Spring 2024

ArcUser

The Magazine for Esri Software Users

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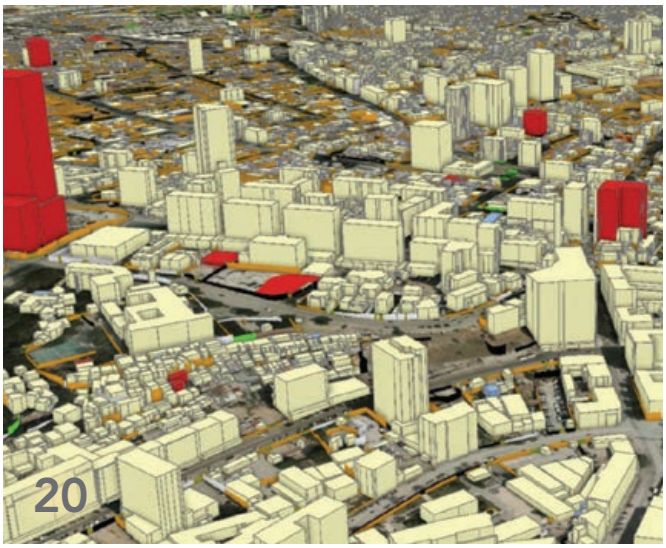

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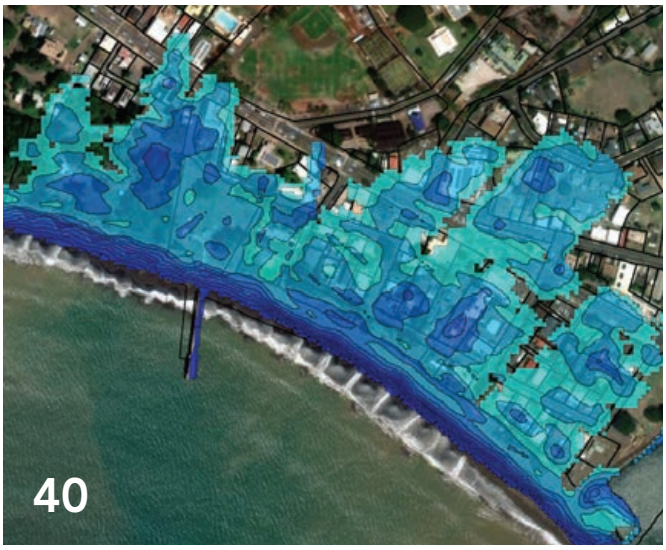

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On the Cover

Oleksandr Ponomarenko, the task group commander for the nonprofit The HALO Trust, documents mine locations in a Ukrainian minefield. (Photo courtesy of The HALO Trust)

Meeting Challenges with the Technology of *Where*

Although GIS started as a project system, it evolved into a system of record and then one of analytics and engagement to become the technology of *where*. It has become a geospatial infrastructure that informs entire organizations and allows them to collaborate.

This infrastructure has been making businesses more efficient and profitable, governments more responsive and effective, and nonprofits more successful. For decades, organizations have been using GIS to solve an increasing number of the most pressing problems their organizations face.

Articles in this issue highlight how organizations use GIS to cut through complexity, identify solutions, and take action. The HALO Trust, a humanitarian nongovernment organization, featured in this issue, is an example. It employs geospatial technology to fulfill its mission of safely clearing land mines and explosive ordnance. Millions of land mines remain in the ground years after conflicts have ended and continue maiming and killing civilians. Highly accurate maps of hazardous areas are essential to successful land mine removal.

Another article in this issue illustrates how understanding the *where* of a problem can be the key to understanding how to mitigate that problem. In this case, the problem is pangolin poaching. A new genomic-geospatial analysis approach for mapping where these endangered animals are trafficked is assisting in the global crackdown on the illegal trade in pangolins.

The application of GIS to the rebuilding of an entire country, described in an article in this issue, demonstrates how applying the geographic approach using GIS is a powerful way to respond to an emergency while helping create a more sustainable future. The Public Union Ukrainian Fund of Energy Efficiency and Energy Saving and Esri Ukraine are developing the ONOVA GIS HUB. Ukraine envisions GIS as the foundation for a renewed, stronger country.

GIS is a powerful technology that is reshaping how we deal with the world's challenges. In the words of Esri president Jack Dangermond, GIS is "integrating science into the way people behave."

Monica Pratt
ArcUser Editor

ArcUser

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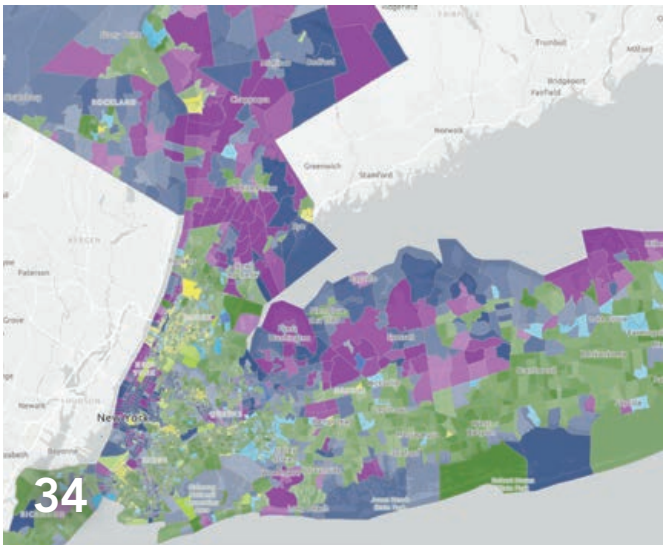

Software and Data

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Briefly Noted

→ Esri Launches Maps.com

In January 2024, Esri officially launched Maps.com, a website for showcasing and celebrating beautiful, remarkable, and insightful maps. The site, accessible to anyone online, is focused on sharing and discussing visually engaging maps across a wide variety of topics and formats including analyses, dynamic visualizations, videos, and 3D models. The Maps.com editors encourage mapmakers, cartographers, and the GIS community to submit their own distinctive and visually engaging maps. The maps featured so far have included a 3D view of Mars, a look at where Christmas trees grow in the United States, and a cross section of an active volcano. To submit a map for consideration, go to maps.com/submit-map.

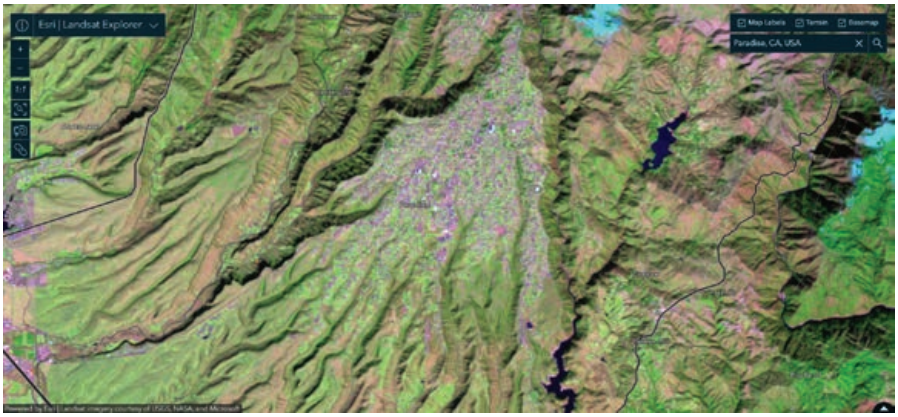
↑ This map shows the ups and downs of global inflation is one of many maps on Maps.com.

→ Esri Chief Scientist Selected as 2024 US Science Envoy

The US Department of State has selected Esri chief scientist Dr. Dawn Wright to be one of four distinguished scientists to serve as a new envoy in the US Science Envoy Program in 2024. Through the program, eminent scientists and engineers help inform the Department of State, other US government agencies, and the scientific community about opportunities for science and technology cooperation. Wright joins fellow cohort members Dr. Rumman Chowdhury, Dr. Stephanie "Steffi" Diem, and Dr. Sian Proctor as a member of the first all-female cohort in the history of the US Science Envoy Program.

Wright has written and contributed to some of the most definitive literature on marine GIS technology. She is an elected member of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts & Sciences. In 2022, she served as mission specialist for a historic descent into the deepest known point in Earth's ocean. To learn more about how Wright and Esri work to advance science using technology, visit esriurl.com/scicomm.

→ Uncover the Earth's Secrets with Landsat Explorer App



↑ Imagery captured by Landsat in the shortwave infrared band combination, a portion of the spectrum not visible to humans, is used to monitor drainage and soil patterns, vegetation, and crop growth.

Esri developed the Landsat Explorer app in ArcGIS Living Atlas of the World to increase Landsat data accessibility. Users, regardless of the level of their expertise, can easily explore more than 50 years of Landsat data to gain a deeper understanding of landscape features through access to multispectral data that captures wavelengths beyond the narrow band of visible light that humans can perceive.

The Landsat program began with the launch of its first satellite, Landsat 1 in 1972 as part of joint program of the National Aeronautics and Space Administration (NASA) and the United States Geological Survey. In the intervening years, Landsat collected a treasure trove of data on the Earth's surface that is invaluable because of its consistency.

The Landsat Explorer app in ArcGIS Living Atlas is a dynamic gateway that lets users explore a range of data layers, maps, and apps. Landsat Level-2 data from as early as 1982 is a dynamic time series of imagery available across the ArcGIS system and is used to power Landsat Explorer. The app leverages ArcGIS capabilities to explore information contained in Landsat data. From urban expansion to the shrinking of lakes, the app makes the Landsat data accessible and captivating.

→ An R package for ArcGIS Location Services

Esri has released {arcgis}, an open-source metapackage that facilitates interacting with ArcGIS location services from R. R-ArcGIS Bridge enables easy access to ArcGIS data and brings it into the R language for specialized analysis. With {arcgis}, ArcGIS users can access, modify, and publish web-based data from the R in the development environment of their choice.

This new addition to the R-ArcGIS Bridge complements the existing {arcgisbinding} package, which bridges R and ArcGIS Pro, by providing new ways for users to combine the powers of data science and statistical R packages with ArcGIS analytical, visualization, and data hosting capabilities. The {arcgis} metapackage provides a single point of access for users to install and load the associated packages.

Together, these packages enable data scientists, analysts, and developers to integrate the capabilities of R and ArcGIS for workflows and applications that use web-based services. Behind the scenes, {arcgis} achieves this by interacting with ArcGIS REST API endpoints. Learn more at developers.arcgis.com/rest.

See What Is Possible with ArcGIS StoryMaps

Subscribe to *StoryScape*

StoryScape is an e-magazine created with ArcGIS StoryMaps and designed for place-based storytellers. Each monthly issue contains a featured story or information on best practices for effective storytelling. *StoryScape* issues have included the following topics:

- Space mapping
- America's racial history
- Humanity's impact on wildlife
- Growing green cities and communities
- Community-based conservation

Additional stories, blog posts, dashboards, videos, and web apps support each issue's theme. Each issue also includes a storyteller profile. To receive *StoryScape* in your inbox, subscribe today at links.esri.com/SubscribeStoryScape.

A Featured story topics have included space mapping.

B Read profiles of talented storytellers.

C See how 3D scenes, imagery, video, charts, and graphs can improve your storytelling.

D Story topics include sustainability and conservation.

E Learn storytelling best practices.

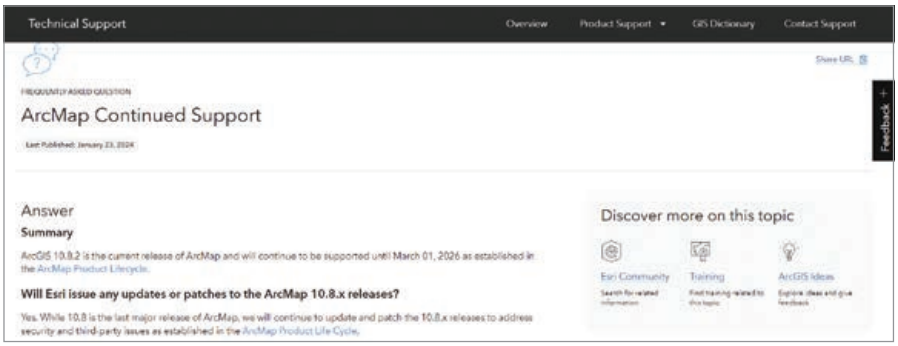
Moving from ArcMap to ArcGIS Pro *after Mature Support*

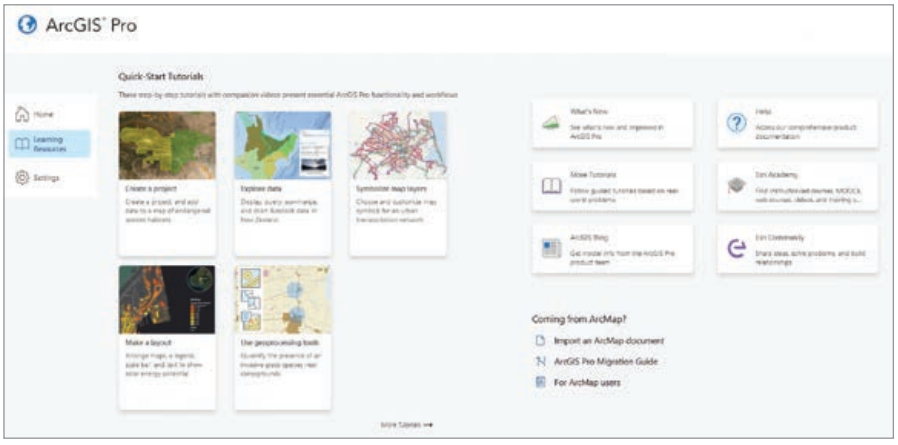
ArcMap entered mature support March 1, 2024. Mature support is the last phase of the life cycle before ArcGIS Desktop is retired. During mature support, technical support will still be available, but there will be no software updates, functionality-based patches, or hot fixes.

During mature support ArcGIS Desktop *perpetual* licenses will continue to work and access to the software will not be cut off. Beginning with renewals on July 1, 2024, ArcGIS Desktop *subscription* licenses will be quoted as user types that include ArcGIS Pro. ArcMap is not included with user types, so it is important to migrate workflows to ArcGIS Pro before your ArcMap subscription expires. There will be no sales of *additional* ArcGIS Desktop licenses beginning July 1, 2024. If you require additional licenses, you need to request a quote before July 1. After that date, you can purchase access to ArcGIS Pro either through a user type or with an ArcGIS Pro stand-alone license.

ArcGIS Pro, released nine years ago, has developed into the most capable desktop GIS application on the market. Many ArcGIS Desktop users have moved their workflows to ArcGIS Pro and incorporated ArcGIS Online and ArcGIS Enterprise into their work.

Maintaining your ArcGIS Desktop licenses gives you continued access to ArcGIS Pro and either ArcGIS Online or ArcGIS Enterprise through the entitlement Creator user type that you get as part of your desktop maintenance. As the date for the retirement of ArcGIS Desktop approaches, users will be able to choose to move forward to user types that include ArcGIS Pro or a stand-alone perpetual license for ArcGIS Pro (which does not include a Creator entitlement).





↑↑ The ArcMap Continued Support_page provides great resources that are available to help you make the move from ArcMap to ArcGIS Pro.

↑ The Learning Resources page in ArcGIS Pro includes the Coming from ArcMap? section plus other resources.

Supporting the Transition to ArcGIS Pro

There are many resources to aid moving workflows from ArcMap to ArcGIS Pro:

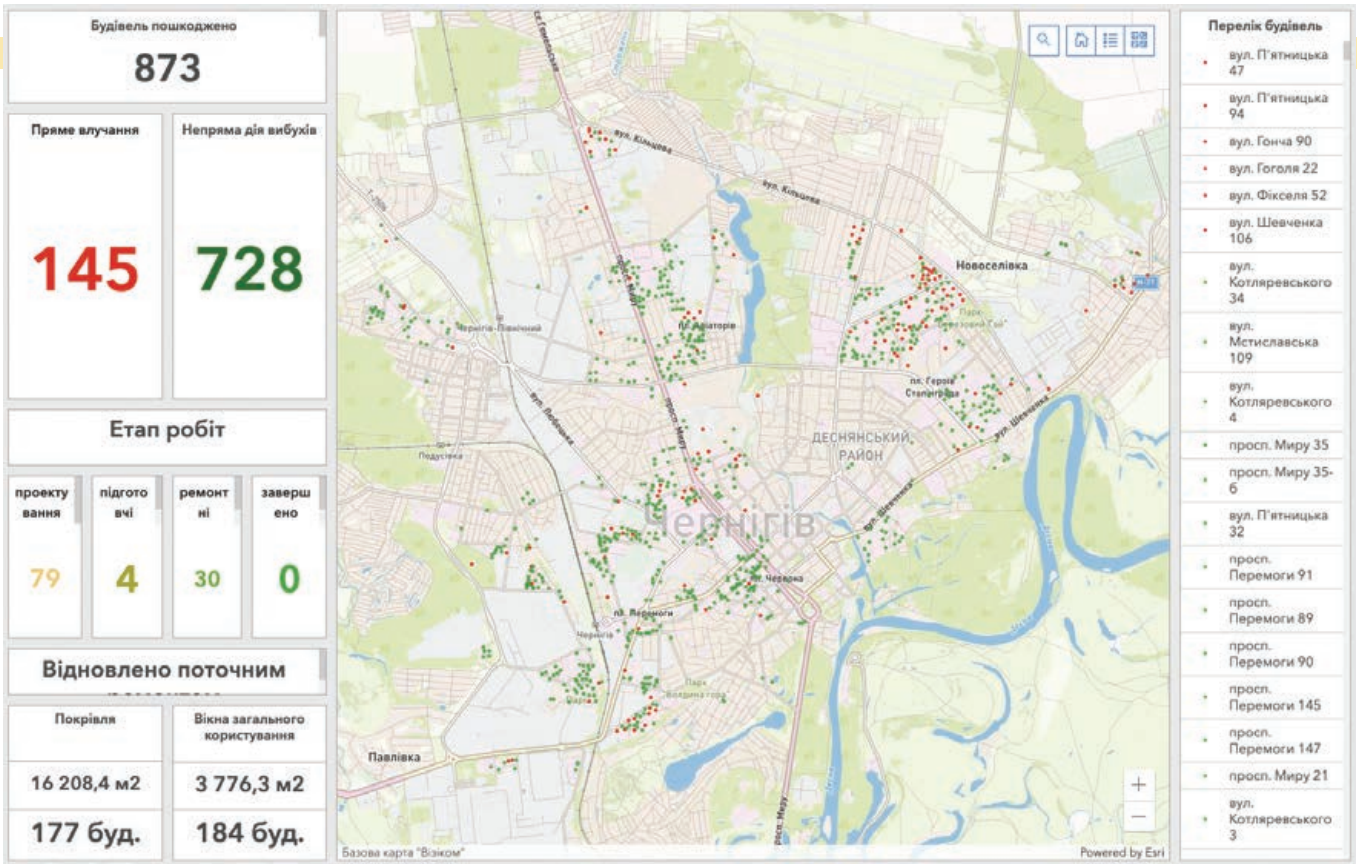
- The ArcMap Continued Support_page (links.esri.com/ContinuedSupport) provides great resources.
- The Migrate from ArcMap to ArcGIS Pro page (links.esri.com/migrate-arcmap) is part of the ArcGIS Pro help and acts as the go-to resource hub to guide your transition.
- The Learning Resources page in ArcGIS Pro includes Coming from ArcMap?, a section with resources for continued learning. Esri understands that many users will have a period of overlap during the time when organizations are working in both ArcMap and ArcGIS Pro. For help with this situation, read the learning resources that are available directly within ArcGIS Pro.
- Study and share the ArcMap Product Life Cycle page (links.esri.com/arcmap-lifecycle) with organization stakeholders.
- Esri realizes that this change may raise questions. If you have any questions or need assistance, call Esri Sales (1-800-447-9778) or your Esri account manager.

Building Ukrainian Infrastructure Back

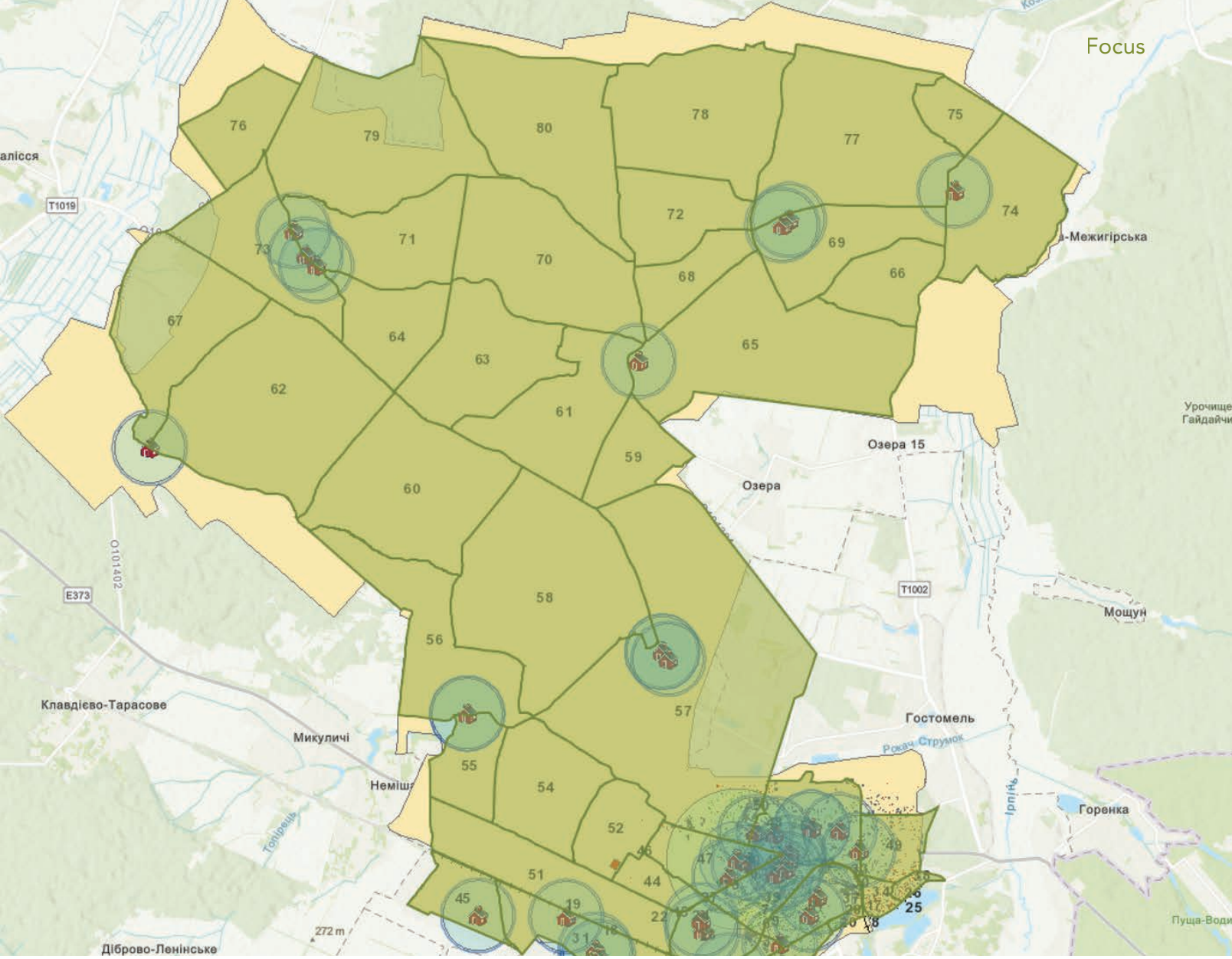
Removing the debris and rebuilding infrastructure is a tremendous challenge that is being faced by Ukraine. Hundreds of thousands of buildings and structures have been damaged or destroyed by Russian aggression. At the beginning of 2023, the country had accumulated as much as 100 million tons of debris from this devastation.

This destruction must be assessed and documented so that rebuilding efforts can be prioritized and coordinated. Assessing damage and coordinating rebuilding projects are supported by ONOVA GIS HUB (https://onova.org.ua/en), a geoinformation technological platform designed to quickly and comprehensively collect data related to specific objects, communities, regions, and sectors in Ukraine for documentation and analysis.

ONOVA, Ukraine's Renovation League, is working with Ukrainian communities, state institutions, and relevant ministries; Ukrainian and foreign investors; international donors; representatives of national and international business contractors such as software developers and real estate developers, service and material suppliers; representatives of nongovernmental organizations



↓ ONOVA GIS HUB, which has both public and private sections, has been used by more than 50 communities in Ukraine. A dashboard for Chernihiv is shown.



(NGOs); independent expert associations; and media. The goal is to renew destroyed territory in Ukraine quickly and efficiently to modernize and make it stronger for future generations.

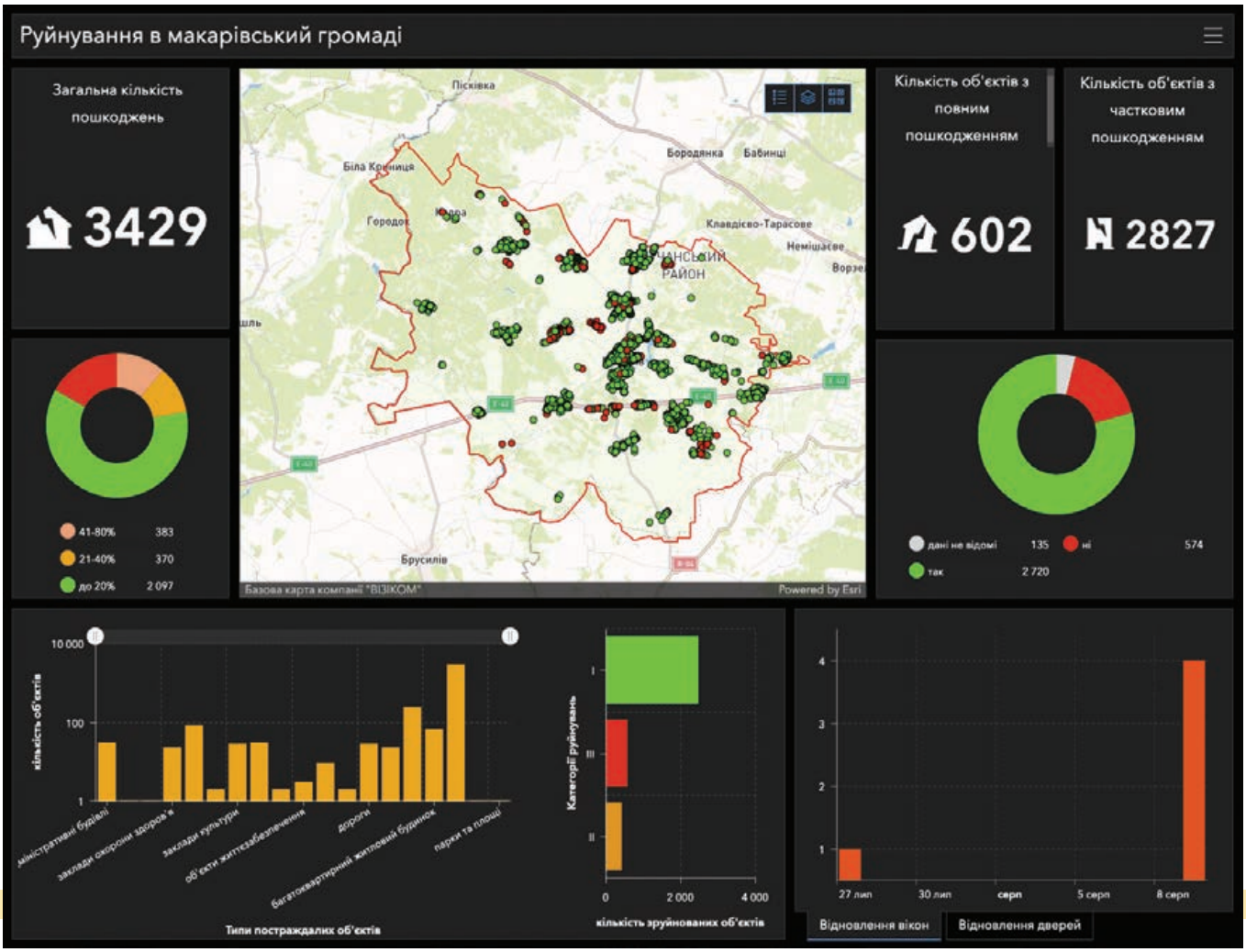
The Public Union Ukrainian Fund of Energy Efficiency and Energy Saving (PU UFEES) with Esri Ukraine LLC and ECOMM Co LLC, is working together to create the ONOVA GIS HUB as a tool to collect damage data and coordinate reconstruction efforts. PU UFEES supports initiatives to introduce incentives and measures to improve the energy efficiency of buildings as well as the implementation of modern European Union (EU) environmental safety standards in Ukraine. It initiated Ukraine's Renovation League ONOVA. Esri Ukraine, an Esri distributor, provides a geographic information platform for creating a corporate GIS. ECOMM has decades of experience developing and implementing GIS in Ukraine.

An interactive online portal, ONOVA GIS HUB has public and private parts. Ukraine's Renovation League ONOVA will use the private portion of ONOVA GIS HUB to:

- Enter, edit, and analyze the data it is contributing.
- Categorize damage by level and extent using photographs and surveys of public and private buildings.
- For each building, collect reports, expert opinions, restoration projects and their estimated cost, and current status of restoration.
- Choose data for maps.
- Choose data for dashboards.
- Link infrastructure to a master development plan, land cadastre, and critical infrastructure networks like water systems, electrical grids, or gas pipelines.

The ONOVA GIS HUB has become an

↑ A data layer of social infrastructure facilities in the Bucha community shows the all damaged facilities.



important tool for the digitalization of communities in the context of reconstruction. It has already been used by more than 50 communities in Ukraine, including Irpin, Bucha, Makariv, Chernihiv, Mykolaiv, Kharkiv, and Kremenchuk. These are areas that have been heavily damaged by Russian Federation attacks.

The platform is used to formulate national programs for the reconstruction and development of Ukraine by the heads and relevant structural units of the Ministry of Energy of Ukraine, the Ministry of Youth and Sports of Ukraine, the Ministry for Communities, Territories and Infrastructure Development of Ukraine, and the Ministry of Reintegration of the Temporarily Occupied Territories of Ukraine. Negotiations are underway with other government agencies.

Using the ONOVA GIS HUB, the Ministry of Youth and Sports has created the most accurate map of damaged sports facilities in all regions of Ukraine and introduced a mechanism for recording information about sports facilities and youth institutions that have been damaged or destroyed during the hostilities.

The development of the ONOVA GIS HUB project is actively continuing, including integration with Ukrainian and global information resources. The Ministry for Communities, Territories, and Infrastructure Development of Ukraine (Ministry of Recovery), as the main coordinator of the reconstruction process, signed a memorandum with the PU UFEES on the creation of the GIS of Infrastructure of Ukraine.

The ONOVA pilot project is currently being implemented in cooperation with the Recovery Agency (a structure of the Ministry of Recovery) in the settlements of Borodianka, Yahidne, and Posad-Pokrovske. Project proposals for the restoration, construction or reconstruction of individual facilities are being mapped on ONOVA GIS HUB.

In total, the ONOVA GIS HUB database includes more than 25,000 objects that have been damaged. As an example, in a joint project with the Ministry

↑ ONOVA GIS HUB has become an important tool for the digitalization of communities, such as Makariv, in the context of reconstruction.

→ ONOVA GIS HUB is being integrated with DREAM, a digital ecosystem for accountable recovery management that collects, organizes, and publishes open data at all stages of recovery projects in real time.

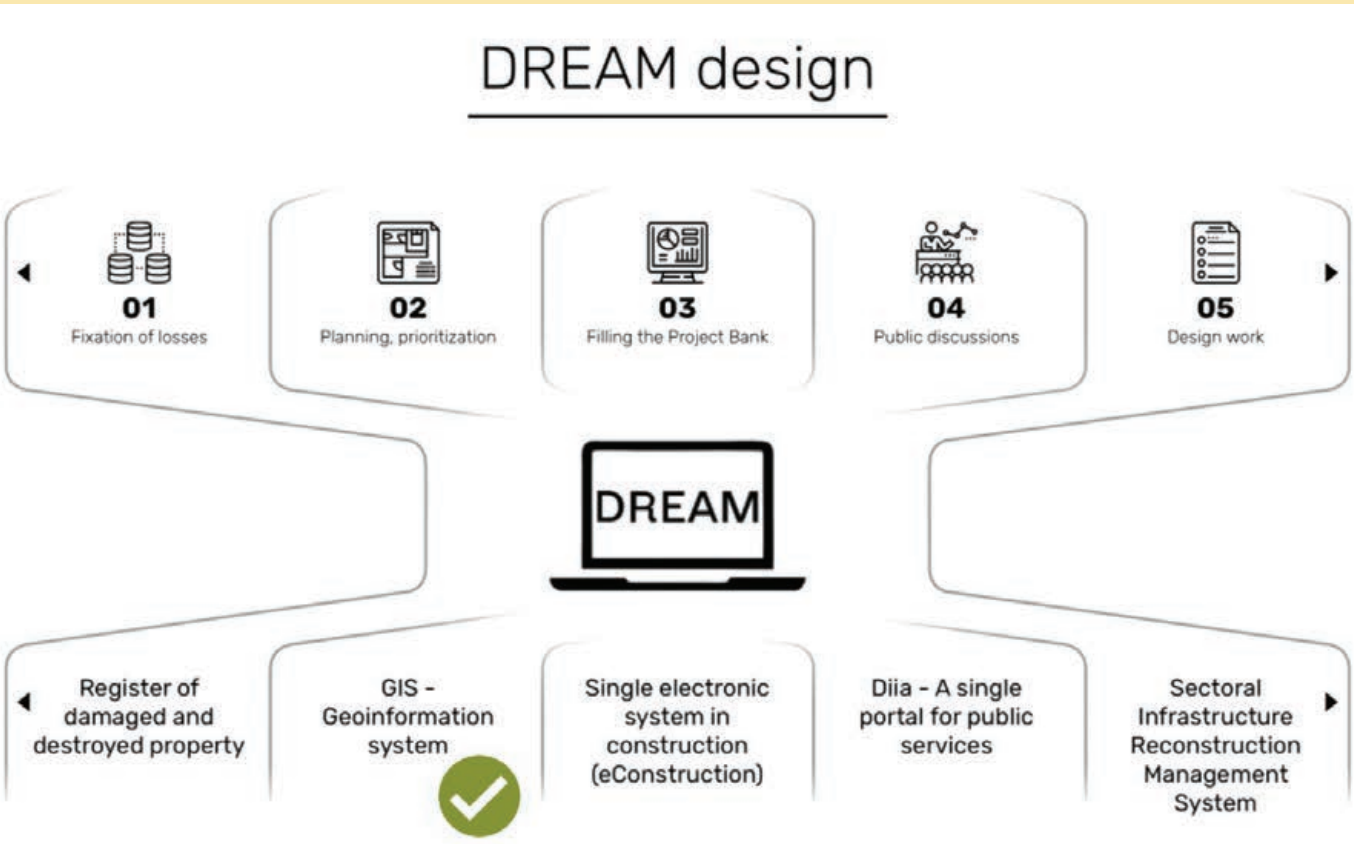
for Communities, Territories, and Infrastructure Development of Ukraine and the Bucha territorial community, ONOVA GIS HUB capabilities are used to create plans for the development of social infrastructure institutions in the Bucha community. Thanks to the capabilities of ONOVA GIS HUB, an analysis is helping match the needs of the community with the available resources. The restoration of Bucha schools is planned, and school bus routes will be reestablished.

The ongoing development of the ONOVA GIS HUB includes integration with Ukrainian and global information resources. Ministry of Recovery, as the main coordinator of the reconstruction process, has signed a memorandum with the PU UFEES for the creation of the GIS of Infrastructure of Ukraine.

In addition, ONOVA GIS HUB is being integrated with DREAM, the state digital ecosystem. DREAM is an accountable recovery management system that collects, organizes, and publishes open data at all stages of recovery projects in real time. The ONOVA GIS HUB is becoming a transparent, extremely effective tool for assisting with the entire Ukrainian renewal process. The platform is already playing a key role in shaping new sustainable development strategies for an independent, European, and prosperous Ukraine.

In commenting on the activities of the executive bodies of the council regarding the ONOVA GIS HUB, Anatoliy Karbovsky, deputy head of the Makariv Community, noted "ONOVA GIS HUB has become an important project for the Makariv community in the context of rebuilding after the destructive actions caused by Russian aggression. Thanks to ONOVA GIS HUB, we have a useful tool for recording destruction [and] collecting and analyzing data on damaged buildings and infrastructure. This is important for further recovery and transparent investment attraction by our community. I hope that this is a significant step forward in the recovery and development of Ukraine, allowing us to collect, analyze, and use data for future planning. In peacetime, the geographic information portal can serve as a tool for analyzing and planning urban development, including master plans, financial information, and indicators of socioeconomic development."

"Thanks to ONOVA GIS HUB, we have a useful tool for recording destruction, collecting, and analyzing data on damaged buildings and infrastructure."



Boosting Land Mine Clearance with Field-Focused Workflows

By Vicki Speed

Sixty million people are directly affected by the millions of land mines that have been deployed in more than 60 states and territories around the world. Land mines kill and injure civilians, deny land use, destroy livelihoods, and disrupt access to essential services. These mines remain in the ground for years—even decades—and are still able to kill and maim long after conflicts have ended.

For more than 20 years, The HALO Trust, a humanitarian nongovernment organization, has used geospatial technology to fulfill its mission of safely clearing land mines and explosive ordnance from civilian land. Its suite of GIS and GNSS solutions have improved the quantity and quality of data that is critical to these efforts.

In recent years, the organization has adopted and adapted field-focused workflows that are not just accurate but scalable, easy to use, and—perhaps best of all—cost-effective. The combination of GIS and GNSS technologies is helping this extraordinary nonprofit organization do more to help communities around the world recover following conflict.

The Need for Accuracy

The scope and scale of land mine and ordnance clearance activities—whether urban

← In a Ukrainian minefield, Oleksandr Ponomarenko, the task group commander in Mykolaiv, uses Trimble DA2 and ArcGIS Survey123 to document mine locations and record survey polygons and area cleared polygons. Each red stake marks an anti-tank mine ready to be destroyed. (Photo courtesy of The HALO Trust)

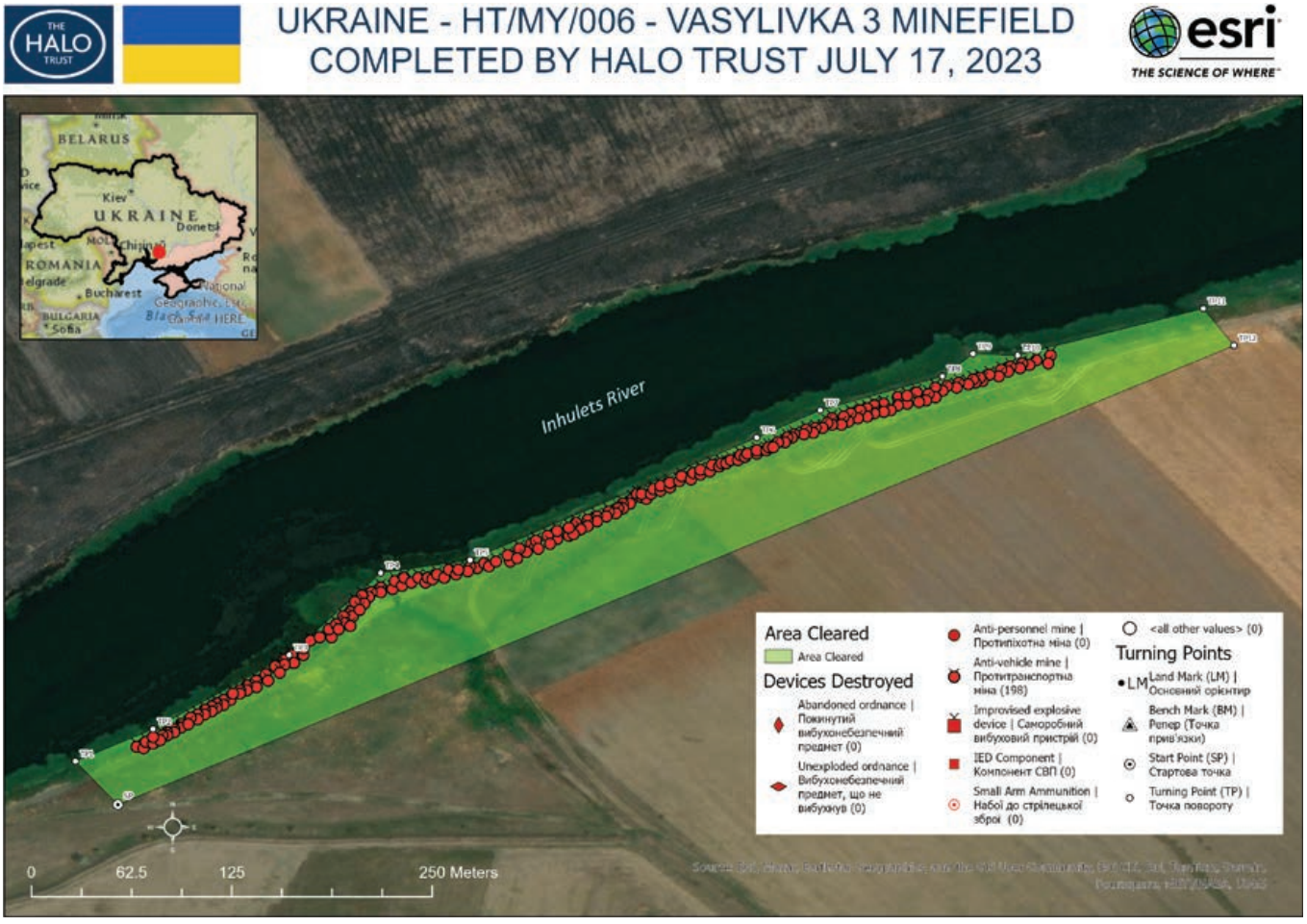
or rural—is time-consuming and resource heavy given the often dense area of contamination. Some minefields have hundreds or even thousands of coordinates that need to be recorded.

Obtaining the high-accuracy spatial data needed to delineate and map the boundaries of suspected hazardous areas and mark specific evidence points in the field has long been a challenge. According to Jesse Hamlin, senior GIS officer for HALO, "We can't be two, three, or four meters off. In this environment, accuracy is as essential as speed."

The organization has relied on differential GNSS and base stations to measure distances and locate points. While this methodology is highly accurate, it requires a significant upfront investment and training for the field crews. Portability and ease of use are important considerations because HALO teams typically work in remote places and many team members who gather position data do not have technical backgrounds.

"It's not really feasible to have every team carry a base station," said Hamlin. "In the past, teams have had to set up and synchronize multiple base stations to begin data gathering in a minefield—and, because these are areas of conflict, theft is a concern. We have to set up in a location where it won't get stolen during the night. Cost is also an issue as in some countries. We have hundreds of teams working in different locations and purchasing one for each team is impossible."

He noted that advances in mobile devices with Bluetooth connectivity to real-time correction sources, such as Satellite-based



↓ A minefield map in Ukraine produced in ArcGIS Pro and shared with ArcGIS Survey123. Red dots indicate the locations of anti-tank mines that were located and destroyed. (Photo courtesy of The HALO Trust)

> The easy integration between the receiver data and the ArcGIS Survey123 forms is especially beneficial.

Augmentation System (SBAS), virtual reference station (VRS) networks, or Precise Point Positioning (PPP) systems, opened the door for alternative solutions.

Over the last two years, HALO has deployed Trimble DA2 GNSS receivers using the Trimble Catalyst subscription-based GNSS positioning service, a technology ideal for working with ArcGIS Survey123 forms. The Trimble DA2 is a real-time kinematics (RTK)-capable GNSS receiver that relies on a simple Bluetooth connection to Android or iOS devices. The subscription-based positioning service supports bundled broadcast corrections, and it supports 60 cm, 30 cm, 10 cm, or 1 cm positioning accuracy, eliminating the need to maintain and pay for separate base station infrastructure.

"We need to limit the time spent transcribing data from a GNSS receiver to another digital document or even a piece of paper, as there's too much chance of error. The easy-to-use interface between the DA2 to Survey123 forms is invaluable when it comes to getting our field teams up to

speed," said Hamlin. The easy integration between the receiver data and the ArcGIS Survey123 forms is especially beneficial. The system just works. "No more worries about handling base stations; it's very portable, easy to learn and use, and we get centimeter precision," Hamlin noted.

HALO staff particularly appreciate that the quality of survey polygons can quickly be previewed on tablets in the field. Once data is gathered and confirmed, it is submitted to ArcGIS Enterprise directly from ArcGIS Survey123. For example, not long ago nearly 600 mines were located and destroyed in one minefield in Angola, where nearly 1,300 coordinates were taken using the Trimble DA2 and ArcGIS Survey123.

↗ A clearance supervisor in Angola recording the location of unexploded ordnance using the Trimble DA2 and ArcGIS Survey123. (Photo courtesy of The HALO Trust)

← Each land mine or ordnance is staked and then located with UTM coordinates in the Trimble DA2 receiver. (Photo courtesy of The HALO Trust)

"Before the DA2 GNSS, mapping this level of detail would have been impossible," confirmed Hamlin.

Prioritizing Mine Clearance

Once the data is collected, a team of supervisors back in the HALO office begins a quality assurance process to verify data accuracy and completeness. Approved data is visualized using web maps in ArcGIS Online or ArcGIS Enterprise. Survey data is analyzed in ArcGIS Pro to assess the extent of contamination and prioritize clearance. Drone and satellite imagery provides some context for the conflict and the area of concern. The map documents survey polygons and evidence points at the micro and macro levels. The data is then published as web service layers in ArcGIS Enterprise and shared across the entire program and with stakeholders.

Once mapped and verified, the clearance process is time-consuming. Within ArcGIS, the team combines satellite imagery, survey polygons, and mine evidence points so that work areas can be prioritized based on humanitarian impact and available resources. For instance, in Ukraine, the group might prioritize the clearance of minefields that impact agricultural land to help farmers growing crops to feed communities in need.

Clearance field maps are broken up into smaller packages that are downloaded to a phone or tablet. Field teams can also use offline maps created using ArcGIS Field Maps on tablets. Since the bundled correction services leverage the global Trimble RTX correction service, the Trimble Catalyst DA2 GNSS receiver is still able to work precisely in areas without reliable internet coverage using satellite-delivered correction data.

Hamlin said, "Then the clearance teams go into the areas, once again with the DA2 and Survey123 forms loaded with the map packages, to begin clearance, recording polygon positions as work is completed. The entire workflow is streamlined, clear to the operators, and highly accurate."

AI and Mine Clearance

Artificial intelligence (AI) is finding its way into HALO workflows. Five or six years ago,

> "The entire workflow is streamlined, clear to the operators, and highly accurate."

HALO started evaluating AI and machine learning techniques in tools such as ArcGIS Pro to assess how it might support and improve various work streams.

One potential use of AI that is currently being tested is automatically detecting land mines from imagery collected by drones. Models are trained on sample images of mines. Machine learning algorithms could help detect patterns in minefields by mapping evidence such as craters from exploded anti-tank mines.

While this wouldn't eliminate the need for field surveys to map minefields, it would help determine resource allocation and an optimal clearance approach. Similarly, the advanced intelligence could help prioritize areas for mapping and clearance based on analysis of multiple data sources. Detecting changes could reduce the need for manual surveys, which would lower costs and improve operational efficiency.

AI could also improve the analysis of damage after a conflict and quantify clearance impact metrics, such as the number of structures that have been rebuilt following a clearance. Hamlin explained, "For instance, in Ukraine, we initially assumed that

← An operator uses Trimble DA2 and Survey123 to find and document mine locations, and record the coordinates of survey polygons and area cleared polygons. (Photo courtesy of The HALO Trust)

→ Jesse Hamlin is senior GIS officer for The HALO Trust. (Photo courtesy of The HALO Trust)

on shortening the recovery time of war-torn regions. "If you look at places like Ukraine, we're seeing an increase in the number of accidents, particularly in agricultural areas because farmers want to get back to work planting and harvesting their land to support their families and their communities—sometimes before the land mine clearance is complete," said Hamlin. "From the land we have surveyed so far, the length of time and cost to clear the area through traditional mine clearance methods can take up to 20 years or more, depending on how long the fighting continues."

Hamlin believes that increased capacity and resources with the deployment of technology and new methods will shorten the time to clear mines. This improvement in productivity will go a long way to helping communities recover as quickly as possible.

About the Author

Vicki Speed is a freelance writer who specializes in writing about the engineering and construction space. She has written for publications including *Engineering News-Record* as well as other trade-specific media. She holds bachelor's and master's degrees in engineering. For more information, contact vickispeed1@gmail.com.

we would be working in urban areas. As it turned out, the need was much greater in rural areas. When we clear a minefield, we have people that are actually building homes and farming the land right up to the border of the minefield. Tracking this rebuilding is typically very resource intensive as it would require teams to be sent around the country to assess the human activity in close proximity to cleared minefields. A solution with AI might be able to perform that analysis in minutes."

All HALO's technology investments, whether in GIS, GNSS, or AI, are focused

Angola Modernizes Land Administration with GIS

Accurate landownership records and cadastral management are foundational to a country's information infrastructure and underpin the wealth of its citizens. Geospatial technologies—especially GIS—are critical to rapidly documenting and formalizing land rights.

Millions of people move to cities to seek better livelihoods, education, and health to improve their quality of life. This rapid population growth within cities is posing challenges for governments worldwide.

For example, the African nation of Angola has an urbanization rate of 68 percent, according to the World Bank. Its capital city, Luanda, has experienced population growth of 3.8 percent from 2022 to 2023. Struggling to keep up with this growth, the country's real estate sector is facing issues such as illegal land occupations and informal, unregulated land transactions.

Many buildings are constructed without proper registration or documentation of land and property ownership. Most of the citizens in urban areas lack official ownership documentation and security of tenure. The high demand and tenancy turnover have also created problems for public institutions that must collect the appropriate fees and taxes for property sales. This has led to a lack of necessary revenue for basic infrastructure such as water, electricity, roads, and education for municipalities.

Land management in Angola is also complex and involves many stakeholders and entities. The country's two main land management entities are the property registry offices Conservatória do Registo Predial (CRP), under the Ministry of Justice (MINJUS), and the national mapping and cadastre agency Instituto de Geodesía e Cartografia de Angola (IGCA). IGCA works under the Ministry of Planning, Urbanism, and Construction (MINOPUH), which is responsible for mapping Angola's terrain and infrastructure and managing the national cadastre—a comprehensive land registry that records property boundaries, land values, and land concession details.

The government of Angola realized that its goals of providing affordable housing, improving the real estate market, and collecting land-based taxes were impeded by the lack of accurate parcel boundaries and legal documentation of ownership. The government contacted the Mitrelli Group, an international group of companies that promotes and executes sustainable large-scale social and economic growth projects in the developing world. It has been working in Africa for more than two decades.

Angola worked with Mitrelli Group and Geo Data, an Esri partner that specializes in advanced land management GIS and mapping solutions for national entities. Geo Data implemented a solution to modernize and streamline the country's land administration process.

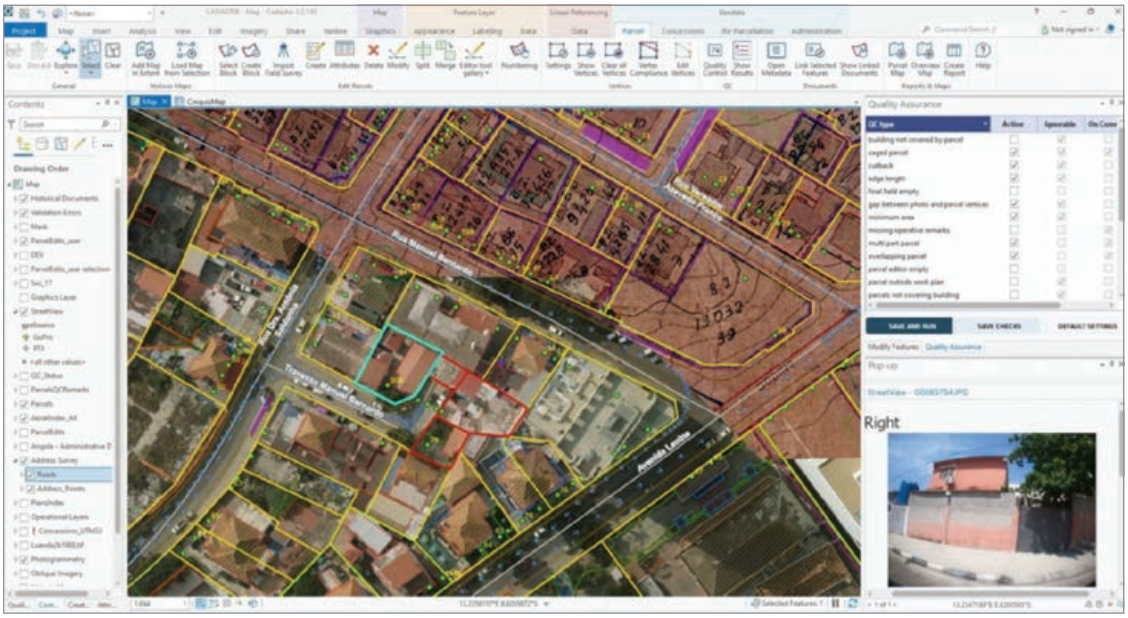
Helping Make Growth Possible with GIS

One specific focus of Angola's government has been to improve land cadastre accuracy and consistency. Cadastre plays a critical role in preventing land disputes and provides essential details such as ownership, boundaries, and the value of real property.

The Angolan government faced the challenge of mapping hundreds of thousands of parcels in a cost-effective way in just a few years and registering properties on a massive scale. To address these challenges, Geo Data purchased a software agreement with Esri to implement the Land Administration Modernization Program (LAMP). LAMP provides access to ArcGIS software for developing countries to enable land agencies to undertake needed modernization initiatives. Utilizing the LAMP program, Geo Data was able to develop a distributed cadastre system employing professional workflows using ArcGIS Pro, coupled with ArcGIS Enterprise for distributing, viewing, querying, and managing data by authorized stakeholders.

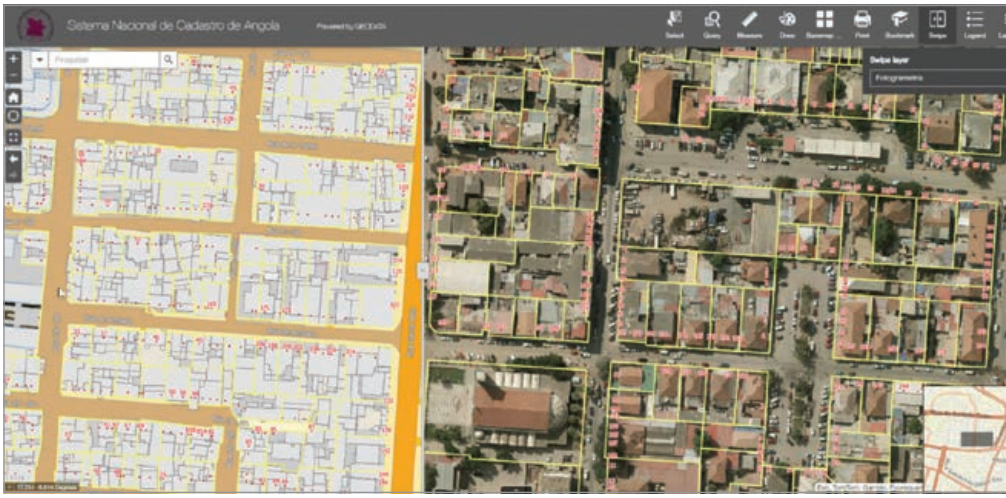
Geo Data leveraged drone-acquired imagery with photogrammetric mapping techniques using ArcGIS Drone2Map and geospatial artificial intelligence (GeoAI) to automate feature extraction and analysis. Geo Data helped IGCA save time and dramatically improve data quality by creating

↓ Geo Data used 3D mapping to help meet the challenge of mapping hundreds of thousands of parcels rapidly in a cost-effective way and registering properties on a massive scale.



← Geo Data developed a distributed cadastre system by employing professional workflows using ArcGIS Pro.

↓ Having accurate land parcel boundaries with efficient digital land registration processes will help Angola achieve its goal of building one million new homes on those vacant parcels with appropriate right-of-use and ownership.



orthophotographs with centimeter-level accuracy and performing 3D mapping. Address surveys using the mobile app ArcGIS Collector updated and improved the address database by including street names with all historical name versions and house numbers.

Geo Data combined imagery, 3D mapping, and an address database with existing historical data, maps, and other documentation to create 450,000 accurate urban parcel boundaries. These were implemented into the cadastre system. The entire process was completed in less than three years.

The company also developed a system for the registration process at the CRP offices to support and automate the legal mass registration of 100,000 properties as part of an affordable housing project managed by the state. Geo Data implemented the registration system in all 22 registry offices in all 18 provinces of Angola.

The new cadastre system was distributed throughout all 18 province offices of IGCA with comprehensive training, technical support, and knowledge transfer. The two systems are connected via a bidirectional interface, which enables the registry office to view related properties on a map.

Implementation of a cadastre system based on geospatial technology and integration with the land registry achieved several objectives. These efforts increased security and legal certainty for registrants regarding ownership of the property as well as fostering public land tenure by providing accurate boundaries of the property parcels. The reliable property information obtained through these efforts has improved land management and tax collection and support urban planning.

Enabling Future Growth

The government of Angola has an ambitious goal to provide affordable housing to millions of people and increase the number of registrations to more than a million properties by 2027. Esri's LAMP has provided critical technology that is helping realize that goal. The new interconnectivity of the cadastre system with the registration system now enables the generation of a deed or legal document and displays an accurate map of each property. Since Angola's General Tax Administration will interface with this system regularly, property-related taxes and fees collected are expected to increase significantly.

As the national economy grows and the number of individuals looking for housing increases, the Angolan government expects to see a marked expansion of new home construction. Having accurate land parcel boundaries and efficient digital land registration processes will assist the government in its goal of building one million new homes on vacant parcels with appropriate right-of-use and ownership documentation.

From Legacy System to Long-Term Success at Douglas County

When Vyla Grindberg joined Douglas County, Oregon, as its GIS coordinator in 2020, the county had taken tentative steps to transition to Esri's ArcGIS Enterprise. Grindberg targeted the critical process of managing tax parcel data, which was in demand by numerous departments for important functions across the organization.

"Tax parcel data is an incredibly valuable asset that is used for emergency management, planning, public works as well as by local municipalities and individual citizens. With so many needs and requests to fulfill, it was clear that we needed a system that would allow us to manage, update, and share it efficiently with those who needed it," said Grindberg.

Data was being manually updated to work with other systems in place at the county, such as iWorQ Systems *[cloud-based software for public works and community development].* A great need existed for parcel data that would meet the county's needs for emergency response. Grindberg saw that these needs could be met more efficiently using Esri's ArcGIS Parcel Fabric to manage data.

With approval of a grant application from the Municipal Wildfire Assistance Program (MWAP), Douglas County was able to move forward with research and planning for deployment of the new software.

Preparation and Transition

Grindberg identified a small, six-week window of time—when tax rolls were being finalized—for moving the county's data to the Parcel Fabric environment. Douglas County engaged Pro-West & Associates, an Esri partner with expertise in data migration that could aid in the parcel fabric implementation process. Along with Pro-West, Grindberg performed testing to prepare for transitioning data from the county's legacy system. This ensured that the county would be able to access Parcel Fabric in ArcGIS Pro and use an Esri map series to generate 3,108 plat maps.

The entire project—including the migration to Parcel Fabric in ArcGIS Pro and the deployment of Python scripts to publish data on a daily basis—was completed within a four-month period.

Training for Success

Critical to the success of the project and ongoing maintenance of parcel data was training. Grindberg, who also teaches college GIS courses, trained the county's cartography department, whose team was new to ArcGIS Pro. In addition, she set up ArcGIS Pro projects so that cartographers could work on an ongoing basis.

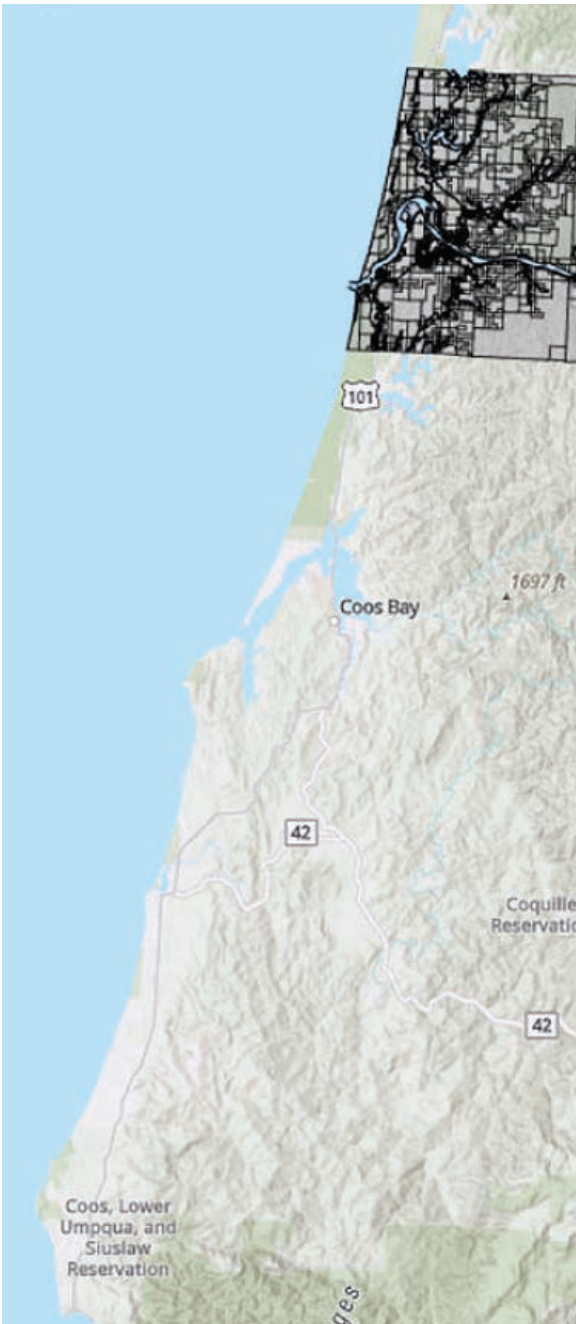
Then, Pro-West joined the county on-site for a week to provide customized training to Grindberg and the cartography department. The training focused on editing in Parcel Fabric using the county's unique data, handling specific scenarios as well as a range of topics that would equip county staff to maintain up-to-date, accurate parcel data.

Delivering Value for All

By implementing ArcGIS Parcel Fabric, Douglas County can now deliver accurate data that is automatically updated each day to meet the needs of departments including planning, assessors, and emergency services. Grindberg no longer must manually work with data to prepare it for various uses. Thanks to automated processes in Parcel Fabric and integrations that connect it to other business systems within the county and partner agencies, data is no longer out-of-date by a week or a month. It's accurate every day.

Grindberg can now use the time she used to spend processing data on other tasks that help advance the county's policy goals. Also, departments and agencies can receive updated data even if she is unavailable.

"Previously, if I was out of the office or working on an urgent task, I couldn't truncate and append the data that was needed," said Grindberg "At times, a three- to four-week wait existed for data requests to be fulfilled. Thankfully, that's no longer the case. Others are not relying on me to personally work on and deliver the data they need—they automatically receive it.



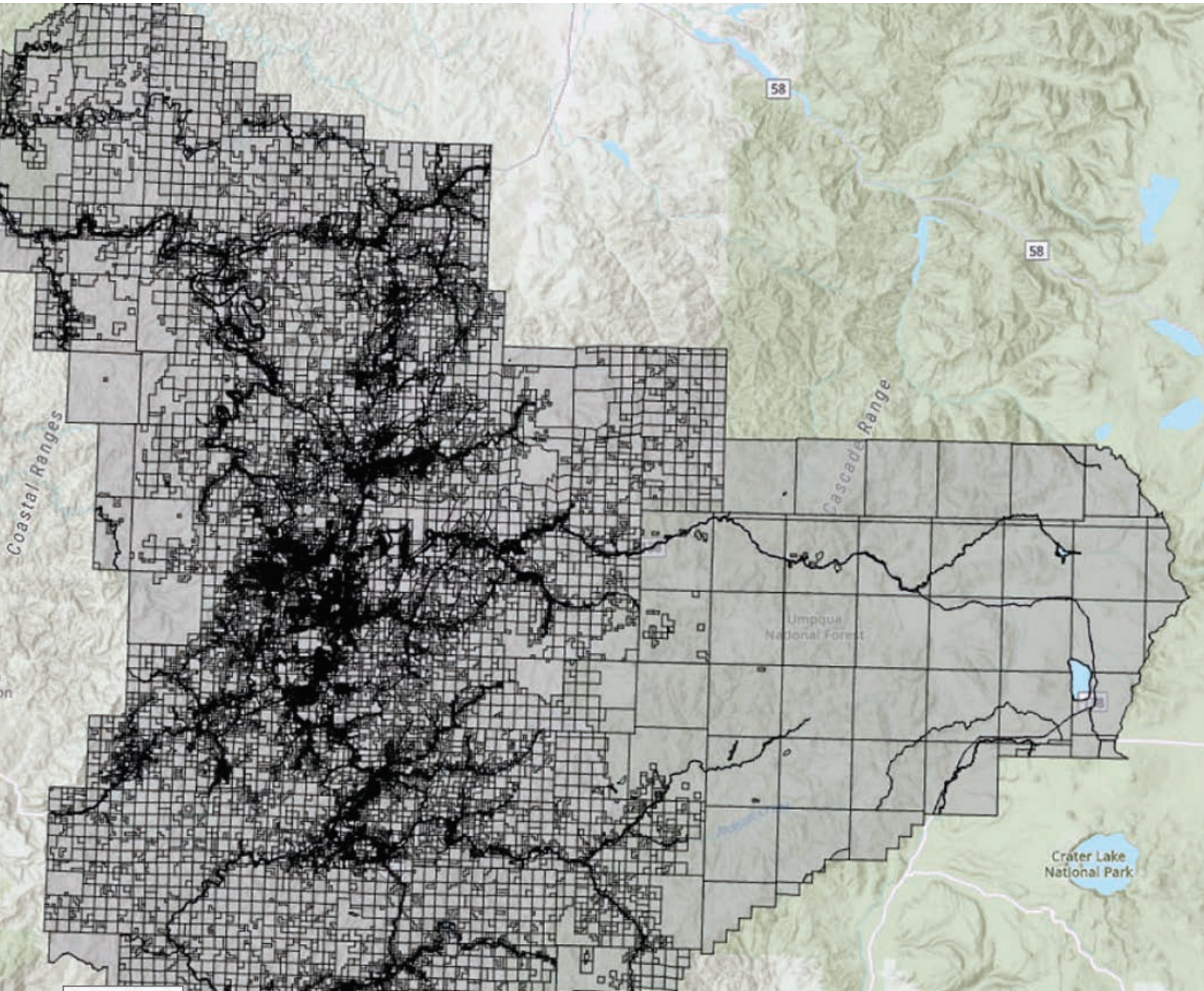
That represents great value for the county and our end users."

Providing More Value

As GIS coordinator, Grindberg's mission is to use GIS to provide high-quality services to the public. She sees many opportunities across the county to integrate GIS to enhance services.

"Implementing Parcel Fabric has been an important step forward for Douglas County, but it's just one piece of the puzzle," said Grindberg. "There are so many opportunities to provide value to residents through GIS. We're looking at *[using]* ArcGIS Hub *[to develop a hub]* site for emergency management, leveraging Esri software to replace other aging applications, and integrating processes for zoning inquiries into GIS, for example. I'm looking forward to bringing even more of the benefits of GIS to Douglas County's citizens."

↓ Tax parcel data is used across local government for emergency management, planning, and public works and by individual residents.



SAVING IMPERILED BIRD HABITAT

By Jim Baumann

The Salton Sea, located in the Imperial Valley of Southern California, is both an important wildlife area and an endangered ecosystem. The State of California has embarked on a decade-long program to save this area. The program's progress is monitored using GIS.

Accidentally formed in 1905 when an irrigation canal carrying water from the Colorado River breached its banks while under construction, the Salton Sea became California's largest lake. Water flowed unabated into the Salton Sink for more than 18 months before engineers were able to stem the flow. The result: the Salton Sea.

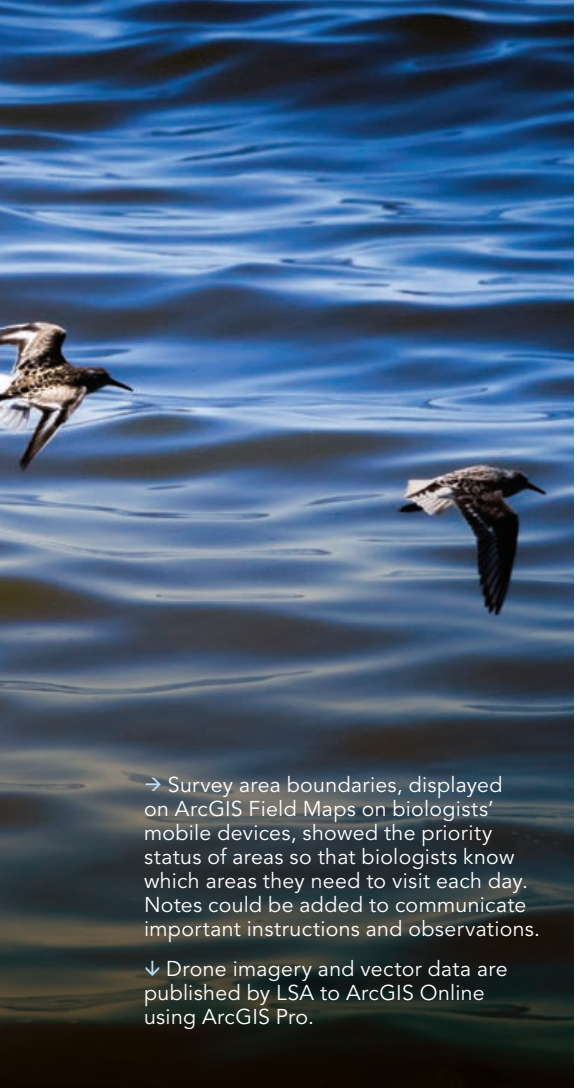
Although irrigation runoff from the Imperial and Coachella valleys and local rivers collects in the Salton Sea, its location 225 feet below sea level means that water does not flow out of it. The increasing concentration of salts has caused salinity that is now 50 percent greater than that of the ocean.

Despite its degradation, the Audubon Society considers the Salton Sea to be one of the most important nesting, wintering, and stopover sites for millions of birds in the western United States. It has been designated an Audubon Important Bird Area (IBA) of global significance that more than 400 species of birds regularly use. However, BirdLife International, the world's largest partnership for nature conservation, has designated the Salton Sea an "IBA in Danger," indicating that the habitat area is at severe risk.

The State of California is responding to the urgent need to revitalize the Salton Sea before it suffers irreparable damage. The Salton Sea Management Program (SSMP) is a 10-year program that includes funding and oversight for rehabilitating a portion of the Salton Sea by developing aquatic habitat and reducing exposed lake bed.

The $206.5 million Species Conservation Habitat (SCH) project, a part of SSMP, will cover exposed lake bed in the southern region of the Salton Sea, build berms, and create habitat that supports fish and provides resting and nesting areas for birds. The project will also mitigate significant health hazards from dust produced by the dry lake bed that contributes to the poor air quality for people living in the region.

The state contracted with Kiewit Infrastructure West Co., which began the project construction in 2021. Kiewit hired LSA, a California-based environmental



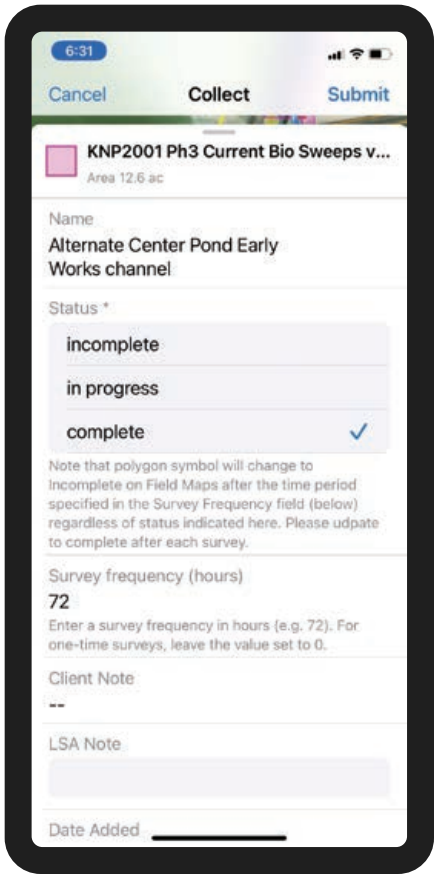
→ Survey area boundaries, displayed on ArcGIS Field Maps on biologists' mobile devices, showed the priority status of areas so that biologists know which areas they need to visit each day. Notes could be added to communicate important instructions and observations.

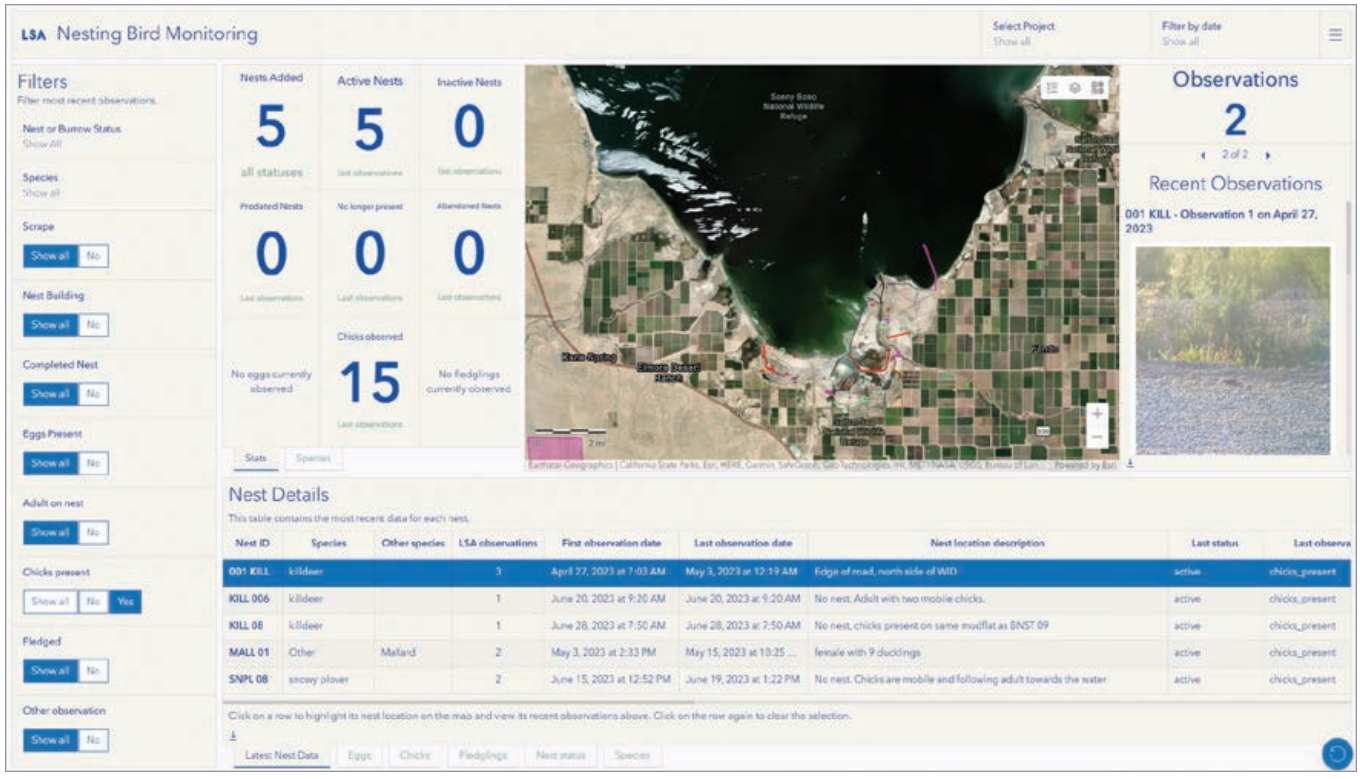
↓ Drone imagery and vector data are published by LSA to ArcGIS Online using ArcGIS Pro.

consulting firm, to conduct biological monitoring to comply with environmental regulatory requirements and permit conditions. The incorporation of GIS has streamlined all biological monitoring processes for the project.

"Our biologists record detailed observations about nest location, status, and activity," said Holly Torpey, senior GIS specialist/developer at LSA. "In addition, they report on the presence of adults, eggs, chicks, fledglings, and bird mortality. We monitor both resident and migratory nesting birds and record observations of any special-status species spotted within the site."

In addition to its use by Kiewit for construction activities for permit and regulatory compliance, LSA biologists submit the data they collect to state and federal agencies involved in environmental monitoring. The firm also facilitates access to the site for the Audubon Society and Point Blue Conservation Science, a 501(c)(3) not-for-profit organization, so that they




LSA Nesting Bird Monitoring
Select Project
Show all
Filter by date
Show all
Filters
Filter most recent observations.
Nest or Burrow Status
Show All
Species
Show all
Scrape
Show all
No
Nest Building
Show all
No
Completed Nest
Show all
No
Eggs Present
Show all
No
Adult on nest
Show all
No
Chicks present
Show all
No
Yes
Fledged
Show all
No
Other observation
Show all
No
Nests Added
5
all statuses
Active Nests
5
Inactive Nests
0
Predated Nests
0
No longer present
0
Abandoned Nests
0
Chicks observed
15
No eggs currently observed
No fledglings currently observed
Stats
Species
Observations
2
2 of 2
Recent Observations
001 KILL - Observation 1 on April 27, 2023
Nest Details
This table contains the most recent data for each nest.
Nest ID
Species
Other species
LSA observations
First observation date
Last observation date
Nest location description
Last status
Last observa
001 KILL
killdeer
3
April 27, 2023 at 7:03 AM
May 3, 2023 at 12:19 AM
Edge of road, north side of WID
active
chicks_present
KILL 006
killdeer
1
June 20, 2023 at 9:20 AM
June 20, 2023 at 9:20 AM
No nest. Adult with two mobile chicks.
active
chicks_present
KILL 08
killdeer
1
June 28, 2023 at 7:50 AM
June 28, 2023 at 7:50 AM
No nest, chicks present on same mudflat as BNST 09
active
chicks_present
MALL 01
Other
Mallard
2
May 3, 2023 at 2:33 PM
May 15, 2023 at 10:25 ...
female with 9 ducklings
active
chicks_present
SNPL 08
snowy plover
2
June 15, 2023 at 12:52 PM
June 19, 2023 at 1:22 PM
No nest. Chicks are mobile and following adult towards the water
active
chicks_present
Click on a row to highlight its nest location on the map and view its recent observations above. Click on the row again to clear the selection.
Latest Nest Data
Eggs
Chicks
Fledglings
Nest status
Species

← Drone imagery shows a portion of the Species Conservation Habitat (SCH) project area that was flown by LSA staff members Eva Newby and Mitch Alexander.

→ ArcGIS Survey123 allowed repeated observations of the same location without creating a new point each time.

↙ Dashboards were used to share field data and monitor changes over time and filter and extract requested data for reports.

can conduct migratory bird counts at the Salton Sea for the Pacific Flyway. The flyway is a north-south migratory route that extends from Alaska to Patagonia.

"The initial challenge in this project was to configure a data collection template for the biologists that enabled repeated observations of the same location without creating a new point each time," said Torpey. "This was achieved through the use of repeats and related tables in *[ArcGIS]* Survey123."

Another challenge was communicating with a large crew at a large, remote site. The location has limited internet access, and real-time communication among field crews, clients, and the project manager was sometimes spotty.

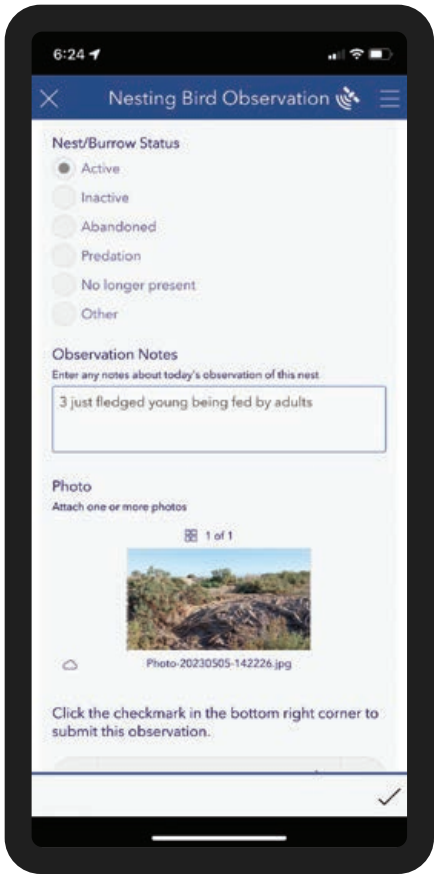
"We overcame the connectivity concerns by configuring both Survey123 and *[ArcGIS]* Field Maps to work offline and sync when an internet connection became available," said Torpey. "To address communication issues, we developed dashboards and web applications to share field data with the lead biologist and project manager. The dashboard capabilities also allow them to monitor change over time and filter and extract requested data for reports.

"Kiewit and our project manager use the ArcGIS Instant Apps Sidebar to communicate priorities to our field biologists. They draw new nesting bird survey area boundaries and update their status each week," said Torpey.

Survey area boundaries, displayed on biologists' mobile devices in Field Maps and symbolized by priority status, let biologists know which areas they need to visit each day. The construction field engineer and the biologists can add notes to each area to communicate important instructions and observations.

ArcGIS Pro is used to perform spatial analysis, generate cartographic products for reports, and maintain field data collection templates. Kiewit supplies data on construction progress in CAD format, which is converted to geodatabase feature classes in ArcGIS Pro. Drone imagery and vector data are published to ArcGIS Online using ArcGIS Pro.

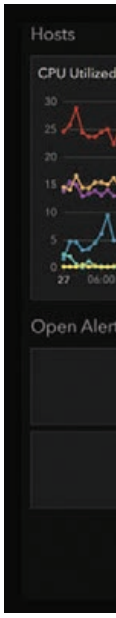
"GIS empowered our team to improve communication, workflow, and safety in a complex project environment," concluded Christina Van Oosten, a senior biologist at LSA. "In addition to saving time and thus money, it helps keep the project in compliance with environmental regulatory requirements and permit conditions, which ultimately protects the sensitive natural resources at the site. The flexibility of the GIS applications gave us an opportunity to adjust and adapt as conditions and project needs changed. This flexibility is especially important to support the best management practices needed at restoration and habitat improvement projects."



About the Author

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

Enterprise Monitoring Boosts Multimachine GIS Deployment Performance



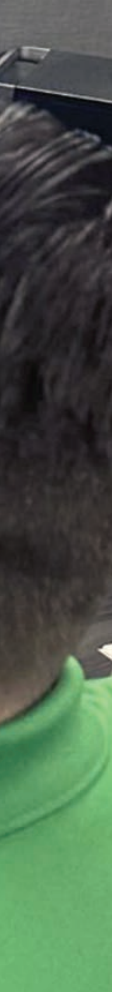
To support a booming population that is growing at a rate of 2.32 percent annually, the City of Grimes, Iowa, is broadening its essential services such as utilities, law enforcement, and building infrastructure. To keep up with its residents' needs, Grimes realized it was necessary to expand the city's enterprise system and ensure dependable IT infrastructure that would enhance operations and boost productivity.

The city, which deployed ArcGIS Enterprise in 2022, has a robust multimachine GIS implementation. Greg Jameson, GIS technician for the City of Grimes, is responsible for managing the city's enterprise GIS, including deploying servers, managing licenses, and gathering metrics. He wanted more data and details than were available from the previous monitoring solution to ensure the system was running optimally.

More Performance Information Needed

The self-hosted monitoring tool the city used previously delivered limited information on system health. Although it was helpful in validating that GIS server administration web pages were up and had responded within the last 20 minutes to a web service, it didn't provide details on how the enterprise portal was working. Essentially, it just showed whether a service could receive web traffic. Jameson wanted more insight and capabilities.

"At the end of the day, our city council wants to make sure we're being the best fiscal stewards that we can. And so *[it's helpful]* having some metrics to highlight what is our uptime, how much is being used, how



is it cutting down on staff time to find data to do things. And [our previous tool] just doesn't give us any of that," said Jameson.

The additional insight would also help Jameson know if he was properly publishing services. As the ArcGIS Enterprise deployment was new to the city, he wanted to get data on specific items such as the accuracy of load balancing numbers, maximum instances being used, performance of services, or identification of the core services that might have more end-user demand. With limited time, Jameson wanted more informed metrics delivered to him.

"Because I'm new to ArcGIS Enterprise, I want to *[see]* if I should select a shared or a dedicated instance? That is so specific, and I don't have that time to go and hunt that *[data]* down," he explained. "I only have so much time in the day to validate services or things that are up. So, it was more of a reactive situation for me."

The City of Grimes has evolving needs, and its fast-growing multimachine GIS deployment must be flexible. The current system includes an enterprise portal, a web server, a GIS server, ArcGIS Data Store, an image server, a single machine test/development ArcGIS Enterprise deployment, a shared Microsoft SQL Server instance, and an ArcGIS Monitor server.

One-third of the city staff—some 20 to 25 people—use internal services daily. Jameson noted that since it's impossible to know what city staff use cases may be in the future, he wanted a tool that would grow with the city's needs.

"Initially monitoring and making sure that things were OK, I was trying to check at least once a week to make sure all the services were there. Well, each week I'm adding another service or two," said Jameson. "So, each week it only extends more and more."

Affordable and Seamless Integration

Through the city's enterprise agreement with Esri, Jameson had access to the entire ArcGIS technology stack. He was looking for an Esri tool that would provide seamless integration and be affordable. Jameson connected with Esri staff and learned about ArcGIS Monitor, a solution designed to help analyze and optimize the health of an ArcGIS implementation throughout the life cycle of an enterprise GIS.

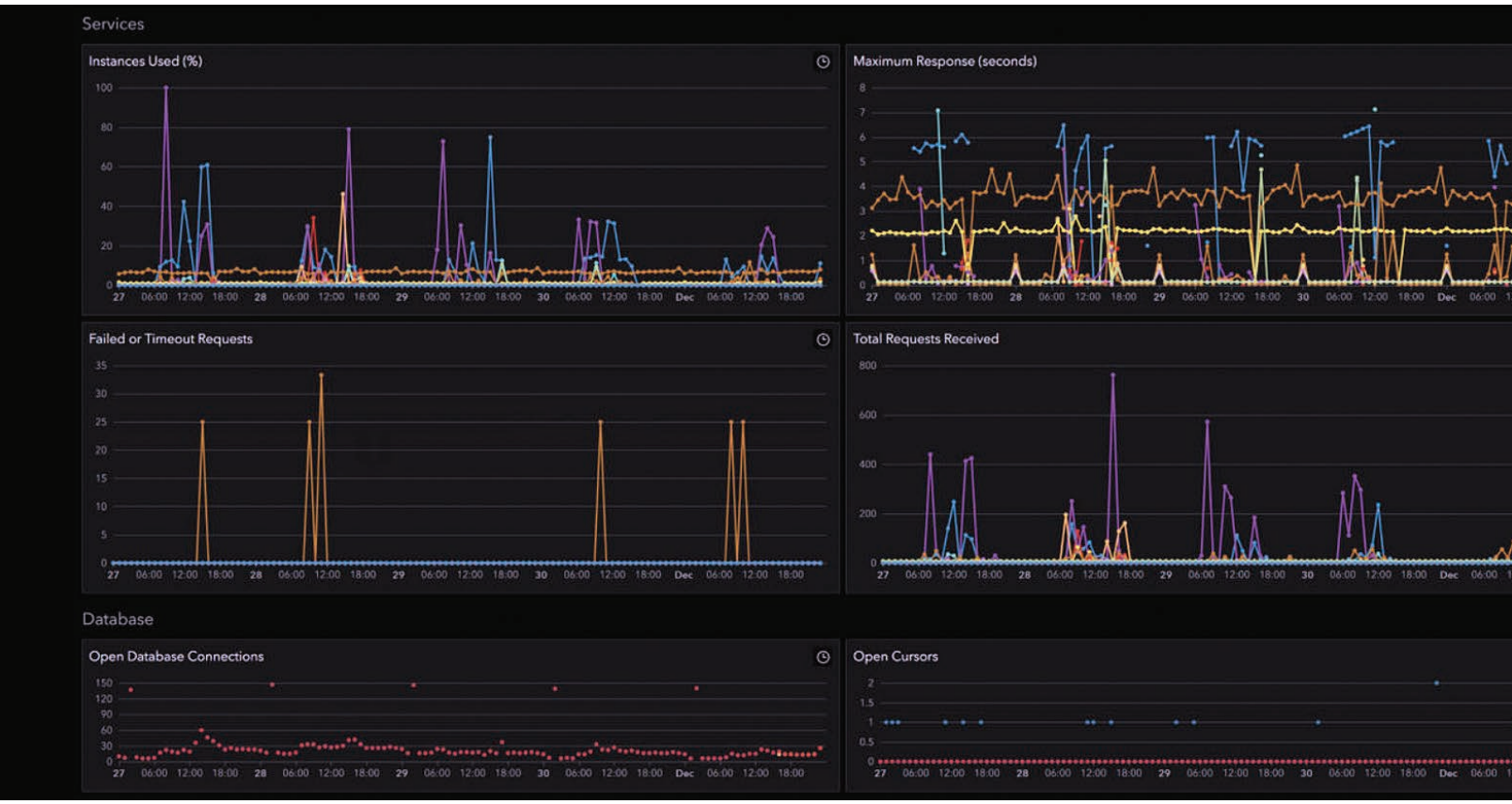
He chose ArcGIS Monitor, an enterprise-grade monitoring solution, to provide the information about the health and performance of the GIS he required. Jameson liked that ArcGIS Monitor provided a user experience similar to that of the enterprise portal and could provide more meaningful insight into the GIS. During deployment, he found Monitor documentation was very helpful. Jameson worked with a colleague who was also testing and setting up Monitor in his organization. Jameson says they frequently talked to exchange ideas and tips.

Jameson began setting up Monitor by asking the IT department to provide a server for Monitor with Esri's recommended specifications. He installed the software, built the PostgreSQL database, and began registering components with Monitor. He began receiving data metrics about the GIS system within minutes.

Now, Jameson checks Monitor every morning to see if any errors occurred overnight that need his attention. These alerts are also sent directly to his email inbox via notifications. The IT department has login information as well to view and help address potential system issues.

← Greg Jameson, GIS technician for the City of Grimes, looks at ArcGIS Monitor in the morning for any alerts.

↓ ArcGIS Monitor automatically opens and closes alerts and tracks CPU and memory usage.



↑ The serial charts that Jameson added focus on the performance of services by showing the percent of instances used, maximum response, and failed or timeout requests.

> "At the end of the day, our city council wants to make sure we're being the best fiscal stewards that we can."

Ensuring Enterprise Reliability

Since its deployment in February 2023, Monitor has helped deliver reliability to the City of Grimes staff. It gives Jameson a snapshot of the entire GIS system and its performance. He primarily looks at CPU, memory allocations, alerts, and status changes for the enterprise GIS and he can easily see how all the components are working together.

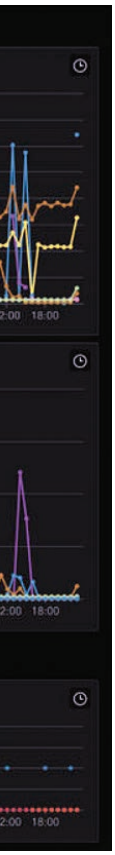
"Because it is just me as a staff member between managing the training of the staff and launching Esri solutions, Monitor has helped me to free up that time to focus on other things. Monitor is my go-to thing to put up, to engage [with]…because it tells me if there's an issue or a latency," said Jameson.

Jameson ensures that the organization's 90-plus services are properly running and response times for users are adequate. Monitor has given Jameson deeper insight into the system, which has helped him be more proactive when addressing GIS issues.

Jameson can also determine the layers that staff use most often, which helps confirm proper delivery. For example, Jameson's golden rule for delivering aerial image cache is under one second. He can better monitor this internal benchmark and current system demand. When new services are published, they are immediately available to view in Monitor. This has been especially helpful for Jameson since he adds new services weekly, and metrics are gathered automatically. According to Jameson, the metrics give him the core information he needs to make a quick decision.

"That level of automation and connectivity within Monitor is fantastic. I don't have to do any more maintenance [because] it takes care of itself for me. It's one less thing for me to update when I build the next thing," said Jameson.

The metrics also help Jameson understand the new ArcGIS Enterprise system and gain better insight into how the software functions. For example, he can better understand the demand on the system



when there is an upgrade by checking the upgrade or patching loads.

The alert notifications sent by Monitor and the custom reports (e.g., Analysis views) that are producible have been a significant advantage for monitoring system health. For example, Jameson created a custom report to check ArcSOC usage. *[When a client app makes a request to any service running on your ArcGIS Server site, such as to draw a map, geocode a dataset, or run a geoprocessing job, that request is passed to an ArcSOC process on one of the machines in the site.]* The custom report provides details on the load when a new service is deployed. This helps Jameson know when the new services are being used without having to review them layer by layer within the database. ArcSOCs are the process on the server handling dedicated and hosted services. A serial chart produced by Monitor allows insight into the demands of service on the hardware itself.

Jameson finds the default alerts in Monitor very helpful, particularly those that check storage space. Monitor allows him to tailor the alerts, such as changing the data retention policy to keep at least six months of information so he can view growth trends in the long term. Leadership at the City of Grimes has been very supportive of Jameson's work and sees the value of GIS.

ArcGIS Monitor has given Jameson the metrics he needs to get a complete view of the system and deliver reliable services to city staff. He looks forward to expanding the city's GIS capabilities and continue monitoring system health so that he can deliver a better experience to staff. "ArcGIS Monitor has given me back *[time every week for]* monitoring our deployment as a whole, whether that's log files or making sure services are up. It allows me to be proactive rather than reactive, and then allows our platform to continue to accelerate faster and faster," Jameson said.

"What is our vision? We want to empower location-based data to anybody. We just want to have every employee have access to GIS at their fingertips as a tool to perform their job more efficiently," said Jameson. "And additional efficiency will be gained over time as we continue to mature our GIS environment and our city."

Improved Security & Privacy Compliance

Esri has recently implemented new measures to help ensure its customers meet rapidly evolving privacy regulations as well as address cybersecurity threats most effectively.

ArcGIS Enterprise Hardening Guide

This guide was developed over several years and incorporates input from users and security experts from around the globe. Users with a production ArcGIS Enterprise deployment in place or in process should ensure that these best practices are in place as soon as possible. Download the *ArcGIS Enterprise Hardening Guide* at links.esri.com/hardening.

EU-US Data Privacy Framework (EU-US DPF)

Esri's certification by the Data Privacy Framework Program was completed in January 2024. This demonstrates Esri's commitment to upholding the data protection standards required by the European Union (EU). Esri still maintains the Standard Contractual Clauses (SCCs) as part of its Data Processing Addendum, which provides European Union (EU) customers stable privacy assurance despite evolving US regulations. For more information, look at out the ArcGIS Trust Center DPF page at links.esri.com/compliance.

FedRAMP Moderate Controls, Revision 5

ArcGIS Online has been operating and validated by a third party to be in alignment with the Federal Risk and Authorization Management Program (FedRAMP) Moderate controls for more than a year. Some users have moved forward with their own agency FedRAMP authorizations. Based on recent discussions with the PMO, the moderate authorization should be listed in the 2024 Q2 timeframe. In the meantime, Esri has been shifting to newer Revision 5 controls, which include stronger supply chain validation. Esri plans to complete the 2024 Accredited FedRAMP Third Party Assessment Organization (3PAO) assessment by the end of Q2.

ISO 27001

Esri continues to move forward the alignment of its EU Region systems and operations with this ISO 27001 certification, which will cover specific ArcGIS Online and Platform capabilities. Esri aims to have this in place before the end of 2024. Visit the ArcGIS Trust Center ISO compliance page at links.esri.com/compliance for details as they become available.

Contact Esri's software security and privacy team at SoftwareSecurity@esri.com.

Save Credits When Using Analysis Tools

By Bern Szukalski

ArcGIS Online provides analysis tools that enable you to perform spatial analysis and gain insights from your data. If you have appropriate privileges, these tools can let you summarize data, find locations, analyze patterns, enrich data, and perform proximity analysis and other operations. These tools can be accessed by clicking the Analysis button on the Settings (light) toolbar. Raster analysis tools and raster functions are available via ArcGIS Image for ArcGIS Online.

Credits are the currency used in ArcGIS Online. While most of what you do when using ArcGIS Online does not require credits, credits *are* consumed when you use analysis tools. The number of credits consumed depends on which tool you use, which tool options you choose, and the number of features involved in the analysis.

While many of the analysis tools you commonly use consume very few credits, when you are working with large numbers of features, batch geocoding, or enriching layers, the credits consumed can add up. Here are some tips on how to economize on analysis tool credit consumption for your organization.

Govern Analysis Tool Access

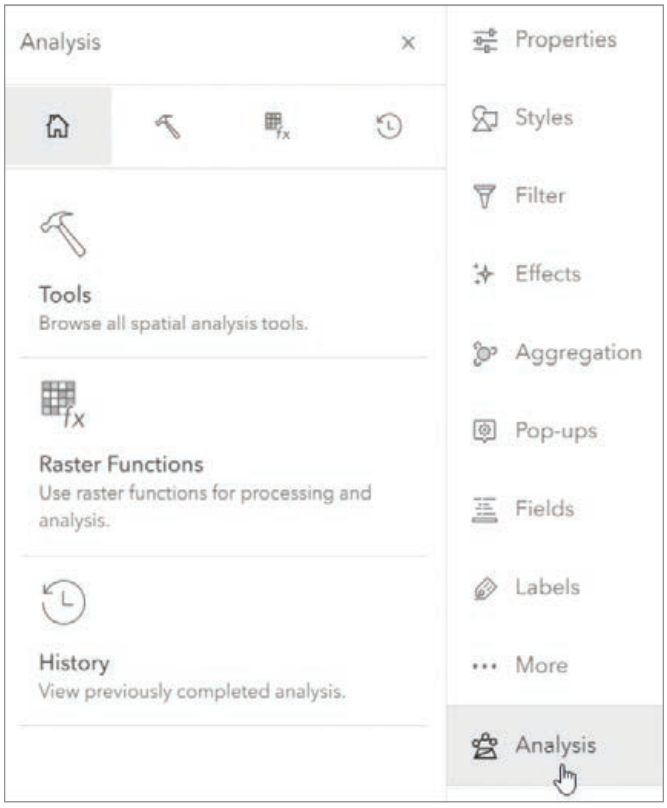
Savvy administrators will govern access to analysis tools and other functions within an organization by assigning the appropriate user type, role, and privileges to members. In general, spatial analysis use requires a Creator or GIS Professional user type or a Publisher, Facilitator, or Administrator role, or an equivalent custom role.

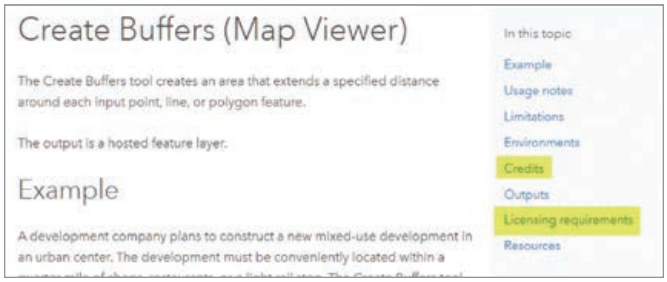
While these roles and user types enable most tools, some tools require additional privileges. To learn more about the credits consumed and licensing requirements for specific tools, view the tool Help documentation. Each tool has sections that cover credits and licensing requirements.

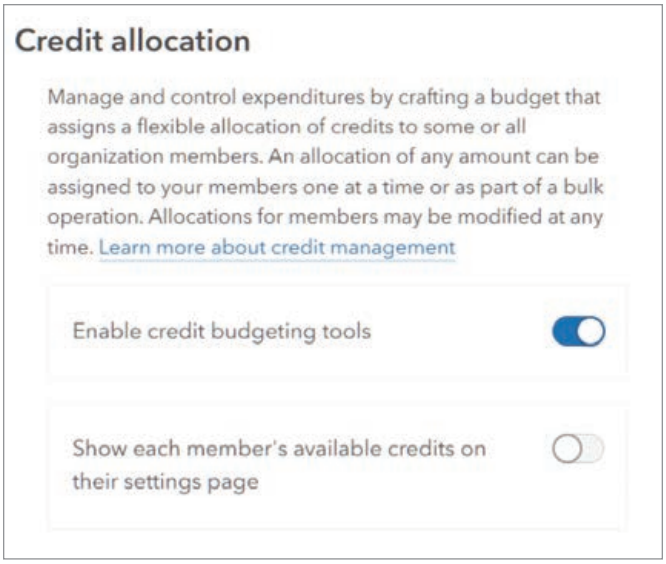
For example, when you read the Help documentation for the Generate Travel Areas tool, you will learn it consumes credits and requires licensing for Network Analysis privileges. The Zonal Statistics tool consumes credits and requires an ArcGIS Image for ArcGIS Online license.

Configure Credit Consumption

Administrators can also configure credit consumption for members. These limits apply to members using analysis and other tools. Credit budgeting applies to transaction-based services and tools, such as data enrichment, publishing, and spatial analysis. Click the Settings tab for your organization, and in the Credits section enable credit budgeting tools.







Use Analysis Settings

At the bottom of the Analysis pane, you will see Analysis settings for the web map. When you set analysis environment settings in the web map, any new tool or function that is opened will inherit the map level environment settings.

In the General environment section, you can specify the processing extent. Although full extent is the default, you can set this parameter to Display extent or use other options that will reduce the number of features to be processed. This will reduce the number of credits consumed when you run the tool.

Credit settings can be found under General environments (and under the Raster environment for ArcGIS Image for ArcGIS Online). For more information, see the Help documentation for the analysis settings.

Use Display Extent

By default, the analysis is applied to the full extent—all features in the layer. You can zoom to your primary area of interest and use the display extent setting in the Environment settings to reduce the number of features processed during analysis, which can reduce the credits consumed significantly.

The environmental settings for a tool or function will override the same setting for the web map. These settings will only be used until the tool or function is closed and will not be saved if the tool or function is opened again. If you reopen a tool or function from History, it will repopulate with the environments that were used when it was previously run. For more information, see the Help topic Update the environment settings for a tool or function.

Look Before You Run

You can preview the credits that will be consumed prior to running an analysis. Set all the desired tool options, then click Estimate credits prior to clicking Run so you can preview the credits that will be used with those current settings.

Use Filter Expressions

You can apply filters to limit the features considered during analysis to only those that match the filter. Apply one or more filter expressions to the layer to focus analysis only on those features you want, which will reduce the features analyzed and credits consumed.

Consider Tool Options

Some tool options will increase credit consumption. For example, if you choose lots of enrichment variables, the number of credits consumed will increase. If available in the tool, the measurement type used (e.g., line distance vs. driving distance) will affect the number of credits used. Set the tool options, then estimate credits to ensure you're using credits wisely.

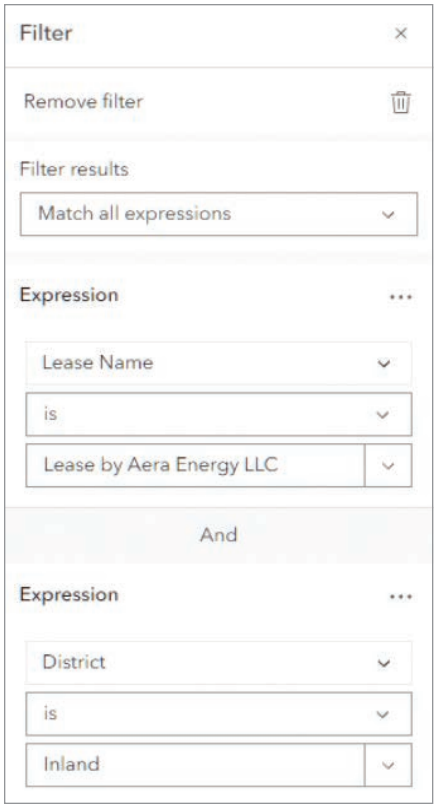
More information

For more information, see the following ArcGIS Online Help documentation topics:

- Understand credits
- Configure credits
- Perform analysis

About the Author

Bern Szukalski is a corporate GIS technology evangelist and advocate at Esri. He focuses on ways to broaden access to geographic information and help customers succeed with the ArcGIS system. On a good day, he is making a map. On a great day, he is on one.



↖ Click the Settings tab for your organization, and in the Credits section enable credit budgeting tools.

← Apply one or more filter expressions to the layer to focus only on those features you want, reducing the features (and credits consumed) for analysis.

↖ Raster analysis tools and raster functions are available via ArcGIS Image for ArcGIS Online.

↙ Learn more about the credits consumed and licensing requirements for specific tools by viewing the Help documentation for a tool.

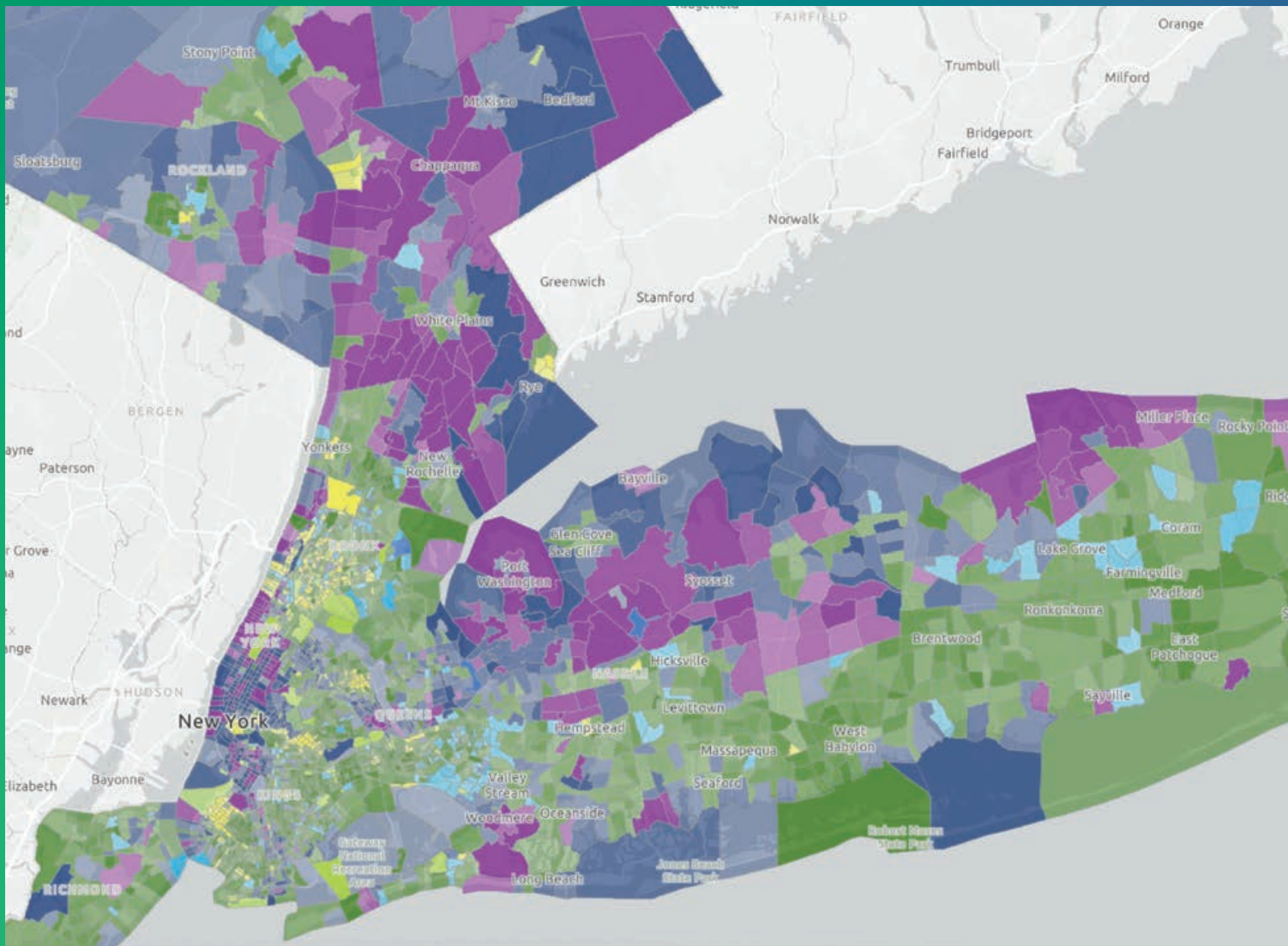
Build GIS Web Apps with JavaScript Maps SDK Components

By Omar Kawach and Julie Powell

Web components simplify the development of web applications and maximize productivity of front-end development.

The October 2023 release of ArcGIS Maps SDK for JavaScript (v4.28) introduced a beta version of Esri's standards-based web components. JavaScript Maps SDK is a component library that currently includes three kinds of reusable custom HTML elements: map, charts, and coding components. The component library will expand over time with more prebuilt ArcGIS experiences (encapsulated into web components) that can be easily brought into your own app.

↓ A simple web map developed using map components.



What Are Web Components?

Web components are a set of technologies introduced by the World Wide Web Consortium (W3C) that allow the construction of custom reusable and framework-agnostic HTML elements. They provide strong encapsulation, custom functionality, and full compatibility with HTML and DOM APIs. There are three main technologies provided by web components: custom elements, Shadow DOM, and HTML templates.

- **Custom elements** allow developers to define their own HTML elements with custom behavior.
- **Shadow DOM** provides encapsulation for the SDK's JavaScript and CSS within a custom element, so it doesn't affect the rest of the DOM.
- **HTML templates** permit the definition of markup chunks that can be used in instances of custom elements, including templates.

Why Use Web Components

While JavaScript Maps SDK has traditionally followed a mostly imperative/procedural approach, JavaScript Maps SDK components offer a declarative-first approach. With the components, developers can rely on pre-built ArcGIS experiences that reduce the need for boilerplate code and instead focus on using HTML markup to accomplish most—if not all—of the required tasks. This simplifies the process of integrating ArcGIS capabilities into your app.

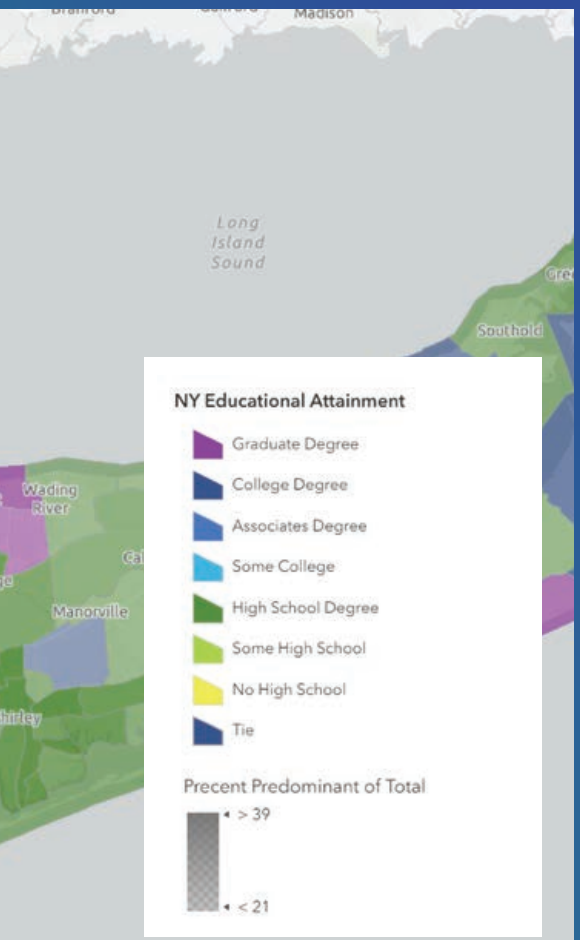
A New Way to Build JavaScript Maps SDK Apps

The map components package includes the map, scene, and many components with functionality equivalent to existing widgets in JavaScript Maps SDK and more. These components are an alternative and modern option for quickly building web map apps and are especially useful when integrating with frameworks.

The new components offer an alternative approach to building apps. You can choose to adopt the new declarative-first pattern for using the SDK or continue to build apps using the imperative pattern using the SDK's core JavaScript API. To understand the difference between the two patterns, let's look at an example.

Listing 1 illustrates a simple app built using the imperative approach—if you've built an app with the SDK in the past, this should look familiar. JavaScript is used to manipulate the container element, which is responsible for displaying the map and its widgets.

Compare the difference between the imperative/procedural approach in Listing 1 with the declarative-first approach of web components shown in Listing 2, which

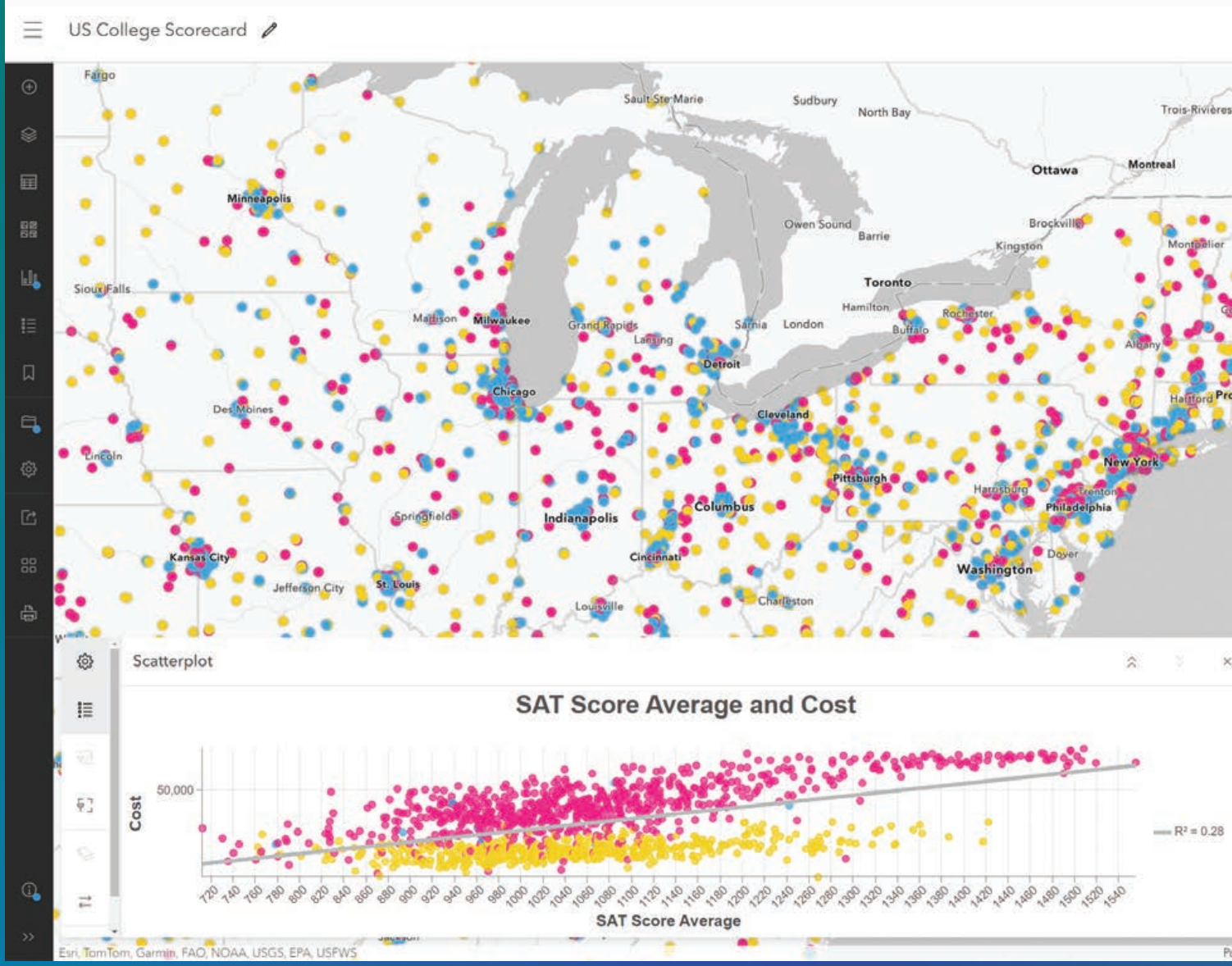



```
<body>
    <script>
      require([
        "esri/views/MapView",
        "esri/widgets/Legend",
        "esri/widgets/Search",
        "esri/WebMap",
      ], (MapView, Legend, Search, WebMap) => {
        const webmap = new WebMap({
          portalItem: {
            id: "05e015c5f0314db9a487a9b46cb37eca"
          },
        });
        const view = new MapView({
          container: "viewDiv",
          map: webmap,
        });
        const search = new Search({
          view,
        });
        const legend = new Legend({
          view,
        });
        view.ui.add(search, "top-right");
        view.ui.add(legend, "bottom-left");
      });
    </script>
    <div id="viewDiv"></div>
  </body>
```

← Listing 1: Web map built imperatively using the core JavaScript API.

```
<body>
  <arcgis-map item-id="05e015c5f0314db9a487a9b46cb37eca">
    <arcgis-search position="top-right" />
    <arcgis-legend position="bottom-left" />
  </arcgis-map>
</body>
```

← Listing 2: Web map built declaratively with components.



↑ The Charts components package adds charting components that can provide another dimension to maps.

→ Listing 3: When web components, the underlying core API is still available.

```
<arcgis-map item-id="05e015c5f0314db9a487a9b46cb37eca">
  <arcgis-legend position="bottom-right"/>
</arcgis-map>

<script>
  document.querySelector("arcgis-map").addEventListener("arcgisViewReadyChange", (event) => {
      const { portalItem } = event.target.map;
      console.log(portalItem.thumbnailUrl);
  });
</script>
```

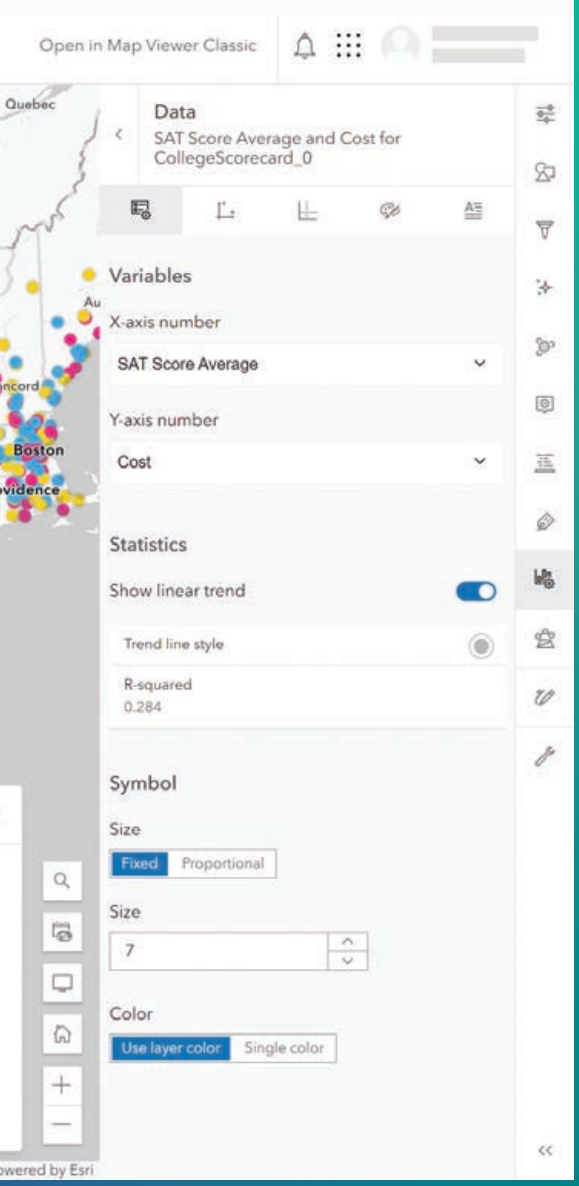
shows code for a web map built with the @arcgis/map-components package from JavaScript Maps SDK components.

You can see that with map components, JavaScript is not necessary to achieve the same solution. This eliminates the need for the viewDiv container element. It also eliminates the need to separately initialize the WebMap and MapView. It is important to note that while the example shown was written purely with web components, the underlying core API is still available, creating a balance between the imperative and declarative programming paradigms, as shown in Listing 3. This flexibility allows you to reap the benefits of both approaches.

Making ArcGIS Experiences Available as Web Components

The adoption of web components by Esri development teams unifies Esri's developers and ensures consistent user experiences across different ArcGIS products. Through this approach, Esri has been able to create a wide range of reusable HTML elements that are not tied to a specific application framework (e.g., React, Angular, Vue). This enables teams to use any framework they want and maintain the ability to share code across teams. Calcite Design System was the first web component library that Esri built, which enabled Esri and the developer community to create consistent experiences throughout ArcGIS-based web apps using shared UI elements like buttons, date pickers, and layout components.

The componentization approach has evolved to include entire workflows that are now encapsulated into components



and added to apps with a few lines of code. These encapsulated ArcGIS capabilities are being made available to the developer community so that everyone has access to proven, user-friendly, and familiar experiences that require minimal effort to integrate into apps and maintain over time. The first examples of this are the charts and coding component packages.

The Charts components package offers a series of charting components that can be added to your applications to provide another dimension to maps—for example, emphasize trends or illustrate comparisons in your data. When used alongside maps, charts can provide a complete data visualization story of your data. They can be configured in Map Viewer and saved to your web map or layer, then simply loaded in the chart component in your app (as shown in Listing 4) or defined directly in code.

Each chart type provided in charts components can help to learn more about your data in following ways:

- **Bar Chart**—Summarize and compare categorical data.
- **Line Chart**—Visualize change over a continuous range—time or distance.
- **Pie Chart**—Group data into slices to visualize part-to-whole relationships.
- **Histogram**—Summarize the distribution of a continuous numeric variable by measuring the frequency at which certain values appear in the dataset.
- **Scatterplot**—Visualize the relationship between two numerical variables.
- **Box Plot**—Visualize and compare the distribution and central tendency of numeric values through their quartiles.

The Coding components package will eventually contain a wide range of tools, resources, code editors, and utilities that support general coding. Currently, the package includes the ArcGIS Arcade editor component. This component allows the end user to create Arcade expressions that drive aspects of a map or app within a solution. Your end users will have the same experience editing their Arcade expressions as they do in Map Viewer and the Arcade playground.

Get Started Using Web Components

Tutorials on the ArcGIS Developer site (links.esri.com/webcomponents) let you discover components to build web mapping applications with minimal code. Additional components will be available in upcoming releases.

For more information, refer to the component documentation (links.esri.com/intro-web-com). To collaborate with others, ask questions, or report issues, visit Esri Community (links.esri.com/js-community).

About the Authors

Omar Kawach is a biotechnologist, geographer, and computer scientist at Esri who works as a product engineer on ArcGIS Maps SDK for JavaScript components and the ArcGIS Arcade expression language. His main focus is helping develop and integrate modern web components such as the ArcGIS Arcade editor.

Julie Powell is a principal product manager who focuses on Esri's web development technologies. She works to ensure that developers can be successful in building state-of-the-art, purposeful solutions using ArcGIS software. She brings 20 years of experience working with global leaders such as Hewlett-Packard and Esri, delivering a variety of software solutions for both the enterprise and consumer markets. Powell has worked on a wide range of projects and consulting endeavors, including serving as technical lead for web mapping solutions for strategic customers.

↓ Listing 4: The configuration for the bar chart is read from the feature layer item that was configured in Map Viewer. The data displayed in the chart will come from the feature layer.

First, add in HTML

```
const barchart = document.getElementById("barchart_chart");
const config = featureLayer.charts[0];

barchart.layer = featureLayer;
barchart.config = config;
```

Then in JavaScript add

```
<arcgis-charts-bar-chart id="barchart_chart"></arcgis-charts-bar-chart>
```

Enhancing Basemaps with Places and Worldview

By Elizabeth Ole, Robert Jensen, and Tony Howser

Customization is a developer's superpower. A simple modification of a basemap layer or tile can shape how users think spatially, analyze geographic information, and ultimately make decisions. In the real world, what developers map and the context they provide to users can be crucial.

ArcGIS Basemap Styles (v2) has been designed to enhance the way developers tell stories with basemaps. With the introduction of two exciting new features, Basemap Places and Worldview, app creators now have greater control over their basemaps. This empowers them to offer more insightful location-based context and cater to diverse mapping, analysis, and decision support needs.

Basemap Places

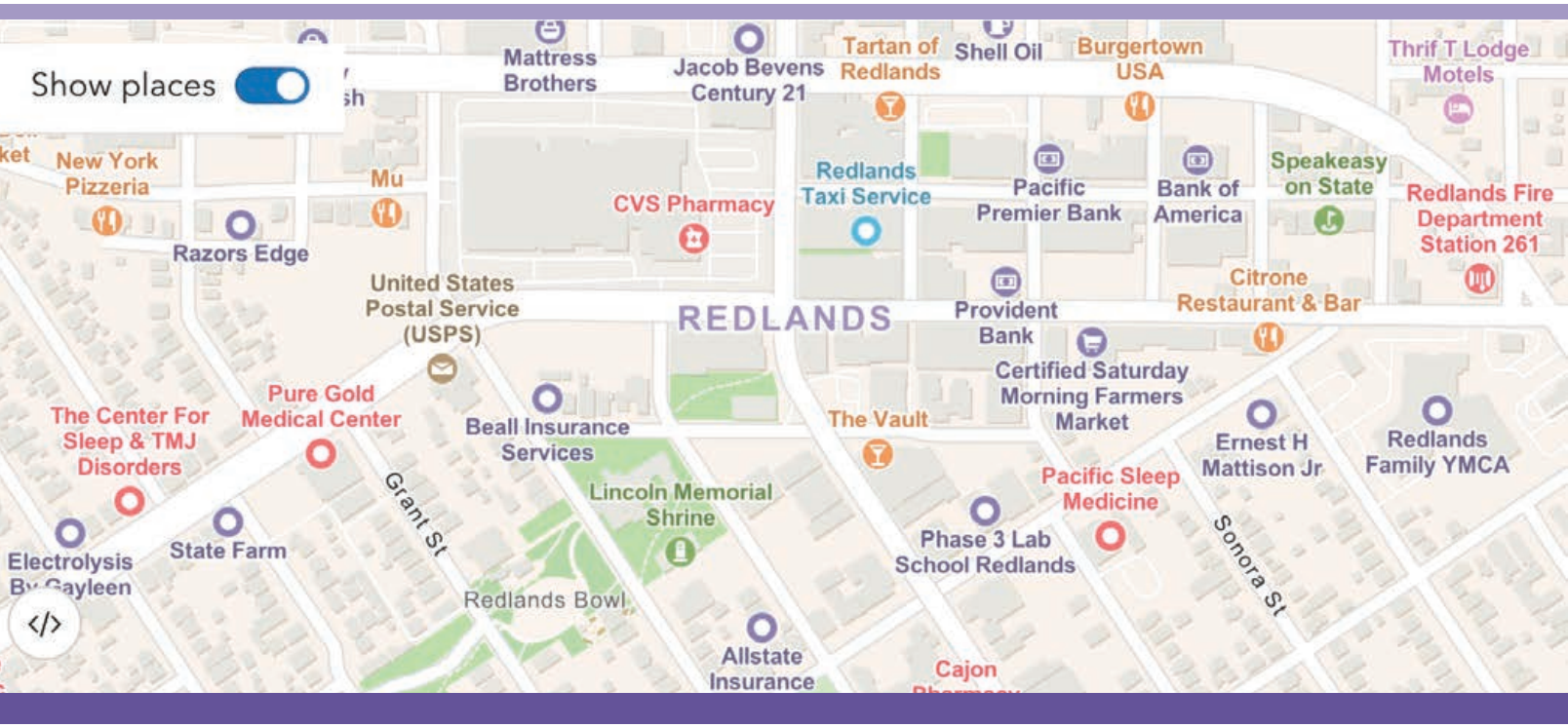
With Basemap Places, you can effortlessly control the presentation and interaction of Places data within your basemaps. This feature unlocks a world of possibilities, including these:

Extended Geospatial Insights

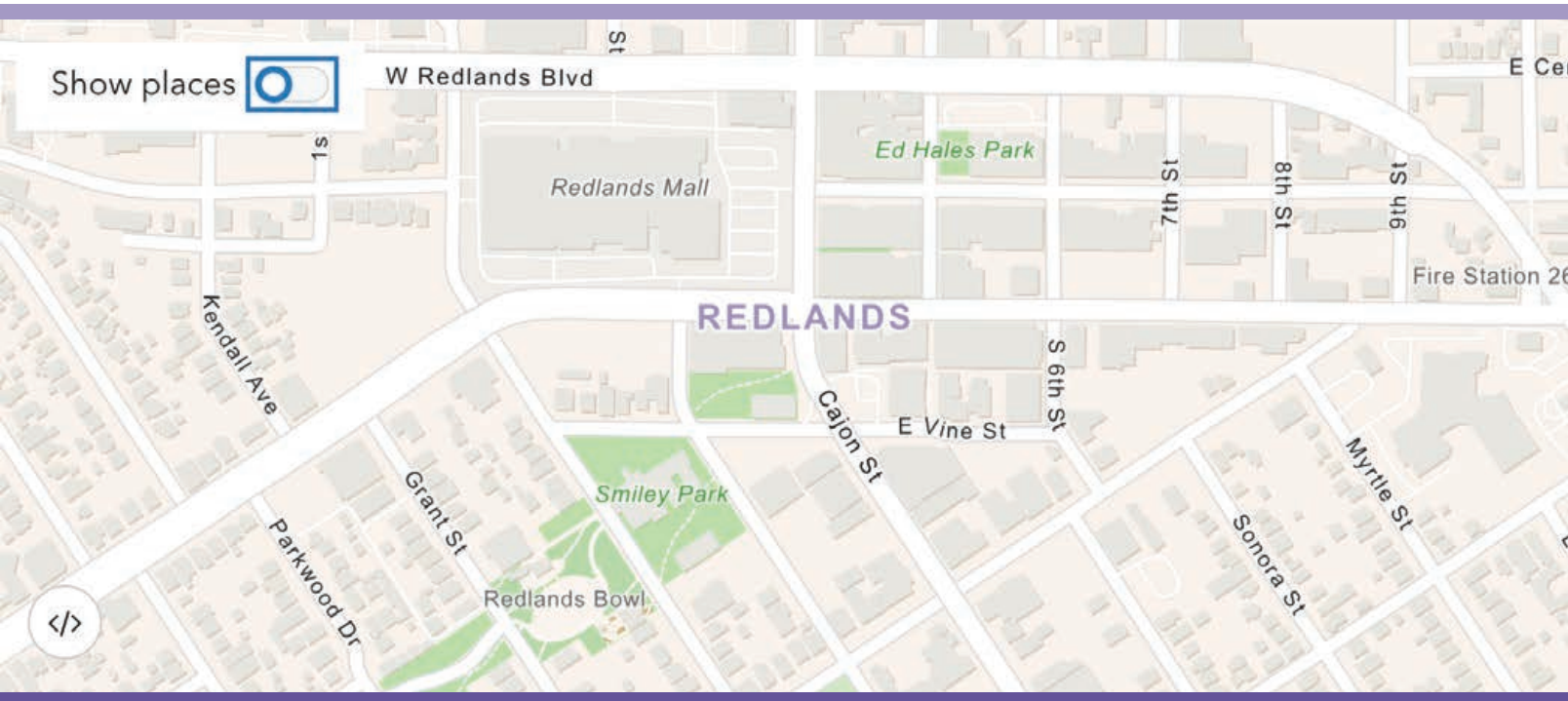
You can choose to show or hide places in your basemaps, providing users with valuable location-based context for areas worldwide.

Curated Maps and Apps

By filtering a subset of places based on selected categories such as food and drink, lodging, or transportation, you can create curated maps and



↓ Places data is displayed on a basemap.



apps. This allows you to tailor your maps to specific user needs and preferences.

Enhanced Interactivity

Basemap Places introduces new levels of interactivity with Esri's basemaps. Users can now obtain additional details about a place by simply clicking on point-of-interest (POI) features within the basemaps. Imagine accessing rich attributes such as street addresses, ride share drop-off locations, business hours, and user ratings, all supported by the new ArcGIS Places service.

Worldview

Worldview is an innovative feature that puts you in control of how international boundaries are displayed. In Esri vector basemaps, recognized international boundaries, such as the Norway-Sweden border, are typically represented with solid lines, while disputed boundaries, such as parts of French Guiana and the Suriname border, are often displayed as dashed lines.

With Worldview, developers can adjust the presentation of boundary lines based on user preferences. By providing an enumeration value or an array of values, they can create a worldview of boundaries. Boundaries are a fundamental element of basemap styles and play a crucial role in customizing the display of maps. Developers can choose which dashed lines to retain, offering map viewers a more tailored experience.

Get Started with Basemap Styles Service (v2)

Basemap Places and Worldview provide heightened control and greater flexibility for developers. Learn more about these features at links.esri.com/worldview. To experience these new features, join Esri's Early Adopter Community and try out the beta version of Basemap Styles service (v2) at links.esri.com/basemap-beta. By participating in the community and providing valuable feedback, you can help shape the future of this service and contribute to its continuous improvement.

About the Authors

Elizabeth Ole is a passionate storyteller and marketer who enjoys utilizing her expertise in creativity, marketing, and technology to craft compelling brand and product stories.

Robert Jensen is the product manager for geocoding, ArcGIS Network Analyst tools, ArcGIS World Geocoder, and ArcGIS Data Appliance.

Tony Howser is a product manager on the data and location services team and is focused on Esri's ArcGIS GeoEnrichment and ArcGIS Places services. His primary goal is to empower users and developers with valuable location-based context to support mapping and analysis needs.

↑ Places data is hidden on a basemap.

Basemap Places lets you provide points of interest on a map and details about those points, and lets your users display or hide points.

GIS and the Future of Spatial Computing

By Greg Milner

The term *spatial computing* dates from the 1980s. Its modern definition entered the lexicon in 2003. In his master's thesis for the Massachusetts Institute of Technology's (MIT) program in media arts and sciences, Simon Greenwold described spatial computing as "human interaction with a machine in which the machine retains and manipulates referents to real objects and spaces."

But spatial computing extends back even further. It has been the cornerstone of GIS technology since it debuted in the late 1960s. Indeed, the theoretical foundation of GIS is that it's not only possible but inherently useful to retain and manipulate real objects within some form of virtual space.

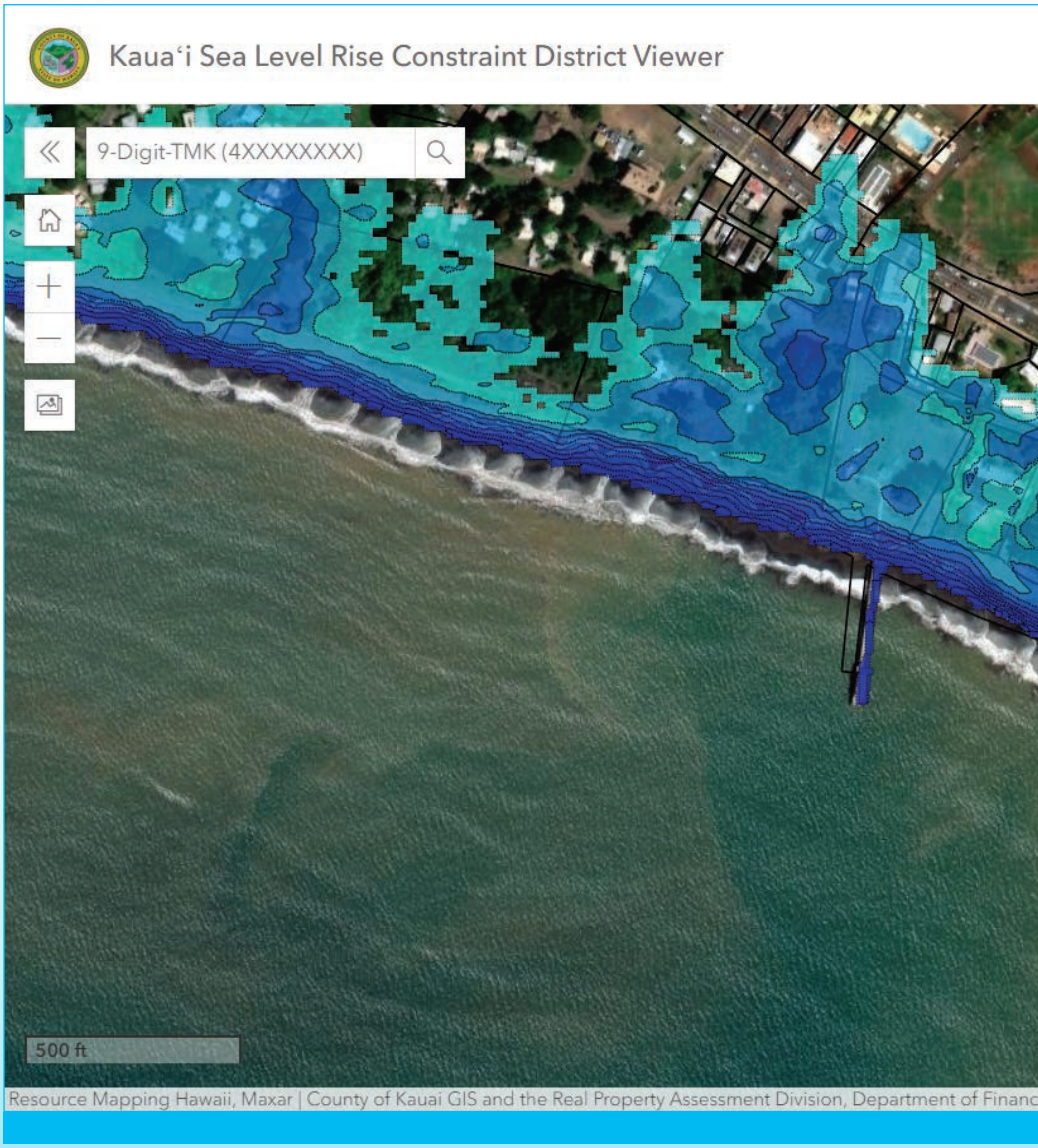
In the first GIS programs, virtual space was synonymous with cartographic space. Spatial computing meant using maps to organize large amounts of data in a visually intuitive manner.

GIS and the Roots of Spatial Computing

Early geospatial technology pioneers applied the concepts of theorists such as Ian McHarg, who described the world as a series of layers of information that exist and interact in the same physical spaces. Analyzing any spot on Earth yields information on elevation, soil type, hydrology, biology, and land use.

GIS brought this idea to life. The technology allows us to visualize and analyze layers of data on a map. GIS has become a key integrator of information about our world for uses that range from scientific research to engineering to commercial operations. Through innovation, GIS has grown beyond the bounds of mere 2D map layers to generate maps that are, in effect, 1:1-scale 3D models called geospatial digital twins.

The ability to provide maximum context is the major benefit of geospatial



digital twins. This is especially useful for smart planning of our urban environments. For example, architects can use a digital twin to test how their proposals will fare under situations like flooding and extreme heat brought about by climate change. City planners can understand the effects of large-scale shifts in the urban environment with interventions focused on enhancing livability. The combination of visualization and hard data allows them to predict impacts and modify plans before making expensive changes to the physical world.

Spatial Computing and Digital Twins

Each advance in GIS technology has improved our ability to visualize, link, and manipulate real objects and spaces in a digital realm. GIS has evolved to offer truly immersive experiences. In particular, the combination of GIS and game engines, such as Unreal and Unity, has transformed the process of large-scale infrastructure projects.

In Brisbane, Australia, for example, a digital twin of the ongoing subway construction has been used to display progress. People can walk virtually through planned subway tunnels and stations. This contextual experience helps project leads show residents how the work is shaping up.

The experience also allows planners, architects, engineers, and construction workers to make decisions with more information than could be provided by a paper map or even a traditional digital twin. They can stand on a platform and see how the design elements of a station will look to people moving through it.

The overall effect is a "visual narrative of space," as Unity VP Matt Collins told *Geo Week News*, an online publication that covers the built world and 3D and geospatial technologies. And not just a narrative, Collins added, but one that can "faithfully abide the laws of physics within the systems."

← The Kauai Sea Level Rise Constraint District Viewer provides visualizations depicting projections of high waves and passive flooding hazards due to rising sea levels around Kauai, a Hawaiian island.

Spatial Computing to Visualize What Could Be

Digital twins can be crystal balls. The virtual spaces can be reconfigured to model different versions of an environment. In practical terms, digital twins allow various stakeholders to have the same vision. This is especially useful in the age of climate change.

Planners and architects can test different versions of a project. If they are designing a subdivision in a coastal community, they can calculate the flooding and storm surge that will likely occur from storms of different magnitudes. Just as importantly, they can visualize this data, inhabit it, and study it with maximum context.

Fundamentally, they are investigating spatial relations against a realistic backdrop of the world. For the subdivision, these objects include homes, streets, streetlights, and parks, and what matters is their existence in relation to water under multiple scenarios.

This is spatial computing: manipulating referents to real objects in a virtual world that, unlike the real one, can be changed at will.

Spatial Computing to Visualize Hidden Real Spaces

Immersive environments also offer the promise of displaying a world that is real and already exists yet remains largely invisible. As spatial computing hits consumer devices, some of its most useful applications are enabled by GIS.

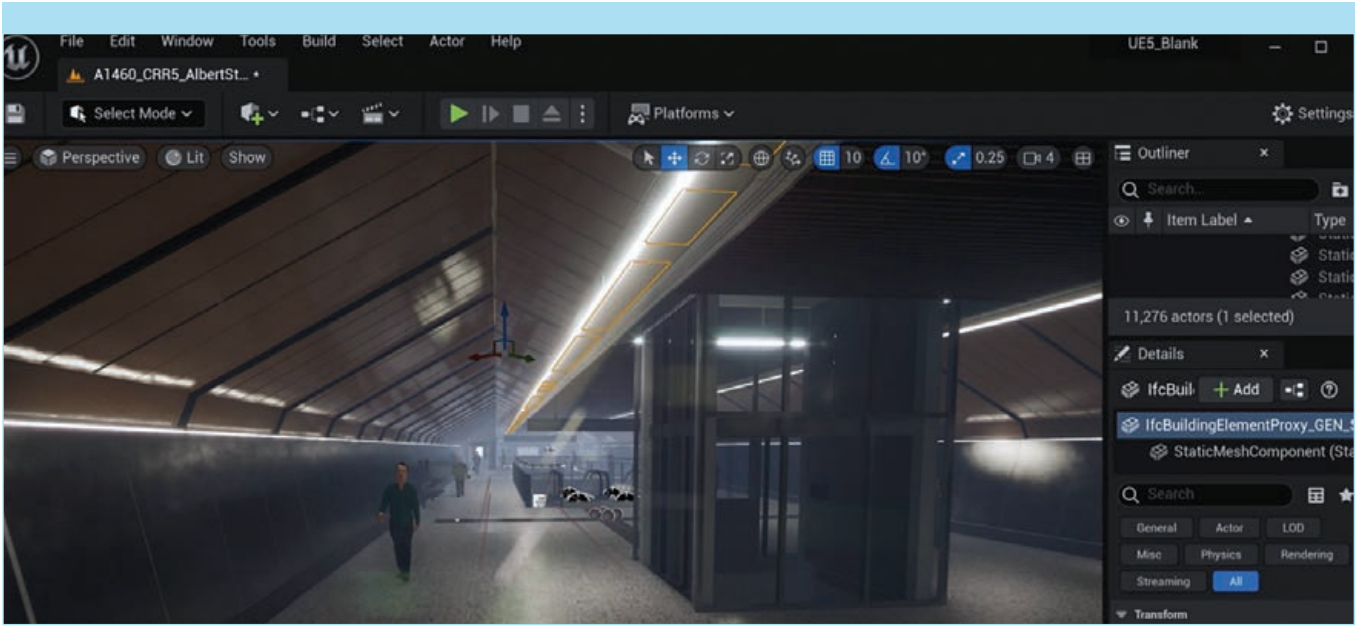
Public utilities and other companies involved with underground infrastructure have been some of the most enthusiastic adopters of digital twins because the experience can reveal critical connections buried beneath the earth—made visible without the need to dig.

In 2017, the Toms River Municipal Utilities Authority (TRMUA) in Toms River, New Jersey, began using mixed reality (MR) headsets to help crews find underground utility assets for electric, gas, water, telecommunications, and sewer services.

GIS stores the location of these assets, and MR displays the underground infrastructure. Traditionally, utilities display this detail on a 2D map. What MR provides is maximum context. Workers in the field can visualize exactly what's under their feet—and see how it's related spatially to what is all around them.

TRMUA credits MR with saving time and lowering the chances of breaking connections in the networks residents rely on for modern living—with savings in the tens of thousands of dollars every day.

Many utilities have followed TRMUA's lead. MR setups serve multiple purposes that include training new employees and sharing information between teams in the field and staff in the office.



↑ Putting BIM models into Unreal Engine allows engineers and other stakeholders to experience each station before they build it.

One utility industry publication recently noted that what these systems ultimately provide is the elimination of guesswork. The ability to know exactly where an asset is located—and to understand how changes will affect the area around it—leads to increased efficiency and customer satisfaction.

The World in Sharper Focus

Apple's Vision Pro headset is not the only recent example of XR rebranded as spatial computing. Meta and Microsoft have also marketed their XR headsets—Quest 3 and HoloLens, respectively—as spatial computers.

Spatial computing will continue into the

↑ Staff at TRMUA use Microsoft HoloLens and an app developed by Esri partner Meemim, Inc. to visualize ArcGIS feature data describing TRMUA's underground utilities.

mainstream of computing. Eventually, it will likely be the norm. As XR hardware increases in number and power, more organizations will look to unlock the value of all the spatial data recorded in GIS. Being able to experience data will add further value to the systems and workflows that create it.

GIS pioneers began exploring the outer limits of spatial computing a half-century ago. More recently, innovators have realized its potential for smarter urban planning, climate risk mitigation, management of operations across industries, and virtual exploration of real-world systems or scenarios via geospatial digital twins. Someday soon, those limits will be reachable by anyone.

As GIS users have learned through the decades, when we get a better sense of where we are in relation to things we care about, we can create the world we want to see.

About the Author

Greg Milner is a writer in the strategic content group at Esri, where he tells stories about how location intelligence is transforming our world and how we perceive it. A former magazine editor and political speechwriter, he is the author of the books *Perfecting Sound Forever: An Aural History of Recorded Music* (which was selected as a finalist for the National Book Critics Circle Award) and *Pinpoint: How GPS Is Changing Technology*, Culture, and Our Minds.

Effective Strategies for Engaging with Your Audience

By Ashley Du

Maximize the impact of your message by using these strategies when building and deploying your ArcGIS StoryMaps story.

How do I plan my story? How much content is too much? And what's the best way to share my story with the world?

We've all been there.

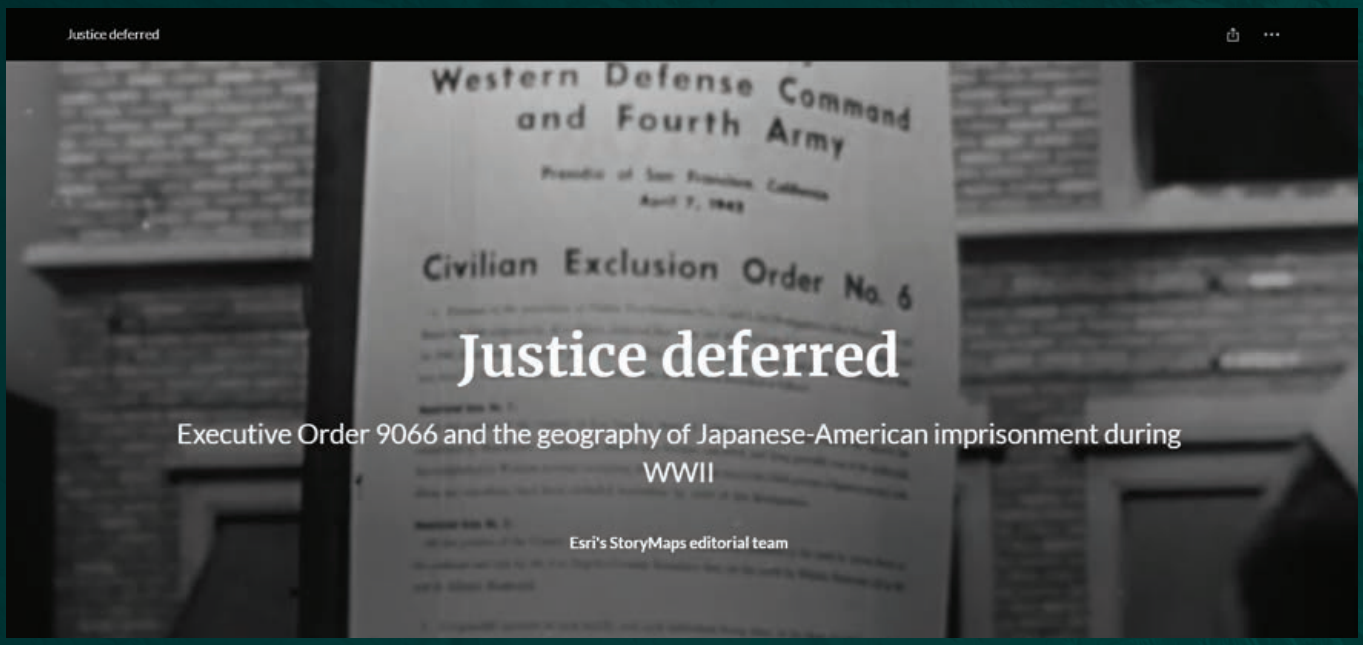
A blank piece of paper—a flashing cursor on an empty screen—intimidates even the most seasoned writers. Here are five strategies to help you build a story that engages readers and keeps them reading. As a bonus, resources are included to help you dig a little deeper into each topic.

- Plan your story with audiences and goals in mind.
- Use high-quality, accessible content.
- Make it easy to share and find your stories.
- Create a communications strategy.
- Leverage analytics for insights and optimization.

1 Plan your story with key messages, audiences, and goals in mind.

Before starting your story, consider your target audience and goals. By planning, you can incorporate elements that resonate with your audience and achieve measurable goals. From narrative structure to eye-catching visuals to overall tone, there are plenty of things to consider when crafting your story.

The ArcGIS StoryMap story, *Justice deferred : Executive Order 9066 and the geography of Japanese-American imprisonment during WWII* (links.esri.com/justice-deferred) was originally written for an advanced audience. The vocabulary was changed to make it accessible to secondary students and it was published as



"Unjustly imprisoned" (https://arcg.is/055SrL0)." The visuals and even the style of writing were considered because of the change in audience.

It can be tempting to put off thinking about how you'll promote your finished piece until after you've hit the Publish button. Don't give in to that temptation! Considering when and where you'll distribute your story before you start assembling it can help you incorporate elements that will make it more effective based on how you plan to get the word out.

2 Manage media like a pro.

Compelling visuals like eye-catching images, graphics, and maps enhance your narrative. One way to highlight your story's important messages is with attention-grabbing tidbits made easy with the ArcGIS StoryMaps builder. For example, you can use the quote block to make critical facts and statistics stand out. These screenshot-ready images speak to your message directly without needing any extra content. As a bonus, these custom quotes often make for sharable social content. The easier you make it for your readers to promote your story in style, the more likely that they'll spread the word.

Make sure those visual elements are properly attributed and accessible to all readers. Provide alternative text for images and captions for videos, which ensures that your entire audience can access your content.

Download this PDF for valuable tips and guidelines for using images and graphics in your stories at links.esri.com/using-graphics.

> "
> ***The World War II history of Americans of Japanese ancestry...is the bitter history of an original mistake, a failure of America's faith in its citizens' devotion to their country's cause and their right to liberty, when there was no evidence or proof of wrongdoing.***
>
> — *Personal Justice Denied*, the Commission on Wartime Relocation and Internment of Civilians, 1982

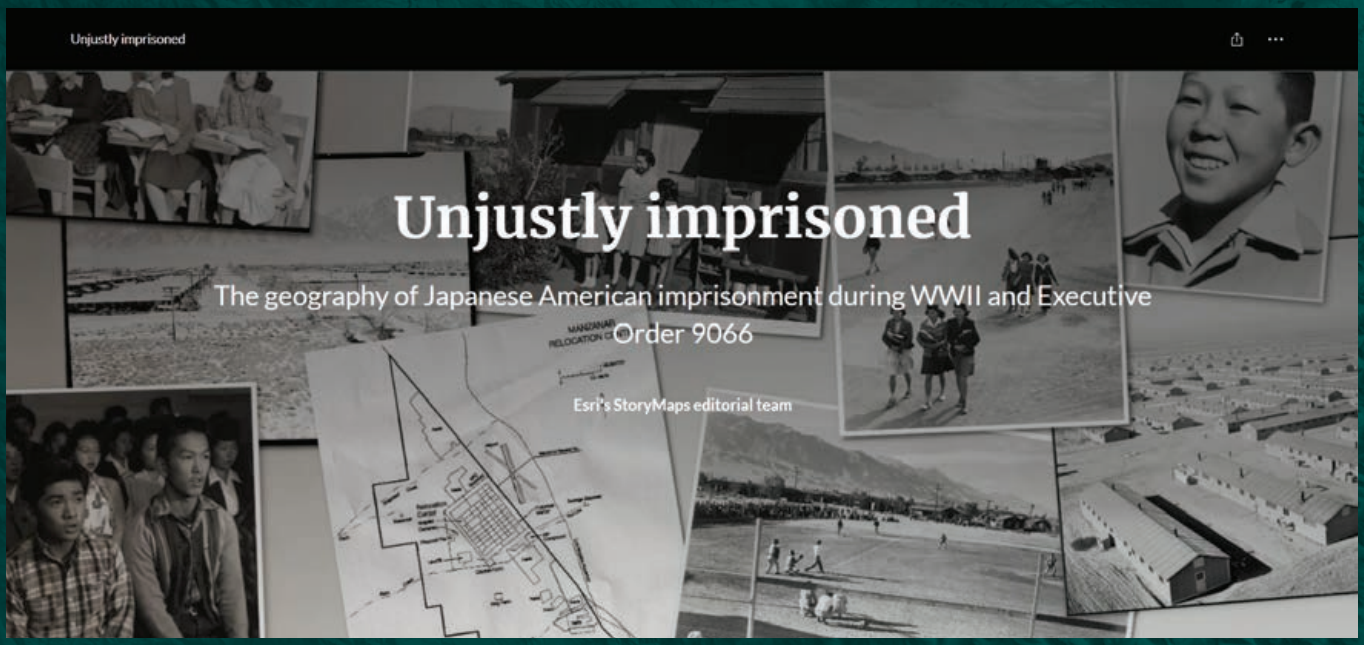
↑ You can use the quote block to make critical facts and statistics stand out.

3 Make it easy to share your stories and continue reading.

To increase the reach of your stories, it's a good idea to ensure that they're easy to find online and that readers can easily share them with their own communities. Here are a few things you can do to prepare your stories to go viral.

First, ensure that your story will look good when it's shared on social media. Most social media platforms will automatically replace links to stories with large cards containing the story's titles, subtitles, and cover images. You'll see a preview of this card when you publish (or republish) a story in ArcGIS StoryMaps, but you can easily overwrite the card's title, subtitle, and thumbnail.

↙↘ *Justice deferred: Executive Order 9066 and the geography of Japanese-American imprisonment during WWII* was originally written for an advanced audience and revised to make it accessible to secondary students and published as *Unjustly imprisoned.*



↑ The customizable story card preview in the ArcGIS StoryMaps Builder
→ The story card as it appears in a social media post

For example, if your story's subtitle appears truncated in the card, or the original cover image isn't a suitable thumbnail, you can change those in the story card menu right before publishing your story. Note that updating these card details won't affect the actual title, subtitle, or cover image of your stories.

Second, consider providing some additional, relevant stories for readers to discover at the end of your story. After all, if they've made it that far, they're probably eager to see more of your work. The embed card in ArcGIS StoryMaps is well-suited for this purpose because it provides an attractive visual hyperlink to the story. Just add an embed block, paste the URL of your story, and then switch the embed block to use the card view. Note that you can edit the contents of this card to better suit your purposes, just like the social media card mentioned previously.

Third, if you're sharing and promoting multiple related stories, consider placing them in a collection. This is a great way to ensure that readers will see your stories in context and have access to all related stories. For example, if you publish three related stories—perhaps as chapters in a longer narrative—and a colleague promotes the second chapter only, readers will see the first and third parts of that story as well, right within the collection.

Finally, ensure that your story—and all its contents—is shared publicly before you promote it. This step is easy to overlook, but essential for a successful launch! When you publish your story publicly for the first time, the ArcGIS StoryMaps builder should warn you about any unshared content in your story. Regardless, it's always a good idea to open your story in a signed-out, incognito browser window to simulate a public reader's first encounter with your story.

4 Create a communications strategy.

You've come full circle. Your storytelling journey began with questions:

- Who is your audience?
- What are your key messages?
- Is this a collaborative project with partners?
- What assets are available for your story?

Now you've built an amazing story, and it's time to share it with the world. Consider a communications strategy as your next step. What is a communications strategy and how do you create it? It's easy, really. You'll build on the work you've already done. While digital media strategies vary by project and organization, most often they include the following content contained in a single document for easy reference and sharing.

Start with a clear call to action (CTA). Add a short description of the story. Assume the stakeholders reading this description know nothing about your story. Keep it short and stick to the basics.

Throw in your key messages. Be sure to you run these by any partners or stakeholders so you're all speaking the same approved language. This should be as easy as cutting and pasting from your initial plan.

List the resources available for promotion. Your story takes center stage here, but blog posts, videos, and other related content add reach to your promotion efforts. Pro tip: Include a link to shareable media assets like photos, animation, and other ready-made media for social media sharing.

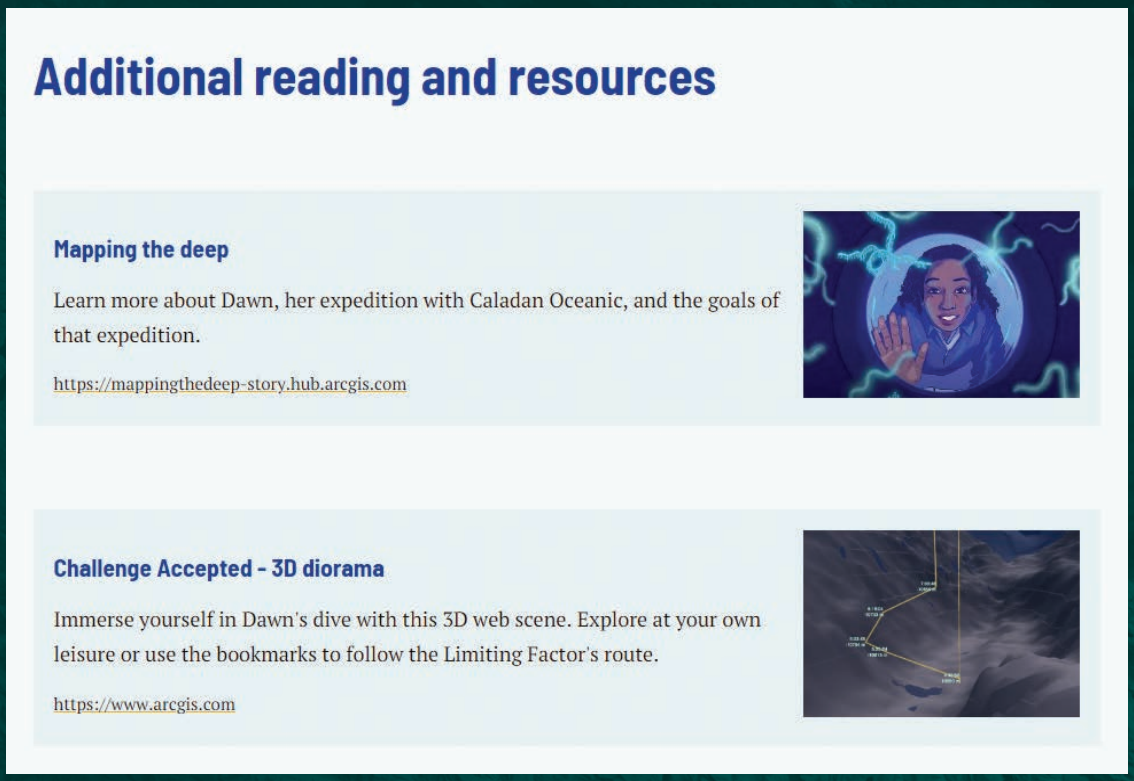
Make a list of hashtags for social media posts. Hashtags can connect you with existing audiences and potential new audiences by topic. For large digital media campaigns, a campaign-specific hashtag (like #EsriUC2023) can bring conversations together.

Create a list of digital platforms and handles. You now have the content for your promotion. Your decision at this point is where will you promote it. You connected your story messages with target audiences. Where do those audiences consume content? Make a list of those platforms and your handle on each. Pro tip: Include partner platforms and handles in your list. Encourage stakeholders to follow and tag each other.

Bonus content: The basics above will ensure that you and any partners have clear messages and structure for your campaign. Include two additional elements to make sharing easy when the story is launched and later.

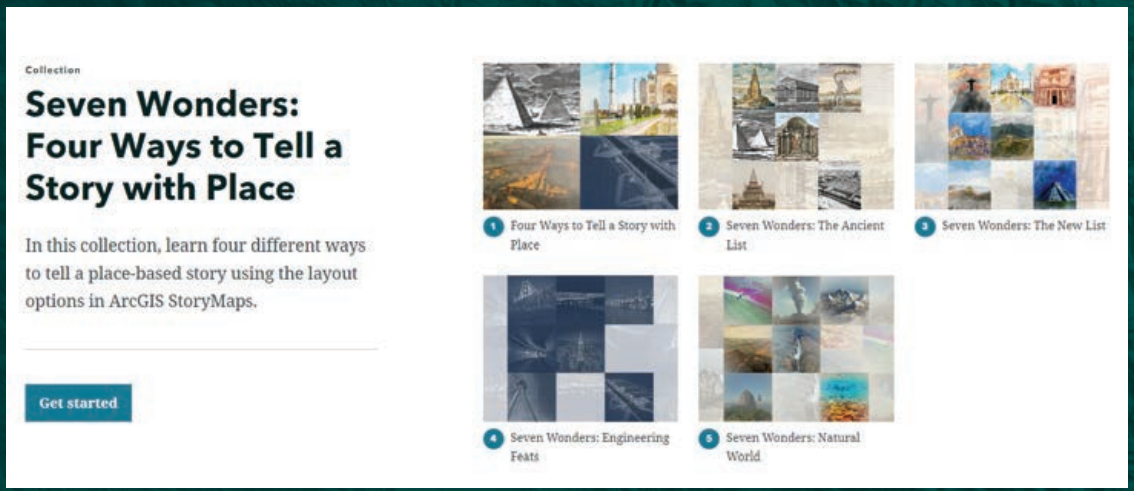
Create a calendar with dates and times. Particularly when working with multiple organizations, a document that spells out who will post content to what channel, and when, keeps everyone on the same page. This is truly a lifesaver.

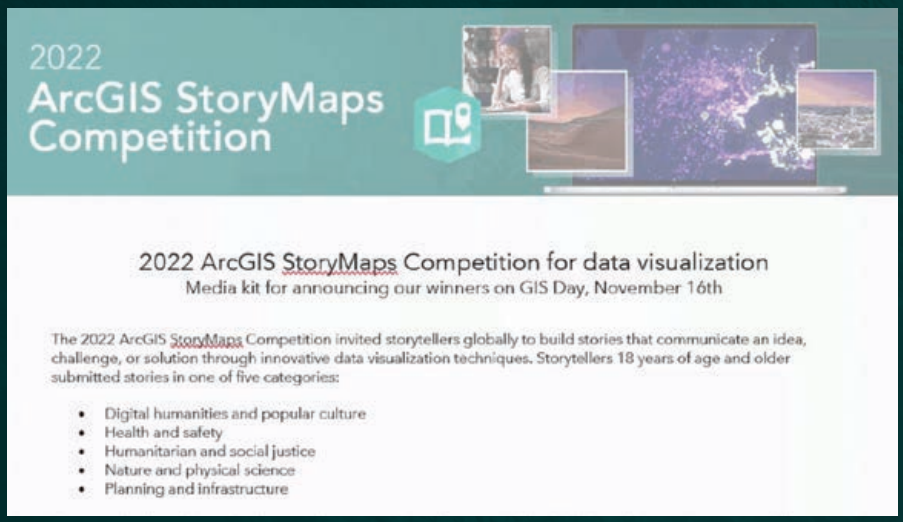
Sample posts. Bottom line, make it easy for stakeholders (and yourself) to share content. This may include social media posts for different channels, and newsletter standard language.



↖ To provide additional, relevant stories for readers to discover at the end of your story, use the embed card in ArcGIS StoryMaps.

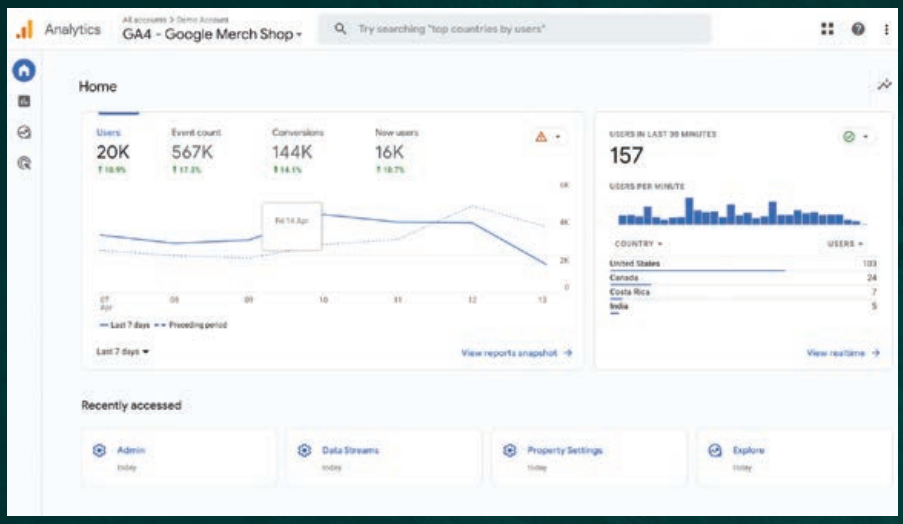
↙ Here, a multipart story is presented in a single collection that contains five individual chapters.





↗ As part of a communication strategy, create a single document for easy reference and sharing.

↘ With ArcGIS StoryMaps, you can add your own Google or Adobe Analytics codes into your stories so you can identify areas for improvement and make data-driven decisions to optimize your future content strategy.



5 Leverage analytics for insights and optimization.

Ask yourself: Did I reach my target audience? Did one platform perform better than another? Make measuring performance with a few key indicators a priority. Analytics can offer valuable insights into audience behavior, demographics, and engagement metrics. You can better understand how your audience interacts with your stories by tracking key performance indicators (KPIs) such as page views, average time on page, and conversion rates.

Most social media platforms have built-in analytics. Some platforms even let you download the data in a spreadsheet. With ArcGIS StoryMaps, you can add your own Google or Adobe Analytics codes into your stories. This approach is particularly helpful if you have Google or Adobe Analytics for your website, social media campaigns, and other digital platforms. With these analytics combined, you can identify areas for improvement and make data-driven decisions to optimize your future content strategy.

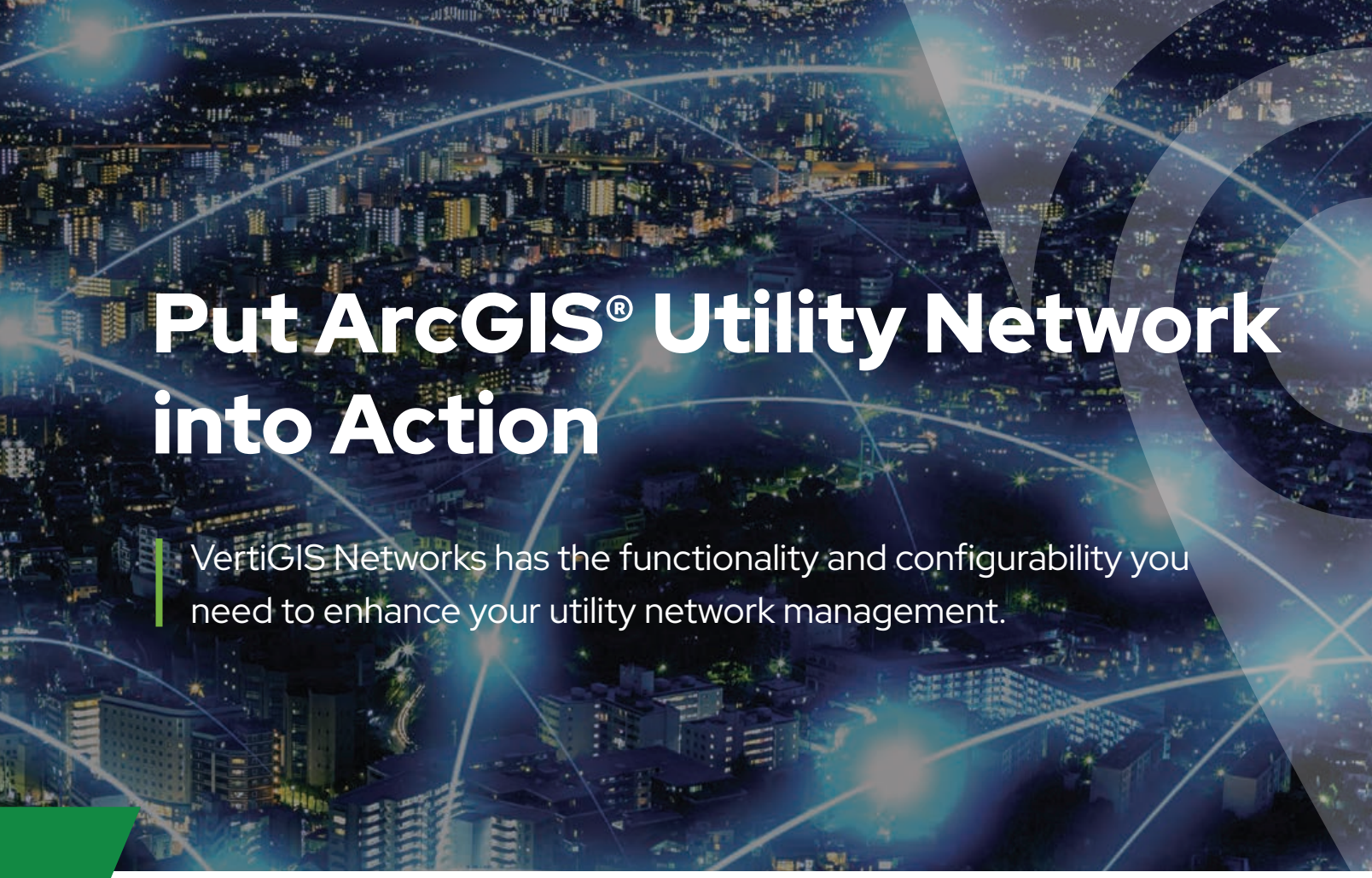
For more information on using analytics, read this blog post links.esri.com/web-analytics.

Happy Storytelling

By implementing these five strategies, you can create compelling stories that effectively convey your messages, engage your audience, and achieve measurable goals. Be sure to tag @ArcGISStoryMaps on X (formerly Twitter) and use #StoryMaps so the Esri StoryMaps team can like and share your content.

About the Author

As a travel blogger turned GIS professional, **Ashley Du** (she/her) has been an advocate for helping folks build their network and grow as a GIS professional. Her GIS work focuses on environmental justice and projects around GIS for equity and social justice. Du also cofounded and leads Ecos, the sustainability employee resource group at Esri. She believes learning about the world and different cultures is an important way to grow personally and professionally.



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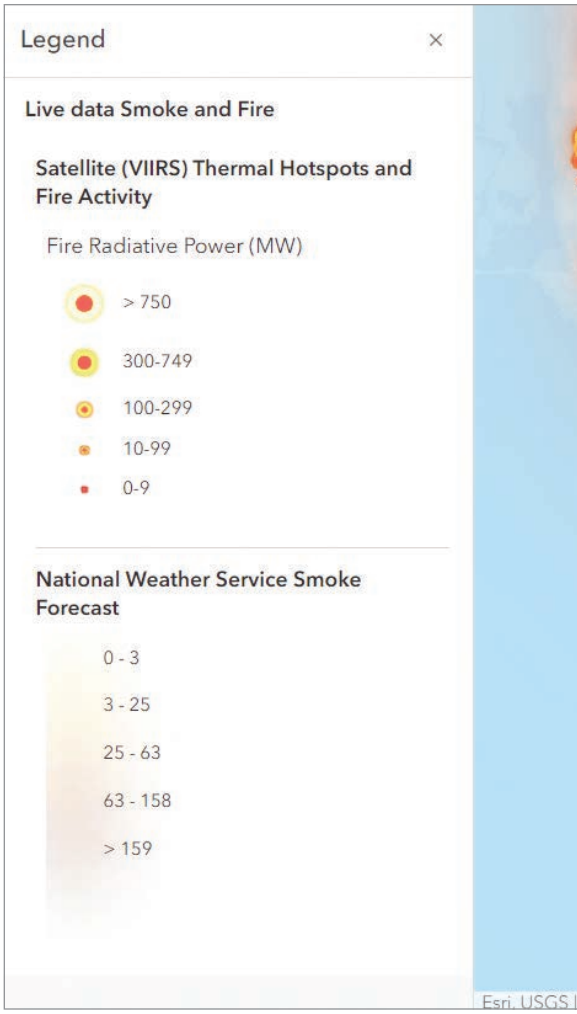
A New Way to Build and Share Content in Map Viewer

By Russell Roberts and Mark Harrower



Map Viewer now supports exporting and saving Group layers as layer items in ArcGIS Online. Group layers have been an essential part of maps and scenes in ArcMap and ArcGIS Pro. Support for Group layers was added to Map Viewer in 2020.

What Is a Group Layer?

Group layers are things that should remain together because they are conceptually related or meant to work together in a coordinated way. The ability to save an entire Group as a single item and share it as one item is a real time-saver for authors. It ensures multilayer, complex maps get imported by others correctly.

For example, a map might have five feature layers with a specific stacking order and with different blend modes applied to each layer to achieve a specific look. When saved as a Group layer item, the order and all settings are preserved. Settings don't have to be manually recreated as they normally would if layers were just imported individually. When sharing multiple individual layers as a Group layer item, there is no need to provide instructions that explain how layers fit together. You can just share this single stack of layers as a Group item, and they are already wired up correctly.

Group layers are also great for adding structure to the table of contents by keeping things organized, much like folders on a desktop keep related things together. With Group layers, you can easily change the drawing order in the Contents pane by moving an entire Group layer.

In June 2023, the standard layer visibility controls for a Group layer were expanded in Map Viewer. By default, you can use a Group layer to turn all layer visibility within the Group on or off with the parent Group. You can set the visibility within a Group to exclusive visibility, which sets the visibility of the sublayers to only allow one sublayer on at a time. This control over layer visibility is supported by the Group layer item.

How to Create a Group Layer

To create a Group layer in your web map, click on a layer in the map and choose the Group option. Add more layers to the Group layer by dragging them into the Group layer. You can also use the option action to move the layer into an existing Group. This makes placing a layer into a Group easy, especially when dealing with nested Groups.

Adding Group Layer Items to Maps and Apps

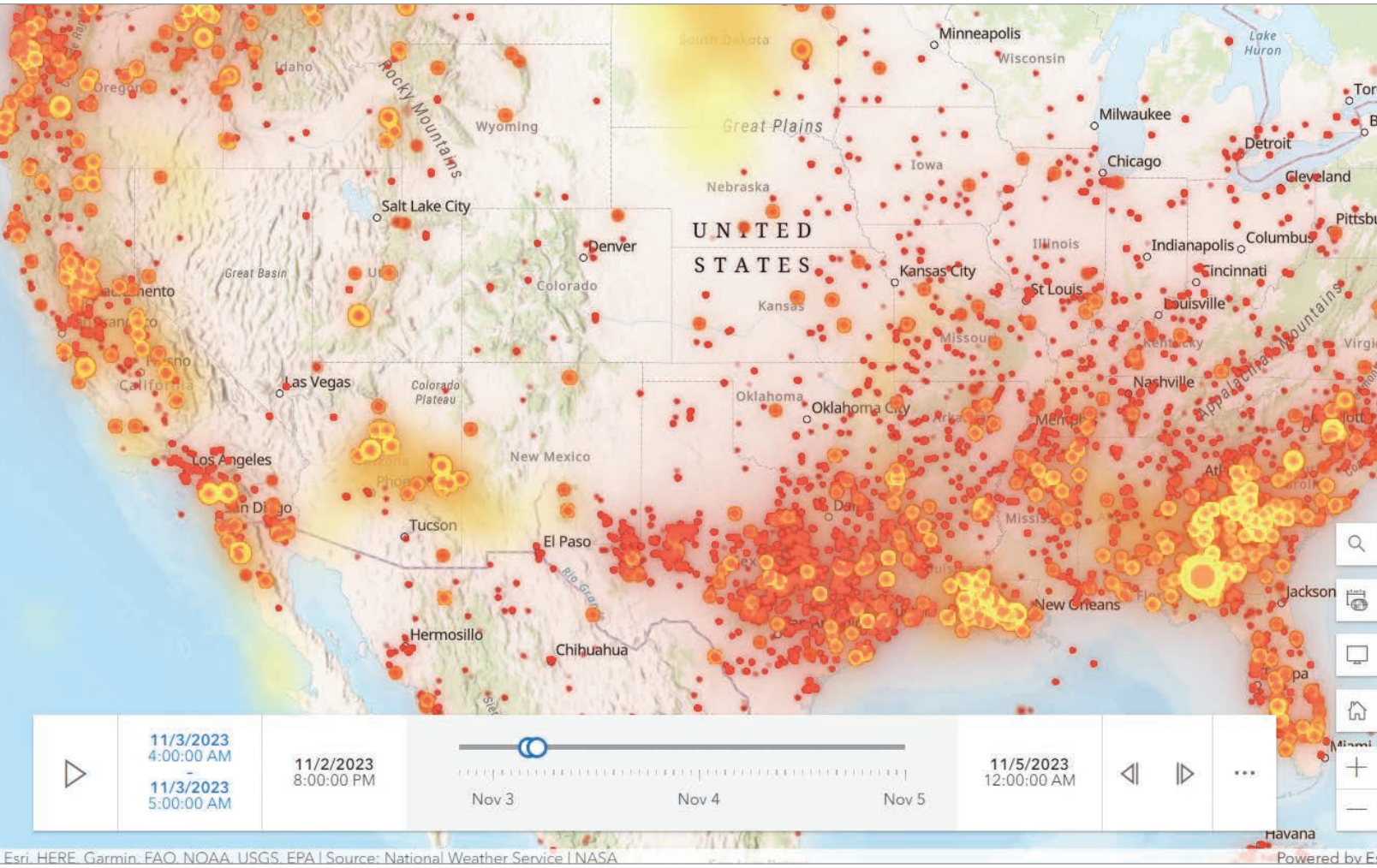
Map Viewer allows you to add Group layers to maps in a variety of ways. You can add Group layers through the item details page and via the item browser. The new Atlas app will also support Group layers in its Add content workflows.

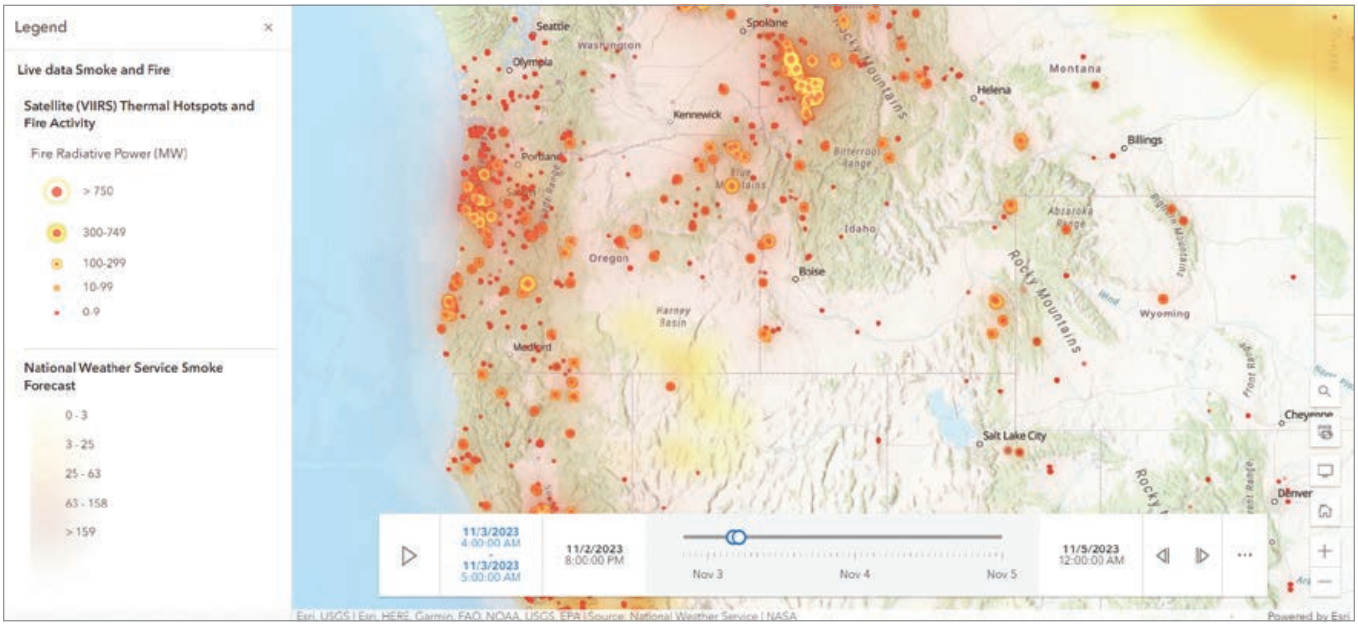
How to Save and Share a Group Layer Item

Once layers have been added to a Group layer, you can click on the options of the Group again and click Save As. This will create a Group layer item with layers.

This follows the same workflow as other supported layer item saving in Map Viewer. Enter in a title, tags, and folder placement.

To share the Group layer item, go to the Properties panel and under Info you will see the Layer Item button, which will open the Group layer item details page. Click Share and set sharing for the Group layer.





↑ Keep live data streams that provide satellite monitoring of wildfires, real-time smoke, and haze together with Group layer items.

This will review the layers within the Group and notify you if any layers in the Group layer item need to have their sharing settings updated.

Use Cases for Saving Group Layers

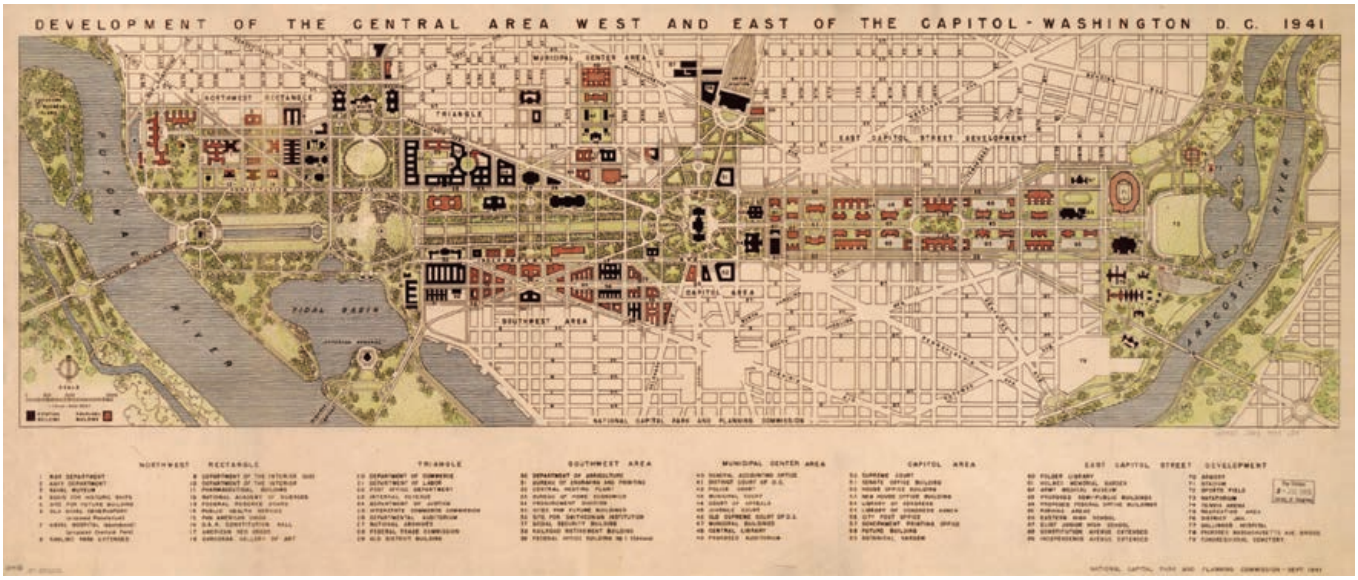
Whenever a map made from multiple layers is shared, it's often very important that all those layers stay bundled so that they will be presented in the correct order with blend modes applied to the right layers. Also, layers with coordinated multiscale behaviors won't be affected. Saving Group layers and sharing them as single items makes the chance of misplacing layers go down and productivity go up.

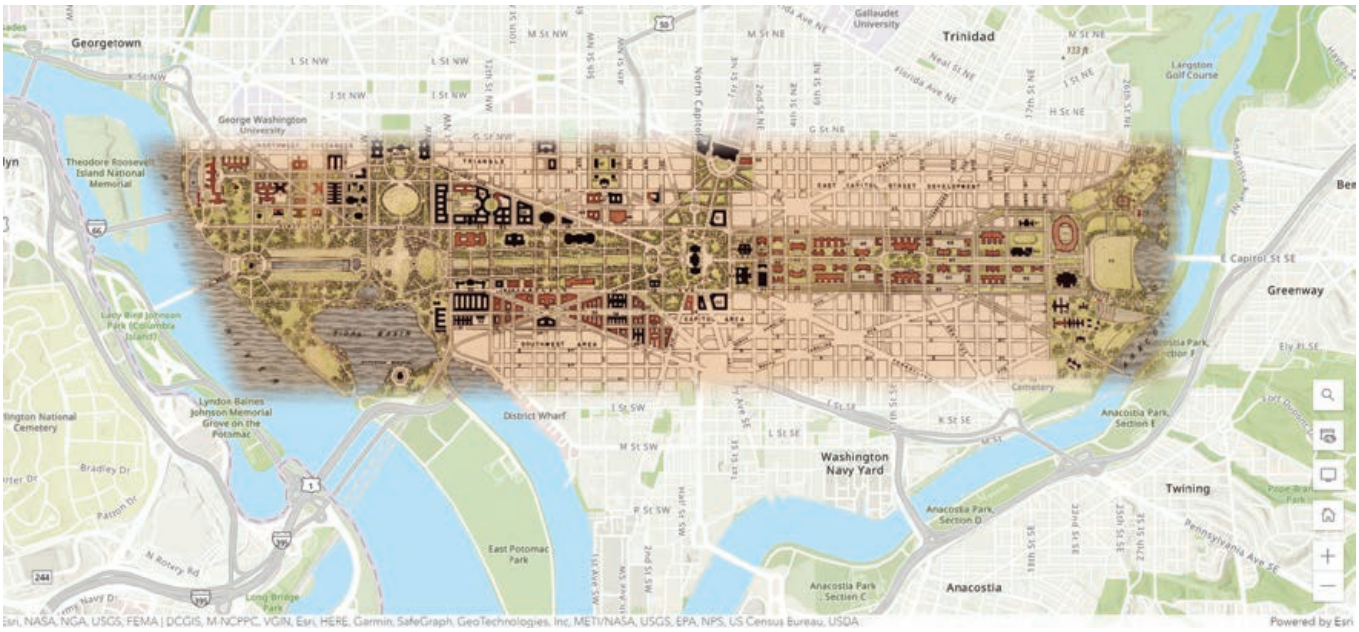
Example 1: Where There's Smoke, There's Fire

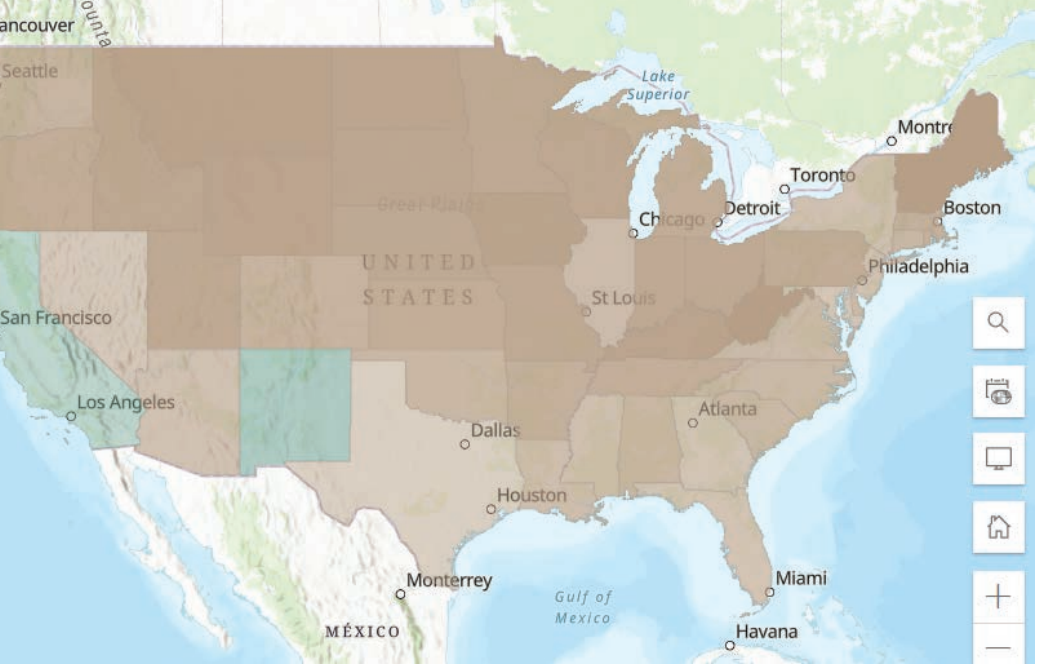
Esri offers many interesting live data streams, including satellite monitoring of wildfires. When combined with data from real-time smoke and haze monitoring, these two data streams show how the places most impacted by smoke can be hundreds or even thousands of miles downwind from a fire's location.

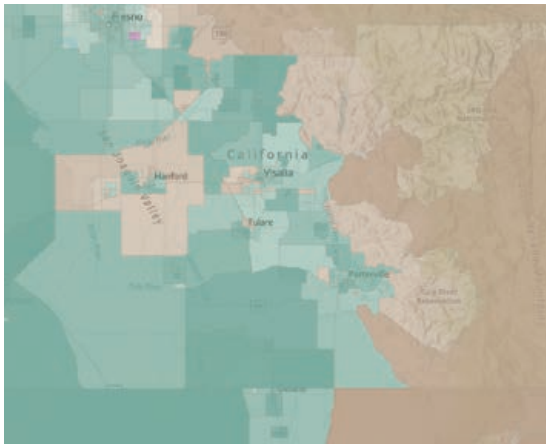
The real-time smoke and haze monitoring layers are related, and keeping them together is a good use of Group layers. In addition, these layers use a mix of blending and map effects to create a glowing, hazy

↓ Keep media and sketch layers together to mask out items in a scanned layer.









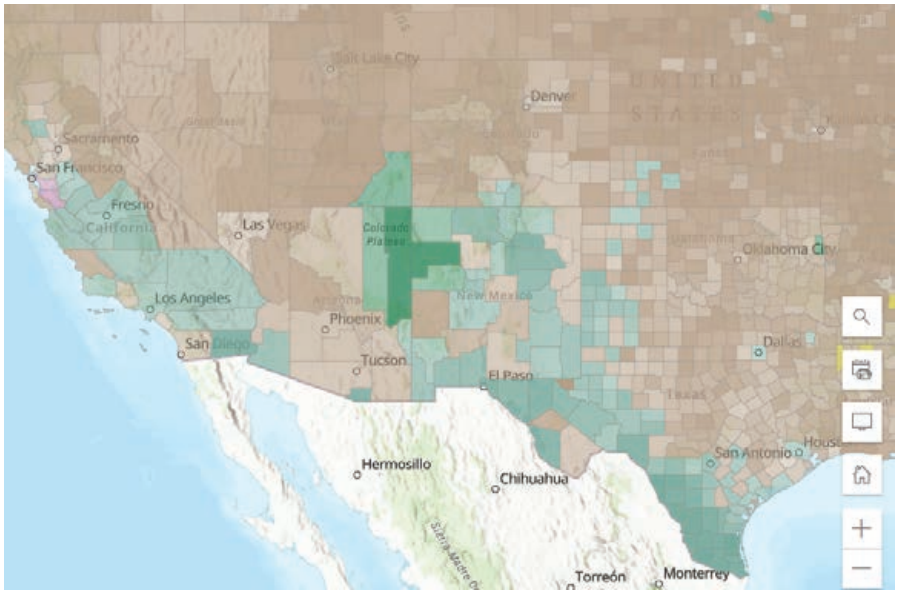
look, which is preserved when these layers are saved as a Group layer. See these layers at work at https://arcg.is/0X5nLG.

Example 2: Trimming Media Layers with Sketch Masks

One of the cooler ways to use sketch drawing tools is as an invisible mask to show or hide parts of other layers in the map. For example, when scanned paper maps are used as georeferenced media layers, you may want to trim away parts of the original print map such as the title or border. Unneeded parts can be masked by a rectangle drawn in on a sketch layer. Since the image, masking, and blend modes all need to be used together as a single item to make the mask invisible, this is a perfect use case for Group layers. See how a sketch layer can be used with a media layer work together in this map (https://arcg.is/1jquzz). Learn more about how this was done by reading "Apply Cartographic Effects to Blend Media Layers into Maps" (links.esri.com/use-blend).

Example 3: Coordinated Multiscale Layers

The ability of web maps to reveal more details as readers zoom in is one of the most useful and expected capabilities in web maps. The way to author a coordinated multiscale map is to first author multiple feature layers that have been optimized and generalized for different spatial scales (e.g., global, continental, and country levels). Then define the visible range for each layer so that as the reader zooms in, layers turn on and off at a scale-appropriate time in a coordinated fashion. The easiest way to keep these layers bundled together is by saving them as a Group layer. And when the Group layer is saved, its characteristics are preserved without any additional work. This Group layer item (https://arcg.is/1n9vqj) shows American Community Survey (ACS) data on race and Hispanic origin variables at three different scales.



↑ Use Group layer items to keep coordinated multiscale layers.

Next Steps

The next time you need to share a collection of map layers, be sure to use Group layers to organize and export them to preserve the relationship between layers. Additional enhancements are planned that will include support for Group layer items saved from 3D Scenes and support for opening and creating Group layer items in ArcGIS Pro. There will also be a growing collection of Group layer items in ArcGIS Living Atlas of the World, which is a great place to start learning more about what Group layers can do for you.

About the Authors

Russell Roberts is a product engineer on the ArcGIS Online team.

Mark Harrower is a map nerd who is passionate about great design, teaching, and doing cool things with data.

Five Tips to Jump-Start Your Parcel Migration to ArcGIS Pro

By Linda Foster

Attention land records managers: Esri will be retiring and no longer supporting ArcMap as of March 2026. It may seem far away, but it is coming fast. Proper preparation is the key to successfully migrating from ArcMap to ArcGIS Pro. If your organization hasn't already completed the transition, you cannot afford to wait. Get organized and approach the process with confidence and complete it before deprecation to avoid operating an unsupported system that is vital to your organization.

ArcGIS Parcel Fabric, the new parcel editing solution in ArcGIS Pro, is highly configurable and efficient and replaces customized workflows in ArcMap. Many organizations report a 50 percent increase in parcel productivity after it is adopted.

For some organizations, migrating seems like a daunting task. There are concerns about retraining staff and managing the migration workload and whether current functionalities will be replicated. There are also concerns about how Parcel Fabric works with third-party tools. All these concerns can make the process seem like a challenge and prevent organizations from moving forward.

But what does parcel migration to ArcGIS Pro really look like? Keep reading this article to learn five tips that will help overcome concerns that might be stalling your migration progress.

1 Learn about licensing needs.

Identifying the organization's licensing needs will help tremendously in the planning process, from budgeting to learning which licenses individuals will need in relation to their job roles.

2 Get help.

For many organizations, working with a partner who is an expert in parcel records and Parcel Fabric migration to ArcGIS Pro makes sense. Since this is a one-time task, having staff members learn how to perform the migration may be inefficient and reduce their ability to fulfill their regular responsibilities. As the deprecation of ArcMap approaches, the pipelines for many vendors that perform ArcMap to ArcGIS Pro parcel migrations are filling up, so contact vendors soon. To find recommended partners, reach out to peers in neighboring counties or ask your Esri account manager.

3 Discover what's possible.

Parcel Fabric has functionalities that do not exist in ArcMap that can increase speed and improve performance. If you have been using customizations in ArcMap, using ArcGIS Parcel Fabric and ArcGIS Pro will mean a lot less work. Work with your Esri account manager to understand what's new and how it can meet your organization's needs.

4 Evaluate how third-party tools will be managed.

If your organization's parcel data connects with other systems to offer additional capabilities to users, investigate how these connections will be handled in ArcGIS Pro. Some third-party capabilities are being included in ArcGIS Pro tools while others may need to be reconnected to the data once migrated.

5 Learn about training options.

Esri Academy offers a learning plan, Parcels and Land Records Management Essential Skills, that will help educate staff members. The curriculum consists of a mix of videos, web courses, seminars, and instructor-led courses. In addition, partners may also offer training options that make sense for your organization. Work with your Esri account manager to learn what's available.

These tips can help your organization move forward in the journey from ArcMap to ArcGIS Pro. Share ideas and strategies for parcel migration on Esri Community (community.esri.com). If you are looking for a partner to help with your migration, reach out to Pro-West & Associates (www.prowestgis.com/contact), an Esri Parcel Management Specialty partner.

About the Author

Linda Foster oversees Esri's worldwide strategic vision for land records, cadastre, surveying, and land administration. Long recognized as a champion for bringing GIS and geospatial technologies to unique and challenging situations, she has spent much of her career improving the outcomes of lands-based challenges. She is currently serving on the National Society of Professional Surveyors (NSPS) board of directors, has served as a mentor for the URISA mentorship network, and led statewide design of low-distortion projections for inclusion in the National Geodetic Survey's (NGS) upcoming datum updates. Foster is a registered professional land surveyor and certified GIS professional. She also holds a bachelor's degree in geological engineering, and a master's degree in GIS from Penn State University.

↓ Proper preparation is the key to successfully migrating from ArcMap to ArcGIS Pro.

Map Viewer Charts FAQs

By Belle Pandya

Here are answers to some of our most frequently asked questions about charts in Map Viewer. If you still have questions, visit the Esri community page (community.esri.com).

Do I need credits to create charts in Map Viewer?

No, creating charts in Map Viewer doesn't consume credits but you do need an ArcGIS account to save and share charts.

My data is usually in CSV format, without geo-locations. Can I still create charts in Map Viewer?

Yes, charting is supported for tables, including CSV files. If your file does not contain location data, it will be added as a table instead of a feature layer. You can create a chart from the Tables pane.

Can I share a Chart Viewer ArcGIS Instant Apps map with viewers who don't have an ArcGIS Online account?

Yes, apps can be shared with the public and viewers don't need any type of license if the data, map, and app are shared publicly.

Can scatterplot axes be displayed on a logarithmic scale?

Yes! Logging axes is possible for scatterplots and line charts. Once you create your chart, simply navigate to the Axes tab. Here, you will see toggle controls for enabling and disabling logarithmic scale for both x-axis and y-axis. Logarithmic scales can only be applied when all values are greater than zero.

How can I get my pie chart to match pie chart map symbology?

You absolutely can make it work! If you create a pie chart using the same numeric fields you used in symbology (Styles), the slice colors will match.

Can I create a donut chart in Map Viewer?

Yes, you can! Choose Configure charts from the Settings (light) toolbar to create a pie chart first. Navigate to the Slices tab and use the Shape slider to increase the size of the hole to create a donut chart.

How do I display a subset of data that falls under a specific range?

There are two ways to do this:

Method 1: Use filters from the Settings (light) toolbar and add an expression to show the data you want and temporarily hide the rest. (To add a filter in Map Viewer, see the "Create a filter" topic in the ArcGIS Online documentation.) Remove the filter and save the settings to redisplay all the data.

Method 2: Select and highlight data points on the chart and choose Filter by selection from the toolbar.

How do I stay updated?

You can either check out ArcGIS Online release announcements or the Charts section of Spatial Statistic Resources (https://spatial-stats-analysis-1.hub.arcgis.com/pages/charts).

More Resources

Here are some articles to help you get started:

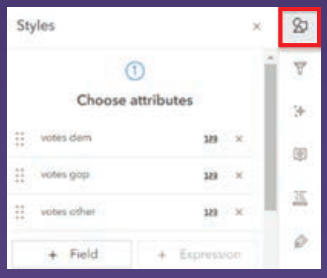
- Introducing Charts in Map Viewer (links.esri.com/intro-charts)
- Explore college scorecard data to make informed college choices (links.esri.com/college-scorecards).
- Visualize Change with Line Charts in Map Viewer (links.esri.com/viz-linecharts)

About the Author

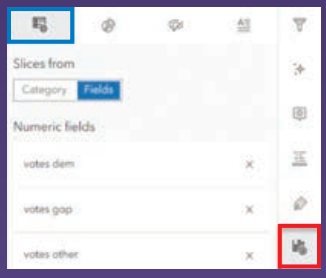
Belle Pandya is part of the team responsible for delivering new features for some of the most popular apps in ArcGIS Online. She focuses on guiding product development for charts in Map Viewer. She loves to write about topics related to descriptive statistics and how some data problems can be solved by just visualizing the data.

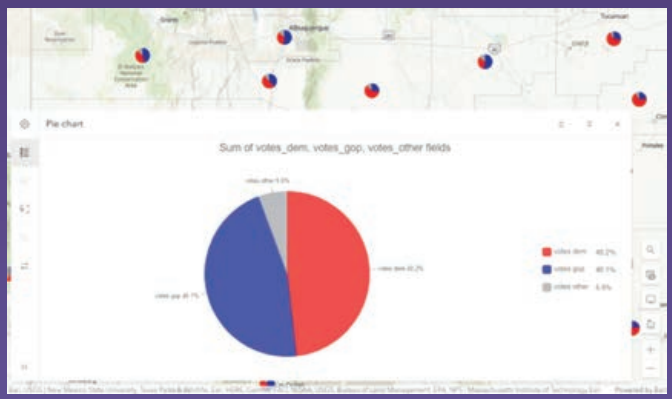
↓ You can create pie charts that match your pie chart map symbology.

Styles



Configure Charts

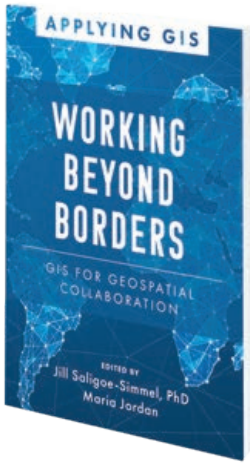




Bookshelf

Working Beyond Borders: GIS for Geospatial Collaboration

By Jill Saligoe-Simmel and Maria Jordan



Working Beyond Borders: GIS for Geospatial Collaboration describes how government agencies, industries, and other organizations use location intelligence and GIS to help people work together and respond to critical issues such as climate change, sustainable development, racial equity, emergency management, conservation, and public health and safety. This title is one of the books in the Applying GIS series. The series helps readers become spatial thinkers and apply location intelligence to various professions, industries, and disciplines. Esri Press, 2024, 140 pp., Print ISBN: 9781589487628 and ebook ISBN: 9781589487635

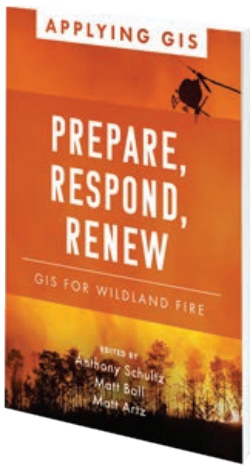
Fieldwork Handbook: A Practical Guide on the Go

By Marika Vertzonis

Fieldwork Handbook: A Practical Guide on the Go is a guide for increasing productivity and becoming more efficient using GIS. This practical fieldwork guide covers preparation, equipment, workflows, and data. It offers best practices for optimizing operations and effectively coordinating resources when making observations, monitoring conditions, or taking samples. The author is a product engineer at Esri whose work focuses on the research and development of field apps. Prior to coming to Esri, Vertzonis worked for local government, regional water authorities, and engineering consulting firms as a GIS professional. Esri Press, 2024, 200 pp., Print ISBN: 9781589487178 and ebook ISBN: 9781589487185

Prepare, Respond, Renew: GIS for Wildland Fire

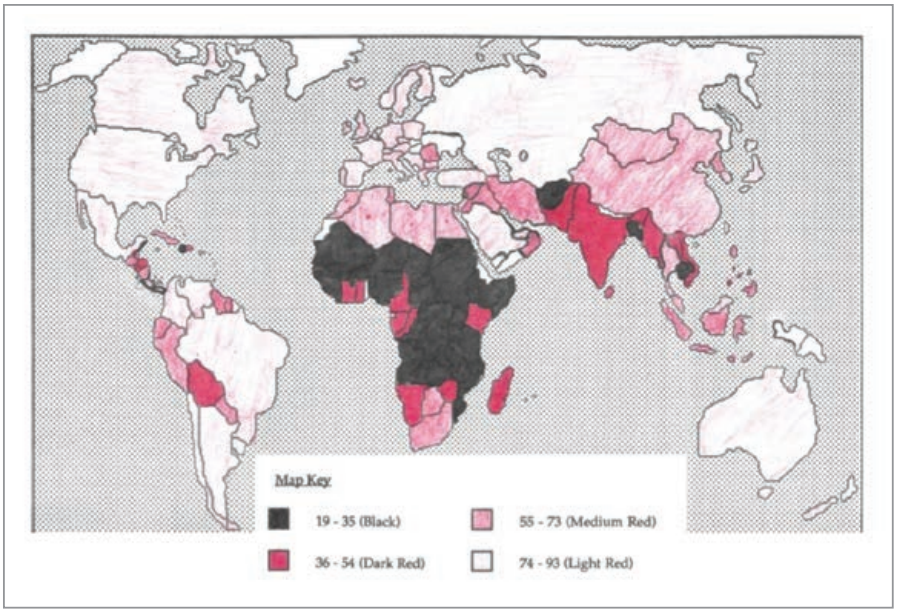
By Anthony Schultz, Matt Ball, and Matt Artz



Prepare, Respond, Renew: GIS for Wildland Fire is a collection of real-life stories about wildland fire agencies that have successfully used GIS to apply the geographic approach to resilience strategies. The threat from wildfire has increased due to patterns of housing development and climate change. GIS helps model how wildfires spread depending on weather, geologic features, and human development. Through predictive analytics and mapping technologies, preemptive action can be taken to mitigate loss, respond quickly, and recover from wildfire. This book includes a section that provides ideas, strategies, tools, and actions to help jump-start the use of GIS for wildland fire management. Esri Press, 2024, 120 pp., Print ISBN: 9781589487703 and ebook ISBN: 9781589487727

For more information on all Esri Press publications, visit esri.com/esripress.

TEACHING WITH THE GEOGRAPHIC APPROACH



↑ Student-Drawn Choropleth Human Development Index Map

YEARS AGO, Jim Hanson, a geography teacher with the Bloomington School District in Minnesota, realized the value of interactive learning.

"It was obvious *[to me]* that sequential education wasn't working. Kids like to create things on their own," Hanson said. His students used hand-drawn choropleth maps to demonstrate how geography could be used by a planning commission or city council member to make better decisions. *[Choropleth maps symbolize the magnitude of an attribute with colored or shaded areas.]*

Hanson bridged textbook curricula with hand-drawn maps and data sheets. "We deconstructed the curriculum and then reconstructed it, which became one of my passions. We studied places that were local to introduce geographic concepts, and then applied them to faraway places where those concepts made more sense to the students," Hanson said.

A full-time teacher with the Bloomington School District for nearly 33 years, Hanson retired in 2000. Since then, he has continued as a reserve teacher in the same district. While computers and GIS were not readily available in classrooms before he retired, Hanson quickly appreciated that interactive maps, surveys, and dashboards built using GIS could help students learn in new ways.

"I used early computer technology to create databases students used to make by hand, the kind of maps that GIS technology can produce today with one click," he said. "I've found that if you get digital mapping technology in front of students, they don't mind the fact that it's technical."

He pioneered the incorporation of GIS in school curriculum. But by the mid-1980s, school district officials wanted Hanson to go back to using mainly textbooks for his classroom lessons even though students, empowered by learning with maps, benefited from lessons that combined spatial thinking, creative problem-solving, and technology.

To support the continued use of the interactive geography lessons, Hanson enlisted the help of three other geography educators. Together, they developed a new method to teach without textbooks. "The students had flexible modular scheduling, so depending on the day, we'd have a small group discussion with 14 or 15 kids, 45 in a lab session, and 75 for a lecture," he said.

Inspiring Geography Teachers

In addition to his work with students, Hanson mentored more than 40 teachers and inspired many geography teachers like Charlie Fitzpatrick, an Esri industry solutions manager for education. "Jim Hanson changed my teaching back in 1986," said Fitzpatrick. Hanson was presenting at the Minnesota Geography Alliance workshop. He showed data about countries of the world and asked simple questions.

Fitzpatrick said that presentation changed everything that he was doing as a geography teacher. "Instead of just knowing all these things about places, you could now start looking at a database and if you have the right kinds of data, you *[could]* come up with all kinds of information. That information was data for something else that you could turn into maps and things like that." That revelation changed Fitzpatrick's path not only as a geography teacher but also as a geographer.

In 2020, Hanson was recog-

↓ Jim Hanson

← Jim Hanson and Charlie Fitzpatrick attended the Teachers Teaching Teachers GIS (T3G) Institute held on the Esri Redlands campus in 2016.

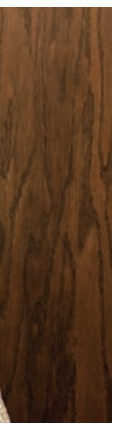
Consortium with the Distinguished Educator Award for his leadership, creativity, and enthusiasm in teaching geography and GIS.

Making GIS More Available

In addition to helping his students find success in the classroom, Hanson is passionate about making GIS tools available to more students. "I was attracted to promoting the use of ArcGIS Online with students because it made the time-consuming process of making a choropleth map almost instantaneous," he said.

When Minnesota was considering holding a GIS contest for students in grades 4–12 in 2016, Hanson volunteered to draft the contest announcement, guidelines, and website. Supported by the Minnesota GIS/LIS Consortium and others, Minnesota on the Map, an ArcGIS Online student competition, was launched.

The contest has transformed the way teachers apply GIS to their curriculum to enhance student learning. The contest uses the ArcGIS Online school bundle subscription. Students use the software to complete a research project on a Minnesota topic. They create digital maps and an interactive story map they use to present their project.



Using GIS to Create Real-World Solutions

Hanson has remained active as a substitute teacher and a member of Minnesota Alliance for Geographic Education. In 2023, a group of sixth graders used GIS to predict the best launch site for a high-altitude balloon (HAB). Students used ArcGIS Online and ArcGIS Survey123 to collect field data; Map Viewer to create high-quality maps of Minnesota; and ArcGIS StoryMaps to present their findings.

For the HAB prediction, students created maps with the 40 miles of Federal Aviation Administration (FAA)-restricted areas for the Minneapolis/Saint Paul and Rochester international airports, including layering in parks, electric power lines, athletic fields, smaller airports, wind farms, highways, rivers, and other layers showing areas that should be avoided when launching or landing an HAB. The entire class traveled to the HAB site that was identified to see the balloons launched.

Hanson sees GIS being incorporated into areas of study beyond geography, science, and social studies. "Exposing middle school students to GIS provides them with problem-solving skills that translate to any workplace situation," Hanson said.

↓ Jim Hanson mentors a student on the use of ArcGIS Online.

Why GIS Is a Powerful Classroom Tool

Lehigh University has a long history of using geospatial technology, including GIS, to prepare future K–12 educators to teach their students analytical thinking and problem-solving skills. The private research university located in Bethlehem, Pennsylvania, first introduced a dedicated geospatial technology course for science and environmental educators in 2008.

"For 15 years we have taught versions of that class for educators across disciplines," said Tom Hammond, associate professor of instructional technology and teacher education at Lehigh University.

Currently, the Lehigh University College of Education offers the Teaching, Learning, and Technology Program, which focuses on teaching future educators how to align technology with standard curricula to create an innovative learning environment. The university also offers a shortened version of the program within its two graduate certificate programs.

The program is designed to meet educators where they are in their learning journey. Through a combination of coursework and field studies, it empowers them to teach with technologies such as GIS in the context of their expertise, Hammond explained.

"Whether it is understanding global issues like climate change or local issues like fast food *[restaurant]* density and redlining policies over time, geospatial tools are an incredibly powerful tool for understanding these complex issues," said Hammond. "We include GIS in our teacher education programs to help educators learn the technology and give them the skills to incorporate a geospatial component in their curriculum."

Aligning GIS with K–12 Curricula in the Community

It's that commitment to providing teacher education and bringing technological tools into more K–12 classrooms that led Lehigh faculty and others to start the Environmental Literacy and Inquiry Working Group (eli.lehigh.edu). Funded through the National Science Foundation, this collaborative organization brings together Lehigh faculty and students from the university's college of education and college of arts and sciences to educate local K–12 teachers on how to improve their classroom with technologies like immersive virtual reality (VR) and GIS.

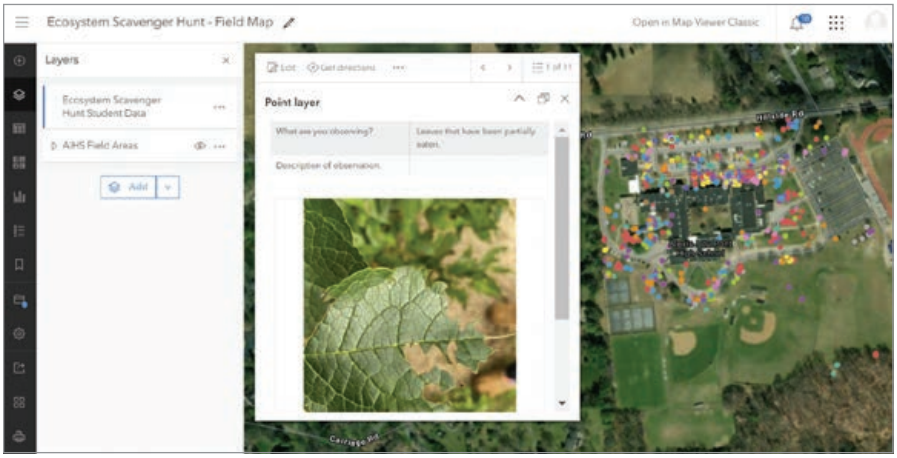
This program has brought these technologies to seven high schools to teach subjects that include robotics, computer science, physics, and social studies. The curriculum is built on inquiry-based learning activities that use dynamic interactive mapping applications to analyze data patterns and relationships. The various topics include climate change, energy, land-use change, tectonics, and socioenvironmental science investigations. Students are encouraged to collect data in their community by using ArcGIS Field Maps and then later manage, query, and analyze the data using ArcGIS Online.

For example, in one participating biology class, students took what they learned about macromolecules (proteins, fats, and carbohydrates) and used GIS to explore a public health issue. They identified local fast-food restaurants where people could be consuming those macromolecules and compared those locations with places where they could burn them off, like gyms. The research added a real-world context to their studies. They mapped their data to find trends and make suggestions to the community, including where to offer fresh food or places to exercise.

"Spatial thinking isn't a part of standard curriculums but is an essential skill set that is cross-disciplinary and helps someone really understand something, especially if it is meaningful or if it's something that they are invested in and can get excited about," said Hammond.

Lehigh's Teaching, Learning, and Technology Program and the Environmental Literacy and Inquiry Working Group received an Esri Special Achievement in GIS Award in 2020 for their innovative use of

↓ Screenshot from an Ecosystem Scavenger Hunt activity. Students documented places around the school campus that illustrated ecosystem functions.



mapping and analytics technology as well as thought leadership in the field of GIS education.

Helping Expand the Use of Geospatial Technologies Across the Nation

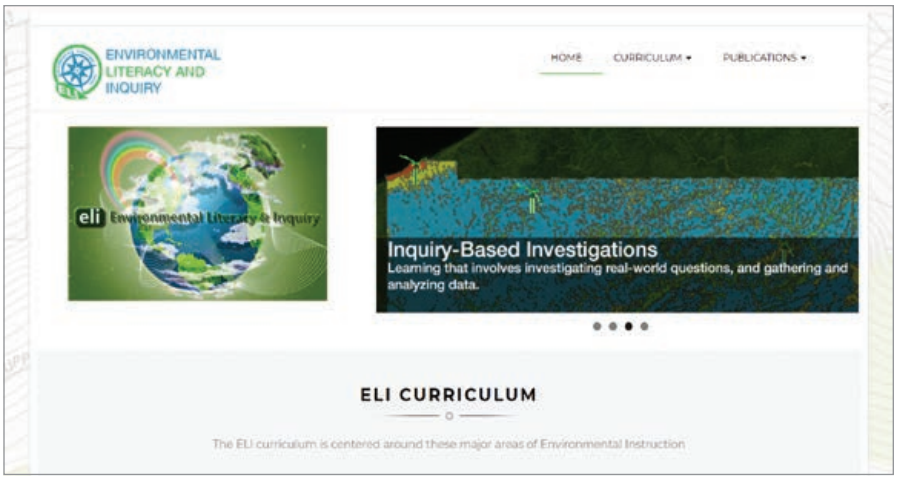
The success of previous projects allowed the Lehigh University College of Education not only continue pursuing other research grant opportunities but also expand its education programs to enhance high school students' geospatial skills and boost their science, technology, engineering, and mathematics (STEM) knowledge.

In April 2020, the National Science Foundation awarded $2.85 million to Lehigh's College of Education and two other universities for geospatial technology research-practice partnerships across three regions of the United States. For the past three years, project leaders worked with teachers at two high schools in each region to develop socioenvironmental investigations that fit within the students' curriculum.

Doug Leeson, a former English teacher and now a doctoral candidate at Lehigh University, worked with the grant team and designed the research studies around GIS in K–12 classrooms. He said the work highlighted the value of honing spatial thinking in formal education. A student project is used to propose changes to the school's campus to make it more ecologically sustainable.

"Spatial literacy has so much value because it helps students grasp the context of what is happening outside of a textbook. When you present a lesson using maps, they can see the patterns and relationships and understand how these systems work in a digestible way," Leeson said.

As part of his doctoral work, Leeson helps high school teachers develop their understanding of GIS and fit it into their classrooms. In one case, Leeson helped incorporate geospatial technology into an exercise testing soil properties as part of the lab work in a chemistry class. He had students take their samples from different areas around campus and use ArcGIS Field Maps to track their location.



↑ A commitment to providing teacher education and bringing technological tools into more K–12 classrooms led Lehigh faculty and others to start the Environmental Literacy and Inquiry Working Group (eli.lehigh.edu).

"It was great because the students checked the box of what they needed to do for the curriculum by learning how to test for pH, phosphorous, nitrogen, and potassium. But then they analyzed that information with the maps and could see correlations like, 'OK, we have high levels of this here because of runoff from cars or from trash,' and use geospatial reasoning to answer why there are differences in the samples," said Leeson.

In another instance, Leeson worked with a social studies teacher to study historical redlining boundaries around Philadelphia and see the changes and trends in neighborhoods over time. "No matter the context or academic level, we have found there is a place for GIS to be used," said Leeson. Some students have expressed an interest in pursuing environmental engineering or going to college to study GIS because they were exposed to GIS.

Although Lehigh's grant funding ends in 2024, Leeson is optimistic about GIS in K–12 curricula expanding as well as the plans to empower participating teachers to involve their colleagues. Leeson noted that anyone with the ArcGIS for Schools Bundle can incorporate GIS in their classroom.

"You don't need a professional or university team of researchers to come into your classroom to teach you about it. You just need that initial introduction and just a little spark of curiosity, and I think from there, *[anyone can]* figure it out," said Leeson.

While there are constraints to incorporating GIS in the classroom, the key to successfully bridging these gaps is meeting educators where they are and within the context of their needs.

"The key to incorporating GIS in our classrooms is ensuring it serves the curriculum and meaningfully enhances it."

Geodesign Student Shares Her GIS Journey and Some Advice for Students

By Rosemary Boone and Logan Stevens

Michele Heilman is an ambitious senior at the University of Southern California (USC) who is majoring in geodesign and has a minor in sociology. She incorporates GIS, spatial sciences, architecture, urban planning, and social equity into her geodesign studies. During a gap year spent in Brazil, she learned about the country's rich biodiversity. This sojourn inspired her to pursue a career path that promotes conservation. In this interview, Heilman shared her GIS journey.

Q: How did you get your start in GIS?

A: In high school, I applied and was accepted into USC with a major that wasn't related to GIS. However, before starting at USC, I took part in a gap-year program in Brazil from August 2019 to March 2020.

After I returned home, my parents encouraged me to decide on a field of study when we heard all classes were going to be online. During my search, I discovered geodesign and GIS, which were completely new to me. Throughout high school, I had always been interested in environmental science, and my time in Florianópolis, Brazil, exposed me to various conservation efforts. I realized that geodesign combines elements of environmental science with the necessary technology to protect the environment. It was a fortunate coincidence that I stumbled upon geodesign, and I ended up pursuing it for all four years of college.

Q: How have you used GIS in your geodesign projects at school?

A: My first project during my freshman year was on food deserts in Washington, DC. We mapped out different demographic factors like age, socioeconomic status, closest transit stops for train or bus, and then figured out what community is most in need of a grocery store. Doing this project at USC after coming from DC was special for me, as it taught me how the skills I was learning could be applied to my community and my home city.

Another time, I participated in a lab where we did modeling of hillshade analysis of wineries in Temecula*[, California,]* to grow different grapes to find the optimal location for a new winery.

Right now, I am working on a project for LA *[Los Angeles]* County for *[its]* 2045 climate action plan to spatialize some of *[its]* goals. Everyone in the class is focused on a different action plan, and my group is focused on the transportation-related aspects of the action plan. We are currently conducting an analysis to find where optimal transit-oriented development projects could be proposed in LA County, or potentially propose new car-free or zero-emission zones.

[Since this interview, Heilman worked with her Geodesign Capstone group at USC to spatialize transportation solutions to meet LA County's 2024 Climate Action Plan goals.]

I'm also in a geospatial modeling class. We did one assignment that modeled different zombie apocalypse scenarios with agent-based modeling. This class introduced us to modeling for video game technologies. I find it very interesting—you can do modeling that is oriented for video games, environmental science, or urban planning.

Overall, these projects have taught me that spatial analysis and modeling can be essential tools across many diverse industries, while helping me learn how to effectively use the software.

↑ Michele Heilman

Q: Did you do any internships while in college?

A: I had the opportunity to participate in an internship with the World Wildlife Fund *[WWF]* during the summer after my freshman year. When I came across the job description, I felt like it was tailor-made for me. I couldn't imagine anyone else with Spanish and Portuguese language skills and GIS experience being a better fit for this role. My position was Amazon rainforest assistant research intern, and I worked under the forest team at WWF.

One of the key requirements was the ability to translate documents from Spanish and Portuguese to English. The internship involved a combination of research and translation work, including analyzing various documents and assessing road and infrastructure developments in the Amazon region.

I also contributed to mapping the WWF focal landscapes, which are WWF's priority conservation areas in the Amazon *[region]*. Throughout the internship, I collaborated with individuals from different parts of South America, and I often encountered GIS data in multiple languages with limited context. Therefore, a significant aspect of my role involved cleaning, organizing, and interpreting data with minimal information.

This role prepared me for my second internship, with the US Chamber of Commerce. My language skills were handy once again as I conducted economic and policy research in South America. Although I didn't need my GIS skills as the Brazil-US Business Council intern, it was a full-circle moment to realize how useful my gap year abroad, internship with the WWF, and the broader geodesign framework for research helped me work towards that internship opportunity. After one internship in the nonprofit sphere, doing an internship in the private sector introduced me to new concepts and new perspectives.

↑ Michele Heilman (on left) posed with her geodesign cohort members outside the Los Angeles Geospatial Summit in February 2024.

Q: What was valuable about your internships?

A: One of the advantages of interning at WWF was the opportunity to develop both my soft skills and technical skills. I had the chance to collaborate with individuals from different teams within the organization, gaining real-world insights and guidance from industry professionals. This experience helped me navigate my career path and make informed decisions about my future. This internship made me realize it was possible to combine my passions of geodesign, language learning, and cross-cultural understanding in my professional career. Going forward, I am able to make intentional choices about where I want to work and the type of work I want to be doing, which is a privilege.

While enhancing my soft skills was a significant benefit, the internship also provided valuable exposure to real-world GIS. Prior to my sophomore year, I had only taken two GIS classes at USC, one of which was heavily focused on lab work and had an instructor readily available for assistance. However, during my WWF internship, I quickly realized the importance of troubleshooting issues independently, as there was no instructor to rely on. Like I mentioned before, data isn't always organized in the best way. You have to be really intentional about the way you organize your data so others are able to interpret and interact with it with limited context. Despite the challenges, I successfully created several maps using WWF's data, which includes the Amazon regional climate change index, integrated risk index, and ecological risk index, and these maps proved to be a valuable tool for visualizing and sharing this data with others.

Q: What's your best advice to other young professionals?

A: I feel really lucky that I pursued geodesign going into college and attended a school like USC, because *[its]* Spatial Science Institute is huge and there are lots of free resources at my fingertips and *[USC provides]* access to Esri software for us students.

With that said, find out if your university provides free access to Esri software. It's more than likely *[it does]*. Then, soak in all the resources you can get and just fully take advantage of accessing the technology.

Next, search for internships that match your interests and career goals while also being open to trying new industries.

Finally, put yourself out there and talk to people. I'm sure people are tired of hearing this, but it's the truth! Try going to events like on-campus events or conferences. Also, just go up and talk to your professor! If you know a professor doing interesting research, reach out to them, saying "Hi, I'd love to find time to learn more about your research and ask you a few questions." The point is to learn more about what people are doing and what they did to get there.

For example, I made time to go to the LA Geospatial Summit, which was happening on campus for one day only. That day I had a class and I had to work after class, but I made time to pop into the event during the networking portion. That is where I met people from Esri and Esri Young Professionals Network *[YPN]* that led to publishing this article.

Overall, just try to show up to any opportunity, and don't think to yourself, "Should I go?" Because the answer is yes, you should!

Q: What are your career plans after you graduate?

A: I have such a diverse range of interests, and I've been exploring different career paths to determine my next steps. One aspect of GIS that particularly appeals to me is its widespread application across various industries, including architectural design, public policy, urban planning, international development, and environmental conservation. These fields intersect with GIS in many ways, and ideally, I would like to work in a role that incorporates all of these aspects or join an organization that is involved in these areas.

My language skills, passion for exploring the world, and interest in learning about different cultures make me particularly drawn to the intersection of international development and conservation. Given the versatility of GIS and its relevance to multiple industries I'm interested in, I am open to a wide range of possibilities. To further explore these industries and expand my professional network, I try to attend a variety of conferences such as the Urban Land Institute's fall meeting and Esri's Geodesign Summit and events to connect with new individuals, learn about new technology, and gain insights from industry experts.

About the Authors

Rosemary Boone works as an education marketing specialist for Esri, concentrating on executing marketing strategies for K–12 schools and higher education institutions. She holds a master's degree in education technology with an emphasis on multimedia. Prior to her career in marketing, she taught elementary school and taught overseas. In her free time, she likes to listen to music; exercise; play with her cats; and explore her favorite city in the world, Claremont, California.

Logan Stevens is a product release engineer for ArcGIS Enterprise at Esri. He works with ArcGIS Enterprise product teams gathering release requirements for new and existing products, which assists in quality assurance testing prior to product delivery. Previously, he worked as an ArcGIS Enterprise support analyst who directly supported Esri's end users by troubleshooting issues related to ArcGIS Enterprise technologies. He holds bachelor's and master's degrees in geography from Virginia Tech.

← The demand for the meat and scales of pangolins has caused extensive trafficking of these unique animals and endangered their survival.

MAP REVEALS THE SUPPLY CHAIN FOR THE WORLD'S MOST TRAFFICKED MAMMALS

By David Gadsden

A new genomic-geospatial analysis approach could help in the global crackdown on pangolin poaching, which is part of an annual trade in illegal wildlife valued at $20 billion, according to INTERPOL.

A pangolin looks like a curious combination of an armadillo, a pinecone, and a baby dinosaur. Pangolins range in size from 10 to 60 pounds and sometimes shuffle upright on their hind feet, although they usually move on all fours. Hundreds of scales made of keratin cover their bodies and keep them safe from all predators—except humans.

The demand for pangolin meat and scales, which are used in traditional medicine across East Asia, has driven Asian pangolin populations to near extinction over the past decade. At the same time, poaching of African pangolins has placed all other species of pangolins in danger, and made Africa's white-bellied pangolin (*Phataginus tricuspis*) the most trafficked mammal in the world.

Pinpointing Poaching

Determining where pangolins are being poached has been challenging. Pangolin scales end up in East Asia, where demand is highest, but the animals range widely across sub-Saharan Africa. Typical analysis techniques are not at a scale that law enforcement can use to map poaching hot spots to prioritize efforts, according to Jen Tinsman, a forensic scientist at the US Fish and Wildlife Service's National Fish and Wildlife Forensics Laboratory and a researcher at the University of California, Los Angeles (UCLA) Center for Tropical Research.

Tinsman and a group of her colleagues at UCLA and elsewhere have gathered genetic data from trafficked pangolin scales to build a new kind of map. This map can identify poaching hot spots within tens of kilometers. The researchers outlined their results in a paper, *Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia,* that was published in the December 2023 issue of *Science*.

"We're getting really fine-scale resolution with where pangolins are coming from in central Africa," said Tinsman, who began studying the white-bellied pangolin at the institute even before the surge in poaching. The animals, hard to study in their habitats, are difficult to tag due to their size and behavior and don't do well in captivity.

"We have a really good sense of how many tigers are left in the wild, how many elephants are left in the wild, how many rhinos are left in the wild, other big charismatic things that we see in the trade, but we don't know how many pangolins are left. It will be so sad if a species like that goes extinct before we can even study them in the wild," she said.

Tracing an international supply chain depends on a network of partners from across the globe. The project was born out of efforts to track and map pangolin poaching by the Congo Basin Institute, a joint initiative of UCLA and the International Institute

of Tropical Agriculture. More than a dozen research organizations and government agencies, including the International Union for Conservation of Nature and the US Fish and Wildlife Service as well as universities in countries, such as China, Gabon, Nigeria, Cameroon, and the Czech Republic, were involved in the project. The idea to map the origins of seized pangolin scales was inspired partially by work done estimating trafficked elephant ivory.

Follow the Birds

The project also depends on a set of techniques first developed for tracking breeding populations of migratory birds. This genomic approach was developed by the UCLA's Center for Tropical Research Bird Genoscape Project. DNA from a single collected feather is sequenced to identify base pairs unique to each bird. Birds with unique combinations of base pairs tend to be found together and strongly indicate geographically separate populations of species. This allows them to be mapped, creating a genoscape. This genscope shows where migratory birds spend the winter. This is vital to conservation efforts. As of the end of 2023, 15 of the 100 geoscapes planned by the Bird Genoscape Project have been completed.

Like birds, pangolins also migrate—just not on their own. Previous genetic research on pangolin scales looked at mitochondrial DNA. Plot that on a map, Tinsman said, "and you can get, 'Oh, they're in West Africa'—so anywhere from Senegal to Ivory Coast maybe."

Instead, Tinsman and her colleagues (including more than 20 African scientists who are authors on the *Science* paper) analyzed the animal's whole genome and built the first range-wide set of genome sequences for pangolins. Shifting from genetics to genomics, "you can just get so much more data, so much finer resolution," said Tinsman. A lower error level combined with enough samples can provide a good sense of not only where pangolins are being poached, but also where they come from.

To connect confiscated scales to their origins on the map, the team needed to gather samples from white-bellied pangolins near their habitats before they were trafficked. Although some pangolin parts would come from recent tissue specimens from natural history collections, the easiest way to gather samples was to go to local bushmeat markets where hunted pangolins were brought for sale.

Scientists in Nigeria, Gabon, and Cameroon—armed with GPS receivers to geotag their samples—went to local markets. To avoid buying meat, which would support the poaching economy, they ask sellers to give them tongues. "Normally, they don't care if you ask for the tongue," said Tinsman. "They want to eat the meat and then sell the scales."

The team ultimately procured a total of 551 samples of blood, muscle, and scales from across the pangolins' habitat, from Senegal and West Africa to Zambia and central East Africa. (Some samples had been gathered during a years-long disease surveillance project that ended years before the pandemic.) From these samples, 111 high-quality genome sequences were extracted. By analyzing 96 individual changes to the genome, five distinct population groups strongly associated with distinct geographic areas—from Sierra Leone to the Democratic Republic of the Congo—were identified.

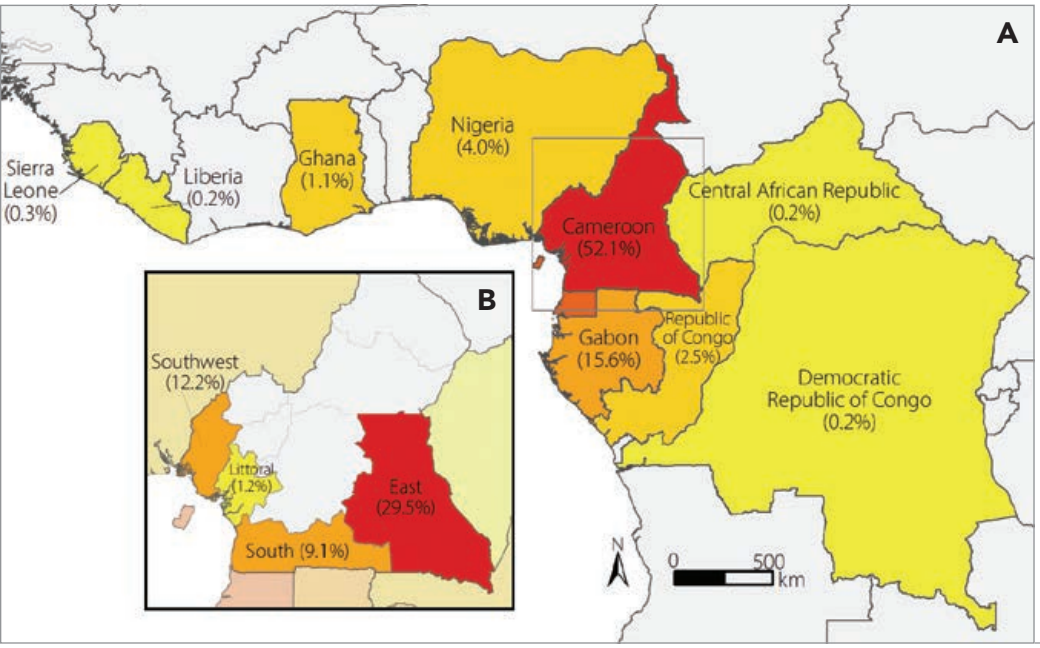
Next, Tinsman and her colleagues began developing a process to quickly and cheaply sequence a pile of hundreds of scales confiscated at ports and markets and donated by the Hong Kong government. Ultimately the researchers analyzed 643 samples of scales, each tagged with a date between 2012 and 2018, a period when pangolin trafficking reached a new peak.

Mapping Shifts in Poaching

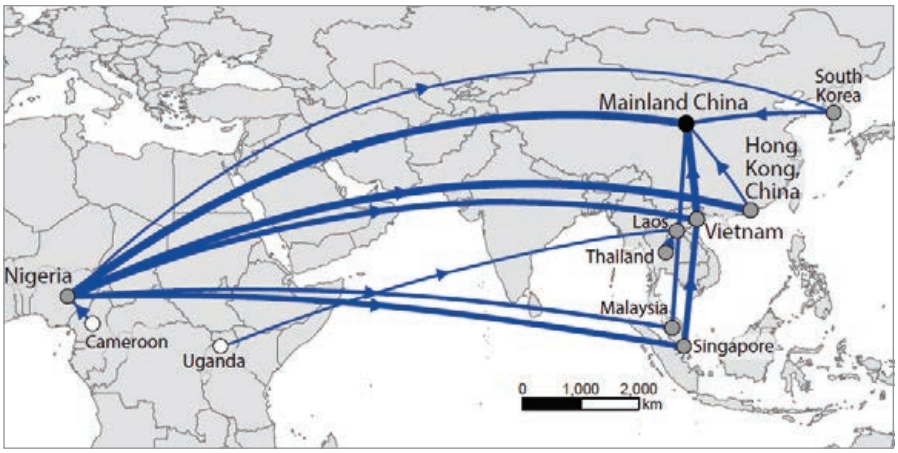
Previously, the official seizures database simply indicated Nigerian origins for pangolins that transited through Nigeria. Of all seized animals, 95 percent of seized animals have no recorded source other than Nigeria.

However, the DNA painted a far more detailed—even opposite—picture. When traced to their true source, only 4.2 percent of pangolins that were shipped from Nigeria originated there. While Nigeria is a key hub, most confiscated scales came from two major hot spots: along Cameroon's southern border with Equatorial Guinea and Gabon, and from western Cameroon, near the border with Nigeria.

When mapped over time, the scales reveal a decade-long shift. In 2012 and 2013, most shipments were from West African pangolins, but over time, researchers documented a shift in intensity and geography as poaching expanded into central Africa to Cameroon, Gabon, and Equatorial Guinea. A remarkably large number of pangolins



← This map of the national and regional origins of smuggled pangolin scales shows more than half of them come from Cameroon. (Image from *Science*, 14 Dec. 2023, vol. 382, issue 6676, pp. 1282–1286 *[supplemental]*, DOI: 10.1126/science.adi5066, JC Tinsman, *Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia*. Reprinted with permission from American Association for the Advancement of Science *[AAAS]*.)



→ This map shows the major trafficking routes for African pangolin products. White dots show origins, black dots represent destinations, and gray dots show transit spots. (Image from *Science*, 14 Dec. 2023, vol. 382, issue 6676, pp. 1282–1286 *[supplemental]*, DOI: 10.1126/science.adi5066, JC Tinsman, *Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia*. Reprinted with permission from AAAS.)

originated in the border areas between those countries, a multinational area where enforcement is difficult. "It's shocking that so many pangolins are coming out of such a small geographic area," said Tinsman.

The DNA contains no clear explanation for the shift, but Tinsman and her colleagues speculate that the trend could reflect a few factors: increased enforcement; declining pangolin populations in West Africa, or traffickers taking advantage of new, more convenient trade routes—or some combination of all three.

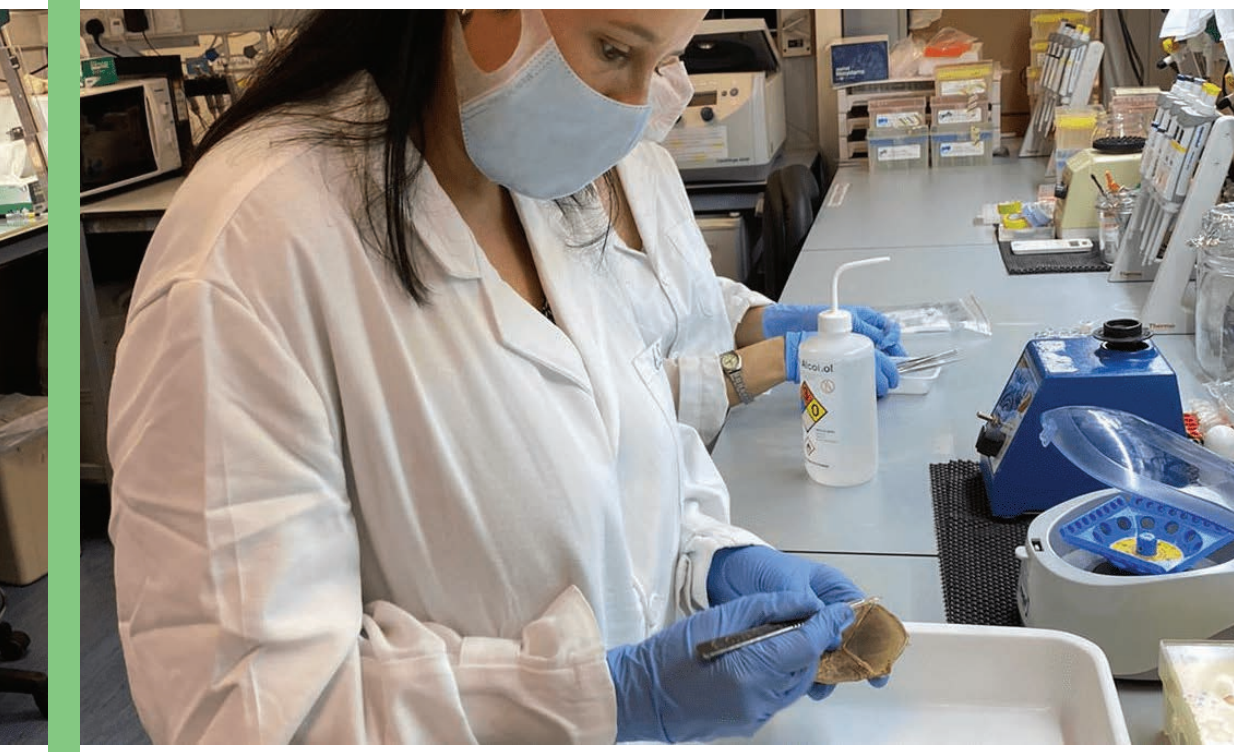
They also noted the full scale of the pangolin industry was grossly underestimated. Many shipments are never detected and are estimated to range from 400,000 to 2.7 million African pangolins per year.

The testing process to determine the origin of scales that Tinsman and her team built was also crucial. Eventually the team could analyze scales for $8 per sample and get results delivered in under a week. The project's goal was to make a quick and simple assay.

Researchers hope maps will help anti-trafficking authorities focus their attention on traffickers. More generally, maps could help capture the public's attention by instantly illustrating the impact that demand has on faraway—and increasingly connected—ecosystems. "You need a map to understand the whole story," Tinsman said.

Pangolin Supply Chain

Consider the typical pangolin supply chain. Hunters in countries in central Africa sell an animal to a middleman for around $10, "which is a lot of money for them, but nothing for the middleman," Tinsman said. Locals will eat or sell the meat, but the scales are dried and gathered into overseas shipments at ports, mostly in Nigeria. They arrive in a port in Southeast Asia, like Hong Kong, Singapore, Malaysia, or Vietnam, before being distributed to markets across the region. To see how scales from poached pangolins move across central Africa, get amassed and shipped, and move to end consumers in Southeast Asia, you need a map.



← A pangolin scale is being prepared for genomic testing by Tracey-Leigh Prigge, a PhD student at the University of Hong Kong and coauthor of the paper in *Science*. (Image courtesy of the Congo Basin Institute)

Tinsman pointed to the construction of the Kribi Deepwater Port in Cameroon, which opened in 2018, as a development that increased poached pangolin traffic. Port construction led to building roads into the forest for timber—and, incidentially, wildlife harvesting. "And it's really easy to just pop a dead pangolin on a truck with some timber and send it to the port as well and make some money that way," said Tinman. "So all of this increasing economic activity that's really good for Cameroon is actually really bad for Cameroon's biodiversity."

Tinsman sympathizes with colleagues who jump through all the permitting hoops to legally obtain samples and send them to the West. "I feel very personally attached to pangolins, but it's got to be a whole other level to work on them, to spend months trying to track one down to get a radio collar on it, and then to have them just completely bulldoze their habitat. That's got to be hard."

Nobody Wants Another Pandemic

The demand for African pangolins is a relatively recent phenomenon, largely fueled by the growth of a Chinese middle class in search of traditional medicines. Growing economic ties between China and Africa have likely accelerated the trade. There is no evidence that pangolin scales have anything more than a placebo effect.

Regulations haven't helped much. In 2016, after years of diplomatic wrangling, pangolins were finally listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which extends to them the highest level of protection under an international agreement to regulate the wildlife trade. And yet, despite the ban, approximately 600,000 pangolins were illegally traded between 2016 and 2019 alone.

"We didn't really see the intended effect, which would be a reduction in the trade of pangolin," Tinsman said. "It really ramped up to 2019, which was sort of the peak year." The locations where pangolins were being killed shifted over the course of two decades from Asia to Africa. According to Tinman, this was an abrupt change in the ecosystem and "we have so little data to project what we think is going to happen. It's concerning."

Tinsman emphasized that wildlife trafficking doesn't just hurt critical animals and the surrounding ecosystem—it also feeds a rise in violence, political instability, and multinational criminal organizations. Trafficking animals is the fourth-most lucrative kind of trafficking, after smuggling humans, guns, and drugs.

"It is these major international criminal syndicates that are involved in this because they already know how to ship stuff illegally," she said. "It's not just about the pangolins. These organizations are driving political instability and violence in habitat countries for pangolins."

Battling wildlife trafficking could also reduce the risk of zoonotic diseases. Pangolins in seized shipments have been found to carry novel severe acute respiratory syndrome (SARS)–related coronaviruses. In the ongoing search for the origins of COVID-19, many analysts implicated a poached pangolin.

"Nobody wants another pandemic," Tinsman said, "and even if it wasn't pangolins this time, it could be the next."

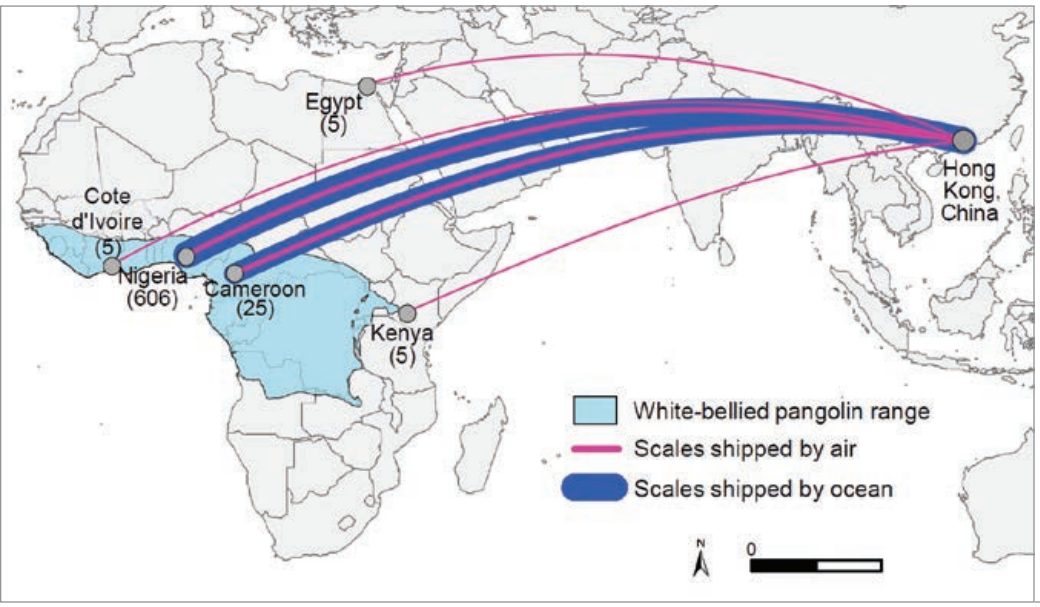
A Global Movement

Given the difficulties of studying pangolins in the wild, genomic-geospatial analysis is giving conservationists a new weapon, and at a moment of urgency. Researchers are digging up more clues in trafficked pangolins. A team of researchers who studied pangolin scales confiscated in Hong Kong in 2012 and 2013 and in Yunnan, China, in 2015 and 2019, found that some samples came from a line of Asian pangolins that belong to a previously unrecognized ninth pangolin species that doesn't map to any known genetic population using mitochondrial DNA.

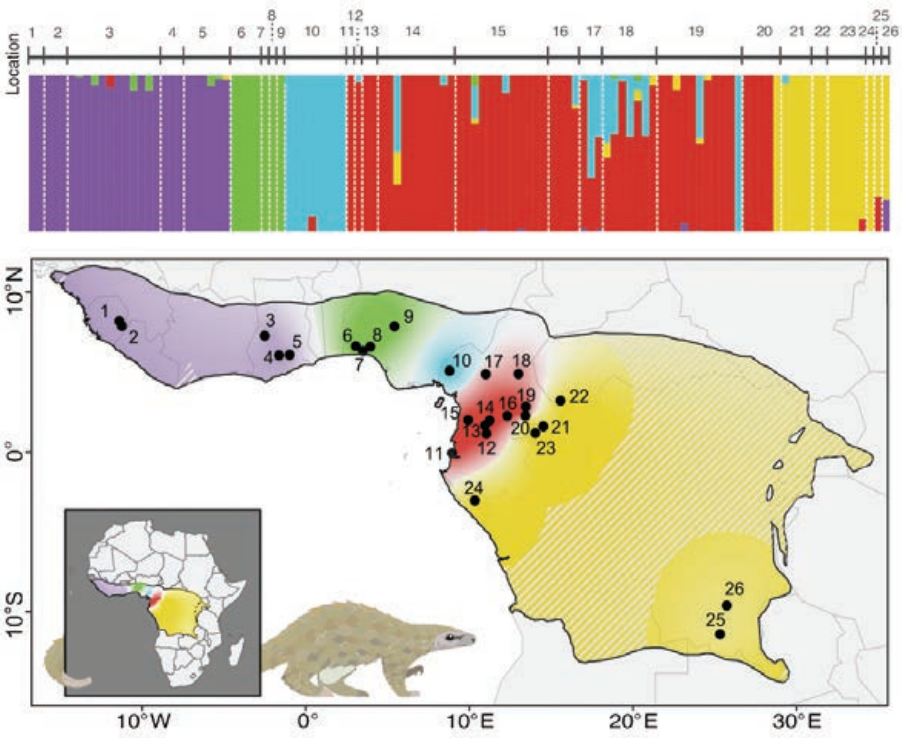
A paper on this research was authored by researchers at Kadoorie Farm and Botanic Garden in Hong Kong, another partner in the mapping project. "But we don't know where the mystery pangolins occur in the wild," said Tinsman. She hopes that further research and new techniques, such as environmental DNA (eDNA), will offer more answers to these questions.

She looks forward to getting the genomic assays into the hands of the people closest to the pangolins. The biggest problem is figuring out how to get the technology and adequate supplies of chemical reagents to central Africa where pangolins are being harvested. That would save precious time and resources because currently, samples are sent to California for genotyping. However, because pangolins are protected by CITES, Tinsman and her team had to apply for a permit to receive those shipments. The process took 17 months. Export permits were also needed from each country, as well as research permits in Cameroon.

She is encouraged that the technique



← This map shows trafficking routes of confiscated pangolin scales that were genotyped in this study. (Image from *Science*, 14 Dec. 2023, vol. 382, Issue 6676, pp. 1282-1286 *[supplemental]*, DOI: 10.1126/science.adi5066, JC Tinsman, *Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia.* Reprinted with permission from AAAS.}



↑ This map of genomic data shows the location of distinct population clusters of white-bellied pangolin. (Image from *Science*, 14 Dec. 2023, vol. 382, issue 6676, pp. 1282–1286 *[supplemental]*, DOI: 10.1126/science.adi5066, JC Tinsman, *Genomic analyses reveal poaching hotspots and illegal trade in pangolins from Africa to Asia.* Reprinted with permission from AAAS.)

provides a high level of resolution that will enable mapping in near real time where poaching is happening. "If somebody in Cameroon confiscates a scale, if they were able to do this in their own lab and they send it, it would take less than a week," said Tinsman.

In 2022, a team from UCLA went to Cameroon to lead what Tinsman hopes will be the first of many local workshops bringing together scientists, conservationists, and people from government and nongovernment organizations to share their findings and demonstrate the limitations and promises of this geospatial-genomics approach.

One of the project's most encouraging outcomes is that researchers and conservationists are part of a growing global community of pangolin lovers and experts, which includes networks such as the volunteer-run International Union for Conservation of Nature (IUCN) Pangolin Specialist Group. Tinsman sees the glimmers of a budding global movement to conserve pangolins that is long overdue for respect and recognition.

Not Penguins (But Them Too)

"Half the time when I tell people I work on pangolins, they think I've said penguins because nobody's heard of them," Tinsman said. "And then when I explain them, they're like, 'Are you sure you don't want to work on penguins? Because pangolins are so weird.'"

The new research, she hopes, will help keep them and all their weirdness on the map. "The genomics are cool," Tinsman said, "but what's really exciting about this is the momentum that pangolins have. People are finally starting to pay attention."

About the Author

David Gadsden is the director of conservation solutions and administers the Esri Conservation Program. Gadsden, who joined Esri in 2002, has spent more than two decades helping organizations use GIS in humanitarian and conservation work. He has also served as a technical adviser to the United Nations, US Department of State, and the Bill and Melinda Gates Foundation.

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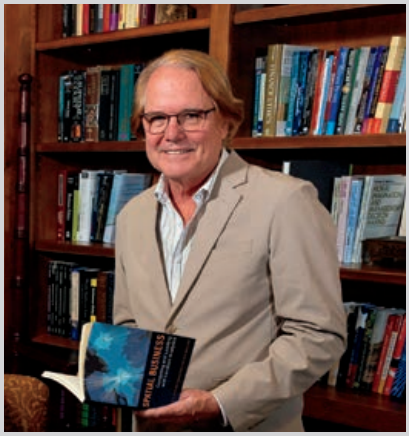

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