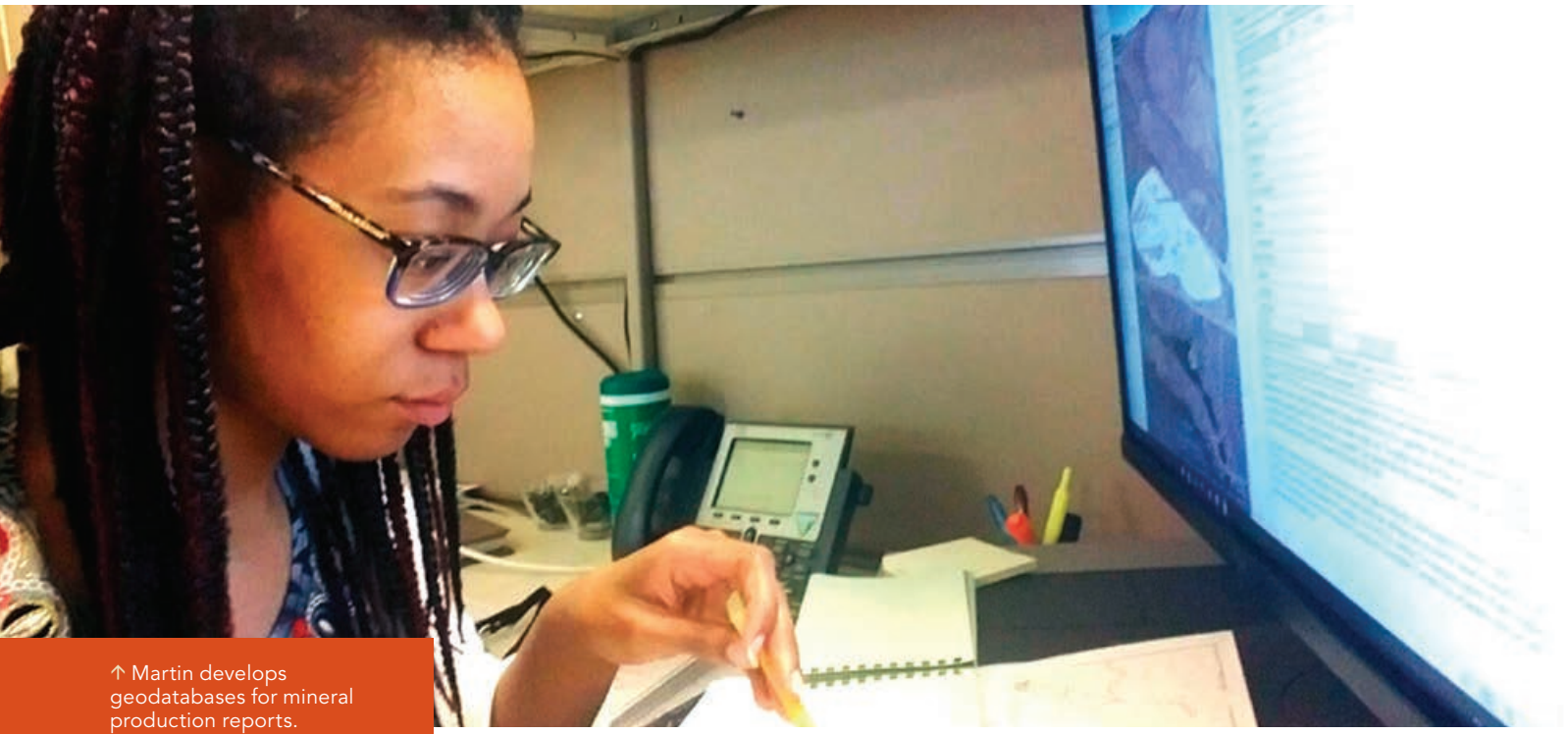
Q: WHAT GIS PROJECTS HAVE YOU WORKED ON?

A: The geography club that I was a part of at George Mason University was a local chapter of YouthMappers, where we would work together to collect open-source data through OpenStreetMap, with the Humanitarian OpenStreetMap Team. We would schedule different map-athons to develop different maps for communities in need.

The Healing Yemen project (https://healingyemen.wixsite.com/healingyemen) was a personal project of mine that I started in the beginning of 2020. I started noticing a trend in topics related to Yemen, asking, Where is Yemen? Having a geography and geospatial background, seeing this "where" question pop up was a big indicator of a gap *[in]* knowledge *[of]* location. Once you understand the where, you start to understand why certain events are happening in specific areas.

Going off that knowledge and background of different courses, I started to reach out and consolidate resources specific to Yemen. During this consolidation, I developed a resources hub for people to go to so that they can educate themselves on the crisis and details of where they can go to provide support to this area or just begin to have the conversation about what we could do to help support them.

It was about taking all the resources out there on specific projects and consolidating them into a website where you can find



↑ Martin develops geodatabases for mineral production reports.

reading materials and video links. With all those resources in one place, you can take a step back and see where we can fill in gaps or start talking about where we can better provide support.

Q: DID YOU DO ANY GIS INTERNSHIPS IN COLLEGE?

A: Yes, I held an internship with the *[Department of the Interior]* Bureau of Land Management as a geology and GIS research assistant. My responsibilities were developing infographics to better communicate what the division salt and minerals were. I was incorporating different data visualizations and geospatial visualizations. I was working on geodatabases for field specialists to better manage and have access to different minerals through a geospatial lens.

Q: DID YOU HAVE A MENTOR, AND WAS IT IMPACTFUL?

A: Yes, I had a mentor during my internship at the Bureau of Land Management—my immediate supervisor would always check in on me. One of *[the]* things that he said to me that I still carry with me today was, "Never say you're bad at something." For example, I said, "Sorry I'm taking so long; I'm bad at math." He replied, "You're not bad at math; it's a skill you're improving." Those words stuck with me, and *[now I]* look at something from that perspective. He's been a tremendous influence *[on]* my career and self-confidence and an all-around amazing mentor.

It can be intimidating to try and ask, Can you be my mentor and share your knowledge, because I need guidance? If emerging young professionals are struggling to find that mentor, don't be afraid to send that email, because it's worth it. Or if you happen to bump into a potential mentor at a conference or school event, you can put yourself out there by saying, "That was a great talk you gave; I would love to learn more about it. Would you be open to connecting and talking more about this over a cup of coffee in person or *[virtually]*?"

Q: WHAT TRAINING WOULD YOU RECOMMEND TO OTHER YOUNG PROS?

A: I would recommend the Esri training courses because they are phenomenal. The Esri MOOCs *[massive open online courses]* are a great resource as well.

Q: HOW DO YOU SEE YOURSELF USING GIS IN THE FUTURE?

A: Looking ahead, I would really like to use GIS and geography to better communicate what seems complex on paper and turn it into a visual representation. I am very much interested in using GIS for humanitarian purposes and communicating the why of what is happening—not just humanitarian but local communities as well that need to have their stories told.

Q: WHAT ADVICE DO YOU HAVE FOR STUDENTS AND YOUNG PROS?

A: My best advice to other emerging professionals is that if there is something you are passionate about or you have an idea that seems too difficult to achieve—do it. Break your ideas down into smaller, more manageable steps and work from there. Maybe you don't have many resources at your disposal, but if you believe it's an idea worth pursuing, use what you do have as a starting point. Being resourceful is all a part of GIS as you research and develop data.

It's never too late or too early to learn new skills regardless of what stage of your career you're in. Often, it feels like you're more behind than you are ahead when you're trying to build your expertise. If you're interested in learning something new, take your time and explore those skills. Invest in yourself because you deserve to learn and grow.

If something is taking you a long time to work, try and accept that it's perfectly OK and just continue to go at your own pace—especially in the technology field. It's very easy to compare the pace of your projects to others. Once you start doing that it, negative thoughts can begin to snowball.

So, if you encounter that, it's crucial to take a step back and reflect on how far you've come—that and the fact that you're taking an initiative to take on this question is a huge win for yourself. Just remember that this research or project is special because you're doing it, and no one else is going to have that exact curiosity and passion that you're bringing to that project.

About the Authors

Rosemary Boone is a senior industry marketing manager for Esri. Her work is focused on executing marketing strategies for K–12 schools and higher education institutions. She holds a master's degree in education technology with an emphasis on multimedia. Prior to her career in marketing, she taught elementary school and taught overseas.

Alexa Vlahakis is an associate industry marketing manager for Esri, who supports conservation and education activities. She holds a bachelor's degree in communication studies with minors in human relations and mass communication/journalism from the University of Iowa.

Raquel Perez is an industry marketing manager for Esri. She develops marketing strategies for conservation, climate change, earth sciences, and Esri's federal partners. She also manages Esri's Young Professionals Network. Perez holds a master's degree in management from the University of Redlands and a crime and intelligence analysis certificate from her previous career as a crime analyst.

↑ Martin performs safety inspections at a mineral materials rock quarry along the Dalton Highway in Alaska.

Master a Career in a Growing Field

In August 2022, the University of Redlands welcomed Cohort 42 to the Department of Geographic Information Science, marking the program's twentieth year offering personalized GIS graduate education. Since its inception, more than 450 GIS professionals have graduated from the program and are pursuing careers in consulting firms, health care, nonprofit organizations, local governments, businesses, and other fields.

According to the US Department of Labor, the need for people who understand geospatial technology and can apply it is expanding. The skills now required range from software proficiency to programming and data management and analysis. This demand will continue as geospatial technology is applied to an increasing number of industries and disciplines, from emergency management and public health to business, transportation, and urban planning.

This has led to a substantial increase in Master of Geographic Information Systems programs since 2000 that provide a professional education and include general business and management skills as well as technology-specific knowledge and software skills. A master's degree in GIS provides the expertise in geospatial technology and management to succeed in the public or private sectors.

The University of Redlands Department of Geographic Information Science offers two graduate degrees: a master of science in geographic information systems (MS GIS) and a master of GIS (MGIS). Each year, two cohorts of students are enrolled. The program has four full-time faculty and adjunct faculty from the Center for Spatial Studies and Esri.

The MS GIS degree is designed for professionals and recent undergraduates who want to enhance their knowledge of the analysis, management, and communication of geographic information. It is available as a one-year program that includes 10 months of coursework and the completion of a major individual project that addresses the needs of a real-world client. The two-year program consists of six 14-week semesters that include summer attendance. Graduates from either program will gain an in-depth understanding of geographic information systems and theory and develop strong technical skills.

The MGIS degree is an accelerated program for professionals who want to deepen their knowledge of the analysis, management, and communication of geographic information. The in-person program consists of 8 months of coursework and a 400-hour internship. Coursework for the online program spans 20 months and includes a 400-hour internship.

Both master's degree programs include six Esri training courses covering the use of ArcGIS Pro, ArcGIS WebApp Builder, and ArcGIS Enterprise and include topics such as geoprocessing scripting, managing geodatabases, and sharing GIS content. Students also have unlimited access to Esri online training classes.

Blythe Spendlove, who graduated with an MS GIS degree in 2018, is a business systems analyst for the Southern California Gas Company. While completing her bachelor's degree, she took an introductory GIS course and fell in love with the discipline. When she was considering pursuing a master's degree, she realized that GIS could be a smart career move if she found the right school.

"I didn't want to go to a school that just taught students how to use GIS programs," she said. "I already knew that. I wanted to dive deeper into the science of GIS. Ultimately, I chose the University of Redlands because I felt it would give me the best education."

Her coursework, which included GIS programming, remote sensing, projections, and project and database management, provided her with a solid foundation that has allowed her to excel in the field.

To learn more details about the MS GIS and MGIS degree programs, visit the Department of Geographic Information Science website (https://bit.ly/3dxWtsB), email gis@redlands.edu, or call 909-748-8128.

Optimize GIS Education Results

Esri instructor-led training classes are designed to help students obtain the specific knowledge and skills required to achieve the learning outcomes that are important to organizations and the individuals who attend these classes.

In 2021, Esri developed and released preclass and postclass assessments to help identify learning goals and measure to what extent they were achieved during the course. Optional and online, these assessments are designed to work together. They supplement instructor-led class readiness assessments, which determine if a course is appropriate for a potential student based on the prerequisite knowledge and skills defined for the course. Together, these assessments help ensure student success.

All three assessments are now found in a single location: on the My Assessments page under the My Academy section. This section has all available assessments as well as the results for assessments that have been taken.

It's also the place to review recommendations to materials that reinforce understanding of course content or take readiness assessments for any instructor-led courses listed, with or without registration in that class. Readiness assessments are also a convenient way to identify e-Learning resources to use in generating learning plans tailored to individual needs. The My Assessments page is a great way to grow an ArcGIS skill set, measure progress, and achieve GIS-related goals.

Microcredential Program Ensures *Workplace Success*

By Cassandra Galindo

A new microcredential program offered by Monroe Community College (MCC) in Rochester, New York, enhances students' skill sets with specialized training in geospatial data acquisition and management, web mapping, and geospatial programming.

Designed to meet industry trends in modern GIS and emerging workforce needs, the program can be taken on its own, or credits can be applied to a Geospatial Information Science and Technology (GIST) certificate and associate of applied sciences in geography degree with a concentration in GIS. For more than five years, MCC has offered courses in GIS technology, remote sensing, cartography, spatial analysis, and a capstone course as part of an online 24-credit GIST certificate program and the associate degree.

According to 2019 Bureau of Labor Statistics findings, the geospatial job market was projected to grow faster than the average growth for other occupations. In response, MCC launched a nine-credit microcredential program in 2021 to keep pace with modern GIS skill sets.

"When it comes to modern GIS, these courses are touching on what is new in this industry—problems like streamlining GIS workflows, using dashboards, and how to create or modify scripts," said Nia Beazer, a recent MCC graduate. "We are not going to touch on everything because we only have so much time in these courses. But we've dabbled in a little bit of everything, which has prepared me so much for my future in this industry."

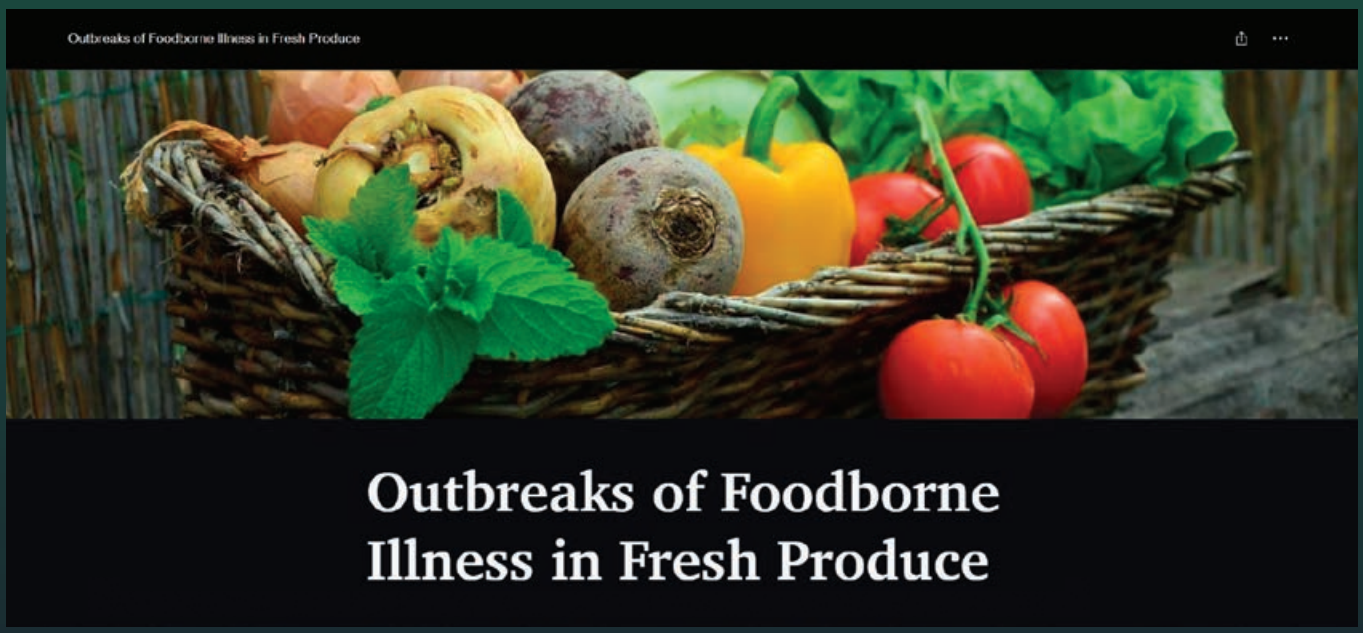
Students can either enroll in three classes to earn the microcredential or use the earned credits toward a GIST certificate or the new associate degree in GIS. Funding for the new degree and microcredential came from the National Science Foundation, which also offered support through its Integrated Geospatial Education and Technology Training (iGETT): Remote Sensing project and the Advanced Technological Education Mentor-Connect Program.

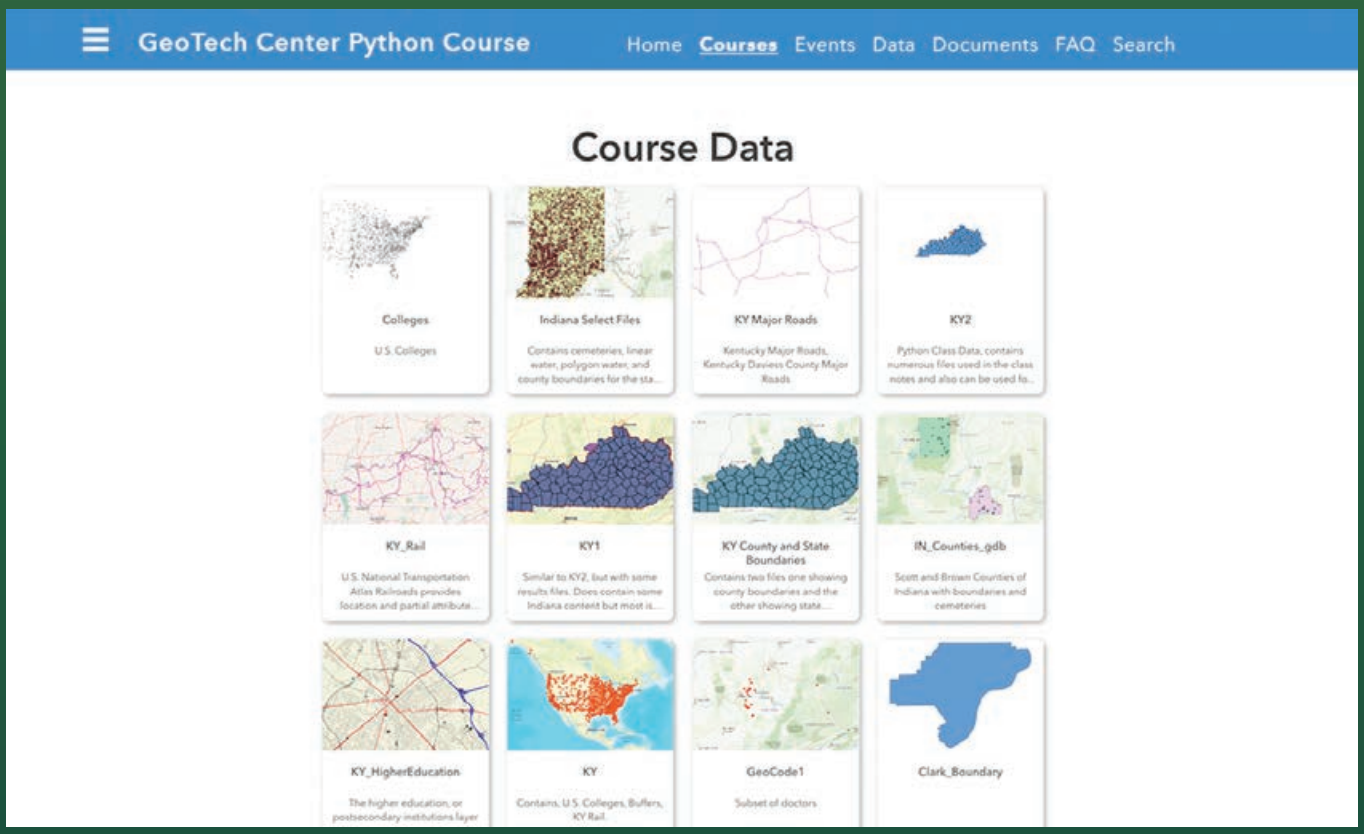
Building a Curriculum That Reflects How GIS Is Used Today

To develop the coursework, Jonathon Little, associate professor of geography and GIS at MCC, sent a survey to geospatial professionals across the state who subscribed to two GIS list servers maintained by the New York State GIS Association and the Geographic Information Sharing Special Interest Group.

"We were really trying to get a feel for our local or state GIS needs, and I think it proved very valuable," Little said.

↓ This ArcGIS StoryMaps story was made by MCC student Angela Ager as a final course project for the microcredential program.





↑ As part of her internship at the National GeoTech Center, Nia Beazer created a hub site to house all the Python courses and data that other institutions could use for their courses.

The survey asked them to assess topics and skills that were most desired in the workplace. It revealed the specific skills and technological knowledge needed in the workforce. The survey also revealed that professionals who had graduated several years earlier needed to learn new skills such as web mapping or programming with Python.

"Our goal in developing these courses was to bring geospatial awareness to traditional students and upskill incumbent GIST professionals," said Little. With colleagues Wayne Howard and Heather Pierce from the chemistry and geosciences departments, Little developed three pillar courses that focused on geospatial data acquisition and management, web mapping, and geospatial programming. These topics addressed competency skills that were identified in the survey and were based on feedback from the college's GIST advisory board.

Additional feedback was given by members of the National GeoTech Center, a National Science Foundation-funded organization that provides GIST educators with curriculum resources and model core competencies that meet workforce needs. The courses at MCC needed to reflect how GIS is used today and ensure that students would be competitive job applicants.

Beazer used ArcGIS StoryMaps to create a series of maps comparing the size of urban populations with the rate of urban population change in Africa.

"In the first year, we have already received feedback from students telling us, 'This course is why I received the job,' which is amazing," said Little. "The program has a lot of interest from professionals across the state." The program has seen tremendous growth this past year, with 150 new students enrolled in the introduction to GIS course and more than 40 new students enrolled in both the web mapping and remote sensing courses. In 2021, nearly 150 students completed the microcredential interest form for the upcoming year.

The curriculum includes classroom and lab experiences for students to learn specialized software like ArcGIS Dashboards, ArcGIS Field Maps, ArcGIS Hub, ArcGIS Online, ArcGIS Pro, ArcPy, and ArcGIS Survey123. In addition to the coursework, students are required to create a portfolio using ArcGIS StoryMaps to showcase their best work and sign up for a LinkedIn profile to begin professional networking.

The combination of flexible online courses and detailed preparation for students to enter the workforce is what drew Beazer to MCC's GIST programs. Beazer decided to change careers in early 2020, just before the pandemic started. "I've watched my husband *[work in GIS]* for years, and I knew I had to do this too. I absolutely love it."

For one course project, Beazer created four maps representing safety, shelter, donation, and relief efforts conducted during the 2021 La Soufrière volcanic eruption in St. Vincent and the Grenadines (SVG).

As a mother caring for two young children at home during the pandemic, flexibility was a must-have for her associate studies.

"When I read about MCC's fully remote program, I knew it was the one for me," said Beazer.

Modern GIS Education Is Workforce Preparation

While Beazer pursued the associate of applied sciences in GIS degree, she also earned the GIST certificate and microcredential credits to advance her skills. Some of the advanced GIS topics in her coursework included unmanned aerial system (UAS) data collection and processing, mobile data collection, automation using Python, and the enterprise geodatabase. "We touched on so many things," said Beazer.

For Beazer, the web mapping course was a favorite because she learned the usefulness of applications, Web GIS tools, Google Earth, Google Maps, ArcGIS Online, and ArcGIS Hub, which proved essential in her internship at the National GeoTech Center. She created a hub site to house all the Python courses and data that other institutions could use for their courses. Beazer also learned to automate the production of a map series using Python in her introduction to programming course.

"This was my first time learning how to customize and automate GIS applications using Python scripting language," she said, noting that in almost every advertised job she sees, recruiters are looking for applicants with Python experience.

Alumni mentors, led by Catherine DuBreck, work with students to ensure they understand the material and offer career advice as they prepare to enter the geospatial field. For Beazer, having a mentor to work with her through every step in her programming course was key to her final project's success. "It's great to be able to communicate with someone who's been exactly where you are, and they ended up becoming successful in this industry."

For Little, ensuring students succeed in the workplace was key to the microcredential program. MCC staff will continue to evolve the program to keep pace with GIS advances. The program meets students where they are in their careers. "As technology changes, the courses are going to be changing, and we'll be modifying them as needed based on feedback from the advisory board," said Little.

Little also hopes to expand the classroom curriculum to include challenges facing the global community through higher education partners in Kazakhstan, Malawi, Jordan, Colombia, Costa Rica, and Mexico. "I'm working on a grant to support diversity, equity, and inclusion through our partners in a global virtual community," said Little.

About the Author

Cassandra Galindo has been a writer on Esri's content writingteam since 2020. She has a bachelor's degree in creative writing from the University of California, Riverside, and worked in journalism and public relations before joining Esri. She enjoys reading, yoga, and hiking.

↓ Beazer used ArcGIS StoryMaps to create a series of maps comparing the size of urban populations with the rate of urban population change in Africa.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PROACTIVE GEOSPATIAL ANALYSIS TARGETS AID IN SUDAN

By Jim Baumann

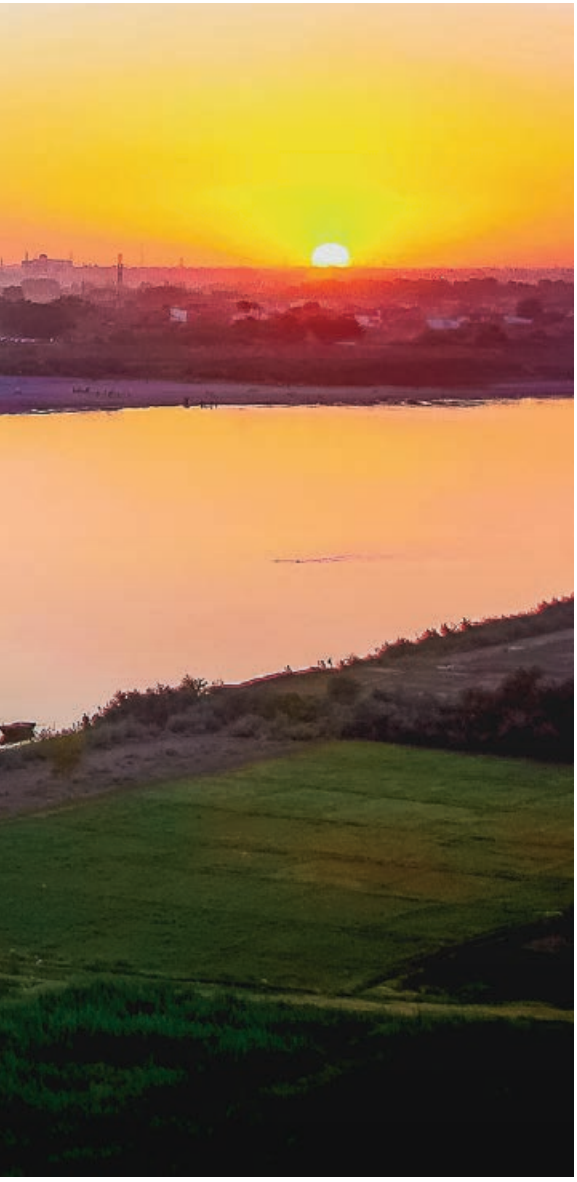
Humanitarian organizations are using ArcGIS to analyze conflicts, natural disasters, and deprivation to preemptively mitigate their effects on people in high-risk areas of the world such as the Republic of the Sudan.

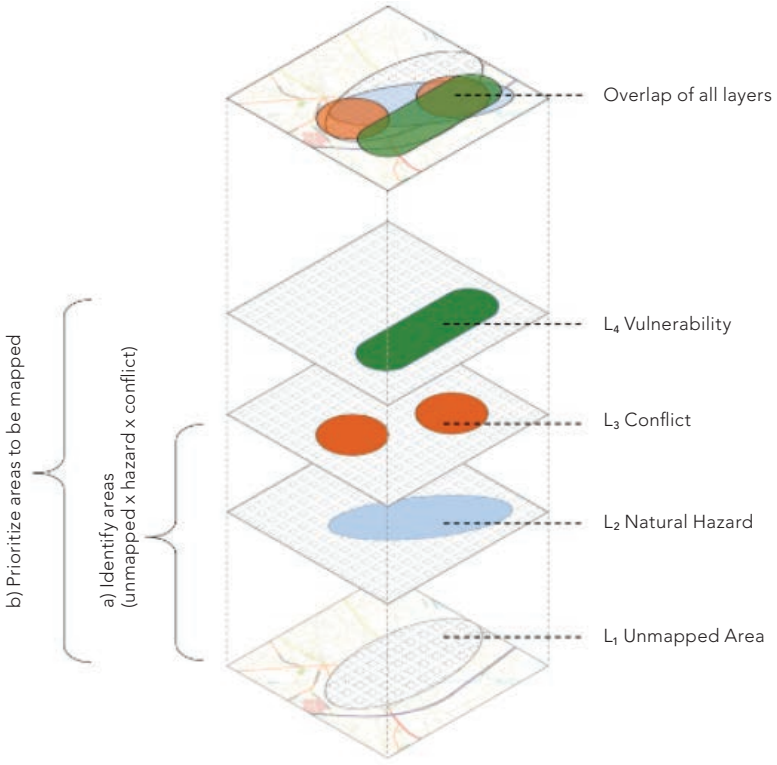
Since its independence in 1956, Sudan has suffered from numerous armed conflicts, including two civil wars. In addition to combat deaths, the famine and disease that followed claimed many more lives. According to a 2022 report by the humanitarian information service ReliefWeb, the war-related deaths is estimated at nearly two million, and the number of internally displaced persons was estimated at more than four million.

"The lack of geospatial data in conflict-affected areas hinders the planning and implementation of humanitarian aid, such as forecast-based actions (FbA) in the Sudan," said Cornelia Scholz, consultant at the Red Cross Red Crescent Climate Centre.

FbA is an innovative approach to providing humanitarian aid by using risk and threat analysis to anticipate need and facilitate the preparation of emergency service elements before a disaster strikes. This approach is faster and less expensive than traditional relief and reduces losses and suffering.

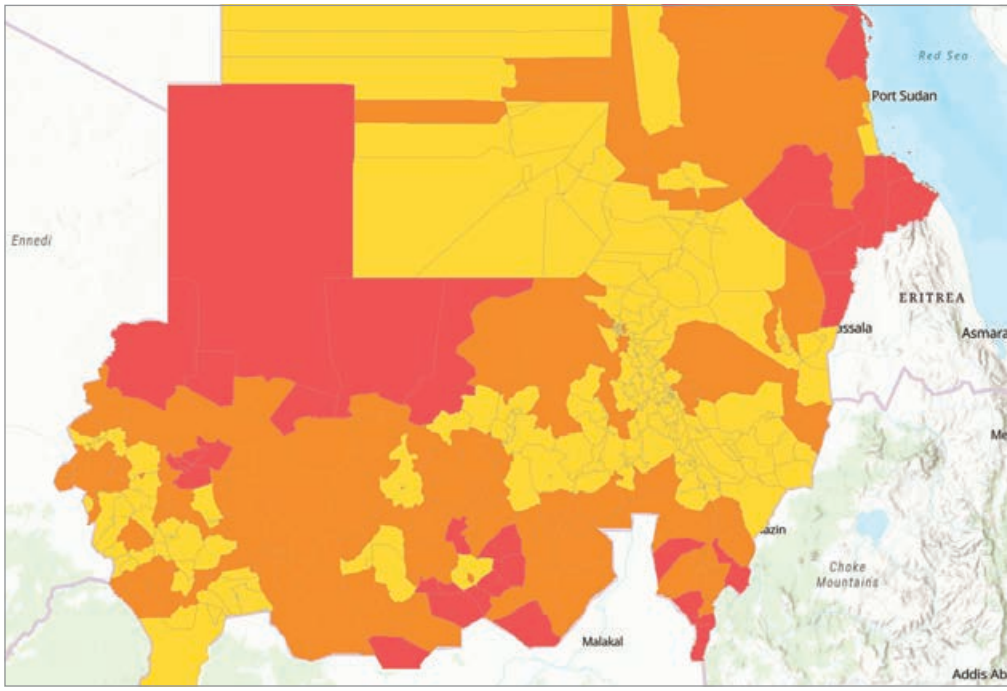
Because up-to-date maps of Sudan are often unavailable, it is difficult to identify





↑ Risk factors, such as a history of conflict, exposure to natural hazards, and other vulnerabilities, are mapped on separate layers for analysis.

↓ Food insecurity mapped by administrative area. The most vulnerable areas shown in red. 2020 data is from the Famine Early Warning Systems Network (FEWS).



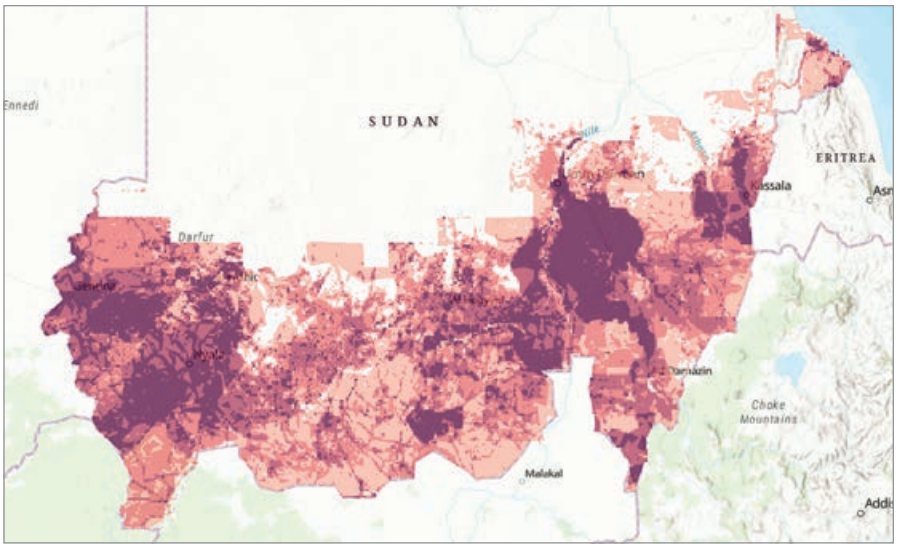
populations in the country that are at high risk from armed conflicts, disasters, and threatening factors such as poor nutrition and contagious disease. This data would allow the implementation of FbA as well as support long-term climate adaptation efforts and emergency response.

"For several years, we have been working on various mapping projects with Missing Maps to improve the quality and availability of open mapping data in data scarce areas," said Scholz.

Missing Maps, led by a collective of organizations, provides free mapping services for humanitarian organizations throughout the world. It was founded in 2014 by the American Red Cross, British Red Cross, Humanitarian OpenStreetMap Team, and Médecins Sans Frontières.

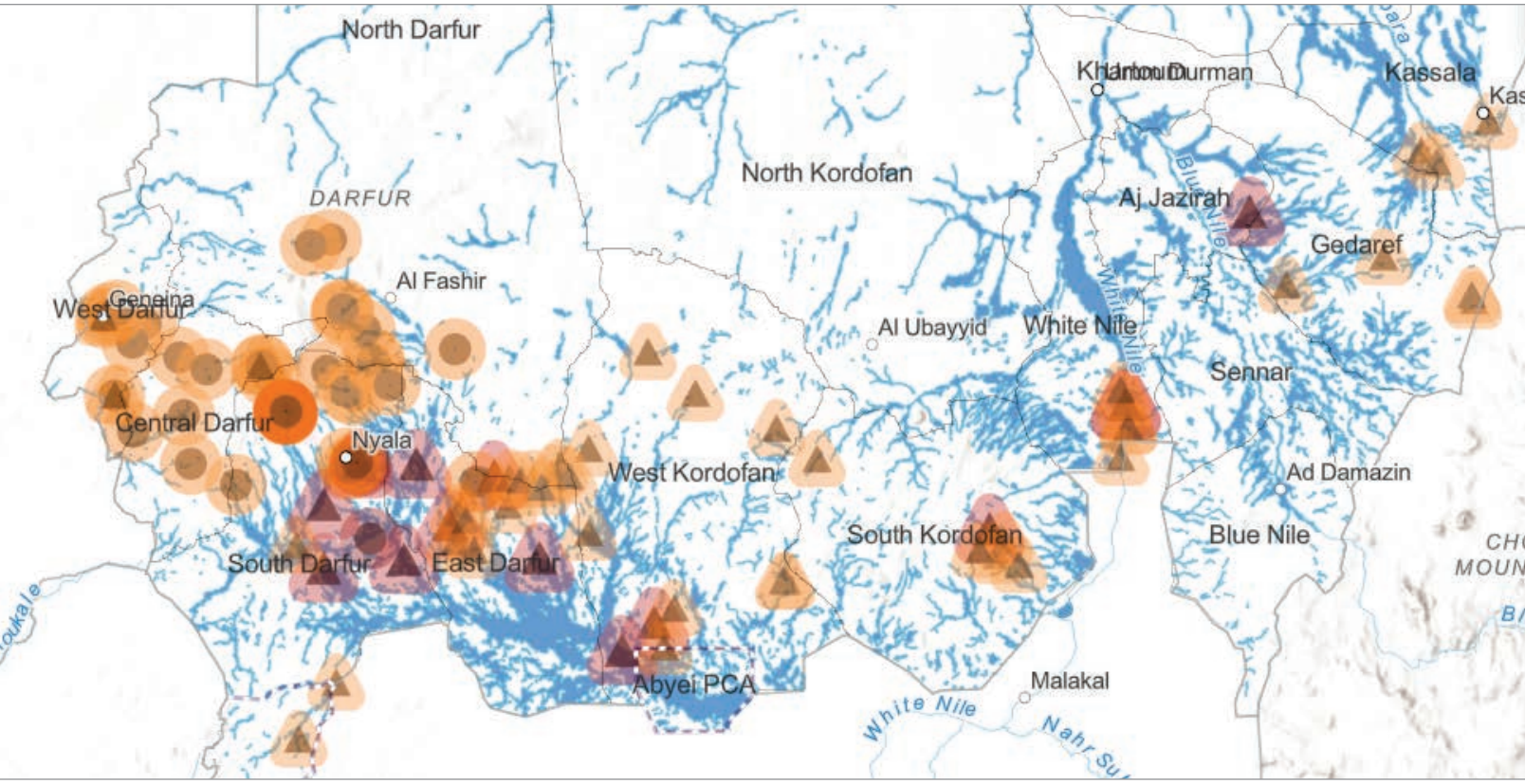
Analyzing Climate and Conflict Together

"Throughout the past year we have been working on developing a compound risk analysis of climate and conflict," said Scholz. "Basically, the analysis examines the interconnection between the various impacts affecting the Sudanese population and their cascading and cumulative effects. With the development of up-to-date mapping data for hot spot mapping of yet undetermined and unmapped high-risk areas, we can enable the planning of early actions to help mitigate the severe consequences from those impacts."



↑ This map shows where people living in the southern half of Sudan are threatened by drought. Historical drought data from 2014 obtained from United Nations Environment Programme (UNEP).

↓ Analysis combined data on flood areas with the locations of refugee camps and internally displaced persons (IDPs). 2021 flood data from FATHOM, 2019 refugee camp location data from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), and 2021 IDP data from the United Nations High Commissioner for Refugees (UNHCR).



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Cornelia Scholz
Red Cross Red Crescent Climate Centre

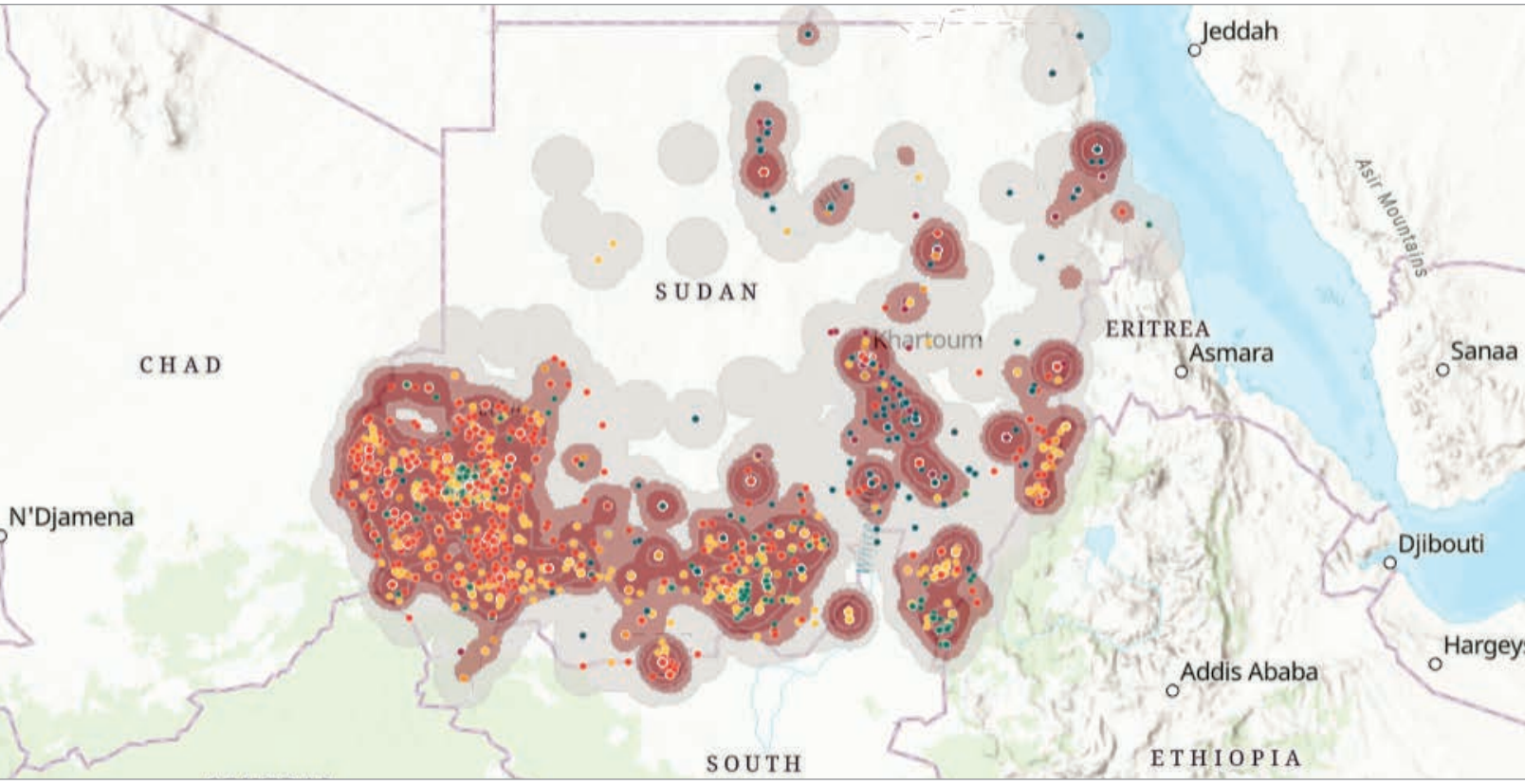
Risk factors, such as a history of conflict, exposure to natural hazards, and other vulnerabilities, are mapped on separate layers for analysis. The conflict layer includes data on reoccurring combat and hot spots that took place between 2000 and 2021 and highlights those areas that have suffered from the greatest impact from war. The natural hazard layer includes datasets on flood and drought. The layer for vulnerability includes datasets on food security, medical care, education, and the locations of internally displaced people and refugees. The satellite imagery used for the project was captured in late August of 2021 by the European Space Agency.

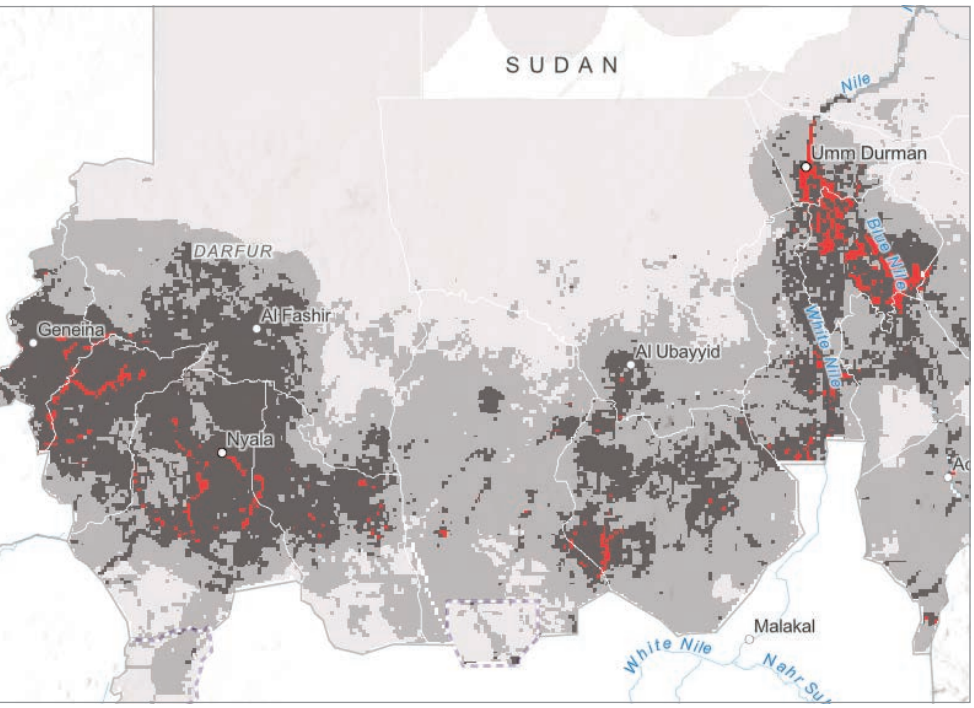
"The analysis to identify mapping data gaps of high-risk or hot spot areas was performed with ArcGIS." said Scholz. Using open-source mapping with Esri's OpenStreetMap feature layers, the datasets for flood exposure, drought exposure, food insecurity, the location of internally displaced people, and conflict hot spots were analyzed using weighted overlay. For each layer, weights were assigned by experts so that multihazard hot spot maps could be created.

This allowed the identification of geographic areas with compounding hazards. A weighted overlay of the areas was conducted, which allowed the extraction of insights from quantitative, georeferenced indexes, with weights assigned according to expert opinion to create multihazard hot spot maps.

Areas determined to have poor quality mapping data that was incomplete, outdated, or inaccurate were then prioritized for mapping, based on the

↓ Density analysis of conflict areas for 2000–2021 identified areas of historic conflict. 2021 data is from Armed Conflict Location & Event Data Project (ACLED).





↑ Analysis of conflicts, natural disasters, and deprivation factors identifies areas that are at highest risk.

open-source, georeferenced data layers. An OpenStreetMap (OSM) mapping task was developed in the HOT Tasking Manager. *[HOT Tasking Manager divides large mapping projects into smaller tasks so they can be completed more rapidly through the collective efforts of many people.]* This work was supported by Médecins Sans Frontières and led by the Netherlands Missing Maps team, with the help of a group of volunteering professional mappers, who mapped and validated the data.

Expanding the Use of the Database and Its Methodology

Information from this project has been included in the Red Cross Red Crescent Anticipation Hub to fill in missing Sudanese geospatial data for subsequent relief efforts and other initiatives.

The Anticipation Hub is a platform that promotes action and advocacy for humanitarian relief efforts. It is hosted by the German Red Cross in cooperation with the International Federation of Red Cross and Red Crescent Societies and the Red Cross Red Crescent Climate Centre, with funding support from Germany's Federal Foreign Office.

"The methodology we developed for this project provides a means of mapping uncharted territories, not only for emergency response but also anticipatory action and long-term disaster risk reduction and emergency planning," concluded Scholz. "It provides complete, accurate, and reliable geospatial data for first responders and humanitarian and development actors, as well as the country's decision-makers and residents."

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.

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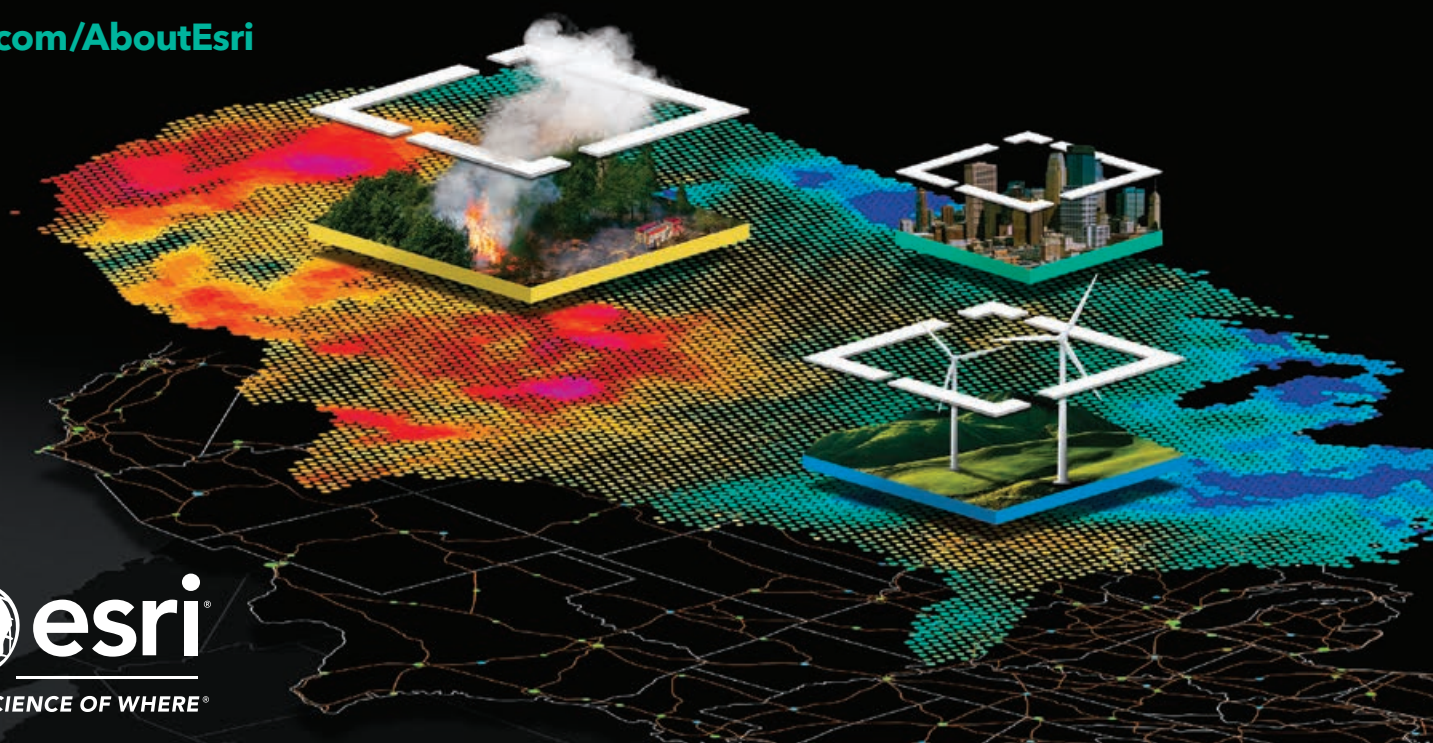

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