ArcNews

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Briefly Noted

***World Terrestrial Ecosystems* Map Released**
In partnership with Esri and The Nature Conservancy, the US Geological Survey (USGS) launched the *World Terrestrial Ecosystems* map, which breaks up the globe not by political boundaries but by areas of similar climate, landform, and land cover. "Ecosystems give us goods and services like food, water, *[and]* fuel… so we need to take care of them," said Dr. Roger Sayre, senior scientist for ecosystems at USGS and the lead on the project. "A requirement for managing ecosystems is first knowing what they are and where they are on the planet. That's why we classify and map ecosystems." The map—which is available in ArcGIS Living Atlas of the World and as an explorer tool at rmgsc.cr.usgs.gov/wtee—can be used for conservation planning, analyzing ecosystem health and resilience, formulating how to make progress toward achieving the Sustainable Development Goals (SDGs), and more.

Esri Named Leader in Understanding Climate Risk
Independent research firm Forrester recognized Esri as a leader in offering advanced data processing and visualization to help decision-makers tackle climate risks in its report, *The Forrester New Wave: Climate Risk Analytics, Q4 2022*. Esri received a differentiated rating—the highest score possible—in 9 out of 10 criteria, including advanced data processing, visualization, and threat modeling. The report notes, "If you have physical assets that could be threatened by climate, Esri can bring the data and processes to bear to target operational resiliency opportunities."

Geospatial Technology Forms Basis of Digital Twin of Pompeii

By Dr. Alex Elvis Badillo and Dr. Stephen P. Aldrich, Indiana State University

For archaeologists, the ancient city of Pompeii in southern Italy—located less than six miles south of Vesuvius, the infamous volcano that destroyed the city in 79 CE—has garnered much interest over the centuries. Yet some areas of the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site remain understudied and even largely unexplored.

Currently, a team of researchers, led by Dr. Allison Emmerson of Tulane University, is exploring Insula 14, a block in the southeastern part of the city that could reveal new information about Pompeii's early existence, how the city developed over time, its economy and infrastructure, and the lives of residents who lived on the margins. The project, called Pompeii I.14, includes a digital data initiatives team that is employing geospatial technology to more efficiently and accurately collect, organize, analyze, visualize, and share the data that's being unearthed at the site. ArcGIS Survey123, ArcGIS Pro, ArcGIS Dashboards, and web scenes in ArcGIS Online are working in concert to improve daily decision-making on the ground and disseminate project findings in compelling formats more quickly than ever.

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→ This scaled and georeferenced 3D model of Insula 14 served as the spatial reference for all subsequent 3D models made of the excavation.

Milk Bank Embraces Geospatially Focused Business Intelligence Tools

Supply chain issues beleaguered consumers throughout 2022. But perhaps none were as jarring as the baby formula shortage that distressed new parents across the United States from early summer almost through the end of the year.

One of the country's biggest formula manufacturers recalled several products in February when four infants fell ill—and two of them died—after consuming the product. The company then ceased production at one of its plants for several months after bacteria was found on-site. Wider supply chain issues and inflation hindered efforts by other US-based manufacturers to increase production, and because the United States has stringent regulations for importing formula, it was difficult to get reinforcements from outside the country. By May, more than 40 percent of baby formula was out of stock in US stores, according to retail tracking group Datasembly.

As families desperately tried to find ways to feed their infants, Mothers' Milk Bank in San Jose, California, faced drastically increased demand for the human breast milk it typically supplies to medically vulnerable infants and other families in need. Staff members at the organization recognized the pressing need to inform community members of the rapidly growing demand and seek out more breast milk donations. To do this, they turned to ArcGIS Pro and ArcGIS Business Analyst.

← An Esri Tapestry Segmentation profile of milk banks in California shows the socioeconomic and demographic characteristics of nearby populations.

Accelerating GIS Use to Find Target Audiences

Mothers' Milk Bank's mission is to collect human milk donations safely and provide equitable access to this nutritional alternative to as many vulnerable

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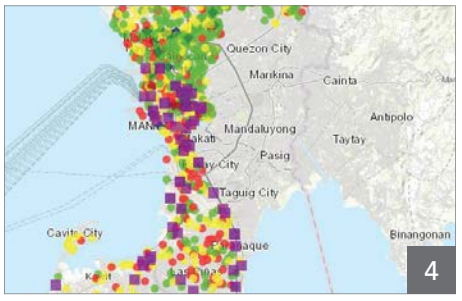
When presenting information to various groups with disparate needs, it can be a good idea to create different apps for different audiences. Follow along as the GIS team at a large organization uses ArcGIS App Builders to help the Security Operations Center get time-sensitive event and security details to those who need them.



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Esri Creates New Application for Intelligence Analysis

ArcGIS AllSource Integrates Disparate Information Sources to Facilitate Advanced Analytics

For intelligence organizations and agencies that manage and respond to national security, defense, public safety, and corporate security threats and incidents, their always-evolving missions are complex. Staff are expected to gather and analyze increasing amounts of data—often with limited resources—to tackle dynamic situations efficiently and precisely.

To ensure that threats are accurately identified, disrupted, and overcome, organizations like these need intelligence analysis software that works how they work. ArcGIS AllSource, a new desktop app from Esri being released in March, is built with intelligence analysts' workflows in mind. And it requires minimal experience with GIS.

AllSource fuses location- and time-based data to help analysts working in law enforcement, the military, civilian intelligence agencies, and the private sector discern patterns and relationships in their intelligence flows. It can be used as a stand-alone product in connected or disconnected environments, and it integrates with other Esri products, including ArcGIS Enterprise; ArcGIS Mission; ArcGIS Excalibur; and the new ArcGIS Video Server, which enables users to index, search, and publish video services with geospatial and temporal context.

Several organizations are already using AllSource to identify threats to security, safety, and supply chains; investigate fraud, waste, and abuse; and combat other criminal activities. The app's intuitive display makes it easier for analysts to integrate structured and unstructured data, imagery, video, and many other data sources so they can conduct advanced analyses and develop actionable intelligence about the incidents they're responding to.

The key features of AllSource revolve around integrating disparate data, producing and sharing advanced analysis, and scaling the app so it matches each mission's unique needs.

Synthesizing All Sources of Information

The amount of data in intelligence flows is only increasing, so being able to quickly process various data types to uncover connections is important. AllSource helps intelligence analysts explore all their sources of information—from structured and unstructured data to imagery and videos—and develop understanding through rich visuals. The desktop app has tools to perform imagery exploitation and link analysis, make and explore 2D and 3D maps, build and dissect timelines, and more. It can assist analysts in identifying key people, places, events, relationships, and patterns in an investigation.

Streamlining Analysis Production

Intelligence analysts must generate timely, relevant, and accurate insight for decision-makers. AllSource streamlines the process of turning raw information into high-quality intelligence products that stakeholders can easily view and comprehend. Final assessments can be presented as web-based or printable products, including maps, dashboards, and reports. These can also be integrated with other business systems, such as Microsoft SQL Server and SAP HANA. Additionally, analysts can share best practices and workflows with their colleagues by creating project templates in AllSource. This ensures that everyone working on a case adheres to the same systems and standards.

Scaling to the Mission

AllSource scales to support a range of mission sets, from conducting movement analysis to understanding patterns of life. To combat human trafficking, for instance, analysts can use AllSource to pinpoint where possible victims and their traffickers are—not only in space but also in time. The timeline tool in AllSource parses out individuals into separate timelines so that their movements can be compared across space and time. Selecting a portion of the timeline can highlight any overlap in two individuals of interest, both in the timeline and on a map. In another example, when it comes to investigating where legal supply chains of opioids are being broken to divert the drugs for illicit use, auditors can use AllSource to track down irregularities in the spatial connections among physicians' offices, pharmacies, and beneficiaries. Auditors can analyze and visualize the data in multiple ways—including as maps, charts, and timelines—to identify outliers that indicate possible fraudulent activity.

Controlling Data, Analytics, and Workflows

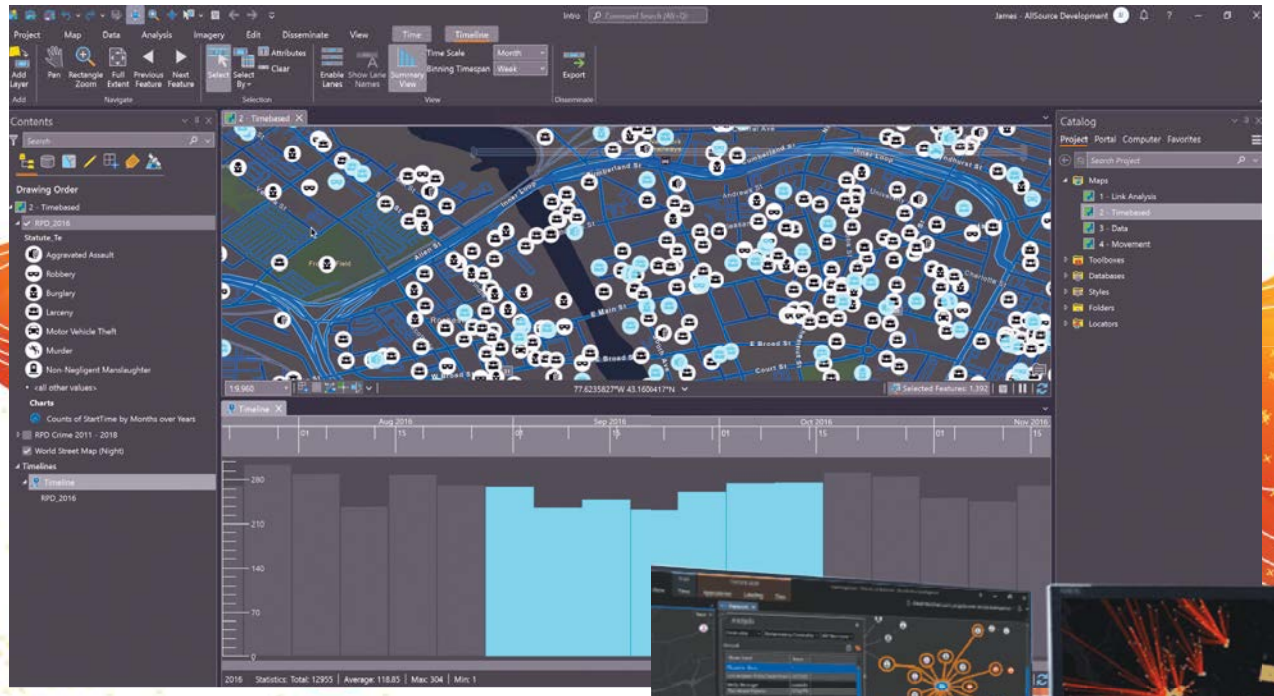
AllSource is completely integrated within an organization's ArcGIS infrastructure, which facilitates cross-platform collaboration while also ensuring that the organization maintains control of its data. The desktop app works in harmony with ArcGIS Enterprise and supports established standards for data sharing, security, and interoperability. Additionally, AllSource functions wherever analysts need it to, whether at headquarters on an internal network or in the field in a disconnected environment.

How to Get Started

The Early Adopter Community program for ArcGIS AllSource is up and running and will be available until the product's initial release this March. The program allows Esri partners and users to gain insight into the early stages of product design and development. Find out more about this community and how to join it at go.esri.com/AllSourceEAC/arcnews.

AllSource will be introduced at the Esri Federal GIS Conference, being held in Washington, DC, February 7–8. Attendees will be able to learn about the product, participate in workshops, and connect with the product team at technical development workshops and in the ArcGIS Product Teams showcase. For more information on the conference, visit go.esri.com/fedgis.

To learn more about AllSource and stay up-to-date on the latest offerings, visit go.esri.com/AllSource/arcnews.



↑ The timeline tool can show overlap among individuals or events of interest, both in a timeline and on a map.

→ ArcGIS AllSource works how intelligence analysts work and requires minimal experience with GIS.

GIS Team in Manila Boosts Water Security with Near Real-Time Network Data

Climate change, population growth, and infrastructure limitations are some of the factors that pose challenges in the water sector. Maynilad Water Services, Inc., the largest private water concessionaire in the Philippines in terms of customer base, is no stranger to these kinds of hurdles.

Since it was reprivatized under new owners in 2007, the company has invested heavily in infrastructure enhancements that have dramatically improved water and wastewater services for millions of customers. It continues to keep pace with the demands of the industry through innovation and technology.

Now serving almost 10 million customers in the west zone of Metro Manila and portions of Cavite province, Maynilad's dramatic transformation from what its lead GIS engineer, Juan Paulo De Leon, called a "financially crippled, bureaucratic utility" to a "dynamic, customer-focused organization" is due in great part to enhanced operational efficiency generated by the full utilization of its GIS.

Among the GIS-related initiatives of Maynilad is the development of a custom web map for its Anti-Illegal Unit, which investigates illegal water connections. With the help of this tool, the unit's overall efficiency increased by 300 percent, enabling the company to recover the equivalent of US$410,000 in commercial losses.

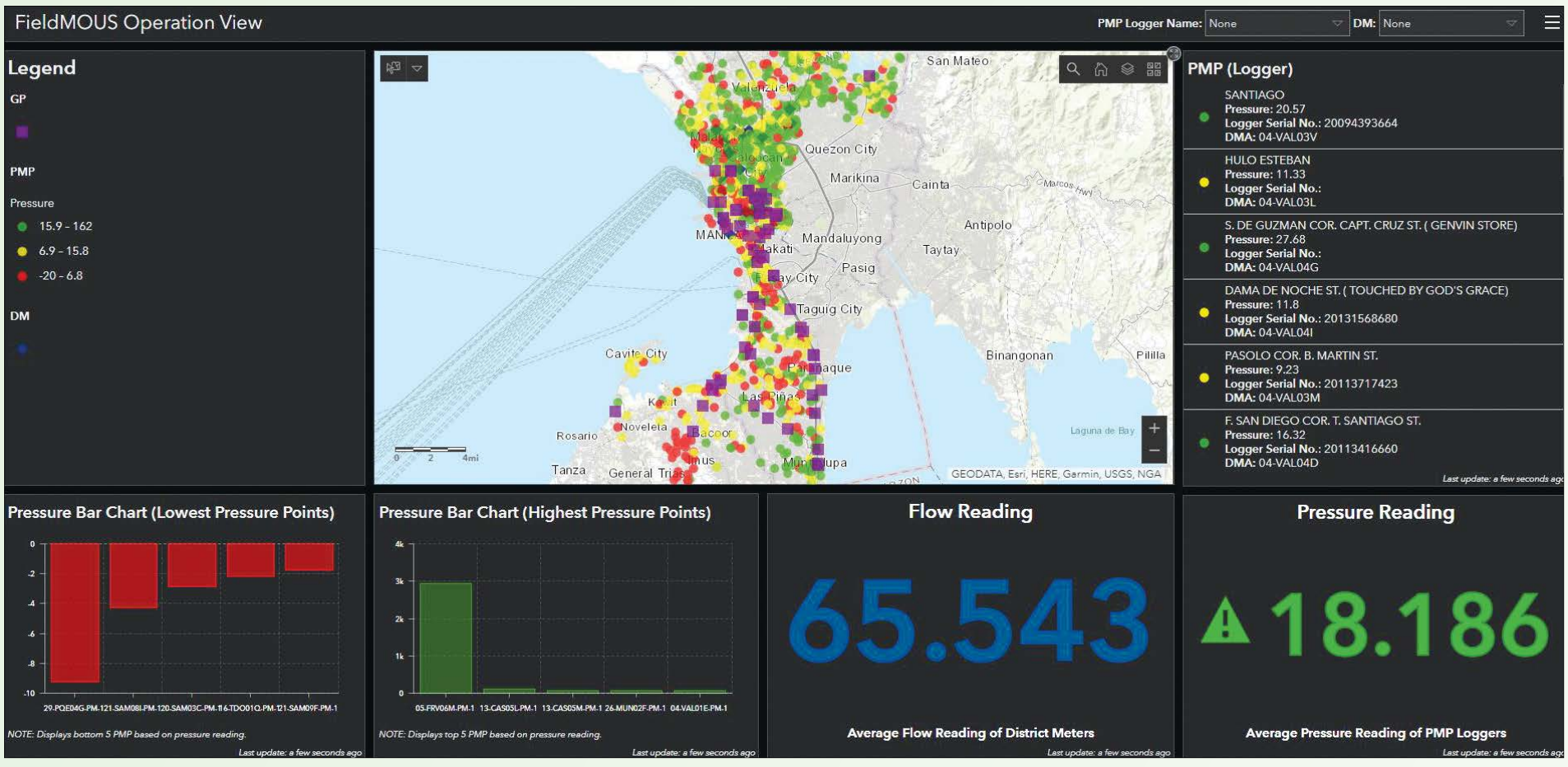
"The dynamic digital maps, dashboards, and data analysis capabilities that GIS provides are still mostly unfamiliar in the Philippines," said De Leon. "Since we expanded the Maynilad enterprise-wide use of GIS in 2011, we have generated major improvements in our service delivery, prompting us to share the benefits of this technology for other water utilities."

Enhancing Water Security

When the new Maynilad owners took over, the goal was to improve water security overall and enhance customer satisfaction. To help accomplish this, the GIS team needed a more accurate and up-to-date record of its network.

↑ Maynilad's web map can be used to validate assets in the utility's network and display customer information by location.

↑ The parcel map helps Maynilad staff identify land parcels for titling and protect them from informal settlements.



↑ Maynilad Water Services' operational dashboard provides up-to-date information about the network, including water pressure levels and flow readings.

Improving the record included identifying the location of waterlines and other components, as well as verifying that only paying customers were connected. Having a better understanding of the network improved the company's efficiency in responding to service calls from customers and performing system maintenance. Reliable data also helped reduce significant commercial losses from fraud.

Internally, Maynilad's GIS team consolidated records from multiple databases to make it easier for response teams to investigate and resolve problems that disrupt services. Further, Maynilad's team sees automation as the most efficient way to create standard, repeatable processes for collecting and organizing network data and making it available to stakeholders.

Technology Brings a Turning Point

ArcGIS Pro and complementary Esri products gave Maynilad's GIS team the solutions needed to continually monitor the network while also investigating and resolving problems more quickly. Early on, the team got started integrating network information from multiple databases into ArcGIS Pro. This created a single system of record and updated network maps for daily operations. The maps, enhanced with ArcGIS Experience Builder, show the location of waterlines and other network components above- and belowground. This eliminated the time-consuming processes of requesting maps, plotting and printing the documents, and carrying them into the field to validate information.

With an accurate inventory of assets, planners can investigate the source of problems more often, and they can do it from the office rather than send someone to the field. Reliable and up-to-date customer information also makes it easier to spot unauthorized water connections.

Moreover, a dashboard built with ArcGIS Dashboards integrates service indicator maps to give workers near real-time awareness of field operations. The dashboard lets internal teams see the location and status of service requests and outages, making it easier to prioritize responses.

"GIS is becoming the backbone of our operation," De Leon said.

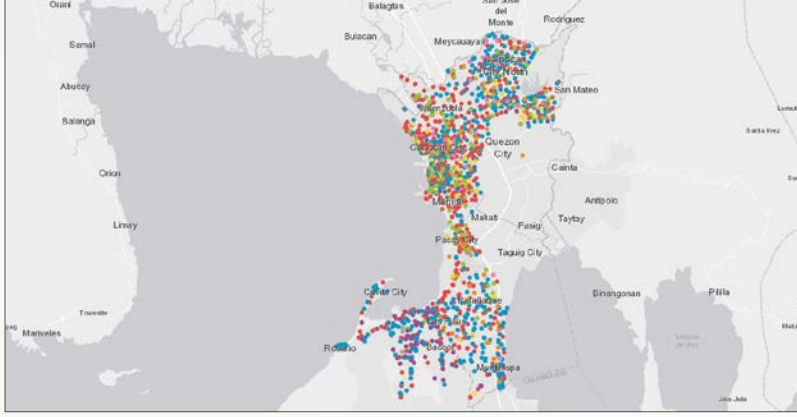
Modernization Opens the Door to a Different Future

A single, up-to-date system of record gave the Maynilad GIS team a greater understanding of the existing network and more dependable data for doing maintenance and upgrades. This has helped the utility improve the reliability of the water system. As a result, new customers get connected faster, and existing customers get repairs done more quickly. Additionally, the GIS team can easily evaluate and report on network performance.

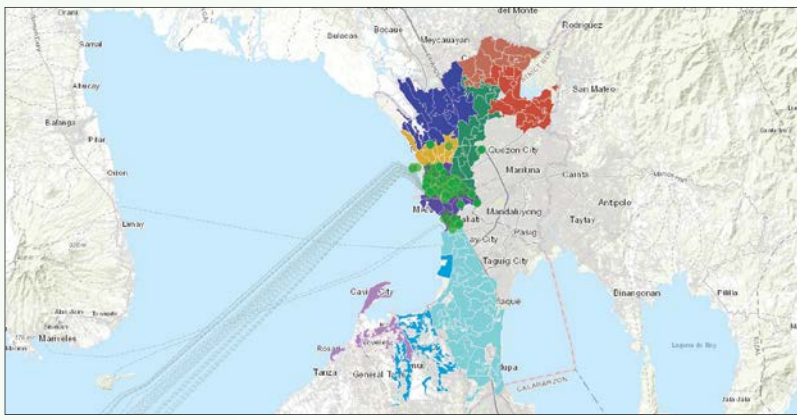
Moving from data on spreadsheets to digital maps and dashboards that offer up-to-date information about network status has helped stakeholders understand the power of GIS. The utility's asset management team is now using data generated by the GIS team to help identify deteriorating pipes to include in future maintenance plans. Teams focused on hydraulic modeling and water pressure also now rely on GIS data as they make decisions about water distribution.

An unexpected benefit of GIS-based automations is that De Leon's team has gained time to focus on system improvements. Programmers are optimizing GIS apps, while others are mining network data to identify patterns that point to risks and opportunities that other teams should know about. As the scope of work of the GIS team evolves, its influence grows within the organization and the GIS industry.

"The work of the GIS team saves lives and sustains citizens and businesses in and around Metro Manila," said De Leon. "It's really part of nation building. That's why it's important that we plan and do it well."



↑ The water quality team monitors sampling points daily, and this web map provides a detailed representation of water quality throughout the network.



↑ Being able to visualize confidential data to investigate water pilferage improved recovery by 306 percent between 2020 and 2021.

↑ The Automated Customer Communication (ACC) map provides call center agents with location-specific information about service interruptions. The data is useful for planning, analysis, and improving responsiveness for customers.

ArcGIS Monitor Transforms Enterprise GIS

Public utilities typically have sprawling work crews, administrators, and IT staff, all working to provide customers with power, access to clean water, and other services. By necessity, many of these entities have robust GIS infrastructure—from ArcGIS Online organizational accounts and dashboards that allow utilities staff to track projects and maintenance, to an ArcGIS Enterprise framework holding it all together.

Key to keeping all this infrastructure running efficiently is software such as ArcGIS Monitor. Monitor tracks the status, system performance, and resource usage of an ArcGIS Enterprise deployment, allowing an administrator or manager to optimize the health and efficacy of back-end tasks. Although most end-user utilities' customers will never explicitly see this software operating, it has the potential to make life much easier for GIS and IT staff.

Two utilities in Minnesota—Rochester Public Utilities (RPU) and Moorhead Public Service (MPS)—have incorporated Monitor effectively into their day-to-day activities. It has proved instrumental in streamlining the operations of their GIS and IT departments.

"We're using ArcGIS Monitor for identifying infrastructure performance issues as well as *[deployments]* like our ArcGIS Server," said Ryan Moore, GIS manager at RPU. "We're also monitoring the status of our outage management service. If that service goes down, we'll get an email alert."

By quickly alerting RPU of GIS application and infrastructure problems, Monitor helps the GIS department keep performance up and helps RPU stay on top of service issues—and ahead of customers reporting these problems.

MPS, on the other hand, typically uses past performance metrics to identify and mitigate issues.

"Once something does happen, we can look at ArcGIS Monitor and try to establish a baseline or a trend to look for," said Todd Copeland, GIS coordinator for MPS. "We're monitoring performance issues and identifying *[what]* within our infrastructure might be impacting that."

In analyzing data tracked by Monitor, for example, Copeland found that system performance slowed each week around the same time, and he suspected an automated backup routine might be the cause.

"*[ArcGIS Monitor allows us]* to dig in a little deeper to see exactly what the cause is and if we can manage it," he said.

Putting Data First

"We didn't really have a good mechanism to track how things happened beforehand," noted Copeland. "Usually, we got a phone call saying, 'Hey, maps are down,' or, 'Hey, things are running kind of slow. Is there anything you can do to help performance or speed things up?'"

Though staff will still get these phone calls from time to time, Monitor has helped create a more cohesive picture of overall enterprise GIS system health, according to Copeland.

"We're seeing if there are issues that are continually cropping up," he said. "If we can see a trend or pattern, day over day, hour over hour, then we know there's something potentially looming that could create downtime or affect the users long term. In the past, there was no good metric to see if there were performance issues."

"From a GIS admin perspective, it was difficult to pinpoint where some of those problems were," added Moore. "ArcGIS Monitor makes it easier to interpret what's going on with your system."

Even as they touted the ability to respond quickly to GIS outages or slow performance, both Copeland and Moore emphasized the importance of prevention when it comes to potential issues with GIS infrastructure.

"We're always continually looking at three or four reports," said Copeland. "*[We're]* looking at our data store, our ArcGIS Server, and our SQL Server. If any of them are high usage, we're going to see a negative impact on performance. *[We want]* to see if there's a way to catch something before it gets worse."

Monitoring the Future

As RPU and MPS have incorporated Monitor more heavily into the day-to-day operations of their GIS and IT departments, new ways to streamline tasks have cropped up. Additionally, the long collaboration between Copeland and Moore—beginning with the Mid-West Esri Utility Users Group conference in 2011—has enabled them to share useful ideas. Taking inspiration from RPU's use of Monitor, for instance, Copeland sees the implementation of email alerts for outages and other performance issues as key in the future.

"That's where I see real added value for us," he said. "*[This includes]* having predefined benchmarks set, and—once those thresholds *[are met]*—sending us a notification that something might be creating a bigger problem for the users."

In addition, the utilities have used Monitor to not only track the web apps used by field crews but also manage administrative certificates and licenses that need to be renewed.

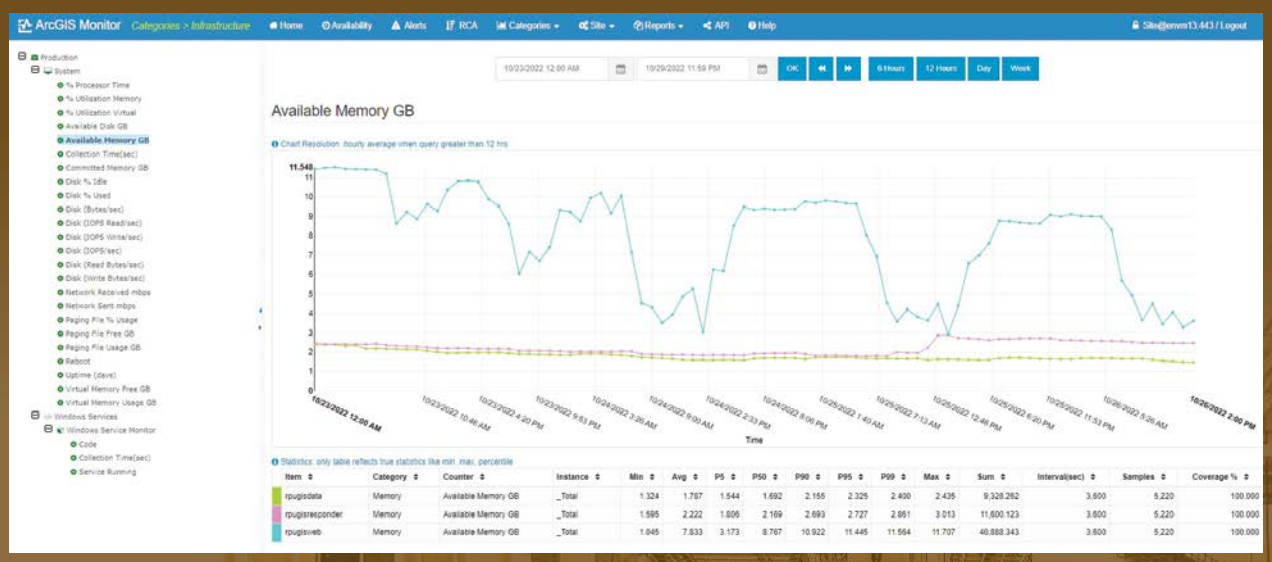
"*[Monitor]* gives you a high-level countdown," said Copeland. "You know how many days are left before your license needs to be renewed. There are half a dozen certificates out there, and they all expire at different times."

Moore agreed that Monitor could be instrumental on the administrative side of things, noting that he would like to use long-term performance metrics over time to improve RPU's hardware resources.

"Whether it's RAM or CPU, *[it's]* something to justify improvements in our landscape," he said.

What's clear is that products like ArcGIS Monitor have a variety of uses across even a single industry, all in the service of streamlining the work of GIS and IT professionals. At its heart, Monitor is a product designed to make ArcGIS Enterprise systems function more efficiently and effectively, with fewer wrenches thrown in the gears.

"It's a good tool to identify root problems," said Copeland. "It really helps identify potential problems quicker."



↑ By tracking performance and resource usage, ArcGIS Monitor lets administrators optimize their ArcGIS Enterprise deployments.

→ Moorhead Public Service (MPS) regularly monitors its SQL Server report to catch any possible negative impacts on performance.

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Geospatial Technology Forms Basis of Digital Twin of Pompeii

Tools That Transcend Traditional Methods

Most archaeologists are familiar with the benefits of using geospatial technology for their work. Archaeological research generates mountains of spatial, metric, and observational data that gets unwieldy as archaeologists try to make sense of it all. Employing GIS to assist with data collection, management, and analysis can improve archaeological practice and reveal patterns that facilitate deeper understanding of how people lived in past societies as well as the complexities of human culture.

The focus of the digital data initiatives team, which joined I.14 in October 2021, was to implement a paperless data collection workflow that would easily tie descriptive data, photographs, and sketches recorded on-site to the detailed and highly accurate 3D models the team was planning to produce of the study area. In looking at different software solutions, it became clear that Esri technology provided a one-stop shop for all the apps that would be needed for the project.

ArcGIS Survey123 forms could be used to record data on-site and implement paperless workflows. That data could be linked to dashboards made with ArcGIS Dashboards to keep track of progress and foster collaboration during the excavation. ArcGIS Pro excels at managing, analyzing, and visualizing both 2D and 3D data. And all three solutions easily link to ArcGIS Online, where the digital data initiatives team built a web scene that allows project participants to revisit the excavation site virtually (to review earlier phases of the excavation, for example) using digital tools that transcend traditional archaeological methods.

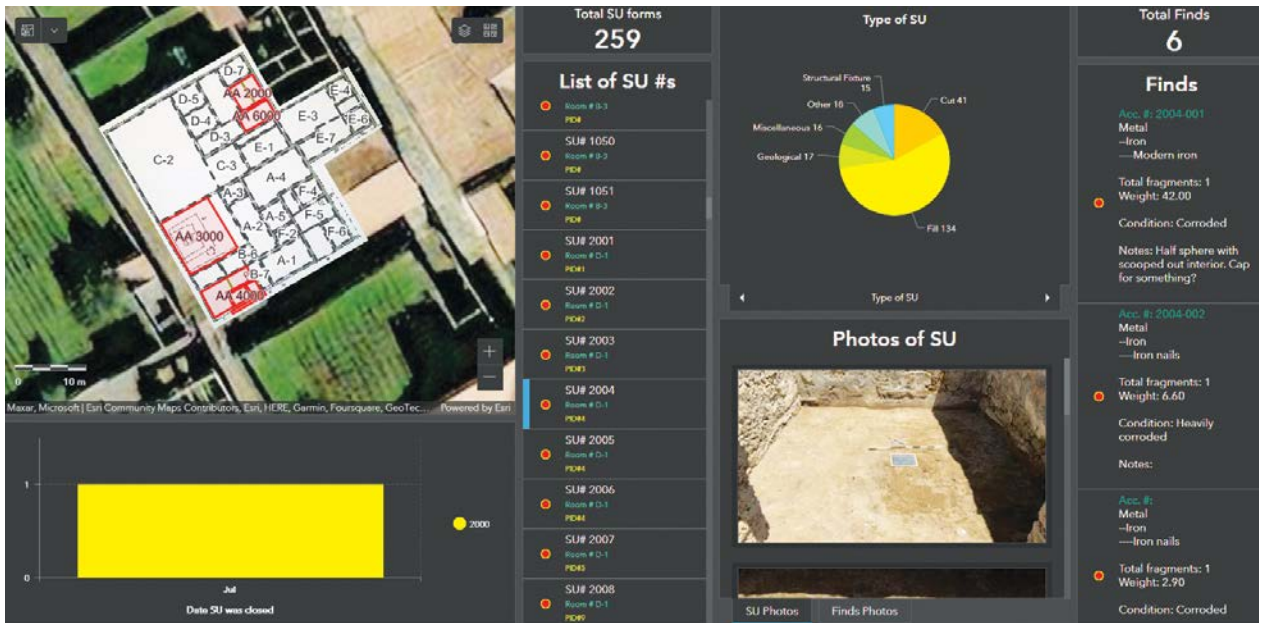
A Paperless Process Fosters Agility

In the lead-up to I.14's summer 2022 excavation at Pompeii, members of the digital data initiatives team used Survey123 to design digital data entry forms for various aspects of the project. The custom forms would work on Apple iPad Pro tablets, and researchers would use them to record data about stratigraphic units (SUs), discrete layers or features in soil that develop through natural processes or human activity; each of the artifacts found in them, including ancient plants and ceramics; and the architectural features of Insula 14.

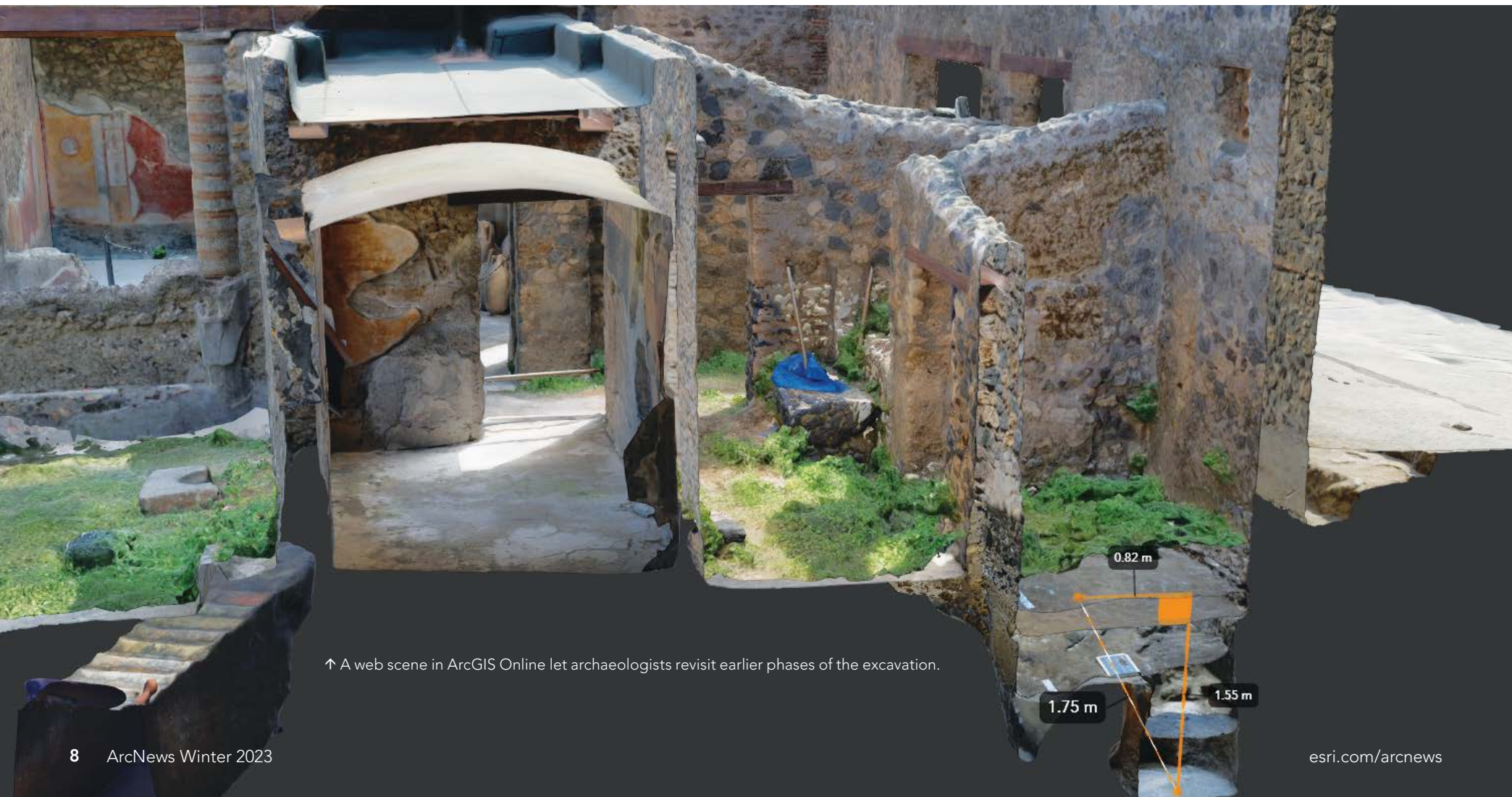
The SU form was the principal form used during the excavation because the number assigned to each SU became the unique ID to which other data was linked. Each time an SU was excavated, researchers completed a corresponding form that included all the data collected for that SU, such as soil properties, physical descriptions, and in-field interpretations; metric data, which ranged from elevation measurements to the counts of ceramic fragments found; and excavation photos and field drawings. Other forms—such as the Finds form for artifacts and Pottery form for ceramics—also created records that were linked to each SU using the SU number. This enabled the team to query not only the data collected in each SU but also the data pertaining to recovered artifacts.

During the excavation, trench supervisors were given iPad Pro tablets and Apple Pencil stylus pens to record data in their archaeological areas. The Survey123 app was loaded onto the iPads, and the project forms were accessible through the app. Once trench supervisors began to dig an SU, they opened a new SU form in Survey123 and started recording their data. They took photos of their SUs using the iPad's camera and created scaled digital field sketches in another app called Concepts. These were saved as attachments in the Survey123 form. When an SU was finished, the trench supervisors saved their forms locally on the iPads and then, when they had access to Wi-Fi or a cell network, sent them to cloud storage via ArcGIS Online. Because Survey123 collects location data, it was easy to spatially link 3D data to researchers' field notes, images, and sketches.

The digital data initiatives team also employed Dashboards to create an interactive dashboard that researchers at Pompeii used to track the dig's progress. Taking the data being submitted by the Survey123 forms, the dashboard showed a map of the excavation, broke down the various types of SUs, tallied and described all found artifacts, and displayed photos of the SUs and archaeological finds. The dashboard allowed researchers to check their data while still in the field, which improved data quality, and aided in making the day-to-day decisions required to keep an excavation moving forward smoothly.



↑ Researchers used an interactive dashboard to track progress during the excavation.



↑ A web scene in ArcGIS Online let archaeologists revisit earlier phases of the excavation.

↑ The photo-realistic 3D models of excavated areas were spatially linked to each stratigraphic unit (SU).

Seeing the Excavation in a Whole New Way

Another responsibility of the digital data initiatives team was to document the I.14 excavation in 3D. The team relied on structure-from-motion (SfM) photogrammetry to do this, which entails generating 3D models from 2D imagery, such as a series of digital photographs. This technique can be used to document 3D space with high accuracy and is gaining popularity in archaeological workflows.

Before the excavation, team members created a scaled and georeferenced 3D model of Insula 14 that would serve as the base to which all subsequent 3D models would be aligned. The team carefully and evenly placed alignment points—small dots of highly visible pink paint—throughout the interior spaces where the excavation would take place. Calibrated scale bars with coded targets were also situated throughout the site to serve as internal checkpoints.

Once all the alignment points were in place, the team took photos of the insula using both terrestrial and aerial photography. Ground control points (GCPs) were recorded using a total station and high-accuracy real-time kinematic (RTK) GPS receivers that were accurate to within about 2 centimeters. The GCPs were used to georeference the final base model.

As the excavation got underway, supervisors of the three teams that were working simultaneously in seven archaeological areas of Insula 14 were told to identify moments that required 3D documentation. A member of the digital data initiatives team would then photograph the excavation at that stage, ensuring that all available alignment points were captured in the images to facilitate alignment with the base model. Moments later, the team would process the images in the field lab using a standard SfM workflow in Agisoft Metashape Professional to create a digital twin of the excavation at that moment in time. In the end, each excavation that took place in Insula 14 had a series of corresponding models that showed the progression of the excavation through time. And the models contained the geospatial, morphological, and visual information for each SU.

When the photo-realistic 3D models of each excavated area were ready, the digital data initiatives team imported them into ArcGIS Pro in a local scene. The data that researchers recorded using Survey123 was then spatially linked to each SU, as documented in the 3D model. This was accomplished by using the Move To tool in ArcGIS Pro to relocate the points associated with each record to the x-, y-, and z-coordinates of each SU location. Finally, all this was transferred to an interactive web scene in ArcGIS Online.

In the web scene (which the researchers plan to make publicly available once they publish their findings), viewers can virtually explore the excavation site by using tools that measure and slice the 3D models. This allows them to see all the data and notes that were collected in the field and explore stratigraphic relationships in a whole new way.

The Benefits of Efficiency and Accuracy

While traditional methods of archaeological documentation are still useful, I.14 researchers experienced myriad benefits from relying on geospatial technology in Pompeii.

With Survey123 allowing archaeologists to instantly digitize their field notes and other records, the team saved the hours it usually takes to digitize data. This paperless workflow also allowed everyone working on the project to share their documentations widely—to a team spread across states and countries—and has cut down on the data loss that typically stems from digitization errors, bad handwriting, and accidentally discarded or damaged notes. Being able to use a dashboard to monitor the excavation in near real time also improved decision-making on the ground and kept things running efficiently.

Having all the documentation, including photos and drawings, available quickly in scaled 3D models and in an ArcGIS Online web scene has enabled researchers to disseminate their project findings with everyone from students and GIS lay users to project stakeholders and the public. These easily accessible records have also begun to facilitate useful discussions about methods of digital and 3D cultural documentation in archaeology.

The I.14 project has made it clear that employing GIS-based methods for field documentation in archaeology is viable and advantageous. The team is looking forward to refining its processes and techniques in future excavations at the site.

→ The Pompeii I.14 project involves excavating a block in the southeastern part of the ancient city.

For more information, email Dr. Alex Elvis Badillo, the digital data initiatives team lead, at alex.badillo@indstate.edu or visit alexelvisbadillo.weebly.com. Or contact digital data initiatives team member Dr. Stephen P. Aldrich via email at steve.aldrich@indstate.edu or on LinkedIn at linkedin.com/in/aldrichsteve46237. Indiana State University's Department of Earth and Environmental Systems and the Geospatial and Virtual Archaeology Lab and Studio provided the software, hardware, and support to develop and carry out the workflow.

About the Authors

Dr. Alex Elvis Badillo is an assistant professor of anthropology in the Department of Earth and Environmental Systems and Indiana State University (ISU). He is an anthropological archaeologist and a specialist in applying new technologies to archaeological practice. Dr. Stephen P. Aldrich is a professor of geography in ISU's Department of Earth and Environmental Systems. His GIS and remote sensing work focuses on understanding the relationship between humans and the environment, especially when it comes to drivers of landscape change.

continued from cover

Amid Formula Shortage

Milk Bank Embraced Geospatially Focused Business Intelligence Tools

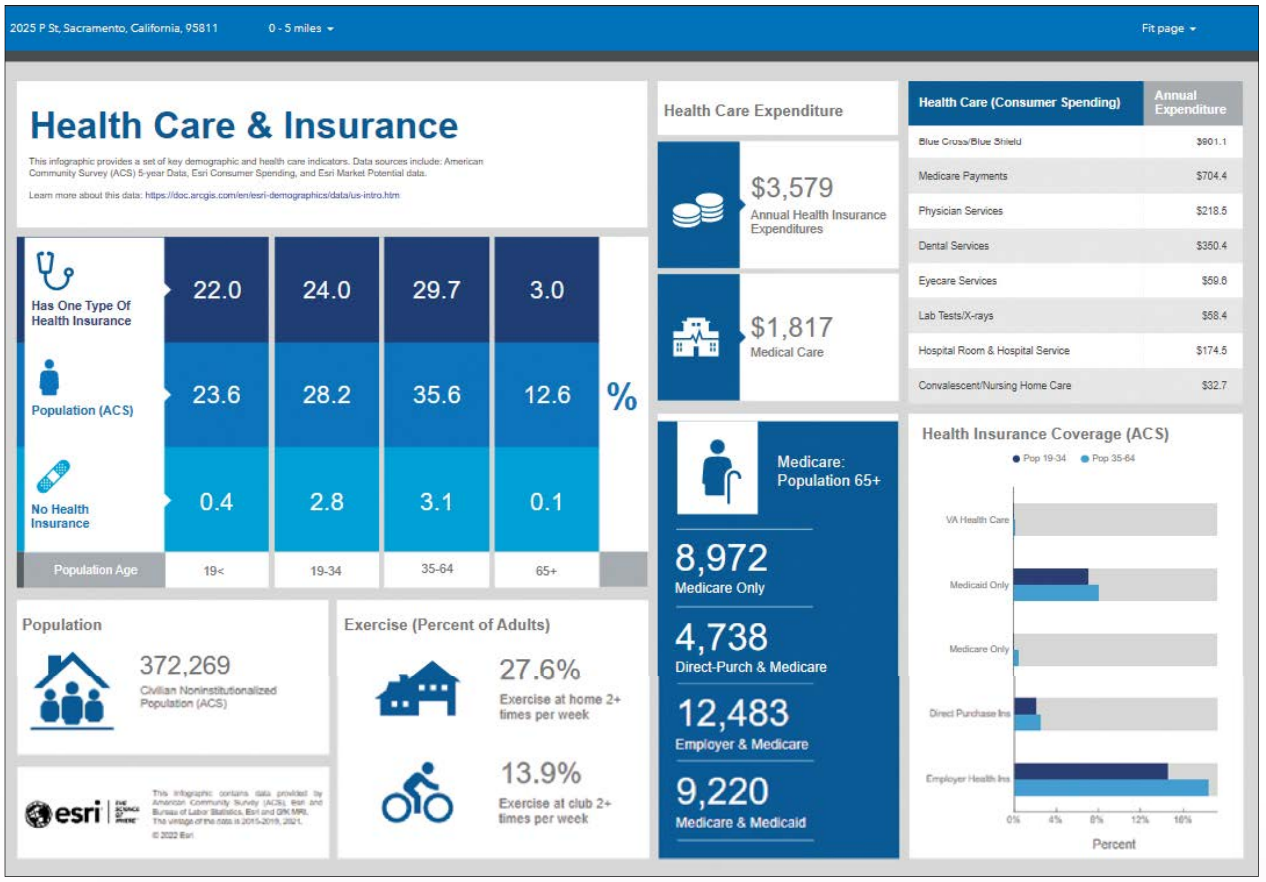
families as possible. Typically, thousands of newborns in intensive care units and parents who are unable to produce breast milk rely on the organization's services. Last year, parents with limited access to baby formula became another key customer.

Jonathan Bautista, executive director of Mothers' Milk Bank, had previously experienced the value and effectiveness of using GIS to organize, analyze, and visualize imperative data while working for a blood bank organization. To reach more milk donors in 2022 and educate the milk bank's community about the crucial need for donations, Bautista determined that GIS would be the best tool to use.

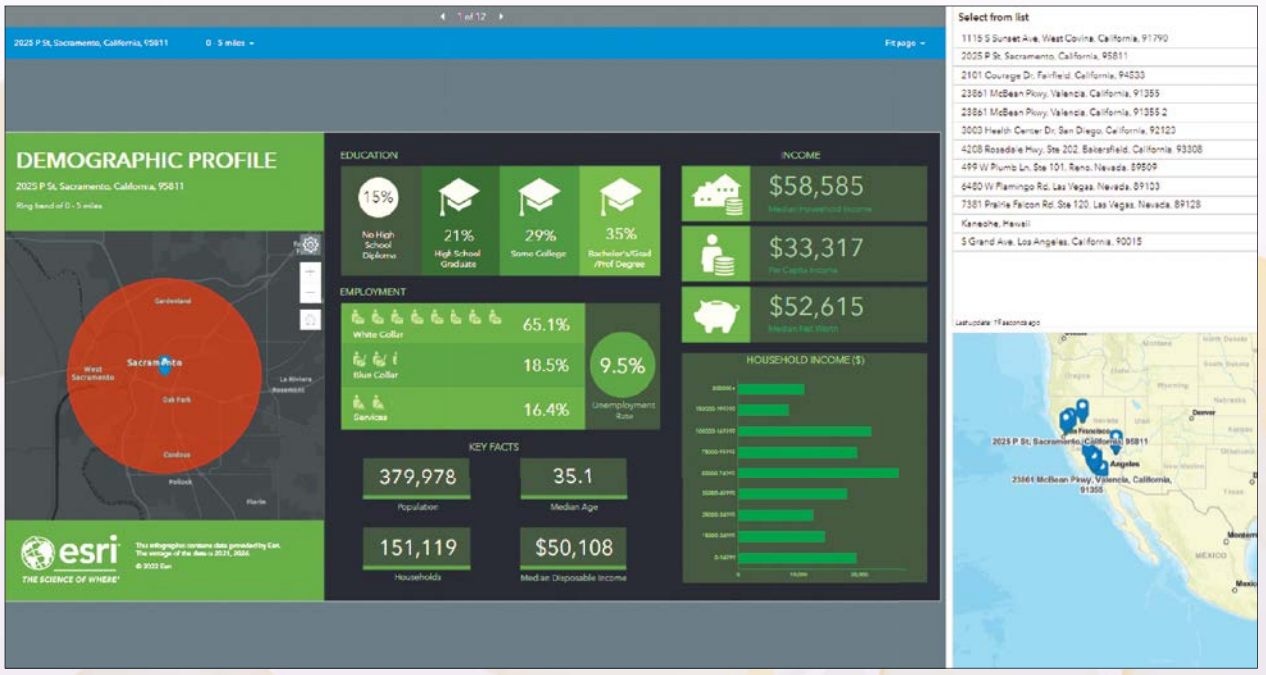
Bautista's goals were to raise people's awareness of a safe alternative to formula, provide the opportunity for breastfeeding parents to donate their breast milk, and identify which communities are most likely to donate. He also wanted to use Business Analyst to go through the same process that corporations and stores do to determine their target audiences.

Prior to implementing GIS in its work, Mothers' Milk Bank relied on a self-built data management system, which was limited in its abilities to collect data, analyze it, and serve as a tool to make data-driven decisions. Bautista knew that applying a geographic approach to the problem he was trying to solve would bring location to the forefront and provide new insight.

"Something we are hoping to accomplish by implementing GIS is to reach as many prospective donors as possible and increase the likelihood *[that they will]* donate their milk, if possible," said Bautista.



↑ Milk bank staff can use ArcGIS Business Analyst to see health-care and insurance indicators for residents of San Jose.



↑ A demographic profile done in ArcGIS Business Analyst shows the education levels, employment statuses, median household incomes, and more, for residents near a milk donation center.

Adjusting Marketing Messages to Connect Donors with Demand

The milk bank incorporated its donor data into ArcGIS Pro and used Business Analyst—a demographic mapping software tool—to layer in additional contextual information, including socioeconomic backgrounds, the locations of current donors, and lifestyle data for past and present donors. The availability of thousands of datasets in Business Analyst has helped the milk bank determine the characteristics and profiles of eligible donors, identify where they are located, and see which areas require prioritized access to breast milk.

After creating maps in ArcGIS Pro, staff members exported the map layers into ArcGIS Business Analyst Web App. This allows the organization to visualize a combination of its existing data and analyze new data added from the web app. For example, staff have organized new and existing variables of data to see comparisons between birth rates in one area and the historical total amount of donated breast milk consumption in that same area. With the analysis results, the milk bank can establish if its current supply will meet anticipated increases in demand. Additionally, the milk bank can locate where outreach to eligible donors is needed the most.

So far, Mothers' Milk Bank has determined that most donors are between 25 and 35 years old and are in densely populated areas. However, only 2 percent of eligible donors are donating breast milk. With this insight, the organization has modified its marketing messaging to resonate with young women and is targeting local neighborhoods with the highest population rates. In 2022, the milk bank received 18 percent more ounces of donated milk compared to the previous year.

One additional result that the GIS analysis has enabled staff to visualize is how far beyond San Jose's city limits the milk bank's reach extends. Throughout 2022, the organization supplied more than 900,000 ounces of breast milk to families in need all over California and across the country.

When the milk bank eventually performs a complete analysis of demographic, socioeconomic, lifestyle, and other types of crucial data, that will help the organization make data-informed decisions about how to adjust its marketing messages to a range of eligible donors. And as the organization's GIS operations become more robust, Bautista and his team plan to use ArcGIS to map not only San Jose but also other communities in need across the state and, hopefully, the country. Ultimately, they want to establish a precedent for using a geographic lens to track and understand their work so that other organizations within the Human Milk Banking Association of North America can replicate these efforts.

Keeping Up with Changing Circumstances

As the demand for breast milk changes over time, the results of Mothers' Milk Bank's data analyses will continue to help answer pressing questions, such as whether families are aware that donated breast milk is available and if breastfeeding parents know that they can donate their breast milk to a family in need. The team will also continue to track where likely donors are located and which areas have the greatest demand.

Staff members at the milk bank are motivated to keep using ArcGIS technology to enhance their data management workflows as well.

"The *[staff]* is excited and working to pull information from our database with ArcGIS Pro so that it can later be made public to local residents," said Bautista.

The organization's GIS work will continue to increase community engagement by educating more people on how to become donors, what it takes to be a donor, and how they can support Mothers' Milk Bank and even become breast milk donation advocates.

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Proving the Value of Earth Observation Data for Small-Scale Agriculture

Extreme weather events, droughts, and other environmental and climate issues—along with social and economic challenges including human conflict and poor governance—are exacerbating food insecurity around the world. Right now, 222 million people in 53 countries and territories, largely in sub-Saharan Africa, likely don't have enough food to meet their daily nutritional needs and require immediate assistance, according to a recent *Hunger Hotspots* report from the United Nations' (UN) Food and Agriculture Organization (FAO) and World Food Programme (WFP).

One of the ways that governments, nonprofit organizations, and businesses can identify food insecurity indicators and forecast potential food shortages is by using earth observation (EO) data to monitor crops and catch potential crop shortfalls early. In small landholding systems, however, it is challenging to use EO data for crop monitoring because of small field sizes, mixed cropping, and the reliance on rainfall for production. It is critical, therefore, to gather ground truth data on small landholding systems so that EO-based products, models, and remote crop assessments can be better trained and validated in these contexts. When that happens, people's trust in the products improves, and they start using them.

NASA Harvest, the global food security and agriculture program of the National Aeronautics and Space Administration (NASA), employs EO data, products, and models in a range of agricultural circumstances to support crop monitoring and bolster food security—and it is focused on increasing the use of EO at public and private organizations. In a pilot project conducted with the FAO's Global Information and Early Warning System on Food and Agriculture (GIEWS), NASA Harvest worked with FAO Malawi and Malawi's Ministry of Agriculture to use ArcGIS Survey123 smart forms to collect ground truth data on small farms across the country. The project has successfully tested and validated remote sensing technology-based products, models, and assessments in small landholding contexts. And now, that data is being used in the Ministry of Agriculture's national crop assessments, as well as by the broader research community.

Big Data Gaps for Small Landholdings

EO data is obtained from remote sensing technologies, such as satellites orbiting Earth, that monitor the planet's physical, chemical, and biological structures. This frequently transmitted, repetitive data can reveal crop anomalies and detect when plants are unhealthy. These early warnings of crop shortfalls can help governments and humanitarian agencies get appropriate aid to the people most affected by environmental and climate shocks.

Satellite imagery has high accuracy when mapping large agricultural systems that have set cropping regimes and clear field boundaries. But even at high resolution, satellite imagery can lack the detail required to accurately map small-scale agricultural systems. In many countries, small landholders farm less than half a hectare (about one acre) of land. Multiple farmers often plant multiple crops on one piece of land within the same season—yet, to satellite imagery, it all looks like one field. Thus, mapping these kinds of landholdings typically requires someone to walk each field boundary with the farmer.

Mapping field boundaries is important, though. It allows farmers and decision-makers to gain a better understanding of cropped areas, especially as crop conditions change drastically due to pests, drought, and flooding. Field boundary delineation also provides more accurate data to train machine learning models to predict crop yields and forecast the agricultural impacts of natural hazards.

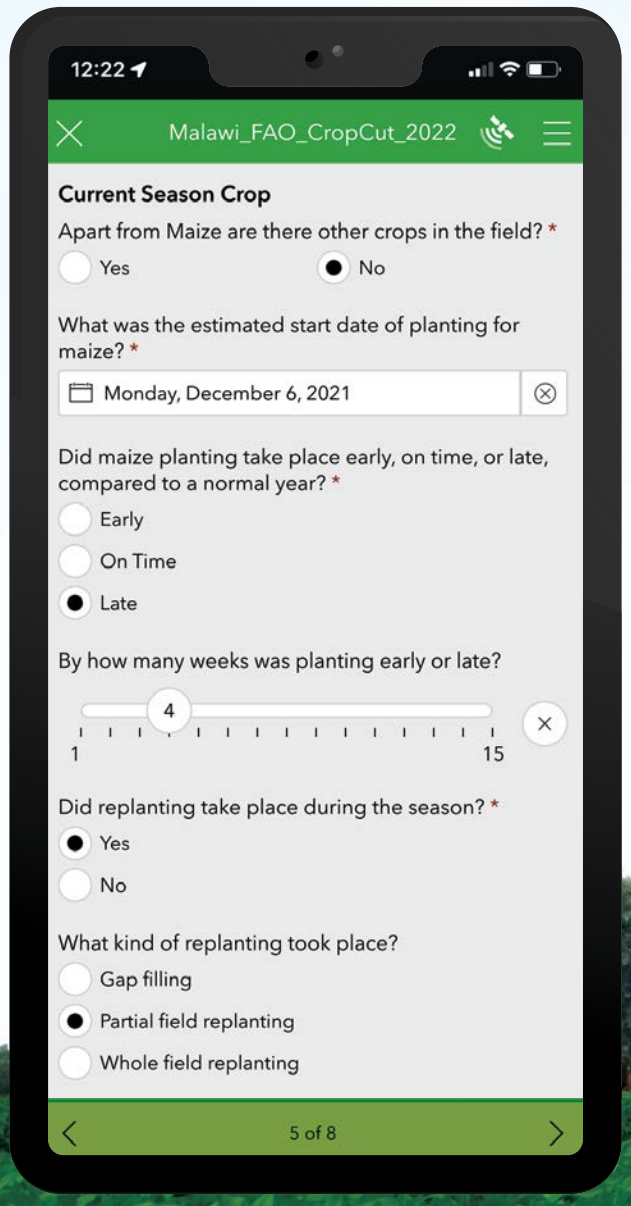
"Satellite data is the first and easiest tool *[to use]* to monitor changes to agriculture at scale and identify where impacted areas may be," said Christina Justice, principal faculty specialist in the University of Maryland's Geographical Science Department and the food security and early warning colead for NASA Harvest. "But ground data to verify and validate these satellite products is lacking, and *[that's]* a huge bottleneck to advancing this work."

This is because collecting data on the ground can be costly and onerous. At many ministries across Africa, specialists are sent into the field to do crop assessments using paper-based forms, and the information they gather is summarized back at the office. The whole process—from data collection to analysis—is costly and time-intensive. And the resultant data isn't geolocated, which means it's next to unusable for EO apps, according to Justice. So when it comes to collecting ground truth data (known data from the real world) to validate satellite data-based products and models and test their accuracy in small landholding scenarios, there is a significant lack of usable data.

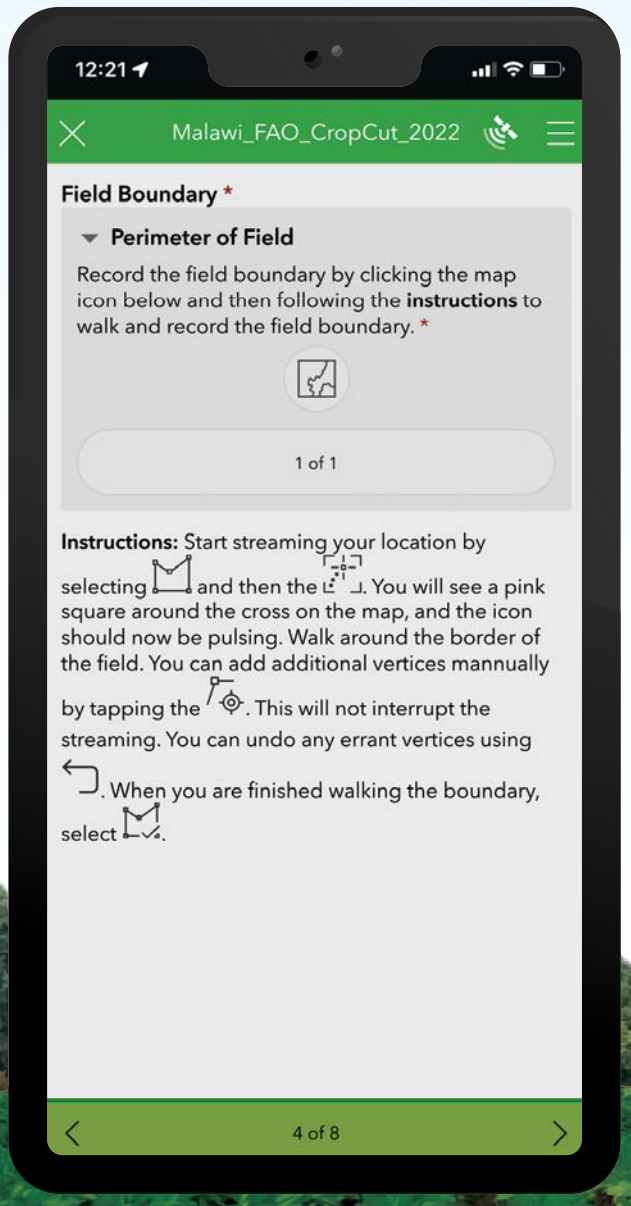
This presents a big opportunity for ministries in Africa and the EO community to work together to solve this problem. Justice and her team at NASA Harvest thought that a new geospatial app, based on easy-to-use Survey123 smart forms, could help.

A Solution to Meet Local Needs

NASA Harvest had tested Survey123 during previous projects, so Justice and her team knew that its simple interface and ability to collect data offline would be an advantage for gathering ground truth data in small agricultural settings. They liked the product's out-of-the-box capabilities, which would allow the organization's developers to focus on other things besides building a digital survey form. Additionally, they liked that Survey123 works seamlessly



↑ Using HarvestNow, an app based on ArcGIS Survey123, local enumerators collected crop data and geolocated crop types.



↑ The team worked with Esri to develop a GPS streaming tool that allowed enumerators to delineate the size and shape of a field boundary as a polygon.

with ArcGIS Online. This would enable the team to use ArcGIS Dashboards to make a dashboard for staff at the Ministry of Agriculture so they could see summarized survey results in near real time—showing the difference in how quickly this system works compared to typical, paper-based assessments.

For the pilot project in Malawi, NASA Harvest and GIEWS employed Survey123 to create HarvestNow, a data gathering app that local experts could use to collect crop data and geolocate various crop types. Because these community-based enumerators were familiar with the land, culture, and language, the idea was that they could gather crucial agricultural data on tablets or smartphones that could inform the Ministry of Agriculture's national crop assessments. If the pilot project worked, the ministry would roll the system out to farms across the nation.

Survey123 lacked one feature that the team needed, however: a GPS streaming tool. The app's annotation tools worked well for identifying and drawing clear, long boundaries on a map, but NASA Harvest required something that could accurately delineate both the size and shape of a field boundary as a polygon. This would help the organization calculate the area of each holding with limited user intervention, since the data was being collected by local representatives who walked the fields with the farmers.

"Thankfully, the Survey123 development team saw the real potential for this streaming feature *[for]* both this and other user needs and took on the project," said Justice. "The Survey123 team developed it better than we could have ever imagined, with the ability to determine the level of accuracy and user-friendly features for easy data collection."

Within a month, the team had a beta GPS streaming tool for the solution that was ready to be tested in Malawi.

Offline Data Gathering Proves Successful

When the 30-day pilot project launched, HarvestNow was made available to 20 enumerators who worked in teams of two to record crop assessments and yield data on tablets. The survey worked even when cell and internet coverage weren't available.

"When users got the hang of it, they found it easy and used it quickly," said Justice.

The solution included a locally stored basemap in the Survey123 field app that the enumerators downloaded to use offline. This enabled them to collect information across their entire area without using cellular data.

"With the basemaps, our teams were also able to see the local roads and terrain and visualize the results of their work in real time," Justice explained. "Having the field boundaries visible on the screen was an exciting new feature that allowed the teams to share with the farmers a bird's-eye view of their fields and communicate both the field size and shape in a different way than before."

Once the enumerators were done recording field boundary and other agricultural data, they returned to their offices, connected to Wi-Fi, and submitted their forms. The teams at NASA Harvest then populated a dashboard to display the submitted data so that everyone—including staff at the Ministry of Agriculture—could monitor the progress of the campaign.

In all, the enumerators visited up to four fields per day across three districts, resulting in more than 560 visits. Along with collecting field boundaries, they geolocated crop types; took more than 1,120 sample crop cuts, which are used to estimate yield; and conducted interviews with farmers to gain a better understanding of their cropping seasons and the impacts of pests, delayed rains, droughts, and floods on crop conditions and yields.

For NASA Harvest, the FAO, and Malawi's Ministry of Agriculture, the project was a success. By employing local experts and digitizing the on-the-ground data collection process, it became easier and more streamlined to do data analysis. In addition, the resultant crop assessments were more agile and accessible than they had ever been before.

Big Potential for the Tool in the Future

As NASA Harvest expands its EO-validating data collection efforts, the baseline surveys gathered in the pilot project in Malawi give the organization something to build on.

"To truly develop an accurate early warning system based on EO, there is a critical need to collect ground truth data that can help inform our models and products," said Justice. "There is no substitute for this for small landholders, and there is big potential for the tool to be used and applied to the regular operational activities of multiple ministries across the world."

After the success of the pilot project in Malawi, NASA Harvest expects to expand this data collection method into other areas. Until then, the team will continue to compare Malawi's national yield estimates to the actual yields collected with Survey123 to build out forecasting models that can support early warning and help get food security aid to those who need it.

↓ Mapping small landholdings usually requires someone to walk the field boundaries with the farmers.

↑ In addition to delineating field boundaries, enumerators geolocated crop types, collected sample crop cuts to estimate yield, and conducted interviews with farmers.

From the Meridian

By Dr. Marilyn Raphael
University of California, Los Angeles

How Geography Can Make Climate Science More Just

Scientists are trained to cultivate intellectual distance from their topics. Physical geographers and climate scientists, like myself, are no exception. We have historically treated the climate as if it were a complex phenomenon that functions on its own—largely beyond human control—and with a variability that we can objectively measure, describe, and analyze. We have studied how a changing climate affects human comfort and survival, and we have analyzed it to prepare for droughts, floods, and the like. But rarely have we reduced our separation and considered more deeply the human causes—and impacts—of the changes we observe.

To be sure, abstraction and distancing have a role to play in grasping the implications of climate change. For example, University of Reading climate scientist Ed Hawkins's warming stripes are abstract visualizations that show, quite viscerally, the dramatic trend of warming over the last 120 years, approximately. Yet the urgency of climate justice—the recognition that climate change affects underprivileged and underserved communities more acutely than other populations—demands more of physical geographers and climate scientists. We can no longer ignore the inequities of climate change. We must take an approach to science that recognizes and redresses the ways in which our scientific methods and practices contribute to climate injustice. Geography is at the heart of that approach.

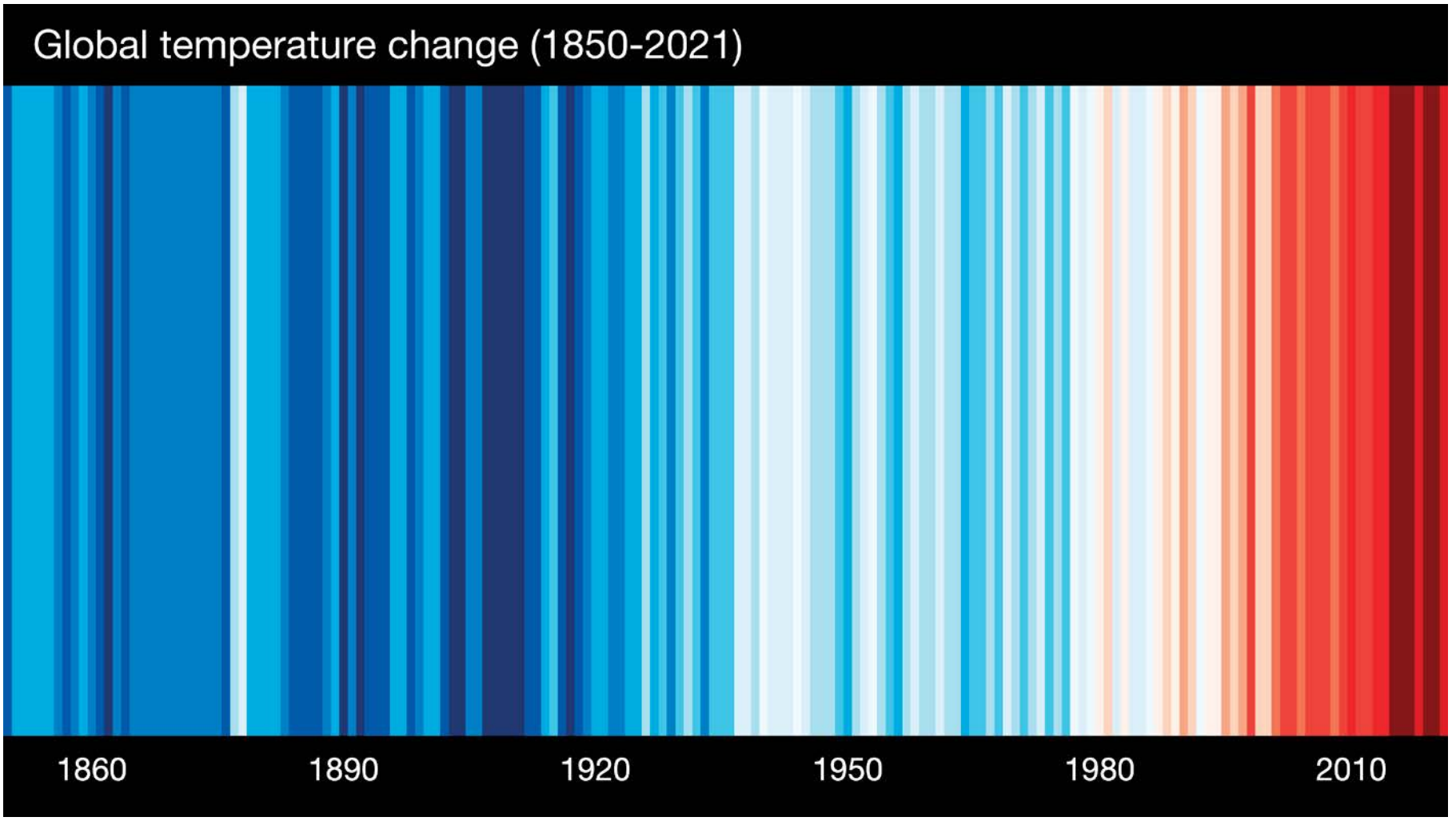
We Are Part of the Problem—and the Solution

Earth observation (EO) is a powerful tool for measuring the physical impacts of climate change. EO refers to any effort to bring together data about the earth—most typically, satellite-based remote sensing, but also airborne observations, fixed sensors, cameras, and other recording devices. By definition, these are distance-based methods for gaining insight. They are routinely used to measure climate and terrain changes, ice flow and loss, tree canopies, and habitats—as well as human phenomena such as migration and humanitarian crises. EO data is incorporated into maps that are used for a variety of purposes, from planning to policy making.

Human-induced climate change, however, challenges everything we thought we knew about how to best apply EO methodologies. Human beings are directly implicated in the profound changes occurring with earth's climate—and some are more heavily implicated than others, especially at the institutional level. We cannot stop observing and measuring. But as we are learning, remotely conducted measurements alone cannot lead us to actionable conclusions. We also need methods and practices that support deeper inquiry into how and why the causes and impacts of climate change are unequally distributed, rendering most vulnerable those who are already disadvantaged and are least responsible for the greenhouse gas emissions that drive climate change. Climate justice—which recognizes the historical underpinnings of this uneven privilege and privation and how these inequities are further exacerbated by climate change—is a movement as well as a way of approaching the climate crisis.

In the kind of climate science we need to practice now, physical scientists must know what the people working to advance climate justice need. We must understand who is applying the datasets and models we construct and what they are using them for—both now and in the future. Also, these groups often don't need additional research. Rather, they need financial and technical resources—such as funding for environmental cleanup and carbon reduction programs—to be redistributed so they can tackle problems whose causes and consequences are already sufficiently clear, especially to those who are most affected by them. So we have to think in terms of community data needs and bear in mind the relationships between producers of scientific knowledge and affected communities.

More generally, physical scientists need to pay more attention to the role that scientific representations of climate change play in obscuring climate injustice. This is an ongoing issue. For example, responsibility for climate change is often attributed to humans in general rather than to a specific set of powerful, human-run institutions that have a long track record of harming, exploiting, and extracting wealth from colonized and marginalized people and places. Taking this context into consideration, climate change might be more productively addressed as a symptom rather than a cause. We, rightfully, talk about the disproportionate impacts of climate



↓ These warming stripes, by Professor Ed Hawkins of the University of Reading, are abstract visualizations of the increase in average temperature experienced around the globe in recent decades. (Image courtesy of showyourstripes.info.)

change on marginalized groups, but this framing can elide the underlying processes that produce both climate change and systemic marginalization.

A recent example of a study that exposes these connections is a set of maps that Antenor Vaz, formerly of the Brazilian government's agency for Indigenous affairs (known by its Brazilian acronym, FUNAI), put together in 2017. They show Indigenous territories in the Amazon overlaid with oil and gas leases, mining claims, hydroelectric dams, and areas suffering from deforestation. The maps demonstrate that deforestation and other environmental degradation go hand in hand with the exploitation of Indigenous lands by outside actors—and that the impacts cannot simply be stemmed or undone through private or even public conservation efforts without ensuring protection for the people and their lands. (More about the maps can be found at links.esri.com/amazon-maps.)

A Geographic Approach to Linking Climate Science and Climate Justice

In geography, an emerging body of work called critical physical geography may be used as a lens and guiding framework for bringing climate justice into climate science. Critical physical geography advocates paying more reflexive attention to how knowledge is produced—that is, how we conceptualize our research and the methods we use. It argues that social inequities and power relations are implicitly woven throughout what we study and should not be ignored if our goal is to produce more robust and valuable results. (A handbook on critical physical geography is available at links.esri.com/cpg.)

A recent paper by geographer Dr. Núbia Beray-Armond puts urban climatology at the center of this discussion. As she argues, the city is where human impacts on the landscape and climate are most concentrated and where measurable and perceived climate change was noted well before global climate change was widely confirmed. Even today, the temperature increases attributed to large cities—what's known as the urban heat island—are larger than the average increase in temperature across the globe. And cities are major sites of greenhouse gas emissions. Cities are also where much work on environmental justice is done because of how unequally distributed the negative impacts of high temperatures and air pollution (among other things) are in urban areas.

Critical urban climatology draws on the tenets of critical physical geography to argue that we need both urban climatology and environmental justice to fully understand urban climates. This is because these spaces are shaped by the nature of urban energy budgets (the balance of how energy from the sun is used and lost in urban areas), variations in air quality, and their thermal and moisture characteristics—as well as by race, gender, class, and the legacies of colonialism.

Bringing Climate Science Closer to Understanding

There is so much more that physical and climate scientists, including geographers, need to learn about how we practice and use our science. We have made great strides in our understanding of the physical nature of climate and climate change. However, our understanding is limited by the fact that we do not incorporate the human element well enough.

The divide between these perspectives is nothing new, as Dr. Mei-Po Kwan, geography professor and director of the Institute of Space and Earth Information Science at the Chinese University of Hong Kong, pointed out in her 2008 paper, *Beyond Difference: From Canonical Geography to Hybrid Geographies*. But this must change because our environments are no longer only physical or only human. Was it ever so?

Bridging the gap between physical and human geography and manifesting it in our applications and practice will not only better address climate justice, but it will also improve our science.

From the Meridian is a regular column from AAG, a nonprofit scientific and educational society whose members, from nearly 100 countries, share interests in the theory, methods, and practice of geography. Find out about AAG's programs and membership at aag.org.

About the Author

Dr. Marilyn Raphael is a professor of geography at the University of California, Los Angeles (UCLA), and a climatologist specializing in southern hemisphere atmospheric dynamics, climate change, and Antarctic sea ice variability. Her work includes global climate modeling with an emphasis on improving the simulation of sea ice and the atmosphere in the southern hemisphere. She is currently president of the American Association of Geographers (AAG) and a member of the American Academy of Arts and Sciences. She is also the director of UCLA's Institute of the Environment and Sustainability. A portion of this column was adapted from Raphael's October 2022 newsletter to AAG members.

Scientific Currents

By Dr. Dawn Wright
Chief Scientist, Esri

Esri Adds an Emphasis on Social Science

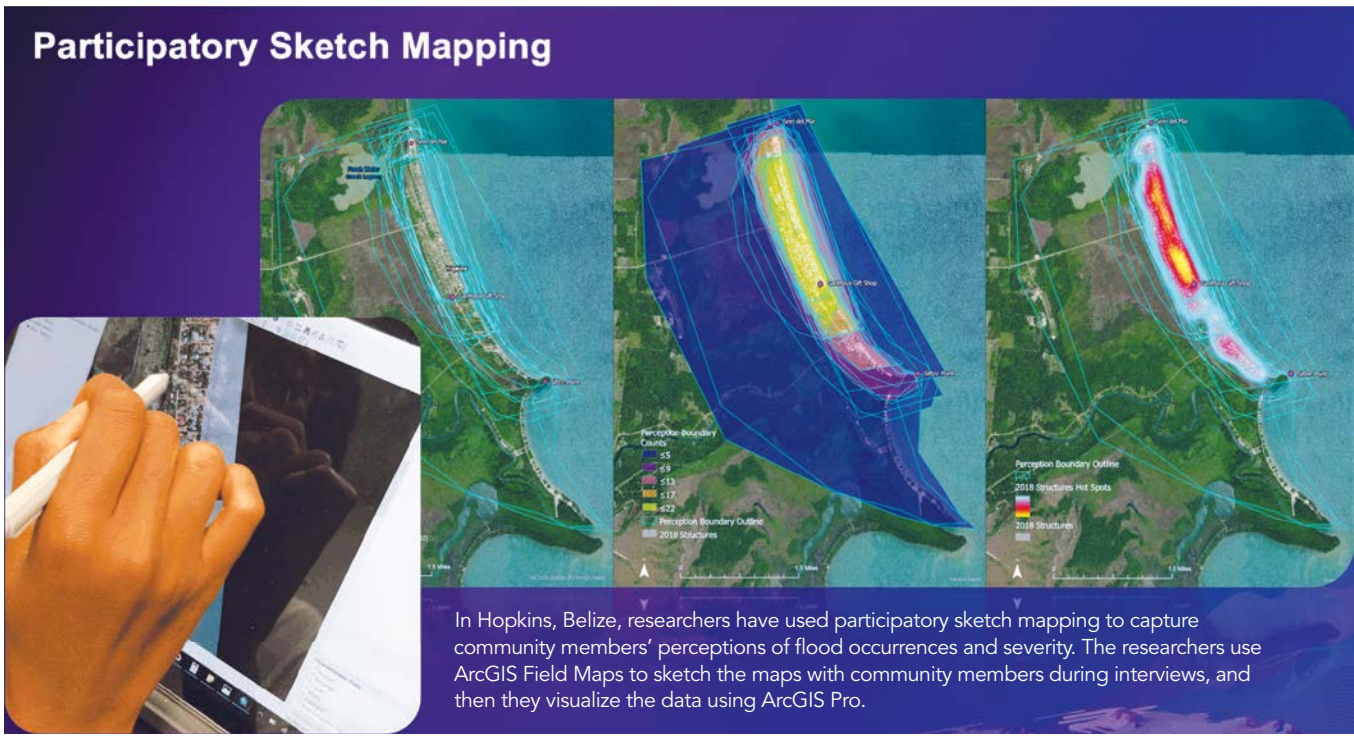
In social science research, there is growing recognition of the significance of space, place, and spatial analysis. Research institutes such as the Center for Spatially Integrated Social Science (CSISS) at the University of California, Santa Barbara, have long championed this geographic slant toward social science and, accordingly, the need for social scientists to embrace a computational approach to their work when appropriate. Yet for many social scientists—especially in sociology, economics, history, political science, psychology, anthropology, human geography, ethnography in archaeology, and even the digital humanities—mapmaking is as far as they go. The power of GIS, however, lies in the analysis that's done behind the map. And there is still a major need to strengthen the awareness of geographic information science (GIScience) principles among social scientists.

Many social scientists will happily perform simple regression analyses on spatial data. What they don't realize is that Tobler's First Law of Geography—that everything is related to everything else, but near things are more related than distant things—violates the assumptions made in these analyses. Additionally, it's easy to find in published social science studies instances of ecological fallacy—the erroneous assumption that an inference about an individual applies to the broader population to which that individual belongs, especially spatially. There's also a lack of awareness of the modifiable areal unit problem (MAUP), the profound notion that when data is reduced to more basic spatial units, the results of any analysis of that data will change when those basic spatial units change.

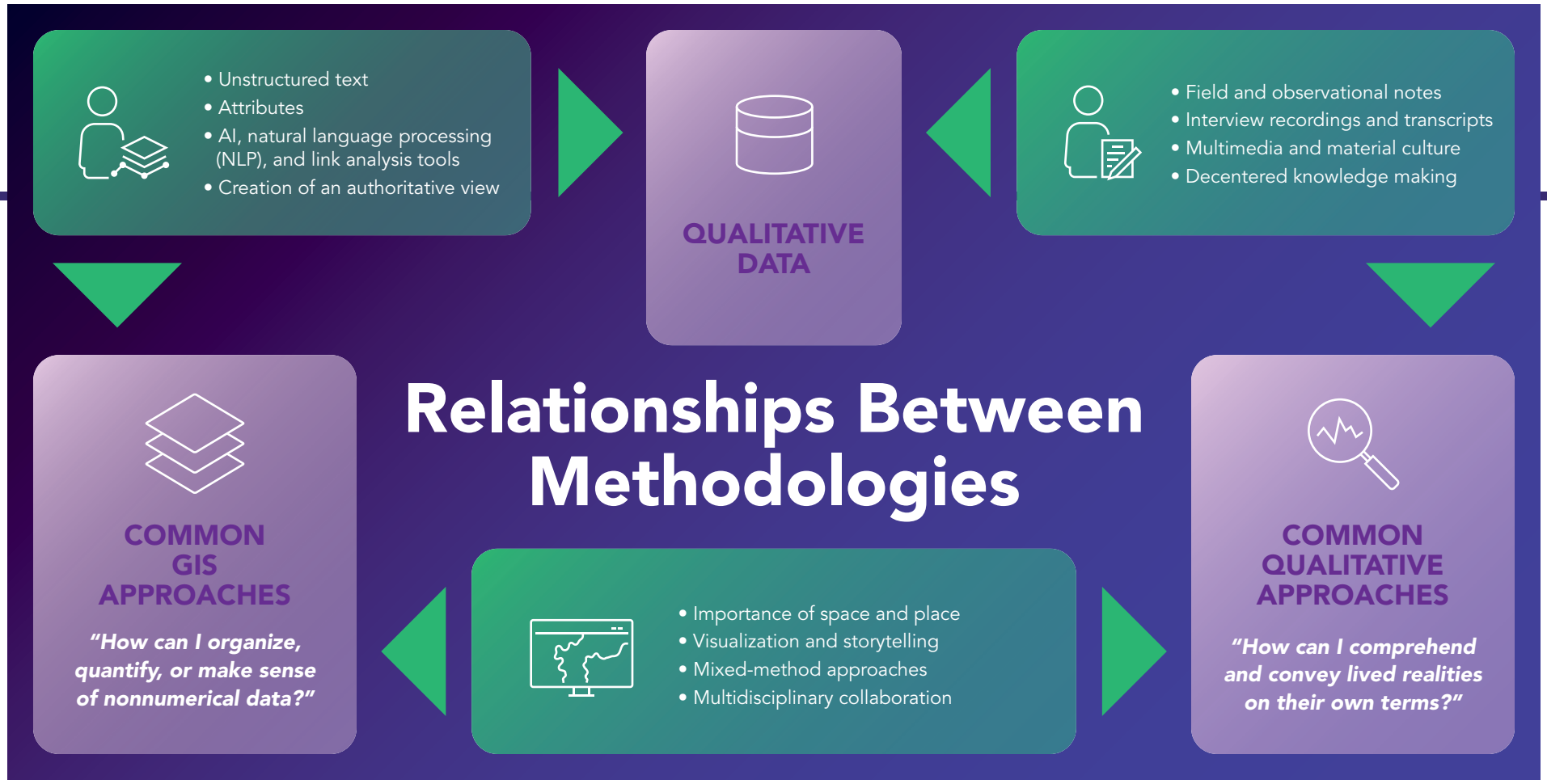
So many researchers still struggle with how to best integrate quantitative and qualitative geographic data. What an impact it would have if GIS were seen by social scientists as the gold standard for implementing spatial methodologies.

To that end, Esri has formed its new Social Science Collaborative, a small task force of trained social scientists at Esri (many of whom have PhDs) who are developing very specific projects and resources as solutions to the issues cited above. While quantitative social science has been served well by GIS, not as well-known is how suitable GIS can be for the qualitative side of the discipline—that is, conducting interviews and focus groups and analyzing texts. Part of the focus of this collaborative is to not only make ArcGIS technology easy for social scientists to adopt and use but also ensure that this comes with easy access to related documentation, workflows, use cases, apps, tutorials, and more, on issues such as the ecological fallacy, the MAUP, uncertainty in data, social justice, racial equity, and the ethics of data privacy and artificial intelligence (AI).

The collaborative made a great start in 2021 by offering the first of what will hopefully be an annual technical workshop at the Esri User Conference (Esri UC). Called Enhancing Qualitative Social Science Research with GIS, the workshop showcased the power and utility of ArcGIS technology for qualitative social science—especially to address current and long-standing issues of racial equity, population and demographic studies, economic and environmental justice, public health, and community resilience to climate change. Technical topics ranged from learning how to configure ArcGIS Survey123, ArcGIS Field Maps, and



In Hopkins, Belize, researchers have used participatory sketch mapping to capture community members' perceptions of flood occurrences and severity. The researchers use ArcGIS Field Maps to sketch the maps with community members during interviews, and then they visualize the data using ArcGIS Pro.



↑ Common approaches in GIS are interconnected with the methodologies used for qualitative research.

ArcGIS QuickCapture for field-based qualitative data collection to exploring spatial data, producing geospatial visualizations, and using GIS-based analysis and presentation tools (including how to bridge ArcGIS technology with other qualitative data analysis packages). The workshop showed several hundred virtual attendees just how much ArcGIS has to offer to social scientists who need to employ qualitative, as well as quantitative and mixed-method perspectives, in their work.

In the summer of 2022, members of the collaborative participated in a webinar, put on by the National Academy of Sciences' Mapping Sciences and Geographical Sciences committees, called *Humanitarian Responses to Forced Migration and Displacement: New Insights from Quantitative and Qualitative Geographic Data*. Their presentation used ArcGIS Insights and ArcGIS StoryMaps to show how both quantitative and qualitative data and tools can track human movement and displacement in near real time. They also explored some of the limits, opportunities, and errors associated with these datasets and how to best visualize and communicate them.

At the 2022 Esri UC, the collaborative followed up with another tech workshop augmented with new demos featuring ArcGIS Insights, ArcGIS Knowledge, GeoAI, and crowdsourcing with ArcGIS StoryMaps. It also put on another webinar, *Enhancing Qualitative Social Science Research with GIS*, for several hundred registrants.

In addition to providing a way to compile and create best practices and online resources, these workshops and webinars promote community. With this community-building goal in mind, members of the collaborative also aim to attend more of the conferences that social scientists frequent, such as the annual meetings of the American Sociological Association and the American Anthropological Association. The collaborative will continue to reach out to prominent programs and institutes—such as Spatial@UCSB; the Australian Urban Research Infrastructure Network (AURIN); and universities including the University of Chicago, the University of Toledo, Brown University, Harvard University, the University at Buffalo, the University of Central Florida, New Mexico State University, and UMass Global—to collaborate on projects and establish more resources. Additionally, members will be engaging with organizations such as the American Library Association, the Association of College & Research Libraries, the Educational Testing Service (regarding relevant content that could be included in high school advanced placement human geography and geographic information science and technology classes), and several Esri distributors that focus on higher education (such as those in Japan, the Netherlands, and Germany as well as throughout Africa). Finally, the collaborative would like to invite researchers, librarians, and practitioners to write *ArcGIS Blog* posts about their social science research and create other kinds of content about what they do and how they employ ArcGIS technology.

In sum, Esri's new Social Science Collaborative is singularly focused on using and improving GIS to strengthen how qualitative and quantitative data and methods work together within the social sciences. The aim is to illuminate how GIS provides an organizing context that makes both the data and information more accessible and usable, generating powerful insight about problems that range from racial equity and climate-driven migration to global health challenges.

And while CSISS and other centers have been pioneering these advancements since the late 1990s and early 2000s, much more needs to be done. For example, manual data preparation and manipulation processes are too time-consuming, especially as many kinds of qualitative data are still not well supported in GIS tools. There is a definite lack of integration between GIS and computer-assisted qualitative data analysis software (CAQDAS) tools, and the tools that exist can still be nonintuitive and difficult to use. Indeed, these tools' user interface/user experience (UI/UX) need to be improved with better design and new features, functionality, and workflows.

There are so many opportunities for innovation, which speaks to the heart of Esri's research and development needs and goals. And this leaves those of us in the collaborative wondering, What would you like to see improved in ArcGIS technology when it comes to using it for qualitative and broader social scientific research? Please reach out to me at dwright@esri.com or the collaborative at socialscience@esri.com, and look for the hashtag #EsriSocSci on LinkedIn and Twitter.

Resources

- Get to know members of Esri's Social Science Collaborative: **links.esri.com/collaborative**
- Watch the Enhancing Qualitative Social Science Research with GIS technical workshop, from the 2021 Esri User Conference (Esri UC): **links.esri.com/sosci21**
- Watch the Enhancing Qualitative Social Science Research with GIS technical workshop, from the 2022 Esri UC: **links.esri.com/sosci22**
- Watch the 2022 *Enhancing Qualitative Social Science Research with GIS* webinar: **links.esri.com/sosciweb**
- Watch the National Academy of Sciences' *Humanitarian Responses to Forced Migration and Displacement* webinar: **links.esri.com/migration**
- Learn more about resources that can enhance data and analysis in qualitative research: **links.esri.com/sosciblog**
- View the social science initiative within Esri's larger science portfolio: **links.esri.com/socialscience**
- Find out how common GIS approaches intersect with typical qualitative research methodologies: **links.esri.com/aag-news**
- Discover GIS solutions for racial equity, social justice, and inclusive development: **esri.com/racial-equity**
- Check out two relevant Esri Press books: *GIS Research Methods: Incorporating Spatial Perspectives* (**links.esri.com/research-methods**) and *Resilient Communities Across Geographies* (**links.esri.com/resilient-communities**)

About the Author

As chief scientist of Esri, Dr. Dawn Wright aids in strengthening the scientific foundation for Esri software and services while also representing Esri to the scientific community. A specialist in marine geology, she is an elected member of the National Academy of Sciences and has authored and contributed to some of the most definitive literature on marine GIS.

How to Develop a Strategic Equity Plan in FOUR STEPS

By Sophia Garcia, Esri

Organizations, government agencies, and communities around the world are urgently trying to foster equity in their institutions. To generate equity, these groups need to implement solutions that meet the needs of the underserved and unserved, whether those conditions stem from racism, variations in physical or mental health, lack of access to services, the effects of climate change, or other circumstances.

We all want to live in a more equitable world. But what does that mean in practice? With budgets to abide by, constituents to listen to, and limited time and resources, how do our leaders aim to make a more equitable world despite real-world constraints?

While governments, nongovernmental organizations (NGOs), and community groups seek ways to incorporate equity into their existing workflows, many GIS users have discovered that they already do this through geospatial technology. For state and local governments that employ the geographic approach, for instance, equitable thinking is already ingrained in their daily work. Public works professionals who maintain streetlights, sidewalks, park benches, drinking fountains, and public restrooms are pushing toward equity of open and green spaces. Social services and public health staff who collaborate with community-based organizations to improve access to medical facilities, prescription services, and preventative health care are striving to achieve health equity. Transit planners who expand bus, train, trolley, and ferry service and improve mobility for people of all abilities are making progress toward equity of movement.

GIS provides the data, tools, and geographic lens through which to approach, discuss, and address equity issues. Using ArcGIS technology, governments, NGOs, and community groups can identify the needs of their clients and constituents and prioritize areas for intervention and long-term investment.

But many organizations—even the ones already using GIS—lack an enterprise-wide strategic plan for achieving equity. A plan like this outlines the organization's overarching equity goals and details how GIS can be leveraged to support these objectives, empower staff to take action, track program effectiveness, and communicate results.

A strategic equity plan helps organizations establish an organizational strategy for achieving equity rather than relying on ad hoc, project-by-project or department-by-department results. With a strategic equity plan in place, organizations can better understand their community's needs, identify opportunities to intervene, and develop solutions that enact real change. They can also use the plan to introduce tools to foster involvement from community leaders, residents, and other stakeholders.

So how can an organization build a strategic equity plan and put it into practice? By following four simple steps.

1 UNDERSTAND YOUR COMMUNITY

To build a strategic equity plan, organizations first need to add an equity lens to how they approach their work. This involves gaining a better understanding of the communities they serve and their needs, which requires taking a spatial approach.

To start heading in the right direction, decision-makers should ask themselves the following questions:

- How well do we know the communities we serve, both in general and geospatially?
- Where are those without access to our key services (like broadband or transit) located? What age groups, races, or ethnicities do they belong to?
- Who are the local community leaders in the area?

GIS can be used to answer questions like these to provide decision-makers with more insight into where there's a lack of service and who is affected by it. When organizations understand their communities geospatially—by visualizing demographics, patterns, and trends in maps—they can make more informed decisions and discover opportunities to engage with their clients and constituents. Once organizations better understand their communities, they can prioritize where to put their resources and investments.

2 BUILD A LOCATION STRATEGY

A location strategy is a high-level vision for using geospatial technology as a key method to finding answers to problems. For decades, geospatial technologies such as GIS have helped organizations of all sizes unlock the full potential of data to remain agile, improve services, and meet new challenges.

Governments, NGOs, and community organizations can achieve equity when they apply a location strategy to all their work and employ GIS to help achieve it. During the COVID-19 pandemic, for example, libraries across the United States experienced upticks in Wi-Fi usage when schools and workplaces closed. Overlaying the locations of these libraries with data on broadband coverage showed where critical gaps existed. Local governments were able to take these location-based findings to inform where broadband build-outs needed to take place to foster equity in access to information.

A location strategy can be used to take on issues department by department or tackle a cross-cutting challenge, such as homelessness or the local impacts of climate change. These efforts, in turn, aim to meet more substantial goals, like increasing economic opportunity, improving mobility, or achieving healthier and safer communities.

3 DELIVER REAL SOLUTIONS THAT ADDRESS YOUR PRIORITIES

Once organizations have embraced a location-centric approach, they need to deliver data, tools, apps, and solutions to employees and decision-makers that will allow them to consider equity and incorporate equity-based approaches in their work.

Returning to the broadband example, an ArcGIS Survey123 form can be used to gather data from residents and business owners on broadband access to further inform who lacks it and where broadband service needs to be expanded. In another example, real-time dashboards, built with ArcGIS Dashboards, can be used to monitor air quality, and air quality maps can be overlaid with demographic data to pinpoint which populations are adversely affected by pollution. Esri also has ArcGIS Solutions configurations—such as the Social Equity Analysis and Police Transparency solutions—that provide focused maps and apps to help organizations perform targeted analysis and increase community engagement.

By employing performance monitoring dashboards, public information hubs, and feedback tools, organizations can gain valuable insight into where their efforts would be most effective and how to equitably allocate resources so that underserved and unserved populations have better opportunities for success.

4 MEASURE YOUR IMPACT

Putting a strategic equity plan into operation allows organizations to turn abstract ideas and observations into measurable results. When staff members have the tools and solutions they need to incorporate an equity lens into their work, entire organizations can begin to see and measure the impact of their initiatives.

Use GIS-based hubs and dashboards to develop indexes and models that can be used to set benchmarks and establish milestones. Tools like these allow organizations to model alternative approaches to attaining their goals and see where adjustments need to be made along the way. And throughout the process, leverage apps like ArcGIS Survey123 to do quantitative and qualitative data collection, ArcGIS Business Analyst to analyze the data, and ArcGIS Hub and ArcGIS StoryMaps to communicate progress with community members.

Now, it's time to get started. Follow these four steps to develop a strategic equity plan, and begin investing your organization's time and resources where they are needed most.

About the Author

Sophia Garcia is Esri's industry solutions specialist for equity and civic nonprofit organizations. In her previous work at the Dolores Huerta Foundation and as a consultant, she collaborated with community organizations and local governments across California to enact equitable redistricting and champion community GIS.

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Different Apps for Different Audiences

Using ArcGIS for Security Operations

Many organizations have a Security Operations Center (SOC) that works around the clock to prevent, monitor, investigate, and respond to threats and events. These can range from cybersecurity attacks to natural hazards—like wildfires or hurricanes— that put employees, customers, and supply chains at risk. The SOC team's job involves communicating with internal and external stakeholders, so data sharing is critical. It is also vital that the right information gets to the right people in the most efficient and effective way possible.

Given that SOC teams present their findings to various groups that have disparate needs, it can be a good idea to create different apps for different audiences. ArcGIS App Builders from Esri, which works directly with ArcGIS Online and ArcGIS Enterprise, makes it easy for users to build interactive geospatial apps—while writing little or no code.

Discover how an SOC team at a big company could use ArcGIS App Builders to get important, time-sensitive security information to those who need it. Then think about how your organization could implement app builders to help people in different departments pinpoint problems and find solutions.

Going from Static Communication to Dynamic Decision-Making

At one large organization with diverse operations, SOC analysts used to spend most of their time monitoring news outlets, searching social media posts, and communicating with other departments to unearth and carefully watch security incidents. To report an event, SOC analysts typically entered information about the event into a legacy, spreadsheet-based desktop system.

When it came to keeping stakeholders informed, SOC analysts relied on static communication technologies. Company executives received a succession of PDFs or PowerPoint presentations, depending on the nature of the incident; employees were sent text-based incident reports via email; and technicians tasked with responding to security issues could only access the most up-to-date information when they had internet or cell service. All this made decision-making during dynamic situations more difficult than it needed to be.

Recognizing these problems, company leaders asked the organization's GIS team to find a way to pull all relevant incident data into one system that could also handle reporting and communication. Team members knew of several apps within the company's existing ArcGIS Online deployment that could work.

Two Workflows Come Together in One Experience

To help SOC analysts more easily review threats and submit data about potential and ongoing incidents, the GIS team members wanted to create one solution that combined the two workflows. For this, they chose ArcGIS Experience Builder, a highly configurable app builder that has flexible layout options and a rich set of widgets with drag-and-drop functionality.

The GIS team developed multiple pages for each workflow: one page that displayed news and social media feeds, another page that SOC analysts could use to fill out and submit incident reports, and a third page that showed existing threats. The pages incorporated the organization's 2D and 3D data, including asset data, threat and incident layers, aerial imagery, and 3D web scenes.

The GIS team also embedded another app within the larger app—an ArcGIS Survey123 smart form that SOC analysts could use to provide the location, description, areas impacted, and date and time of each incident or threat. And since analysts often use mobile devices to complete their work, the GIS team optimized the app built with Experience Builder for all screen sizes, giving it an intuitive user experience.

Maps, Charts, and Graphs Summarize Incidents at a Glance

Executives wanted to be able to understand incident data at a glance, so the GIS team used ArcGIS Dashboards to build a dashboard that displayed real-time information about incidents and threats coming in from both the Survey123 form and the app created with Experience Builder. Once the dashboard was built, intuitive maps, charts, and gauges showed incident types and counts, as well as the number of incidents reported over the previous 24-hour period.

With this, executives could now monitor security incidents as they happened—without waiting to receive static incident reports—and make quick decisions about what to tell employees and how to curtail losses.

Situational Awareness Is Gained in an Instant

Enabling all employees to gain situational awareness of security incidents was the next challenge. Members of the GIS team thought that building a web app with ArcGIS Instant Apps could do the trick, since the app builder is easy to use and provides users with a focused experience.

They chose a purpose-driven Instant Apps template called Nearby to allow employees to view security incidents both holistically and in relation to company locations and assets. The team configured and deployed the app in five minutes. Now, the SOC team no longer had to compile static reports that quickly lost their relevance. Instead, employees could stay informed about dynamic security incidents by accessing the web app whenever they needed to.

Off-Site Incident Response Goes Offline

For the company's technicians, who often work to remedy security incidents off-site in places with no internet access or cell service, the GIS team needed to create a native mobile app that could be used anywhere to monitor and respond to changing situations. No GIS team members had development experience, however, so they wanted to avoid writing code.

The Nearby web app that the team had just built in Instant Apps was ideal for technicians to use to stay abreast of security situations and get from one impacted location to another, since the app can use a mobile device's location to search for nearby incidents. The app just needed to be made available offline. Luckily, that was easy. All a GIS team member had to do was find the app in the My Apps section of Instant Apps, click on its menu, and choose ArcGIS AppStudio. That simple step transformed the Nearby web app into a native mobile app as well, enabling technicians to access an interactive map of security incidents wherever they had to go.

While apps built with AppStudio can be published to public app stores, the GIS team at this company wanted the app to be shared only internally to keep security information private. So GIS team members used ArcGIS AppStudio Player to deploy the mobile app, which allowed the company to control who could access it.

Map-Based Narratives Give Context to Ongoing Threats

To keep company leaders abreast of recent and ongoing security incidents and threats, the SOC team manager holds a weekly briefing for executives and other stakeholders where she presents a rundown of notable incidents and how her team responded to them. Instead of putting together presentation slides, the SOC team manager now uses ArcGIS StoryMaps to create engaging, map-based narratives of the week's happenings.

Live web maps show where notable incidents occurred in relation to the company's assets, and brief narratives describe each incident, its impact, and its status. Some weeks, the SOC team manager embeds other ArcGIS apps, such as dashboards or workbooks, in the ArcGIS StoryMaps narrative when it helps to have more detailed data visualizations. The live web maps and apps allow company leaders to see the incidents in context, interact with the data, and better strategize for how to respond to ongoing threats.

To learn more about ArcGIS App Builders from Esri, visit **esri.com/appbuilders**.

What Can You Do with 100 ArcGIS Online Credits?

ArcGIS Online credits are essentially a form of currency. They are used to "purchase" specific cloud-based services.

Organizations consume credits when they employ certain services to complete a project or as part of their recurring workflows. A few common ways that credits get consumed are through performing geocoding, conducting spatial analysis, and doing data enrichment.

To get a better understanding of how easy and inexpensive it can be to use credits in ArcGIS Online to create maps and communicate data to stakeholders, check out the following sample workflow:

The Situation

A local fire department recently expressed interest in gaining access to grant money offered by the state to increase countermeasures aimed at preventing traffic accidents. These countermeasures include installing speed safety cameras, enhancing the visibility of crosswalks, and building meridian barriers.

To qualify for the grant money, the organization had to provide compelling data to support where specific countermeasures would be most effective on local public roadways. The fire department needed to identify where most of the accidents in its jurisdiction occur. Members of the fire department partnered with staff at the local Department of Transportation (DOT) to do the research and present their findings in a compelling way.

The fire department's ArcGIS Online administrator gave the team a budget of 100 credits for this project, which took about two months to put together, present, and hear back on. Here's what they were able to do.

Geocoding = 38 Credits + 0.48 Credits for Storage

The fire department started by pulling data from its dispatching system on the addresses of past 911 calls related to traffic accidents. The team members gathered accident report records from the previous year and compiled that data into a spreadsheet based on the addresses. The total number of reported incidents equaled 950.

Using ArcGIS Online, the GIS analyst assigned to the project dragged the CSV file into Map Viewer and created a hosted feature layer. The analyst then geocoded the data, converting the list of addresses to points in a feature service. The point locations were displayed on a street map and visualized by when the accidents took place.

Geocoding can be done using addresses or specific coordinates, and once this data is entered in Map Viewer, the software displays specific locations as points on a map. This is also the first step in turning data from a file into spatial data. It consumes 40 credits per 1,000 geocodes.

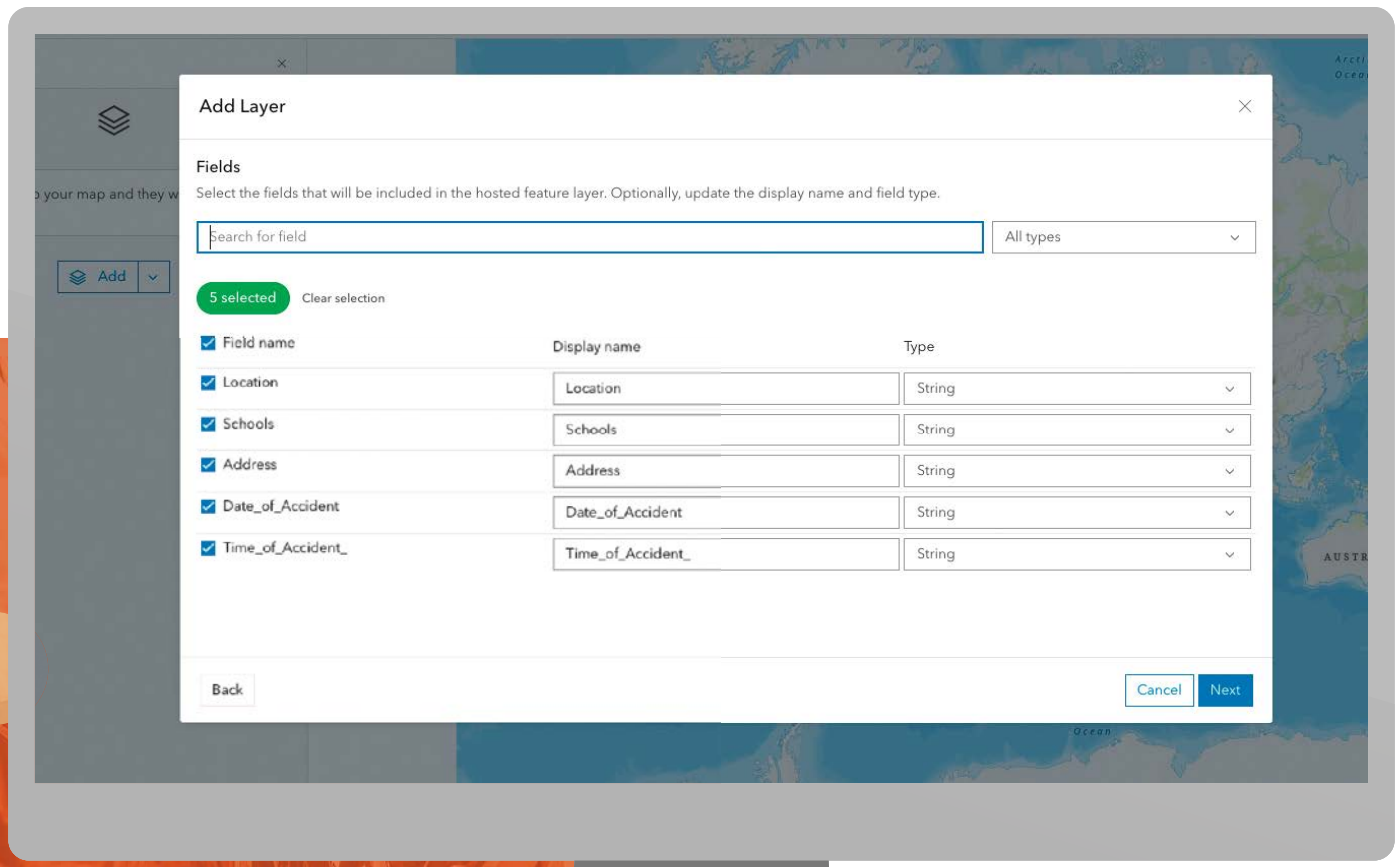
The fire department's resultant hosted feature layer stored 1,000 geocodes, which took up approximately 1 MB of storage space. Storing a hosted feature layer consumes 2.4 ArcGIS Online credits per month for every 10 MB stored, making the total storage charge 0.48 credits for two months.

The fire department needed to do all this to analyze previous traffic accidents and understand if there were any commonalities or trends in those incidents, such as where they happened (near schools, perhaps) and what time of day more accidents occurred (during school drop-off and pickup hours, for example).

Publishing a Roads and Schools Layer = 26 Credits

Once the fire department team members had their geocoded data on traffic accidents, they presented their findings to the local DOT. The DOT's GIS analyst shared a file geodatabase with the fire department that showed schools and roadways in the area. This was used to create a map that displayed the traffic accident points overlaid on the schools and roads layer.

The GIS analyst from the fire department published the file geodatabase as a hosted feature layer and then added it to Map Viewer. The published hosted feature layer was 54 MB, which consumed approximately 13 credits per month for two months.



↑ The fire department's GIS analyst geocoded the data, converting the list of addresses to points in a feature service.

Analysis = 1 Credit + 0.48 Credits for Storage

The fire department's GIS analyst then used the Summarize Nearby tool in ArcGIS Online to find traffic accidents that happened near schools. By running an analysis on the schools and the traffic accidents layer, the team determined which accidents occurred within one mile of a school.

Employing the Summarize Nearby tool consumed 1 credit per 1,000 features. The fire department's jurisdiction contained 50 schools, and 950 total accidents occurred throughout the previous year. The GIS analyst published the results as a hosted feature layer that was 1 MB. This consumed 0.48 credits over two months.

Communication = 0 Credits

Once the analysis was complete, the fire department's public information team leveraged the resultant map and data to create visual assets. Working with the fire department's GIS analyst, the public information team used ArcGIS Dashboards to build a public-facing, interactive dashboard that could be submitted with the organization's grant application.

With its easy-to-understand visuals, the dashboard showed state grant makers where the majority of traffic accidents took place and what countermeasures were needed in those areas. GIS allowed the fire department to take data collected from 911 calls, plus the locations of schools, to prioritize where countermeasures should be installed. Ultimately, this would improve residents' quality of life.

Total = 65.96 Credits

Taking the geocoding, hosting, publishing, and analysis functionalities included in ArcGIS Online, the fire department was able to show—using just 65.96 credits—which countermeasures would be helpful in areas where traffic collisions occur most frequently. In addition, the team was able to use a data-driven narrative to communicate the significance of the fire department's application and clearly articulate the value of GIS for such a project.

The state awarded the team the grant money, and the fire department was able to use it to improve key roadways and pedestrian amenities in its jurisdiction. Overall, the project received positive feedback from community members, and the organization will continue to use ArcGIS Online to make decisions and assist with future capital improvement initiatives.

Use Only What's Needed

This example is one of many that shows how using ArcGIS Online credits can produce reliable analytics and communicate data quickly to both internal and external stakeholders. Whether you need to visualize important data, prepare for a capital improvement project, or simply store data, ArcGIS Online credits allow your organization to pay only for the specific capabilities it needs. What's more, all these functionalities can be performed in the cloud, so no need to manage your own infrastructure.

If you have purchased an ArcGIS Online subscription and have questions about your organization's credit consumption, reach out to your account manager. For more general information about credits, visit go.esri.com/ArcGISOnlineCredits.

Make Your GIS Team **Proactive**, Not **Reactive**

By Kara Shindle, Franklin County, Pennsylvania

The two key differences between being reactive and proactive are timing and control. When we're reactive, we respond to something that's already happened and that isn't under control. When we're proactive, we cause something to happen and control the situation. Of course, you can't control everything—such as legislative requirements or other people's behaviors—but you can control yourself and how you act.

When I took over as the department head for my local county GIS program in 2018, I jumped out of the frying pan into the fire. I spent the first six months dealing with problems, hoping things would calm down. Fast-forward a year, and it still felt like fighting fire was the norm.

In dealing with so many emergencies, I realized that the more fires you put out, the more burned out you become. I was stressed out, worn down, and tired of complaining about how the GIS team wasn't involved in other departments' projects. I felt like I couldn't accomplish my goals for the GIS program. It was also my first supervisory role, and I didn't have the experience or tools to communicate what my team and I needed—particularly because I didn't understand internal processes, and other departments didn't understand what GIS could do. To them, the GIS department just made maps. Does that sound familiar?

I realized that something had to change, or my team and I would break. So I took some steps to move from a place where fires and emergencies were the norm to where my team and I have established boundaries that protect us so we can grow as a department, and we now look forward to new projects. Here's how you can do that, too:

Step 1: Write Down Your Goals

To be proactive during fires, you must plan for them to happen. Part of this planning process involves figuring out your goals and your team's desired end results. Goals are important because they communicate intent while also giving you something to strive for. Any goal-setting method can work, from generating specific, measurable, achievable, relevant, and time-bound (SMART) goals and performing strengths, weaknesses, opportunities, and threats (SWOT) analyses to sitting down and writing out your objectives. Just do something to set your intentions.

Some of my goals were the following:

- Get involved in projects from the beginning, not just when someone needs a map.
- Fight fewer fires and come up with more firefighting plans; go from reactive to proactive!
- Expand GIS use across county departments.
- Get the resources that members of the GIS team need to do their jobs well.
- Support local municipalities.

I then figured out the barriers to achieving each goal. A lot of them were the same—namely, lack of awareness about GIS and/or its capabilities. From there, I brainstormed how to overcome those hurdles, which revolved around building awareness about GIS across departments and throughout the county. Once I figured all this out, I was able to turn my goals into the building blocks of a long-term, strategic plan.

Step 2: Determine Your Capabilities

When I first took over as the county's GIS director, I had so many big questions:

- What does the GIS department need?
- How many requests can we handle?
- Where does our time go?

But I had a hard time coming up with answers. I knew I would need to ask for help. Yet if I did that, I would have to justify why I needed it, and I wasn't sure how to do that.

I decided to establish a record of my department's capabilities. This would help me understand my team's ability to take on new projects, especially emergencies.

There are many tools available to distill this information, but we used a simple spreadsheet (which we still reference today). It listed all the GIS department's assignments, who requested each project, the date the request was put in, the number of hours the project took to complete, a brief description of the project, and the GIS employee assigned to it.

Once we had a healthy inventory of assignments, we categorized the tasks, such as creating visuals, doing research on parcels, and providing data for emergency services. I also added a few categories for myself to see how much time I spent on database administration, on project management, and in meetings.

This spreadsheet informed many reports. It allowed me to answer various questions about what the GIS department spends time on and can do. It also helped me manage the team's resources and estimate project budgets. In addition, the spreadsheet showed the sheer number of requests that the GIS department receives, plus the types of requests that come in and the amount of time the team spends answering those requests. This is all useful for me when discussing staffing needs and project capacity.

Step 3: Communicate

It is not in my nature to speak out, but I had to start communicating the GIS team's intentions and needs. This can be a double-edged sword because the more you speak out, the more people are aware of you. In a positive light, this can get you included in conversations earlier. In a more neutral light, you may be given more responsibility or invite scrutiny. Always think about the consequences of your actions ahead of time and determine if they're worth the risk. In my case, I decided to accept the risks and rewards in equal measure.

A lot of the challenges in my department stemmed from a lack of awareness about GIS, so I came up with a long-term communication strategy. It's a two-way street. I communicate my team's capabilities and successes with others throughout the county while also meeting regularly with employees in other departments to hear their stories and goals. Open communication like this is essential to preventing program stagnation and identifying new ways to improve.

Using the data I've gathered about my team's capabilities and projects, I'm now distributing annual reports, project highlights, and newsletters. In 2022, my department sent out its first What Is GIS email to all county employees. It's also useful to ask to be included in others' communication efforts. Our public-facing GIS apps were featured in a virtual scavenger hunt hosted by the county. All this has resulted in people reaching out to learn more about what the GIS department does.

Step 4: Conclude That That's Enough for Now

The first three steps of this process require effort and commitment. It takes a while to build and sustain good habits, so just start with these ideas and find the tools you need to begin turning a reactive program into a proactive one. Not everything I've done will work for everyone, but identifying goals, gathering data to support them, and communicating better are critical. For me, these steps have alleviated some of the worry that comes with managing projects, overseeing resources, and prioritizing tasks. Once you establish your department's current capabilities, you can start putting together long-term plans and measuring your team's return on investment (ROI).

Looking back on when I first became the county's GIS director, I am beginning to see the fruits of my department's efforts to be proactive rather than reactive. I know we can't control and plan for everything. But putting the tools in place to collect data and identify our priorities and needs has helped mitigate some of the unpleasantness of surprise fires—and even get ahead of issues before they become fires. I don't always know where or when a fire will start, but I'm not as worried now that I have a fire extinguisher at hand!

About the Author

Kara Shindle, GISP, is the GIS director for Franklin County, Pennsylvania.

Managing GIS

A column from members of the Urban and Regional Information Systems Association

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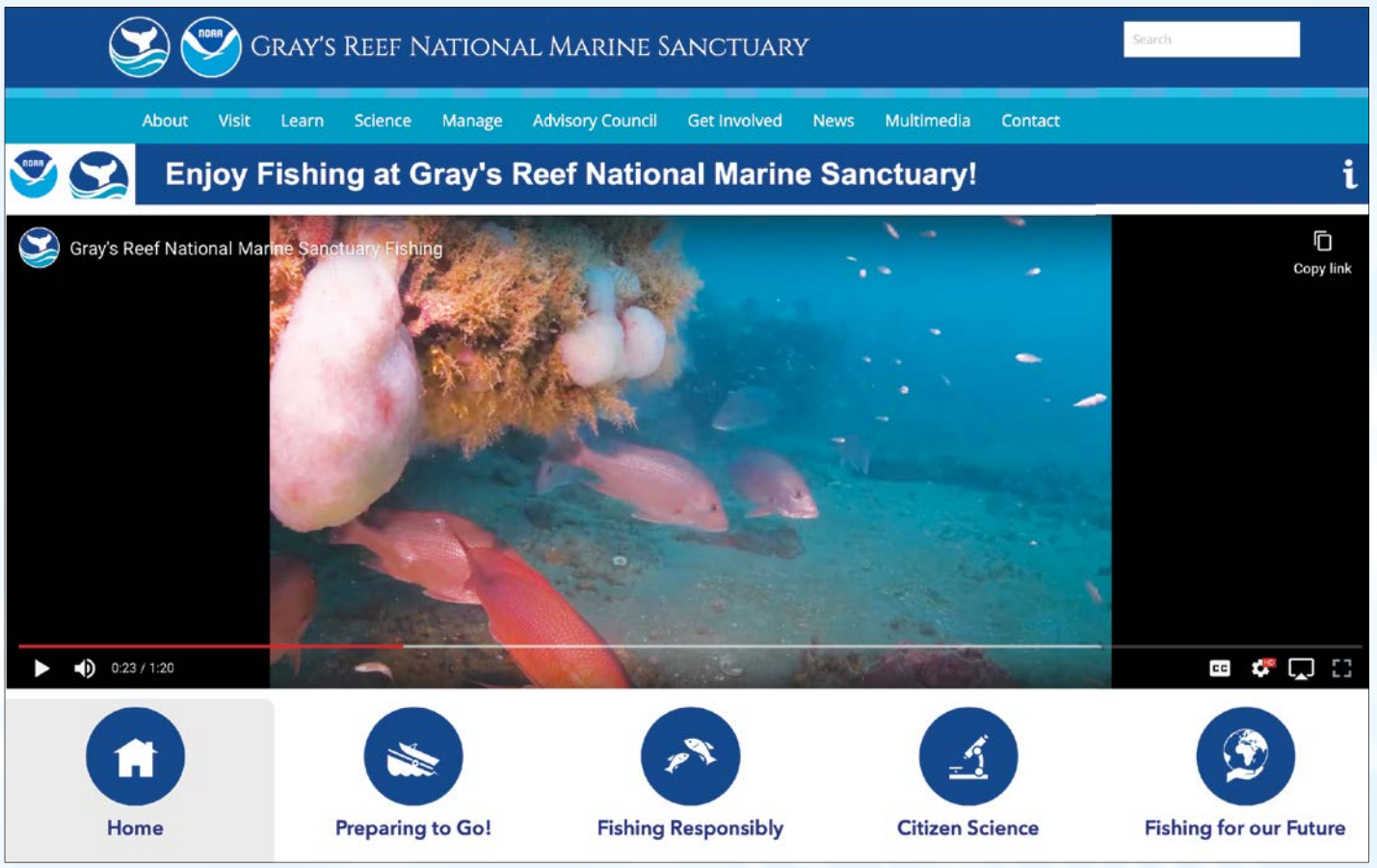
Marine Sanctuary Builds a New Experience to Engage with the Fishing Community

Gray's Reef National Marine Sanctuary, a marine protected area off the coast of Georgia, is one of the largest nearshore live-bottom reefs in the southeastern United States. The sanctuary, managed by the National Oceanic and Atmospheric Administration's (NOAA) Office of National Marine Sanctuaries, is composed of rocky ledges, undercuts, and sand patches that provide habitat for thousands of species of invertebrates, marine mammals, and fish. Fishing and diving are permitted in the sanctuary, giving anglers the chance to catch black sea bass, mackerel, snappers, and groupers.

To conserve the reef's vast resources, an entire team conducts scientific research, provides education, and performs outreach to locals and visitors alike. In 2019, the team began an initiative to connect with fishers through learning exchanges and in-person educational workshops to teach them about Gray's Reef and equip them with best practices.

But when the COVID-19 pandemic hit early the following year, the learning exchanges at Gray's Reef had to shift from in person to virtual. To facilitate this, the team at Gray's Reef collaborated with Esri partner Dewberry to develop an online solution that would live on the sanctuary's website. Built using ArcGIS Experience Builder, the web app—available at links.esri.com/graysreef—has improved how Gray's Reef communicates with the fishing community and boosted cooperation among the project's partners.



← The site's main page features a video on the purpose of the site and why the information on it is important.

Replicating a Dynamic Experience

The learning exchanges were initially held along the Georgia coast. Made possible with National Marine Sanctuary Foundation funding, which environmental organization The Nature Conservancy (TNC) applied for and received, the exchanges sought to find out from community members what they wanted to learn about the sanctuary while equipping them with vital information and general education about it.

When such in-person gatherings ceased in 2020, the group working on them—which, in addition to Gray's Reef and TNC, included the University of Georgia's Marine Extension and Georgia Sea Grant, the South Atlantic Fishery Management Council, FishSmart, and the Georgia Department of Natural Resources—opted to create an online product on the Gray's Reef website that people could access from anywhere, at any time.

"We wanted to make it…as interactive and dynamic of an experience as we could, but be safe," explained Robert Crimian, southeast ocean conservation specialist for TNC. "The idea of this living on the website for years to come instead of being a stagnant, workshop-based project seemed appetizing."

According to Stan Rogers, superintendent at Gray's Reef National Marine Sanctuary, the initiative doesn't simply explain fishing regulations to fishers; rather, it connects people through education and best practices and improves understanding of critical issues at the sanctuary.

"Gray's Reef is…in federal waters. It belongs to all US residents. It's yours; it's mine; it's ours," Rogers said. "It's our obligation to communicate these things to the people at large, not just specific user groups or people who live on the coast."

The critical issues at Gray's Reef include combating barotrauma—injuries that deepwater fish, like snappers and groupers, can get from being pulled to the surface too quickly and experiencing rapidly changing atmospheric pressure. Best practices encompass learning which hooks are best for catching certain fish and the maximum amount of time a fish can be out of water.

"Gray's Reef has been an ideal fishing destination for 40 years, and it's because of past generations conserving the fish *[and]* the habitat there that our children and grandchildren can, hopefully, fish at the levels that *[people]* did in the past," said Ben Prueitt, outreach and social media coordinator at Gray's Reef.

Creating an Immersive, Informative Site

The team members at Gray's Reef wanted the online site to be eye-catching, interactive, and dynamic. They wanted participants to be able to move at their own pace and click buttons to receive more information on specific topics. They also wanted to give visitors a view of Gray's Reef under the surface so fishers could better understand the incredible resources that the rules and regulations are put in place to protect.

In addition, because previous analytics revealed that a large number of mobile phone users access the Gray's Reef website, the team wanted their online solution to have responsive design and be optimized for mobile devices.

To build the site, Siddharth Pandey, geospatial technology manager with Dewberry, selected ArcGIS Experience Builder, which would allow the site experience to happen all in one space. The app builder enables users to create mapcentric (or nonmapcentric) apps without having to do an extensive amount of coding.

Pandey discussed the desired user experience with the team and considered things like what people need to know before getting to the reef, such as important regulations. He then read some documentation to learn how to use Experience Builder, but he mostly did a lot of trial and error to get the look and experience right.

"It was fun," Pandey said. "There's a fairly steep learning curve, but…once you get past that, then it's really easy to use."

There was a significant focus on making the site accessible and simple, so Pandey included pop-up windows with additional information. Alternative text was also added to images to help individuals who use assistive devices. The app is hosted on NOAA's GeoPlatform—which provides geospatial data, maps, and analytics to the public—but Gray's Reef team members have direct access to it and can edit and adjust the experience based on user feedback.

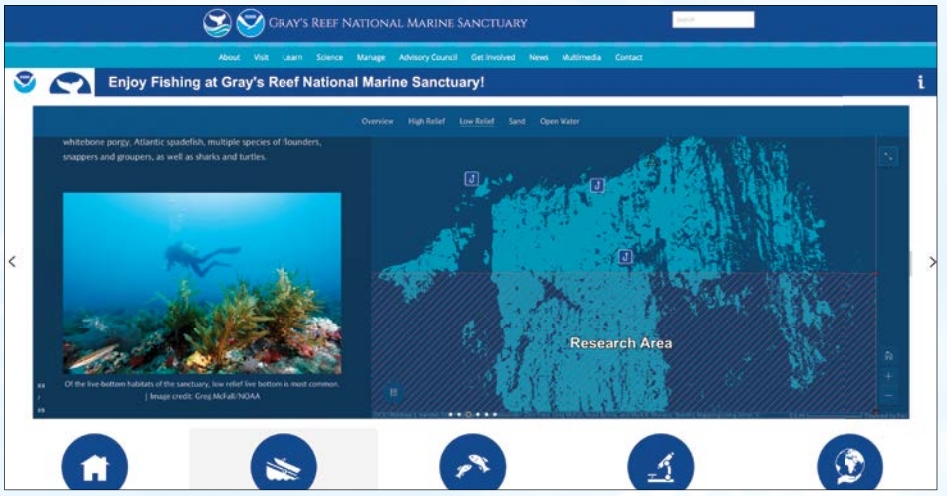
"It was really about making it as immersive as it is easy to use," Pandey said. "You can look at different buttons and get a sense of exactly what you're going to experience when you click on *[one]* and go to that *[page]*."

The final site includes several pages. The main page showcases an introductory video on the purpose of the site and why the information is important. Another section, on preparing to go to Gray's Reef, displays information on the reef's habitats via an ArcGIS StoryMaps narrative. It also includes videos of some of the animals that live on the reef, like black sea bass and a school of ladyfish. Another section details the regulations of the sanctuary and the reef's research area. Additionally, there are sections focused on community science, such as how to participate in a catch-and-release program for shallow-water fish, and the future of fishing at Gray's Reef.

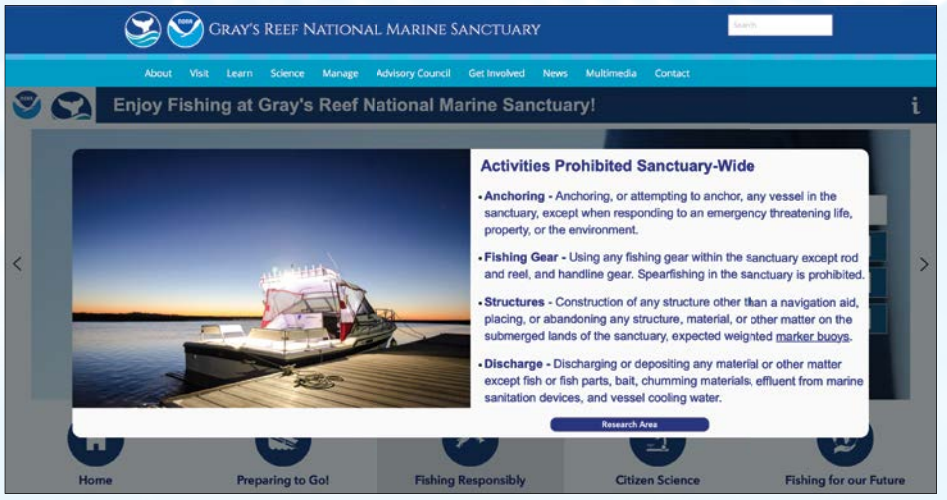
Reaching a Broader Segment of Society

The new Gray's Reef best fishing practices experience launched in November 2021, and the results have been outstanding. It became one of the top 10 experiences on the sanctuary's website, and it was the one that visitors spent the most time on.

According to Crimian, anglers are enjoying the new site and were major contributors to the



↑ A section put together like an ArcGIS StoryMaps narrative displays information on the reef's habitats.



↑ The site operates like an orientation for fishers who are new to Gray's Reef National Marine Sanctuary, except people can access it from anywhere, at any time.

content, which they see reflected in the experience. Additionally, the site has allowed the Gray's Reef team to reach a larger portion of recreational fishers, said Elliott Lam, state program manager at Gray's Reef National Marine Sanctuary.

"When we go out to talk with local *[fishers]*, we end up talking with the ones that are living at the coast, where we are, but not necessarily encompassing all the ones that travel down…from other parts of the state or the region," Lam said. "By having access to this year-round, at their convenience, they get to have the same content of a new fisher orientation as they would get from one of our in-person meetings."

The visual components of the experience are exciting for Rogers, who believes the team can reach more people with multimedia elements, such as 360-degree videos of the reef, slideshows, and maps. Despite having to curtail in-person events for a while, the website has been a great way to enhance engagement with the public.

"It's our obligation to make sure we are reaching a broad segment of society…and that we are speaking in a language that the general public understands," Rogers said. "Products like these are more engaging…so it's going to hit a broader community."

Having all the different sections housed in one site has improved information gathering as well. Because each of the partners on the project has its own website, it helps that the site built with Experience Builder can bring all that information together in one place. This makes it easier for users to absorb content while also providing an interactive experience, according to Prueitt.

Pandey enjoyed using Experience Builder as well. Once he had created a custom template with the app builder, he was able to customize and expand on it. Staff members at Gray's Reef can also now update the site, even if they don't have any experience with coding. This means that Gray's Reef no longer has to hire specialists to do this.

"Should the team *[members]* decide they want to add pieces to it or construct something similar, it's a template. You just kind of continue to add more sections or buttons to modify things," said Pandey. "A lot of that work doesn't need to be redone, which is really nice."

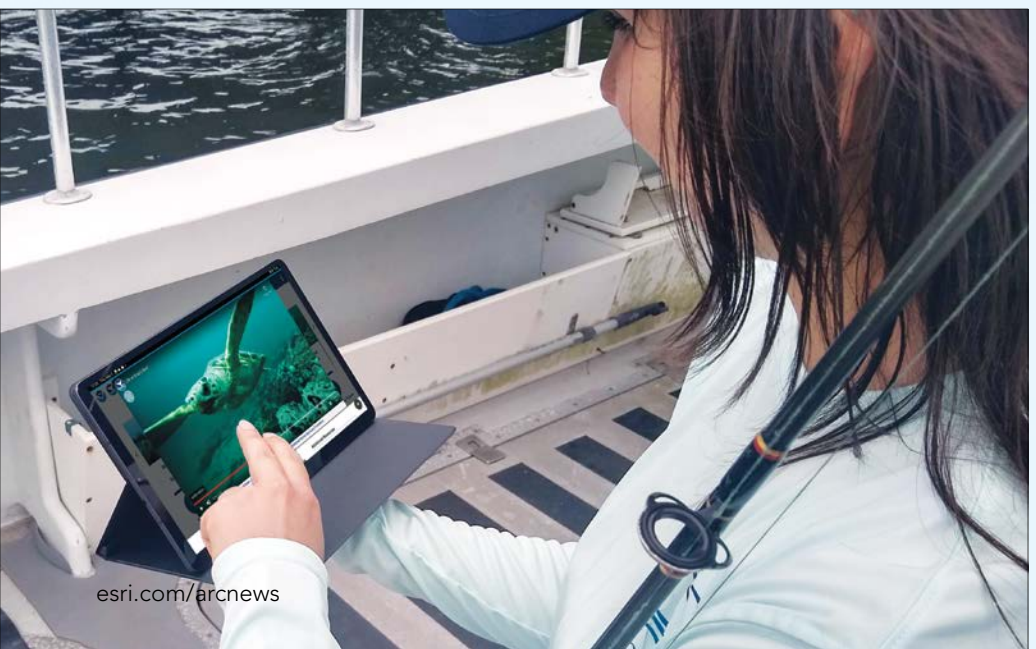
Looking Forward to More Collaboration

The Gray's Reef team has already built a similar scuba diving site with Experience Builder and looks forward to using the tool to create additional resources for visitors. Rogers said that other sanctuaries are interested in creating similar sites as well, so the team hopes for more opportunities to collaborate with other groups.

"That's where the strength is in *[Experience Builder]*," he said. "It's not coming from one voice. It's coming from a collection of information from various partners. And that really builds trust and believability into these things when you see it coming from multiple sources."

Rogers also believes that this is only the beginning of efforts at Gray's Reef to use apps like this to reach people.

"I can imagine that more dynamic content—like this site built with Experience Builder—is going to receive a lot more visitation and longer exploration of our web content," he said.



← The interactive site is responsive and optimized for mobile devices, so anglers can use it in the field. (Image courtesy of Ben Prueitt, Gray's Reef National Marine Sanctuary.)

Progressive GIS Use Helps Conserve Natural Resources

As a trained biologist focused on conservation, Joe Lemeris, the GIS and data manager for the Heritage Trust Program within the South Carolina Department of Natural Resources (DNR), has used GIS to map wildlife extents, monitor endangered species, manage habitat restoration projects, and more. Yet where he really shines is in employing geospatial technology to transform how whole organizations operate.

"Joe is relatively young in his career, but he gets it," said Sunny Fleming, Esri's environment and conservation industry specialist. "He has an intuitive sense of strategy and the value of GIS, and he translates that into developing useful tools not only for the benefit of South Carolina's natural resources but also for the conservation field at large."

Joe Lemeris

After attending Boston University, where Lemeris majored in biology with specializations in ecology and conservation, he enrolled in the Master of Environmental Management program at Duke University.

"It was at Duke that I was first exposed to GIS," he said. "One of the first meetings we had was in the career office, and they said, 'We have a strong GIS program here, and it's probably one of the more marketable skills you could acquire. We encourage everybody to at least take the intro class.'"

So that's what Lemeris did. While he found the course challenging, he liked how mapmaking brought out his artistic side and was amazed at how widespread the applications of GIS were.

"I thought, 'Wow, you could do so much with this'—and specific to the areas I was focused on: ecology and conservation," he recalled. "That's still my passion, and the fact that I can apply GIS to solve those types of problems is what really led me down this path."

Lemeris earned a certificate in GIS while he got his master's degree. He put his geospatial skills to use right away when he interned as a GIS analyst with the N/a'an ku sê Foundation in Namibia, where he studied the translocation of cheetahs and leopards that were causing problems for local farmers.

"We would take the animals, put a radio collar on them, and release them into protected areas that weren't near as much human activity so that, in theory, they wouldn't be problematic anymore," said Lemeris.

He parlayed this experience into his final master's degree project, developing a solution called the Carnivore Translocation Suitability Tool (CaTSuiT) to analyze the best places to put big cats when they're taken away from a problem site.

"The tool took the cat's original location, along with survey data from landowners, and spit out a raster of potentially suitable habitat in Namibia for that particular cat," Lemeris explained.

He and a colleague from the foundation published a few papers together that employed CaTSuiT. And after graduation, Lemeris continued this work by becoming the intern coordinator for the National Geographic Society's Big Cats Initiative at Duke.

"We worked on some cool projects. One of them was redrawing the range maps for leopard distribution worldwide," Lemeris said.

The finer-scale range maps that Lemeris and his team members produced led, in part, to several subspecies of leopards being declared more endangered than previously thought. This can help with conservation efforts to preserve their habitats.

"It was pretty amazing to have that kind of impact," Lemeris reflected. "The intersection between humans and conservation is unavoidable, so you have to figure out a way to balance that. And GIS is the perfect tool for that."

After a year and a half with the program, Lemeris got a senior biologist job at the South Carolina Department of Parks, Recreation and Tourism.

"The job description really didn't have any GIS in it, per se, but as soon as I got there, I recognized that GIS could be used to create better, more efficient processes," he said. "I was responsible for things like habitat restoration, survey design, and monitoring endangered species in the parks. All that has to be mapped, so we started beefing up our software."

With support from the agency's chief information officer, Lemeris encouraged his colleagues to upgrade their GIS and take advantage of newer technology, such as ArcGIS Online and ArcGIS Pro. They began making web apps and building ArcGIS StoryMaps stories to enhance public engagement.

"We were showing where prescribed burns would happen," said Lemeris. "Our historian also made some fascinating *[stories]* about the cultural significance of our parks."

Lemeris and his team earned a Special Achievement in GIS (SAG) Award from Esri for their use of cloud-based GIS to make data collection and analysis more efficient and accessible. Around that time, Lemeris moved into his current, GIS-focused role at the state's DNR.

"I'd spent so much time investing in my GIS expertise that I felt like I didn't want to lose it," he said. "I saw that there was an opening for a GIS analyst position at the DNR to revamp the state's heritage database with support from the Department of Transportation *[DOT]*, and I thought that sounded like a perfect fit."

While the DNR had been actively managing its heritage database—which catalogs the sate's natural and cultural resources—the data backlog had grown, and a lot of species records were missing, according to Lemeris.

"There was data everywhere, but it wasn't getting updated in a central location, and there wasn't an easy way to share anything," he explained. "DOT *[staff were]* experiencing issues where, if they were redeveloping a road or building a new bridge, it would cost them extra time and money because they'd find out that there was, say, a rare plant or freshwater mussel in the stream nearby—something that they never knew was there. But they would have known had the data been kept up and easily attainable."

Lemeris was hired to work through the data backlog and figure out how to make heritage data available to anyone who needed it. One of the first things he did was sign up for the Esri Advantage Program (EAP).

"Originally, our grant indicated that we were going to hire an in-house developer to build our system, but I was worried about what would happen when the developer left," he said. "The Advantage Program was actually less expensive than our alternative options."

In his first few years at the DNR, Lemeris spent a lot of time cultivating relationships with other biologists, foresters, and anyone else who could benefit from expanding their use of GIS.

"Within his own agency, Joe quickly proved the value of GIS for a wide variety of environmental workflows," Fleming pointed out.

He showed colleagues how to use GIS to collect data more efficiently, which also ensured that the information flowed into the heritage database.

"I would show them how using ArcGIS Survey123 could save them data entry time and allow for data sharing without having static copies floating around," said Lemeris. "After many meetings and presentations, people began thinking about how they could use GIS in their own work—and they started reaching out to us."

This process has worked very well for Lemeris and the Heritage Trust Program—not only in terms of buy-in for GIS but also because it makes a wide range of data very accessible.

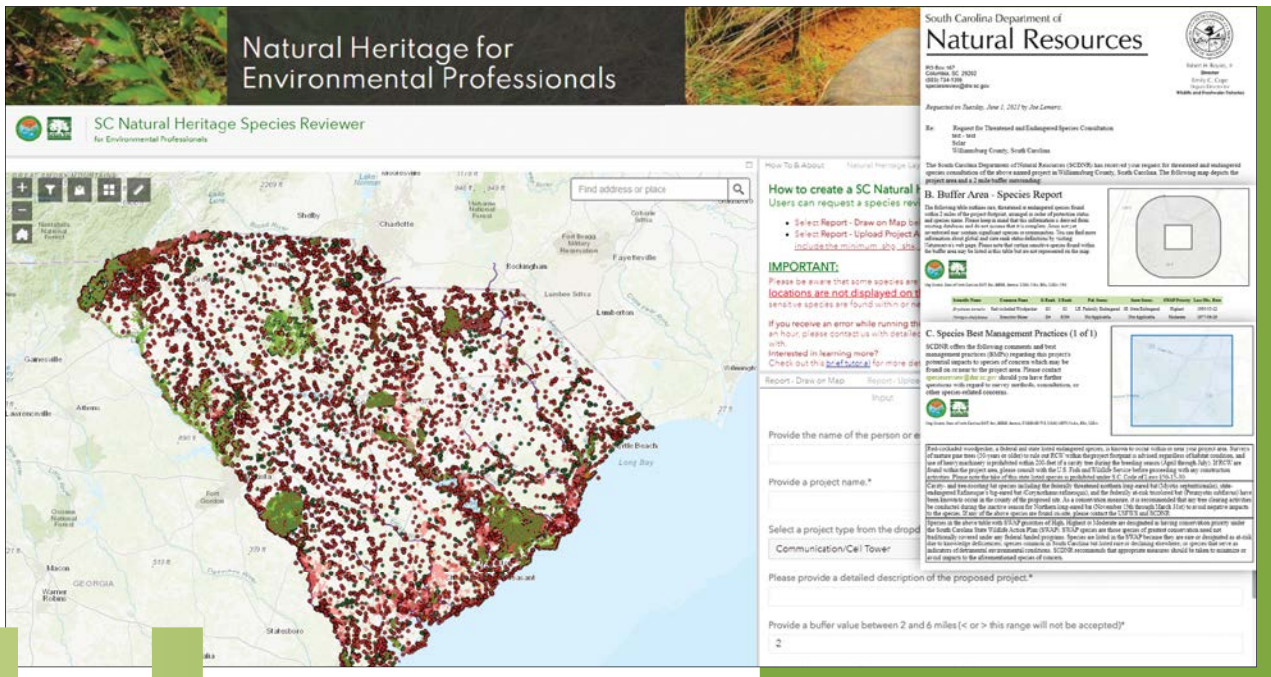
"For example, our herpetologist has technicians running all over the state collecting data on reptiles and amphibians, and every six months to a year, I'll go in and pull the rare species data and put it in our database," said Lemeris. "Then the data is available for everyone who needs it to protect those species."

The system that Lemeris and his team have developed, which includes publicly available web apps, lets both internal and external stakeholders access heritage data on a self-service basis. So everyone, from private developers to employees at the DNR, can get the data they need when they want it, curtailing manual processes and cutting down on the time it takes to retrieve the data.

"The return on investment is huge," said Lemeris. "It's helped with data sharing across agencies, and people trust that they're getting authoritative data."

This work earned Lemeris and his current team a SAG Award in 2021. It has also inspired other state DNRs and natural heritage programs that collaborate with NatureServe, which consolidates data from these programs across North America.

"I could not do what I do without the support of everyone at DNR who encourages us to charge forward in the progressive way that we do with GIS," Lemeris reflected. "There's a growing sense here that if we put our data to use spatially, it will generate powerful solutions to help care for our state's natural resources."



↑ The South Carolina Department of Natural Resources (DNR) Heritage Trust Program makes a wide range of plant and animal species data available to both internal and external stakeholders.

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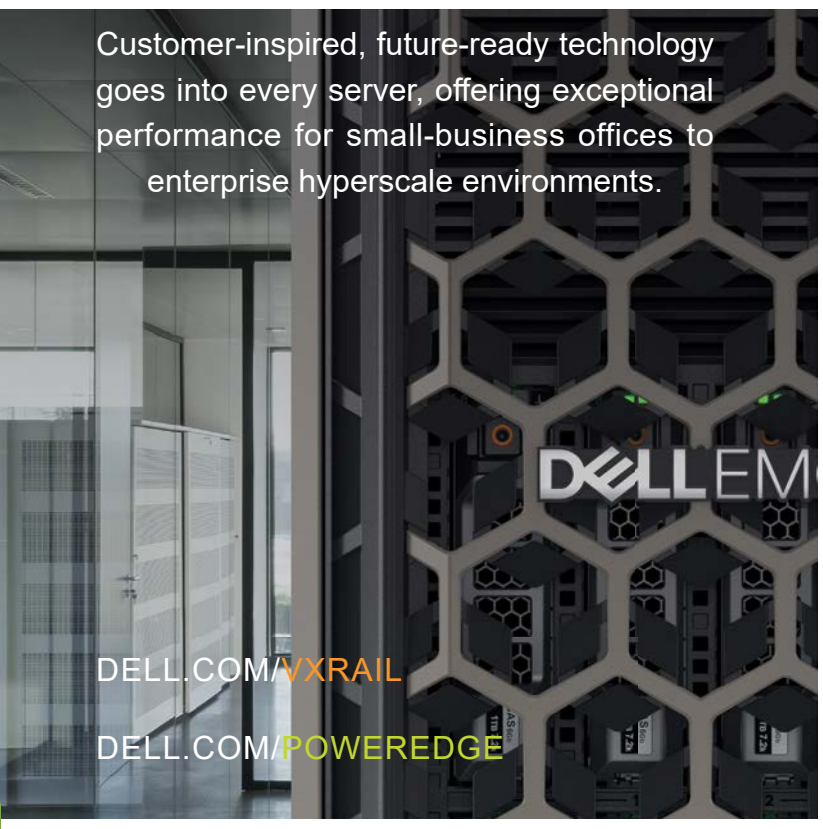

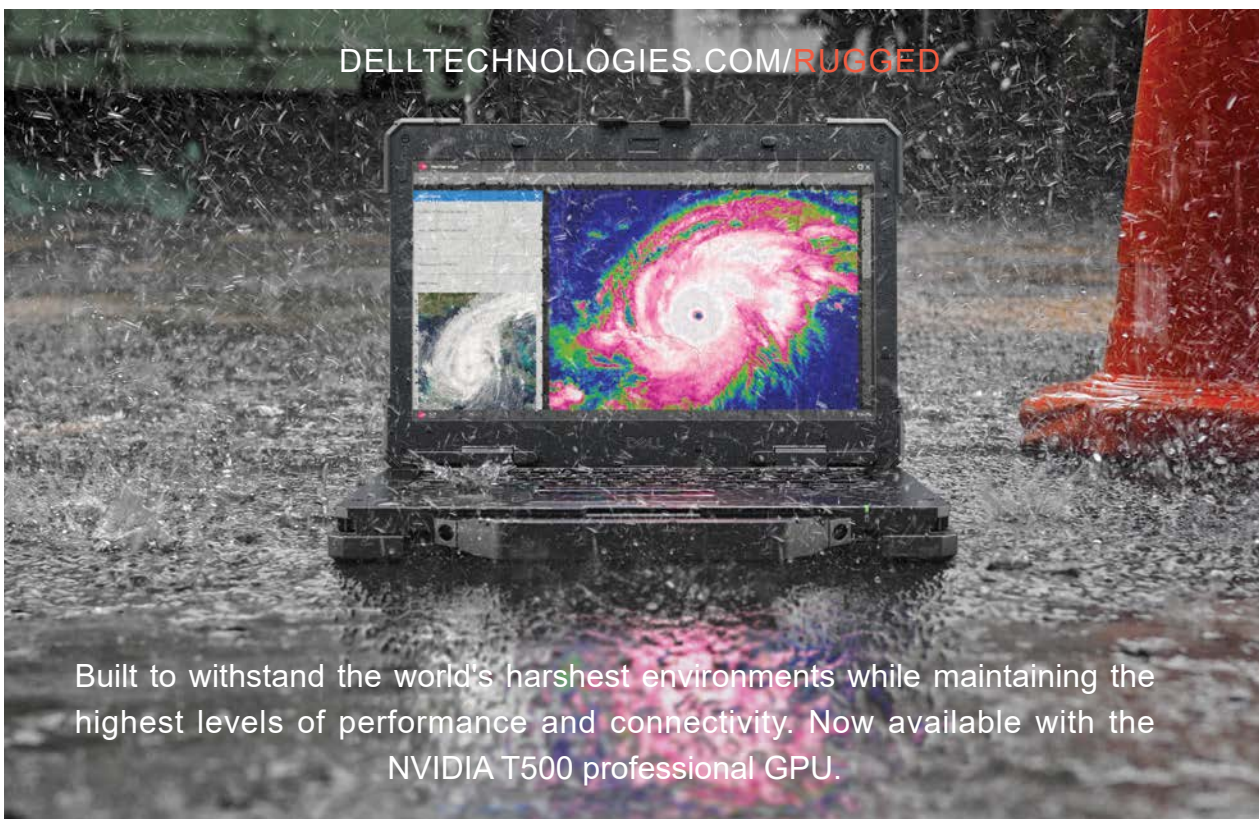

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REAL-TIME FLOOD INTELLIGENCE HELPS COASTAL CITY BUILD RESILIENCE

By Bruce Grady, FloodMapp

Norfolk, Virginia, is no stranger to the hazards of climate change. Flood events—including rapid rainfall, river floods, rising tides, and storm surges—have become more intense. In recent years, these natural hazards have caused significant disruptions to transportation, impacting residents' quality of life. The disruptions affect all modes of road transport and frequently upend economic and social activities in the area.

Recognizing that sea level rise will continue to be a reality in the region, the City of Norfolk is building resilience against climate-related hazards. Through RISE, a nonprofit economic development organization that helps coastal communities adapt to a changing climate, the city partnered with Esri startup partner FloodMapp (floodmapp.com) to implement flood modeling technology that delivers inundation data quickly and at more than 90 percent accuracy.

"As our streets flood more often due to climate change, we need to find a sustainable way to alert community members about the risks they face," said Kyle Spencer, deputy resilience officer for the City of Norfolk. "FloodMapp's technology provides affordable, citywide situational awareness that current solutions, such as sensor networks alone, don't offer."

Lots of Information, But No Actionable Intelligence

Norfolk, which is home to 235,000 residents, encompasses 66 square miles and has 144 miles of shoreline along lakes, rivers, and the Chesapeake Bay. Much of this waterside land consists of residential neighborhoods.

Prior to working with FloodMapp, the city had access to a lot of information from flood sensors and static flood studies. But given the speed and scale at which current flood events are unfolding, staff needed more actionable intelligence to be able to respond to sudden storms, surges, and floods.

The city sought help from RISE, which put out a call through its Urban Mobility Resilience Challenge to get Norfolk equipped with flood modeling technology that it could use to help navigate traffic around flooded roads. FloodMapp's solutions—which provide real-time, street-level predictions and alerts for flooded roads—turned out to be the scalable, cost-effective system that the City of Norfolk was looking for.

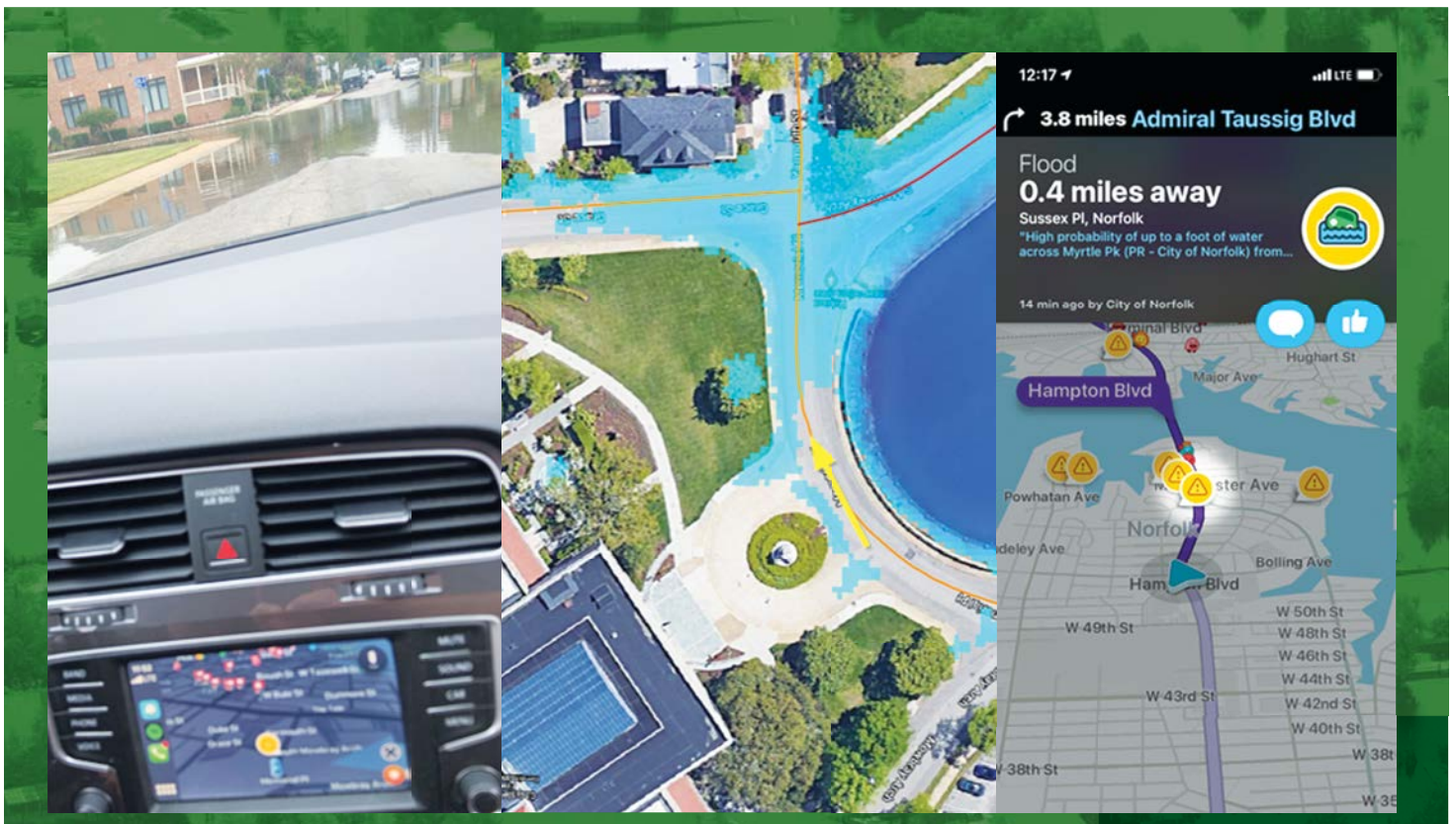
Street-Level, Property-Specific Flood Data

Coastal Virginia is not alone in suffering the impacts of increasingly devastating floods. Last year, communities in Australia and Pakistan experienced some of the worst flooding that's ever been documented. Flooding is among the most frequent, dangerous, and costly natural disasters. The risks for drivers are particularly grave. About half of all flash flood-related fatalities in the United States occur in motor vehicles, according to the Federal Emergency Management Agency (FEMA). And auto insurance claims for flood damage in the United States averaged $3.5 billion annually from 2005 to 2014, according to Cover, an insurance technology company.

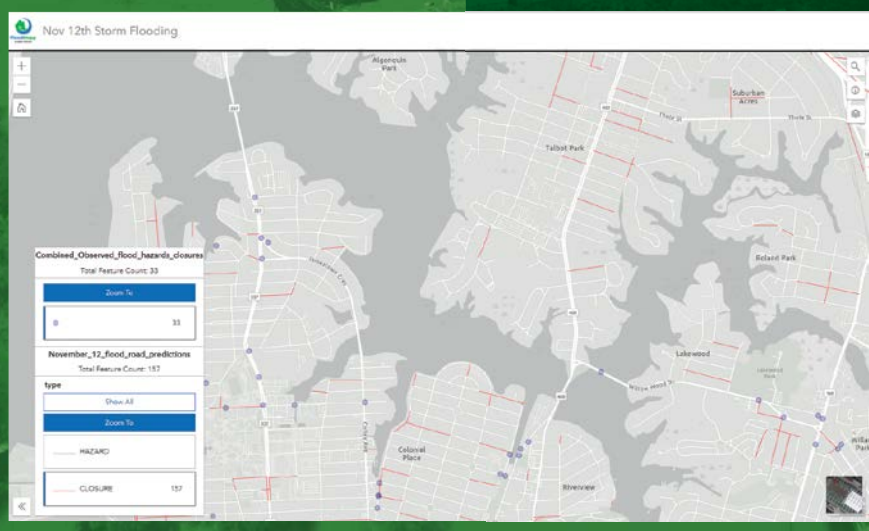
FloodMapp's mission is to improve safety and prevent damage from flooding on a global scale. Its proprietary flood modeling technology, DASH (which stands for Dynamic Automated Scalable Hydro-informatics), accesses live rainfall, river, and tide gauges to feed its hydrologic and hydraulic models. The models are powered by artificial intelligence (AI).

DASH produces updated model outputs of coastal conditions at state and national scales in a matter of seconds, whereas traditional 2D hydraulic models can take hours or days to produce a single catchment. This solves the historic problem of there being long delays in delivering accurate inundation data, which can hinder situational awareness. What's more, the dynamic flood inundation and depth models that DASH produces have street- and property-level accuracy.

With this technology, FloodMapp can supply customers with live flood intelligence before, during, and after flooding events. Additionally, the company's other products—ForeCast, NowCast, PostCast, and RoadSafe—are live mapping feeds that integrate seamlessly with ArcGIS Pro and ArcGIS Online to support

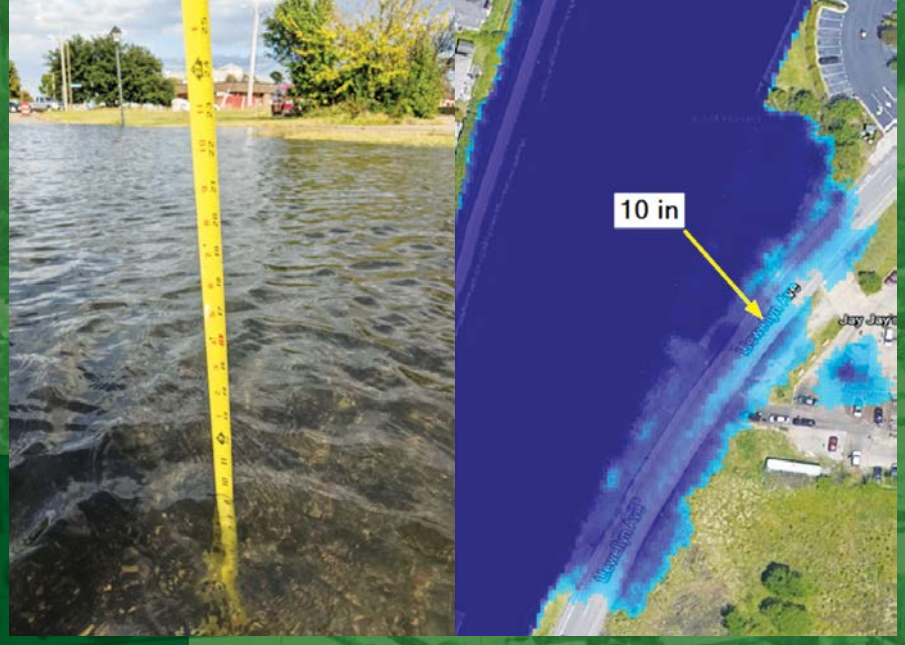


↑ FloodMapp can monitor the flood models' performance in real time via feedback from Waze users.



← NowCast (right) shows flood inundation extents and depths in near real time.

↑ City staff can view live road closures and road hazards, which get updated dynamically in ArcGIS Online as a flood event unfolds.



← FloodMapp's flood inundation models are accurate to within inches.

emergency managers working for governments and in the private sector.

Each product provides dynamic, street-level, property-specific flood intelligence that can be scaled up to a national view. Emergency managers can overlay FloodMapp's models with their existing ArcGIS data layers on people, property, and critical infrastructure to provide accurate situational intelligence. With this information at hand, they can then issue flood warnings, coordinate evacuations, protect critical assets, reroute traffic, safely deploy response resources, and quickly target recovery actions.

For Norfolk, FloodMapp focused on using its technology to help city officials alert residents of potential flood hazards and establish targeted road closures. The project was made possible by a grant from RISE, which is funded through the US Department of Housing and Urban Development's Community Development Block Grant Program and administered by the Virginia Department of Housing and Community Development.

Dynamic Solutions for Fast-Changing Events

A team at FloodMapp worked with staff members at the City of Norfolk to understand the detailed requirements of meeting this challenge. After the teams drew up a plan, the first step was to implement NowCast, which delivers near real-time flood inundation extents and depths as a mapping service. This allows city staff to see flood inundation models based on tidal and rainfall observations that get updated every 15 minutes and are accurate to within inches.

Next, the FloodMapp team set up RoadSafe, a powerful analytics service that predicts which roads will flood, based on the inundation data from NowCast. Flood depth thresholds, developed in collaboration with the city, are used to define road hazards and road closures based on the depth of flooding over each road segment. The solution was then delivered to the City of Norfolk's ArcGIS Online organization, where staff members can view live road closures and road hazard segments that get updated dynamically as a flood event unfolds.

Additionally, the FloodMapp team worked with navigation company Waze to integrate RoadSafe's flooded-road predictions with the Waze app via the Waze for Cities platform. This enables the City of Norfolk to notify app users of roads that have the potential to flood by placing flood hazard icons on local Waze maps.

"The successful integration of FloodMapp's technology into Waze has the potential to save property and lives and help coastal communities worldwide adapt to the threats from climate change," said Paul Robinson, executive director of RISE.

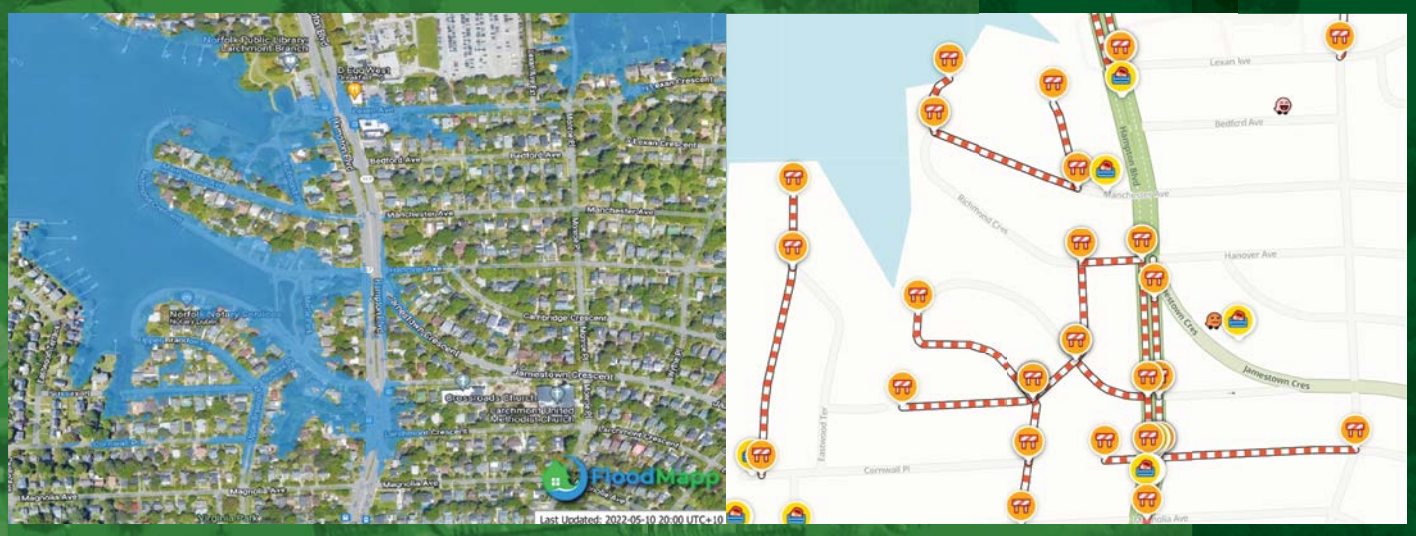
A Common Operating Picture for Flood Events

Because FloodMapp is integrated with ArcGIS Online and ArcGIS Pro, City of Norfolk staff members and other stakeholders are able to use NowCast and RoadSafe to develop a common operating picture during a flood event. The solution provides the City of Norfolk and staff at the Emergency Operations Center with hyperlocal flood data in real time. This vital situational awareness helps inform emergency managers and public works officials as they respond to flood events, so they can craft accurate community messaging and make safe and effective plans.

The integration with Waze also allows motorists to contribute feedback to the program. They can give a notification a thumbs-up in the app or utilize the app's flood hazard reporting feature. This powerful, crowdsourced ground truth data enables city staff and the team at FloodMapp to monitor the flood models' performance in real time. This quality assurance is valuable for ongoing validation, as FloodMapp is continually seeking to improve its flood models and road closure predictions.

Since launching the system for Norfolk residents in October 2021, Waze users have confirmed more than 4,300 flooded roads predicted by RoadSafe. Drivers have provided nearly 9,500 thumbs-ups to validate FloodMapp's predictions (which average 2.2 and top out at 72 confirmations per hazard). Not only do these crowdsourced observations aid in validating and improving the models, but the engagement statistics also indicate that they are helping thousands of drivers navigate around flooded roads. Those drivers have prevented losses and damages to their vehicles and have been able to get home safely to their families.

The flood prediction solutions that FloodMapp implemented in Norfolk have provided the city with an infusion of innovation as it continues to adapt to the increasingly dire effects of flood-based hazards. The solutions are highly responsive to local resilience issues and can be rapidly adapted to the needs of other communities.



↑ The flood inundation extents from NowCast (left) get reflected on a road closure map in Waze (right).

The Esri Startup program gives emerging businesses an edge by helping them integrate spatial functionality into their products and services. Learn more about the program at developers.arcgis.com/startups.

About the Author

Bruce Grady is the business development and partnerships manager at FloodMapp. He has more than 30 years of executive-level and consulting experience in business, risk, and disaster management. For more information on FloodMapp and its solutions, email Grady at bruce.g@floodmapp.com.

Working with Esri Partners Brings In Vital Experience and Perspective

Some GIS projects just benefit from having an outside perspective to ensure accuracy and increase efficiency. Esri partners are experts at implementing ArcGIS products and services to meet their clients' needs. Find out how three Esri partners—Blue Raster, Dymaptic, and RAMTeCH—refined three organizations' GIS implementations to make them more streamlined and user-friendly.

Evaluating the Carbon Benefits of Conservation Efforts

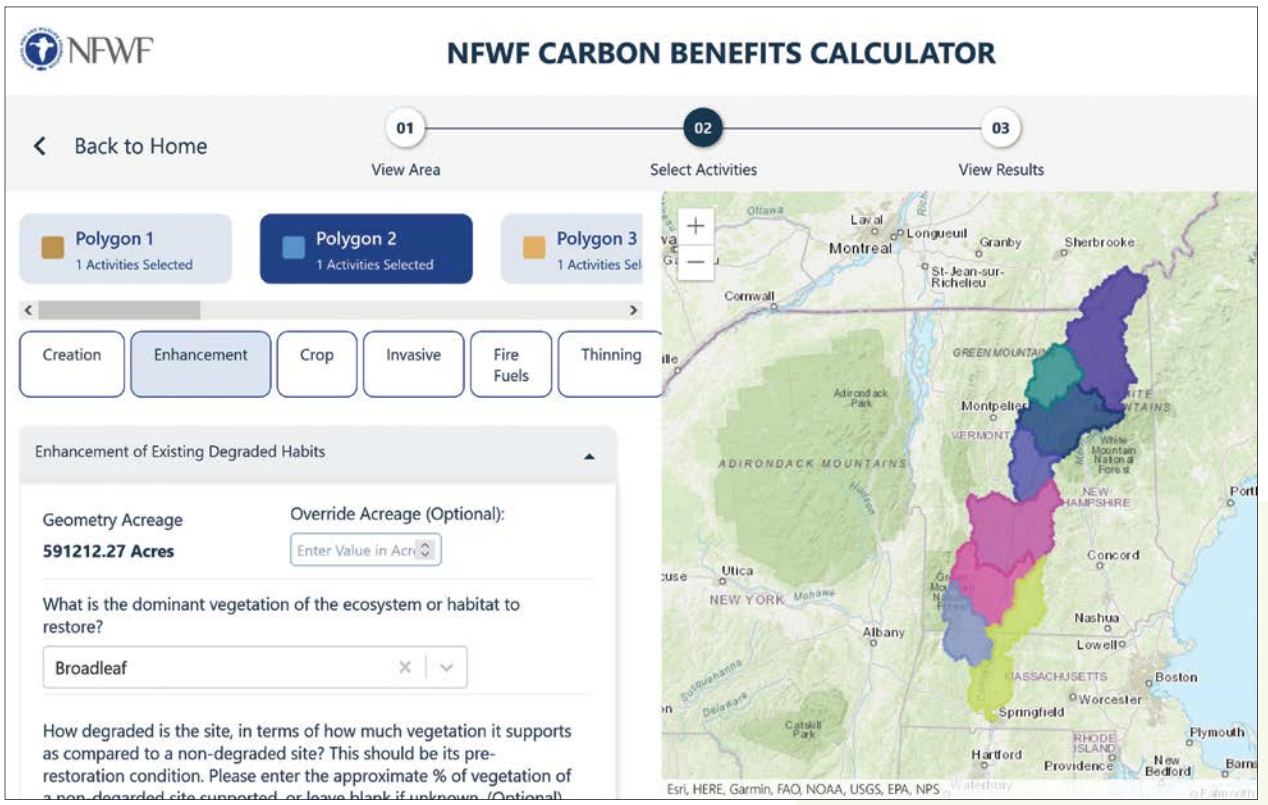
As the United States' largest private conservation grant maker, the National Fish and Wildlife Foundation (NFWF) funds projects that sustain, restore, and enhance the nation's fish, wildlife, plants, and habitats. Many of the conservation and restoration projects that NFWF supports also serve to offset greenhouse gas emissions that exacerbate climate change. The foundation uses an in-house carbon calculator tool to estimate and visualize the carbon impact of these projects.

NFWF developed the initial version of its carbon calculator using spreadsheets. This was limiting, however, because the calculator could only be used to analyze one county at a time. Evaluating projects that span counties—including those that affect large national parks or entire states—was a challenge because it required compiling values from multiple spreadsheets. To calculate carbon storage by land-cover characteristics, NFWF had to rely on county averages.

Seeking a simpler and more meaningful user experience, NFWF partnered with **Blue Raster** (blueraster.com) to develop the more robust NFWF Carbon Benefits Calculator. The team at Blue Raster understood NFWF's need for a spatially explicit tool that would eliminate having to use hard-coded values and provide more precise calculations.

Blue Raster employed ArcGIS Enterprise, ArcGIS Image Server, ArcGIS Online, and ArcGIS API for JavaScript to design NFWF's new Carbon Benefits Calculator as a web app. The tool applies Python logic and geoprocessing services to allow NFWF staff to upload polygons that represent the areas where specific activities have an impact. Using raster datasets, the calculator delivers multiple values within that area—including its climate, location, size, carbon stock, and land-cover characteristics—and automatically calculates the carbon benefits of the project based on the precise boundaries of where the activity occurs. The tool also allows users to save an analysis and mark it as authoritative, making it easier to find analyses that have already been completed.

With the new Carbon Benefits Calculator, staff members at NFWF can now make faster, easier, and more comparable estimates to measure the carbon benefits of conservation projects over a 30-year period.



↑ The new NFWF Carbon Benefits Calculator allows National Fish and Wildlife Foundation (NFWF) staff to upload polygons that represent a project's impact area.

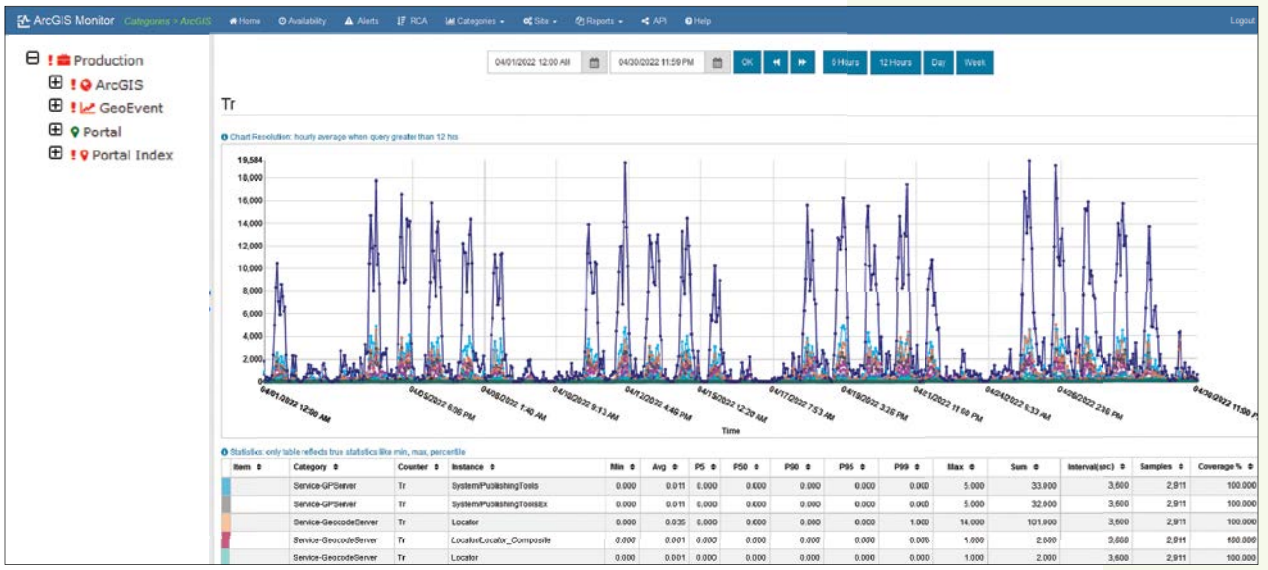
Monitoring an Enterprise Deployment to Stay Ahead of Problems

The geospatial services team at Houston Public Works provides support for GIS operations while also maintaining the GIS IT infrastructure that underpins the daily operations of five business units that keep the fourth-largest city in the United States—Houston, Texas—running smoothly. The team relies on an enterprise portal and a separate system of GIS servers that includes a federated portal of three servers and regular map and feature services.

When Anthony Powell, GIS manager and current interim chief technology officer (CTO) for Houston Public Works, took over in 2015, the organization's GIS was poorly structured and inefficient. Departments were saddled with slow save processes and unable to access relevant data. The data existed, but without a cohesive structure, everything was competing against one another. To meet this challenge, Powell eventually turned to GIS services provider **Dymaptic** (dymaptic.com).

The developers at Dymaptic are experts at implementing Esri technology, and they frequently use ArcGIS Monitor with clients to help them keep track of their enterprise systems and proactively address any issues. Dymaptic CEO Mara Stoica loves that, as part of the ArcGIS portfolio, Monitor remains compatible with all Esri updates and new products.

For Houston Public Works, the solution was to implement Monitor across the organization. Within a day of coming on board, Dymaptic's developers were able to get Monitor up and running. They then gathered all the organization's sprawling GIS infrastructure and configured it to capitalize on Monitor's functionality, providing a live overview of the entire network of tools. The team also used the Monitor API to create customized alerts for Houston Public Works—homing in on only the critical alerts that Powell wanted to see—and added them directly to a Microsoft Teams channel.

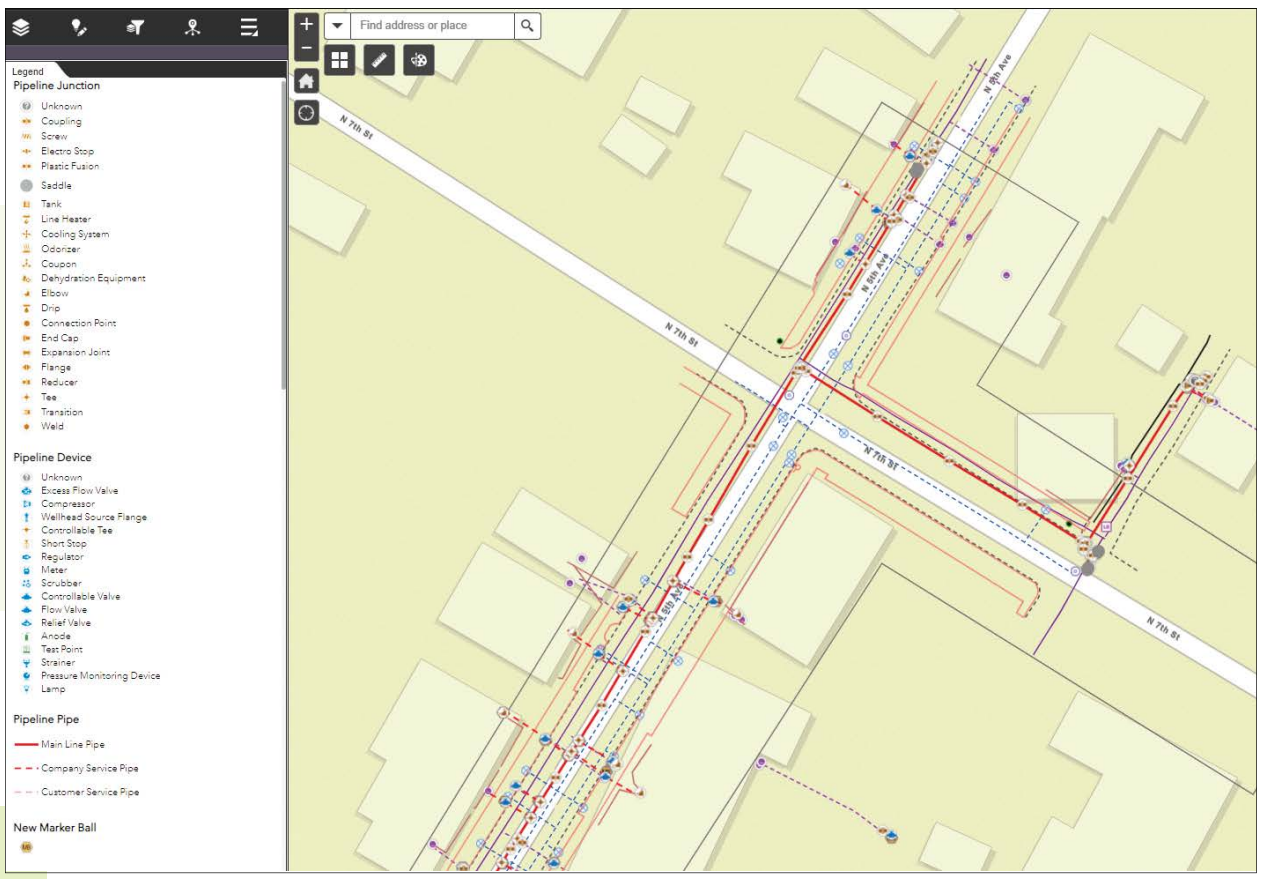


↑ The geospatial services team at Houston Public Works uses ArcGIS Monitor to see what's happening, in detail, across its whole database server.

The deployment of ArcGIS Monitor has resulted in improved performance across the organization's ArcGIS implementations, a better user experience for ArcGIS software and GIS data users, enhanced troubleshooting, and a fourfold increase in GIS usage at Houston Public Works. Being able to see what's happening, in detail, across the whole database server—including performance statistics, server and database statuses, and activities—has allowed the geospatial services team to get ahead of problems. This has led to a marked decrease in tickets submitted to the team for support, despite the increase in GIS usage. The result is an improved system with faster performance and fewer hiccups.

Streamlining Mobile Data Collection to Mitigate Risk

Peoples Gas, the largest natural gas distribution company in Pennsylvania, serves approximately 740,000 customers. In 2015, the Pipeline and Hazardous Materials Safety Administration (PHMSA) proposed an amendment to its regulations to address safety concerns with plastic piping. To comply with the new requirements, Peoples started looking for a solution that could track and trace assets and their materials. The goal of the solution was to mitigate system risk, increase efficiency for field- and office-based operations, and enhance public safety by improving how assets are identified and located and making it easier to track down and report defective materials.



Through a competitive bid process, Peoples selected **RAMTeCH** (ramtech-corp.com) to support this critical initiative. Using ArcGIS Enterprise and an app built with ArcGIS Runtime SDK for .NET, the RAMTeCH team implemented a proven tracking and traceability solution that allowed staff members at Peoples to maximize their existing investment in Esri technology.

The solution automates the process of capturing location, material, and manufacturer information for new gas assets when they're installed. Mobile workers use barcode scanners and high-accuracy GPS receivers to record the data. The scanners record attribute information from barcodes on the assets, following the ASTM International F2897 Tracking and Traceability standard. And the GPS receivers capture the installed locations of distribution pipes, fittings, valves, and more—as required by the proposed PHMSA amendment. This information feeds into the iOS app that RAMTeCH built, which mobile workers use on Apple iPads. This ensures that the data gets represented in the company's GIS as features.

Since implementing the solution, Peoples has reduced the need for paper records in the field, which has streamlined both mobile and office-based workflows. This digital data collection process has eased mapping backlogs at Peoples, since field-based data collection now seamlessly integrates with the organization's enterprise GIS. The solution has also improved the use of GIS for identifying and locating pipeline components, as well as any defective materials, reducing the risks associated with gas distribution operations and improving public safety.

← Peoples Gas now employs a GIS-based solution to gather data about gas assets when they're installed during new construction.

Esri partners represent the rich ecosystem of organizations around the world that work together to amplify The Science of Where by extending the ArcGIS system and implementing it in distinct ways to solve specific problems. Search for and discover partners that meet your needs at **esri.com/partners**.

Facilitating Solar Energy Production While Protecting Biodiversity

Indonesia's 275 million residents inhabit about 6,000 of the more than 17,500 islands that make up the equatorial archipelago. Almost 97 percent of the population has access to the country's electrical grid, according to the World Bank. About 87 percent of the grid's capacity comes from fossil fuels such as oil, natural gas, and coal, while the rest comes from hydropower and geothermal sources. Because of electricity shortages in some rural areas—such as West Kalimantan, a province on the island of Borneo—Indonesia imports electricity from Malaysia as well.

This reliance on fuel-generated electricity is a burden on the country's financial sector. It also negatively impacts the environment. So SolarBoost—a collaborative project between the university Politeknik Negeri Pontianak in Indonesia and the University of Leicester in the United Kingdom—is seeking to implement solar power plants throughout Indonesia to increase the nation's grid capacity. The project also includes developing minigrids for small, rural communities.

To determine the optimum locations in which to build solar plants—particularly in rural areas—the SolarBoost team has developed a GIS-based system that integrates satellite and regional data for conducting site suitability assessments. In a pilot project carried out in West Kalimantan, whose forests and biodiversity are of global concern, SolarBoost performed geospatial analysis on vast amounts of data to figure out where large-scale solar plants could be developed. Now, government officials and energy developers can use the results of the study to aid in decision-making and accelerate the development of solar energy infrastructure across the region.

Solar Power's Role in Shifting to Renewable Energy

In addition to expanding the capacity of Indonesia's electricity production, SolarBoost seeks to help reduce the country's dependence on fossil fuels. Recently, Indonesia pledged to cut its carbon emissions by at least 31.89 percent by 2030. The country has also set a goal to increase the share of renewable energy in the national energy mix to 23 percent by 2025.

"We believe that solar energy can play a major part in *[Indonesia's]* shift to renewable energy," said Dr. Ibrahim-Bathis Kunhali, a project scientist at the Kerala State Council for Science, Technology, and Environment (KSCSTE) in India and a former research associate for the SolarBoost team.

Given this context, SolarBoost has attracted extensive interest and support from the government of Indonesia. Currently, SolarBoost is working with 11 government agencies and departments that range in scope from rural development to environmental conservation. These groups provide data and status reports on land cover, land use, soils, climatology, infrastructure, and more, which the SolarBoost team stores, analyzes, and processes using ArcGIS technology.

The Spatial Analysis Toolbox Proves Key

Indonesia's diverse cultural and ecological conservation areas cover about 18 percent of its landmass. To ensure that these critical locations are protected when selecting sites for solar energy facilities, the SolarBoost team had to study and spatially analyze extensive amounts of data. This included solar irradiance and weather condition data derived from satellite imagery, as well as the land usage, topography, population, roadway, conservation area, and electrical grid connection point data provided by government stakeholders.

"The collected data defines the characteristics of an area in terms of its suitability for the development of a solar PV *[photovoltaic]* power plant," said Kunhali.

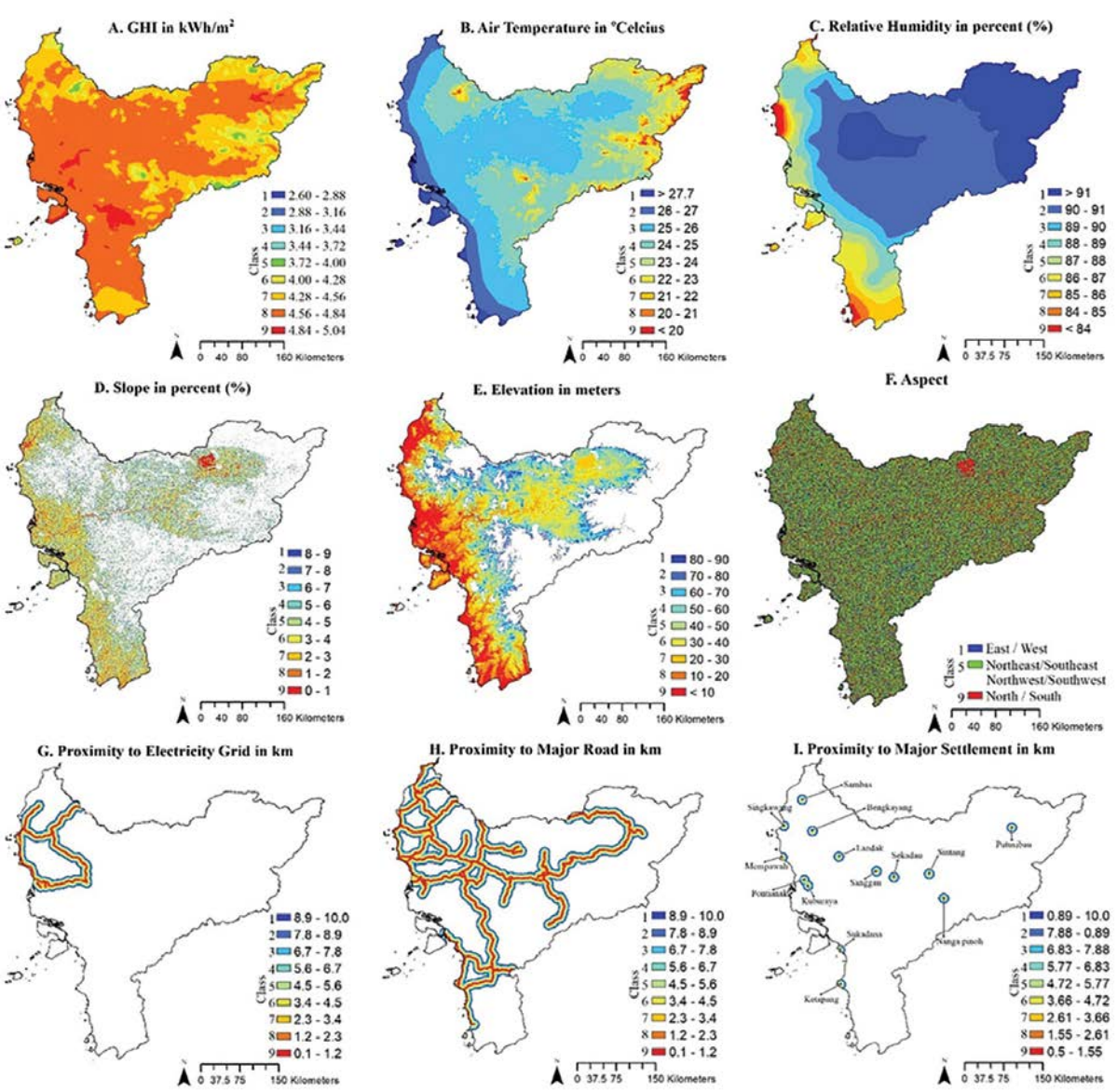
The data is organized into two planning processes that rely on geospatial analysis: demarcating barrier zones, which are protected areas where large-scale solar power plants should not be developed, and identifying feasible zones, where PV plants can—and probably should—be developed.

To conduct these analyses, the team employed what's called the Analytic Hierarchy Process, a method of organizing and analyzing complex data that helps determine which sites should be prioritized over others. The process included doing a multicriteria decision analysis, which evaluates options that have conflicting criteria.

"The Analytic Hierarchy Process was used *[to rank]* all *[the]* data to get a final weighted value according to *[each site's]* importance for large-scale solar photovoltaic plant development," said Kunhali.

All this was done using tools in the Spatial Analysis toolbox in ArcGIS.

"We used *[the toolbox]* for spatial data creation, data classification, analysis, *[and]* mapping," said Kunhali. "Overlay analysis was performed to combine all the *[data]* layers for an accurate spatial analysis of the best site location for large-scale PV plant development."



↑ By integrating satellite and regional data, the SolarBoost team has developed a GIS-based system for determining where photovoltaic (PV) plants should be developed.

A Successful Project Guides Future Development

The spatial analysis done on West Kalimantan was highly successful. It quantified an area of 18–42 square miles that has the potential to generate an impressive 2.034–4.785 gigawatts of electricity. Most importantly, the location wouldn't require cutting down forests or overrunning protected areas or Indigenous communities, supporting the country's requirement to manage and maintain its biodiversity.

"With web-enabled…maps and GIS data layers, we created the first-ever surface solar irradiance analysis that enables the inclusion of solar energy farms within the policy making strategy for energy production in Indonesia," said Kunhali. "We focused on the *[West Kalimantan province]* because of the challenges of grid development there due to its remote location and the necessity to protect its natural resources and Indigenous communities. By selecting this area, our study also provides the guidance *[to assess]* PV plant *[sites]* for similar…rural areas of the country."

SolarBoost also demonstrated how critical it is to use GIS for processes like these.

"We used it to perform multiple assessments on the cost of electrical power generation and the benefits that could be derived from the installation of a solar farm *[in]* West Kalimantan and other Indonesian provinces," said Kunhali. "ArcGIS also supported the reporting of legal and infrastructure constraints that could affect the timely deployment of PV projects."

GIS FOR A BETTER WORLD

PROTECTING AQUATIC HABITATS IN THE GULF OF MEXICO

"To help protect reef and coral communities in the Flower Garden Banks National Marine Sanctuary, I developed a dashboard using ArcGIS® Dashboards that accessed a National Oceanic and Atmospheric Administration (NOAA) data server to display related live oceanographic conditions (currents, wave height, wind, sea temperature, and salinity) to assist in maritime transportation for the health and safety of sanctuary monitoring programs."

J. Keaton Thompson
MS GIS '22
B.S. Environmental Science, Spanish, Spatial Studies Minor '21

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The Relevance of Cartography

A Cartographer's Perspective

By Tim Trainor
President, International Cartographic Association

Cartography Remains Critical in the Digital Mapping Age

The next time you're sitting in a meeting, attending a conference, or watching the news, take note of how many presenters use maps to make a point. Maps help people gain a better understanding of the world, and they're becoming more prevalent.

People love maps, and interest in mapping is high. This is due in part to the diverse nature of cartography itself. The number of maps and the range of topics shown on maps continue to grow. And the number of people making maps is increasing exponentially, thanks to simplified mapmaking methods and technology. Varied means of sharing maps has also made it possible for more people to access, view, interact with, and study maps.

Cartography offers a means of understanding the world near and far. For most people, it is much easier to detect patterns and trends graphically—displayed on a map—than look at rows and columns of numbers on spreadsheets. The flexibility of today's mapping tools offers various options for encouraging that understanding. Mapmakers often begin with an interest in the locations and events closest to them and then zoom out to explore wider worlds beyond their comfort zones. The desire to learn more about new and unexplored places and ideas adds fuel to mapmakers' never-ending agendas, inspiring their future work and interests.

In the early days of automating cartography, there was genuine concern about machines' ability to replicate the quality of graphic images traditionally created by skilled cartographers. Would the lines be as sharp as those made by a jewel-tipped pen or in a deep-etched image? Would the curves of the letters be as smooth as those written by a steady hand or using a French curve? Would machines be able to create the geometries needed for differentiating content on a map? These and many other concerns were alleviated in a relatively brief amount of time. Early machines were crude, but it didn't take long for every aspect of the image construction process to be overtaken by one device or another.

However, while instructing a machine to draw images was largely a factor of software, replicating a skilled cartographer's map construction techniques was not a simple process. Over time, these facets were addressed in different ways. Some required research to better understand the thought processes used in mapping, while other approaches employed simple trial-and-error practices with lots of testing. The road to modernization in mapping was littered with inaccurate assumptions, insufficient capabilities, dead-end ideas, and failed attempts. But in the end, the ingenuity of individuals made it possible for machines and software to replicate—and even expand—the high-quality cartographic images of modern-day experts.

Now anyone can dabble in the craft, thanks to various software tools. Yet after using a few mapping templates, novices usually realize that there is more to mapping. This democratization of cartography initially caused concern among cartographic professionals; they wondered if, by giving anyone easy access to mapping software, that would render them redundant. The result has been quite the contrary, however. Many novice mapmakers recognize that designing and producing effective maps isn't like painting by numbers. Good cartographers get trained and hone their skills. So there is a growing market for learning about cartography, and more people are gaining exposure to and employing cartographic techniques. (As an aside, universities should maintain and even add courses in cartography to help address the increasing demand for trained cartographers.)

The expansion of cartography is good for society. The digital age has brought with it an overabundance of data and data types that are readily available to cartographers, and the amount of structured and unstructured data is only growing with time. Each day brings new data from transactions, sensors, satellites, and social media. And maps, made using sound cartographic principles, can help people get a sense of what all that data means.

Cartographers are experts at selecting the most important information to feature on a map, based on the map's purpose. They employ different techniques to graphically elevate key content while reducing or eliminating unnecessary informational noise. They also generalize how the subject matter is represented to aid with comprehension. For example, a cartographer may purposefully displace a railroad that is right next to a road, moving it slightly to the side, to ensure that map readers can discern both the road and the railroad. When creating digital maps, where map details reside in a database, trained cartographers are skilled at bringing critical data to the forefront as users zoom in and out on the content. In this example, the cartographer determines within the software at what zoom point the content should get exposed.

Designing maps that effectively communicate specific messages is the principal responsibility of cartographers. They may need to seek out new data types or more current data to address the challenges presented by putting a particular map together. Cartographers are also in a position to help fill data voids—like voluntarily submitting data to OpenStreetMap—because they are experts at identifying the types and locations of data that are missing.

Cartographers are problem solvers, and they have much to contribute in this digital age. Sustaining the cartographic field is imperative both now, as maps permeate so many aspects of people's lives, and in the future. And efforts to do so are well underway.

Young people are demonstrating a growing interest in cartography, and new opportunities are emerging for them. One objective of the International Cartographic Association (ICA) is to encourage the next generation's interest in cartography. The organization does this by providing funding to students who want to attend and participate in ICA conferences. EuroCarto 2022, which took place in Vienna, Austria, in September, drew 34 applications for scholarships from 15 different countries. This was an unprecedented number of submissions for a regional cartographic conference endorsed by the ICA. AutoCarto 2022, which followed in November and took place in Redlands, California, hosted nine ICA-sponsored students.

The pervasiveness of maps and increasing interest in cartography are helping humans address many of the challenges that communities and nations around the world are facing. Cartographers—and their work—matter. So let's expand the profession by making more maps and ensuring that young cartographers and novice mapmakers are encouraged to employ simple and even more complex cartographic techniques.

About the Author

Tim Trainor is a part-time consultant to the United Nations (UN) and is the former chief geospatial scientist for the US Census Bureau. He is a member of the US Federal Geographic Data Committee's National Geospatial Advisory Committee, has served as cochair for the UN Committee of Experts on Global Geospatial Information Management, and was the senior agency official for geospatial information for the US Department of Commerce.

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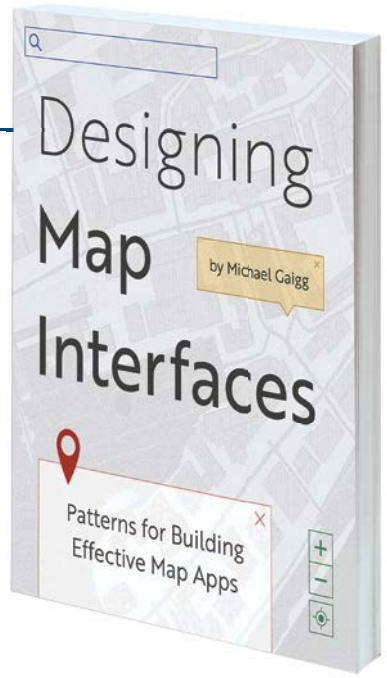
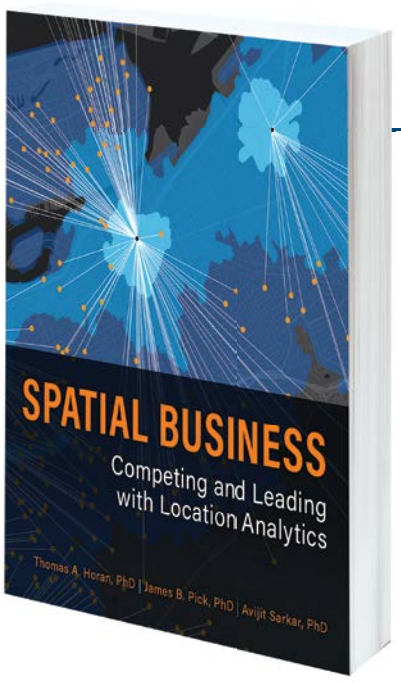


Designing Map Interfaces: Patterns for Building Effective Map Apps

By Michael Gaigg

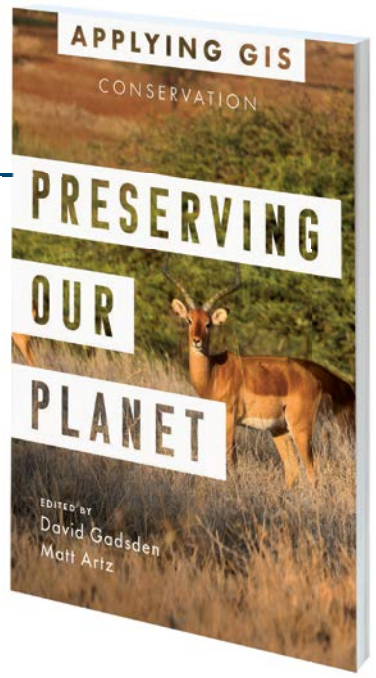
Designing Map Interfaces: Patterns for Building Effective Map Apps is the essential guide to creating geospatial app interfaces that are usable, efficient, and stunning. Whether configuring an out-of-the-box solution, building an app with an app builder, or working on a custom app project, readers can rely on the book's practical tips to assemble a meaningful user interface (UI). Intended for GIS professionals, solution engineers, developers, and designers, *Designing Map Interfaces* identifies several recurring problems in UI design and outlines specific UI patterns to employ to fix them. December 2022/March 2023, 173 pp. Ebook ISBN: 9781589487260 and paperback ISBN: 9781589487253.



Spatial Business: Competing and Leading with Location Analytics

By Thomas A. Horan, James B. Pick, and Avijit Sarkar

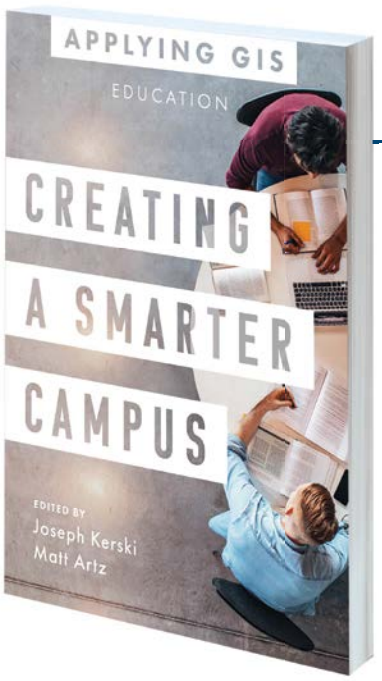
In today's global economy, business leaders need to know where to source materials, operate, and grow their customer bases. *Spatial Business: Competing and Leading with Location Analytics* shows how real organizations have designed, deployed, and managed GIS solutions to improve decision-making and add value in both strategic and operational ways. Written by experts in spatial business, the book provides managers, professionals, and students with a road map for realizing the potential of geospatial data across the entire business value chain. August/December 2022, 264 pp. Ebook ISBN: 9781589485341 and paperback ISBN: 9781589485334.



Preserving Our Planet: GIS for Conservation

Edited by David Gadsden and Matt Artz

By employing maps and apps, conservation professionals can more easily observe what's happening on the ground, analyze and organize their data, and collaborate with other organizations and members of the public to harness opportunities and address threats. *Preserving Our Planet: GIS for Conservation* showcases how several conservation organizations have successfully used GIS to help preserve biodiversity. The book provides ideas, strategies, and tools to help readers jump-start their own uses of GIS for conservation. It also comes with a collection of online resources, including stories, videos, and downloadable content. September 2022/January 2023, 130 pp. Ebook ISBN: 9781589487222 and paperback ISBN: 9781589487215.



Creating a Smarter Campus: GIS for Education

Edited by Joseph Kerski and Matt Artz

GIS has a wide range of uses in the educational sphere. It provides educators with novel ways to teach problem-solving to tech-savvy learners. Researchers can employ GIS for data visualization and integration. IT professionals can use it to improve their cloud-based platform offerings. And administrators can wield the technology to visualize and manage everything from campus facilities to expansion opportunities. *Creating a Smarter Campus: GIS for Education* shows how educational institutions are actively integrating spatial reasoning and GIS technology into teaching, research, and management. August/December 2022, 170 pp. Ebook ISBN: 9781589487383 and paperback ISBN: 9781589487376.

Protecting the People: GIS for Law Enforcement

Edited by John Beck and Matt Artz

Protecting the People: GIS for Law Enforcement is a collection of real-life stories about how law enforcement agencies have used GIS to improve crime analysis, streamline operations, practice open policing, and enhance field mobility. Through these accounts, the book illustrates how police departments and law enforcement organizations employ GIS to drive decision-making in everyday operations. August/November 2022, 114 pp. Ebook ISBN: 9781589487307 and paperback ISBN: 9781589487291.

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- **Cartography., February 22–April 5:** Take a deep dive into the art and science of cartography. A team of experts discusses foundational cartographic concepts, design principles, and pro techniques that participants can use to create accurate, beautiful maps at multiple scales in 2D, 3D, and 4D. Participants get to explore the suite of ArcGIS Pro mapping tools and learn how to avoid common cartographic pitfalls. Sign up at go.esri.com/carto-course.

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- **ArcGIS Developer Foundation:** This certification is designed for app developers, GIS developers, GIS analysts, GIS administrators, and others who have at least two years of experience building and delivering apps that interact with the ArcGIS system and its application programming interfaces (APIs). Learn more at go.esri.com/developer-foundation-exam.

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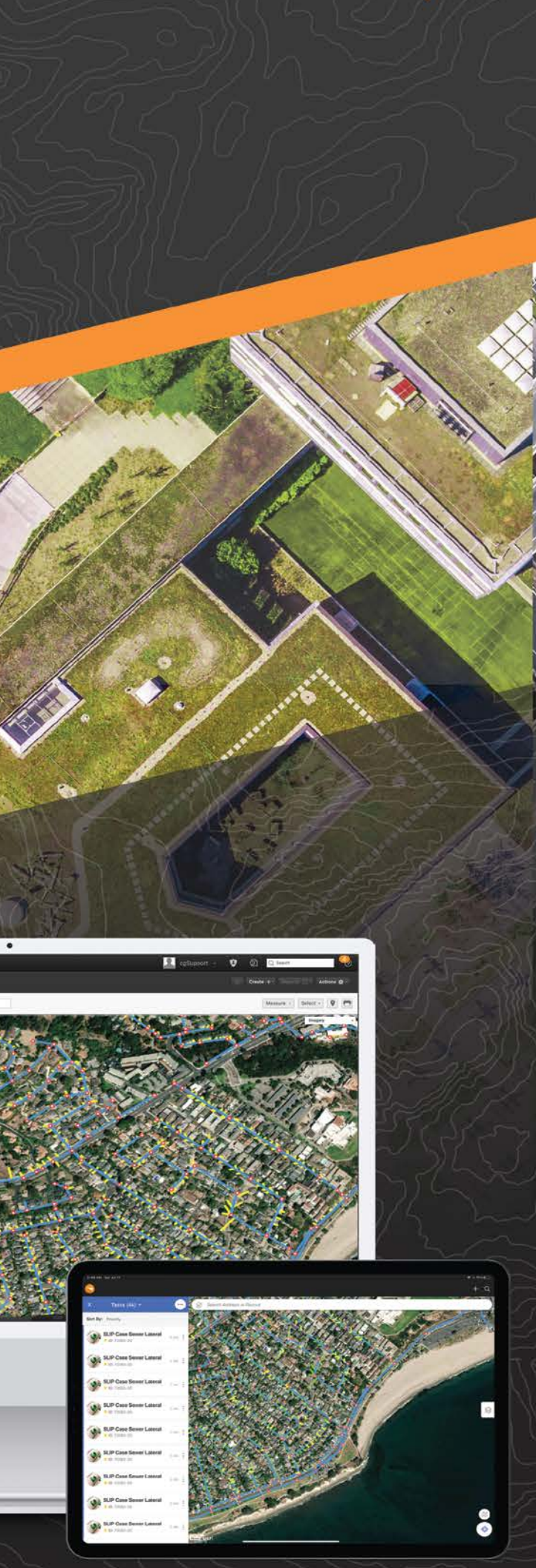

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