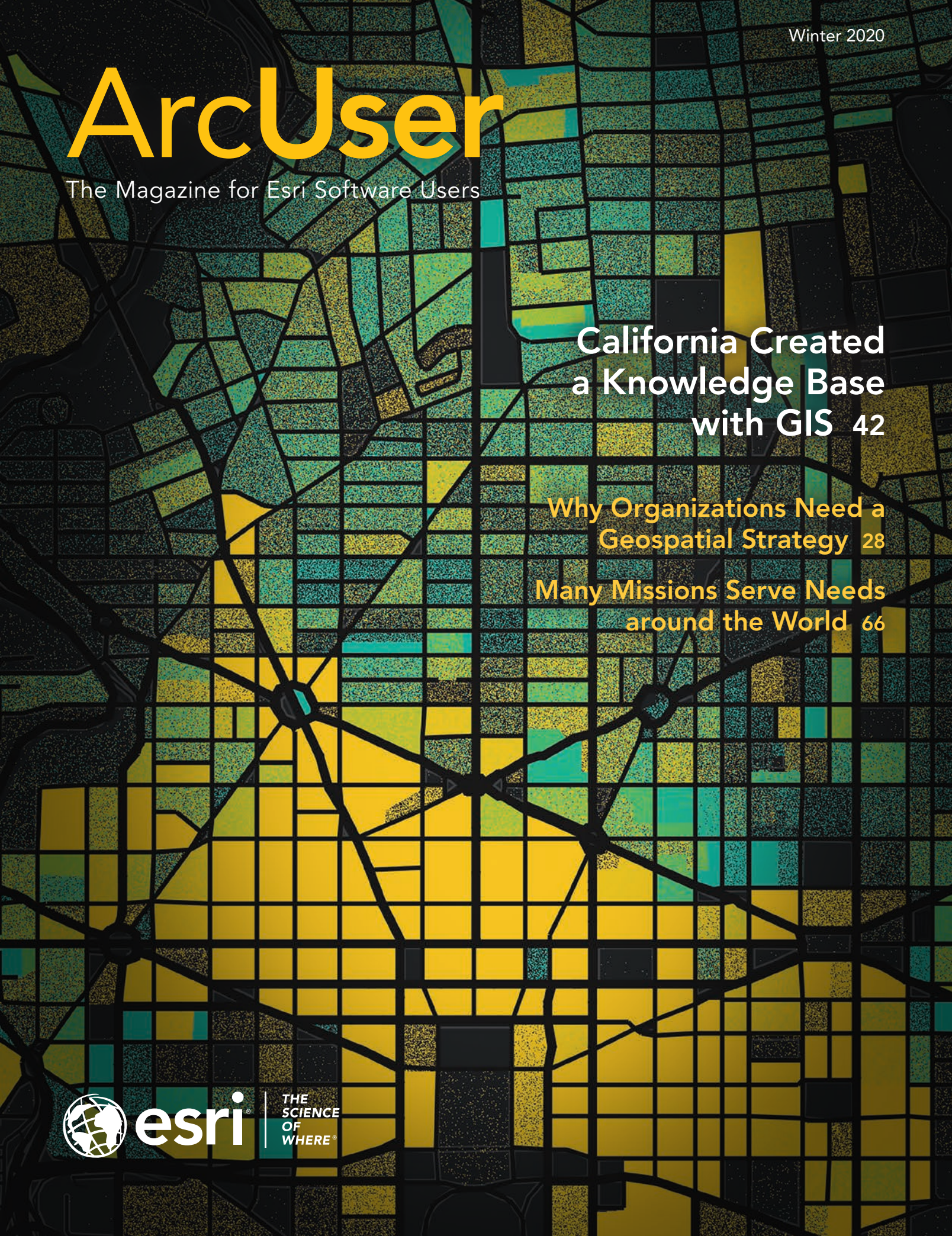
Winter 2020

ArcUser

The Magazine for Esri Software Users



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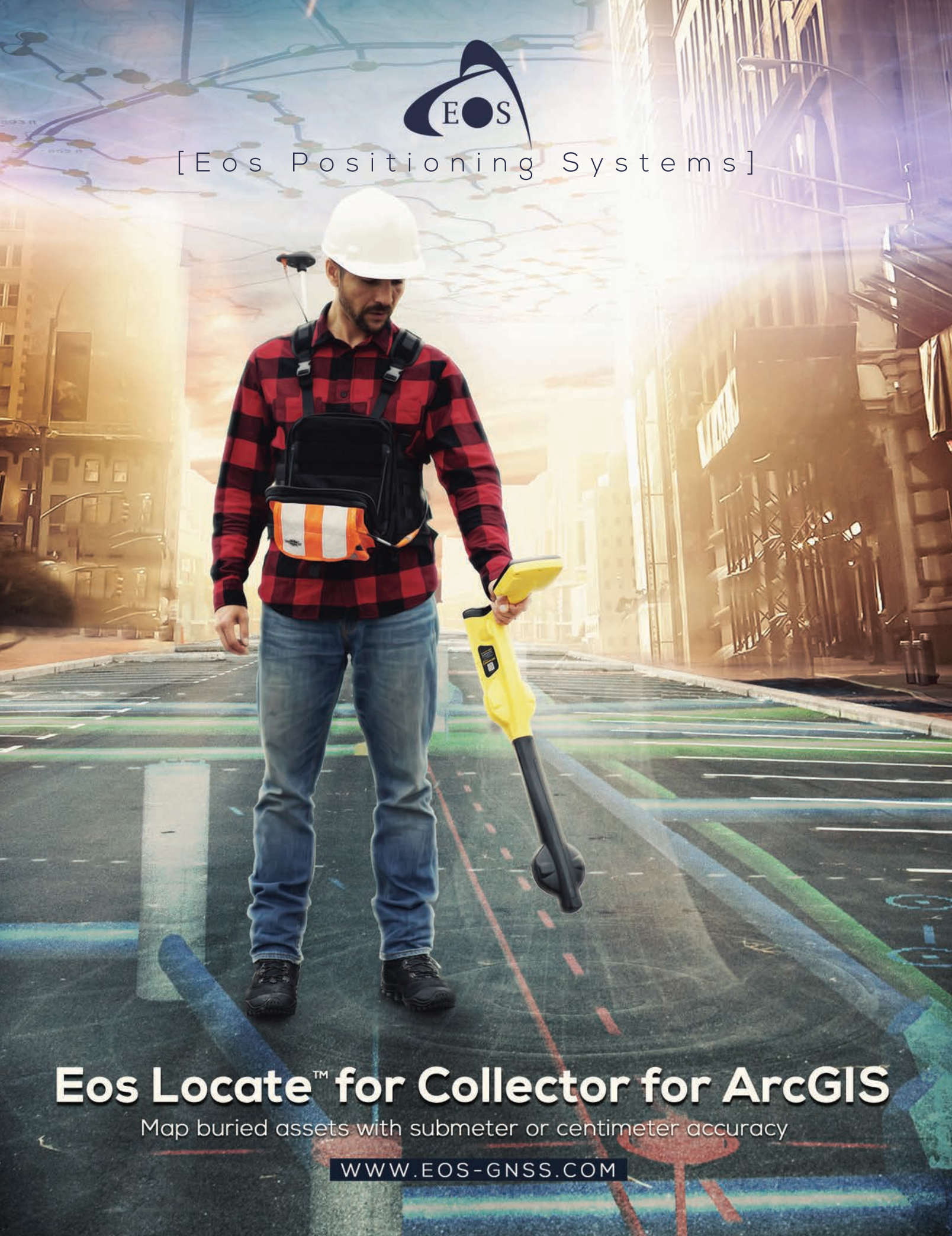
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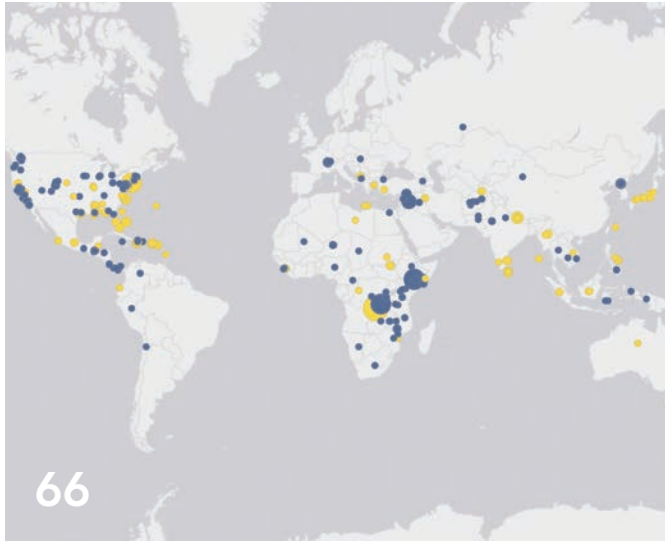

End Notes

On the Cover

In this dot density map of Washington, DC, created in the Map Viewer Beta by Esri cartographer Jennifer Bell, yellow areas show higher daytime population, where workers predominate. Blue areas show higher nighttime population, composed mostly of residents. Where the numbers of workers and residents are nearly equal, yellow and blue combine to produce green areas. The dataset was created by combining Census Longitudinal Employer-Household Dynamics (LEHD) commuter block data, District of Columbia Office of Tax and Revenue (OTR) computer-assisted mass appraisal (CAMA) data, and Esri demographics.

Enhancing Understanding

We begin this new decade with more powerful GIS tools for seeing and understanding the problems we face and devising better solutions for them. The integration of big data processing and analysis and the incorporation of artificial intelligence (AI) in image analysis across the ArcGIS platform furnish context for decisions to a degree that was not previously possible. Several articles in this issue demonstrate how organizations are benefiting from these capabilities.

Monitoring the 4.8 million square kilometers that encompass the Argentinean Exclusive Economic Zone is the mission of the Prefectura Naval Argentina. Not only is this task profoundly geographic in nature but it also requires real-time data—and lots of it—to identify and track illegal fishing, smuggling, and drug trafficking activities in this vast area. Rapidly analyzing and consolidating data across the organization on the ArcGIS platform have given Prefectura Navel Argentina a comprehensive view of the area under its jurisdiction.

In an interview in this issue, Frank Avila, director of the Commercial GEOINT Discovery & Assessments Office at the National Geospatial-Intelligence Agency (NGA) explained why the agency is making much greater use of the AI capabilities in ArcGIS. This strategy has made NGA analysts more efficient by eliminating repetitive tasks and more effective by enabling them to consider more information, more rapidly so they can make decisions that are both better and timely.

Another article describes how the NGA is using AI to improve the collection and processing of satellite imagery. By eliminating visual interpretation of imagery and adopting a streamlined process that incorporates a computer vision algorithm, NGA can use lower-resolution imagery and fewer staff to obtain superior results when monitoring port activity.

The rapidly evolving data processing and analysis capabilities in GIS are helping organizations enhance understanding of the challenges they face and take more effective action.

Monica Pratt
ArcUser Editor

ArcUser

Winter 2020 Vol. 23 No. 1

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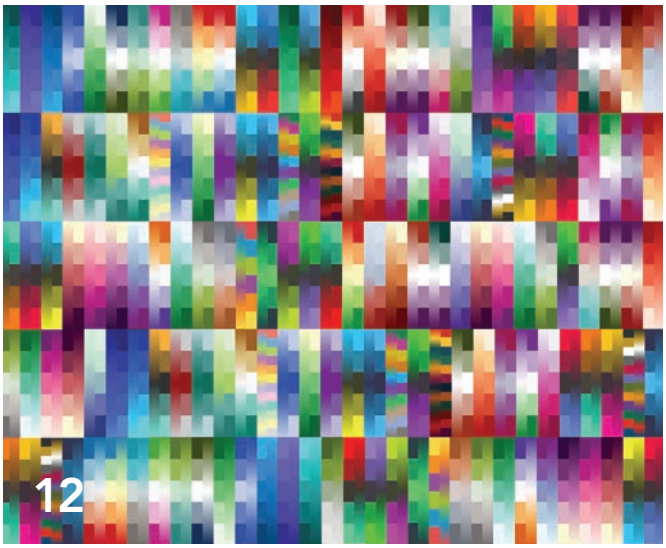
Departments



Briefly Noted

New Expressive Tools for Storytelling

↑ Turn your story map into a live presentation with Slideshow, the new immersive block.

ArcGIS StoryMaps, Esri's new storytelling app, has several new features to help you design and tell your stories more creatively. Turn your story map into a live presentation with Slideshow, the new immersive block currently in beta. Best for displaying full-page media, such as images or videos, with small amounts of descriptive text in a narrative panel, you can add a series of slides to sections of your story maps. Make related and thematic stories and apps easier to present and share by authoring collections (also in beta). Create a collection by simply clicking on your profile picture and then clicking My Collections to add story maps to a set. Collections can be shared with everyone or just your organization. Use the Preview button in the ArcGIS StoryMaps app header to see how your story map will display on small, medium, and large screens. Adjust your story map so it will look its best when displayed on a phone, tablet, or desktop computer. If you are displaying a story on a kiosk monitor or at a conference, you can automatically play it from beginning to end on a loop. To learn more, see great stories from the story maps community, and find helpful resources for getting started, visit esri.com/storymaps.

Esri Is a Key Geospatial Partner for Salesforce

Salesforce has selected Esri as the key provider of geospatial content for Salesforce Maps, which enables organizations around the world to combine their business data with geospatial analytics and mapping. By integrating ArcGIS Living Atlas of the World and enabling Salesforce Maps users to access ArcGIS Online, Salesforce is giving businesses the ability to analyze and visualize massive amounts of geographic and demographic data and gain a competitive advantage.

Mozambique Improves Its Land Administration System

Mozambique's National Directorate of Lands (DINAT) successfully implemented the Esri Land Administration Modernization Program (LAMP), which helps developing countries jump-start and modernize their land administration systems. By using LAMP, DINAT is already making land administration business processes more efficient and productive while improving parcel data accuracy.

→ An End-to-End Enterprise Drone Data and Analytics Solution

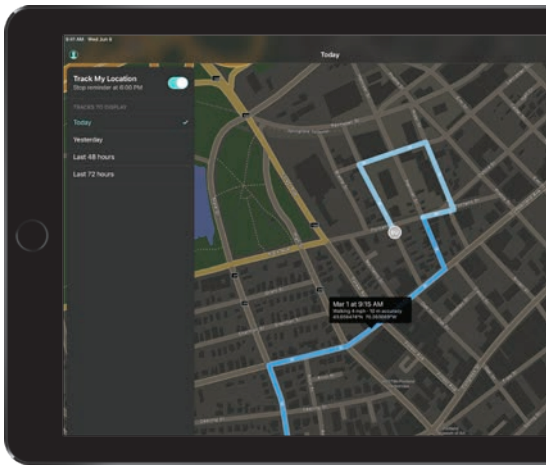
Esri has partnered with 3DR, a leading US drone data company, to expand Esri's current drone imagery offering, Drone2Map for ArcGIS, with an end-to-end enterprise drone data and analytics solution for the ArcGIS platform. With the new ArcGIS Drone Collection, which employs 3DR's powerful Site Scan unmanned aerial systems flight planning and processing software, users ranging from small operators to enterprise-wide drone programs can access scalable solutions that work for their needs. Learn more about ArcGIS Drone Collection at https://bit.ly/39WvVup.

→ Tracker for ArcGIS Is Available in ArcGIS Online

The Tracker for ArcGIS mobile app records the location tracks of field personnel, and the corresponding Track Viewer web app lets authorized supervisors view them. The Track Viewer web app leverages the location tracking layer. Previously available only in ArcGIS Enterprise 10.7, the web app is now accessible in ArcGIS Online and provides the benefits of a fully hosted solution. With Tracker for ArcGIS, organizations can keep better track of fieldworkers and support supervisors, managers, fieldworkers, and customers in numerous ways. Improve efficiency in the field by identifying areas lacking in staff or where they are too concentrated. Track history can be used to verify where and when an asset or site was last visited, the duration of the visit, and who made the visit to demonstrate that service-level agreements are being met. Supervisors can better respond to unanticipated events because they always know where staff are and can monitor fieldworkers' safety. Tracker for ArcGIS is a premium app that can be added to any ArcGIS user type license. Learn more at esri.com/tracker.

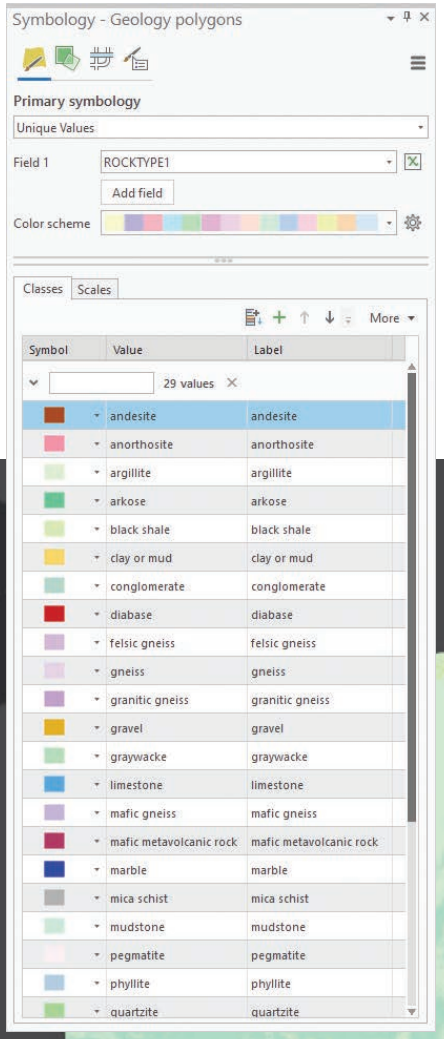
→ Explorer for ArcGIS Brings Simple Map Viewing to Windows

Explorer for ArcGIS is great for field users who just need a simple map viewer to take their GIS data with them, make some quick notes on the map, and share those notes with colleagues who are in the field or in the office. While these capabilities have been available for Android and iOS for some time, they are now available in Windows 10. In addition to being able to download mobile map packages for offline use, Explorer on Windows adds offline areas, another way to use Explorer in a disconnected environment. A map author defines as offline areas those areas with little or no network connectivity. ArcGIS packages the layers and basemaps for these areas and makes them available for download. Included when defining an offline area is a specification for how often map areas are automatically updated with the most current info from the web map.



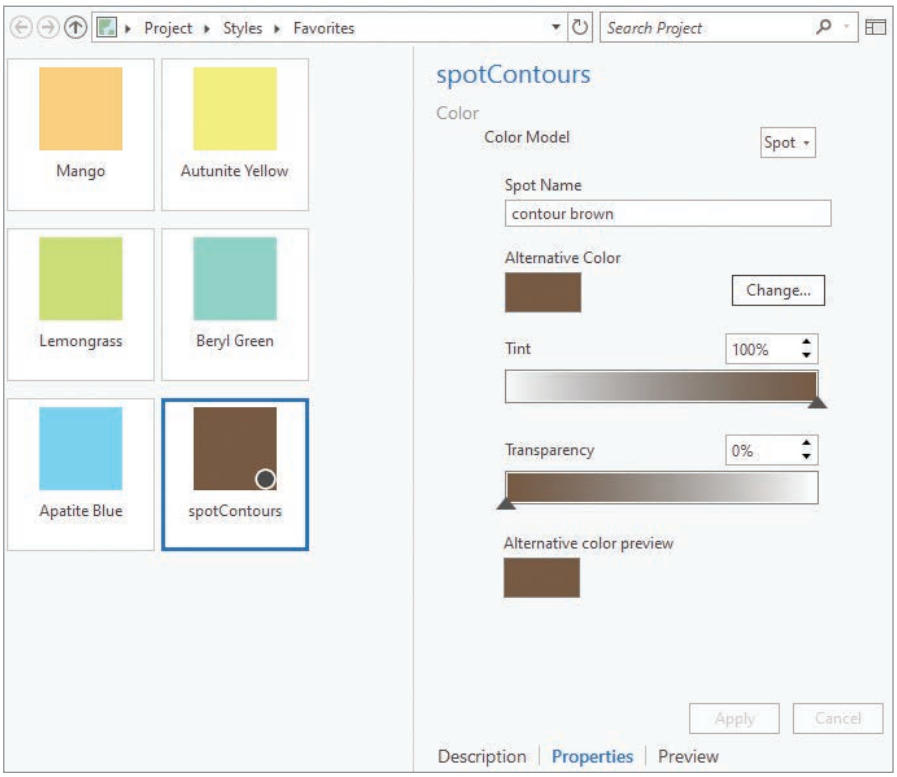
↑ The Tracker for ArcGIS mobile app records the location tracks of field personnel.

Mapping and Productivity Are Enhanced in ArcGIS Pro 2.5



ArcGIS Pro 2.5 gives you more control over mapping and lets you perform tasks more efficiently using familiar workflows. This release incorporates many customer requests and items submitted to ArcGIS Ideas.

↓ The Match Layer Symbology To A Style tool, available at all licensing levels, matches symbols to feature attributes and efficiently maps detailed datasets with standardized symbology such as US Geological Survey data.



↑ Offset printing features, such as defining spot colors to specify the use of custom inks, are now available.

Mapping Improvements

ArcGIS Pro 2.5 improves production workflows to streamline and standardize map production, meet mapping agency requirements, and provide more control over the final product that meets or, in some areas, exceeds functionality in ArcMap.

ArcGIS Pro 2.5 supports professional map production with color management that lets you control the reproduction and conversion of colors. Color management settings in ArcGIS Pro support ICC profiles and ensure that the colors specified for a map are rendered consistently across devices. Because color management is an application setting, it is applied to every map, layout, report, or style you create. Offset printing features—such as defining spot colors to specify the use of custom inks or overprinting on the symbol layer—are now available.

A new export type, Adobe Illustrator Exchange (AIX) format, has been added for use with the ArcGIS Maps for Adobe Creative Cloud extension. The extension converts vector and raster map content into editable, layered artwork that can be opened and edited in Adobe Illustrator. These files can be used for high-end graphic design or map finishing workflows and migrated across the other Adobe Creative Cloud applications.

The Match Layer Symbology To A Style tool is available in ArcGIS Pro at all licensing levels. It matches symbols to feature attributes in an automated fashion and is a big time-saver when mapping detailed datasets with standardized symbology such as US Geological Survey data.

Perform QA/QC on densely labeled maps more easily in ArcGIS Pro 2.5 with the new Lock Labels capability. When this is turned on, labels are not reconfigured when zooming the map extent, and label placement can be reviewed in both map and layout view.

Three new map projections have been added: Adams square II projection, Tobler cylindrical I, and Tobler cylindrical II. The Tobler projections were implemented in ArcGIS as the 100th and 101st map projection algorithms in honor of cartographer and GIS pioneer Waldo Tobler.

More options for visualizing attribute data are available in ArcGIS Pro 2.5 using chart symbology, which has been added for point, line, and polygon feature layers. Chart symbols can be pies, bars, or stacked bars. Each part of the chart represents one attribute value. Chart symbol size can be fixed or be determined by an attribute.

Now that all symbol properties for embedded symbols are available, you can construct an exact color scheme for point symbol halos, gradient fills, and gradient strokes. All symbol properties for embedded symbols used to symbolize elements within a shape marker symbol layer can be accessed, modified, and saved to a style for reuse.

Vertex editing tools let you edit text blocks in a layout for clarity and design purposes.

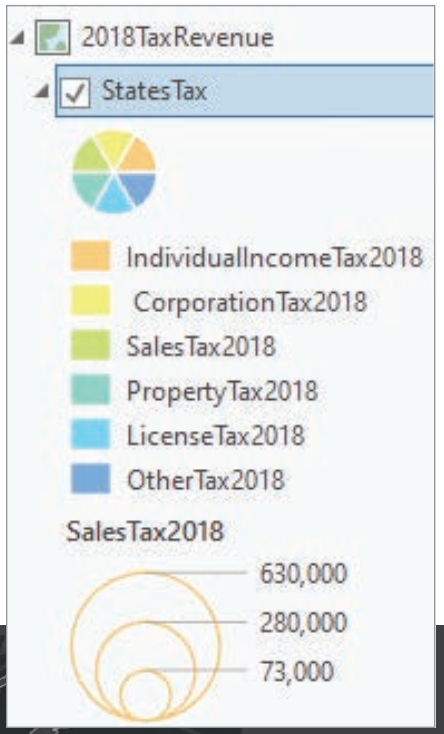
Improved Productivity and Performance

Browsing for and opening files on local and network shares is much faster. Among many performance improvements at 2.5, ArcGIS Pro is more responsive to symbology and selection changes, snapping, and identity requests.

Update tables more efficiently using the new find and replace in table view capability to find content in a table, make mass updates to tables, and identify and replace invalid values in a table.

Drawing enhancements include a more efficient level of detail (LOD) selection algorithm in 3D scenes that is tuned to balance high-resolution versus low polygon count features based on distance from the camera. Scene layer drawing allows faster loading and drawing of I3S content. LAS dataset loading and drawing speeds are greater, so frame rates are higher for the same volume of data. Chart data is rendered faster and asynchronously, and charts with axes have zooming and panning functionality.

Decide which layout will be most effective for your map using the new Layout Template Gallery. It lets you choose from the 12 predefined layouts that come with this release. Alternatively, you can customize the Layout Template Gallery by setting a path to the file containing your



organization's layout templates.

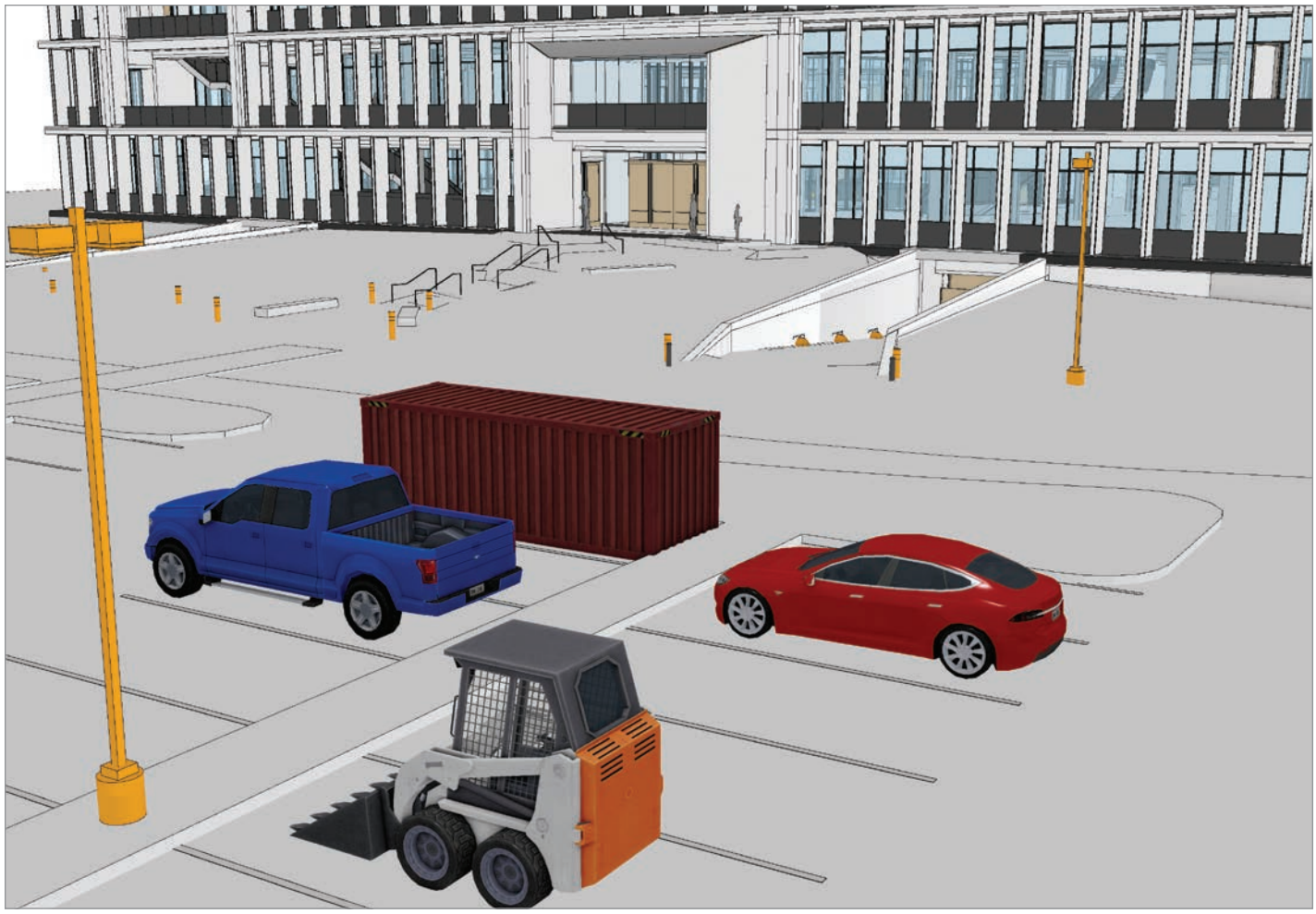
Get more done with export and print dialogs that now work in the background so you can continue working while those processes are taking place. For the first time, you can also set export size in pixels for your map view and verify that the map has the desired extent and aspect ratio using Show Preview.

Exporting a ModelBuilder model to a Python script has been improved to help you learn how tools and environments are used in Python and to edit and use the export as a stand-alone file. Export to a Python file or a Python window has been enhanced at version 2.5.

Geodatabase Replication Added

This is the first release of ArcGIS Pro that includes geodatabase replication capabilities. Replication in ArcGIS Pro will resemble the process in ArcMap and will require traditional versioning. Geodatabase

↓ Chart symbols can be pies, bars, or stacked bars, and each part of the chart represents one attribute value.



↑ Drawing enhancements include a more efficient level of detail (LOD) selection algorithm in 3D scenes that is tuned to balance high-resolution versus low polygon count features based on distance from the camera.

replication lets you create copies of data across two or more geodatabases so changes to the data can be synchronized. For example, this allows an organization to disperse data maintained in a geodatabase as needed from its central server to its regional or local offices by replicating all or a portion of the geodatabase. As the replicas are updated, changes are coordinated between the offices through a synchronization process.

Geodatabase replication supports other workflow options in addition to those offered through traditional versioning. These workflow options can include supporting both production and publication versions of geodatabases; centralizing data from many sources into a central repository; allocating data management responsibilities in organizations that share them across different groups; and accommodating contractors who provide periodic updates to a geodatabase. The tools provided for geodatabase replication include Create Replica GP tool, Synchronize Changes GP tool, and New Replica Manager.

These are just a few highlights from the many improvements to ArcGIS Pro at the 2.5 release. Other improvements were made in parcel management, 3D visualization, high-fidelity visualization, and in ArcGIS Pro SDK for the Microsoft .NET Framework. For a complete list of ArcGIS Pro 2.5 enhancements, see "What's New in ArcGIS Pro 2.5" in the documentation.

Map Meaningfully and More Easily with New Map Viewer

You already have a new mapmaking tool that lets you more easily transform data into impactful maps. Map Viewer Beta is available directly from the app launcher in ArcGIS Online, so you can use it today to create new maps or open existing ones.

It supports improved functionality and adds a dot density mapping style, smart summaries for field attributes, additional color ramps, interactive data filtering, and improved pop-ups. These features let you explore and map your data in compelling ways.

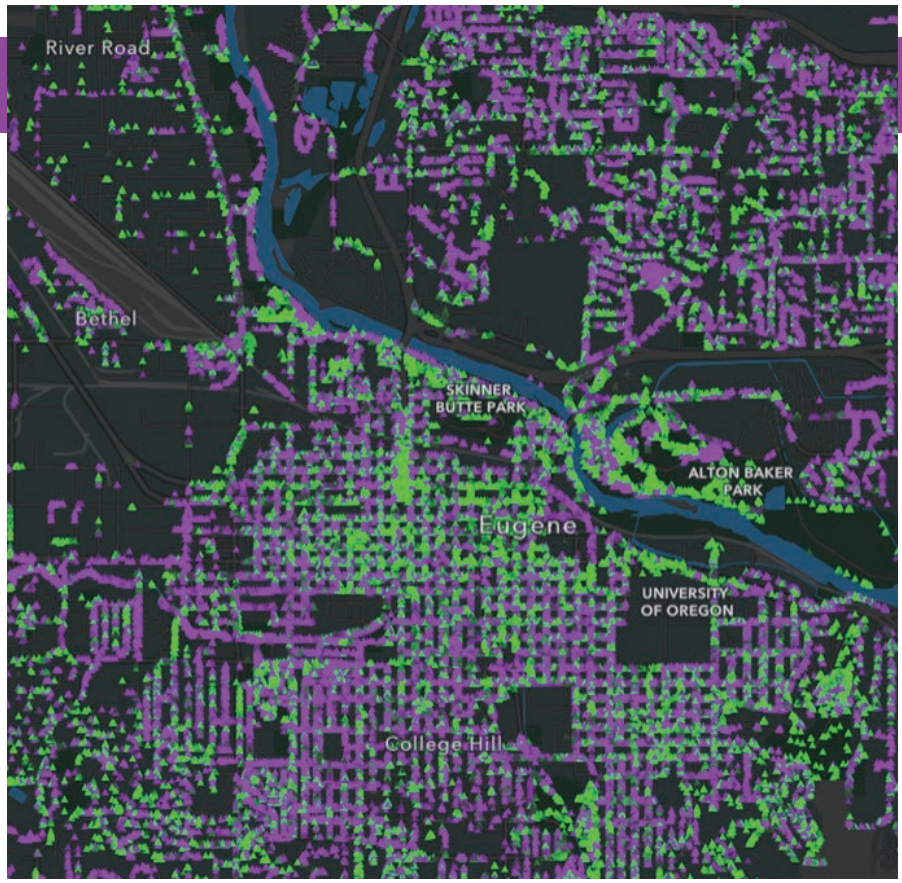
Only in ArcGIS Online

The dot density mapping style is only available in the new Map Viewer. This style works well with polygon data containing count attributes, such as census data or crime incidents, to visualize the distribution of one attribute or compare multiple attributes.

This mapping style personalizes data by representing a single count with a single dot. For example, one person experiencing homelessness could be symbolized with one dot, and together, the dots reveal where homelessness occurs and to what degree, humanizing the data describing this problem.

Exploring and Understanding Data

The immediate feedback and interactive filtering in the new Map Viewer make it much easier to locate the data you are interested in mapping. Layers can contain hundreds

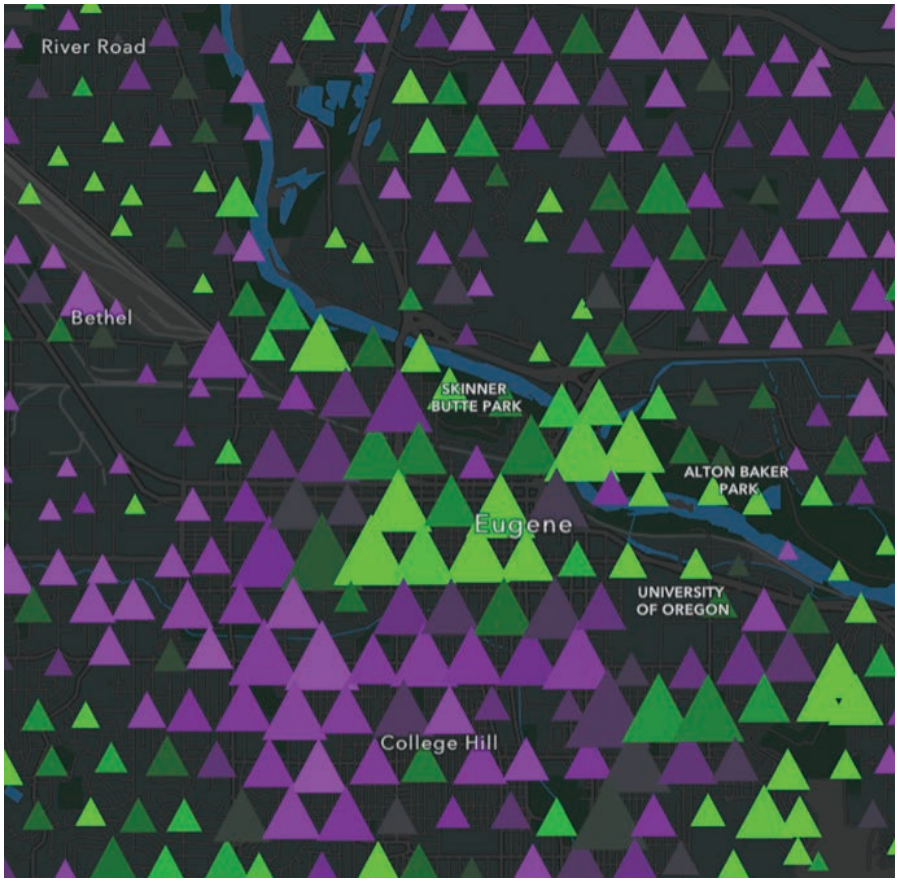


← Dot density, a mapping style currently available only in the Map Viewer Beta, personalizes data by representing a single count with a single dot.

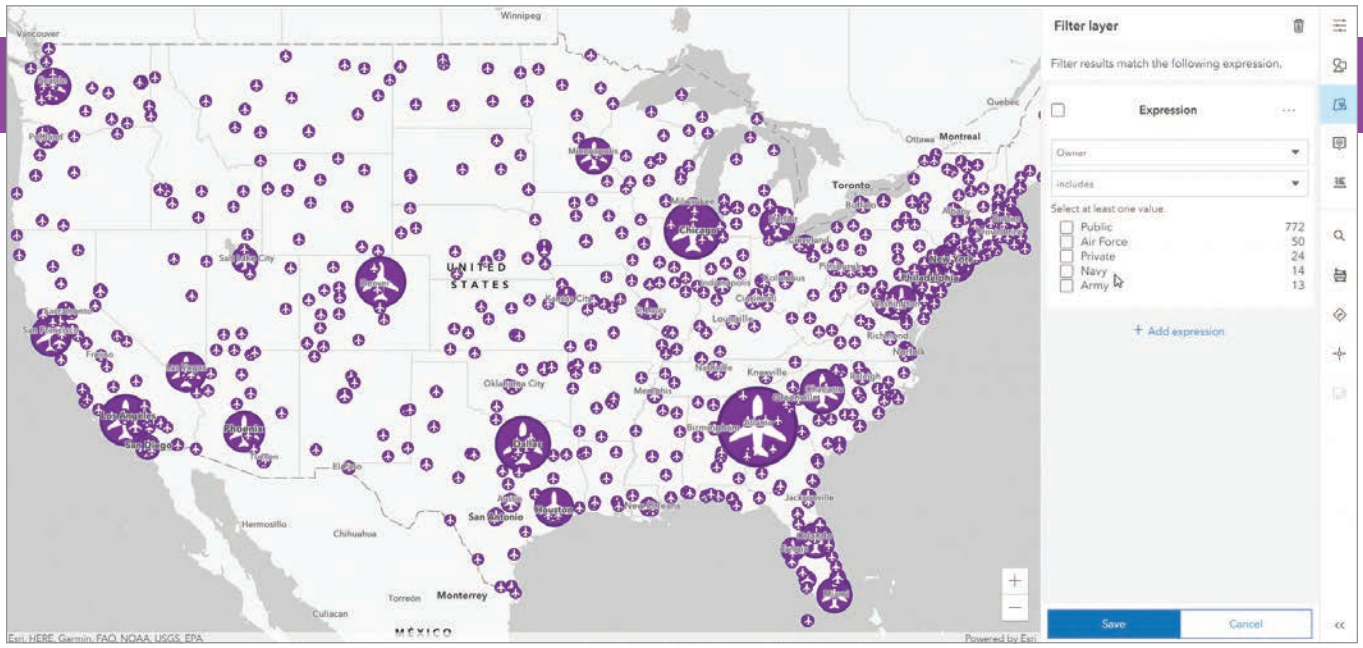
→ Instead of being overwhelmed with individual point locations (top), use clustering to make sense of data (bottom).

of fields, but you just need to find the one containing the data you are interested in. With a convenient search bar and sorting options, you'll be able to find that field quickly and then interactively find the best visualization for it.

In addition to sifting through many fields to find the data you need, another related mapping challenge is deciphering often cryptic file names so you can understand what the data represents and use it intelligently.



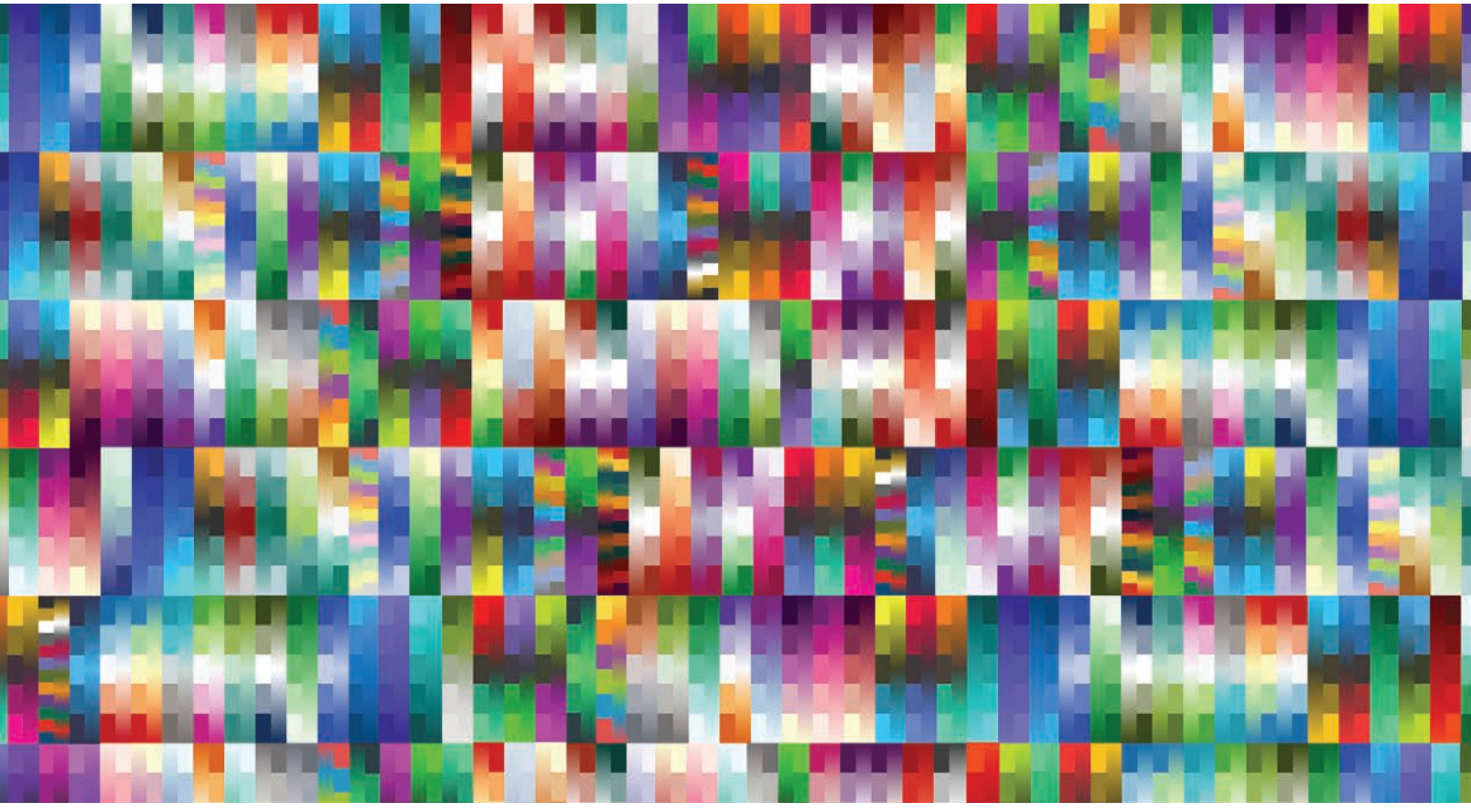
↓ The smart summaries available in the new Map Viewer provide a description, data sample, and numeric statistics for the values in each field.

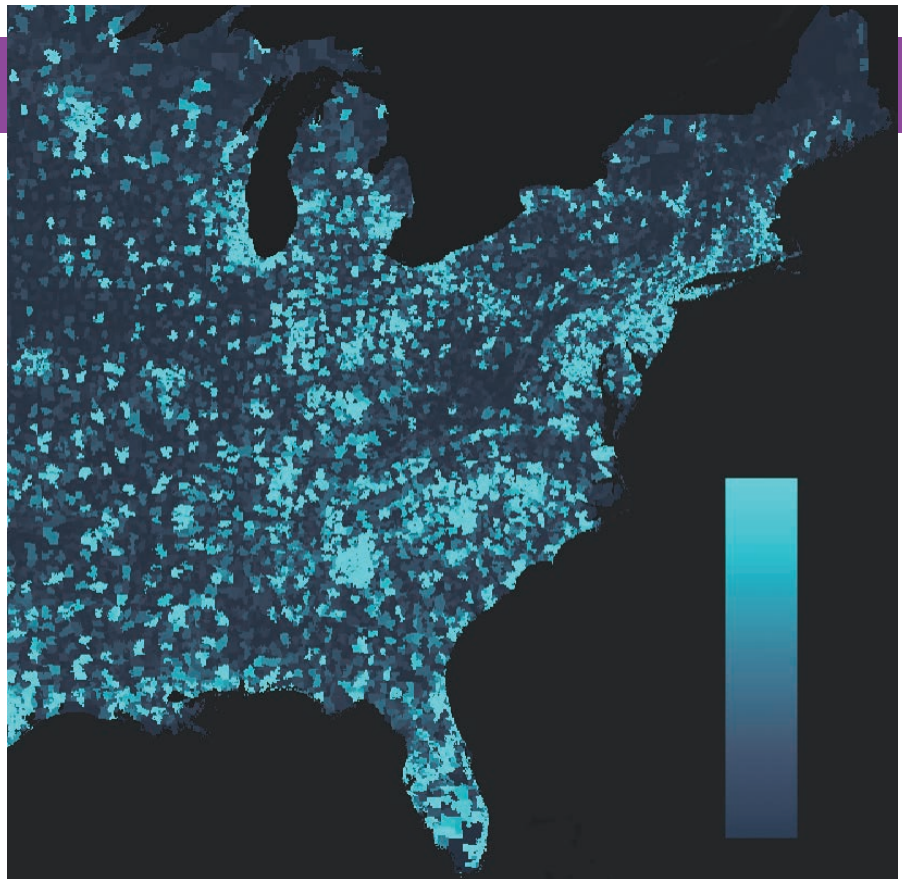


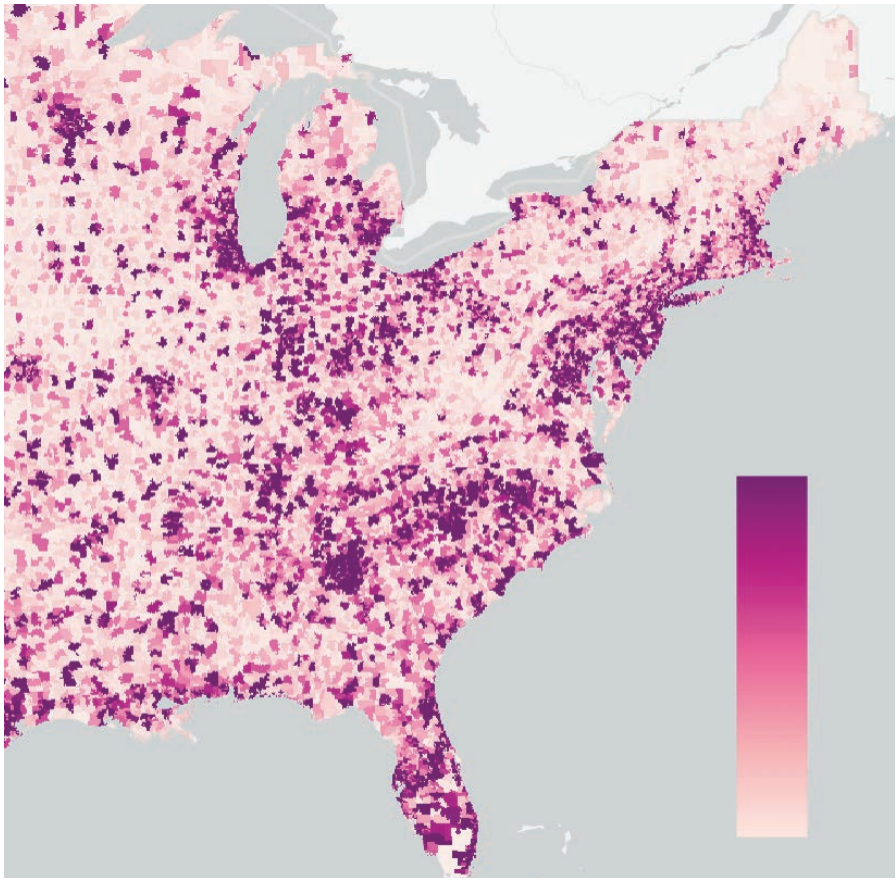
The smart summaries available in the new Map Viewer provide a description, data sample, and numeric statistics for the values in each field. Data organization is more understandable, and the item detail information is displayed. Data for the field is quantified with the number of records; sum of all values; minimum, maximum, average, and standard deviation of field values; and the currency of the data.

↑ The largest symbols represent airports with more than 40,000,000 enplanements. Smaller circles show airports with less than 10,000,000 enplanements.

↓ Map Viewer Beta contains more than 300 color ramps.







→ Each color ramp is tagged and categorized by use so you can easily explore mapping options and find the best ramp for your data, for example, Best for Dark Backgrounds (top) and Best for Light Backgrounds (bottom).

Color Ramps Categorized

Map Viewer Beta contains more than 300 color ramps! Each is tagged and categorized by use (e.g., Best for Light Backgrounds, Subdued) so you can easily explore mapping options and find the best ramp for your data. Ramps show color groupings, and depending on the mapping style and theme, specific color ramps are displayed to guide you to the best combinations.

Interactive Data Filtering

Filtering can help you see the most important features by limiting the visibility of other features in a layer. As you adjust the data filter in the new Map Viewer, it provides instant visual feedback so you can better understand and explore the data.

Pumped Up Pop-Ups

Mixing and matching pop-up content elements, such as attributes, images, and text, lets you logically organize information for your map's viewers. Easily reorder content elements by dragging them. Add attachments to pop-ups by choosing from the multiple image attachments that automatically appear in a carousel. The Map Viewer can dock pop-ups, improving the viewing experience on mobile devices.

Currently, the new Map Viewer is available only to ArcGIS Online users, but in future releases, it will be available in ArcGIS Enterprise. Resources for getting started, as well as feedback and discussion forums, are available in the ArcGIS Online Map Viewer Beta GeoNet space at go.esri.com/GeoNetMapViewer. Learn more about this next generation mapping tool at go.esri.com/MapViewerBeta.

Harness the Power of Location *in the Internet of Things*

The massive amounts of real-time sensor data collected by organizations has the potential for creating smarter systems, but organizations need to make sense of it. ArcGIS Analytics for IoT, a new, real-time, big data processing and analysis capability of ArcGIS Online, can help organizations use this data to gain spatial insight and awareness. It works at scale in the Esri Geospatial Cloud to process streaming and historical observations from Internet of Things (IoT) devices. It requires no deployment or maintenance.

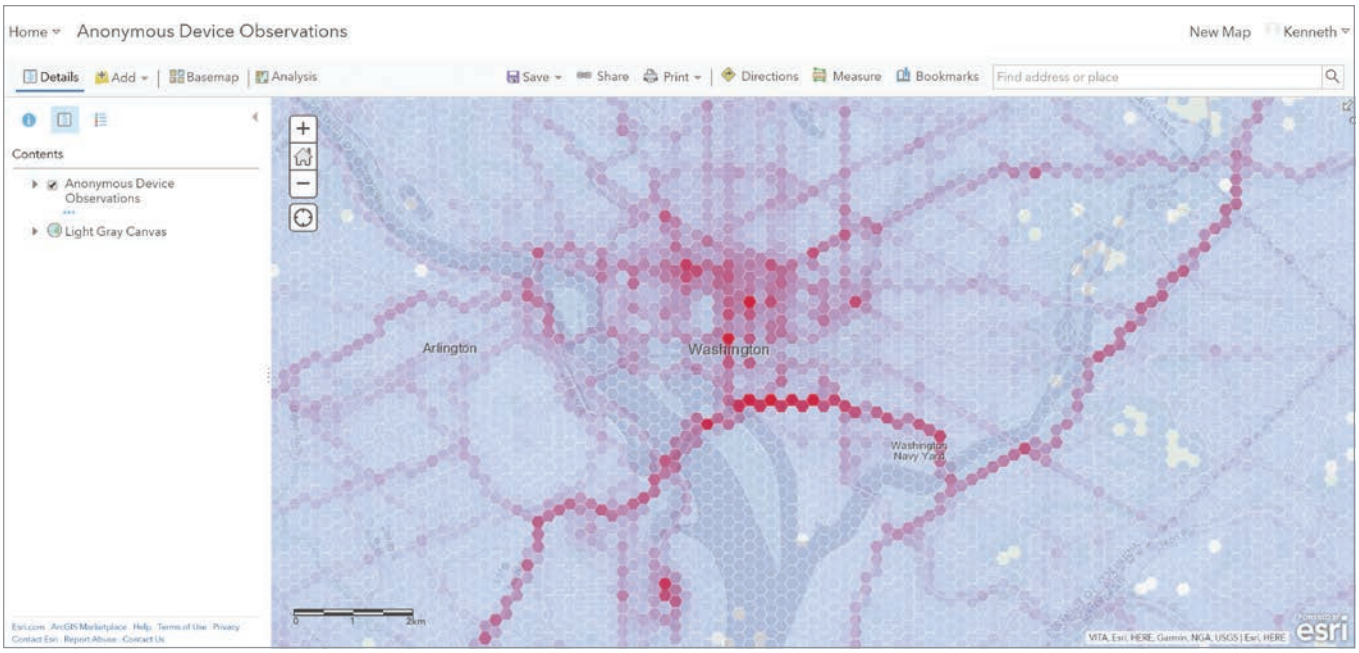
Analytics for IoT can ingest, visualize, analyze, and act on data from IoT sensors. The modern, streamlined user experience enables users to effortlessly tap into sources of observation data and make it available to anyone in an organization. GIS analysts, operations officers, and data scientists can analyze streams of real-time sensor readings or existing historical data.

The diverse set of data connectors and analytic tools in Analytics for IoT supports workflows for industries ranging from city agencies and electric utilities to commercial companies and nongovernmental organizations. Analytics for IoT capabilities can

- Connect to IoT systems to visualize sensor observations.
- Geofence areas of interest to detect the spatial proximity of events.
- Process high-velocity and high-volume data.
- Enrich and filter observations to focus on the most interesting event data.
- Provide data management as a service when data has grown in real time.
- Cut through the noise in the data and identify important incidents and trends.
- Apply spatial statistical analysis and machine learning tools to large datasets.
- Provide a cloud solution for real-time and big data workflow.

With Analytics for IoT, users can configure feeds and ingest streaming data to immediately visualize real-time information in web maps and dashboards. Real-time data can be brought in over HTTP and from cloud platforms such as Microsoft Azure IoT and Amazon Web Services (AWS) IoT or consumed from industry-standard messaging technologies like Apache Kafka, MQTT, and RabbitMQ. Analytics for IoT also works

↓ With ArcGIS Analytics for IoT, users can configure feeds and ingest streaming data to immediately visualize real-time information in web maps and dashboards.



↑ Real-time data from sensors can be brought into ArcGIS Analytics for IoT over HTTP and from cloud platforms.

with IoT observations that have already been collected, such as data in ArcGIS feature layers or in external big data sources like Amazon Simple Storage Service (Amazon S3) and Azure Blob Storage.

Beyond data visualization, Analytics for IoT can filter, process, and use high-velocity event data to trigger action. Users can leverage virtually any kind of streaming data and automatically alert personnel when specified conditions occur. For example, an electric utility operations officer can construct a process to receive readings regularly from smart meters. When those readings indicate a power outage, Analytics for IoT can automatically notify the field crew closest to the affected area.

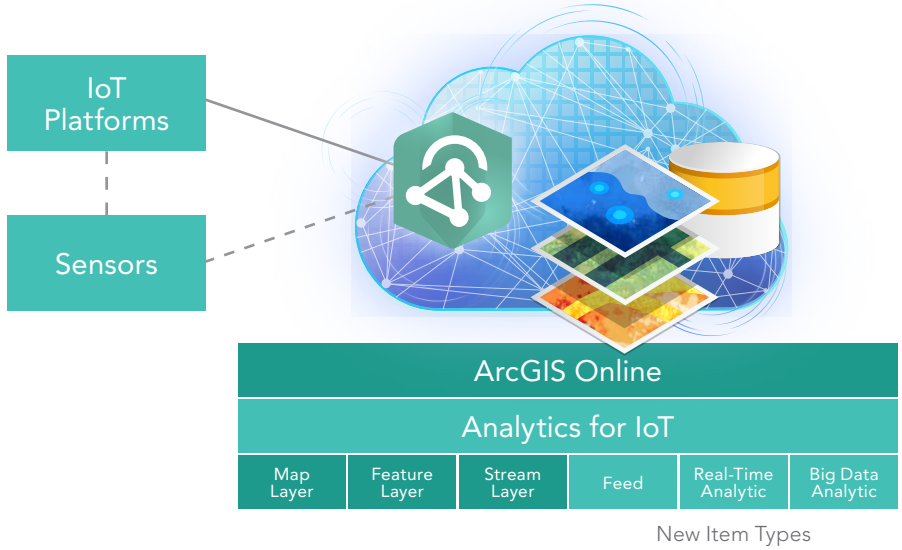
The real-time analysis tools in ArcGIS Analytics for IoT include fundamental and powerful spatial operators for

- Analyzing patterns.
- Finding locations.
- Managing data.
- Summarizing data.
- Using proximity.
- Data enrichment.

These tools can easily be combined to mine incoming information that's relevant to the mission at hand. Whether performing geofencing, detecting incidents, identifying trends, or finding areas of data clustering, Analytics for IoT has myriad ways to uncover hidden meanings in incoming data.

While Analytics for IoT is well suited for workflows that deal with observations received from IoT devices and sensors, users can also employ it to work with nearly any source of real-time or big data. For instance, users could design an analytic model to process high-volume historical crime data to assess patterns and trends or summarize human movement data in urban areas to better understand how workday population cycles ebb and flow. In addition, analysis results can be stored in ArcGIS so they can be shared with key stakeholders or further explored and evaluated on maps. Users can also deliver their results to external cloud stores, such as Amazon S3, for additional processing.

ArcGIS Analytics for IoT unlocks the power of location in the Internet of Things. With this capability, smart cities, federal agencies, utilities, oil and gas companies, retailers, and many other organizations can start taking advantage of the IoT in innovative ways and gain real-time visibility into day-to-day operations. This increased situational awareness supports data-driven decision-making at both the right time and the right place.



Argentine Coast Guard Improves Coastal Policing with Real-Time, Big Data System

As recently as five years ago, the Argentine Coast Guard, or Prefectura Naval Argentina, faced an uphill battle. It patrolled miles of coastal waters, monitoring vessels for illegal activities such as drug smuggling and fish poaching. However, implementation of real-time technology to track and analyze its patrols has improved the naval prefecture's decision-making processes and made them more effective.

Prefectura Naval oversees an area of almost 1,400,000 square nautical miles (4.8 million square kilometers) of water along the Argentinean Exclusive Economic Zone (EEZ), which extends 200 nautical miles from the coast and encompasses more than 3,800 kilometers of waterways. Portions of these waterways traverse lush subtropical forests that are attractive routes for smugglers and drug traffickers.

"We had very little information about the use of our seas," said Ernesto Miguel Klocker, the director of informatics and communications for Prefectura Naval.

Previously, the coast guard's primary enforcement tool was vigilance: constant patrolling and investigation of all ships within the porous, 200-mile EEZ border. The coast guard, as part of the Ministry of Security of Argentina, deployed ships, helicopters, and observer planes to protect the EEZ from illegal fishing activities.

Vessels would attempt to sneak into the zone to poach fish or conduct illegal activities. The only way the coast guard could get evidence of poaching or illegal activity was through patrolling the area, confirming the activity visually, and taking appropriate action. The process was limited by the number of patrolling ships and confined by the effective reach of its radar.

The process of accurately identifying and tracking illegal activities was time-consuming. Data was stored on isolated, multiple systems. The coast guard could only see a portion of the information at one time. Getting a complete picture of the activities of a specific vessel required working with different systems and calling on an analyst to create a report to charge the illegal vessel. Prefectura Naval faced the same challenges patrolling internal rivers, such as Paraná and La Plata, where many smugglers of both drugs and people operate.

Esri distributor Aeroterra S.A. worked with Prefectura Naval to implement a real-time tracking system. Called Guardacostas Pro, it consists primarily of ArcGIS Enterprise and ArcGIS GeoEvent Server, with analysis capabilities provided by ArcGIS GeoAnalytics Server and ArcGIS Insights.

Vessels involved in illegal activities, such as poaching, usually do not transmit their positions. The real-time system monitors every vessel and alerts the coast guard immediately when vessels illegally encroach on Argentine waters. Through signal processing

↓ In addition to coastal waters, the Prefectura Naval Argentina safeguards 3,800 kilometers of waterways that wend through lush subtropical forests that are attractive routes for smugglers and drug traffickers.

↑ The coast guard, as part of the Ministry of Security of Argentina, deployed ships, helicopters, and observer planes to protect the EEZ from illegal fishing activities.

and radar images, mission control can track the positions of ships inside and outside the EEZ in real time and detect ships that are not transmitting their position.

Using ArcGIS GeoEvent Server, Prefectura Naval ingests and manages the data feeds, filters the incoming data for events of interest, and configures alerts to be sent out when needed. ArcGIS GeoAnalytics Server was also implemented to conduct deep analysis on the huge amounts of data collected to see trends and patterns. Not only is the whole process automated, but Prefectura Naval now also had a way to consolidate data from various systems for a common operating picture.

By using the ArcGIS platform, Prefectura Naval can now get data from different systems and combine it with geographic information to provide a complete operating picture. It can now track more vessels with more data than ever before, resulting in keen situational awareness and better enforcement.

The improvement over the previous manual visual system is striking. From just 3 million records from about 20 feeds, Prefectura's database has grown to more than 17 billion records coming in from 50 feeds. With ArcGIS GeoEvent Server, Prefectura can process 1,000 records per second and analyze them in real time.

The success of the Guardacostas Pro system has led to its wider adoption within the Ministry of Security. Prefectura Naval is rolling out Esri technology in other groups such as the federal police, the airport security police, and the national guard. The ArcGIS system is used to track assets through mobile phones, radios, and vessels with location sensors. Prefectura Naval also uses ArcGIS Enterprise sites to share data with other security forces to improve deployment of personnel in the field.

Gathering all the information available from different systems represented a substantial technical challenge. Since the implementation of the ArcGIS platform, data is received in real time and can be processed, displayed, and archived instantly. The information produced is available for security purposes, further analysis, inclusion in statistics, and levying fines. The Guardacostas Pro system helps Prefectura Naval Argentina meet one of its most important objectives: having a full view of the area under the control of the Argentine Maritime Authority.

High-Fidelity Insight from Medium-Resolution Imagery

By Jim Baumann

↑ The image on the bottom, captured by Planet on July 17, 2019, shows Puerto Cabello, the largest and busiest port in Venezuela. The areas of interest, defined by an analyst, are outlined in red. The image on the top shows the vessel segmentation mask produced by the PISCES algorithm applied to show ships.

At any given time, more than 50,000 ships are at sea or in port throughout the world. These include military ships, cargo ships, tankers, and commercial fishing vessels. While most are engaged in declared (and legal) activities, monitoring ship movements is a critical part of United States' frontline defense from potential threats to national security.

Key to this monitoring process is the collection and analysis of satellite imagery to produce geospatial intelligence (GEOINT). The National Geospatial-Intelligence Agency (NGA) is the primary source of GEOINT for the United States Department of Defense (DoD) and the 16 other US intelligence community agencies.

Analyzing and disseminating GEOINT is complex. NGA embeds analysts at US military, diplomatic, and allied locations around the world, including DoD combatant commands such as the United States Southern Command (USSOUTHCOM).

USSOUTHCOM is responsible for the landmass of Latin America, south of Mexico; the waters adjacent to Central and South America; the Caribbean Sea; the Gulf of Mexico; and a portion of the Atlantic Ocean. Its duties include operations, contingency planning, and security cooperation.

Automating the Image Analysis Process

In 2018, NGA set a mission goal to enhance the speed at which it provides insight to its partners, the precision of its assessments, and the scope of its mission through artificial intelligence, automation, and augmentation (AAA). To achieve this goal, USSOUTHCOM and NGA developed the Port Imaging Ship Change Exploitation Service (PISCES), which monitors port activities in about 20 countries, 60 port facilities, and over 150 geofenced areas of interest within these ports.

"This is a machine learning initiative that is fundamental to the command's port monitoring and pattern of life understanding efforts and falls in line with the broader AAA initiative as a computational system," said Michael Kurey, an NGA senior geospatial analyst at USSOUTHCOM.

PISCES was developed to overcome the constraints of limited resources and personnel. "The output is augmenting human intelligence by taking advantage of automation to achieve more efficient and accurate results than otherwise possible due to resource constraints and ever-increasing availability of data," said Kurey.

"USSOUTHCOM focuses on building relationships with the other countries within our AOR *[area of responsibility]*. The GEOINT we produce is used for monitoring rather than combat purposes," said Patrick Oakes, an NGA senior GEOINT analyst at USSOUTHCOM.

Imagery analysts were performing time-consuming visual interpretations of satellite imagery while continually getting new requests for analyses. An automated solution was needed to streamline and prioritize analysts' daily workflows as well as develop deeper insights. PISCES was designed to free up analysts to focus on higher-priority issues in the AOR while not relinquishing their duty to monitor facilities.

To accomplish this, PISCES first needed to automatically segment vessels in imagery using a computer vision algorithm. In late 2016, the first proof of concept was attempted by the USSOUTHCOM Planet Power User Working Group using features designed to categorize a given pixel as water or not water, based on its spectral properties across the red, green, and blue (RGB) image bands. This provided evidence that medium-resolution imagery might be useful in monitoring maritime port activity.

Based on the positive result of this experiment, engineers on the 3GIMBALS COGINTTM team at USSOUTHCOM created a robust machine learning computer vision algorithm that could make assessments involving varying water spectral properties, image quality, cloud cover shadows, and other factors. To do so, the engineers trained a neural network using annotated images. The resultant model was very effective at segmenting vessels under varying conditions.

"Our application takes advantage of high-temporal cadence imagery," said Oakes. Medium-resolution imagery of the same geographic area is processed on a nearly daily basis in the PISCES model. That imagery is obtained from Planet, a US-based company that maintains the world's largest constellation of earth imaging satellites, which scan the earth's entire landmass each day.

Planet's Dove constellation is used to support the PISCES model. Dove CubeSats, designed and built in-house in San Francisco, California, collect orthorectified imagery in four spectral bands (red, green, blue, and near-infrared) at 3- to 5-meter resolution.

The PISCES Workflow

USSOUTHCOM'S PISCES initiative began with a port listing obtained from the United States Transportation Command (USTRANSCOM), which is responsible for monitoring all waterways and ports worldwide.

Once a port is determined to be of interest, imagery analysts create geofences around specified AORs. These geofences are saved in GeoJSON, an open standard geospatial data interchange format, and ingested into the PISCES model for use in ship segmentation.

ArcGIS Enterprise connects directly to the PISCES database to pull the resultant algorithm predictions. As the algorithm runs, its results are automatically discovered by ArcGIS GeoEvent Server and appended to the feature class. This information is visualized in Operations Dashboard for ArcGIS using ArcGIS Arcade (an expression language) to render symbols using clustering that summarizes information for an AOR at different zoom levels. Dashboards let analysts summarize the entire AOR at both spatial and temporal scales and perform aggregation across both to quickly see summaries of anomalous activity in graphic form. Because the dashboard is on demand and self-service, it is an improvement over traditional weekly summary emails.

"This helps them develop meaningful insight from PISCES by visualizing events and performing trend analysis. A decision-maker can quickly visualize top-level summaries, and an analyst can drill down to discover additional details," said Kurey.

USSOUTHCOM plans to utilize ArcGIS GeoEvent Server to append additional feature classes statistically summarizing aggregated assessments across time and space to render more powerful strategic stories. One idea for increasing PISCES capabilities would be to integrate its results with data from systems that automatically track ships. Vessels fitted with transponders broadcast identification, position, course, and speed. Integrating this data would enable the identification of specific vessels.

The Future of Machine Learning at USSOUTHCOM

In the future, USSOUTHCOM would like to adapt the feature segmentation algorithm framework and methodology developed for PISCES for both air and land domains. Rather than creating multiple individual dashboards, one comprehensive dashboard would include air, ground, and sea domains. All data would be stored in the same portal, and analysts could simply select an environment of interest.

"We believe our experiences with PISCES and the machine learning process would allow us to establish these new projects much faster. We would also like to make greater use of the results we obtain from PISCES by using the predictive analysis tools. This will allow us to better analyze ship movement trends in order to anticipate future events in our monitoring process," concluded Oakes.

About the Author

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

↓ PISCES machine learning computer vision algorithm segments vessels as seen in the left-hand image of Carrefour Lafiteau, a port town in Haiti near the capital of Port-au-Prince.

Using GIS to Build Safer Highways in the Skies

By Daniel Bradshaw

It's no secret that the popularity of drones, for both commercial applications and recreational use, has exploded over the past few years. In the US alone, drone registrations currently stand at nearly 1.5 million units according to the Federal Aviation Administration (FAA).

How well are local communities prepared to handle this new kind of traffic?

State and local governments work diligently to ensure the safest possible conditions for vehicular traffic on the ground. With the growth of drone activity, a new system of traffic control is needed in the skies above. Although entities, such as the FAA in the United States, have long had protocols for maximizing safety for manned aircraft, how will unmanned aircraft, or drones, be managed?

Working Together

The FAA has adopted a collaborative approach for sharing local airspace between government and private industry with the introduction of the UAS Data Exchange, an umbrella organization. The Low Altitude Authorization and Notification Capability (LAANC) is the first of several partnerships UAS Data Exchange will support.

LAANC is intended to directly support the integration of unmanned aircraft

← How well are local communities prepared to handle drone traffic?

system (UAS) vehicles into US airspace. Other countries have adopted similar initiatives, such as the Swiss U-space or Drone Alliance Europe. In each case, regulators want to support technology innovation while still providing air traffic professionals with information on where and when drones are operating. Although much work remains to be done, early integrations have strengthened these programs and are paving the way for continued growth.

With growth in mind, safety remains the priority for federal regulators when considering drone integration. Despite education and technological solutions, drones are still sometimes found in places where they do not belong. A recent study by Embry-Riddle Aeronautical University that was published in the *International Journal of Aviation, Aeronautics, and Aerospace* in 2018 looked at drone flights over a two-week period around Daytona Beach International Airport. The results showed that 21 percent of flights exceeded the recommended maximum altitude for the area in which they were operating, creating an inherent airborne risk.

However, with so much focus on what's going on in the air, the stakeholder with a more down-to-earth perspective remains underutilized: local government. GIS data, already being maintained by a community, can be the source for current, on-the-ground information used to enforce drone regulations within that community and pave the way for constructing a new UAS infrastructure.

Community Safety and Risk

What would happen if a 20-pound drone, plus payload, crash-landed in your community? The wealth of GIS information generated by cities can help answer questions like this one. Land use, land cover, slope, building footprints, street centerlines, school locations, and other GIS data that cities maintain can be used for drone risk analysis.

Some cities utilize computer vision (the ability for computers to see) or remote sensing processes to conduct urban analysis projects. For example, using artifical intelligence (AI) and GIS, workflows can be developed for calculating the number of vehicles in a parking lot to estimate how many people are in the area at a specific time, which could inform risk analysis for operating drones over specific locations.

As drone egress and ingress locations proliferate, GIS will help community officials place and approve individual or common landing hot spots. Regulating these locations may rely on a process of permitting that incorporates automated approval/denial decisions based on risk data, visual inspection, and operation verification to help satisfy safety requirements. GIS already plays an important role in existing permitting workflows, and the progression into UAS infrastructure will be a natural extension of this process for many communities.

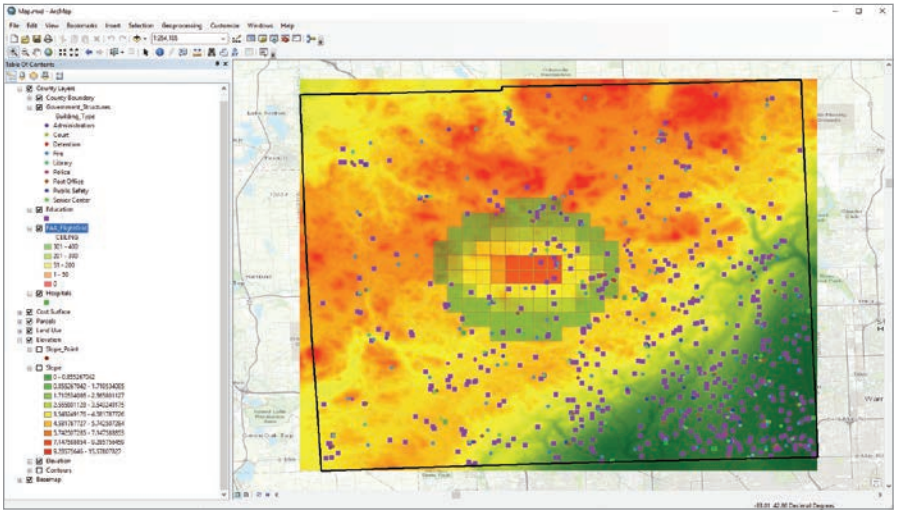
Drones and Raster Analytics

Perhaps the gold standard many drone technology evangelists are working toward is the operation of drones autonomously or remotely from the pilot's location. Known as Beyond Visual Line of Sight (BVLOS), these modes of drone operation are *not* allowed in most regulated environments. A better understanding of the types of paths a drone would take if left unmonitored is required before these restrictions will be lifted.

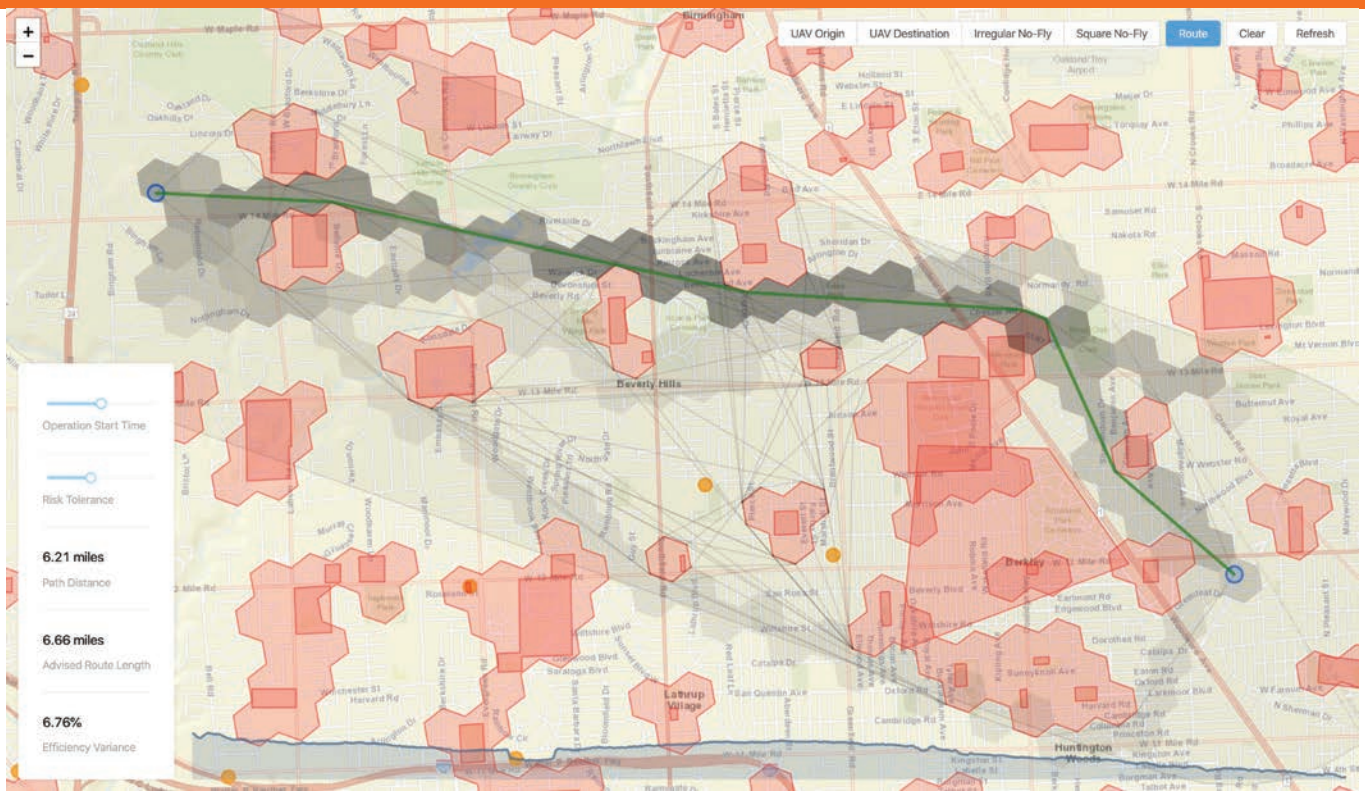
By most measures, an "as the crow flies" path is usually the optimal one for any given drone operation. This is especially true with limited onboard battery storage. Dynamic variables, such as weather, can make total battery life unpredictable. Unfortunately, a straight-line path is not always the safest path, and safety must be the controlling factor for mission planning.

Utilizing community data, raster analytics can be put to work to generate BVLOS risk analysis for drones. Part of this analysis is deriving a cost surface. By chaining together raster functions (image processing algorithms), a data product can be derived that represents the cumulative risk for operating drones over specific geographies based on datasets provided by local government.

A cost surface empowers decision-makers and automated systems to calculate the optimal travel path over the length of the planned mission. Given any origin and destination, this path will have the least accumulated risk. This capability will



← Various risk factors are gathered to generate cost surfaces. Cost surfaces provide a basis for making decisions about least risk corridors.



↑ Drone operations generate usage statistics for discrete sections of airspace. Regular traffic could potentially generate "cooldown" periods to avoid overuse.

enable use cases such as point-to-point delivery, remote inspections, and "drone in a box" (i.e., drones launching autonomously from remote charging stations).

GIS Supporting the UTM Ecosystem

In addition to static risk analysis, many countries are also developing Unmanned Traffic Management (UTM) ecosystems that tightly integrate existing manned aircraft services with unmanned drone operations. GIS would be key to keeping these types of operations location aware.

For example, imagine that a delivery drone flying a preprogrammed route happens to cross paths with a medical helicopter airlifting someone out of an area. With a functioning UTM system, the drone and the helicopter would communicate automatically and avoid a collision. Alternatively, in this example, the drone would be flying in an established drone corridor, and the helicopter pilot would allow for that in formulating the flight plan.

In a UTM ecosystem, emergency managers in communities will use GIS tools to grant authorizations to drone service providers, issue notifications to drone operations regarding air and ground activities relevant to their safe operation, and share this information with multijurisdictional stakeholders.

Aside from safety, urban designers are often concerned about sound levels in neighborhoods. Mechanical buzzing doesn't fit with anyone's idea of a pleasant community. GIS can be incorporated into applications that track the number of flights intersecting subsections of a city and "deactivate" airspace for a predetermined cooldown period. In the future, urban airspace designers will construct drone corridors using a combination of risk and noise pollution factors.

Conclusion

As technology advancements push innovation into the skies, cities can lean on GIS data already being generated by local governments to prepare for and benefit from a Jetsonian future rather than reacting to issues arising from unregulated drone activity in local airspace.

Airspace Link, a certified FAA UAS Service Supplier (USS) and an Esri partner, is building solutions that incorporate existing geospatial data gathered by communities for the implementation of sustainable drone infrastructure that meets the needs of state and local government. By collecting, analyzing, and delivering the most relevant community data to the drone industry, Airspace Link helps maximize safety from both ground- and air-based hazards.

For more information, contact Daniel Bradshaw at daniel.bradshaw@airspacelink.com or visit airspacelink.com

About the Author

Daniel Bradshaw is the chief technology officer of Airspace Link. He is an ardent disciple of geospatial problem solving and has 20 years of experience architecting geospatial software solutions across a wide industry cross section, including all levels of government, Fortune 500 organizations, and startups.

Your Winter Prep List for GIS Cloud Migration in 2020

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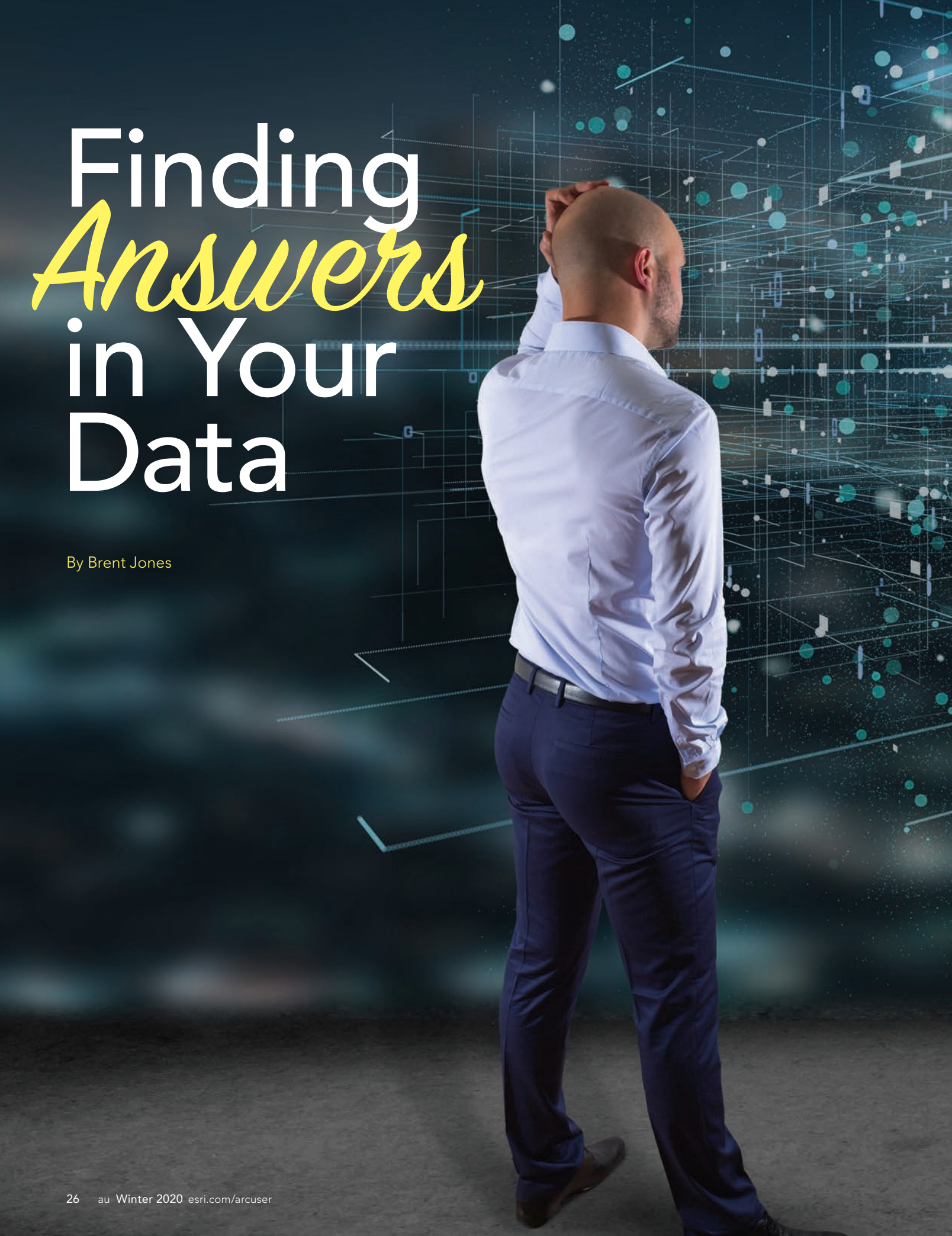
Finding *Answers* in Your Data

By Brent Jones



What do you want to *learn from your data?*

In my last article, "Innovating with Data," in the fall issue of *ArcUser*, I discussed how you can extract value from a sea of data by using GIS tools you may have overlooked, such as Operations Dashboard for ArcGIS and ArcGIS Insights.

But what if you just don't have the data you need to get the answers you need? I'm not sure how to say this, but your data isn't as good as you think it is.

No one's data is.

Although we use it every day and it gets the job done, our data could be cleaner, more accurate, and more complete. Valuable core capabilities of GIS can improve your data. By applying spatial analysis and visualization tools in GIS, you can detect gaps, errors, and outliers in your data. Going farther, you can gain more value from your data by location enabling unstructured data or leveraging machine learning for better analysis.

But that's still not enough. Augmenting your data with external data using the ArcGIS GeoEnrichment Service is an extremely powerful capability that is enabled by GIS. It is a force multiplier that joins data together using location to unlock the answers to questions such as

Where do I site a new store?

How can I improve fire preparedness?

What factors are impacting property values?

These are just a few of the questions that can be better answered by incorporating GeoEnrichment.

You can access the vast amounts of data available across the ArcGIS platform to enrich your analysis using solutions such as ArcGIS Business Analyst and ArcGIS Community Analyst. For example, thousands of variables on recreational, retail, and medical expenditures—as well as demographics describing populations by age, income, education, and many other dimensions that can enhance your analysis and visualizations—are available from these solutions.

For example, enriched data can be accessed using ArcGIS Business Analyst, which is available as an extension for ArcGIS Pro, as a web app, as a mobile app, and as a widget for Web AppBuilder for ArcGIS. ArcGIS Business Analyst provides powerful analysis, visualization, and mapping capabilities that leverage these comprehensive datasets and use preloaded, easy-to-configure reports for understanding and sharing analysis results. You don't have to be a GIS expert to use these solutions and data, either.

It's been said that data that is not used has no value, but data that is not used to its full potential is an underutilized asset. If you don't enrich your data, you are missing the opportunity to get the most from your data.

You want to use the best data available so you can be confident in your analyses. You want to make the best decisions you can. Enriching your data will help you find the answers you seek.

About the Author

Brent Jones oversees Esri's worldwide strategic planning, business development, and marketing activities for land records, cadastre, surveying, and land administration. As a recognized innovator, Jones specializes in modernizing existing land administration systems and designing new GIS-based cadastral management systems for small and large governments globally. He is a professional engineer and professional land surveyor. He is also a past member of the URISA board of directors, past president of the Geospatial Information and Technology Association, and a current member of the United Nations Committee of Experts on Geospatial Information Management, sitting on the Expert Group on Land Administration and Management.

Why Organizations Need a Geospatial Strategy

An executive perspective

By Matthew Lewin

"Why do we need a geospatial strategy?"

asks a skeptical CIO.

It's a fair question, but no matter how often I'm asked, I find I'm caught slightly off guard. Because if what they mean is, why does this geospatial stuff matter, and why is it worthy of a strategy, then the importance of *geo* at the executive level is still unclear.

That may be why the question is asked with a tone of skepticism, implying a geospatial strategy really isn't important—not on the level of a marketing strategy or a talent strategy or a climate strategy. These strategies address issues of critical importance, so (obviously) a strategy is needed!

As someone who helps organizations devise geospatial strategies, I've often responded to this question without addressing the deeper issue: What makes a geospatial strategy actually strategic? What problem does it solve? What advantage does it create?

In articles and in person, I've talked about the mechanics of crafting a geospatial strategy. I've talked about best practices for implementing a geospatial strategy. Essentially, I've focused on the *how* of strategy and not the *why*.

Let me fix that right now.

Here are five reasons why organizations need a geospatial strategy:

- To unlock new sources of value
- To strengthen a digital strategy
- To enrich the customer experience
- To establish a shared data foundation
- Because the IT strategy missed geo

Unlock New Sources of Value

Organizations exist to create value for: customers through quality products and services; for shareholders through robust financial returns; for employees through satisfying work; for society through active corporate citizenship

It's all about value.

Location intelligence, the product of a geospatial strategy, empowers organizations to look at value creation in a different light. They can discover new routes to value by considering *where*.

When equipped with location intelligence, organizations can flip conventional business problems on their heads. How? By reframing them as problems of location.

This can be game changing.

For instance, take the financial services company USAA. As an insurer, USAA protects the assets of military members and their families. In 2018, the Woolsey Fire in California damaged thousands of homes and properties owned by USAA members. Processing that many claims could have taken months and required extensive manual effort to verify the validity of claims. At least it would have, if USAA had followed conventional thinking.

Instead, USAA looked to geospatial analysis for help. Using drones, USAA captured high-resolution imagery of the areas impacted by the fire. Then it used artificial intelligence (AI)—specifically, deep learning—to scour the imagery and spatially verify damaged versus undamaged properties. Using this approach, the process took hours instead of weeks. By thinking geospatially, USAA unlocked new value for stakeholders. This value translated into faster claims for customers, greater efficiency for claims adjusters, and more stability for communities.

On its own merits, this is a strong example. But the big payoff comes from driving this kind of geospatial innovation continually and taking it from a one-off project to a core capability of a business. That's why a geospatial strategy is so important. It creates an enduring ability to unlock new sources of value.

Strengthen a Digital Strategy

As digital technology and business models transform industries, organizations are scrambling to respond with their own digital strategies. Their results vary considerably.

According to a survey of executives published by McKinsey & Company in April 2019, 8 in 10 organizations have established a digital strategy, but just 14 percent have realized major performance improvements. Even fewer have been able to sustain these improvements.

Organizations that report success point to several key factors. Chief among those factors is focus on implementing solutions that make information more accessible. This is where a geospatial strategy makes its mark.

A large percentage of data is geospatial. Some researchers and geoscientists have indicated that 60 percent to 80 percent of data is georeferenced in some way. Despite this, many digitalization efforts fall short when it comes to the geospatial dimension. Even though the raw data may be accessible, the tools and know-how needed to reveal insights locked away in the geodimension are not. To bolster a digital strategy, organizations need a geospatial strategy that ensures the avalanche of geospatial information generated can be leveraged.

BP, the British multinational oil and gas company, recognized this in its digital

"To bolster a digital strategy, organizations need a geospatial strategy that ensures the avalanche of geospatial information generated can be leveraged."

transformation program. A major goal of BP's strategy was to improve data access across the organization. To do this, the company adopted an official open-by-default mandate, which made approximately 95 percent of geospatial data available to users.

However, BP also recognized that geospatial data on its own is only so useful. Consequently, it ensured that its users had the right tools to exploit this data and were encouraged to become "citizen developers." As a result, BP saw an explosion in the number of maps, geospatial apps, and dashboards across the organization.

Clearly, digital transformation is challenging. Having a complementary geospatial strategy to implement the right mix of specialized tools and capabilities can help to accelerate a digital vision.

Enrich the Customer Experience

Transforming the customer experience is among the top priorities for modern CEOs. In fact, "Customer Experience Is the New Brand," an article in the July 15, 2018, issue of *Forbes* magazine, notes that an amazing 89 percent of organizations indicate they compete primarily based on customer experience. It's not just what you sell anymore but also how customers engage with your products and services that sets you apart.

Improving the customer experience enhances the customer journey. Understanding this journey involves mapping out all the ways a customer engages with your business and identifying the interactions that drive customer satisfaction. Organizations monitor these interactions and adapt their products and services to improve the customer experience.

The opportunity for innovation lies in discovering new ways of connecting with customers at crucial points along the customer journey. Enter geospatial technology and the concept of hyperlocalization, which personalizes customer experiences based on location.

For utility providers, a customer's experience during a power outage is a significant driver of overall satisfaction. Creating a personalized experience—from the time of an outage to when power is restored—is a strategic focus for all providers. In fact, during a severe weather event, that experience often begins even before the outage occurs.

Many utility providers use geospatial technology to deliver localized outage communications before, during, and after an outage. Before an outage, publicly available outage maps and notification systems alert customers of potential severe weather events affecting their homes or businesses. These alerts aren't broadcast blindly. They are sent where the weather impacts will likely be experienced.

During an outage, customers can see the status of their property and neighboring areas on mobile devices as well as the estimated time until power will be restored. They are provided guidance on navigating the outage. Once power is restored, customers are notified and provided with channels for feedback.

A geospatial strategy that enables precise localization enriches and deepens the customer experience. It's like adding rocket fuel to the customer journey.

Establish a Shared Data Foundation

Geospatial data is ubiquitous. Often, we don't even realize we are using it. From logistics to customer analytics to health and safety management, geospatial data is an essential part of the knowledge base of most organizations.

The problem is, many organizations haven't adjusted how they collect, manage, or share geospatial data. Data is still primarily acquired and maintained through projects or by a specific department. Duplicate data purchases are common. Disconnected datasets and poor integration are rampant because geospatial data isn't considered to be a strategic asset.

Without a common geospatial data foundation, organizations struggle to support a business environment that increasingly requires collaboration across the enterprise. The vision of Norway's national geospatial strategy, described as "Everything happens somewhere," addresses this issue. As part of its Digital Agenda, the country is advancing a national knowledge base of geospatial information that collates data from many government sectors and industry partners. For Norway, a common geospatial data infrastructure is vital for addressing societal challenges such as climate change, international trade, emergency planning, and urbanization.

In the digital world, data is king. A shared foundation of geospatial data is fundamental to the new reality of this digital world.

The IT Strategy Missed Geo

While many organizations don't have a geospatial strategy, they likely have an IT strategy. So why another strategy? Isn't the IT strategy good enough?

My experience is that it's not good enough. Not because it's not a solid piece of work, but because usually an IT strategy glosses over the geospatial function because geospatial technology is not the focus. It's not uncommon to see the geospatial discipline relegated to a single line item in an annual budget. The IT strategy promotes a vertical, technology-centric view as opposed to a horizontal, capability-centric view.

To do great things with geo on an organizational scale, geo needs to be treated as an organizational capability. Building a capability requires a strategy. That's why, in a broad sense, you need a geospatial strategy. You need to define how your organization wins with location intelligence. Geo shouldn't be a footnote to an IT strategy but a primary focus of your business.

About the Author

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

"To do great things with geo on an organizational scale, geo needs to be treated as an organizational capability. Building a capability requires a strategy."

Enhancements for Mapping More Data, More Efficiently in the Browser

By Kristian Ekenes

Visualizing large spatial datasets on the web has always been a challenge. Over the last couple of years, Esri has made substantial improvements in its software that allow you to visualize and interact with larger amounts of data efficiently in the browser.

A web map containing more than 550,000 polyline features that represent water distribution pipes in Bangkok, Thailand, will illustrate the effects of these enhancements on performance when using modern web technology available in the ArcGIS API for JavaScript, ArcGIS Online, and ArcGIS Enterprise to render all this data in a single view.

More Data Is More Challenging

Effectively rendering large datasets in web apps, such as the water distribution pipes in the example, presents several interrelated challenges. Large payloads in query responses (lots of data) mean more storage space and more data needs that are delivered for each query.

Larger payloads lead to longer wait times from server queries. When the client requests a heavier load from the server, you should generally expect it to take a little longer to be delivered to the client.

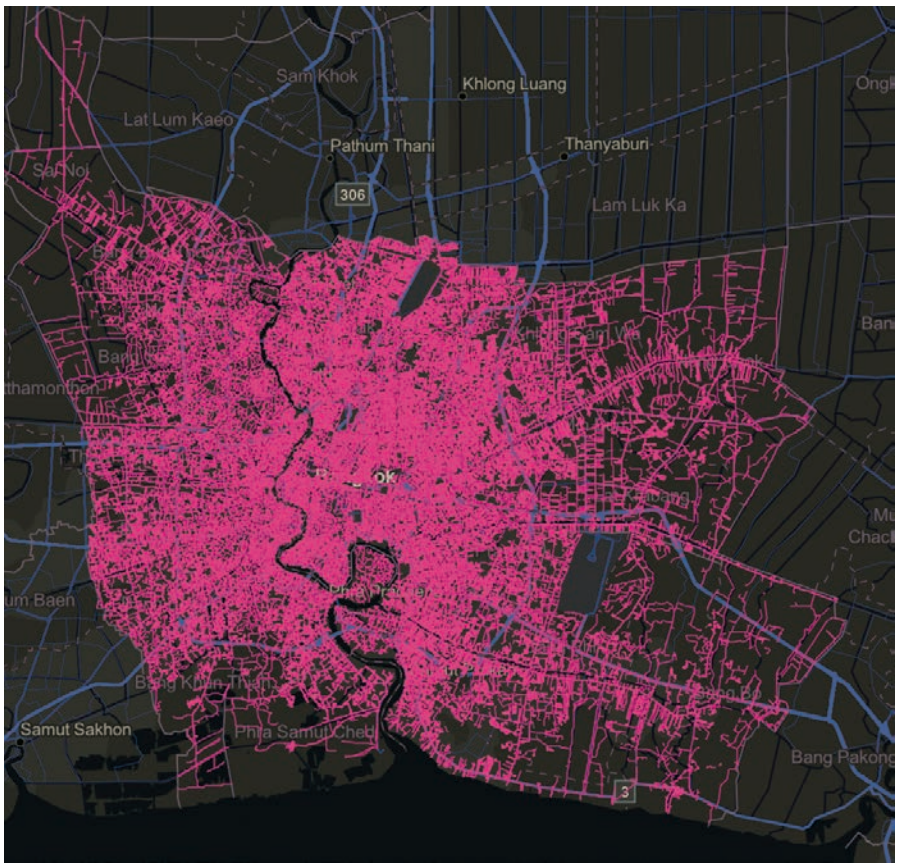
Larger payloads also lead to longer drawing times. When the browser downloads a large amount of data, the drawing engine used to render the data has more vertices to draw. It will take more time to draw the lines. The effects of these challenges can snowball, creating a slow app and a bad user experience.

Minimize Payload Size for Faster Apps

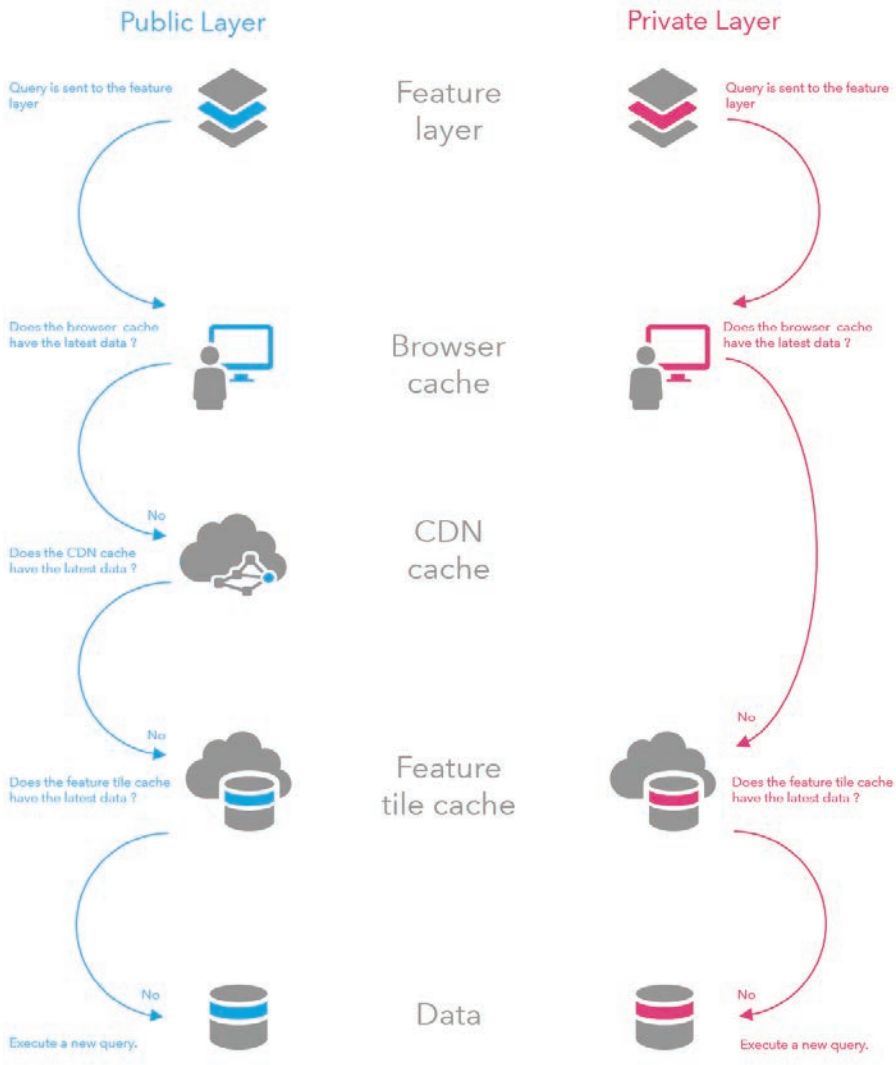
If the size of the dataset is the root of the problem, then the solution lies in decreasing the size of each query's payload. Use the following methods to minimize the size of the dataset. A query of a 6.5 MB dataset with 10,000 lines with time to fetch of ~11 seconds is used as a baseline for measuring performance improvement as each method is applied.

Compression

Queries to ArcGIS Online hosted feature services (not ArcGIS Enterprise services) are compressed using Brotli compression *[a generic-purpose, lossless compression algorithm]* that significantly reduces payload size. The query response payload for the 10,000 lines previously mentioned,



→ The web map, containing more than 550,000 polyline features representing water distribution pipes, will be used to illustrate performance enhancements in recent releases of the ArcGIS API for JavaScript, ArcGIS Online, and ArcGIS Enterprise.



↑ Figure 1: Feature tiles cached in tiers

including all geometries and attributes, decreases by 65 percent when compression is used.

Quantization

Highly detailed geometries can substantially increase payload size. Higher precision geometries (i.e., more vertices and/or more floating-point precision in the coordinates) require heavier lifting by the server.

Quantization is the process of thinning vertices based on a given tolerance in map units. Typically, the tolerance equals the resolution of the view (i.e., the length of one screen pixel in map units). This ensures coincident vertices that fall within the same pixel will be reduced to one vertex. If the size of an entire feature at a small scale (i.e., zoomed out) is smaller than the size of one pixel, then that feature will be dropped and won't render. Feature tile queries execute with a quantization tolerance equal to the resolution of the current scale, ensuring the layer is drawn in the most efficient way for the given view scale.

When the data is served by ArcGIS Online and ArcGIS Enterprise as hosted services or from your own database with ArcGIS Enterprise, even datasets that span large extents can be as precise as you want, thanks to quantization. After the client queries geometries from the database, the coordinates are quantized to reduce payload size.

Quantized coordinates for a polyline path are delivered in screen coordinates so that the first vertex represents the position relative to the tile origin. Each subsequent coordinate in the path represents the position relative to the previous coordinate (e.g., [345, 894], [+1, 0], [-1, -1], [0, 1]). This format is much smaller than raw coordinates and compresses well, which reduces the payload for each query, thus increasing the speed of the application.

For the baseline uncompressed payload size of 6.5 MB for 10,000 features, quantization, when added to Brotli compression, reduces the payload size by 85 percent.

Remove Unnecessary Attributes

Requesting data attributes that aren't required for rendering is one of the most common causes of unnecessarily large payload sizes. Often only one field is required for rendering. The polyline layer in the example contains 32 fields. By restricting the query to the one field needed for rendering, payload size is decreased from 6.5 MB to 52.6 KB. In conjunction with Brotli compression and quantization, limiting the request to one attribute reduces the payload size by 99.2 percent.

By default, the ArcGIS API for JavaScript requests only the attributes required for rendering. If other attributes are required, the appropriate requests are made to include those attributes. For highly interactive apps, it may be more beneficial to request all fields intended for use in the app up front so the user can explore the data without waiting for additional requests.

PBF

The ArcGIS API for JavaScript also requests data in protocol binary format (PBF) by default. Vertex encoding improves when data is requested in PBF, which leads to faster drawing times because less triangulation on the GPU is required. PBF reduces the payload size for the baseline query of 10,000 features by an additional 12 KB to 40.8 KB. The application of Brotli compression and quantization combined with limiting the request to one attribute and requesting data in PBF format reduces the payload size by 99.4 percent.

Caching: Reducing Client and Server Load

Even after implementing all these methods, the first query for the data may still take

several seconds before a response comes back. The actual download time is pretty fast, so most of the time is spent waiting on a response from the server. That's because a lot of data needs to be queried directly from a database.

When you publish a large dataset to the ArcGIS Online cloud as a hosted feature service, you immediately benefit from a system involving tile queries and several tiers of response caching that speeds up performance and reduces load on the client and server that occurs after the first query. Executing the same query for 10,000 features a second time shaves the response time down dramatically to between 100 and 200 milliseconds. Table 1 summarizes the cumulative reduction in payload size as each of the methods discussed is applied.

Feature Tile Caching

To avoid a few large requests, features are requested in tiles. This splits the query up into several smaller spatial queries. Tile requests have the benefit of being consistent across different users and apps. This consistency allows query responses to be cached in your browser and once on the server so they are shared among all users. This frees up the resources on both the server and the underlying database, allowing feature layers to scale to millions of users and clients without the need to explicitly generate tiles ahead of time. (However, ArcGIS Online does support generating tiles when needed.)

Feature tiles are cached in tiers, shown by the diagram on page 33. A feature tile cache can be persisted on the browser, server, or content delivery network (CDN). If a cache is requested using a client request, the underlying database doesn't need to be queried.

Cached responses from the server are automatically invalidated as the data is edited. This ensures that clients using the layer always get the latest information.

CDN Caching

CDNs are the backbone of a speedy internet. A CDN is composed of many servers within a network that copy or mirror content and deliver it to clients based on geographic location. For example, content published to the CDN from Japan can be quickly downloaded in Brazil if a CDN server on the same network is located in Brazil.

For publicly shared, hosted feature services, CDN caches query responses so everyone (not just you) using the same layer benefits from a smaller payload. The CDN is distributed all over the world and mirrors the cache. That means even if the servers hosting the data are located halfway around the world, the cache is most likely much closer to you, making it faster to download.

This is extremely powerful. While it may have taken my original query about 10 seconds to complete, anyone else executing the same query from the same service will get a cached response based on my original query in just a few milliseconds.

Server-Side Caching: Shared and Stored in ArcGIS Online

To protect the privacy of nonpublic services, layers shared only with users in your organization do not make use of the CDN response cache.

However, the internal infrastructure of ArcGIS Online also provides server-side caching so that other users in your organization can reuse the cache when the browser cache and the CDN can't be used. As a result, queries come back quickly, put less load on the underlying databases, and keep everything running smoothly at scale even under heavy load. (Future versions of ArcGIS Enterprise will have similar server-side capabilities available.)

Cache Control

You can further improve the performance of data loading by increasing the length of time the current cache is considered valid. The maximum amount of time you can set is one hour before updates are seen. This comes at the cost of users not immediately seeing updates to the data until the refresh interval kicks in.

Optimize for Scale

ArcGIS Online offers the option to selectively optimize different layers that contain complex polylines and polygons. This saves several versions of each feature's geometries at various levels of resolution, so the initial query for those features is faster. This benefit is most clearly seen in the initial query. Because of the caching described above, you may not see much of a performance difference after you load the data for the first time.

Since the example polyline dataset contains many vertices that will be viewed at small-to-medium scale, choosing this option will increase performance at those scales and maintain performance at larger scales but will come at the cost of increased storage space on the server.

↓ Table 1: Comparison of the cumulative effect of performance improvements applied to a baseline test dataset of 6.5 MB and 10,000 features.

Performance Enhancements Added	Payload Size	Percent Reduction in Payload
+ Brotli compression	2.3 MB	65
+ Quantization of coordinates	1.0 MB	85
+ Request only required fields	53 KB	99.2
+ PBF	40 KB	99.4
+ Feature tile cache	40 KB	99.4

You can optimize layers for drawing by checking the Optimize layer drawing option on the settings tab of the layer's item details page of ArcGIS Online.

Conclusion

You can visualize a lot of features on the web in a performant, interactive way. Although the ArcGIS API for JavaScript, ArcGIS Online, and ArcGIS Enterprise don't specify specific limits on the number of features you can display and analyze at one time, there are limitations. See the accompanying article "Visualization Best Practices" for some tips to improve the effectiveness of your web map while maintaining responsiveness.

Ultimately, the data size and feature limit for layers depends on factors including network bandwidth, your hardware (e.g., mobile devices won't allow you to download as many features as a desktop browser), and how much the browser can handle.

This article highlighted some of the ways the ArcGIS Online, ArcGIS Enterprise, and the web API teams at Esri improved performance over the last few releases. These teams are continually working to improve these products for future releases.

Paul Barker contributed to this article.

About the Author

Kristian Ekenes is a product engineer on the ArcGIS API for JavaScript team.

Visualization Best Practices

Just because you can visualize hundreds of thousands of features in a single view doesn't mean you should. You should always design your visualization in a way that communicates a meaningful message. Here are some things you can do when visualizing large datasets at small scales that will optimize performance and improve understanding. These tips reference a web map containing more than 550,000 polyline features that represent water distribution pipes in Bangkok, Thailand, that is shown on page 32.

Set a Visible Scale Range on the Layer

The Bangkok pipelines layer is detailed and dense. While you can view all data at the full extent of the layer, the data is more appropriately viewed at larger scales (i.e., zoomed in closer). A maximum scale of zero may be appropriate so the features are always viewable as you zoom in, but setting a minimum scale so that you can't view the data as you zoom out to view several neighborhoods at once may be more appropriate than viewing it at a citywide scale.

Thinning

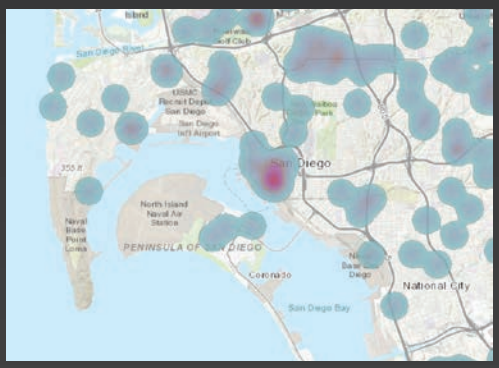
While quantization provides a certain measure of thinning out of the box, you can more aggressively thin your data using filters. For example, instead of turning layer visibility off at a citywide scale, you can display only large pipes at that scale and include the smaller pipes as you zoom in. Views of moderately thinned and aggressively thinned layers will appear almost identical because most of the small lines in the full dataset can't be seen.

Aggregation

ArcGIS Online and ArcGIS Enterprise allow you to cluster point data. When points become very dense, you can no longer make sense of your map. Clustering will reduce the number of visible features in the view by summarizing them as cluster graphics.

Binning similarly summarizes point data as polygon bins instead of icons. Keep in mind that client-side clustering and binning still require that all features be downloaded to the client before aggregation takes place. Server-side clustering and binning are available with ArcGIS Enterprise for enterprise geodatabase-backed services. These capabilities will be available in ArcGIS Online soon.

ArcGIS Online and ArcGIS Enterprise also provide aggregation analysis tools that create new layers for feature reduction and data summarization. Aggregation tools are intended for improving understanding, because displaying everything isn't always the best thing to do.



← One strategy for handling visualization of data that is detailed and dense is to use scale-dependent visualization (left). A heat map is ideal for visualizing large, dense point datasets at small scales (right). Setting a scale threshold lets the layer's renderer switch to discrete marker symbols that are more useful when conveying information at large scales.

Support for Powerful Utility Network Field Apps with 100.7

By Nick Furness and Rex Hansen

ArcGIS Runtime SDKs 100.7 continues the track-focused development introduced with 100.6. This release expands capabilities for utilities and provides additional defense and public safety enhancements along with more platform-driven functionality.

Utility Networks

As a framework for modeling electric, gas, water, stormwater, wastewater, and telecommunications systems, utility networks demonstrate how features are connected and how dynamic devices are configured. Development for utility networks at 100.7 includes more network trace options and introduces the SubtypeFeatureLayer. While the SubtypeFeatureLayer is important for utility networks, it is beneficial anywhere subtypes are used.

With the 100.7 release of ArcGIS Runtime SDKs, subnetwork, downstream, and upstream traces have been added to provide a full suite of options. The subnetwork trace discovers all features that participate in a subnetwork (i.e., a logical subset of the network such as a circuit or a zone). The downstream trace option finds out what is being fed from a specific part of the network. The upstream trace is useful to discover what's feeding a specific part of the network.

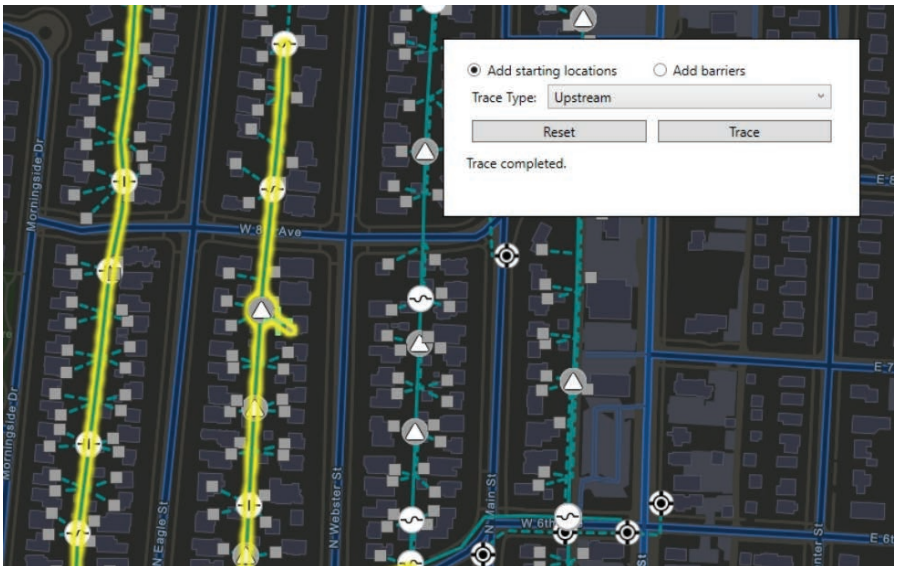
Building on the foundation introduced at 100.6, ArcGIS Runtime SDKs now supports a much richer collection of tracing options. Traces can be configured to stop based on complex attribute expressions or function barriers. Advanced attribute propagation is also supported so phase-based electrical traces can be authored. Connectivity associations and structural attachment associations can now be queried, and additional utility network schema information is available. Consequently, ArcGIS Runtime SDKs can now serve as the basis for truly powerful utility network field apps.

An ArcGIS Utility Network Management extension maintains real-world network element types, such as fuses, transformers, and switches, as subtypes in a single feature class. This benefits performance but can be challenging when customizing how each subtype is presented to the user as pop-ups or visible scale ranges, for example.

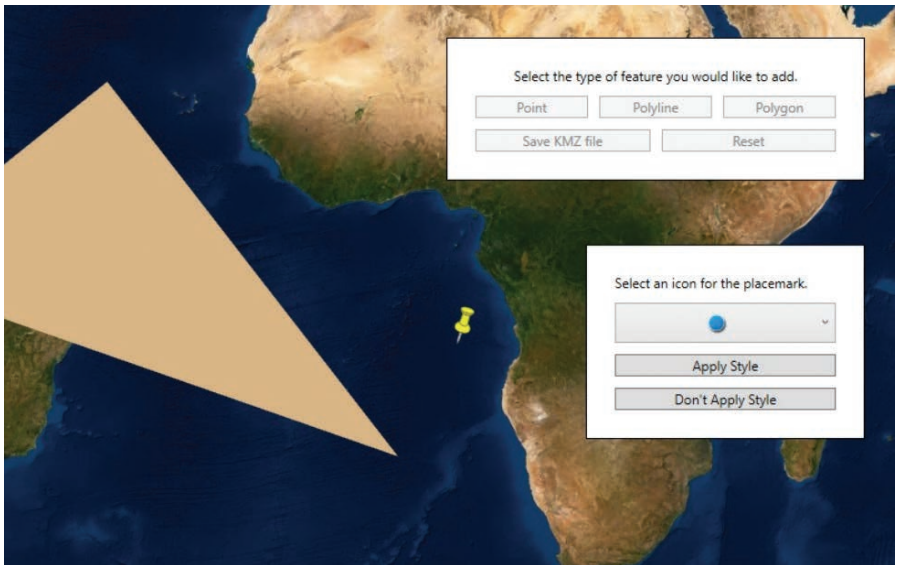
The new SubtypeFeatureLayer provides a clean solution for these challenges. When pointed at a single feature class, it acts as a group layer that automatically includes a feature layer for each subtype in the source feature class. These sublayers can be configured independently of one another, and queries are optimized across all sublayers. For example, a pan of the map sends a single request to the source feature class to cover all the sublayers. *(Note: Manually creating a feature layer for each subtype would have resulted in a query per feature layer.)*

Access to utility network data and analysis (e.g., tracing) now requires an extension license. However, the extension is not needed during development, only when deploying an app for production use. For named users, the Utility Network user type (available with ArcGIS Enterprise 10.8) can be added to a named user. A new ArcGIS Utility Network Management license key can be purchased for ArcGIS Runtime SDKs deployments. In either case, the extension enables licensed access to utility network functionality in the ArcGIS Runtime SDKs.

With the upcoming release of ArcGIS Enterprise 10.8, a new user type will be introduced for ArcGIS Utility Network Management extension, which covers the capabilities of utility networks across the platform. ArcGIS Runtime SDKs utility network licensing is rolled into the Utility Network user type and included with GIS Professional Standard and GIS Professional Advanced user types. It can be assigned as an add-on to all other user types, although the Viewer



← Discover connected features in a utility network using subnetwork, upstream, and downstream traces now available in 100.7.



→ Now you can construct a KML document and save it as a KMZ file.

user type will be limited to viewing and tracing utility networks.

Augmented Reality

Tabletop was one of the three augmented reality (AR) modes introduced with the ArcGIS Runtime 100.6. With this mode, the developer provided a scene to the ArcGIS Runtime Toolkit's AR component and determined the surface on which to place it. With version 100.7, the scene can be clipped for a better fit to the surface specified. In addition, various optimizations for downloading scenes more quickly and efficiently were incorporated. Other improvements enable

- Use of a map's reference scale with graphics overlays.
- Use of scale-based symbol classes for layers delivered via mobile map packages (MMPKs).
- Working with Preplanned Areas defined by polygons.
- Use of custom styles for vector tile package (VTPK)-based layers in MMPKs.

Defense and Public Safety

Improvements for the defense and public safety track enhance symbology and working offline. Marker symbols draped on the ground in 3D scenes can be displayed either billboarded or flat. Mobile scene packages (MSPKs) can include rasters as elevation sources and transportation networks. Rasters can be read directly from an MMPK or MSPK without unpacking it. ArcGIS Runtime apps can now also create and edit KML screen overlays. Previously, KML files could only be displayed.

Licensing by User Type

User types can now enable all levels of ArcGIS Runtime licenses via an ArcGIS Online or ArcGIS Enterprise named user login. Named user logins now enable Standard and Advanced level licenses. A new Runtime Analysis extension can also now be assigned as an add-on to Creator and GIS Professional user types. These user types include a Runtime Standard or Advanced license.

Also Included in 100.7

In addition to bug fixes, improvements, and optimizations, new samples have been added to the SDK samples apps, and the guide and reference docs have been updated. The open-source apps team has updated the Data Collection .NET WPF *[Windows Presentation Foundation]* app with new functionality to bring it in line with the Data Collection iOS app. The team has also released a new version of the Data Collection .NET UWP *[Universal Windows Platform]* app.

Please note: There is no update to Local Server at 100.7.

See the release notes for each individual SDK (Android, Qt, .NET, Java, and iOS) for more details.

User Type	Runtime Level
Viewer/Lite [partner]	**Lite**
Editor/Field Worker/Basic [partner]	**Basic**
Creator/GIS Professional Basic/Standard [partner]	**Standard**
GIS Professional Standard/GIS Professional Advanced/ Advanced [partner]	**Advanced**

Download It and Get Started

To get 100.7, go to the ArcGIS for Developers (developers.arcgis.com/) website, browse the ArcGIS Runtime page of your choice, and download the SDK. You can also reference ArcGIS Runtime through NuGet, Gradle, or CocoaPods. If you're new to developing with ArcGIS Runtime and don't have an ArcGIS for Developers subscription, visit the ArcGIS for Developers website and sign up for a free account. You'll be able to access everything you need to develop your apps.

About the Authors

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

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

← What is included with ArcGIS user types and Partner user types

New Tool Identifies the Value of Floodplain Preservation and Restoration

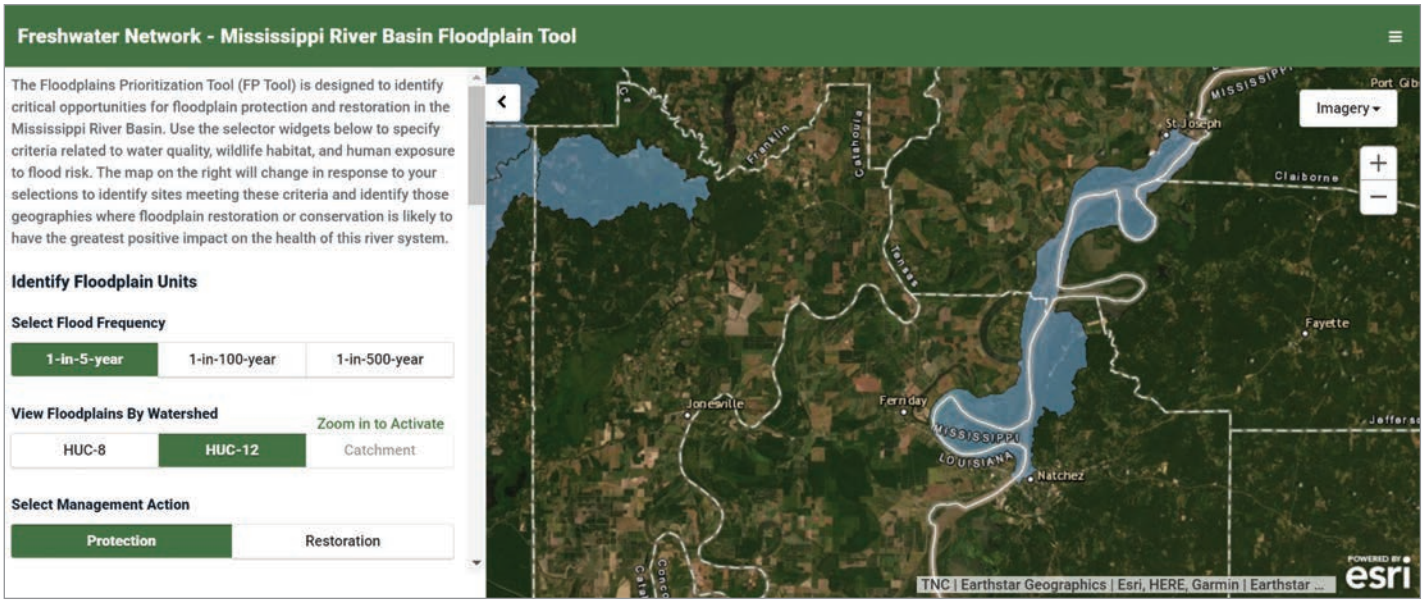
By Jay Harrod

As planners, land trusts, and government officials look for ways to protect communities from flooding and safeguard water supplies, they're increasingly looking to natural solutions, like protecting or restoring floodplains. But in places as vast as the Mississippi River basin, which floodplains are most valuable? Which places—if protected or restored—will provide the best defense for communities given the money spent?

Thanks to the sophisticated use of GIS, a solution is now available. Developed by The Nature Conservancy (TNC) and partners using Esri's ArcGIS, the Floodplain Prioritization Tool (FP Tool) can help communities throughout much of the Mississippi River basin decide where and how best to use limited financial resources to protect or restore floodplains.

"Protecting and restoring floodplains help reduce flooding and avoid damages from further development of flood-prone lands, while providing improved habitat for fish and wildlife and offering people improved water quality and recreational opportunities," said Kris Johnson, who led development of the tool. Johnson is the TNC deputy director of agriculture for North America.

"We wanted to provide a science-based tool that can help decision-makers—like *[those in]* federal, state, and local governments; county planners; land trusts; and businesses—optimize their protection and restoration investments and minimize the impacts of



development," Johnson added. "The FP Tool does just that. It's designed to help guide investments and assess trade-offs related to different goals, like water quality, wildlife habitat, and estimated flood damages."

Handling a Lot of Data

Developing the FP Tool relied on refining a huge amount of data from government agencies and natural resource organizations. The University of Iowa; the University of Bristol in the United Kingdom; and Fathom, a flood risk analysis company also based in the United Kingdom; provided data for the tool that had been previously unavailable to the public.

ArcGIS Desktop was essential in creating the tool, said Eugene Yacobson, a conservation information manager for TNC. "The FP Tool analysis included more than 15 data layers and covers a study area that spans approximately 23 percent of the continental US," he said. "Analyzing that data was carried out primarily using features within Esri's ArcGIS Desktop." Yacobson explained that the tool has multiple modes including three flood frequencies and two management actions. This meant that each data layer needed to be processed multiple times with small variations in workflow, so scripting and automation were essential for carrying out the process efficiently and keeping the process both well documented and replicable.

The integration of ArcGIS with the Python programming language via the ArcPy module made this simple. Complex table manipulations could be carried out in Python, those tables joined to spatial layers, and the layers fed directly into tools in ArcGIS. "Python integration also made it possible to do multiprocessing to take advantage of multiple CPU cores to rapidly crunch through 30-meter-resolution floodplain raster layers stretching from North Dakota to Louisiana and eastern Colorado to northwest Pennsylvania," said Yacobson.

The project's other goal involved producing a tool that could be employed by a wide range of online users. TNC senior web developer Casey Schneebeck used ArcGIS API for JavaScript to build an online presence for the tool that's easy to navigate and can direct users to practical, tangible solutions for communities. Although the tool was initially built for the Mississippi River basin, it could potentially be used across the continental United States.

↑ Flooding like this in Peoria, Illinois, and other communities in the United States costs taxpayers billions in damages. The Floodplain Prioritization Tool can help planners select sites where nature can help reduce flood risks and safeguard water quality while providing wildlife habitat. Copyrighted photo provided courtesy of Jay Harrod/The Nature Conservancy.

← The Floodplain Prioritization Tool is most useful when applied in partnership with local planners and stakeholders. The FP Tool is currently helping inform a collaborative floodplain management plan for Missouri's Lower Meramec River.

The Need for More Solutions

"In the past, you might have portions of large, thousand-acre-plus floodplains that flooded every 25 or 30 years," said Colin Wellenkamp, director of the Mississippi River Cities and Towns

↑ Kris Johnson, the TNC deputy director of agriculture for North America, led the development of the Floodplain Prioritization Tool to aid in protecting and restoring floodplains and help reduce flooding. Copyrighted photo provided courtesy of The Nature Conservancy.

Initiative, an association of mayors from cities along the Mississippi River corridor. "Now we're seeing entire floodplains flood more often, and they're inundated with water for months at a time. If we have to go through many more years like 2019, natural assets like floodplains will be the only way we'll be able to deal with the impacts of flooding, which are becoming worse."

With more frequent and more intense floods, floodplains can provide communities with efficient and effective solutions. Flood protection, water filtration, wildlife habitat, and other services supplied by floodplains have dollar values, according to Wellenkamp. "The Floodplain Prioritization Tool can help us guide protection or restoration investments or better understand the impacts of the development choices we make." Wellenkamp also believes the science-based reports that the tool generates can help communities when applying for federal, state, or county grants aimed at reducing flood risks or improving water quality or wildlife habitat.

A new study by TNC and its partners attempted to determine which floodplain strategy would cost American taxpayers more. Based on current projections, should undeveloped areas that are likely to flood in the coming decades be protected now, or should development be allowed to proceed and the subsequent flood damages to be paid for when they inevitably occur?

The study, "A benefit-cost analysis of floodplain land acquisition for US flood damage reduction," was published in the December 9, 2019, issue of *Nature Sustainability*. It identified more than 104,000 square miles—an area roughly the size of Colorado—located in 100-year floodplains where conservation would be an economically sound way to avoid future flood damage.

> "The Floodplain Prioritization Tool can help us guide protection or restoration investments or better understand the impacts of the development choices we make."

"For just over 21,000 square miles of this area, the benefits are at least five times the cost, meaning that a dollar invested in floodplain protection today returns at least five dollars in savings from avoided flood damages in the future," said Johnson.

See the Floodplain Prioritization Tool at https://bit.ly/2R1U6ij. For more information, contact Jay Harrod at jharrod@tnc.org.

Acknowledgments

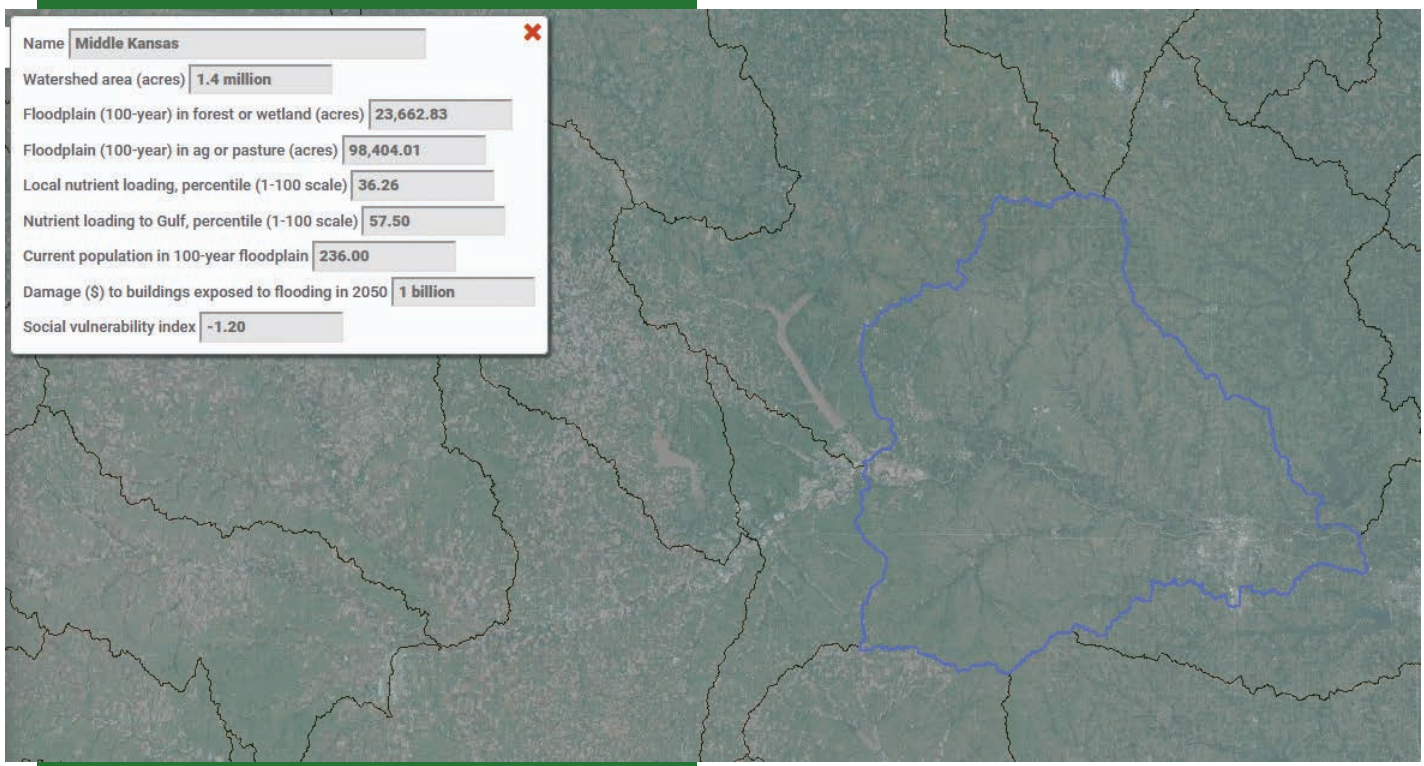
The development of the FP Tool was supported in part by the Enterprise Rent-A-Car Foundation and the McKnight Foundation. Thanks to the partner organizations that contributed data used in the basin-wide version of the FP Tool. These partners included US Geological Survey, US Army Corps of Engineers, US Environmental Protection Agency, National Fish Habitat Partnership, US Fish and Wildlife Service, American Bird Conservancy, Natural Resources Conservation Service, and USA National Phenology Network. Project partners the University of Bristol, United Kingdom; Fathom; and the University of Iowa provided data that was previously unavailable online.

About the Author

Jay Harrod is the associate director of marketing for The Nature Conservancy. Based in central Arkansas, Harrod serves as TNC's communications lead for the organization's Natural Climate Solutions-Adaptation strategies, among other programs.

← Every dollar spent toward protecting or restoring floodplains like this one in Louisiana can provide at least $5 in savings from avoided flood damages in the future, according to a recent study by TNC and its partners. Copyrighted photo provided courtesy of Byron Jorjorian.

↓ Through pop-ups, the Floodplain Prioritization Tool (FP Tool) makes a wealth of information on the extent and impact of floods on communities throughout much of the Mississippi River basin.



California Created a Knowledge Base with GIS

California—like many other states—collects treasure troves of data that could not only provide a better understanding of problems but also, if integrated, help develop novel solutions. Unfortunately, this valuable data is typically siloed in departments and not centrally accessible. The need to quickly locate the most current data on a topic is most acutely felt when natural disasters happen, such as the wildfires that have punished the state in recent years. Departments scramble to locate the best data so they can effectively respond. In emergencies, having authoritative data centrally available can save a lot more than just time.

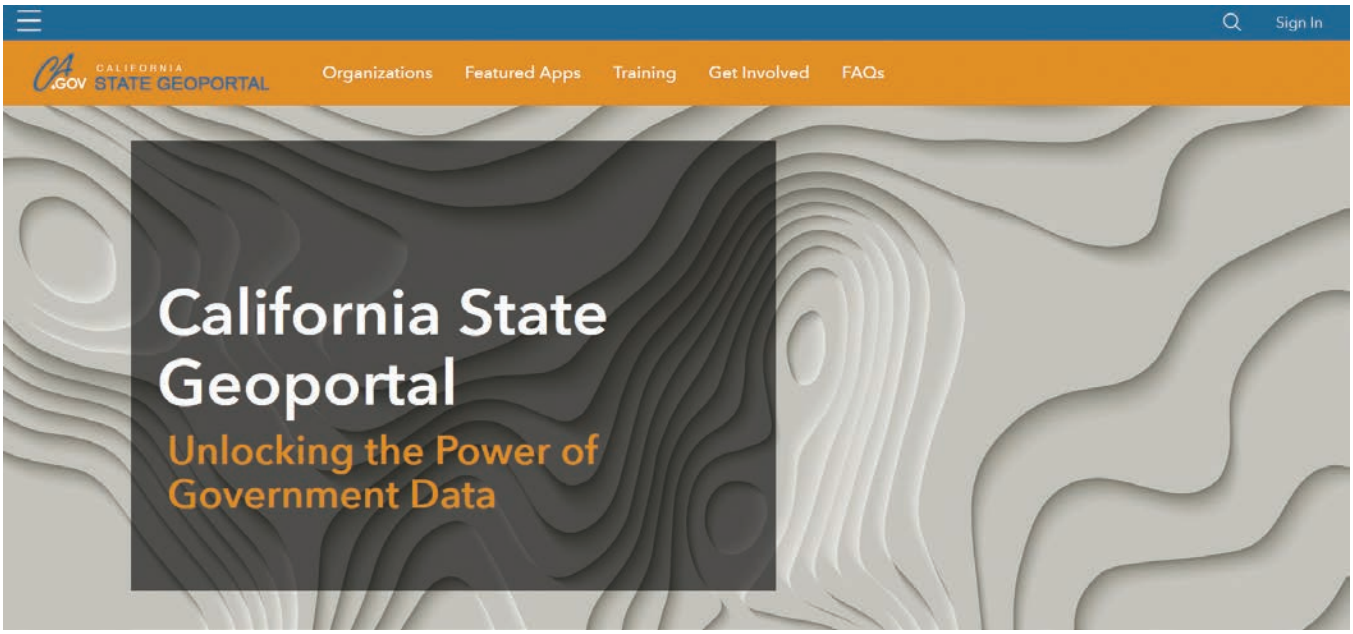
Esri has been working with California to address this issue. The effort was sponsored by Michael Wilkening, the Special Advisor on Innovation and Digital Services in the Office of the Governor, and Amy Tong, Director of the California Department of Technology (CDT) and the state's chief information officer (state CIO). Previously, Wilkening served as the Secretary of the California Health and Human Services (CHHS) agency. While with CHHS, Wilkening was a strong advocate of data sharing and the executive sponsor of CHHS' efforts to set up an open data portal that increases public access to nonconfidential health and human services data.

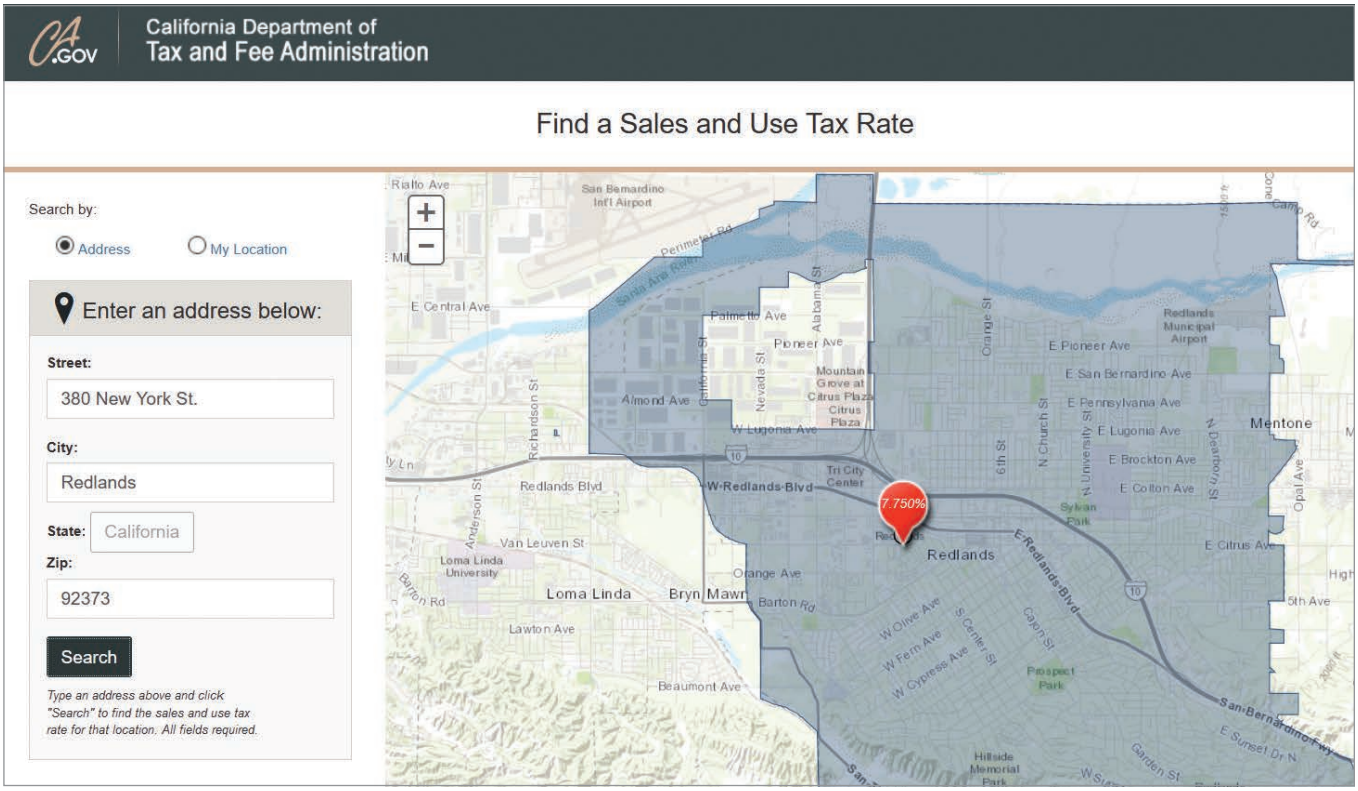
Wilkening and Tong discovered that the state already has the technology that could unlock the value of the state's data. Since most data has a spatial component and these agencies were on the ArcGIS platform, all that data could not only be accessed but also integrated, analyzed, and visualized using GIS. More than 40 of the state's departments use GIS, including the California Governor's Office of Emergency Services (Cal OES), California Department of Forestry and Fire Protection (CAL FIRE), California Census, California Department of Transportation (Caltrans), California Environmental Protection Agency (CalEPA), and CalEPA Department of Toxic Substances Control (DTSC).

California capitalized on the ArcGIS software the state already licensed to rapidly implement a solution at no additional cost using the basic version of ArcGIS Hub that came with its ArcGIS Online subscription.

Making publicly shared data and apps already developed by various California state agencies available from a single site would be immediately beneficial. By federating the agencies' websites using ArcGIS Hub, someone seeking state data would

↓ The California State Geoportal (gis-california.opendata.arcgis.com) includes data and information products—web maps, apps, and story maps—from more than 25 state agencies





↑ California State Geoportal can now visit just one site to answer questions such as What is the sales tax in my area?

no longer have to know which agency was responsible for the data they needed to easily find it.

CDT staff member Sam Hayashi, an open data and visualization specialist in the Office of Enterprise Technology, did most of the work that rapidly realized this solution. Prior to taking his position with CDT, Hayashi had been a research program specialist for GIS in the California Department of Conservation. He was well versed in GIS and had previously made an ArcGIS Open Data site to share data.

Working alongside Hayashi and the CDT project team was the Statewide Geoportal Task Force, a group of dedicated and eager GIS professionals from a wide variety of state agencies and departments. The unselfish collaboration of task force members was of special note, as it was only through this antisilo, data-sharing effort that the portal became a reality. Task force members recognized for their individual contributions included Jane Schafer-Kramer, technical lead for the California Stewardship of the National Hydrography Dataset at the California Department of Water Resources, and Nate Roth, geographic information officer at the California Department of Conservation.

The initiative to create the California State Geoportal was announced on November 1, 2019, and it took less than a month to launch the site. The California State Geoportal (gis-california.opendata.arcgis.com) includes data and information products—web maps, apps, and story maps—from more than 25 state agencies. Many of the participating agencies had already created agency ArcGIS Hub sites to facilitate sharing data, maps, and apps. Because the agency websites are federated through the ArcGIS Hub, the most recent datasets from individual agencies will be available from the California State Geoportal immediately as the data is refreshed by each agency.

Each dataset can be visualized using ArcGIS Online tools. California's residents can now visit just one site to answer questions such as

- What is the sales tax in my area?
- What state parks are near me?
- What are the fishing regulations for a specific stream?

Implementing ArcGIS Hub as the solution to data access also provided different ways to visualize data, and easy-to-use tools like ArcGIS StoryMaps and Operations Dashboard for ArcGIS to communicate information without requiring GIS expertise. The state could make its stores of data on water conservation, homelessness, or wildfires not only available but also understandable.

This initial project is part of a larger vision for facilitating data-driven policy development by extending the site with a non-public portion that would be primarily for use by the state's analysts and researchers. Currently, researchers download data, work on it, and then delete it. This means that their work has limited benefit and cannot be used for additional research. With ArcGIS Hub, access to data, maps, and apps can be controlled so analysts can retain and build on the results of their work.

Ultimately, the California State Geoportal could be used to not only access data the state has already been amassing but also to access and combine it with data from both federal and local government in analyses that will more comprehensively inform government decisions.

Learn ArcGIS Arcade in Four Easy Steps

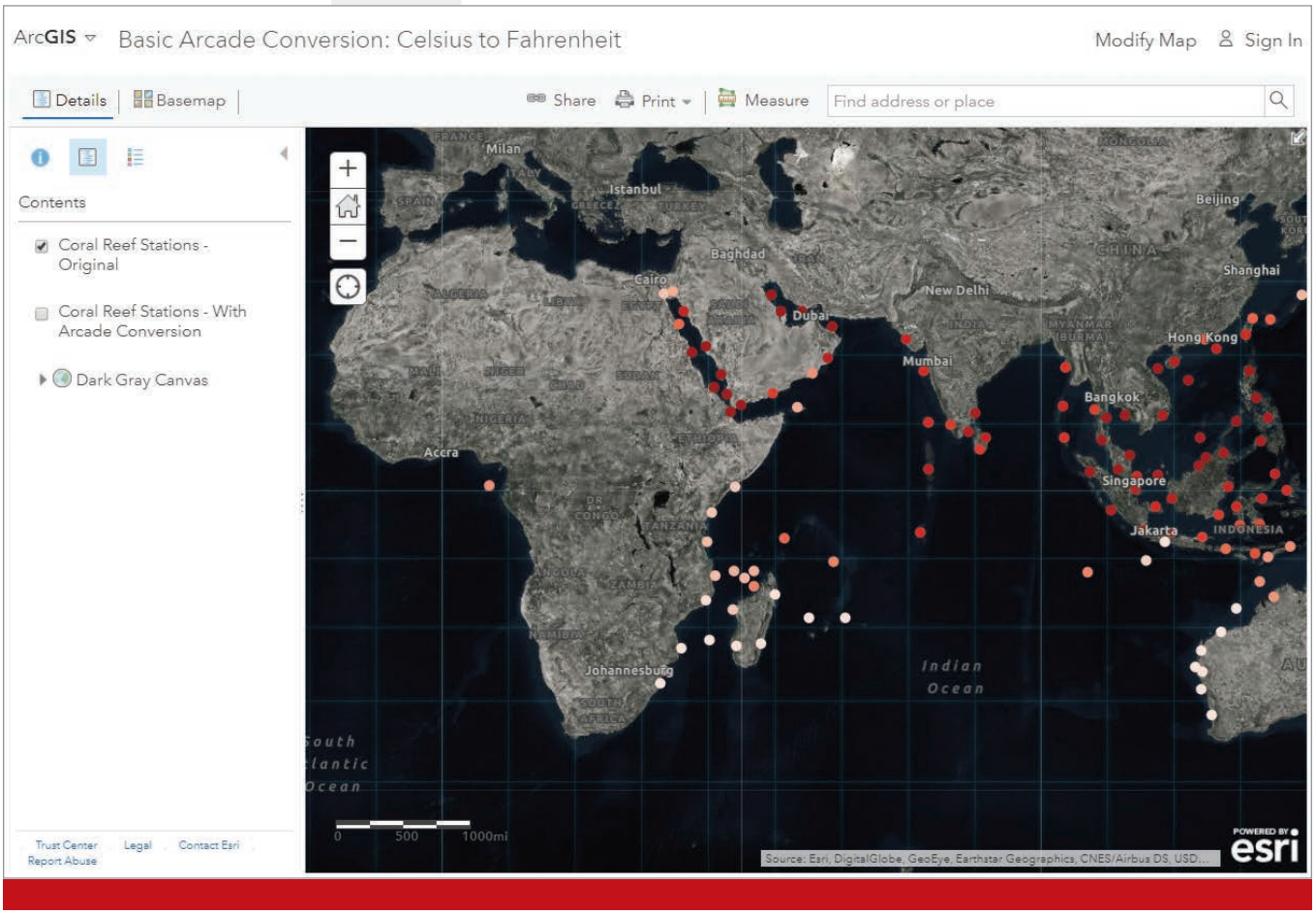
By Lisa Berry

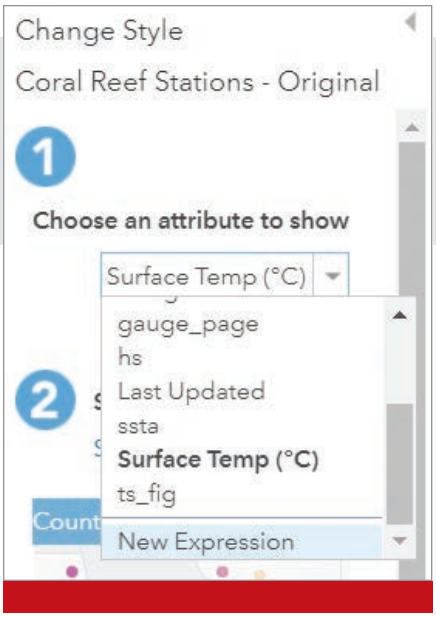
Using ArcGIS Arcade, a basic scripting language from Esri, you can map the values you need or create completely new data values in minutes. Within ArcGIS Online, ArcGIS Pro, ArcGIS Runtime, and ArcGIS API for JavaScript, you can create expressions for visualization, labeling, pop-ups, calculations, and aliases.

In this exercise, you'll write an Arcade expression to get comfortable with the interface. To follow along, open Basic Arcade Conversion: Celsius to Fahrenheit (arcg.is/0yX1W), a map I've shared on ArcGIS Online.

Click Modify Map at the top right of the window.

This example uses an ArcGIS Living Atlas of the World layer that shows virtual coral reef stations to help identify reefs at risk of coral bleaching. The data is in real time,





← Select the drop-down arrow to see the layer's attributes. At the bottom, click New Expression to open the expression window.

↓ Under Expression, write the Arcade expression. By default, a sample expression appears that is shown in comments denoted by //.

meaning the data values are constantly being updated by the National Oceanic and Atmospheric Administration (NOAA). Warmer water temperatures can cause coral bleaching, so monitoring the temperature of the ocean using this data can help pinpoint reefs that are in danger. These "virtual stations" are not actual buoys or in situ stations transmitting data but rather derived reef locations from 5-kilometer-resolution raster data.

The map's legend and the pop-up show the sea surface temperature of the virtual stations in Celsius. Celsius is a measurement that's widely used around the world and within the scientific community, but if the people in the map audience are based in the United States, they might understand temperature better in Fahrenheit.

Because the data comes from a live feed that is updated regularly and the layer is owned by someone else, Arcade is the perfect tool for adjusting this map to degrees of Fahrenheit. The conversion from Celsius to Fahrenheit is a simple equation:

$$F = C \times 1.8 + 32$$

You can convert this data value quickly using Arcade, and because the data is updated in the layer, your map will always reflect the newest values. Let's get started!

← To follow along with this tip, open "Basic Arcade Conversion: Celsius to Fahrenheit," a map I've shared on ArcGIS Online, and click Modify Map.

Step 1:
Create a New Expression

In many of the places where you use data attributes in your maps, such as symbology, you'll find an option to use an expression.

To use an expression for the map's symbology, first go into the Change Style options for the Coral Reef Stations - Original layer under Contents.

Select the drop-down arrow to see the layer's attributes. At the bottom, click New Expression to open the expression window.

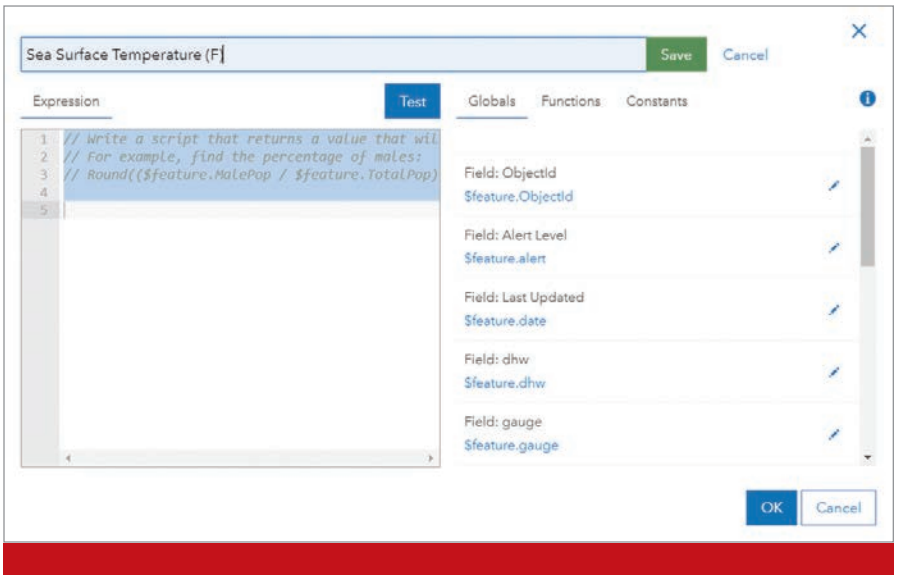
The expression window will appear, and at the top of the window you will see the default name of the expression: Custom. This will appear in the map's legend, so it is a best practice to first name your expression something meaningful so that your map reader will understand what they are seeing.

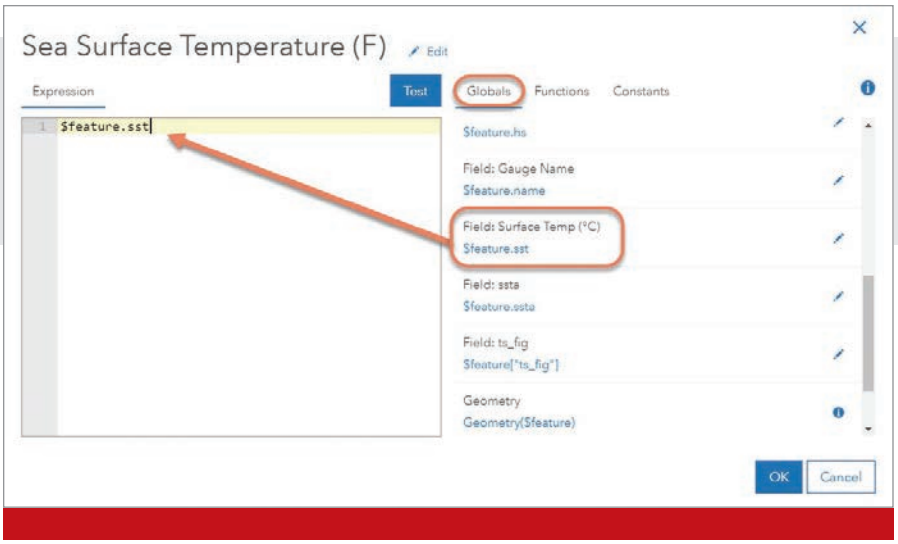
Click Edit next to Custom and rename it "Sea Surface Temperature (F)", then click Save.

Under Expression, write the Arcade expression. By default, a sample expression appears that is shown in comments denoted by //. You can delete this sample when writing your own expressions.

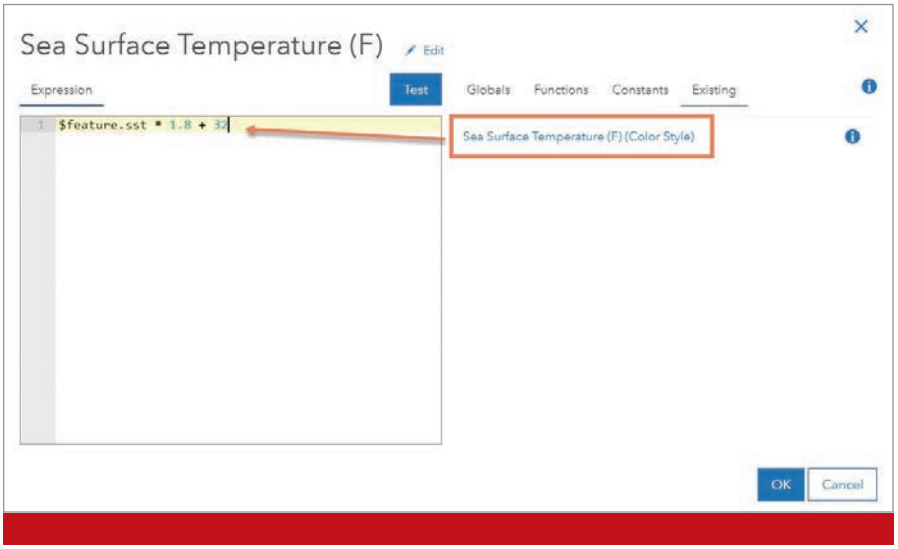
Step 2:
Use an Attribute from the Layer to Calculate a New Value

Take a closer look at the expression window to better understand how to use it. On the right side of the window, you'll see the list of fields from your data under the Globals tab. They have $feature in front of the field name, which means that Arcade will process the expression for each feature in the map. When working with Arcade within pop-ups, you'll see additional Globals such as $map, which is used for accessing data from other layers in a map using a function called FeatureSet().





← On the Globals tab, find the attribute field for Sea Surface Temperature (C). Click $feature.sst to add it to the expression. The attribute's alias appears above it as Field: Surface Temp (C).



↑ Write out the equation for the Celsius to Fahrenheit conversion.

Under the Functions tab, you'll find a list of built-in functions. The documentation for each function is accessible through this window, making it easy to learn and use new functions.

When you want to reuse an expression you have already created on a layer, it will appear under the Existing tab. This tab will only appear once you have created an expression elsewhere.

The Constants tab contains formatting tools and other universal constants such as the value of pi.

To write your expression, go to the left portion of the window. On the Globals tab, find the attribute field for Sea Surface Temperature (C). Click $feature.sst to add it to the expression. The attribute's alias appears above it as Field: Surface Temp (C).

Now, write out the equation for the Celsius to Fahrenheit conversion covered earlier. The asterisk (*) symbol can be used for multiplication, just as in Microsoft Excel. The expression should look like this:

```
$feature.sst * 1.8 + 32
```

Step 3:
Test and Use

Test your expression to make sure it works. The expression will return the last line of code, meaning that if your expression is only one line, it will return the result of that line. If your expression is more advanced, you can use a return statement to control what the expression returns. Read my *ArcGIS Blog* post "Use Arcade Expressions to Map Your Ideas" to see how return statements are used.

Click the Test button, and a console will appear with the result of your expression. In this example, the result is the number 81.4189998626709. The expression was tested using the value 27.454999923706055, which, when converted to Fahrenheit, is 81.4189998626709. This means the expression worked as expected.

This result is using a value from a feature in the dataset to test, but because this is real-time data that is constantly updating, the result you obtain may be different.

To see or change the value being tested, find the attribute in the list on the right, select the pencil to the right of that attribute, and click it to see the value being used by the expression in the test. Confirm that the result is correct.

Now you can use your expression as if it's a normal data attribute. Change the symbology to the Counts and Amounts (Color) option.

Click Options > Symbols > Fill and change the color ramp back to a bright red to replicate the map you started with.

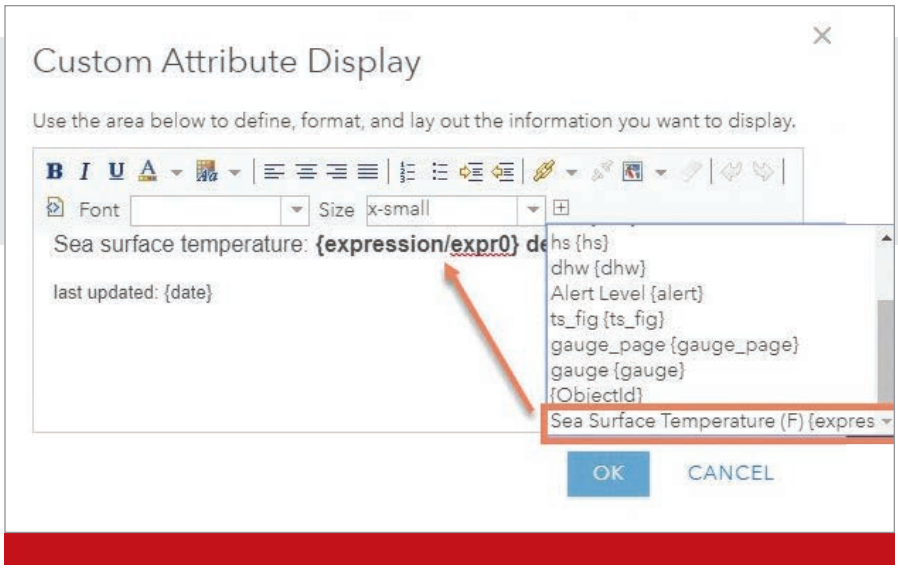
Move the Transparency slider to 0%, click OK, click Done, and your map is now in Fahrenheit. You did it! You wrote your first Arcade expression!

Now, let's reuse this expression in the pop-up.

Step 4:
Use an Existing Expression

Once you have used an expression on a layer in your map, you can easily reuse it without needing to rewrite it.

→ Use the expression just created in the pop-up by highlighting {sst}, clicking the plus sign, and choosing the expression. Change deg C to deg F, and make the expression and reference text size small and bold.



Go into the layer options and choose Configure Pop-up. Under Attribute Expressions, click Add. The expression window you saw earlier will appear, and now there is a new tab in the window called Existing. This contains any expressions being used on the layer. You can see the previous expression you wrote called Sea Surface Temperature (F), and it tells you where it is being used within the map (Color Style).

Click the existing expression and it will automatically appear within the expression window. As you did before, give the expression a useful name so that you can easily reference it later. Click OK to save the expression.

Within the Configure Pop-up panel, click the green Configure button to edit the existing custom attribute display. It currently uses an attribute called {sst}, which is the sea surface temperature in Celsius. Highlight {sst}, click the plus sign, and choose the expression you just added. Change deg C to deg F, and make the expression and reference text size small and bold. Save all your changes, and now your pop-up shows the value in Fahrenheit to match the map.

What You've Learned

Arcade is a powerful way to save time and do on-the-fly calculations. You no longer need to own a data layer or perform field calculations to see immediate adjustments to your data values.

About the Author

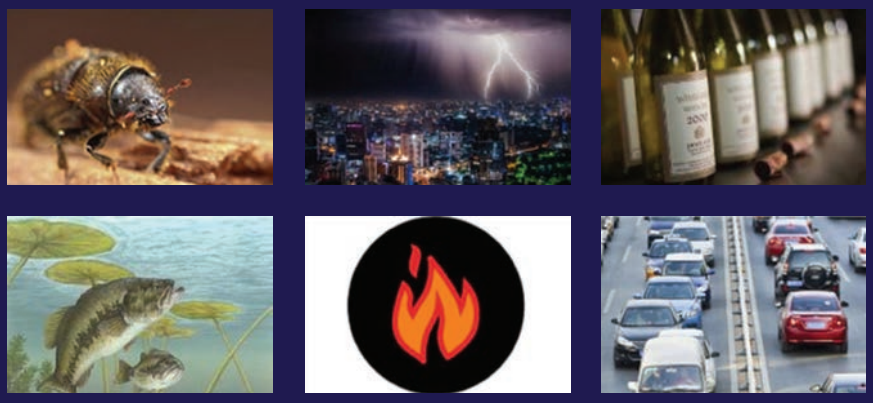
Lisa Berry is a cartographic product engineer on the ArcGIS Living Atlas of the World team at Esri. She works to create clear and concise stories about demographic data using cartography. She also builds data layers and tutorials to help others create their own map masterpieces.

Use Style and Brand to Make Your Thumbnail Stand Out

By Bern Szukalski

When creating thumbnails for items in ArcGIS Online, you can go beyond the basics and consistently use a unique style and/or brand. Your style and brand can reflect on your organization or you as an individual.

↑ Thumbnails that provide an obvious visual reference to the geographic context of the map help users anticipate what they will see when they open the item.



↑ Thumbnails can also give visual cues to the subject of the content provided. These thumbnails represent content about insects, weather, wine, fish, fire, and traffic.

Thumbnail style can be thought of as a distinctive visual appearance that can provide context for the content behind it.

Branding is a practice in which an organization creates a unique design that is easily identifiable, making one organization's contributions easily distinguishable from others.

The importance of branding can be seen in search results that make it easy to recognize authoritative content. Each style and branding approach described in this article offers ways to help users find and anticipate content and distinguish your organization from others.

Use Geographic Context

Thumbnails can provide an obvious visual reference to the geographic context of the map, helping users anticipate what they will see when they open the item. While most thumbnails use a map to show that context, in the illustration at right, New York City used an easily recognizable photograph—the Statue of Liberty.

Provide Content Hints

Sometimes thumbnails provide a visual cue to the content with graphics that deliver an expectation of subject matter.

Foreshadow Functionality

Thumbnails for story maps, dashboards, apps, and models can highlight the functionality or tools provided.

Try Organizational Branding

Applying organizational branding to thumbnails is recommended for top-tier authoritative content that a government agency or other organization shares. Using a visual brand (the organization's logo, colors, and text) indicates the authoritative source for the map. Many thumbnails also indicate what type of content will be provided using words and maps. Decide if you prefer to see geographic context in the thumbnail or if words and a logo are sufficient.

Be Consistent in Your Branding

An important aspect of branding is consistency. Organization thumbnails don't need to be identical, but they must carry forward a branding theme, be it color, logos, or other graphic elements. The examples of organizational galleries in the accompanying illustrations show the strength of branding and demonstrate how branding helps viewers to easily recognize the publisher and find authoritative content.

For more information about thumbnails, read "Put Your Best Thumbnail Forward" (https://bit.ly/2To9DvM) in *ArcWatch*.

About the Author

Bern Szukalski is a tech evangelist and product strategist at Esri, focusing on ways to broaden access to geographic information and helping users succeed with the ArcGIS platform. On a good day, he is making a map; on a great day, he is on one.

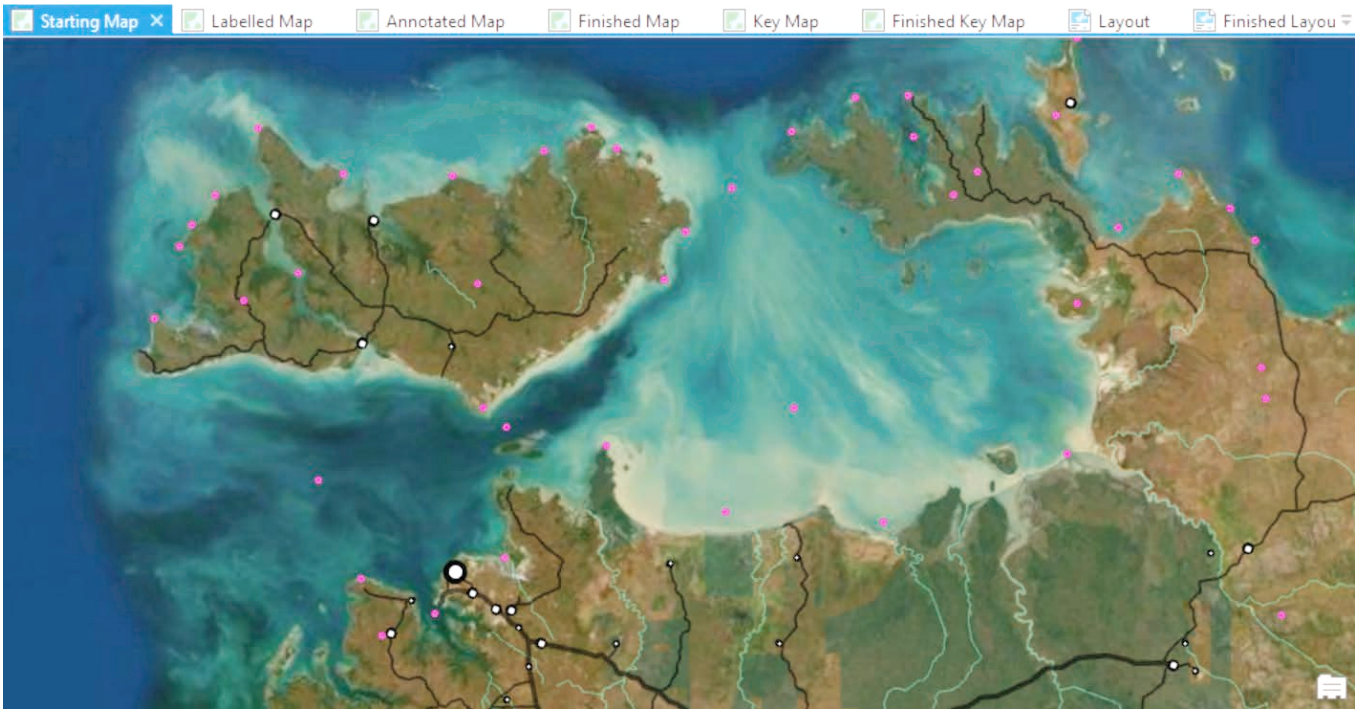
↑ Thumbnail images can highlight the functionality of story maps, dashboards, apps, and models or of the kind of tool being shared.

↑ The Kansas Department of Transportation (www.ksdot.org) uses unique thumbnails but applies its logo as a design element, which helps to unify the collection, deliver recognition, and provide an authoritative tone.

↑ The State of Utah School and Institutional Trust Lands Administration (SITLA) (trustlands.utah.gov) uses strong colors, design, and logo branding, but it also uses text and graphics to help identify different content types. This distinctive style gives viewers the ability to easily recognize and understand the content.

Improve Your Labeling Skills in ArcGIS Pro

By Heather Smith



↑ Begin the exercise with Starting Map, which is already symbolized.

My favorite part of mapping is the text. Perhaps you disagree and find the task of "lettering" a map to be time-consuming and tedious. To me, getting it right can feel like solving a particularly satisfying puzzle.

Text can make or break a map. There are three kinds of text on maps made with ArcGIS Pro: labels, annotation, and layout text. This tutorial will help you improve your labeling skills. You can follow along with this tutorial (to whatever degree of perfection you prefer) using the Darwin.ppkx project package at arcg.is/0rSX8H. By the end, you will have a map of the region around Darwin in Australia's Northern Territory that you can convert to annotation in the following companion tutorial in this issue of *ArcUser*, "Place Text Exactly Where You Want with Annotation in ArcGIS Pro," which shows you how to refine the map by converting labels to annotation.

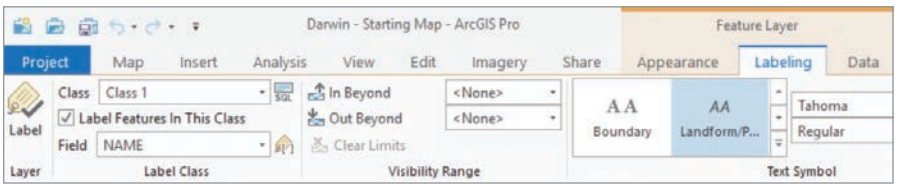
Or you can read this tutorial and simply enjoy learning about labelling.

Getting Started

Start by opening Darwin.ppkx in ArcGIS Pro and opening Starting Map. This map is already symbolized. Anything pink won't appear in the final map, but it's useful to visualize while you are working with text. Of course, it's your map now, so you can resymbolize it any way you like—but please wait until after you make the labels.

Most of the data is from Geoscience Australia, which is Australia's preeminent public sector geoscience organization. Look at the metadata within the project for more information on the data.

In the Contents pane, select the Places layer. On the ribbon, on the Labeling tab,



← On the ribbon, click the Labeling tab and click Label.

click Label. The labels look alike. The labels would be more useful if they used different styles to represent different kinds of features. For example, different label styles would help the map reader know if a place called Port Darwin is a town or a bay. To accomplish this, you can set up label classes.

On the Labeling tab, expand the Class menu and choose Create label classes from symbology. In this case, I've already set up symbol classes to match the different label classes that I want to use. However, most of the time, your data will not be so nicely classified. It's worth your time to examine your data and classify it in a way that supports the kind of labels that you want. It will save you some headaches down the road.

Uncheck Append to current label classes and Scale range and click OK. In the Contents pane, click the Labeling tab. Here you can see all your new label classes. They are all selected, and that's a good thing, because the first problem you want to fix applies to all labels. The text is black, and it's hard to read. Typically, maps with an imagery basemap use white text. On the Labeling ribbon, change the text color to white.

The second problem is that all labels are in all caps, which looks classy but makes labels harder to read. Typically, you want to reserve uppercase text for large areas or particularly important features. In this case, the problem is that place-names are stored as uppercase text in the attribute table.

To fix this, click the Expression button next to Field on the ribbon. The Label Class pane opens. Unfortunately, it's empty because you have multiple label classes selected. You need to do one label class at a time.

In the Contents pane, select Coastal Feature. Now you have options! Ensure that Language is set to Arcade.

Under Expression, type Proper($feature.NAME).

The Proper function will display uppercase words in proper case without altering the underlying data. Click Apply.

Repeat these steps to make proper case labels for the Cultural Feature, Homestead, Mountain, and Water Feature layers. You'll leave as uppercase text the other label classes to make them appear either large or important. Save the project.

Next, you need to choose a font. On most maps, I recommend that you stick to only one font (sans serif). You still have a lot of options for variety by mixing up the size, color, and style (italic, bold, and so on). This map is text heavy. In this and similar cases, it's common practice to choose a pair of fonts: one serif and one sans serif. The convention is to use the serif font to label natural features and the sans serif for cultural features.

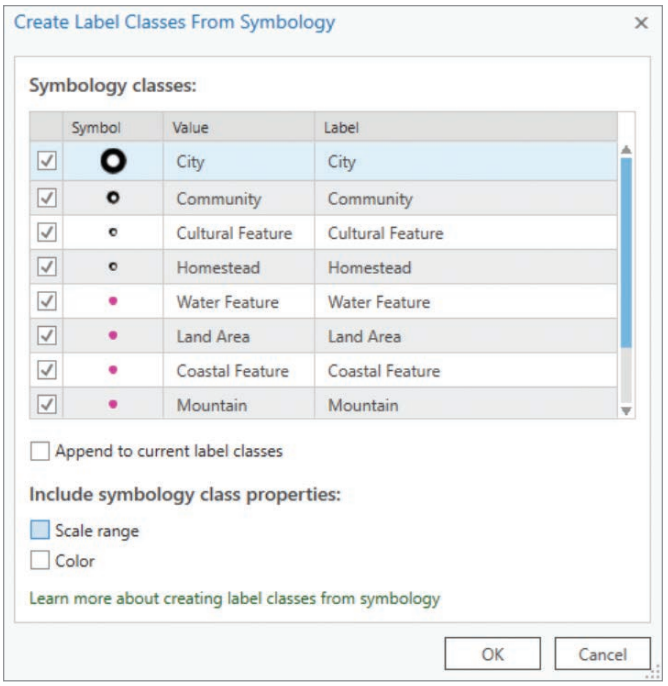
For this map, I chose Bodoni MT as the map serif font because it has a particularly broad range of styles. For the sans serif font, I chose Century Gothic, which is a classic, reliable mapping font.

In the Contents pane, select the Coastal Feature layer. On the Labeling ribbon, change the font to Century Gothic, and change the size to 7.

Wait a minute. Didn't I just tell you to use serif fonts for natural features?

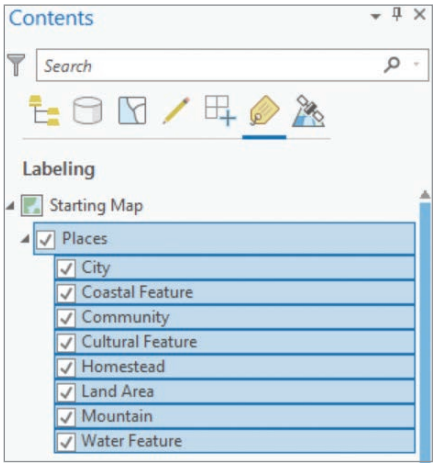
Well, that's why it's called a convention and not a rule. I decided that this map has more natural than cultural features, and that Century Gothic is easier to read. I reserved Bodoni for only water and terrain features. For your own map, it's your call.

↓ All the labels look alike, so you will use different styles to represent different kinds of features.



↑ On the Labeling tab, expand the Class menu and choose Create label classes from symbology to see the symbol classes that have already been set up.

→ In the Contents pane, click the Labeling tab and you will see the label classes, which are selected.



Next, select the Water Feature label class. On the ribbon, change the font to Bodoni MT, Bold Italic. For Color, choose Turquoise Dust (HEX #9ED7C2).

Water features are almost always labeled in italics. Italic text is slightly harder to read but suggests something flowing. Water features are also often labeled in blue. In the regular text world, bold imparts emphasis to a word. But in the map text world, bold is sometimes used as the default, since it makes short bits of text in small sizes easier to read. On the ribbon, on the Labeling tab in the Label Placement area, click Centered Point.

The labels for gulfs and bays on this map are all different sizes. Later you'll have to adjust some of the labels to match—but for now, 10 point seems like a good starting size.

Select the Homestead label class. Change the font to Century Gothic Bold 7 point. It's quite common to use very small text on a map to accommodate crowded features. Six-point text is generally considered the smallest legible size, so don't try anything smaller.

On the ribbon, click the expander button in the Text Symbol group. The Label Class pane opens. On the Symbol tab, click the Formatting button. On the map, you can see that some of the labels are stacking, and that's a good thing. However, their stacking could be tighter. The default space between lines of text is designed for paragraphs, not for maps. Text on a map almost always benefits from condensed line spacing because this makes it more obvious which label goes with which point.

In the Label Class pane, change Line spacing to -2. This property is also known as leading. I usually use a default line spacing of -2 for all map labels. For larger fonts, you may want to decrease the leading even more.

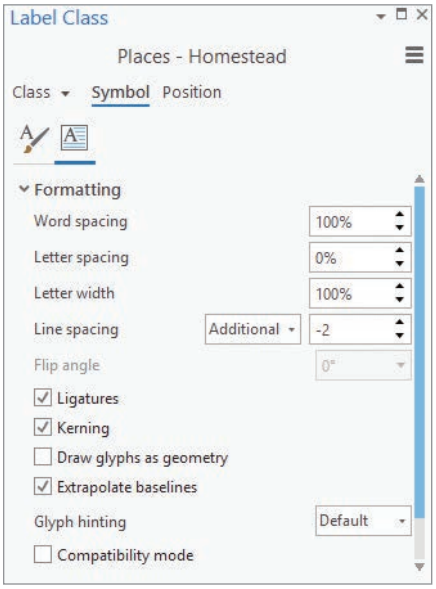
Next, we'll work on rivers. In the Contents pane, switch to the List by Drawing Order view. Right-click Streams and choose Label.

These labels look bad. You don't need to set up label classes for this layer, since you don't need to distinguish between different kinds of streams. However, you need to use the Arcade expression Proper($feature.NAME) again to convert these labels to proper case.

Change the font to Bodoni MT Italic 8 point. For Color, choose Turquoise Dust. The rivers already look better. In the Label Class pane, click the Position tab. For Placement, choose River placement and Offset curved. Click the Fitting strategy subtab (knight chess piece symbol) and uncheck Stack label.

Click the Conflict resolution subtab, expand Unplaced labels, and check Never remove (place overlapping). Before you checked this box, some of the river labels were not being drawn on the map because there wasn't enough room for them. That's good if you are going to use automatic labeling; but if you intend to convert labels to annotation, you probably want to decide for yourself which labels are important and which labels can be removed.

Next, turn on labels for the NationalParks layer. Change the font



← In the Label Class pane for the Homestead layer, change Line spacing to -2.

to Black 9 point Century Gothic Bold. In the Label Class pane, click the Position tab then Placement, then choose Regular placement and Horizontal in polygon. This time, you have the opposite problem: the text is stored in proper case and you want to display it in uppercase. You can make this change on the Symbol tab.

Large areas (like national parks) are often labeled with uppercase text. It's part of a strategy that tries to suggest the expanse of an area without dominating the map with large text that appears more important than it is. By making the text black, which has low contrast with the basemap, you're also helping to push these labels into the background. If you were converting labels to annotation, you could spread the letters out to cover a larger area without increasing the text size.

The next problem you have is that the park names don't include the words *National Park*. Click Class in the Label Class pane and use Arcade to fix this problem with the expression $feature.NAME + " N.P."

You can handle the rest of the labels on your own. You can set them up any way you like, or you can copy the properties I've chosen. Refer to the map named Labelled Map in the Darwin project.

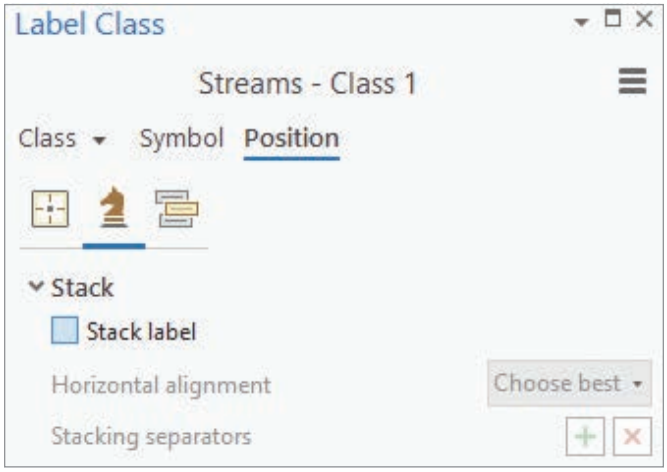
Warning! It's going to look messy. That's okay.

You can change anything and everything later when converting to annotation in the next tutorial. The goal with labeling is to choose and apply the best defaults for each label class so you have less work to do later.

In the next tutorial, I will show you how to convert these labels into annotation and edit them into cartographic perfection.

About the Author

Heather Smith is a cartographer and artist who mixes both practices to express and understand landscapes. She works as a product engineer at Esri, where she writes and edits lessons for the Learn ArcGIS website. View more of her work at www.heathergabrielsmith.ca.

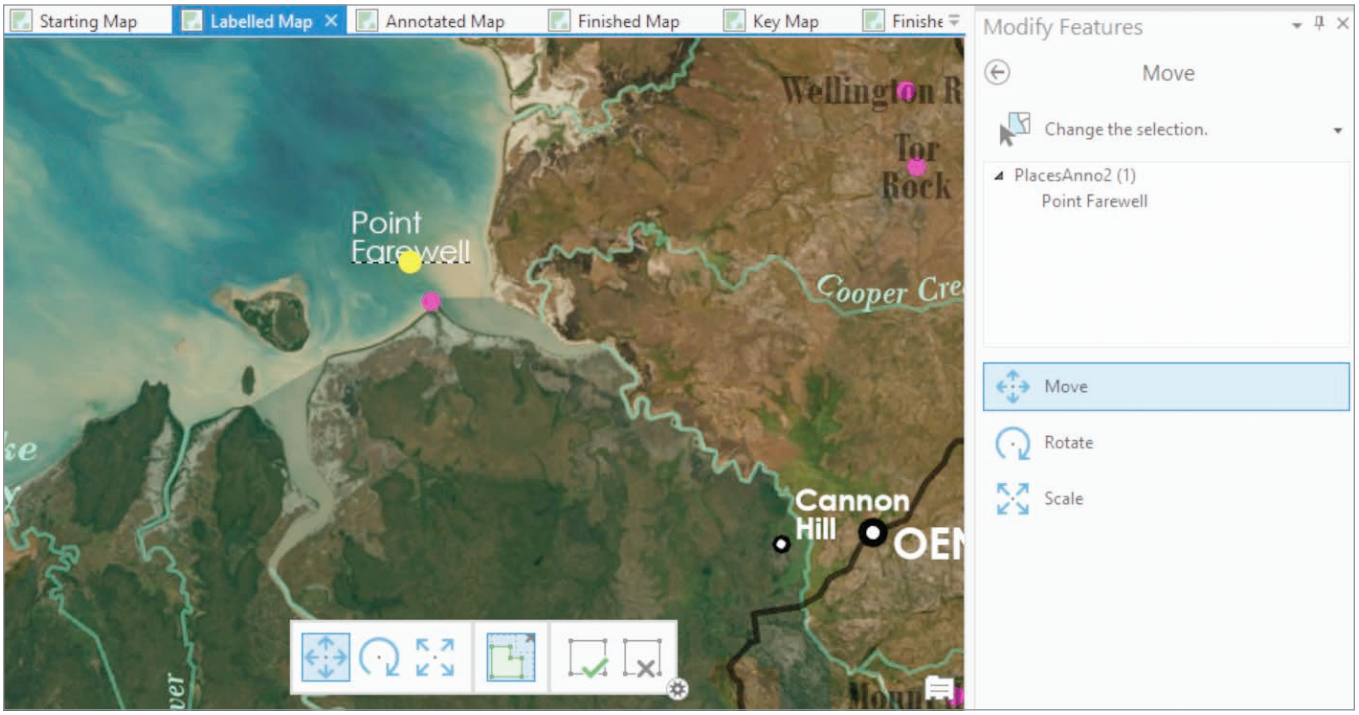


→ In the Label Class pane for the Streams layer, click the Position tab. For Placement, choose River placement and Offset curved.

↓ This map looks messy; but remember, the goal with labeling is to choose and apply the best defaults for each label class so you have less work to do later when labels are converted to annotation.

Place Text Exactly Where You Want with Annotation in ArcGIS Pro

By Heather Smith



↑ On the ribbon, click the Move button and click the text for Point Farewell. Drag it into a better position and click Finish (with the green check mark) on the toolbar when you're happy with the placement.

In the first article in this series, "Improve Your Labeling Skills in ArcGIS Pro," I shared some best practices to use when labeling a map. This article tackles annotation using the same ArcGIS Pro project that was used in the first article. You can use this same project to follow the steps in this tutorial. If you haven't done the labeling tutorial, that's okay. You can download the Darwin.ppkx project package at arcg.is/0rSX8H and start with this annotation tutorial.

Let's Dive In

What is annotation? Basically, it is labels that you can fully control. Annotation acts like features because it is a type of feature! It is stored in an annotation feature class and even has attribute tables. Most important, you can edit each annotation feature so its position, size, and style are exactly as you like.

Open Darwin.ppkx in ArcGIS Pro and open the map Labelled Map in the project. You are about to convert the labels on this map into annotation, but only those labels in the current map extent will be included in the conversion. If you can't see the entire map, right-click the pink MapExtent layer in the Contents pane and choose Zoom to Layer to make sure the map extent is correct.

On the ArcGIS Pro ribbon, on the Map tab, click Convert To Annotation. In the Geoprocessing pane, for Output Geodatabase, choose darwin.gdb and click Run. A new group layer, named GroupAnno, is added to your Contents pane.

The map doesn't look different because labeling has been turned off for all layers in the map and replaced with the new annotation layers that are ready for editing.

On the ribbon, on the Edit tab, click the Move button. Click the text for Point Farewell and drag it into a better position. Click Finish (with the green check mark) on the toolbar when you're happy with the placement.

I think that Point Farewell could also be improved with some center alignment. If necessary, select the Point Farewell text on the map. On the ribbon, click Attributes. In the Attributes pane, under Annotation, click Center.

Next, let's fix a river label. Zoom to the West Alligator River in Kakadu National Park. (Your text may look different than the image shown here. That's okay.) On the

ribbon, click the Annotation tool and click the West Alligator River text.

This piece of annotation happens to be multipart text. If you hover over each word, you can move it individually. However, your goal is to create a river label with a simple curve. As with all other things cartographic, simple is almost always better. Right-click the text and choose Convert to Single Part.

The text is now all in one curve, but it has too many vertices to be considered simple. Right-click the text again, point to Curvature, and choose Horizontal. Right-click again; point to Curvature again; and this time, choose Curved. On the ribbon, click the Vertices tool.

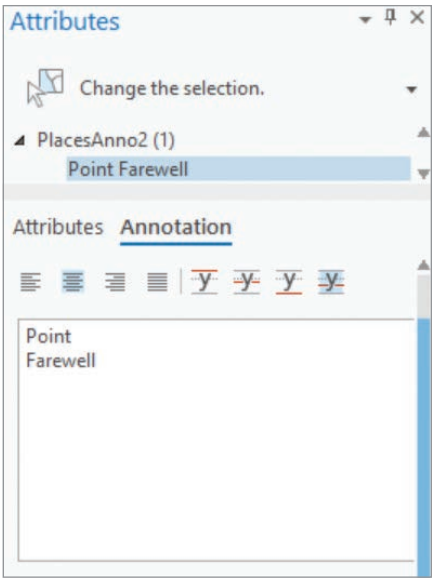
Now you have a nice, simple, two-point curve. Move those points around to create an elegant spline that hugs the river. Click the Finish button and save your edits.

Next, label Kakadu National Park. But first, I recommend pausing to look up some photos of Kakadu National Park. Mapping places you've never been to before comes with its hazards (such as doing research), but the reward is increased knowledge and understanding of the world or at least another item for the travel wish list.

Select the KAKADU N.P. text and click Attributes in the Selection section of the Edit tab to open the Attributes pane. This park is much bigger than the others, so you can get away with larger text. In the text box, replace N.P. with NATIONAL PARK and stack the words. Change the font size to 12. Click Symbol to access more text properties. Under Formatting, change Letter spacing to 200%. Click Apply.

Now your label is much larger without the font itself being too large. But it still doesn't convey the expanse of the park very well. With the Annotation tool selected, right-click the text and choose Convert to Multiple Parts. Now you can drag each word around until the words are spread across the park. Don't be too precious with the placement of these words just yet. By the time you've rearranged all the other text, they'll need to be moved again. Save your edits and the map.

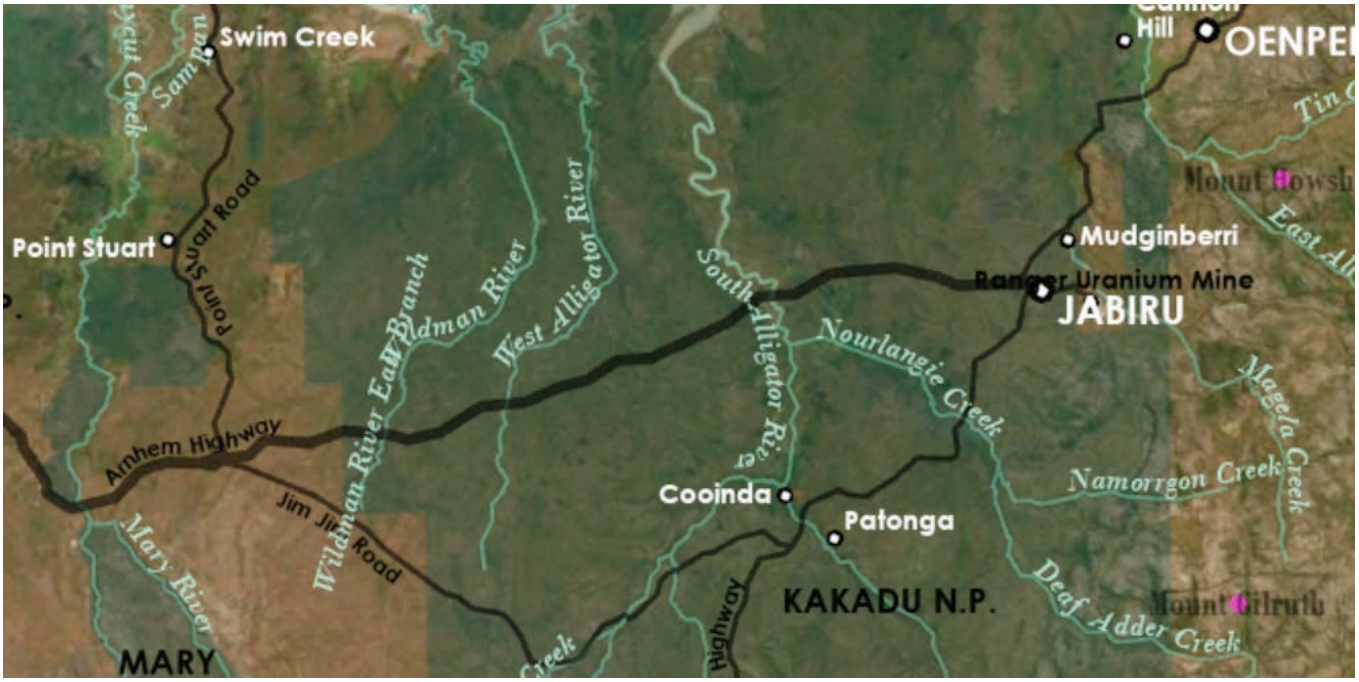
It's time to work on Darwin. Every map is going to have a place that looks like this. It just might be the biggest difference between maps of fantasy worlds and maps of the real world. The real world likes to put all the important things in the same place.

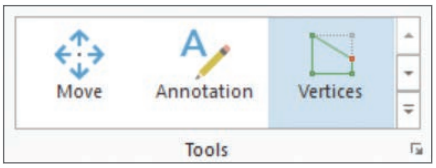


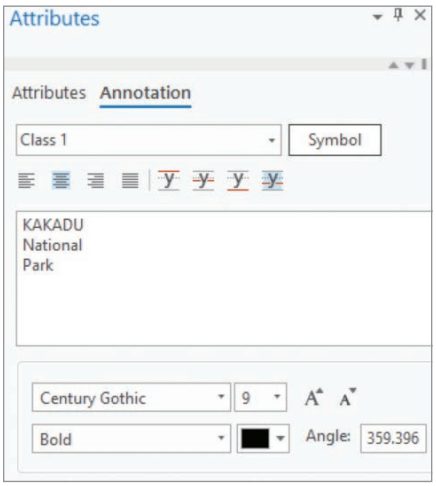
↑ The Point Farewell text could also be improved with some center alignment, so select Point Farewell on the map. On the ribbon, click Attributes, and in the Attributes pane, under Annotation, click Center.

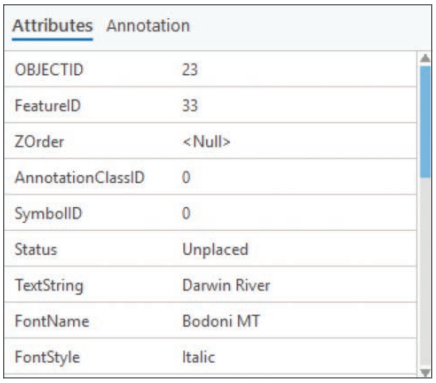
What you need to do next is eliminate many labels. If you're going to do that properly, you need to research the area to find out which features are important and which are not. You can look at other maps in atlases or on the internet to guide you. I

↓ Zoom to the West Alligator River, click the Annotation tool, and click the West Alligator River text. Your goal is to create a river label with a simple curve.









↖ With the Annotation tool selected, right-click KAKADU NATIONAL PARK and choose Convert to Multiple Parts so you can drag each word around until the words are spread across the park.

← In the Attributes pane, stack KAKADU NATIONAL PARK and change the font size to 12. Click Symbol to access more text properties. Under Formatting, change Letter spacing to 200%.

↙ Select a piece of text that you don't want to show on the map and open the Attributes pane. Update the Status attribute to Unplaced.

have already done this work on the place-names for you. (My apologies to the people of Darwin if I chose poorly!) But there are still plenty of river and road names for you to delete.

Does the thought of deleting features make you uncomfortable? Relax. You can remove annotation from your map without deleting it from the geodatabase. Select a piece of text that you don't want to show on the map, and open the Attributes pane. Update the Status attribute to Unplaced. The text will disappear from the map. If you want to review the annotation you removed in this manner, open the Symbology pane and check Draw unplaced annotation.

Tip: *This is also where you'll find missing text if you didn't choose the Never remove option when you were setting up labeling properties.*

Even with heavily thinned annotation, many compromises will have to be made. For example, the ideal place to put text for a point is at the upper right, but not if it interferes with other text. The next best place is at the upper left. After that, lower right. Avoid crossing over roads and rivers. Matching text color to feature color really helps in crowded scenarios. For example, it is clear that the white text goes with the white point and not with the green park.

Don't expect the process of resolving all conflicts and making compromises to go quickly. You can refer to the Finished Map in the same project for examples on how to resolve text issues.

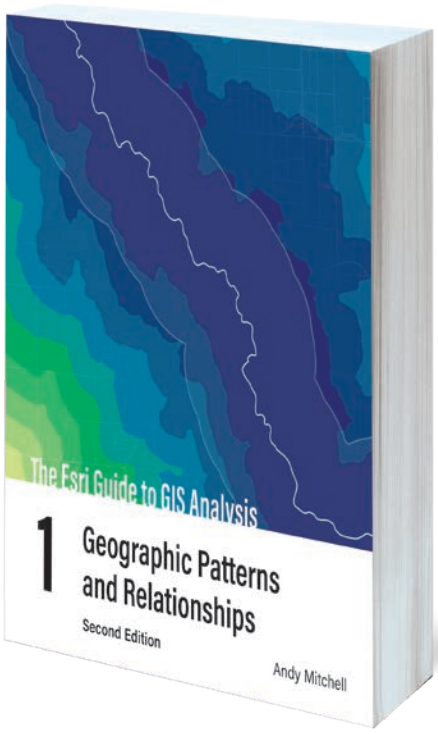
About the Author

Heather Smith is a cartographer and artist who mixes both practices to express and understand landscapes. She works as a product engineer at Esri, where she writes and edits lessons for the Learn ArcGIS website. View more of her work at www.heathergabrielsmith.ca.

↓ Continue refining text placement. The process of resolving conflicts will take time. You can refer to the Finished Map in the same project for ideas on resolving issues.

The Esri Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships, Second Edition

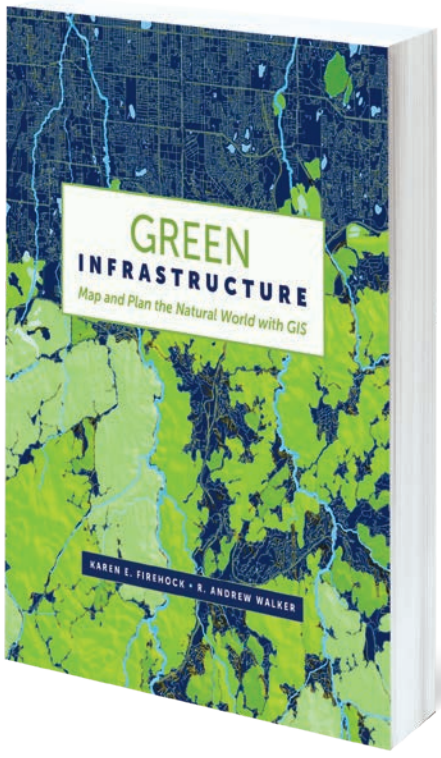
By Andy Mitchell



Whether you are new to GIS or an experienced user of the technology, *The Esri Guide to GIS Analysis,* Volume 1, will help you learn the foundational concepts needed for basic spatial analysis tasks and will let you progress to more sophisticated problem solving and advanced GIS skills. These skills enable your GIS use to go far beyond mapping. Use spatial analysis to reveal the patterns, relationships, and trends in your geographic data. This second edition features maps that are easier to read and online lessons that reinforce the concepts presented in the text. Author Andy Mitchell is a technical writer who has more than 30 years of experience in GIS. He is the author or coauthor of several books including *The Esri Guide to GIS Analysis* series and *Zeroing In: Geographic Information Systems at Work in the Community.* Esri Press, 2020, 300 pp., ISBN: 9781589485792.

Green Infrastructure: Map and Plan the Natural World with GIS

By Karen E. Firehock and R. Andrew Walker



A belief that all people should be able to enjoy beautiful green spaces is the notion that ignited the early conservation movement and one that Esri has supported since its founding 50 years ago. The idea of developing green infrastructure is fundamental for many environmental planning efforts.

Green Infrastructure: Map and Plan the Natural World with GIS, a new Esri Press book, is one of the few books that deals with green infrastructure and the use of GIS. Conserving natural assets requires mapping them and planning how to protect the most valuable portions. This book explains how to utilize the national green infrastructure model that Esri has built to develop a prioritized strategy for conserving or restoring the most highly valued natural resources. This analysis can inform a host of planning applications to protect resources such as water, conserve endangered species, and preserve culturally significant landscapes. The book uses real-world data to create two case studies that demonstrate the application of the national green infrastructure model to local planning.

The book's principal author, Karen E. Firehock, is the executive director and cofounder of the Green Infrastructure Center and is on the adjunct faculty in the Department of Urban and Environmental Planning and Landscape Architecture at the University of Virginia. With over 30 years of working in the environmental field, she has received numerous awards for her work in planning and conservation. Coauthor R. Andrew Walker, a GIS analyst, modeler, and land planner, provided graphics support and technical instruction on mapping for this book. He has more than a decade of experience with high-level GIS analysis and modeling, specializing in the use of GIS for urban and environmental planning applications. Esri Press, 2019, 282 pp., ISBN: 9781589484863.

Discovering the Context of Complex Problems

NGA's Frank Avila talks about a career in imagery science and the future of geospatial intelligence

By Carla Wheeler

On airplane flights, Frank Avila always liked to peer out the windows and study the terrain thousands of feet below.

But it was the colorful Landsat imagery Avila saw in an introductory geography class at Hunter College that captured his attention and altered his career path forever.

↑ Frank Avila, director of the Commercial GEOINT Discovery & Assessments Office at NGA

"I was thinking of going to medical school," said Avila, the director of the Commercial GEOINT Discovery & Assessments Office at the National Geospatial-Intelligence Agency (NGA). "I started working in the *[college's]* microbiology lab. A year into it, it wasn't as interesting *[as I expected]*. Then I took that geography class, and that sparked a different interest. In a way, Landsat is art. Just how beautiful the imagery was and how colorful it was—all of that attracted me to it."

So rather than study the science of medicine, Avila opted to study geography, photo interpretation, remote sensing, and related sciences while working on imagery-related research projects at Hunter College with the National Aeronautics and Space Administration (NASA), NASA's Jet Propulsion Laboratory, and the US Army Corps of Engineers. He received bachelor's and master's degrees in geography.

He enjoyed analyzing imagery to see what others couldn't easily see. "Slowly the interest in imagery evolved into, 'Hey, maybe there is a career out of this,'" Avila said. After joining the intelligence community (IC) in 1987 as an imagery scientist, Avila rose through the ranks to become a national geospatial intelligence (GEOINT) officer in imagery science and then a senior scientist with NGA's Office of Sciences and Methodologies. He assumed his current role—leading the office that assesses and acquires commercial GEOINT products—in 2018.

Esri *ArcWatch* editor Carla Wheeler spoke with Avila at the 2019 Imagery Summit @ Esri UC in San Diego, California, where he was the keynote speaker. During that address, he stressed the importance of investing in the people at the NGA, giving them the advanced technology they need, and shifting toward service-enabled analytics.

Wheeler: What has been the biggest change you've seen in your field over the last three decades?

Avila: One is the additional amount of satellite imagery available that we can use. Certainly, over the last five to seven years, *[it has been]* the move from manual analysis—we used to *[call it]* "putting eyeballs on imagery," *[meaning]* the human trying to infer what activities are unfolding in the imagery—to now start looking at how we can best use machines and automation to start doing that kind of thing.

Wheeler: Is that being done a lot at the NGA, or are you just starting out in artificial intelligence *[AI]*, deep learning, and machine learning?

Avila: We have pilot *[programs]* where we are looking at how we can best use that kind of technology and what applications seem good to apply that kind of technology. We are working quite a bit with industry to see what applications they have *[and]* what technology they've developed. Part of my job in my current role is *[finding out]*, how do we bring some of those technologies to bear on the mission sets that we are supporting? Why invent it if somebody else has done it? Take advantage of innovation that *[is]* going on outside *[the NGA]*.

Wheeler: Could AI replace or reduce the need for imagery analysts?

Avila: No. As I mentioned in my talk, there's a cultural change *[occurring]*. Part of that is the evolution of how we do imagery analysis today. It's not so much replacing a human with a machine *[as]* it's, more so, changing what the human—the analyst—should be focusing on. There are a lot of repetitive tasks that an analyst does, and it eats up a lot of their time. So can we *[use]* machines and automation to do those repetitive tasks faster and at a larger scale, and allow the human analysts to do the cognitive and more complex tasks, which the human does better than the machine.

→ This 2018 Landsat 8 image of Argentina shows the Candeleros Formation, a sedimentary rock formation made up primarily of eolian sandstone that is more than 90 million years old. Landsat imagery courtesy of NASA Goddard Space Flight Center and the USGS.

Wheeler: Give me some examples of the kind of things machines could do.

Avila: There's object detection. I think technology has gotten today to the point where we can train algorithms to identify cars in a parking lot. We may need to monitor patterns of life, and we may need to look at *[the]* volume of traffic or *[the]* volume of cars in a parking lot. So instead of having a human—day in and day out—count how many cars are in a parking lot, a machine can do that much faster and, with the volume of imagery that we now have, can keep up with that workflow. Now the analyst can spend time trying to make sense of *[the question],* What does it mean if there are 20 cars as opposed to 100 cars?—more *[of]* the contextual aspect *[of analysis].*

Wheeler: Could analysts also spend more time focusing on training or improving deep learning models?

Avila: In some cases, yes. Part of their workflow could be that. We may have one group, data scientists, do the training of the model initially, but in some cases, we may have the analyst help validate or improve the algorithm. Initially, we can get the algorithm to a certain accuracy level, but then we can continuously try to improve and increase the accuracy.

Wheeler: Would this help save money, improve efficiency, or increase national security?

Avila: All of the above. We could be more efficient in how we use imagery and how we use our data sources. We can be more efficient in the information we derive. And we could also use our analysts in a more efficient and effective way.

Wheeler: What is the role of the Discovery & Assessments Office, which you lead at the NGA?

Avila: The Discovery & Assessments Office was established in October 2018, bringing together, into one location, work that was being done that focused on commercial solutions and market research. There's a lot of innovation going on out in academia and in industry. Many market sectors have evolved that are making use of what we traditionally call geospatial intelligence *[GEOINT]* . Why reinvent the wheel when somebody has already done something that we can apply in the way it was developed or, *[with]* minor tweaking or modification, it can better suit our mission needs?

Wheeler: What do you look for in a commercial solution?

Avila: Starting from square one, I see ourselves as a matchmaker. Understanding the mission needs that we are trying to address, we go out and look for the solutions in industry that can satisfy those mission needs. Then we start screening those solutions.

Beyond knowing what their capabilities are, we need to know how accurate they are and what are the limitations of the solution. Selected commercial capabilities are brought into our environment to *[let us]* assess them to see if they will meet our mission needs. We need to determine the accuracy of the data and the limitations of the applications because many times they may have been tailored for a specific market sector and we may be trying to use it for something totally different.

We also *[ask]*, How challenging is it going to be to integrate that solution into our production and analytical environment? We have to bring those solutions into our environment where the analysts are working and integrate that data source or that imagery source

in with everything else that we use.

Then we also look at company viability. We would hate to start buying a solution from a company that may not be around in a year or two years.

Wheeler: What types of commercial solutions are you looking for?

Avila: We are looking at the gamut, including imagery sources and analytics products. We keep a pulse on where industry is going and what are the new companies that are evolving, especially in the small satellite market. We have quite a number of new entrants into that business sector. At a minimum, we want to understand who the players are and what do they bring to the table. Is it a new modality? Is it hyperspectral *[imagery]*? Is it a new synthetic aperture radar *[SAR]* vendor? Is it somebody who is looking at automatic identification system *[AIS]* technology or radio frequency *[RF]* detections—what we consider nontraditional sources that differ from what we've used in the past?

The interesting part of *[working in]* my office is, we get a chance to peek and see what's going on in all the emerging technologies. We get a chance to speak to all these members of industry and, in some cases, influence a bit where the technology is going to better meet our mission needs. We are not only doing this for NGA…but it's on behalf of our *[GEOINT]* community—intelligence, the Department of Defense, and the federal sector.

Wheeler: During your keynote speech, you mentioned that you were interested in advances in hyperspectral imagery. What is hyperspectral imagery, and why is it important as an emerging technology?

Avila: When you look at earth observation, think of it as a camera. You may have different cameras that look at an image—at a picture—each from a different perspective. Panchromatic was black and white; multispectral starts seeing the color of an object, and that brings a new, different dimension. SAR *[technology]* can see through clouds and see at night. Hyperspectral *[imagery]* allows us to discriminate and identify material composition. Much like every human has a different fingerprint, every material on earth has a different fingerprint. Hyperspectral imagery allows you to detect, What is that fingerprint? It tells you this is material *x [and]* this is material *y*. Colorwise, they may look the same, but when you start looking at that other dimension, the hyperspectral dimension, now you can tell that the two materials are different.

Wheeler: What are some examples of how this can be used?

Avila: The oil and gas exploration industry may want to determine where *[to]* drill based on the materials they are looking for. Hyperspectral imagery could be one technology they could use to determine the composition of the materials in the landscape. In agriculture, you may be able to tell what the different types of crops in farmlands are, based on hyperspectral imagery. In national security, it's determining the types of materials *[found]*. It's one other data point we can add into our analysis and say, "Maybe these materials are different than the ones that were here last week or last month. What is the meaning of that?"

Wheeler: Turning to GIS, what type of geospatial solutions do you look for or would you like to see?

Avila: Since I am more of an imagery person, from my perspective it would be tighter integration and more seamless integration with what has traditionally been GIS data—your vectors and points—with AI-derived analytics. It's bringing all that information under one source and *[having]* GIS help us make better sense of all that information.

← Imagery from the Landsat 7 satellite and elevation data from the USGS National Elevation Dataset (NED) combined to create this visualization of Glacier Bay National Park and Preserve in Alaska. Landsat imagery provided courtesy of NASA Goddard Space Flight Center and the United States Geological Survey (USGS).

I saw examples of that this morning *[at the Imagery Summit @ Esri UC]*, where all that technology is going. The AI and machine learning capabilities are being added *[to GIS]*… It's bringing it all under one platform. I think that's really exciting. …In the future, service-enabled data streams will support analysts to look beyond just images to search for and discover the context of complex problems.

Wheeler: What are the most significant demands and requirements of your customers?

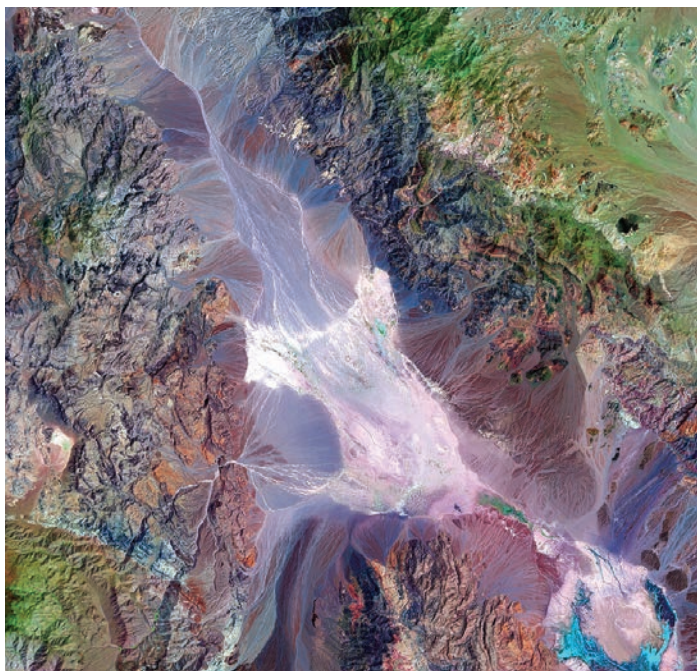
Avila: It's always going to be speed of information. Many times, when we get a task, when we need to provide answers to something, it's, "I need it yesterday!" It's how quickly we can answer the questions that we are getting asked.

In some cases, it's being able to predict what are the questions we are going to be asked and ensure that we have the right information to be able to answer those questions quickly. With all the data that we are getting, with all of the types of analysis that we are able to do—time-series analysis and trending analysis—in a way, it's the next evolution. Knowing what has happened in the past and what patterns we've seen, we can predict what may happen in the future.

Wheeler: Do you see more emphasis on predictive analytics right now?

Avila: In the research arena, there's emphasis put on going down that route. It's all *[being]* fueled by the amount of data we have access to today and the kinds of algorithms that are being developed, where we can now start seeing trends and patterns and information that lead us then to that predictive analysis. The next step is operationalizing all that activity into platforms like ArcGIS. Esri as a company is realizing that is where *[it needs]* to go. It's great to see emphasis has been put on that type of development of predictive analytics.

↓ This image of Death Valley National Park was captured by Landsat 7 in 2000. Landsat imagery courtesy of NASA Goddard Space Flight Center and the USGS.



Wheeler: In your roles at the NGA, you've promoted geospatial technologies and image sciences to young people. How do you get them interested in working for the NGA when there is competition from private industry?

Avila: At the NGA, the challenges we try to address are challenges you will not find anywhere else. Looking *[from]* the image science perspective, it's not the type of job where you are doing the same thing every day. As an image scientist, one day I'm working with an analyst, understanding the mission need that they are trying to address. And then I look at what data sources that I have that can inform the question the analyst is trying to address.

On another day, I might be working with our industry partners—a Maxar *[provider of advanced space-based technology solutions]* or a Planet *[earth imaging company]* or an Esri—to look at how can the solutions that they provide—be it imagery sources or software—better help us address our mission. On another day, I could be working with our NGA college, helping train our analysts.

Wheeler: I heard that one of your earliest assignments after joining the IC was to study the imagery in the aftermath of the Chernobyl nuclear power plant disaster in the former Soviet Union. What was that like?

Avila: It was interesting. I was coming in fresh out of school and that was one of the first projects I was given. This was a few months after the incident had happened, and it was basically, "What can you tell us *[about]* what is happening there from the imagery sources that we have?" In some cases, visually some of the damage was not evident because it was only a few months after the nuclear explosion had happened. But also *[we asked]*, "How much can we start inferring about what is the damage to come, *[based]* on the imagery sources that we *[have]*?" At the time, Landsat was one of the imagery sources. It was a good project to cut my teeth on.

About the Author

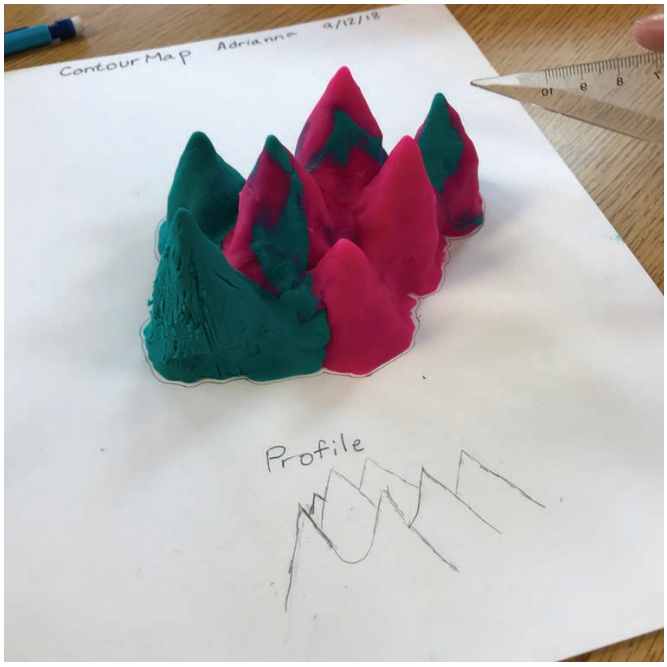
Carla Wheeler is a technology writer and editor at Esri and a former journalist. She graduated from the University of Minnesota with a bachelor's degree in journalism and political science. She currently edits *ArcWatch* and works with ArcGIS StoryMaps, creating stories with the app. Follow her on Twitter @gisjourno.

A REAL-WORLD EDUCATION

By Heather Smith

↓ Lauren Sinclair is a middle school teacher and National Geographic Educator who loves enabling kids to make great maps.

↓ Sinclair starts her sixth graders with concrete exercises, such as building topography contours with modeling compound.



ALMOST EVERY DAY that Lauren Sinclair teaches one of her middle school GIS design classes, she gets asked by a student if the data they are working with is real. Is this information about real people from the real census?

These students are amazed and impressed by a fundamental fact about GIS that can be easy for the rest of us to forget. Everything else in their education is hypothetical, but in GIS class, they work with real data from the real world. They recognize why that matters: it means they can make decisions that have a real impact.

A middle school teacher who loves enabling kids to make great maps, Sinclair teaches sixth grade and eighth grade GIS design classes at the French International School in Portland, Oregon. In addition to GIS design, she teaches woodworking and environmental science. A National Geographic Educator, she is constantly brainstorming new ways for middle school students everywhere to unlock the power of GIS. She is also a Where's Waldo aficionado and a Carmen Sandiego lookalike.

Her teaching methods are varied. She starts sixth graders with concrete exercises, such as building topography contours with modeling compound. This year her eighth grade students are working on the Learn ArcGIS lesson "Map Voter Data to Plan Your Campaign" and are participating in the *Going Places with Spatial Analysis* massive open online course (MOOC). Both are offered by Esri at no cost. Students at either level finish the course by creating their own maps. Sixth graders must map something on their school campus, while eighth graders are given free rein to map anything they choose.

Instead of starting each class with a description of what the students will do that day, Sinclair begins with a discussion on why they should care about the day's assignment. Middle school kids may be adopting a "Who cares?" attitude, but that's not necessarily because they don't care. They just want some justification for why they should. Sinclair's GIS classes this year have focused on political participation, specifically redistricting and gerrymandering. Students are passionate about these topics and want to make maps that propose fairer solutions.

Sinclair wants students to know that it's empowering to use real data in a real way. This year, her students participated in a mapathon for the Missing Maps program. Missing Maps, an open, collaborative project, helps map areas where humanitarian organizations are trying to help vulnerable people. As soon as Sinclair's students understood they would be contributing to maps that would be used by real people in humanitarian organizations on the other side of the world, they couldn't wait to get started.

↓ Each semester, students in Sinclair's GIS Design classes learn how GIS works, how to make maps, and the basic principles of map design.

IF STUDENTS CAN FOLLOW INSTRUCTIONS, THEY CAN DO GIS, SO TEACHERS CAN GUIDE THEM WITHOUT BEING GIS EXPERTS.

Sinclair also volunteers to teach other classes using GeoInquiries, short, standards-based inquiry activities for teaching map-based content found in commonly used textbooks. GeoInquiries are available from Esri for free at https://bit.ly/349ZSnm. The other teacher logs an hour of professional development time observing as Sinclair guides their students through map-based learning and is introduced to a powerful teaching tool at the same time.

Sinclair wants other teachers to know that they don't need to be good at GIS. They don't have to take time to learn this new technology because GeoInquiries are easy for both students and teachers to use. If students can follow instructions, they can do GIS, so teachers can guide them without being GIS experts.

Although she studied GIS at Portland State University, it was back before there were readily available resources for K–12 GIS education, so Sinclair got started using GIS in teaching by enrolling in the GeoMentors program, which matched her with local GIS experts. Next, she attended the Esri User Conference, where she met like-minded educators who became a valuable peer group. Now she's ready to help others. She encourages teachers curious about teaching with GIS to reach out to her via Twitter @MrsSinclairMaps or email at lsinclair@faispdx.org.

ABOUT THE AUTHOR

Heather Smith is a cartographer and artist who mixes both practices to express and understand landscapes. She works as a product engineer at Esri, where she writes and edits lessons for the Learn ArcGIS website. View more of her work at www.heathergabrielsmith.ca.

ArcGIS Online Simplifies Lab Lessons

By Crystal Bae and Liz Chrastil

Two university instructors improved students' learning experience by moving the labs for a geography course from ArcMap to ArcGIS Online. The move simplified the students' interaction with the software and made it more accessible. The move also saved the instructors time when writing labs and gave them easy access to diverse and current datasets.

Crystal Bae, a PhD student at the University of California, Santa Barbara, worked closely with faculty member Liz Chrastil to redesign the GIS-based labs for their department's introductory Urban Geography course. As the course instructor, Chrastil had inherited the Urban Geography course from a faculty member who recently retired. The labs, originally designed in ArcMap, were modeled and adapted from the lab activities presented in the textbook *Exploring the Urban Community: A GIS Approach*, 2nd Edition, by Richard P. Greene and James B. Pick.

Many lab assignments used data from the 2000 US Decennial Census. Chrastil and Bae worked together to redesign the labs, so they would be easy to update as the US Census Bureau released new demographic data, either from the decennial census or the American Community Survey.

In Bae's experience as a teaching assistant and instructor for Urban Geography, she found that undergraduate students who were less experienced with file organization and data structures struggled setting up, saving, and retrieving lab files in ArcMap. A significant amount of time was spent explaining and troubleshooting common issues. This detracted from the time that could be spent interpreting the results of spatial analyses or reflecting on possible explanations for the results obtained.

Urban Geography is a topical course rather than one that is primarily methodological, so it often draws students from outside the geography department. Although the department's series of GIS courses were not a prerequisite for Urban Geography, Chrastil and Bae wanted to introduce students to using GIS with urban geographic datasets and give them hands-on experience performing the analysis.

Both Chrastil and Bae recognized this was an opportunity to redesign the lab assignments and move them to the university's ArcGIS Online platform. They were motivated to make the move by the simplicity of the ArcGIS Online interface, the ability to access ArcGIS Online from any computer without installing software, and ArcGIS Online's more intuitive definition of spatial analysis.

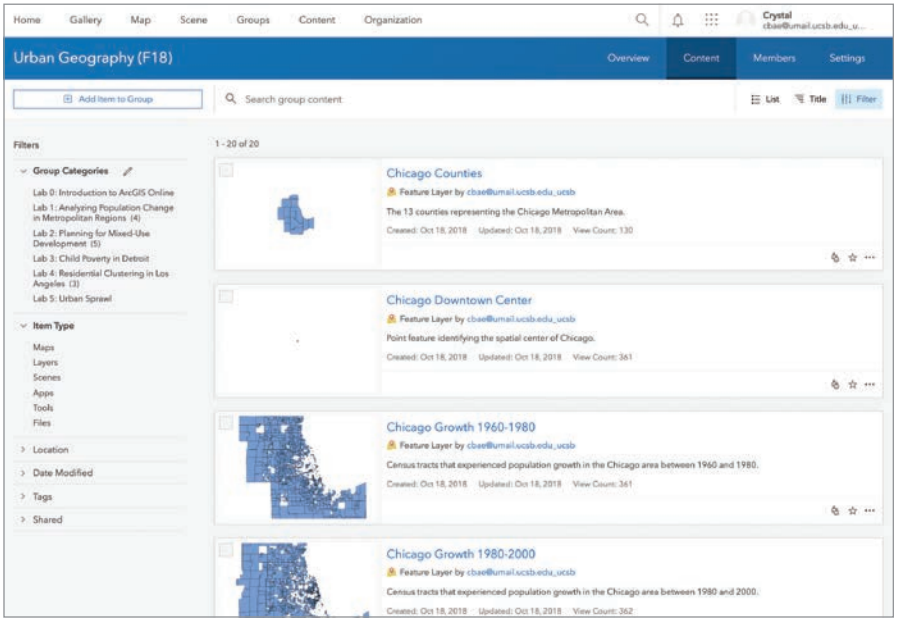
Accessibility was important for students who lived further off campus and would not be able to work on their lab assignments outside of class hours. Previously, students had to find time to come to the computer labs in the geography department to use ArcMap if they were not able to complete the assignments during the designated lab section time. Occasionally, students ran into issues when they began an exercise with one version of ArcMap but tried to complete it in another computer lab that had a different version of ArcMap.

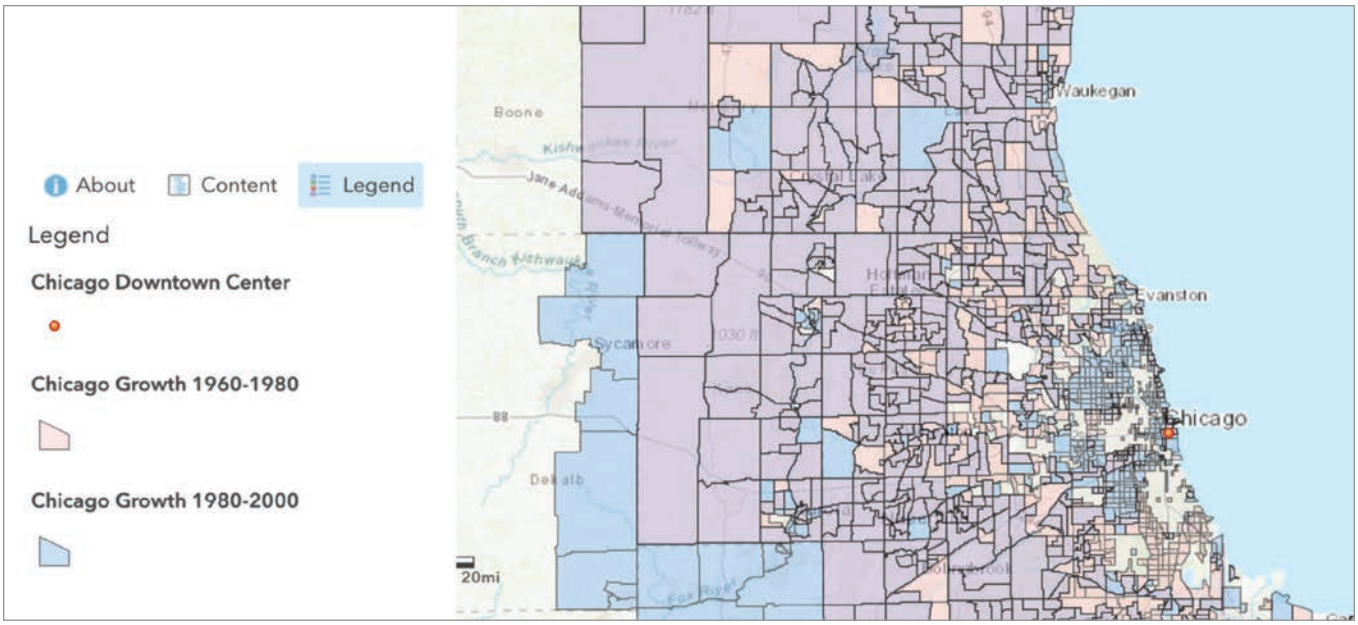
Another benefit is the number and diversity of the huge public datasets available as map layers shared on ArcGIS Online. Finding appropriate datasets used to take instructors the majority of the time they spent writing lab assignments. Now many datasets are available in a format that is ready to use in the platform. In a few cases, Chrastil and Bae started with existing lessons they found in the ArcGIS Lesson Gallery and adapted them to the course's topics.

Using the Groups feature of ArcGIS Online allowed them to set up a group for each year's Urban Geography class and make the appropriate lab files available for each assignment. They shared content by adding the necessary layers to the group and categorizing them by lab assignment. However, when Chrastil and Bae offered the class a second time on ArcGIS Online, they found they had to manually reclassify the datasets associated with each lab after copying the course materials to the new class group.

The Urban Geography course has been taught twice since the lab assignments were moved to ArcGIS Online. The

↓ One of the benefits of moving the course to ArcGIS Online was the number and diversity of the public datasets available as map layers shared on ArcGIS Online that could be used in course exercises.





↑ Using ArcGIS Online for lab assignments made current datasets available for exercises such as this one on population change in metropolitan regions.

feedback from students and instructors has been very positive. Students spend less time downloading and organizing data and more time running spatial analyses and interpreting the results in relation to the lecture content. Students without prior GIS experience become acquainted with the ArcGIS Online interface quickly and keep up with weekly assignments.

In addition, teaching assistants and instructors find it easier to guide students through the work and spend less time troubleshooting. Students had complained about the "stale" data used in labs that was not updated frequently. Now, it will be much easier to update datasets as they become available—a huge plus.

It took Bae only a few months working part time in the summer to adapt the existing ArcMap lab assignments to ArcGIS Online. The first lab assignment was a GIS crash course. It was adapted from an existing tutorial found in the Learn ArcGIS Lesson Gallery (learn.arcgis.com/en/gallery/). Topics for other lab assignments include population change in metropolitan regions, residential clustering, and the urban core and periphery. These assignments use specific regional or city datasets that are either available through the publicly shared data on ArcGIS Online or from other agency resources.

Although Bae was accustomed to the ArcMap interface and the names of spatial analysis tools were different on ArcGIS Online, she found that overall the organization worked better and was much more intuitive for first-time GIS users. Instructors new to teaching the course who want to adapt labs to their own research interests can do so easily.

Next steps will be creating a gallery of available lab assignments for use by instructors within the organization or geography department. Going forward, labs could be adapted as needed, based on the instructor's teaching emphasis or the specific interest areas of the students.

For more information, contact Crystal Bae at cbae@ucsb.edu.

About the Authors

Crystal Bae is currently a PhD candidate in geography at the University of California, Santa Barbara. She conducts research in the areas of spatial cognition and urban geography, particularly in the study of human navigation in groups. Her work spans the disciplines of geography, cognitive science, and sociology.

Liz Chrastil is an assistant professor in the department of geography at the University of California, Santa Barbara, and an assistant professor in the department of neurobiology and behavior at the University of California, Irvine. Chrastil received her PhD from Brown University and completed postdoctoral training at Boston University. She has worked in psychology, geography, neuroscience, and cognitive science, using primarily cognitive neuroimaging and virtual reality methods.

Many Missions Serve Needs Around the World

By Monica Pratt

"Apply geospatial knowledge to heal the world!"

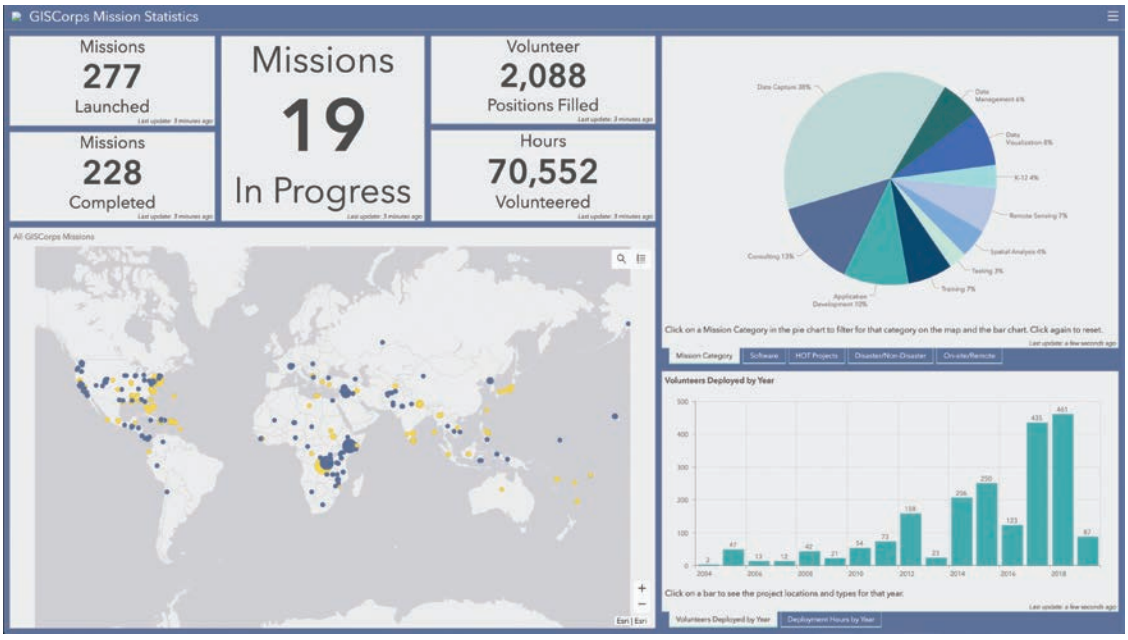
These words from GISCorps volunteer Kiema Kandia embody the organization's work in 2019 and all the years since its founding in 2003. GISCorps members have volunteered more than 70,000 hours since the organization's inception to complete projects, known as missions, around the world. Missions run the gamut from humanitarian response and social justice to environmental and educational projects. These missions apply the full spectrum of GIS capabilities to problems both large and small.

The GISCorps, a program of URISA, operates "to coordinate short-term, volunteer-based geographic information systems (GIS) services to underserved communities worldwide." An international nonprofit, URISA has been supporting the development of professionals in GIS around the world since 1966.

GISCorps matches people who have GIS skills with organizations that need short-term GIS services. Mission types vary from teaching GIS to developing mapping applications to collecting data; some may involve travel, while many others can be completed remotely. The organization notifies volunteers of opportunities that match their skills and expertise, inviting them to apply for the opportunities that interest them. There is no minimum level of education or experience required, and students may apply. Go to www.giscorps.org/become-a-volunteer/sign-up-to-volunteer/ to fill out the form to become a volunteer.

Volunteers are also encouraged to create their own projects by volunteering at organizations in their community that may not be aware of GISCorps.

While organizations benefit from GISCorps missions, volunteers also benefit in a variety of ways. Missions can provide volunteers with opportunities for professional development. "Volunteering with GISCorps is a great way to use and develop your GIS skills while contributing to a good cause and expanding your network of GIS professionals around the world," said GISCorps volunteer Shannon Cox, who provided user support to the Mountain Rescue Association.



→ GISCorps has been using its volunteers' GIS expertise to aid organizations around the world since its founding in 2003.

← GISCorps volunteer Sarah Welt reinvigorated the Capital Area Food Bank's GIS program by cleaning data, creating layers using the latest data, and improving maps to better communicate information and be more visually impactful.

Benefits can also derive from the satisfaction of helping in a meaningful way—benefits that can be less measurable but no less real. According to Johnathan Clementi, who assisted on missions associated with hurricane recovery, "Working as a GISCorps volunteer afforded me the opportunity to aid in relief efforts from a remote location. I feel that I truly made a difference in the recovery effort and would highly recommend signing up to help with this project."

In 2019, GISCorps volunteers continued applying their GIS expertise to assist a broad range of organizations, from international ones like the World Health Organization (WHO) to local conservation groups. Their missions improved emergency response, disaster recovery, and conservation planning activities and helped with projects that addressed such issues as food insecurity and social injustice.

During the last year, GISCorps launched 25 new missions, completed 13 missions, and continued to work on 19 missions. More than 160 GISCorps volunteers participated in these missions.

Of the many missions the GISCorps worked on during 2019, this article briefly describes three of them. These missions focused on reinvigorating mapping efforts of an organization helping food insecure people; using crowdsourcing to document the effects of extreme weather events; and verifying base layer data to ensure the collection of spatially accurate data.

To learn more about all the projects undertaken in 2019, look at the Esri Story Maps app "URISA's GISCorps—2019: The Year in Review" at https://bit.ly/2QwhJ3M. This operations dashboard demonstrates GISCorps' Mission Statistics from 2003 to present: https://bit.ly/37VaKHx.

Ready to Respond

From its early days, GISCorps has rapidly mobilized to help respond to disasters. In 2005, the call went out for volunteers to respond to the devastation caused by Hurricane Katrina in Mississippi. Although only 270 volunteers were registered in the GISCorps database at the time, within a week more than 500 GIS professionals had volunteered. "The response of the community was just amazing, and I was humbled by that every moment of the day," said GISCorps founder and current director Shoreh Elhami.

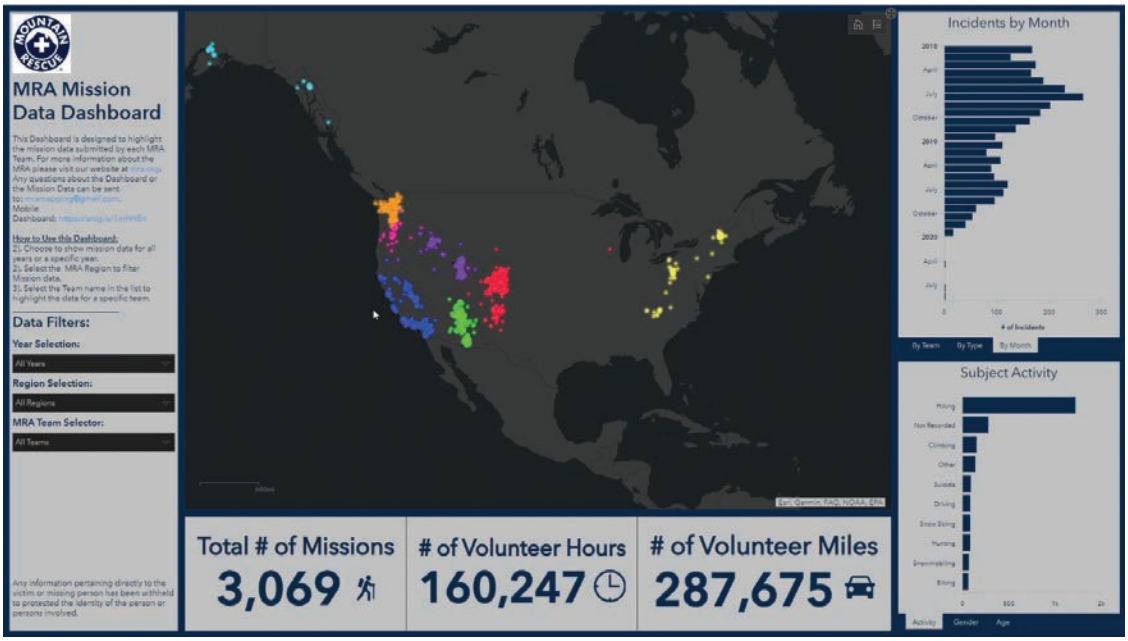
The GISCorps participation in response to disasters of all kinds has continued over the intervening years. In 2018, GISCorps collaborated with the National Alliance for Public Safety GIS (NAPSG) Foundation and CEDR Digital Corps in the creation of crowdsourced story maps to aid responses to Hurricanes Florence and Michael.

The next year, Paul Doherty—NAPSG Foundation programs manager and also GISCorps volunteer—requested support from GISCorps to populate an ArcGIS Online web map used by the staff at the Federal Emergency Management Agency (FEMA) and state and local emergency operations centers to improve situational awareness and inform decision-making in response to Tropical Storm Barry and Hurricane Dorian.

The GISCorps mission mounted to fulfill this request was handled by an administrative team composed of Erin Arkison, Christina Brunsvold, John Haddad, Eadie Kaltenbacher, Melvin Nforba, Holly Torpey, German Whitley, and Dacey Zelman-Fahm. Their goal was to provide emergency managers with increased situational awareness before, during, and after each storm. The team validated and categorized photos that had been submitted, documenting these extreme weather events. They also mined social media for imagery that could be geolocated, provided systems support, and assisted other GISCorps volunteers by geolocating photos and videos and adding them to the 2019 Hurricanes Crowdsourced Photos Story Map: https://bit.ly/2N4tXh. NAPSG Foundation and GISCorps are developing a new solution for next year's hurricane season that combines the Attachment Viewer configurable app, Survey123 for ArcGIS, and Operations Dashboard for ArcGIS.

Analyzing Hunger and Its Effects

In 2018, more than 11 percent of US households were affected by food insecurity, according to the United States Department



→ Shannon Cox and Jessica Beres provided support for the Mission Data Portal users of Mountain Rescue Association (MRA) member team representatives, who use the portal in their search and rescue work.

of Agriculture. In other words, 14.3 million households had insufficient resources to obtain enough food for an active, healthy life. Hunger and the limited availability of wholesome food is also related to problems caused by chronic undernutrition, heart disease, and obesity.

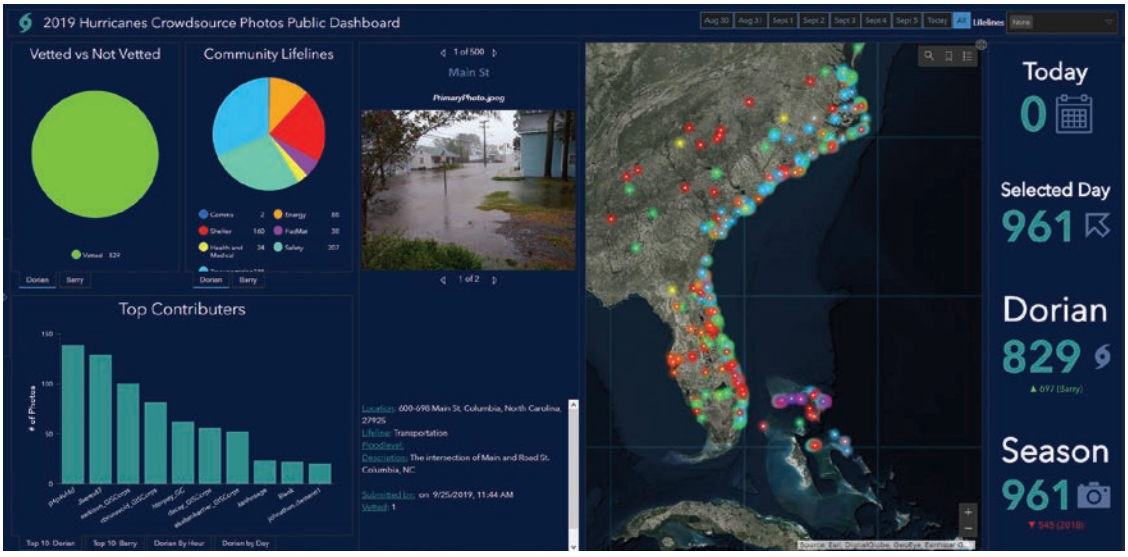
In the Washington, DC, metro area, the Capital Area Food Bank (CAFB) created a Hunger Heat Map to target the communities that would benefit from its services in 2015. Using GIS was effective, but the GIS specialist who made the map left CAFB, causing the map's value to diminish as its data aged. The remaining IT staff lacked the time to continue supporting the map.

When CAFB requested help from GISCorps, Sarah Welt was assigned and essentially became the CAFB's interim GIS specialist. She reinvigorated the GIS program, cleaned data, created layers using the latest data, and improved maps to better communicate information and be more visually impactful.

The GIS specialist CAFB eventually hired was able to immediately become productive by using the foundation Welt provided. CAFB could rapidly release new maps and launch related pilot programs thanks to Welt's contribution. Her efforts were appreciated by CAFB IT director Dan Shenk-Evans, who noted, "Sarah did a great job updating our Hunger Heat Map, and she was instrumental in jump-starting our GIS efforts, which had fallen dormant."

Work on OpenStreetMap Projects

In 2019, GISCorps volunteers answered a call by Humanitarian



→ GISCorps volunteers helped improve situational awareness and inform decision-making in response to Tropical Storm Barry and Hurricane Doria. The web map was used by the staff at the Federal Emergency Management Agency (FEMA) and state and local emergency operations centers.

OpenStreetMap Team (HOT) for help with mapping areas affected by natural disasters including Typhoons Kammuri/Tisoy and Hagibis. HOT is a global community of volunteers, community leaders, and professionals who create open map data to support disaster response and sustainable development. When HOT launches urgent disaster response tasks, a quick response from experienced OpenStreetMap mappers and validators is required, and GISCorps assistance is occasionally requested. A list of HOT projects supported by GISCorps volunteers can be found on this webpage: www.giscorps.org/hot-projects.

GIS Service Pledge Program

GISCorps volunteers who participate in the GIS Service Pledge program identify, design, and manage their own missions, which are chosen because those missions support organizations, communities, or causes that matter to them. Esri donates a free one-year Home Use license to support each volunteer's efforts.

Many Missions Focused on a Larger One

Whether its missions are the work of many volunteers or just one, GISCorps puts GIS in the service of making the world a better place. According to Tené Logan, program director for Charity Co-Op, "GISCorps is that rare organization that actually practices what they preach. Their base of GIS experts, team, and board members are extremely knowledgeable and hardworking and committed to the social impact mission. The level of commitment to accomplishing project objectives is admirable and inspiring."

About the Author

Monica Pratt is the founding and current editor of *ArcUser* magazine, the executive editor of *ArcNews* magazine, the editor of *Esri Globe,* and head of the Publications team at Esri. She has been writing on technology topics, specializing in GIS, for more than 25 years. Before joining Esri in 1997, she worked for newspapers and in the financial industry. Follow her on Twitter at @ArcUser.

The following volunteers completed their GIS Service Pledges in 2019:

Scott Stevens provided GIS data management and mapping for Land Trust of North Alabama.

Joseph Mueller assisted the SoJiBoJa Conservation Club with its efforts in protecting critical endangered habitat vital to a fish that is the base of the aquatic food chain for Minnesota's lakes and many sport fishes in northern Minnesota.

Daniel Specht supported the World Health Organization response to a polio outbreak in the Democratic Republic of the Congo (DRC).

Alexis Handelman supported the Conservation Lands Foundation through GISCorps with spatial analysis, data manipulation, and map creation.

Ali Rehmat Musofer supported the Hussaini Organization for Local Development by studying glacial lake formation and glacial lake outburst flooding (GLOF) in Khurdopin-Shimshal in Pakistan.

Jim Kyle mapped trauma-related deaths in the West Kootenay Region of British Columbia and provided online tools for spatial analysis of this data by the Kootenay Emergency Response Physicians Organization.

David Hansen helped the American Red Cross in the Gold Country region apply GIS to benefit both natural and human communities.

Gabor Bakos created a web-based geospatial server and real-time dashboard that includes all important and available spatial information about Tanzania.

Patrick Hall used GIS to support the local disaster preparedness for Los Angeles Fire Department Community Emergency Response Team (CERT) program.

Samuel Mwenda of Bethune-Cookman University modeled and mapped small catchments in municipalities in eastern Florida to inform residents about the dangers of nonpoint source pollution.

To learn more about the missions GISCorps volunteers have pledged to undertake, visit **www.giscorps.org/gsp**.

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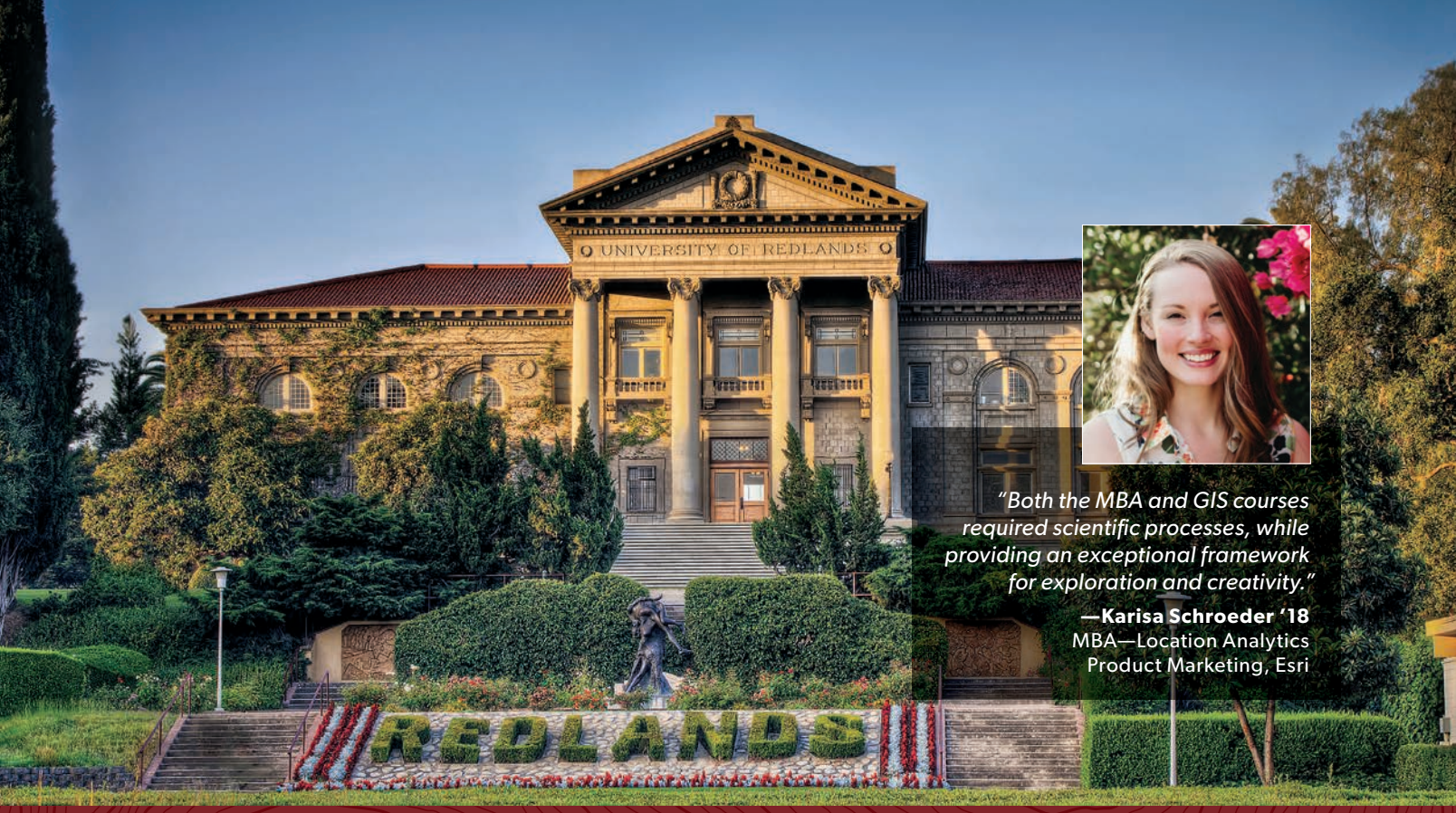

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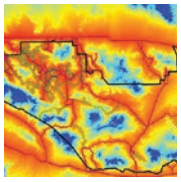

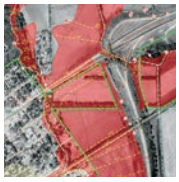

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