Spring 2021

ArcUser

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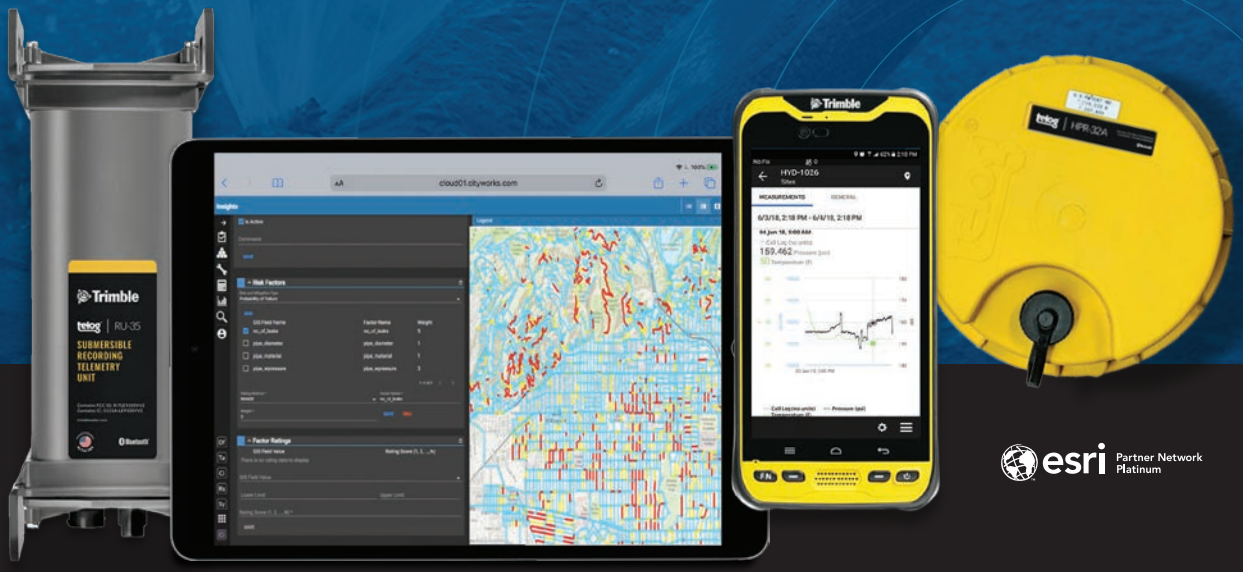

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Contents

Spring 2021 Vol. 24 No. 2

Focus

Special Section

End Notes

On the Cover

The U.S. Vessel Traffic App is a web app built by Esri using ArcGIS API for JavaScript. It is a simple tool for visualizing and accessing a portion of the nautical transportation and commerce data provided by the Automatic Identification System (AIS). This massive dataset, collected by the US Coast Guard (USCG) from onboard navigation safety devices, is provided by the USCG, the National Oceanic and Atmospheric Administration (NOAA), and the Bureau of Ocean Energy Management (BOEM) through Marine Cadastre. (livingatlas.arcgis.com/vessel-traffic)

Making Connections for Better Understanding

Geography, the science of our world, and GIS, the technology based on geography, are both predicated on discovering connections in space and time to create a better understanding of our world. GIS has evolved from a methodology for spatially integrating project data to a geospatial infrastructure for interconnecting knowledge domains and framing human activities at scales from the local to the global.

Advances in GIS technology continue expanding geospatial infrastructure in the cloud. With the introduction of ArcGIS Enterprise for Kubernetes, a cloud-native deployment option for ArcGIS Enterprise, GIS can be more scalable, resilient, and easily maintained. ArcGIS Living Atlas of the World, a cloud-based repository of the foremost collection of geographic information from around the world, powers the development of innovative applications built with ArcGIS technology.

The integration of GIS with other technologies has significantly increased its impact. Because GIS and BIM data can be exchanged, digital twins of neighborhoods, facilities, or even cities can now furnish geographic context for built environments, both existing and proposed.

The release of ArcGIS Platform, a location platform as a service, has made the foundational components of ArcGIS widely available to developers for use in all kinds of apps and technologies. Working with large providers of technology such as Salesforce, SAP, and Microsoft, Esri is making the benefits of location technology more widely available to knowledge workers. Esri is also partnering with major companies and industry groups in fields such as transit and real estate to enhance and integrate ArcGIS location technology in tools and systems.

Articles in this issue illustrate how ArcGIS has adopted IT innovations in data analysis and computing techniques. Machine learning is turbocharging imagery analysis and the basemap update process for Kuwait. 3D visualization is improving housing policy decisions. The KnowWhereGraph project gauges the impact of environmental changes on society.

However, meeting the many challenges we face in society and the world—from racial inequity to the loss of nature to climate change—requires not only the integration of GIS technology but the adoption of geographic thinking. Geography is a powerful and comprehensive way of organizing and integrating knowledge. Geospatial literacy will help us better understand our problems and GIS will help us visualize solutions.

Monica Pratt
ArcUser Editor

ArcUser

Spring 2021 Vol. 24 No. 2

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Departments

Briefly Noted

Esri Joins Digital Twin Consortium

The digital twin is a virtual representation of the built and natural world that allows organizations to capture, model, visualize, simulate, analyze, and predict information by interconnecting many information systems to improve decision-making. The ArcGIS system is the foundation for a digital twin. It provides reality capture, GIS and building information model (BIM) integration, real-time data from the Internet of Things (IoT), advanced artificial intelligence (AI), and machine learning.

To enhance these capabilities, Esri has joined the Digital Twin Consortium, a global community of users from industry, government, and academia who are working together to improve the consistency of the vocabulary, architecture, security, and interoperability of digital twins. Many organizations have deployed some version of a digital twin to meet a specific challenge, but this digital twin is usually implemented on an ad hoc basis and lacks a larger strategy or vision. This approach has resulted in many siloed models that are fragmented and disconnected from other critical information systems. ArcGIS provides context for projects with information about their surrounding environment and connects the model to other networks and systems. To learn more about how Esri is bringing the power of location to digital twins, visit go.esri.com/DigitalTwin.

↑ Esri and Trapeze Group have formed a strategic collaboration to allow transit agencies access to the data required to efficiently schedule services.

A Commitment to Make GIS Accessible to All

The Esri Accessibility website (https://bit.ly/2Rr23l3) provides information on product accessibility and resources for implementing accessible maps and apps using Esri technology. Esri believes there should be no barriers for users in achieving success with ArcGIS. The company is committed to creating accessible products and services that are compatible with the latest assistive technologies and conform to current software accessibility standards and guidelines.

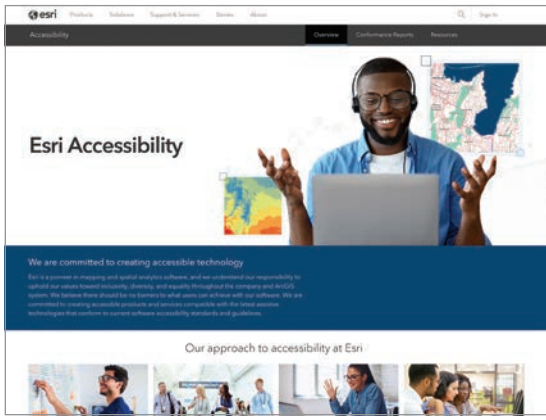
Trapeze and Esri Collaborating to Improve Transit

Esri and Trapeze Group have formed a strategic collaboration to allow transit agencies to access the data required to efficiently schedule services. Trapeze Group works with public transit agencies and the communities they serve to develop smarter, more effective public transit solutions. This partnership will help provide transit agencies with integrated solutions that improve how they deliver services. Currently, transit agencies must access multiple systems in different departments to leverage data when making key business decisions. By providing transit agencies with a central transit platform, these solutions will eliminate inefficiencies and errors and give agencies better insights. Tools for promoting community collaboration and consolidating engagement for all city services will be provided by ArcGIS Hub.

Esri and SAP Advance Business Technology and GIS Integration

The long-standing strategic partnership of Esri and SAP has been expanded with the certification of SAP HANA Cloud, SAP's database-as-a-service offering. With ArcGIS Enterprise support for SAP HANA Cloud, ArcGIS users can leverage the geospatial platform with the powerful database and analytic capabilities of SAP's leading cloud database as a service. This gives organizations dealing with unconnected multiple sources of data a central repository that provides a complete overview of all data. They will have that overview no matter the data source: SAP, non-SAP, cloud, or on-premises. SAP HANA Cloud breaks down data silos and provides a gateway to data and the source of the truth for all data.

SAP and Esri will continue to collaborate around SAP S4/HANA platform integration and cloud initiatives. In addition, SAP is working on integrating with ArcGIS Platform, Esri's new location platform as a service offering with components of the SAP Business Technology Platform to make location services available to the SAP developer community and to line of business applications. To learn more about how Esri and SAP are making location services available to users, visit esri.com/sap.



↑ The Esri Accessibility website provides information on product accessibility and resources for implementing accessible maps and apps using Esri technology.

Online Services Not Affected by Microsoft Exchange Vulnerabilities

Esri products are not affected by the Microsoft Exchange vulnerabilities listed as part of the Emergency Directive 21-02 issued by the Cybersecurity and Infrastructure Security Agency (CISA) in March 2021. Both Esri's Federal Risk and Authorization Management Program (FedRAMP)- authorized services, ArcGIS Online and Esri Managed Cloud Services (EMCS) Advanced Plus, are not affected by this vulnerability, as Microsoft Exchange is not used within Esri FedRAMP authorized environments and Esri does not include Microsoft Exchange as part of its customer on-premises offerings.

GIS Solutions and Services Aid Investors and Regulators

The Emirates Real Estate Solutions (ERES) land development and land market services and Khatib & Alami (K&A) will use ArcGIS to geoenable ERES solutions and service offerings to the international land development and real estate market. By incorporating ArcGIS capabilities for field collection, spatial analytics, and mapping into ERES infrastructure and solutions, ERES now provides real-time data on valuations, sales assessments, and rent indexes. This allows investors and regulators to establish equitable valuation and property taxation through embedded dashboards and maps that provide an instant view of the real estate development market from any device, anywhere, anytime. K&A, an urban and regional planning, architectural, and engineering consulting company and Esri partner, has successfully deployed solutions in the Middle East, central Asia, and Africa.

Apps Are the Key to Unlocking Valuable Data

ArcGIS Living Atlas of the World provides a collection of curated maps, apps, and data layers that is continually updated and augmented. It is contributed by Esri and the global GIS user community. This content includes basemaps, world elevation and imagery layers, policy and community maps, and analysis-ready layers and tools.

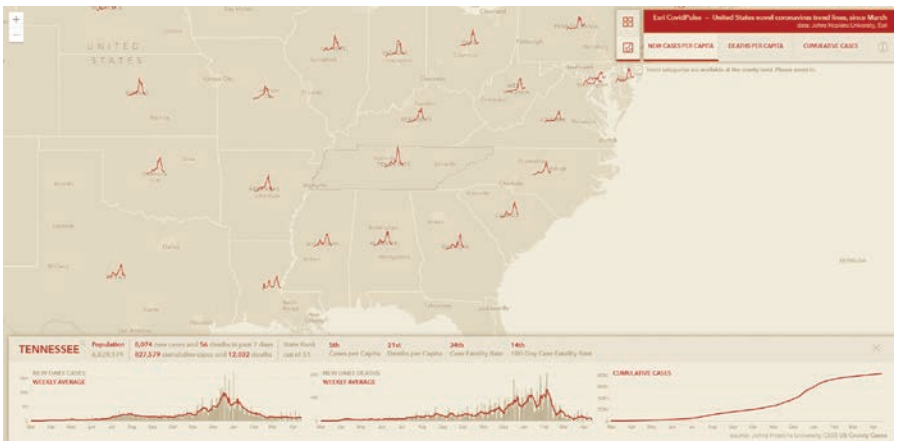
Content from ArcGIS Living Atlas of the World can be mashed up with an organization's data using tools from the ArcGIS system to make apps for visualization and analysis that provide insight and promote solutions.

Outstanding examples of apps are available through the Living Atlas interface. A curated group of apps can be found under the Apps tab or all available apps can be found via the search box on the Browse tab. CovidPulse, U.S. High Tide Flooding, and U.S. Vessel Traffic are examples of powerful apps that were created using ArcGIS Living Atlas content and ArcGIS tools.

Browse the apps and content available from ArcGIS Living Atlas of the World website (livingatlas.ArcGIS.com) for ideas on how to use this data and other resources to build apps and solve problems.

CovidPulse App

livingatlas.arcgis.com/covidpulse



← The CovidPulse app presents daily rates of COVID-19 infection, death, and cumulative cases as simple lines that show visual trends over time.

The app presents daily rates of COVID-19 infection, death, and cumulative cases as simple lines that show visual trends over time in a fashion similar to the continually updated data provided by a stock ticker. To show the proportion of infected persons in a community as it rises and falls, CovidPulse displays not only the current rate of infection but also prior ones for all 50 US states; Washington DC; and more than 3,000 US counties.

The app provides interactive access to three day-over-day trend visualizations: new cases per capita, deaths per capita, and cumulative cases (which is another per capita measurement). Normalizing the data generates a per capita rate that makes valid comparisons possible between states and counties that encompass different geographic areas.

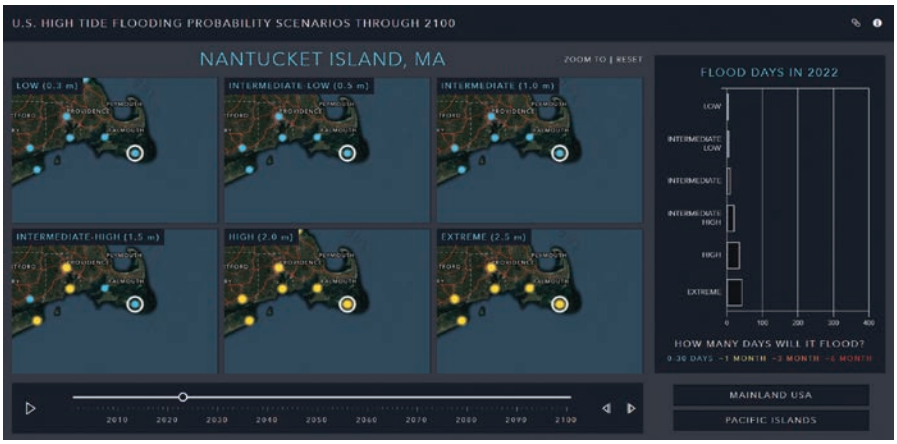
Using the options available in CovidPulse, all three dimensions of analysis can be displayed. For each option, a tremendous amount of data can be communicated effectively because sparklines present it in an intuitive and efficient way. This data-dense technique integrates data and graphics and is hundreds of years old. The style of the visualization used in CovidPulse was inspired by COVID-19 case trend lines created by Mathieu Rajerison, U.S. and charts showing localized outbreaks during the 1918 influenza pandemic drawn by Riley D. Champine.

U.S. High Tide Flooding App

https://apl.esri.com/jg/HighTideFlooding/index.html

U.S. High Tide Flooding app allows quick visualization and understanding of US high tide flooding probability scenarios through 2100. Users can quickly assess how many flooding days are expected to occur within coastal communities each year for the different flooding scenarios, ranging from low to extreme. Coastal planners, state and local municipal leaders, regional planning councils, and alike need this information to better understand potential impacts to help plan accordingly. Increasing this understanding can help impact policy and protect the investments of citizens.

The data in this app came from National Oceanic and Atmospheric Administration (NOAA) Technical Report NOS CO-OPS 086: *Pattens and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold* and aggregated for visualization and sharing in ArcGIS Pro. The application was built with the ArcGIS API for JavaScript and uses a feature service and point layer from the Living Atlas.



← The U.S. High Tide Flooding app allows quick visualization and understanding of US high tide flooding probability scenarios through 2100.

U.S. Vessel Traffic App

livingatlas.arcgis.com/vessel-traffic

This web app was built with ArcGIS API for JavaScript as a simple tool for visualizing and accessing the nautical transportation and commerce data provided by the Automatic Identification System (AIS). Transmissions collected by the US Coast Guard (USCG) from onboard navigation safety devices, AIS data provides the characteristics and current locations of vessels in US and international waters for safe navigation and collision avoidance purposes. This massive data source is provided by the USCG, NOAA, and the Bureau of Ocean Energy Management (BOEM) through Marine Cadastre, an integrated marine information system.

While AIS data can be both useful and fascinating, its enormous size can hamper its use because it contains both current and historical data points. Rather than downloading, converting, and managing gigabytes of AIS data, the U.S. Vessel Traffic app lets its users visualize and export of a geographically specified subset of that data that is further filtered by time period.

→ The U.S. Vessel Traffic app was built with ArcGIS API for Javascript as a simple tool for visualizing and accessing the nautical transportation and commerce data provided by the Automatic Identification System (AIS).

One App
Speeds and Simplifies Work

A new mobile app, ArcGIS Field Maps, gives mobile workers a single app that can perform multiple critical field activities, even in remote locations where internet connectivity is spotty or unavailable. With ArcGIS Field Maps, workers have secure 24/7 access to an organization's most current information via Android and iOS mobile devices.

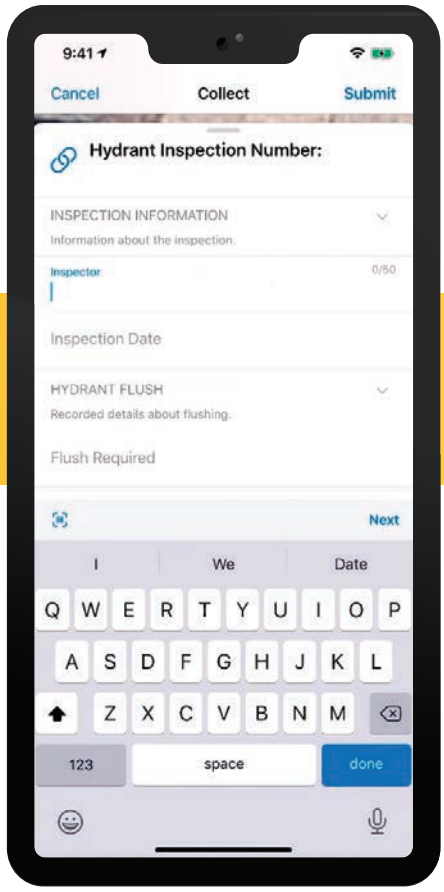
ArcGIS Field Maps combines the functionality of ArcGIS Explorer, ArcGIS Collector, and ArcGIS Tracker into a single app that speeds the tasks of workers in the field and simplifies the work of the people who manage them. Future releases will combine capabilities from ArcGIS Workforce and ArcGIS Navigator.

Field Maps replaces paper maps used by workers in numerous industries—utilities, public safety, natural resources, transportation, health care, and government and can be configured to meet the specific needs of the worker and workflows in these industries.

Nonorganizational workers, such as contractors, can access the maps and asset data needed to fulfill their roles while maintaining the security of the organization's system. Field Maps supports HTTPS to encrypt data in transit.

By centralizing map viewing, map markup, high-accuracy data collection, forms editing, and worker activity tracking into one app, ArcGIS Field Maps eliminates the duplication of offline content to provision multiple field apps. Because maps are only downloaded once, Field Maps saves space on mobile devices.

Workers sign in once and have access to all maps and data needed for all operations. Organizations deploy one app, and workers need to learn only one app for all their tasks.



← Working from the same current data simultaneously saves time, reduces error, and boosts the overall efficiency of staff.

Working from the same current data simultaneously saves time, reduces error, and boosts the overall efficiency of field staff. Collaboration between staff in the field is easier with peer-to-peer email. Updates made in the field in ArcGIS are shared with the office so that decisions can be based on the most accurate and up-to-date information.

ArcGIS Field Maps supports viewing maps rich in cartographic detail and searching by location, address, and feature. All associated layers can be viewed in the map, layers can be toggled off and on, and the basemap changed. Maps are compatible with ArcGIS Indoors and contain Facilities and Levels layers can be viewed on ArcGIS Field Maps.

Map markup using freehand sketching, placing markers, and adding notes and labels makes the correction and annotation of maps more easily accomplished. Markup is saved to the device so that it can be reused.

Because ArcGIS Field Maps provides highly accurate placement of point, line, and area features using external GPS, updates maintain and improve an organization's data quality. The app supports snapping and editing multiple features simultaneously. Assets can be added using a feature template, speeding the collection process.

The companion web app streamlines configuration and deployment information for ArcGIS Field Maps so maps can be accessed more rapidly. In the web app, robust smart form editing ensures valid and rapid input of inspection data. Forms management has been simplified with support for recently used form values and the use of conditional visibility so that workers see only the fields they need to accomplish tasks.

Tracking capabilities supply real-time location awareness of field personnel, so managers know where mobile workers are and can quickly adapt to changing circumstances. All tracks can be displayed on a map, and specific time frames can be selected. Location time stamp, altitude, course, speed, accuracy, and device information (i.e., battery state) can all be shown for each track.

Tracking provides verification of when, where, and by whom work was done. To access the location tracking capabilities in Field Maps, location tracking must be enabled for the organization for the manager and an add-on ArcGIS Tracker license assigned to each ArcGIS account that will be tracked. However, the Field Worker user type license now includes location tracking.

With ArcGIS Field Maps, using the same data simultaneously saves time, reduces errors, supports field workflows, and enhances overall efficiency by bringing modern digital workflows to field activities.

ArcGIS Field Maps is available for download from the Apple App Store and Google Play. To learn more, visit esri.com/fieldmaps.

Machine Learning Becomes Part of the Fabric of Kuwait

For decades, Kuwait has been on the cutting edge of geospatial technology. An early adopter of GIS among countries in the Gulf Cooperation Council (GCC), the government of Kuwait started using GIS in the late 1990s for planning purposes. As the technology evolved and a range of government agencies began implementing GIS, Kuwait's Public Authority for Civil Information (PACI) emerged as a standout user and is now blazing trails in machine learning.

PACI provides civil identification to commercial and residential establishments across the country, as well as to the people of Kuwait. Because of this, PACI keeps authoritative records of every address, business, and individual in Kuwait.

"All these components are linked together with a unique identifier called a PACI number," explained Maher Abdel Karim, GIS project manager at PACI. "Each parcel or building or unit inside a building is uniquely identified through that [number] all over Kuwait, and there is no duplication."

Having to keep track of all this data meant that PACI realized early on the importance of incorporating GIS workflows into its business processes. It has also enabled PACI to consistently innovate with GIS.

↓ Because Kuwait is rapidly developing, keeping its maps and geospatial information current is challenging.

"We embarked on an enterprise-wide GIS project in 2011, where we converted all our CAD-based papers and digital records into GIS and built a complete enterprise GIS by integrating this with our legacy systems," said Karim.

That helped PACI create a comprehensive basemap for the entire country. After that, the organization decided to simplify how people could search for addresses and businesses across the country, so it developed a mobile app called Kuwait Finder. The app provides the public with distinctly local information about all the businesses in Kuwait.

"Five years ago, this was a revolutionary application, and we at Esri assisted in developing a supportive, state-of-the-art back-end infrastructure" said Mansour Raad, Esri's global chief technologist.

"Kuwait Finder provides people with a hyperlocal search engine plus navigation and certain local features, like supermarkets, health centers, or the date and location of a public figure's funeral proceedings so people can go give their condolences," said Karim. "It's a really popular app in Kuwait—the number two app on both Android and iOS."

But in a fast-growing country with unique geographic features, keeping the basemap that supports Kuwait Finder (along with many other projects) current proved to be a constant, complicated, and time-consuming job. What's more, for Karim and

his team to provide Kuwait Finder as a service, like they wanted to, they had to find a better way to update the basemap.

"So over two years ago, Maher says, 'What if we use machine learning for that?'" recalled Raad, whose work revolves around advanced geospatial analytics. "At the time, nothing was done using geospatial artificial intelligence, or GeoAI. But he and I developed a way to use satellite imagery to do road and building footprint extraction. This was a huge time-saver and very groundbreaking."

"The things that PACI is doing are just really transformational for Kuwait as a whole," said Linda Peters, global business development manager for official statistics at Esri. "Doing this deep learning, they're taking a process that used to take five analysts more than a year to complete and running it in less than a week."

Unique Conditions Require Inventive Solutions

Geographically, Kuwait is quite distinctive, which has given rise to unique-looking infrastructure in and around Kuwait City, where almost everyone lives. The country's largely flat and sandy desert landscape gives way to a warm coastline on its eastern edge and small patches of agricultural land in the southeast. Rapid development has been a mainstay of life in Kuwait for decades. In a bid to become a regional and international financial and trade hub by 2035, new construction has soared in recent years.

"Because Kuwait is a burgeoning country, every time you go somewhere, a road will have changed or a new one will appear that wasn't there a few months ago," said Raad. "Keeping up with this is difficult."

This is why Karim wanted to use machine learning to extract road data and building footprints from satellite imagery. But aside from the fact that GeoAI was nascent technology at that time, Kuwait faced other issues as well.

"In the United States, you can find high-accuracy satellite imagery and aerial and drone photos. You'll find a lot of green areas or gardens or structures, and there will be added contrast on the imagery, which can help you distinguish between buildings and the surrounding landscape," said Karim. "In Kuwait, due to its desert landform, the contrast in the satellite imagery

↓ Kuwait's Public Authority for Civil Information (PACI) created more accurate data for building footprints, street polygons, and parking lots to train the model.

↑ PACI used training data (in red) to teach the model to detect what to pull from satellite imagery.

"Maher is very forward-thinking about what he needs to do."

is very weak. So it's difficult to distinguish between the building and the street."

Additionally, the shapes of Kuwait's houses vary a lot, which is not the case in many other countries. And even the shapes of parking lots and streets aren't standard.

"Another problem was the absence of synchronization between satellite imagery and vector data," said Karim. "This vector data is needed for ground truth, which PACI can feed into a model to help it learn what various features look like."

PACI had to start from scratch, creating new ground truth data that includes building footprints, street polygons, and parking lots. These features were used to train the model to detect what to pull from satellite imagery. From there, the team at PACI had to test various models and manually check the GIS features they were producing.

"When we started evaluating the output of the models, we found that it was totally different from what we were looking for," said Karim.

In short, the models didn't reflect what Kuwait actually looks like, so the team had to innovate again.

"Since we were already creating the ground truths for buildings and streets and parking lots, we built a model that can provide us with these three feature types," said Karim.

Then came more training and testing. PACI took a 600-square-kilometer area (about 230 square miles) of satellite imagery of Kuwait and had the model infer where buildings and streets are to provide the prediction raster.

"We ended up taking what Kuwait City looks like, what the desert looks like, what the agricultural areas look like, what the region by the gulf looks like, and we taught the machine those things by explicitly labeing everything," Raad explained. "Maher and his team spent a lot of time labeling the data, which is very important in machine learning, and it paid dividends."

"After postprocessing, we got around 111,000 building footprints and around 78,000 street segments, and this took around one and a half hours," said Karim.

The team then checked the model's output building by building. By Karim's estimate, it took just over 48 hours total to do quality control on the data, which reached 97 percent accuracy.

"Before, this would have taken us 119 days, so we are comparing a week to 119 days," said Karim. "You can imagine the productivity increase by applying machine learning and deep learning models to automate the GIS workflow for basemap updates."

Forging Ahead with New Ideas

While the project has come a long way in two years, it is still a work in progress.

"We are still trying to automate as much as we can from this process in order to reach the point that we minimize manual efforts and manual processes," said Karim. "We are trying to enhance our models and our workflows to achieve this."

At the same time, Karim and his team are already working on adapting machine learning to new projects—namely, 3D street-level imagery.

PACI currently has its own street-level imagery of the whole country and serves it to the public via Kuwait Finder. As with the basemap, this street-level imagery needs to be updated regularly. So what Karim is working on now is how to extract features from this street-level imagery to enrich PACI's GIS layers.

"In order to use deep learning to do this, we decided to create a new training dataset based on the imagery that was captured in Kuwait," said Karim. "We currently have around 41 different classes, like cars, buses, people, manholes, traffic signs, stop signs, and traffic lights. So we are combining these 41 classes…and converting them back to GIS."

"All this is really avant-garde," said Raad. "Maher is very forward-thinking about what he needs to do."

And he has a great team behind him that believes in extending the benefits of GIS, not only across government agencies but throughout Kuwait as well.

"PACI has one of the best GIS teams that work on a range of different projects—not only keeping data updated, but also providing lidar surveys; doing machine learning; updating applications, like the mobile apps and Kuwait Finder; creating different information products; and supporting other government agencies," said Raad. "PACI has been bold enough to embrace the latest developments and cutting-edge technologies, which has helped the country in general understand how effectively GIS technology can be implemented."

↓ The shapes of houses, parking lots, and streets in Kuwait vary a lot, as can be seen in these sample inferred building footprints from the trained model.

KnowWhereGraph Drives Analytics and Cross-Domain Knowledge

By Krzysztof Janowicz

Good decision-makers have a high-level of situational awareness. They understand the broader context in which they operate. However, in today's global, fast-paced, and densely interconnected world, decisions require gathering insights from a wide variety of heterogeneous resources.

Environmental intelligence provides insights into how our changing environment affects society, from predicting how coastal erosion impacts the local real estate market to understanding the long-term effects of unhealthy air quality due to increasing wildfire activity around the globe.

To capitalize on environmental intelligence, decision-makers and data scientists must ingest multimedia and highly diverse data into their analytical frameworks to contextualize their own information with auxiliary data at the interface between humans and the environment. In many regards, the diversity of data sources is more important than the sheer size of individual datasets. This puts data integration and interoperability at the forefront of data science and data-driven decision-making.

For instance, commodity trading companies incorporate climate change effects at different spatial and temporal scales into their decision-making. They also consider the effects of public opinion and changes to environmental policy. Consulting companies offer their customers near real-time analysis of markets and assets based on extracting and geolocating information from unstructured text such as news. Humanitarian relief organizations include causal analysis in their GIS workflows to model relations such as those between hurricanes and cholera outbreaks. And government agencies rapidly integrate economic indicators with anonymized human movement statistics and relate them to a wide variety of forecast models to study the spread of COVID-19 under different scenarios. Such information not only comes from a wide variety of sources and media types, but it also challenges our narrow definition of what counts as geographic or spatial data.

Knowledge graphs are both an emerging paradigm and a technology stack that allows reenvisioning how data is represented by focusing more on the connections between places, people, events, diseases, news, and other factors instead of merely focusing on properties. These graphs combine scalable technologies, semantics, and data cultures to represent densely interconnected statements derived from structured or unstructured sources across domains in a reasonable way that is readable by humans and machines.

These graphs originate from a vision of the World Wide Web that transitions from linked documents to linked data. This vision has partially been implemented in search engines and virtual assistants such as Apple's Siri. It allows those systems to directly answer questions, rather than merely pointing to web pages containing relevant information.

Because knowledge graphs focus on connections among arbitrary entities and their properties, they support complex crosswalks even if not all nodes on a query path are spatial. *[Metadata crosswalks translate elements and values from one schema to another schema. They have been developed between metadata standards such as Dublin Core and MAchine Readable Cataloging (MARC).]*

For instance, with the rising role of environmental, social, and corporate governance (ESG), a company may want to document that none of its value chain suppliers (and *their* suppliers) makes use of forced labor. Such a query would span several datasets, each of them containing partial information about companies, goods, manufacturing processes, people, demographic factors, and policies. Despite the deeply spatial nature of these queries, current geographic information systems struggle with such tasks.

Technically speaking, knowledge graphs enable seamless crosswalks by explicitly representing identity and equivalence relationships between individuals and classes. For instance, they state that a global place identifier used in one data hub signifies the same place as a second identifier in another part of the graph. This allows partial information from multiple sources to be merged, providing a more holistic picture of that place.

Similarly, relationships can be defined on the schema level. For example, by declaring that the meaning of *forest* used by one

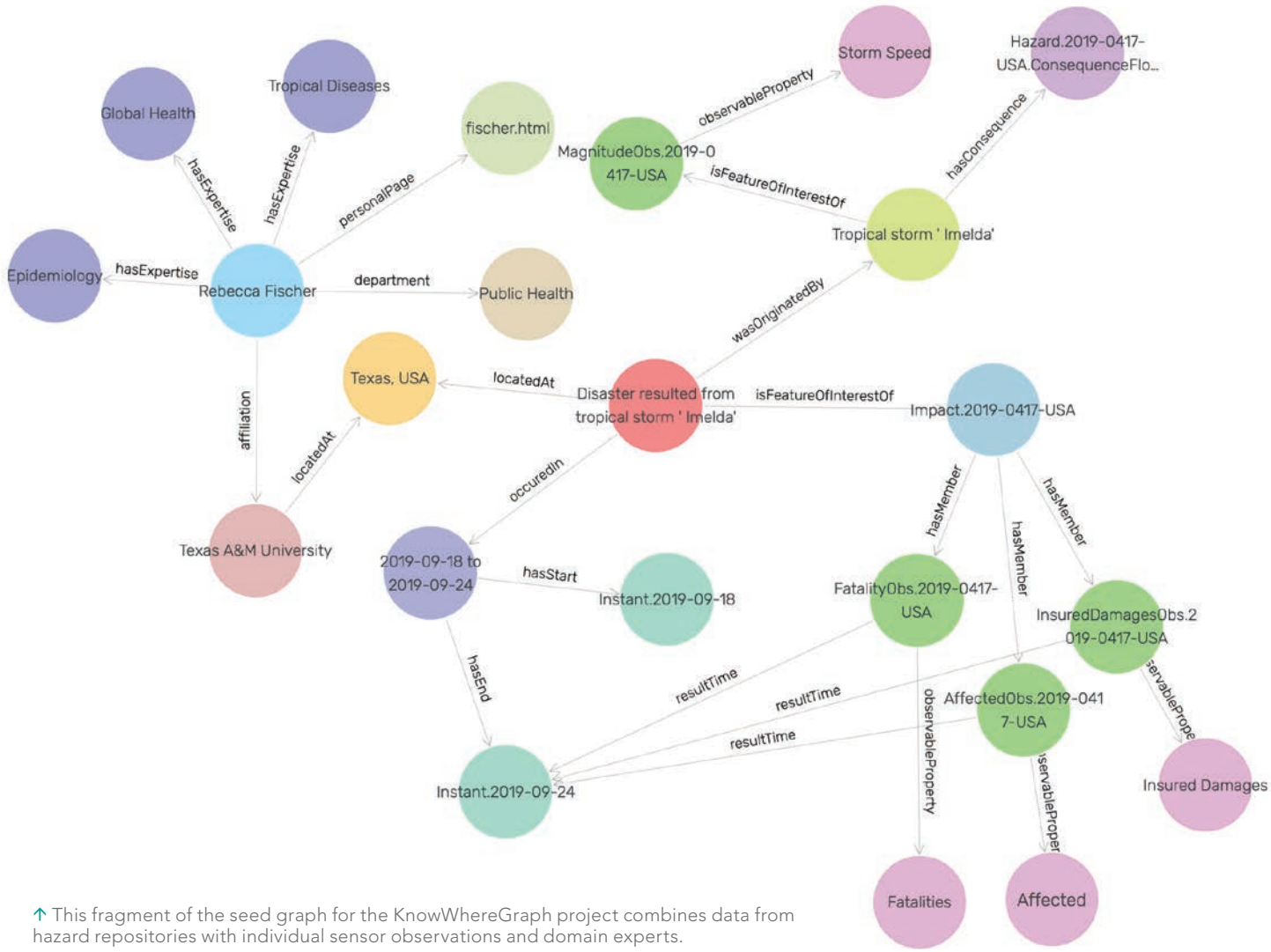
data provider is broader than the definition of *forest* applied elsewhere. These schemata are called ontologies, and their rich axiomatization supports semantic interoperability and machine reasoning. The ability of web-scale knowledge graphs to handle diverse and even contradictory ontologies is a core strength of these technologies. Meaning is in our heads, not in the world. Consequently, concepts such as forest, drought, and poverty are artifacts of human cognition that vary geographically and through time.

The National Science Foundation (NSF) has created a new large-scale structure called the Convergence Accelerator. For one of its first tracks, NSF selected the topic of open knowledge networks. As part of this program, a team of partners from industry, government agencies, humanitarian relief organizations, and academics are working on a project that is creating the KnowWhereGraph. This is an openly available graph and situational awareness services for data at the human-environment interface.

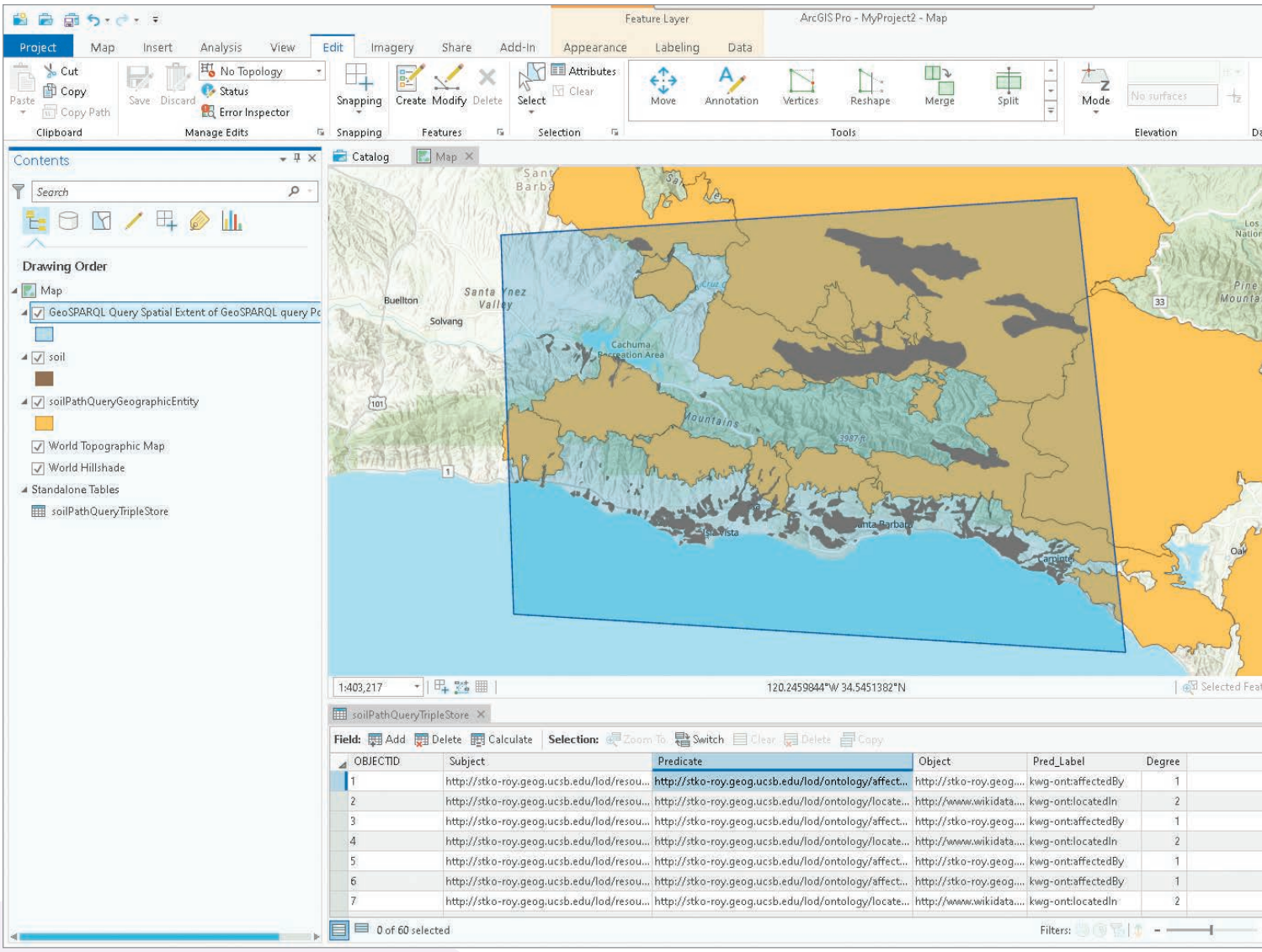
This graph spans topics as diverse as soil health, hazards, food supply chains, commodity markets, human expertise, and the historical slave trade. It is walking the divide between the physical sciences and the humanities. For example, it enables querying of the path of an approaching cyclone to check whether there has been a recent outbreak of cholera in the regions that will be affected by the storm; it also suggests experts who have worked in those regions as well as related hazards that might affect relief operations on the ground.

At first, it may not be clear how identifying human expertise relates to GIS. Interestingly, expertise itself is a deeply spatial and temporal phenomenon. Researchers may have worked on a topic years ago but then moved on. Similarly, they may have expertise in a specific topic related to a given region, such as the effects of droughts and floods in sub-Saharan Africa. Given their strong focus on geometries and absolute reference frames, GIS is not yet well equipped to support such use cases.

The value proposition of the KnowWhereGraph—and knowledge graphs in general—goes beyond providing a



↑ This fragment of the seed graph for the KnowWhereGraph project combines data from hazard repositories with individual sensor observations and domain experts.

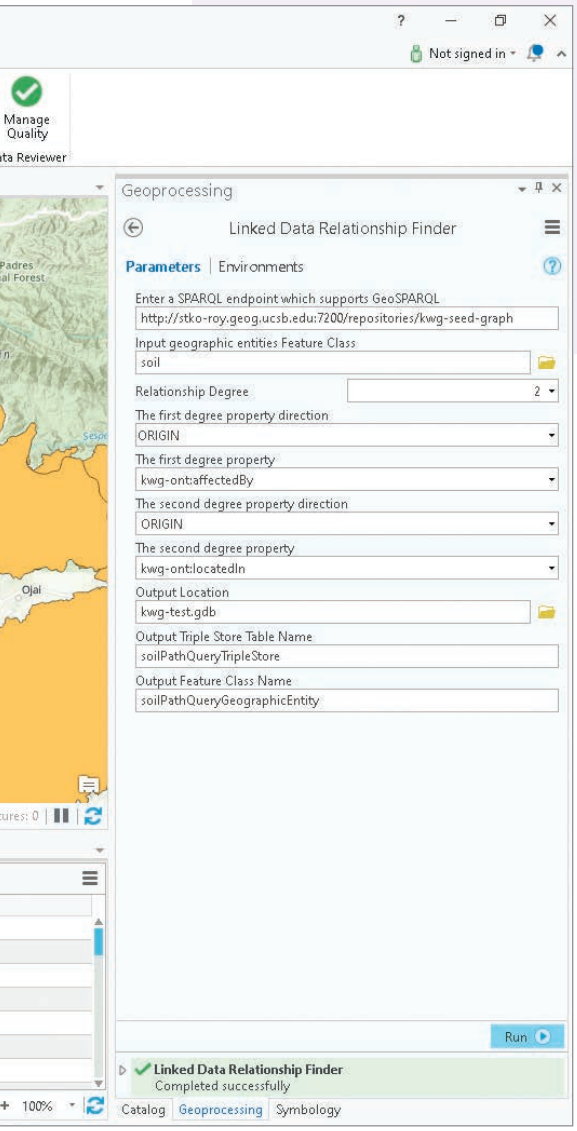


unified framework for accessing data on the level of individual statements (e.g., observations), but also in overcoming the data acquisition bottleneck. Experience shows that most of the resources for a typical data science project—human, financial, and temporal—are spent on data acquisition, cleaning, integration, and apportionment. This leaves few resources for deriving insights from data. This turns the desire for data-driven decision-making into wishful thinking for many smaller projects or companies.

Knowledge graphs and situational awareness services that enable decision-makers to enrich their own data with the full breadth of graph-available, up-to-date knowledge on demand have the potential to become a key part of tomorrow's cyber-infrastructure. The ArcGIS GeoEnrichment Service offers a glimpse into this fascinating future by showcasing how users can overcome data acquisition bottlenecks. It enables them to enrich their data on the fly with a wide range of demographic variables apportioned to their study area.

Connecting such a service to a potentially open-ended, densely connected, cross-domain knowledge graph would be a logical next step. Most work on knowledge graphs so far has focused on freeing data from silos and creating smart data instead of creating smart applications through providing rich data semantics, producing powerful tools for spatial analytics and powerful graphs but no integration between them. Put differently, we must get the graphed data back into our GIS. Existing solutions merely import graph data and flatten it into a tabular structure, thereby reducing the graph to just another data store.

In contrast, the KnowWhereGraph project team is developing a plug-in for ArcGIS Pro that enables native graph queries from within a GIS. The plug-in creates geodatabases and their database schema during query time, allowing users to explore the KnowWhereGraph instinctively while retaining the full analytical functionality of ArcGIS Pro. For instance, a historical geographer may ask for regions studied by explorers who were students of or influenced by the famous geographer Alexander von Humboldt and display those regions together with demographic



← A situational awareness toolbox for ArcGIS Pro connects to the KnowWhereGraph to perform graph-based path queries across topics such as soil health and past wildfires.

and environmental properties. Such a path query would start at von Humboldt, find statements (called triples) about the explorers that he influenced and continue from these explorers to the regions they studied, and, finally, their properties. The data to support this query is already incorporated in graphs such as Wikidata and DBpedia.

In reality, many interesting graph queries will fail because individual links among a path query may be missing. While existing knowledge graphs contain billions of statements, they remain sparse due to their sheer size. The longer a path query gets, the more likely that a single link will be missing. Luckily, in addition to their capacity for rapid data integration, knowledge graphs also introduce entirely new geospatial artificial intelligence (GeoAI) analytics to the GIS community. One such example is the prediction of missing links in sparse parts of the graph. Learning to predict links also provides insights such as uncovering new causal relations, contributing to the explainability of machine learning models, and growing the source graph itself at the same time.

So, what is missing? To fully enable the value proposition of knowledge graphs and their use in GIS will require engineering and research along several dimensions. As demonstrated in the past, spatially explicit machine learning models often substantially outperform more general models when applied to spatial data. One such example is graph summarization. It describes the task of finding a representational subgraph for a given region. In contrast to ArcGIS GeoEnrichment Service, a graph cannot be easily apportioned to the user's study area because it often contains thousands of direct statements about a geographic region.

The number of related statements increase rapidly from the initial statements. For example, the ability to seamlessly navigate from a place to information about the people born there to the companies those people founded to the places where the companies they founded are headquartered is one of the key value propositions of knowledge graphs. Efficiently computing such summaries of geographic knowledge graphs during query time remains one of many unsolved problems.

Another pressing issue results from biases encoded in these graphs and the services that run on top of them. The uneven geographic coverage of data is one such bias. We know more about some parts of the world and less about other parts. Similarly, the knowledge about many notable events, historical figures, famous places, and companies results from a particular perspective that has its own cultural biases. While knowledge graphs offer the technical capability to integrate different views and foster participation and inclusion of data based on open standards, utilizing these technologies to enable a more holistic perspective on Earth and societies will remain a joint challenge for years to come.

Deeply integrating knowledge graphs and graph data models more generally into ArcGIS Pro will not only provide a wealth of diverse data to GeoEnrichment Services and open new types of analytics but also enable graph users to finally analyze their data from within a GIS.

For more information, contact Krzysztof Janowicz at janowicz@ucsb.edu.

About the Author

Krzysztof Janowicz is a geoinformatics professor at the University of California, Santa Barbara, and the director of the Center for Spatial Studies. Janowicz is the principal investigator (PI) for the KnowWhereGraph project. He investigates the role of space and time for knowledge organization and representation. Methodologically, Janowicz combines theory-driven (e.g., knowledge engineering) and data-driven (e.g., data mining) techniques to improve the publication, retrieval, reuse, and integration of geographic information.

Six Ways to Make Geographic Thinking Part of Your Company Culture

By Matthew Lewin

There's a great quote from the book *Atomic Habits* by James Clear that I love:

"[People] don't rise to the level of their goals; they fall to the level of their systems."

This rule also applies to organizations. Most companies have goals and strategies. Some companies thrive, and some don't.

Why is that?

A lot of it comes down to those companies' systems.

Unsuccessful firms view strategy as outside day-to-day activities—separate from what they normally do. Winners, on the other hand, internalize strategy. For these firms, success is a habit made possible by the capabilities that are ingrained into the culture of their organizations.

As a strategist focused on the geospatial industry, I spend a lot of time helping organizations devise and then implement geospatial strategies. I have observed that the most successful organizations get the culture part of it right. They create an environment where thinking about *where* becomes second nature.

How do they do this? I have encapsulated this approach into these six keys to building and sustaining a geospatial culture:

1. Improve geospatial literacy
2. Institutionalize geospatial knowledge
3. Plan with geography
4. Communicate with geography
5. Celebrate GeosSuccesses
6. Create GeoLeaders

1 Improve Geospatial Literacy

A baseline level of knowledge in the tools and science of geography is the first step in building a geospatially-informed culture. Without it, your people will struggle. The jargon will sound foreign and the concepts will confuse them. People will regard geography as a specialist discipline that is for experts and not for them.

First, evaluate your organization's geospatial literacy by creating a role-based assessment. This measures people's proficiency with geospatial concepts and tools across key business functions. The idea is to assess a person's ability to apply some basic geography concepts to their role in the organization. *The Concepts of Geographic Thinking* (https://bit.ly/3kJbR4n), is a great guide for crafting those questions. I also wrote a blog post, "How to find geospatial opportunities hiding in your business," that describes a simple tool for translating business language to geospatial language.

Once you've done that, create a basic geography curriculum. We're not creating experts here, so no need to go overboard. Focus on improving geospatial literacy in terms of applying geospatial analysis to various job functions.

2 Institutionalize Geospatial Knowledge

Institutionalizing geospatial knowledge has a lot in common with the previous step, but it goes further. For knowledge to be ingrained in the organization's collective consciousness, it needs to be organized. That means compiling people's experience and know-how into reusable practices and resources that everyone can leverage.

One of the best ways to institutionalize geospatial knowledge is to establish a geospatial competency center, or center of excellence (COE). A COE is a shared business function responsible for developing practices, providing leadership and training, and advancing innovation with focus on a specific area. It's like having an in-house academy for all things geospatial.

The form a COE takes is unique to the organization. For some organizations, the COE might focus on standards setting. This could include developing rules around proper cartographic representation or external data distribution. For other organizations, the COE might focus on knowledge curation, such as compiling geospatial use cases from across different departments and synthesizing them into consumable content. Still other organizations might focus on researching advances in geospatial technology and serve as an innovation center.

You might be tempted to think that a COE is the exclusive domain of federal government agencies or large academic institutions. Not necessarily. I see COEs in the geospatial and analytics space in organizations that range from local governments to commercial entities.

Even if you don't establish an official COE, it's the process of institutionalizing geospatial knowledge that matters. At a minimum, form a virtual team of cross-department leaders who meet regularly to perform the ongoing work of organizing geospatial know-how.

3 Plan with Geography

How often do your management planning sessions genuinely consider *where*.

Be honest.

Maybe there's a casual nod to geography in the form of an operations map, but do discussions ever delve into the influence of location on your business interests?

To plan geospatially is to consider the impact of location on key business decisions. One way is to include a set of questions in planning meetings that prompt a geospatial perspective, like these:

- How do our customers, assets, and key business interests vary from location to location?
- Are our products or services tailored to account for regional variation?
- Are we considering the localized needs of employees?

There's an infinite range of questions you could ask. The point is to ask some of them. These questions are meant to trigger conversations and geographic thinking. The unanswered questions tend to lead to further investigation, additional education, and increased investment. Planning meetings can drive demand for geospatial knowledge. When demand is linked to plans and strategies, action is more likely.

4 Communicate with Geography

Augment company communications with geospatial intelligence. This builds on my last recommendation. Don't stop at planning—incorporate maps and geospatial insights into company communications.

Every communication is an opportunity to ingrain geographic thinking into the collective consciousness of the organization. Every quarterly update, every annual report, every departmental email is an opportunity. If you're a retailer, it could be as simple as including a map of sales hot spots in monthly sales reports. If you're in health and safety, provide an ongoing map of the change in monthly safety incidents by region. The more information you present this way, the more geographic thinking is internalized in standard communication.

There's no limit to how far you can go when enriching communications with geospatial intelligence. Every time you do this, you make it easier for the people in your organization to see the unique value of geographic thinking.

5 Celebrate Your GeoSuccesses

Anything worthwhile is worth celebrating. Celebrations honor valued accomplishments and show gratitude to those responsible. They signal to those involved and onlookers that what's being celebrated is important to the community. It's a reminder of the values of the culture, so celebrate geography.

Share a success story on your corporate intranet when you launch a new tool. If you're a manager, send a personal thank-you when you see someone demonstrating geospatial excellence. Don't stop at one-off celebrations. Make an annual tradition out of geography. Lots of research shows that traditions are vital to culture because they represent an acknowledgment of common values and beliefs.

GIS Day is a common geospatial celebration that happens every November. It is an international celebration of all things geo. Hold your own GIS Day event or create a separate geotradition. How about introducing a geospatial hero of the month to celebrate people who go above and beyond with geography? Do what works for you—make it fun!

6 Create GeoLeaders

Inspire business leaders to be geospatial champions. Research conducted by Esri Canada and IDC, the global market intelligence firm, shows that leadership engagement is one of the primary indicators of a successful geospatial program. Influential people are known to have an outsize impact on culture. Our celebrity-fueled Instagram culture is a testament to that.

I've observed firsthand the influence of leadership on the success of geospatial initiatives. A curious pattern I've noticed is that leaders outside traditional geospatial functions have more influence. It's as if the more an advocate of geo comes from out of left field, the more sway that their endorsement carries. I think it's because these leaders see opportunities to innovate—and innovation breeds excitement and engagement.

How will you engage influential business leaders and inspire them to be geospatial champions? Try these tactics:

- Invite leaders to geospatial seminars, webinars, and conferences.
- Present examples of geosuccess from peers in other organizations.
- Codevelop an opportunity assessment, identifying how geospatial technology and analytics can better support their area.
- Create a proof of concept that shows the art of the possible.

What if you are one of these leaders? Could you see yourself as a potential geospatial champion? If so, don't wait—get involved! You have a tremendous opportunity.

Remember, organizations that ingrain geographic thinking into the fabric of their corporate cultures unlock a powerful capability. And with modern advances in geospatial technology, this capability is more accessible than ever. Take real steps to make geo a habit.

For additional information on this topic, download my e-book, *Geospatial Strategy Essentials for Managers*, from https://bit.ly/307EU8o.

About the Author

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

Manage Your ArcGIS Online Organizational Account Quickly and Easily

By Jennifer Wrightsell-Hughes

If you're an administrator for your ArcGIS Online organizational account, member management is likely an important part of your work. To ensure that you have enough time for everything on your to-do list, efficiency is key.

Manage App Licenses and Groups

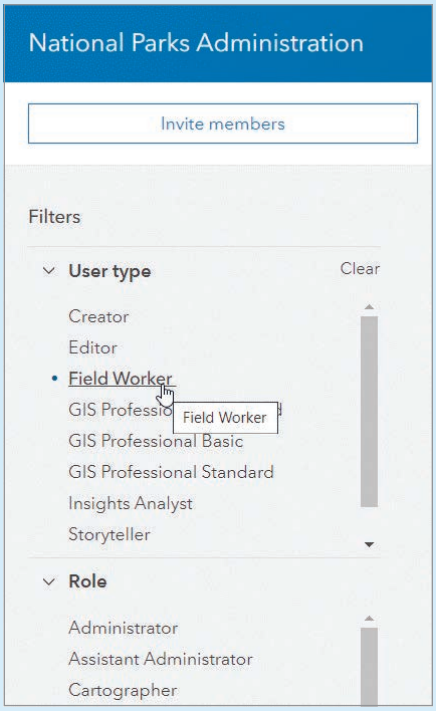
For example, if you wanted to use these management capabilities to assign ArcGIS Navigator licenses to the mobile workers in your organizational account, you would follow these steps.

1. Sign into ArcGIS Online as an administrator and click Organization at the top of the site. Then click the Members tab to see a list of your organizational account's members.
2. Find the mobile workers who need Navigator licenses by using Filters, on the left. Under User type, select Field Worker to filter the list of members.
3. With only the mobile workers listed, you can quickly assign ArcGIS Navigator to these members. Check the Member box at the top to select all the members, then click Manage add-on licenses.
4. Find and select ArcGIS Navigator, then click Save. Now all mobile workers in the organizational account have a Navigator license.

The Members tab on the ArcGIS Online Organization page provides a central location for managing members. Whether you need to assign add-on app licenses, add members to groups, or perform any other member management task, ArcGIS Online includes time-saving capabilities, such as filters and bulk actions, to help you get the job done.

You can see these capabilities at work when doing the following common member management tasks:

- Managing app licenses and groups for members assigned a specific user type.
- Allocating more credits to members who need them.
- Removing licenses from inactive members to free them up for others.
- Changing the ownership of items owned by multiple members.



→ Find the mobile workers who need ArcGIS Navigator licenses by using Filters, on the left. Under User type, select Field Worker to filter the list of members.

Allocate More Credits to Members

Credit management is a common task for many organizational account administrators, but it doesn't have to be time-consuming.

As members of your organization complete their daily work in ArcGIS Online, the number of credits allocated to them may become low. To avoid receiving a slew of email requests for more credits, you can proactively update the credit allocation for members who are running low. Again, the filters on the Members tab are your best friends.

1. If necessary, start by clearing the existing filters and selections to return to the full list of members.
2. Expand the Credits remaining filter. You want to find members who have fewer than 300 credits remaining so that you can increase their allocation to 500 credits. Under Less than, type "300" and click Enter to filter the members list.
3. Select all the members in the filtered list by using the check box at the top, then click Manage credits.
4. In the Set credit allocation box, increase the credit allocation and click Save.

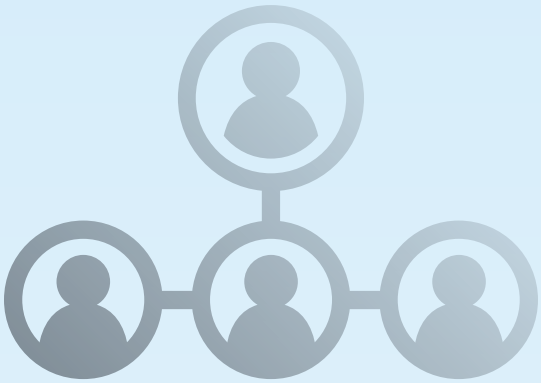
And that's it. Members can continue their work without interruption because they have enough credits. And you don't need to spend time responding to emails. Everyone wins.

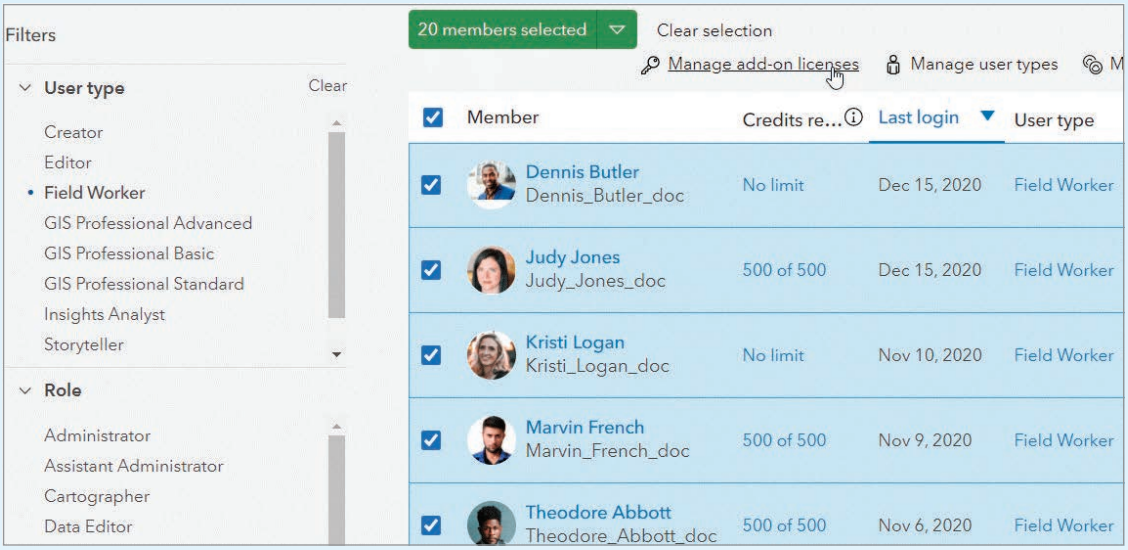
Assign Members to Groups

In the same scenario, the following steps show how you would add the members you just provided with Navigator licenses to a group you created for managing mobile staff and data collected in the field.

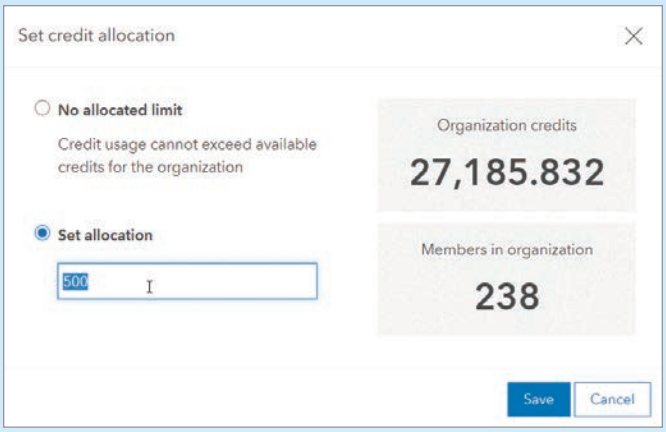
1. With the mobile workers still selected, go to the More menu and click Assign groups.
2. Search for the group, select it, and click Save. The mobile workers are now members of the group.

In just a few clicks, you assigned Navigator licenses to mobile staff in your organization and you assigned those members to a field data collection group.





← Use filters to add members to groups, assign licenses, allocate credits, and identify members with licenses who are not using them so those licenses can be reassigned.



↑ Proactively assigning more credits to members keeps things running smoothly.

Remove Licenses for Inactive Members

As members come and go—or change roles, departments, or teams—some cleanup is required to free up or reassign resources like app licenses. Your organization may have staff members who don't work with ArcGIS Online and you need to make any app licenses assigned to them available for other members to use. You can do this quickly using the Last login and App filters.

1. Expand Last login and click Never. This will filter the list to show members who have never signed in. Then, expand the App filter and select the add-on app you want to reassign, such as ArcGIS Insights.
2. Select the members in the newly filtered list and click Manage Add-on licenses.
3. In the Manage add-on licenses window, uncheck the box for the app license you want to unassign.
4. Click Save. The licenses are removed from the inactive members and are now available to be assigned to members who need them.

Change the Ownership of Items

For organizational account administrators, a common task is managing members' content. For example, suppose several employees have left your company in the last month, but your company wants to maintain the valuable content assets they owned. Reassigning their content to another owner allows the organization to continue maintaining the items. Fortunately, ArcGIS Online offers an easy way to transfer these items in bulk.

1. Find and select each of the members whose content you want to reassign.
2. Click the More menu, then click Transfer content.
3. In the Transfer content window, select a new owner and a target folder for the items, then click Transfer. That's all there is to it.

Resources

To learn more about managing members and other organizational account administration tasks, see the following:

ArcGIS Online resources

Find the latest resources for ArcGIS Online, including blog articles and help documentation.
https://bit.ly/3etEjGj

Administer ArcGIS Online

Videos, lessons, and blog articles show you how to configure ArcGIS Online.
https://bit.ly/3bxysOz

ArcGIS Online Implementation Guide

View essential tasks and best practices for setting up ArcGIS Online.
https://bit.ly/3t6TXM3

Esri Community: ArcGIS Online

Exchange ideas, solve problems, and build relationships with the ArcGIS Online community.
https://bit.ly/2OjBnl7

About the Author

Jennifer Wrightsell-Hughes is the documentation lead for ArcGIS Online. She has a degree in journalism and more than 20 years of experience writing and editing product documentation, lessons, and other content. In her spare time, she enjoys practicing yoga, painting, and spending time at her cottage.

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[1]Based on IDC Quarterly Workstation Tracker, Q4 CY2020 (based on units)

Leveraging Site Suitability Analysis to Validate Policy

By Keith Cooke

A data-driven approach to planning is key to justifying specific designs and developments for a community. This approach moves from a strictly anecdotal approach to one that focuses on attainable metrics.

As a planner, you have an advantage over others in your organization because you understand the types of designs and developments that are likely to look and work best in a neighborhood. A data-driven approach helps you quantify and qualify your recommendations.

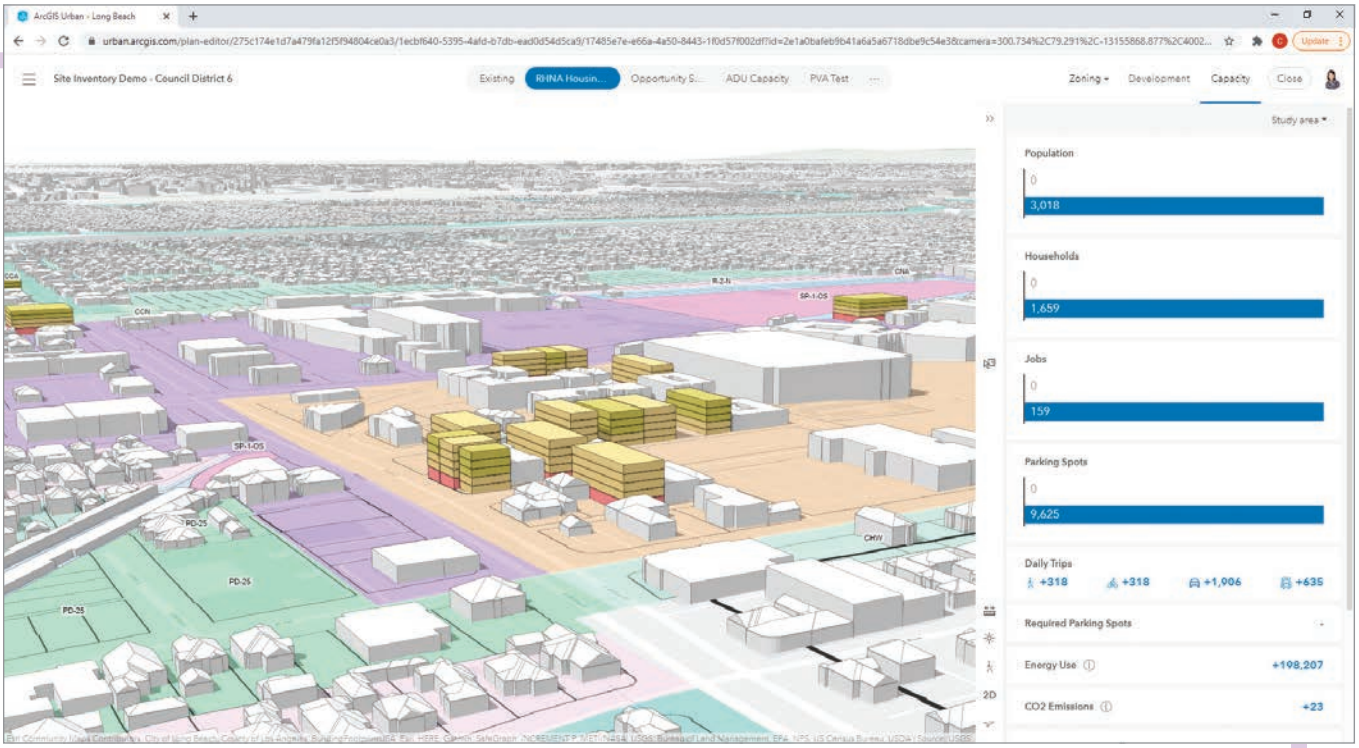
While this is true in the planning of specific developments, it's also equally true in validating policy for determining where and why developments are needed. Often, these policies are created at a higher level—a level removed from the city manager, planning commissioner, or elected official who designs the development.

Planners and GIS play an integral role in housing policy decisions because location is at the center of this topic. Planners and policy makers must be able to define the needs, benefits, and challenges associated with assigning specific areas for affordable housing. They must balance a variety of concerns: encouraging economic development, mitigating homelessness, and understanding the capacity for growth in neighborhoods.

This process starts with planners identifying and analyzing the demographic and socioeconomic variables for neighborhoods to successfully assess their needs. ArcGIS Community Analyst lets planners view more than 1,700 variables to understand the makeup and needs of neighborhoods down to the census block group level.

From a policy standpoint, this data helps planners understand where affordable housing, combined with a sustainable economic mobility policy, is most needed. But, it's not just homeowners who are struggling. Renters also make up a large percentage of those who need affordable housing. This is especially true for younger renters. The Esri Maps for Public Policy app, a part of the ArcGIS Living Atlas of the World, provides free access to data that can be used to help validate policy decisions. With this data, you can overlay maps showing renters and homeowners to

↓ Planners and GIS play an integral role in housing policy decisions because location is at the center of this topic. ArcGIS Urban can be used to visualize planning scenarios.



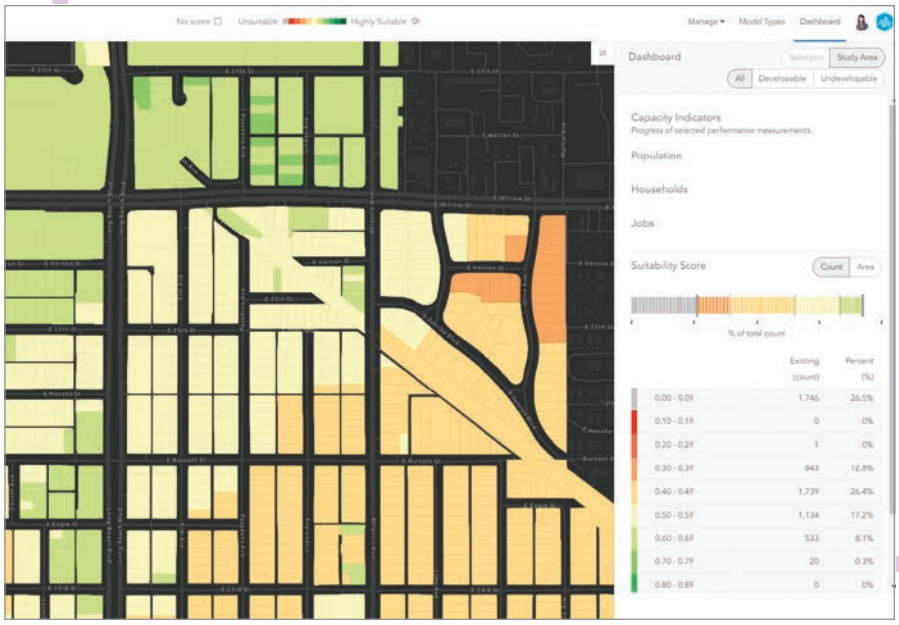
understand where the most crucial need for affordable housing is located.

However, there are often additional factors that drive policy making. This is where the Policy Validation Application (PVA), a free add-on to ArcGIS Urban, can come into play. With this add-in, multiple variables can be considered at the same time. By assigning weights to each metric, the best location for affordable housing can be identified down to the parcel level.

Specifically, you can look at the parameters that would drive the feasibility of affordable housing in a neighborhood, such as proximity to available transit, grocery stores, schools, and health services. Affordable housing as a policy doesn't work unless it's coupled to economic mobility, so you also want to look at employment opportunities currently available and those planned for an area.

Now, administrators, elected officials, stakeholders—and of course, planners—can have a data-driven discussion about where affordable housing is needed and the best locations and methods to address that need. There's no ambiguity about the data. It's clear-cut, and everyone can be on the same page.

Taking a data-driven approach to site suitability, planners can develop multiple housing scenarios in neighborhoods and measure their potential effectiveness. Policy makers can then evaluate and visualize these scenarios, collaborate with community leaders, and engage the public to meet their expectations for transparency and accountability.



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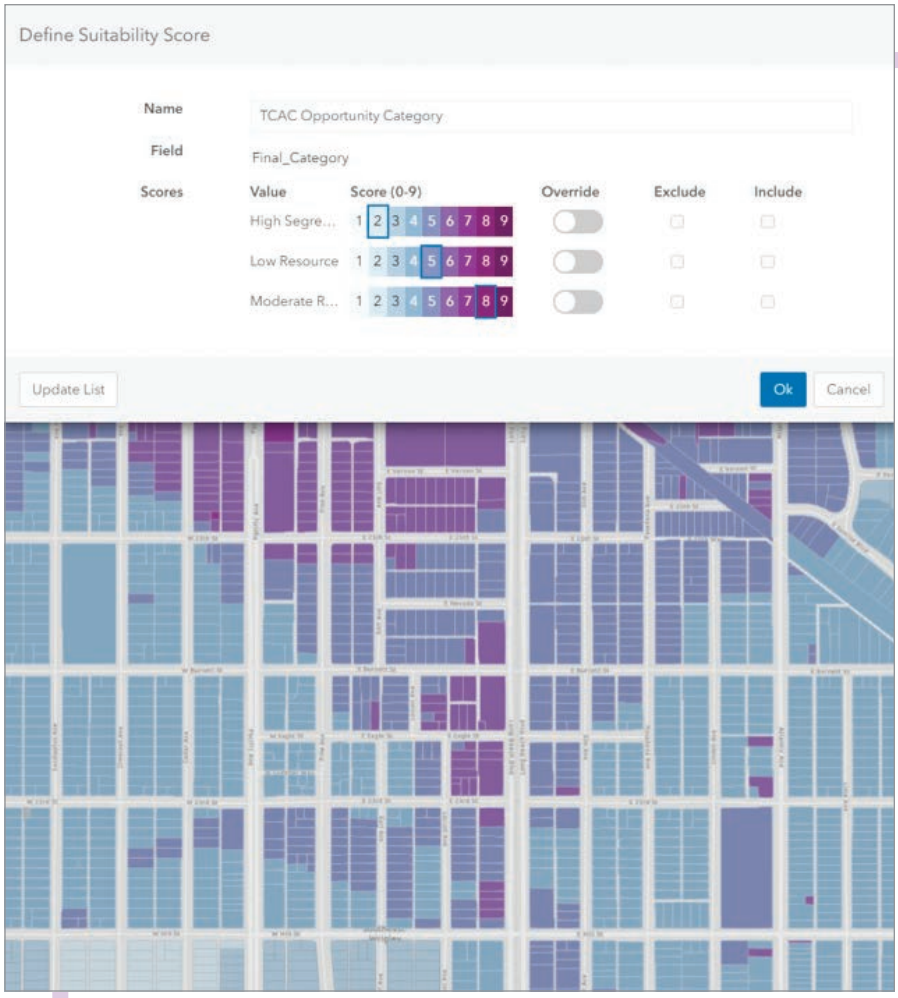


About the Author

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

Introducing Calcite, Esri's Design System

By Julie Powell and Julio Ochoa

Esri's design system (Calcite) enables you to create beautiful, easy to use, and consistent experiences across apps with minimal effort. It includes design best practices, icons, color schemes, and an accessible web component library with UI elements including buttons, panels, accordions, and alerts. The design system also manages spacing and layout with relative positioning so your app can achieve a clean, responsive design for any screen size.

Integration with the ArcGIS Ecosystem

The design system originated as a collaboration between design and development teams at Esri to create a unified visual standard of excellence. Using a shared collection of resources and guidelines allows the creation of consistent, on-brand Esri experiences for use in ArcGIS products and Esri Services projects.

As Calcite evolved and improved, Esri realized that offering it to the broader developer community would provide significant benefits. In addition to building beautiful apps faster, developers would have the ability to create a cohesive product experience by using the patterns and established best practices native to ArcGIS. Apps created with the design system could seamlessly integrate with the ArcGIS ecosystem, providing the familiar ArcGIS look and feel. Consequently, Esri made the design system resources available through the ArcGIS Developers site at developers.arcgis.com/calcite-design-system. It was initially released as beta, and will have a production release later in 2021.

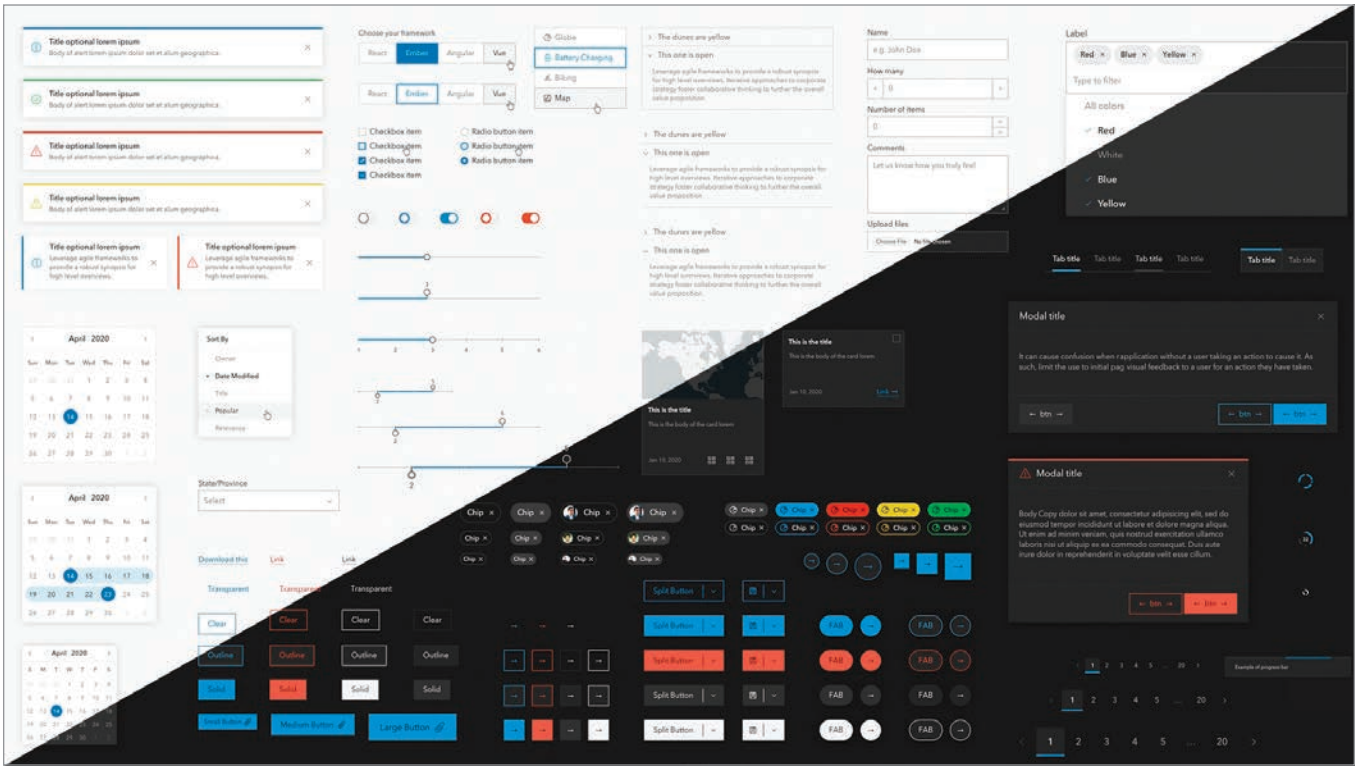
UI Building Blocks: Web Components

Developers can build web apps using the collection of 47 UI components that are the foundational building blocks of any web application. These components are flexible, responsive, localizable, framework agnostic, accessible, and themable.

Flexible—Components can be configured in a variety of ways. For example, buttons can have square or rounded edges.

Responsive—UI components have

↓ Developers can build web apps using the collection of 47 UI components that are the foundational building blocks of any web application.



sizing options and other adaptive traits so apps can adjust to various display sizes.

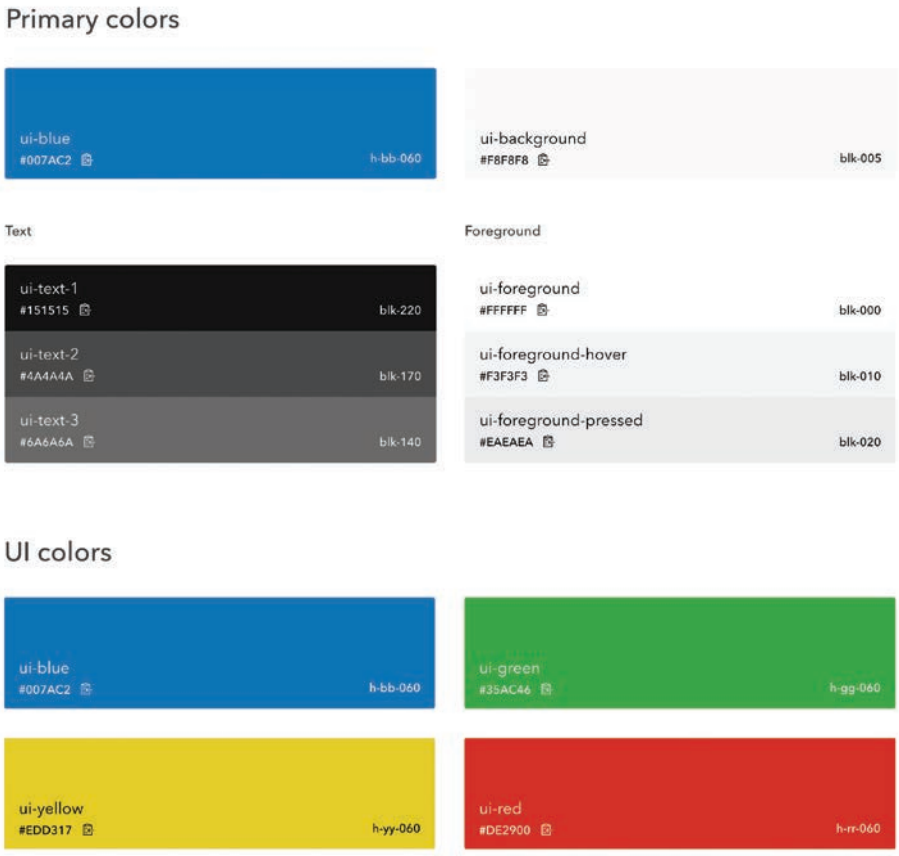
Localizable—Components support both left-to-right and right-to-left localization, and text properties can be set for any locale.

Framework Agnostic—Because components are built on the web component standard, they are framework agnostic so that developers can use these components within their choice of JavaScript framework and will require nothing more than vanilla JavaScript, HTML, and CSS.

Accessible—Components undergo regular, formalized accessibility testing to ensure that they can be easily used by any audience.

Themeable—Developers can apply a light or dark theme or define a custom theme to match their brand.

Esri heavily depends on the design system for creating the UI/UX of ArcGIS products. As products evolve, new products are introduced, and the developer community contributes to requirements, the component library will expand and evolve.



↑ Using the components' color variables, you can configure the color scheme in your app.

Customize to Match Your Brand

Applying a theme allows you to integrate your style or that of your company branding with your app. By default, UI components will use the ArcGIS color palette, font, and component shape. If you want to adapt the look to match your style preference or brand, you can easily customize the components in a variety of ways.

Light/Dark Theme—Using a single property, you can configure all components to use a dark or a light theme. The dark and light themes will style all components and their states (e.g., hover, selected) using the chosen theme.

Colors—Using the components' color variables, you can configure the color scheme in your app. The following CCS will give all components a dark pink color with a slightly darker hover state color.

```
--calcite-ui-brand: #FF1493;
--calcite-ui-brand-hover: #C71585;
```

Component Shape—You can configure the shape of some UI components. For example, you can use a rounded button style.

Typography—You can apply a specific font to the entire app or individually across components.

From Design to App Using UI Kits

What is your process for designing your application? Perhaps you work with a design team first to create the experience. Maybe you design and develop the app yourself. In either case, you can use popular design tools and the Esri design system UI kit, easily dragging and dropping components into your app's UI layout. (Note: In the first release, only Sketch is supported but Esri is working to add support for Figma and Adobe XD later this year.)

In the Esri design system UI kit, you'll find symbolized versions of all the web components, colors, icons, and fonts that are part of the design system. As you construct designs in Sketch, you will be able to implement them in code.

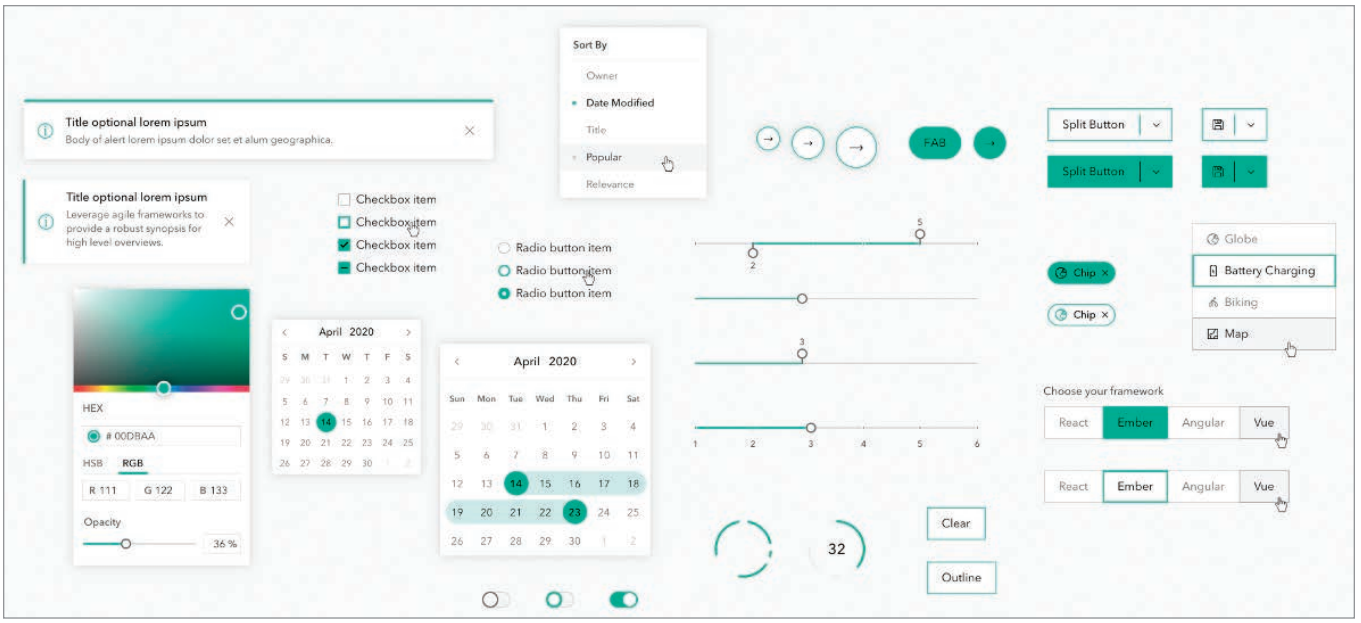
To learn more about how you can use the UI Kit to design your app in Sketch, see the guide page in the online documentation available at developers.arcgis.com/calcite-design-system/sketch-ui-kit/.

Icons

The Esri icon and illustration team maintains a collection of icons for products and marketing efforts. All Esri icons come in SVG format and have tags so that it's easy for you to find the functional or mapping icons you are looking for. You can browse both icon libraries at at developers.arcgis.com. These icons, which can be used in your application UI or as symbology in your map, are offered in two main libraries: calcite-ui-icons and calcite-point-symbols.

calcite-ui-icons

A collection of more than 700 monochrome user interface icons meant for the UI outside of the map. They represent software functions in web and native application experiences. These icons depict straightforward concepts avoiding unnecessary complexity and are implemented with a single fill color. They are built at 16-, 24-, and 32-pixel in a primary 1-pixel outline style.



↑ UI components use the ArcGIS color palette, font, and component shape by default but can be adapted the look to match your style preference or brand.

calcite-point-symbols

The more than 700 calcite-point symbols in this library are monochrome point symbol icons built at 13-, 17-, and 21-pixels sizes for use on maps. Constructing these symbols on an odd-numbered pixel grid means that they can be centered both horizontally and vertically.

Colors

Strong and bold colors are used sparingly, leaving the focus on the primary blue brand color and UI states. In addition, all colors are designed with accessibility in mind. Both light and dark themes pass the Web Content Accessibility Guidelines (WCAG) Level AA accessibility contrast ratio requirements.

Esri's design system enables you to create beautiful, easy to use, and consistent experiences across apps with minimal effort.

Getting Started

The design system is available from developers.arcgis.com. You will find resources such as usage guidelines, best practices (do's and don'ts), writing and copy guidelines, accessibility documentation, and a component API reference. Most notable, you will find knobs for the component configuration to visualize the flexibility of its properties, light/dark theme, and right to left layout for localization. As you adjust the component knobs and properties, you can copy the code from what you modified and paste it straight into your application.

Looking to the Future

As with other state-of-the-art design systems, Esri's design system is constantly evolving with the advancement of ArcGIS technology, the available tooling for web development, and the underlying technology. Since Esri heavily depends on the design system for creating the user experience for products, the component library will continue to grow and be enhanced.

While the current UI components are limited to the web platform, Esri plans to expand the design system to support more platforms. Apps built with technologies other than web can benefit from design system resources such as design guidelines, icon library, and colors.

About the Authors

Julie Powell is a principal product manager. Her primary focus is the ArcGIS API for JavaScript and Esri's design system. She has more than 19 years of experience working with software development, delivering solutions for both enterprise and consumer markets. Powell has worked on a wide range of projects and consulting endeavors, including serving as a technical lead for web mapping solutions for strategic customers. She interfaces with a wide user community to maintain awareness and insight into GIS community needs, meanwhile contributing feedback to development teams to help ensure users can be successful in building state-of-the-art, purposeful solutions using ArcGIS software.

Julio Ochoa is the product owner and team lead of Esri's design system. He has been in the design industry for more than 10 years. He has contributed design solutions to many initiatives throughout Esri. He is an adjunct lecturer at California State University, San Bernardino. He teaches the latest design principles, techniques, and tools. He earned a bachelor's degree in graphic design from The Art Institute of California, Inland Empire and his master's degree in business administration from the University of Redlands.


NEVER ALONE
WHEN YOU'RE CONNECTED TO THIS MANY SATELLITES
Map your assets with higher accuracy in 2021.
Arrow Series GNSS receivers utilize satellites from:
GPS, Galileo, GLONASS, and BeiDou.
Centimeter, RTK, Subfoot, and Submeter options are available.
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Developers Have Direct Access to Location Services with ArcGIS Platform

ArcGIS Platform gives developers access to a comprehensive set of industry-leading location services.

ArcGIS Platform provides a new option for developers to access powerful ArcGIS location services and high-quality geospatial content through this location platform as a service (PaaS). The underlying services that power ArcGIS are directly available to developers building mapping and location-based applications. ArcGIS Platform complements the rest of the ArcGIS system—ArcGIS Online, ArcGIS Pro, and ArcGIS Enterprise.

According to a February 2021 report by International Data Corporation (IDC), the premier provider of global market intelligence, "Awareness—and utility—of location-enabled applications and analytics has increased tremendously over the past year, across new applications and added value for existing solutions. IDC's November 2020 Data Buyers Study shows that 71 percent of data buyers are looking for location-enabled data. To take advantage of the high level of interest, Esri has launched a location-oriented platform as a service, ArcGIS Platform, to attract a wide range of developers to Esri's tools and capabilities."

For many years, ArcGIS users have been developing apps and solutions that use and extend ArcGIS Online, ArcGIS Pro, and ArcGIS Enterprise. These capabilities currently support 350,000 organizations worldwide. Now, with ArcGIS Platform, the broader community of developers can access and use maps and location services to build engaging and dynamic solutions that create deeper understanding.

ArcGIS Platform is made up of three high-level elements:

- An excellent developer experience
- A comprehensive set of industry-leading location services
- A simple, transparent business model

Together, these elements provide an intuitive experience for accessing and using the ArcGIS Platform.

Outstanding Developer Experience

ArcGIS Platform provides a premium developer experience that comes with the robust ArcGIS API for JavaScript and a set of APIs for mobile and desktop development. Developers using ArcGIS Platform can also leverage open source mapping libraries, including Mapbox GL JS, Leaflet, and Open Layers. ArcGIS Platform supports industry-standard authentication using API keys.

The ArcGIS Developers website (developers.arcgis.com) provides resources and tools to help developers be successful with ArcGIS Platform. These resources include a developer guide describing productive workflows, extensive SDK documentation, more than 100 tutorials with a live sandbox that lets developers code and instantly see results, and a dashboard that gives detailed service usage and statistics. On the ArcGIS Developers website, a free account can be quickly and easily created to get started using these tools and resources.

A Collection of Location Services

ArcGIS Platform gives developers access to a comprehensive set of industry-leading location services: basemaps, data hosting, data visualization, geocoding and search, routing and directions, maps and data, and spatial analysis.

Esri delivers billions of basemap views around the world every day, and ArcGIS Platform makes this rich resource available to developers.

Content can be hosted on ArcGIS Platform. This content can include services based on data as well as features; vector and image tiles; GeoJSON; spreadsheets; shapefiles; and text files stored in the ArcGIS Platform, which is secure, scalable, and performant. Note that developers retain ownership of any hosted data, and telemetry data is not collected by Esri from users of apps and solutions developed using ArcGIS Platform.

All the tools for making beautiful maps in 2D or 3D—at scales from hyperlocal to global—and insightful visualizations are provided. The power of Smart Mapping is available to assist in creating intelligent maps by using just a few lines of code.

The geocoding service is powered by industry-leading reference data that comes from multiple authoritative sources that include commercial data providers, government agencies, and a network of Esri partners from around the world.

→ The underlying services that power ArcGIS are directly available to developers building mapping and location-based applications with ArcGIS Platform, which complements the rest of the ArcGIS system—ArcGIS Online, ArcGIS Pro, and ArcGIS Enterprise.

Services provide routing and turn-by-turn directions for single vehicles or for multiple vehicles to multiple destinations. The routing service has global coverage and generates localized directions. The route solver also takes into consideration current traffic conditions and dozens of restriction types.

Through ArcGIS Platform, developers have access to an extensive data library that includes demographic and statistical data (such as income, spending, market segmentation, and psychographic data), real-time live feeds, and high-resolution imagery from multiple commercial and community providers that can be used directly in apps or joined with proprietary data sources.

ArcGIS Platform provides hundreds of spatial analytics tools and operators from geometric processing to attribute and spatial queries and supports interactive analytical operations on 2D and 3D data. These spatial analytic tools can be used in two ways: on the client side by leveraging the power of devices and on the server side. Developers can also work with the big data, real-time analytics, advanced spatial tools, machine learning, and deep learning capabilities provided by the ArcGIS system.

These services can be used in many different deployment patterns for the web, mobile devices, desktops, and even system-to-system integration.

Consumption-Based Pricing

ArcGIS Platform is offered through a new business model that provides frictionless access and consumption-based pricing, so developers pay just for what they use. Getting started is as simple as signing up for an account at the ArcGIS Developers website (developers.arcgis.com) to receive the free tier that includes two million map tiles a month and thousands of other service requests that can be used to search, geocode, and host data.

Frictionless Access to Maps and Data

Leading business companies are already using ArcGIS Platform to incorporate location intelligence into their workflows and decisions. Salesforce used ArcGIS Platform to build location capabilities into Salesforce Maps, which helps its customers visualize customer relationship management (CRM) data. ArcGIS Platform gives SAP's developers and its external developers access to world-class location services to build custom applications that meet specialized business needs.

"With the release of ArcGIS Platform, developers now have access to professional-grade content and capabilities they can readily plug into their apps, allowing them to stay on budget while delivering enormous value by reducing time to market," said David Cardella, Esri product manager for developer technologies.

Sign up for an account at the ArcGIS Developers website (developers.arcgis.com).

Esri Introduces ArcGIS Enterprise on Kubernetes

An entirely new deployment option for ArcGIS Enterprise, built with cloud-native architecture that uses microservices and containerization, will be available as part of the Q2 release of ArcGIS 2021. ArcGIS Enterprise on Kubernetes is designed to optimize scalability, resilience, and maintainability.

This adds another deployment choice for ArcGIS Enterprise but does not replace existing deployment options on Windows and Linux. Esri will continue to support Windows and Linux just as it previously has. ArcGIS Enterprise on Kubernetes will be attractive to organizations that require a highly scalable deployment, particularly those with complex, multimachine environments that are already running Kubernetes.

The initial release of ArcGIS Enterprise on Kubernetes will be similar in functionality to a base deployment of ArcGIS Enterprise on Windows and Linux, with functional parity with Windows and Linux deployments achieved in subsequent releases. Existing GIS Servers on Windows and Linux deployments of ArcGIS Enterprise can be federated with ArcGIS Enterprise on Kubernetes to complement GIS capabilities.

The first release will include both on-premises and cloud patterns. ArcGIS Enterprise on Kubernetes will be available on-premises for Red Hat OpenShift Container Platform and via managed Kubernetes services on the cloud for Microsoft Azure Kubernetes Service (AKS) and Amazon Elastic Kubernetes Service (EKS).

These Kubernetes engines were chosen because they were well represented among existing Esri customers who were already working with the technology or those that planned to adopt it soon. The product road map includes expanding to more engines, such as Google Cloud Platform (GCP) and VMware vSphere. Initially, ArcGIS Enterprise on Kubernetes will support both PostgreSQL and Microsoft SQL Server databases as registered enterprise geodatabases.

The advantages of ArcGIS Enterprise on Kubernetes include a streamlined deployment process that can use templates and automated tools. High availability is built into the architecture, which is resistant to interruptions and, in some cases, can shift resources to preserve uptime for users. While ArcGIS has always been made up of REST APIs for GeoServices and Adminstration, ArcGIS Enterprise on Kubernetes deploys them as loosely coupled processes that are individually manageable and scalable. The use of microservices means that update and patch installation can be accelerated and performed at a more granular level, minimizing downtime and making the upgrading experience more predictable and manageable for organizations.

The scalability of this deployment method lets organizations provide appropriate capacity without being burdened with complex planning for the requirements of worst-case scenarios as is needed with other deployment types, which can cause the maintenance of excess capacity. Using automation and the built-in capabilities of powerful service usage metrics, administrators can scale GIS services up or down to meet an organization's service-level agreements (SLAs).

Kubernetes is a rapidly growing technology that is an open standard. This gives administrators using this deployment option more choices, more tools, and a community that supports this technology. It adds open-source flexibility. Because it is truly a cloud-native architecture—not just a cloud-ready one—it takes advantage of the latest technology.

Key Concepts

Trimble | esri Partner Network Silver

Reality **Captured**.
GIS **Empowered**.
Intelligence **Delivered**.

Trimble® GNSS hardware, apps, and services integrate with ArcGIS® Collector and ArcGIS Field Maps to precision-enable your workflow and drive confidence in your spatial data.

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Geospatial.trimble.com/esri

ArcGIS: A Foundation for Digital Twins

By Chris Andrews

In the last several years, the convergence of geospatial technology, building information modeling (BIM), and interactive 3D has driven a conversation about digital twins and how they may be used to simulate single facilities, entire cities, and even large natural systems. Digital twins are virtual representations of the real world including physical objects, processes, relationships, and behaviors.

GIS can be used to create digital twins of the natural and built environment. It can also be used to integrate many different digital representations of the real world, virtual models of real-world assets, or natural systems along with information models, data, reports, analyses, and user experiences intended to capture the state of a digital twin, monitor its performance, and predict future outcomes using it.

The concept of a digital twin originated in the product manufacturing industry. Precise digital models of complex objects, such as airplanes or cars, can be captured in a database for purposes of reporting, analysis, and eventually simulating and testing an object's performance. The original digital twin concept helped move the use of data about an asset from using it strictly for finance and cost-accounting purposes to evaluating performance and analyzing operations. This enhanced data could then be used to inform into financial aspects of an asset's manufacture and sales.

The digital twin concept is being applied to real-world infrastructure, buildings, and even for systems at scales as large as whole cities and natural environments. The idea

that a model of fixed physical assets can be used to help understand performance, costs, and construction is compelling. Extending the digital twin concept to inhabited systems, is even more interesting and more complex.

GIS has been used to model real-world systems with high accuracy for years. Utility networks, legal parcel boundaries, and traffic networks have been represented in GIS for purposes of asset management, maintenance, and planning. The digital twin concept builds on older techniques and technologies for data warehousing, federated systems, and object-based data models by adding realism, an interactive user experience, and high-resolution 3D and 4D models of assets and systems. Ultimately, the digital twin must help the owner or operator of the real-world asset or system to solve business or mission-critical applications to justify the investment and process changes that will inform and maintain the twin.

Problems That Digital Twins Help Solve

Digital twins can address problems associated with the historical record of an asset, operational performance monitoring, and testing or predicting the future performance of an asset.

Historical Record

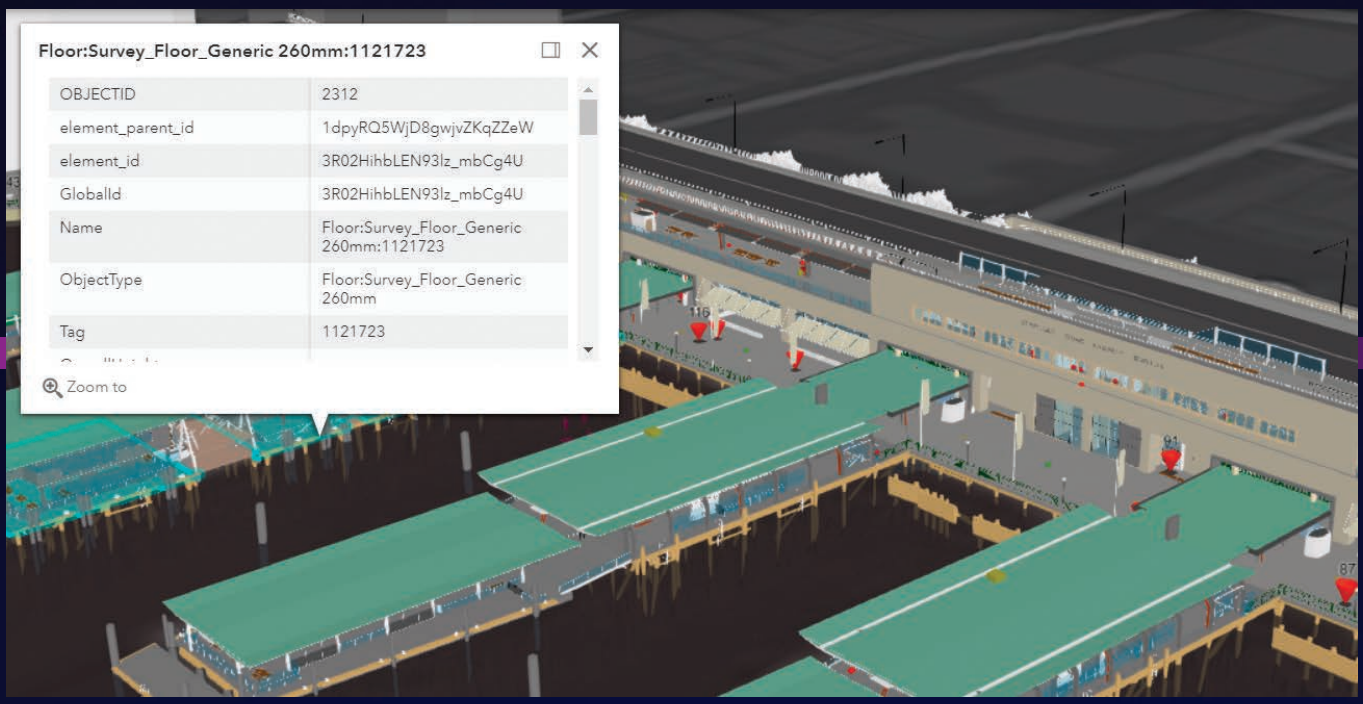
A digital twin can be used to archive a state of an asset or system for a specific time. Parcel boundaries and utility network models are good examples of geospatial twins of real-world systems that can be captured for legal and operational purposes. Reality capture, such as the point cloud and textured mesh output of SURE for ArcGIS, can serve as a high resolution, 3D snapshot of the real world. From these snapshots, some vendors can even extract BIM data that can be used as either historical record or as a starting point for future renovation or operations.

Operational Performance Monitoring

The 3D experiences furnished by a 3D virtual model of an asset can provide a consumer-level interaction and exploration experiences. Users can look at the model and see the real world. For that reason, many digital twin projects use the twin as a dashboard showing current performance of the actual system, often with live feeds and dynamically updated attributes. These systems are often linked to other, federated enterprise systems. One of the biggest benefits that GIS brings to the digital twin is that GIS can store, stream, and provide dynamic experiences to explore 3D assets as small as a building or as large as a city, all in the context of the built and natural world around the assets.

Testing or Predicting Future Performance

Some of the highest expectations surrounding the use of digital twins are based on the use of high-precision versions of an asset that are used to simulate and predict future performance or behavior. In the automotive industry, digital twins can be used to explore aerodynamics of cars. In the Architecture, Engineering and Construction (AEC) industry, aggregated BIM information is used in the practice of virtual design and construction. A digital twin of planned construction is used for detecting possible safety issues or construction conflicts. At the scale of a city,



↑ The Circular Quay Renewal Investigation project by Norman, Disney, and Young uses BIM and GIS for communicating renovation conditions.

GIS can be used to create digital twins of the natural and built environment.

planners want to simulate future change, such as the shape of a new building, changes in a planned highway, or improvements to seawalls. At the scale of a city, the hope with digital twins is that simulation and analysis of future changes can be used to understand and optimize the impact of changes while minimizing the costs of implementation.

Is GIS Necessary for a Digital Twin?

Any digital twin of a fixed asset or real-world system benefits directly from the inclusion of GIS data about the asset as well as the GIS context of the asset. Not only can GIS be used to create digital twins of the natural and built environment, but it can also be used to integrate many different digital representations of the real world.

For single objects in the mechanical world, an entire object can be represented in a self-contained data schema that can be used for observation and hypothesis testing. For fixed physical assets or natural systems, data about soils, asset materials, weather, traffic, maintenance, and utilities can be stored in different data models with diverse data quality, resolution, and ownership. GIS is the only technology that provides a simple key—location—that allows complex analysis of such diverse data models and datasets.

In the last few years, Esri has invested in ArcGIS to dramatically improve its capabilities, turning GIS into the ideal technology for bringing together federated datasets behind dashboards, ArcGIS StoryMaps stories, and 2D, 3D, and 4D maps for facilitating communication, observation, and analysis of complex systems. The more data that is added to GIS, the more benefits that GIS provides.

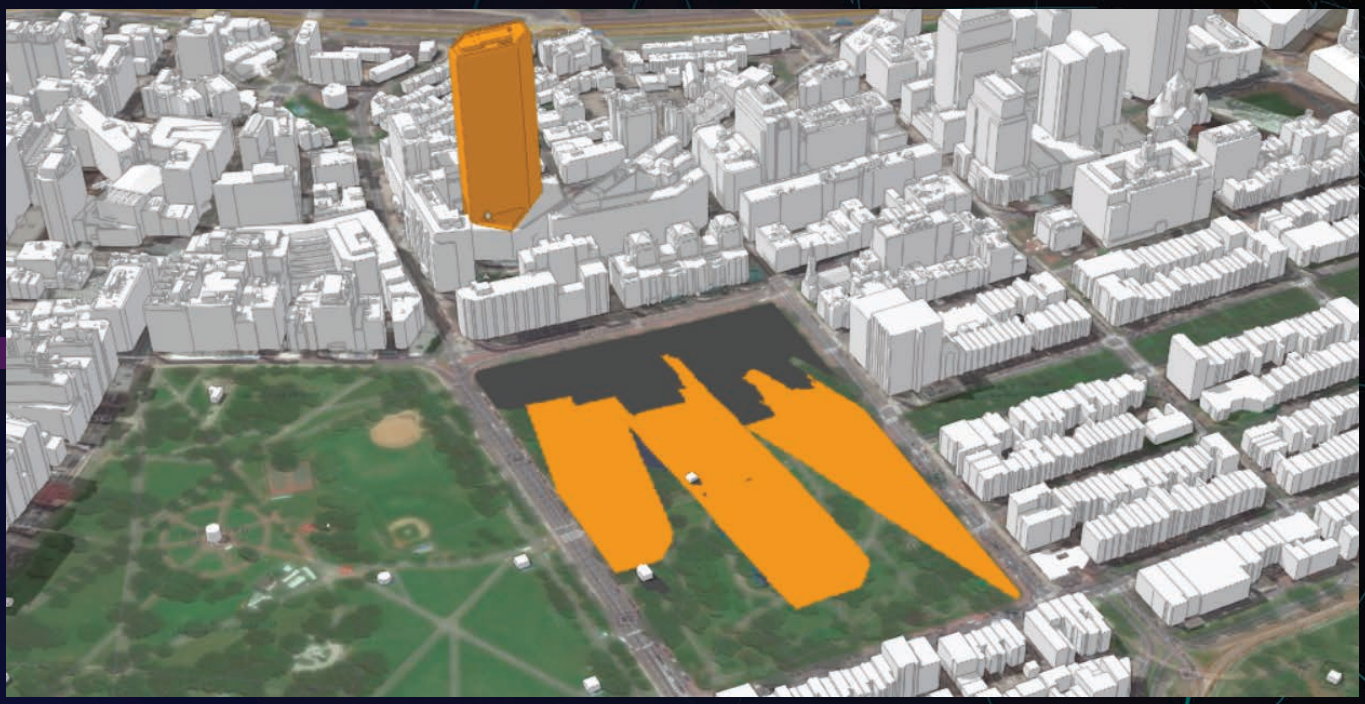
GIS data also powers many simulations of real-world dynamics and behaviors. For simple analyses, such as investigating the shadow impact of a planned structure, 3D GIS provides dynamic, easy-to-use experiences in a web browser. For complex simulations, advanced geoprocessing workflows may be used to simulate changes in large utility networks and then to see those changes in a simple dashboard.

Partner solutions extend ArcGIS capabilities. Simulating airflow through a major urban center or modeling the effects of a power outage in a major utility are just two examples of these partner solutions. The demand for the use of GIS content in game engines led Esri to release the ArcGIS Maps SDKs for Unity and Unreal Engine plug-ins in 2020.

What Determines the Scope of a Digital Twin Project?

Like any complex system design, designing a digital twin project requires identifying criteria that will help limit scope while also supporting longer-term maintainability. Given the diverse uses for digital twins, some of the considerations that will help identify the scope and requirements include:

- Time scale
- Stakeholder diversity
- Systems complexity
- Data ownership
- Data security



↑ Digital twins can be used to simulate the impact of proposed changes, such as the effects of a proposed high-rise building on the surrounding development in the City of Boston.

Time Scale

Will the digital twin used for a single project, or will it be used throughout the life of an asset? For example, in virtual design and construction (VDC) practice, the digital twin is typically used only for the life of a project, and it is not guaranteed that the twin will be usable for operations of assets.

Stakeholder Diversity

Will the people working on or dependent on a digital twin be working on a single project team or be drawn from diverse ecosystem of participants from multiple domains?

Systems Complexity

The complexity of a digital twin will increase—probably exponentially—with the number of systems that are modeled. This is true for building systems, such as plumbing, electrical, mechanical, security, and telecommunications, and even more true for campuses and cities. To help limit complexity, the number of systems modeled in a digital twin should likely be focused on the problems the twin will be used to solve.

Data Ownership

Data ownership drives both access rights to data and opportunity for connectivity between datasets. Owners of a facility, campus, or portfolio of commercial buildings may find that they have good control over available data and the ability to set requirements for incoming datasets. Operators at the scale of a college campus or city may struggle to assemble a digital twin that addresses their planned applications if not all utilities, facilities, or other systems that impact their operations are under their control.

Data Security

The security of a system, such as a digital twin, will be determined by the requirements of the most secure dataset in the system. Just because a highly secure dataset could be included in a digital twin doesn't mean that it should be included if access restrictions will end up limiting stakeholder requirements or other capabilities of the digital twin.

A digital twin is a virtual model. In a scientific context, a model is used to either test hypotheses or predict future states of systems. Scientific models are typically tailored to test specific elements of the system and often can't be stretched to test or predict scenarios that weren't considered when building the model. When building a digital twin project, it's worth considering that success may depend on limiting its scope to achievable outcomes, not expanding its scope to solve every future problem.

Elements That Make a Digital Twin Successful

Many of the elements that go into a successful digital twin project are the same elements that drive successful IT implementation projects in many industries. Fundamentally, a digital twin is deeply dependent on the ability to connect data and create user experiences that help solve problems and increase understanding.

Well-Defined Outputs

Problematic domains and requirements for reporting and analysis directly drive the data requirements and experiences that will be built for the digital twin. Specifying a clear set of desired outcomes, reports, and analyses up front will help make a digital twin more achievable. No technology implementation is static. Future iterations of a digital twin can incorporate more requirements.

↑ Amsterdam Airport Schiphol has built a dynamic, digital twin of its airport premises that incorporates open standard BIM data with live data feeds for aircraft and ground vehicle locations provided by ArcGIS.

A Design Thinking Approach

A deep understanding of how a digital twin will be used to support existing business practices helps inform and design experiences so that the digital twin can be used to get work done. Using a digital twin as a dashboard view into real-time systems will provide a different user experience than an extended reality (XR)-based planning and simulation tool to explore the effects of future changes. Experiences can only be understood by working with engaged stakeholders throughout the planning and design of the twin.

Clear Requirements for Information Architecture

The owner of the digital twin needs to understand—deeply—how the digital twin will be used and ask that data and services be delivered according to specifications that meet those needs. This may require extra up-front investment, but it is the only way to reliably obtain standardized, quality data to feed the digital twin.

Open Data Standards and APIs

Because challenges with data and systems integration make up a large portion of the problem set associated with creating a digital twin, customers need to specify open standards that will allow them to connect to data from many different applications reliably and sustainably. This is true for BIM models delivered according to an industry-standard file type, and it's also true for real-time data feeds that may be accessed through an open REST API.

Standardized Authentication and Licensing

If a digital twin will be used by a small team, access and authentication may not be a huge issue. If a digital twin will be used by many collaborators and stakeholders across an organization, such as a city, requirements must specify how federated datasets will be accessed using standardized authentication and identity patterns. If a common access card (CAC) card will be needed, make sure everyone knows that at the beginning of the project. While ArcGIS Enterprise standard licensing is great for sharing within an organization, ArcGIS Hub Premium licensing lets an organization share content with people outside the organization.

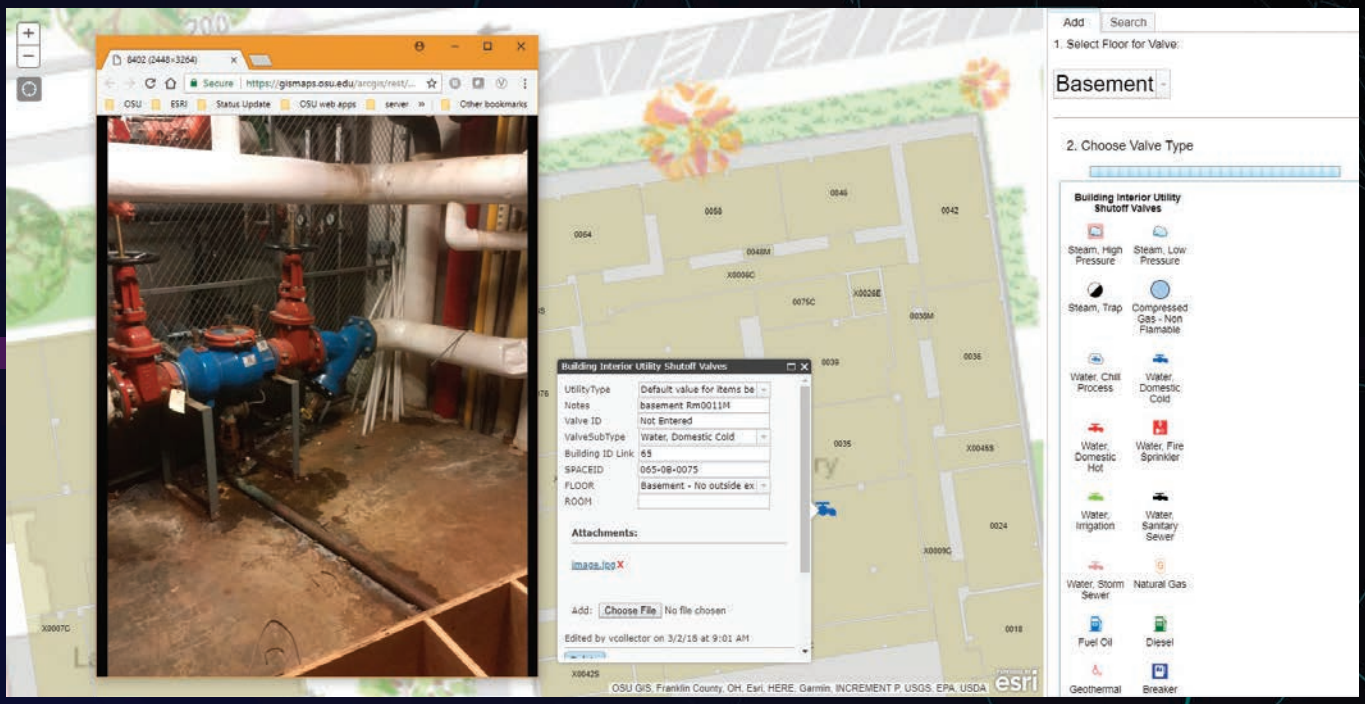
Geospatial Digital Twins in Action

Right now, ArcGIS customers can combine reality capture; 3D, 2D, and planimetric data; and real-time feeds in dynamic, interactive experiences that describe individual facilities, large systems, or entire cities. Geospatial digital twins, built with ArcGIS, can be explored on mobile devices, in a web browser, or through rich desktop applications from Esri and its partners. The geodatabase portion of a digital twin, stored in ArcGIS Online or ArcGIS Enterprise, is accessible through a wide variety of open standard APIs, services, and data formats that facilitate exchange and integration with other enterprise systems such as IBM Maximo or Autodesk BIM 360.

Many Esri customers have benefited from the current capabilities of geospatial digital twins.

Amsterdam Airport Schiphol has built a dynamic, digital twin of its airport premises that incorporates open standard BIM data through Safe Software's FME integration of ArcGIS with live data feeds for aircraft and ground vehicle locations.

HNTB Corporation, an American infrastructure design firm and Esri partner, is using innovative web-based 3D ArcGIS apps to present time and cost visualizations for construction projects. Its Long Island Railroad project allows teams to



↑ Ohio State University (OSU) uses its digital twin to manage assets such as shutoff valves inside and outside many OSU buildings and includes pictures of the valves to assist in locating them.

visualize project progress and even run future work scenarios that explore the impacts of schedule and budget changes.

Hartsfield-Jackson Atlanta International Airport built a digital twin using CAD, BIM data, GIS, and information about the surrounding environment that informs wayfinding and equipment placement, hazard analysis, and space management.

Hazen and Sawyer, an environmental engineering firm, helps customers deliver safe drinking water and limit water pollution. It uses GIS as the aggregator for BIM data, reality capture, and systems information for entire water treatment plants through a dashboard view into the operation and maintenance status of facilities.

The Future of Digital Twins

GIS has played a central role in helping customers model, analyze, and observe their assets and systems for decades. New technologies, such as game engines and real-time data feeds, have added exciting possibilities to create richer interactive, experiences for users to explore, analyze, and experience their assets and the world around them.

Esri is investing heavily in reality capture, BIM integration, buildings system integration, the analysis of the Internet of Things (IoT) data, and related technologies and tools that will be used for creating the next great digital twins with ArcGIS.

Visit the Esri Digital Twin website (esri.com/en-us/digital-twin/overview) to keep up with developments in the use of GIS for creating digital twins.

About the Author

Chris Andrews is an experienced product management and technology leader who enjoys solving real world problems, establishing high-performance teams, and connecting people and businesses in positive collaborations. Andrews began his career at Esri as the senior product manager for 3D implementation across ArcGIS. He now leads a team of product managers responsible for ArcGIS Hub, ArcGIS Excalibur, ArcGIS Urban, and ArcGIS Business Analyst and AEC/CAD/BIM and 3D offerings. Before coming to Esri, Andrews was the lead product manager for Autodesk's Infrastructure Modeler (now InfraWorks) and its Digital Cities efforts.

Crowdsourcing for Digital Storytelling

By Liz Todd and Ross Donihue

Maps create a sense of place, especially when their subject hits close to home. They have the power to evoke emotional responses in us as map readers, particularly when we can see ourselves in the data.

For contributors to crowdsourced maps, that feeling of identification can turn into something actionable because their participation lets them insert themselves into the data, broaden a viewpoint, and even contribute to a cause they care about.

Crowdsourcing a map means gathering opinions, data, or information from a group of people and displaying that information spatially. This is often done by asking a map's readers to answer a series of questions. Mapping these responses is particularly powerful when it's added to a story, complete with a narrative and other media that provide context to the discussion. A live data feed allows the story to evolve as readers contribute more information, making the content richer and deeper.

When Not to Use Crowdsourcing

Although crowdsourcing is a powerful tool, it's not the right tool for every story. Making sure you know the *why* behind that story is particularly important. If it's not compelling enough, or you don't have the right audience for a topic, crowdsourcing may be inappropriate, failing to attract participation—or worse—generating negative reactions.

Here are a few situations that might make you decide against using crowdsourcing in your story:

- You want to ask more than a couple of questions. Long surveys discourage participation, and responses can be cumbersome to display.
- You need to gather information that is sensitive or personally identifiable.
- The answers to your questions will not enrich your narrative and may distract from the map's intent and the map reader's experience.
- Your audience does not know enough about the subject to contribute meaningfully, or it's premature to engage them.
- You do not have time to maintain a crowdsourcing component.

When to Use Crowdsourcing

There are some solid reasons for adding a crowdsourced element and here are some of them:

- You want to engage with a community on a topic that is mutually beneficial.
- You want to connect readers to your topic in a place-based manner and help them see themselves as part of a larger narrative.
- You want a real-time view of community perspectives on your topic now, *and* in the future.
- You have a practical application that requires collecting community reactions, such as understanding where a community may want to locate a new park.

When done right, crowdsourcing can elevate community stories and opinions and even create change or inspire action.

Examples of Crowdsourcing Done Right

In these examples, notice how authors have incorporated crowdsourced data directly into ArcGIS StoryMaps. Explore this collection of stories to see how leading organizations use crowdsourced data to engage their audiences.

Birdability Map Viewer

Birdability Map Viewer (https://arcg.is/1qmb1a), a story by the National Audubon Society, uses crowdsourcing to glean practical information from community members. Audubon uses crowdsourced data to communicate the accessibility of outdoor locations. Each point—representing a trail, park, or birding area—is linked to information about parking, trail slope, trail conditions, and other factors that affect its accessibility. Anyone who enjoys outdoor spaces can submit a Birdability Review through the story and instantly see their contribution come to life on the map. The map also streamlines the search for accessibility information by offering near real-time, honest reviews of sites and their accessible and inaccessible features.

Storytelling for the SDGs

In *Storytelling for the SDGs*, (https://arcg.is/1mHe8S), crowdsourcing is used to gather community sentiments around the United Nations Sustainable Development Goal (SDG) 5: Achieve gender equality and empower all women and girls. The story uses a two-question survey to ask how people feel about the current state of women's representation in government. In the story, the map comes alive with a range of thoughts and opinions from around the

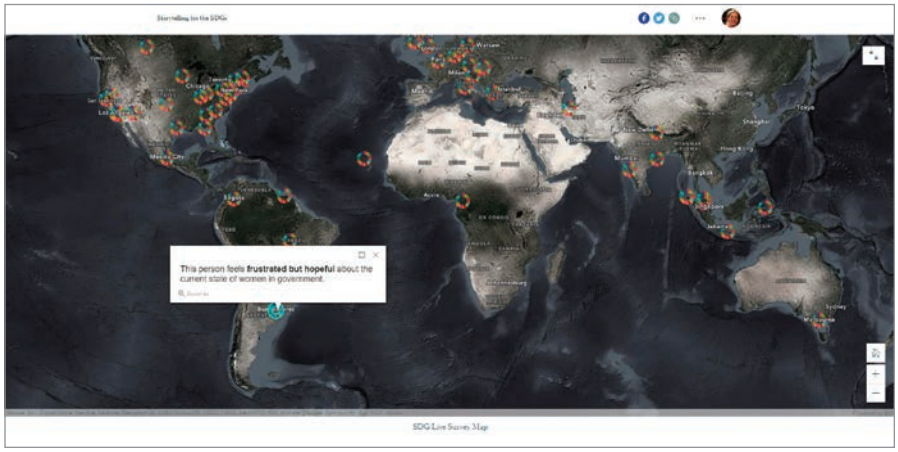
Birdability Map Viewer

↗ Anyone who enjoys outdoor spaces can submit a Birdability Review through the story and instantly see their contribution come to life on the map.

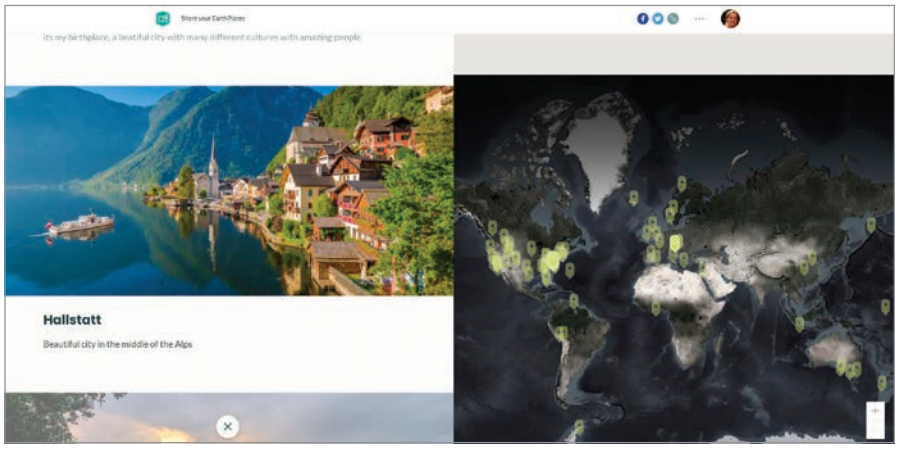
→ *Storytelling for the SDGs* uses a two-question survey to ask how people feel about the current state of women's representation in government.

↘ *Share Your EarthPlaces* relies on crowdsourced data on fascinating locations that was submitted by contributors using ArcGIS Survey123.

Storytelling for the SDGs



Share Your EarthPlaces



world. The questions and the pop-ups are easy to understand, and the story wastes no time getting to the heart of the topic.

Share Your EarthPlaces

Share Your EarthPlaces (https://arcg.is/1GO8HL) relies on crowdsourced data on fascinating locations that was submitted by contributors using ArcGIS Survey123. The survey results are funneled into a data-driven map tour, were the image, location, title, and description supplied by the contributor appear on the map in real time. It's a simple workflow for creating a fun and engaging experience that lets readers share and discover meaningful places around the world.

If crowdsourcing is something you want to try in your next story, look at the authors' tutorial, "Combining crowdsourced data and ArcGIS StoryMaps" (https://arcg.is/1vK0Df). It demonstrates multiple crowdsourcing workflows using Esri technology. These simple workflows can enhance your storytelling and engage your audiences.

About the Authors

Liz Todd is a multimedia specialist and product engineer at Esri on the ArcGIS StoryMaps team. She uses place-based storytelling to elevate and empower voices, with a focus on leveraging GIS for equity and social justice. Todd also coleads LGBTQIA+, an employee community focused on increasing representation, inclusion, and belonging for LGBTQIA+ individuals in GIS. When not at work, she usually can be found climbing, reading a good book, or searching for rocks or fossils to add to her far too large collection.

Ross Donihue is a cartographer and product engineer at Esri on the ArcGIS StoryMaps team. He uses place-based storytelling to engage users through beautiful, informative, and inspiring cartography. When he's not making maps, he's likely carving a spoon, making photos, or dreaming of mountains and fermentation.

Making Smart Type Choices for ArcGIS StoryMaps

By Allen Carroll

A recent enhancement to ArcGIS StoryMaps has made it easy for authors to choose from a long list of typefaces made available by Google. The addition of Google Fonts to the ArcGIS StoryMaps theme builder gives you much more flexibility to express your own aesthetic predilections, evoke a mood or style appropriate to your story, or more closely match the branding guidelines of your organization—especially when you customize color treatments as well as font choices.

I've been a designer for close to half a century, so my eye is perhaps more typographically attuned than most. Poor type choices can offend me, but many people are only vaguely aware of typography. When they see different typestyles, it elicits only a subliminal reaction.

But the subconscious and subliminal are important to storytelling, especially multimedia storytelling, where images, text, maps, color, type, and even sound can all work together to create an immersive little world. The importance of pairing the right type with the right narrative is exactly why Esri expanded the options in the theme builder so dramatically.

However, with freedom comes responsibility. You need to choose typography wisely. Inappropriate fonts can confuse or contradict your story's purpose. A frivolous-looking typeface paired with a serious, issue-driven story can weaken your message and trivialize your narrative. Conversely, a heavy, stern-looking font chosen for a lighthearted tale can send its own kind of mixed messages.

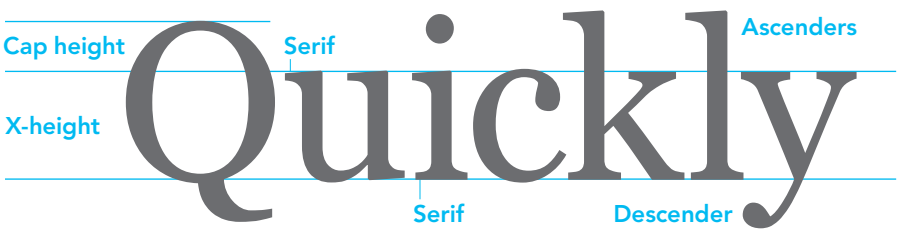
And—perhaps more important—all storytellers should feel ethically obligated to make narratives as accessible as possible to all people, including those with visual impairments. Poor font choices can compromise your story's readability, even for people with 20/20 eyesight.

Typography for Beginners

Before looking at specific examples, and without diving too deeply into the obscure parlance of typography, let's start with a few font basics. With rare exceptions, fonts are either serif or sans serif. Serifs are those little extensions at the tops and bottoms of letterforms.

Fonts often come in sets, or families, with visual weights ranging from spindly (light) to normal (medium or regular) to fat (bold and heavy). Fonts can be squished (condensed) or stretched (extended). They can be upright (roman) or slanted and script-like (italic). And there are fonts that are all capitals or all lowercase—remnants of the type drawers that printers used back in the analog age.

↓ An important detail to consider in type choices is the proportion of the x-height of ascenders to descenders.



A subtle but important detail to consider in type choices is the proportion of the x-height of the ascenders to the descenders. As you'll soon see, some fonts have ascenders and descenders that are quite tall relative to the main part of the letterforms, where most of the action occurs. Older serif fonts tend to have taller ascenders and descenders than more modern versions. How do all these variables come into play when choosing the right font for your story? The best way to explain this is with a few examples.

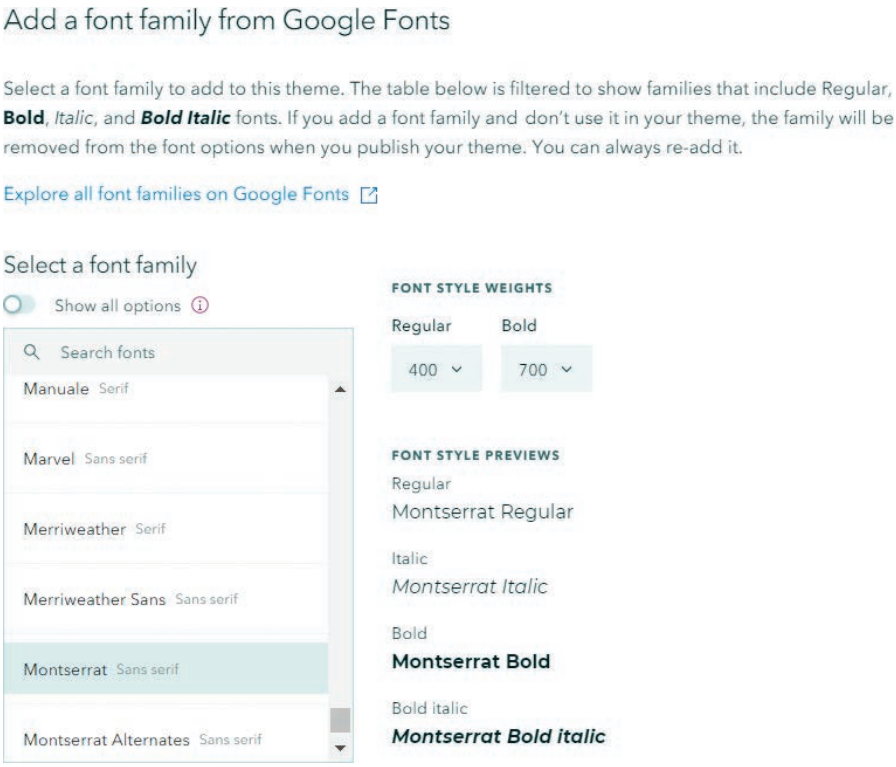
Comparing Fonts in Action

To illustrate the importance of type choices, I created a brief ArcGIS StoryMaps story, *Adventures in typography: 1* (https://arcg.is/1ne5ze). It uses Summit, one of the predesigned themes available with StoryMaps. It employs Avenir Next (a sans serif font) for titles, and Noto Serif for paragraph text. It's an effective combination, but as one of the original StoryMaps themes, it's been widely used and might have lost some of its distinctiveness as a result.

I created this story using dummy type, or greeking, which can be a handy way to evaluate the look of text even before you've drafted your narrative. You can copy dummy text from https://www.lipsum.com/ free of charge and paste it into your draft story.

You might notice that dummy text in this StoryMaps ends with "The quick brown fox jumps over the lazy dog." Why that sentence? Because it uses every letter in the alphabet. This sentence provides an efficient way to inspect a potential type choice.

With my original text choices in place, I made several duplicates of the story. Next, I went into the theme builder to create several font pairings by choosing Design > Browse themes > Create new theme and expanding the Typography section. You'll find Add from Google Fonts under the Typography



↑ To access Google Fonts for use in a custom theme, in the StoryMaps builder, choose Design > Browse themes > Create new theme and expand the Typography section. The first choice under the Typography section is Add from Google Fonts.

menu. This is where you can access the new font choices that are now available.

Mismatched Personalities

For the first part of the experiment, I tried to find fonts that I thought might be particularly inappropriate and that don't work well together. What's wrong with version 2 of the story (https://arcg.is/1afzOm)? The fonts, Almendra and Montserrat, are designed to call attention to themselves rather than to maximize readability. And their styles are utterly different, which means they make poor bedfellows. Almendra's ornate, antique look might work well on a treasure map, and Montserrat's informality might be effective on a takeout menu, but it's hard to imagine that they are appropriate for a story, regardless of topic.

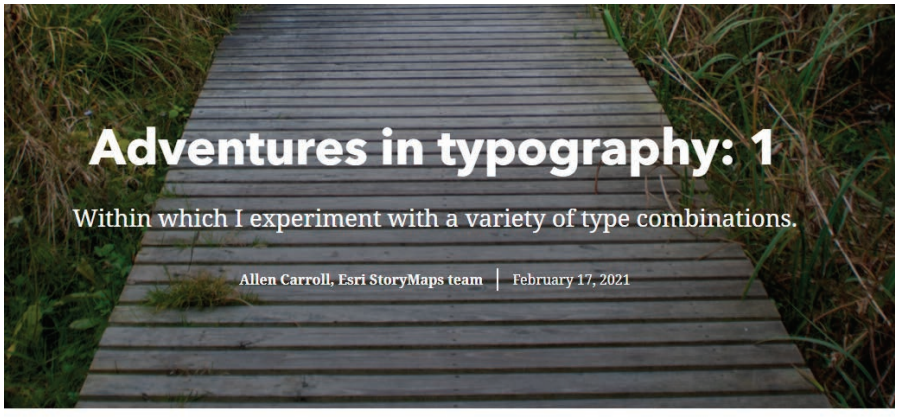
Out-of-Sync Serifs

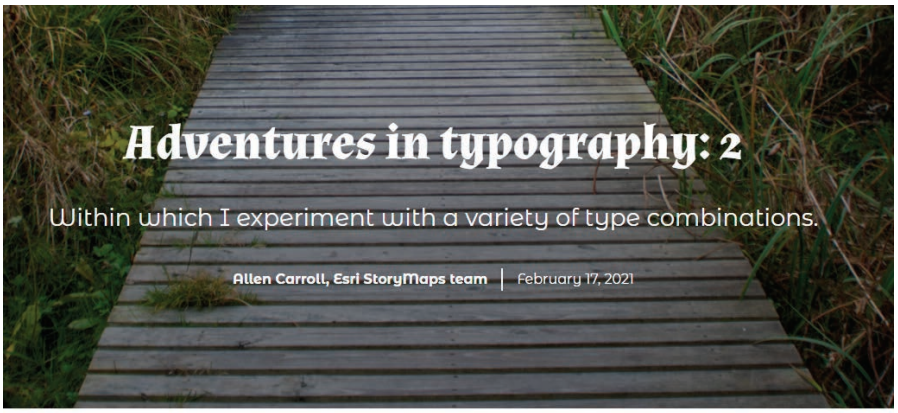
I made two other versions of the *Adventures in typography* story. They both use serif fonts. Note how the paragraph text in version 3 (https://arcg.is/0fa1Kv) uses EB Garamond, which looks much smaller than the paragraph text in version 4 (https://arcg.is/1Ljiqe0), which uses Manuale. The type is the same size in both versions, but the styling of the font makes the text in version 3 look considerably smaller. Blame it on those tall ascenders and descenders. I like the classic look of Garamond, but the Manuale version scores higher in accessibility.

Are serif fonts less readable than sans serif? The conventional wisdom for print media is that serif fonts are easier on the eye, and that those terminal strokes and slabs help our eyes move across lines of text, especially within books and lengthy articles. But reading on screens is a different experience. Those fine serif strokes tend to break up or even disappear on some displays. Thus, sans serif fonts may be a better choice for paragraph text.

But screens on newer computers, tablets, and mobile devices have higher resolutions, so the serif versus sans serif issues are increasingly negligible. What's more important is how ornate and decorative your font choices are. In other words, whether a font is serif or sans serif is less important than the thousands of little design details that, in aggregate, make a font easier or harder on the eye. I'm quite fond of a Google Font called Open Sans, used in version 5 (https://arcg.is/1CPyei). To me it's elegant and readable and has a subtle sense of style that's not fussy and distracting.

↓ *Adventures in typography: 1* (https://arcg.is/1ne5ze) uses Summit, one of the pre-designed themes available with StoryMaps. This theme employs Avenir Next (a sans serif font) for titles, and Noto Serif for paragraph text.





↑ In version 2 of the story (https://arcg.is/1afzOm), the fonts, Almendra and Montserrat, are designed to call attention to themselves rather than to maximize readability.

Carefully Chosen Combinations

Is it kosher to mix serif and sans serif fonts within the same story? The answer is yes. But it's important to strive for pairings that complement each other. That can mean that the fonts provide a clear contrast, or bear a family resemblance.

Let's imagine you're doing a story on 1950s-era drive-in theaters or the television show *Game of Thrones*. In those cases, a more flamboyant font might be appropriate for titles and headers. But I'd choose a paragraph font that's more conventional and readable, rather than making both fonts shout for attention—as shown previously in version 2 (https://arcg.is/1afzOm).

Conversely, you can choose fonts that are designed to be sympatico. A good example from the Google Fonts list is PT Sans and PT Serif, as shown in version 6 (https://arcg.is/0j99DD). They share a name and a family resemblance—and both are easy on the eyes.

By the way, Esri's prepackaged story themes—Summit, Obsidian, Ridgeline, Mesa, Tidal, and Slate—all contain font pairings that were carefully considered for both their aesthetics and accessibility.

Some considerations when making special font choices for your story could be:

- Aligning with your organization's branding and graphic style
- Giving your story a distinctive look and feel
- Reinforcing the topic, mood, and style of your narrative
- Maximizing the accessibility of your story

Regardless of your motivation, any and all typographic choices should be made with accessibility in mind. Esri has already incorporated some items that help ensure the readability of ArcGIS StoryMaps. These include optimizing letterspacing (the gaps between individual characters) and leading (line spacing). Other things you need to keep in mind as you customize your story themes include the following

- Maintaining high contrast between the color of your type and the background color.
- Choosing fonts—especially for your paragraph text—that have a large x-height relative to ascenders and descenders.
- Selecting weights that aren't too heavy (extrabold) or spindly (light). Both are often hard to read.
- Using fonts that have letterforms are clearly different from one another. For example, with some sans serif fonts there's very little difference between capital *I*, numeral *1*, and lower case *l*.

↓ The paragraph text in the upper section is from version 3 (https://arcg.is/0fa1Kv) and uses EB Garamond, which looks much smaller than the paragraph text in the lower section from version 4 (https://arcg.is/1Ljiqe0), which uses Manuale. Both have the same type size, but the styling of the font in version 3 makes the text look smaller.

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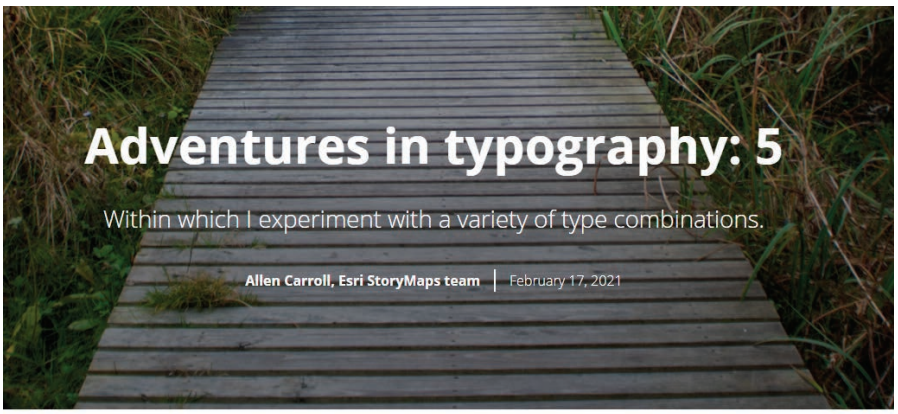
↓ Version 5 (https://arcg.is/1CPyei) uses a Google Font called Open Sans that is elegant and readable and has a subtle sense of style that's not fussy and distracting.

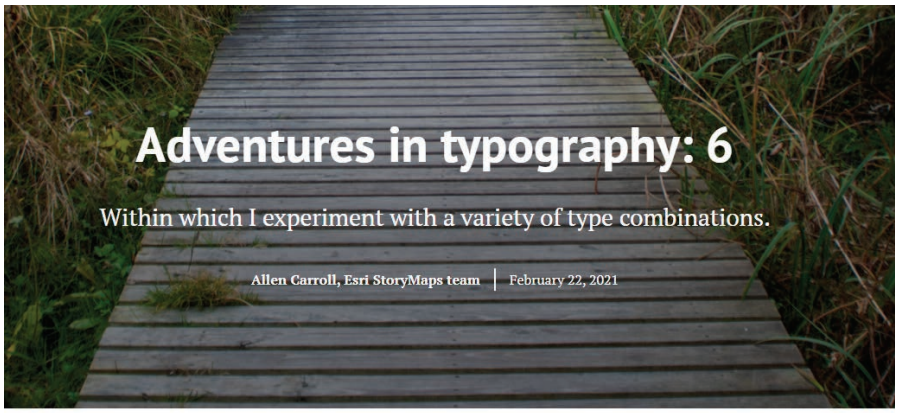


- Testing your choices within the story before finalizing the decision. If you find your text challenging to read, others will, too.

More Resources

For a deeper dive into creating accessible web content, see *Getting started with accessible storytelling* (https://arcg.is/0e9i5v). "A Guide to Understanding What Makes a Typeface Accessible," an artilce from the UX Collective provides lots of valuable detail about type and accessibility. Thinking with Type (http://thinkingwithtype.com/) provides a fascinating deep dive into the world of typography. It is based on Ellen Lupton's book of the same name. Explore this list of 50 font pairs recommended by professional designers (https://bit.ly/2QjdOcP).

Esri is excited to give you lots of new font choices and eager to see what you do with them. Please share your best efforts on Twitter @ArcGISStoryMaps.



↑ Version 6 (https://arcg.is/0j99DD) provides a good example using sans serif and serif fonts together. The story uses the Google fonts PT Sans and PT Serif. These fonts share a name and a family resemblance and both are easy on the eyes.

About the Author

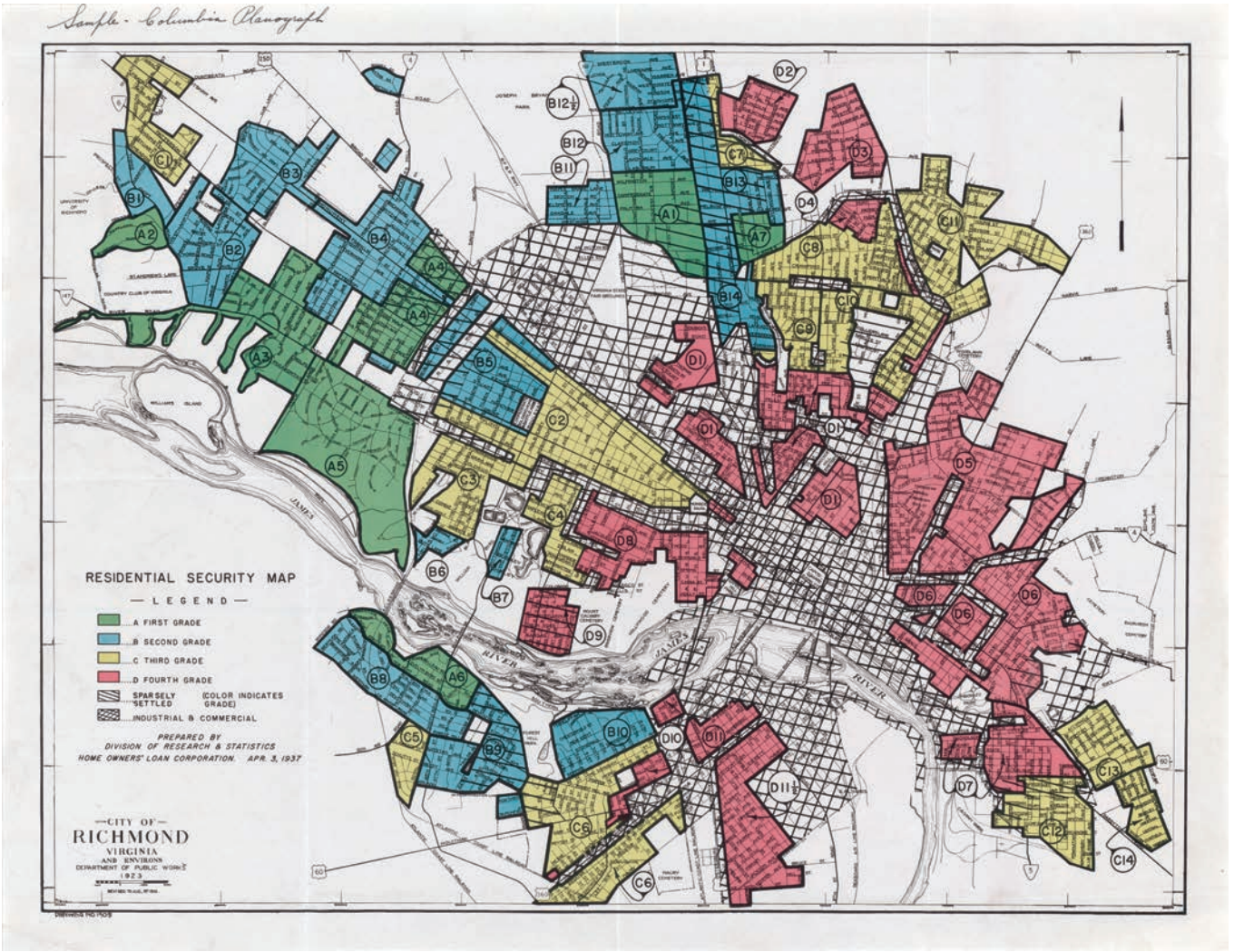
Allen Carroll founded the ArcGIS StoryMaps team at Esri. Prior to joining Esri in 2010, he worked at National Geographic for 27 years in a variety of positions, including art director of *National Geographic Magazine* and chief cartographer at National Geographic Maps.

The Legacy of Redlining Continues to Color Cities

By Emily Meriam, Ross Donihue, and Craig McCabe

In 2020, the University of Richmond, the Science Museum of Virginia, and Esri worked together to examine the environmental legacy of redlining policies from the 1930s. This collaboration was born out of new research, by the Science Museum and the Digital Scholarship Lab at the University of Richmond, that examined the environmental disparities related to redlined neighborhoods.

↓ A residential security map for the City of Richmond, Virginia, created by the HOLC in 1937.



Redlining is the practice of discriminating against residents of an area based on race or ethnicity through systematic policies that deny financial services—especially mortgages—that are applied based on location. The Home Owners' Loan Corporation (HOLC) was created in 1933 to increase homeownership as part of the New Deal. HOLC mapped neighborhoods and assigned grades to areas based on perceived lending risk factors that included racial and ethnic composition. Redlining has had adverse effects on these neighborhoods that can still be seen today.

Researchers in this collaborative project found that environmental factors, such as heat islands, had a striking relationship to HOLC grades. They joined forces to elevate this undertold story and explore this relationship further by performing geospatial analysis on environmental data layers in relation to HOLC grades. These collaborations allow researchers and museum staff to raise awareness of the legacy of redlining.

An ArcGIS StoryMaps story, *The lines that shape our cities* (https://arcg.is/1bzmDG), that profiles the research done by this team. It explores how redlining policies from the 1930s have left an environmental legacy that is visible in cities today. The story identifies four cities—St. Louis, Missouri; Montgomery, Alabama; Fort Wayne, Indiana; and Oakland, California—that haven't received major redlining coverage and performs GIS methods on data from these cities to see how environmental characteristics like tree coverage, impervious surfaces, topography, and heat islands relate to HOLC grades.

As part of this ArcGIS StoryMap story, the team wanted to create a color-based metric for characterizing two different neighborhoods in Montgomery, Alabama. The workflow used to devise the metric is described in this article.

↑ Several approaches were used to summarize imagery colors for neighborhoods.

Units of Analysis for RGB Imagery

One of the first challenges in exploring each neighborhood was determining the appropriate unit of spatial analysis. While the original HOLC grade polygons were logical containers, they didn't provide a way to look at the range or variation in tones within each neighborhood. To remedy this, a more granular, regularly tessellated grid, was used so a resolution approximately twice the size of a standard city block (200 meters by 200 meters) was adopted. Essentially, this created a low-resolution, very large pixel version of the source imagery.

Unfortunately, this tessellation approach introduced some problems with the unpredictable shape, size, and orientation of HOLC neighborhood polygons. While exploring ways to get around the alignment issue, the answer became obvious. Why use a regular grid to approximate the size of a city block when the physical barriers of the street network could be used to generate actual city blocks? Individual blocks in a city tend to be homogeneous in land use and vegetation cover, so it made sense to use blocks as the unit of analysis. This block-based analytical approach was applied to several other cities.

Extracting and Summarizing Imagery Bands

The National Agriculture Imagery Program (NAIP) collects four band (multispectral) imagery during the active agricultural ("leaf on") season for the United States. The first three bands contain red, green, and blue values in the RGB color spectrum. These were used to calculate the mean values among the pixels inside each block. The analysis used the following workflow:

1. The Raster Function Extract Band function was used to separate the NAIP imagery into band 1 (red), band 2 (green), and band 3 (blue) rasters.
2. Street lines were clipped out from the HOLC boundaries and then merged with the line version of each HOLC polygon.
3. Using the Feature to Polygon tool, polygons were created from these lines to generate polygon blocks and add a uniqueID.

↑ Mean color by neighborhood block for two HOLC grades, A on the top and D on the bottom.

↑ These are the palettes created from the average mean RGB value and ranked by brightness. Gray indicates significant areas of impervious surface.

4. The Zonal Statistics as Table tool was run using the Mean statistics type for the red, green, and blue single-band rasters, within each uniqueID block zone.
5. Each mean RGB value was joined back to its polygon block. Three new average color value fields (red, green, and blue) were populated.
6. A text field was added to store the list of the average RGB values for use as a polygon color fill using the format: rgb (R, G, B).
7. A new field for Brightness was added and calculated. This field contained, which is just the mean (of the mean) of the R, G, and B bands for each block. This was used in the legend to order the blocks in each ID according to their relative brightness.
8. The Identity tool was run on the polygon blocks against the original HOLC polygons to reattach the HOLC grades (A, B, C, D) and individual holc_id values (A1, A2, B8, D4).

With an RGB attribute value associated with each block polygon, polygons could be symbolized.

Symbology Using Mean RGB Color Values

The attribute containing the average RGB color values for each block can be read directly in ArcGIS Pro and used to color polygon fill for each block.

1. A single symbol or the block polygons were selected.
2. In the Vary Symbology by Attribute tab of the Symbology pane, Allow symbol property connections was enabled.
3. In the Primary Symbology tab, the database icon for the polygon fill was clicked and then the attribute containing the rgb (R, G, B) string value was selected and applied.

Summarizing block colors in a neighborhood is an interesting way to "fingerprint" the range of colors seen in the imagery and their variation. There was a stark contrast between the lush, dark greens of an A-rated neighborhoods compared to the light grays and browns of a D-rated neighborhoods.

As a final, easy-to-read summary of the color palettes for each HOLC neighborhood, the RGB values for A and D study areas were sorted by brightness, from low to high, to create a custom semi-continuous color ramp. This color ramp was inspired in part by the color analysis in the September 2, 2020 *New York Times*' article "The True Colors of America's Political Spectrum are Gray and Green."

Tree Height Analysis

Lidar data has become more readily available nationwide through the US Geological Survey 3D Elevation Program (3DEP). It is a great source for extracting and modeling 3D features that can include bare-earth terrain models, buildings, trees, and power lines. Lidar data helped researchers gain a better understanding of the differences between tree cover in HOLC neighborhoods.

The first goal was creating drone-like flyover animations to juxtapose the presence of trees in different HOLC grades, from a bird's-eye view. This required RGB information in the point cloud to render 3D points so that they appeared as a continuous surface. If RGB information isn't present, lidar data can be colorized and transformed using NAIP imagery in ArcGIS Pro. Read "Fun with Colorizing Lidar

with Imagery," an Esri Community post, to learn how to easily create a 3D basemap that adds real-world context to projects.

Classifying Trees

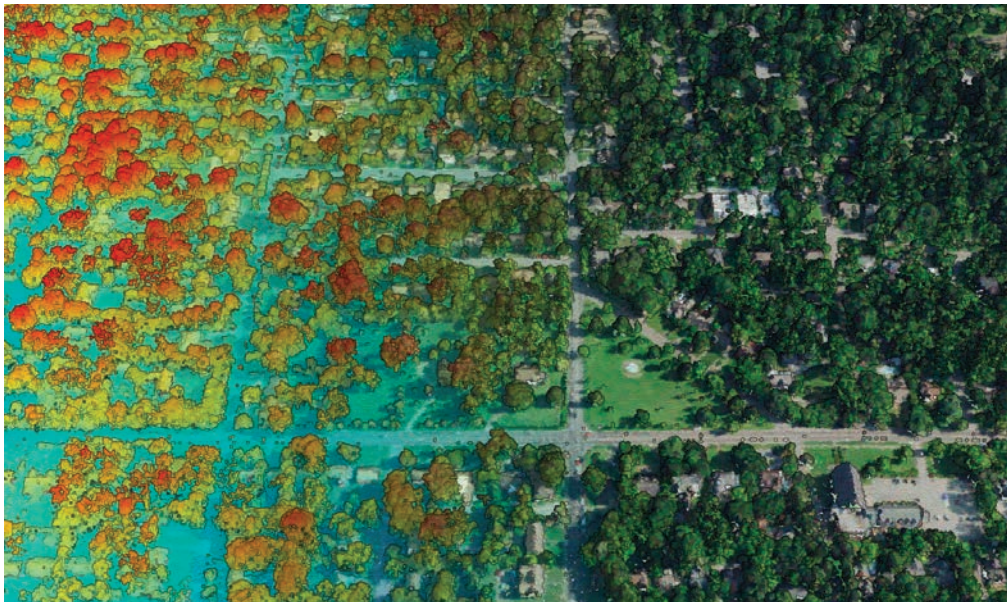
While the project lidar data for the City of Montgomery was already classified for vegetation, unclassified lidar can be classified to extract vegetation information using the 3D Basemaps solution (https://bit.ly/3lqR32e). This ArcGIS solution provides a set of tools and workflows to classify tree points in a lidar point cloud using deep learning. This solution provides new utility to existing lidar datasets, particularly for high-resolution environmental analysis.

By filtering out just the vegetation returns, researchers created a digital surface model and hillshade from lidar, providing a quick visualization of the tree distribution in different HOLC neighborhoods. To dig a little deeper, the next step was looking at tree heights and counts for each HOLC grade.

↑ Classified lidar data can be used to represent vegetation as a 2D surface or for the extraction of individual 3D trees with heights.

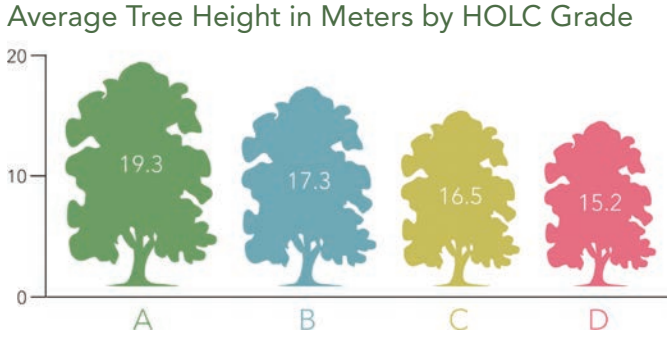
Extracting Tree Heights

To put a metric on average tree heights in the different HOLC grades, the 3D Basemaps solution was used to extract individual tree points from the lidar. In this workflow, a normalized digital surface model was created, which represented the height of objects above the ground. From this surface, the solution uses hydrologic tools to detect reverse sinks, which represent the center (top) of each tree and include individual tree height attributes. These points can then be visualized as realistic 3D models or analyzed. In this case, lidar was used to determine the average tree heights, comparing grade A and grade D HOLC neighborhoods.



↑ Lidar data symbolized by height (left) and by RGB value from leaf-on NAIP imagery (right).

While some individual neighborhoods had greater height differences, the averages across all HOLC grades showed a consistent relationship between HOLC neighborhood desirability and tree height. This reenforces neighborhood descriptions from the period, which often use words like *shady* or *wooded* for A grades. Almost 100 years after these neighborhood descriptions were written, these environmental disparities persist.



↑ Average tree heights across all HOLC grades in Montgomery show a consistent relationship between HOLC neighborhood desirability rating and tree height.

Sharing Analysis

After processing the imagery and lidar data for the project and reflecting on the results of analysis, the next step was communicating these results. Researchers wanted to embed a video in the

↑ Redlined areas that were given a Grade D rating today lack trees and have a high percentage of impervious surfaces.

ArcGIS StoryMaps story that would take viewers on a visual journey, using Esri tools and the data resources that are publicly available to dive deeper into understanding how vegetation has created very specific color palettes that can be correlated to the HOLC grades.

The team began by storyboarding scenes, writing the narrative, identifying transitions, and then putting it all together. Video editing was done with Camtasia software. During the editing process, care was taken to keep the same look and feel as the *The lines that shape our cities*, ArcGIS StoryMaps story, by maintaining the same overall structure and using a similar font and graphics. By keeping the video file size under 50 MB, the video could be hosted in the story—no small feat despite the use of lidar imagery.

The authors hope that this article prompts you to not only read *The lines that shape our cities*, but also to apply this analysis in your own neighborhood or city and question why your hometown looks the way it does. You can use this workflow to find answers.

About the Authors

Emily Meriam is a cartographer with Esri on the environment team for ArcGIS Living Atlas of the World. She has mapped elephants in Thailand, wildlife poachers in the Republic of Palau, land-use related issues around Yosemite National Park, and active wildfire incidents for the State of California.

Ross Donihue is a cartographer and product engineer with Esri on the ArcGIS StoryMaps team. He uses place-based storytelling to engage users through beautiful, informative, and inspiring cartography.

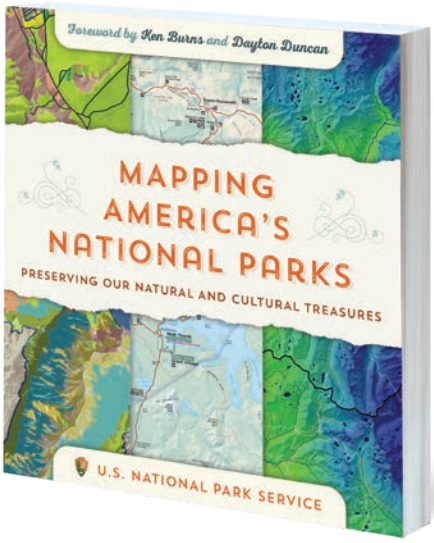
Craig McCabe is a product engineer with Esri on the team that manages the ArcGIS Living Atlas of the World. His focus is on all things 3D.

↓ Areas given a Grade A rating on HOLC maps have considerably greater tree canopy and shade.

GIS Bookshelf

Mapping America's National Parks: Preserving Our Natural and Cultural Treasures

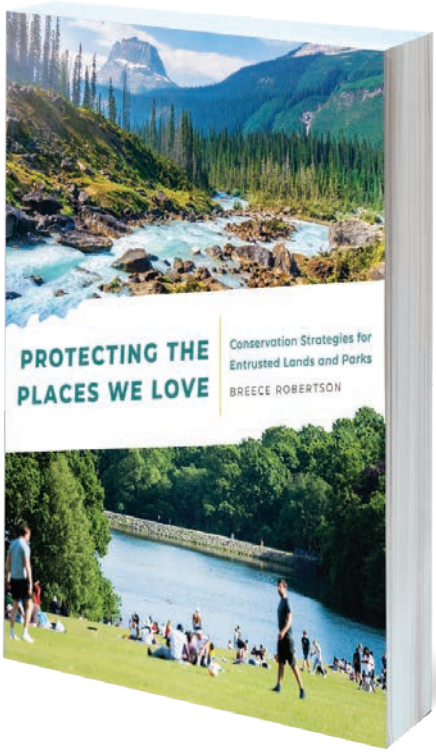
By US National Park Service



The US National Park Service (NPS) uses GIS to manage the natural resources it protects and create maps that help park visitors enjoy them. *Mapping America's National Parks: Preserving Our Natural and Cultural Treasures* provides an inside look at how the NPS uses layers of geographic information, containing the results of scientific research, to perform essential services. The information produced by its GIS helps the NPS provide security for individual wildlife species; manage fires, both unplanned and prescribed; preserve cultural resources, such as archaeological sites and historic buildings; and establish and maintain facilities, infrastructure, and transportation. Geospatial analysis assists the NPS in locating and rescuing stranded visitors and developing strategic plans and budgets. This book contains more than 240 full-color maps and photographs of national parks, monuments, battlefields, historic sites, lakeshores, seashores, scenic rivers, and trails. Esri Press, 2021, 200 pp., ISBN-13: 978-1589485464

Protecting the Places We Love: Conservation Strategies for Entrusted Lands and Parks

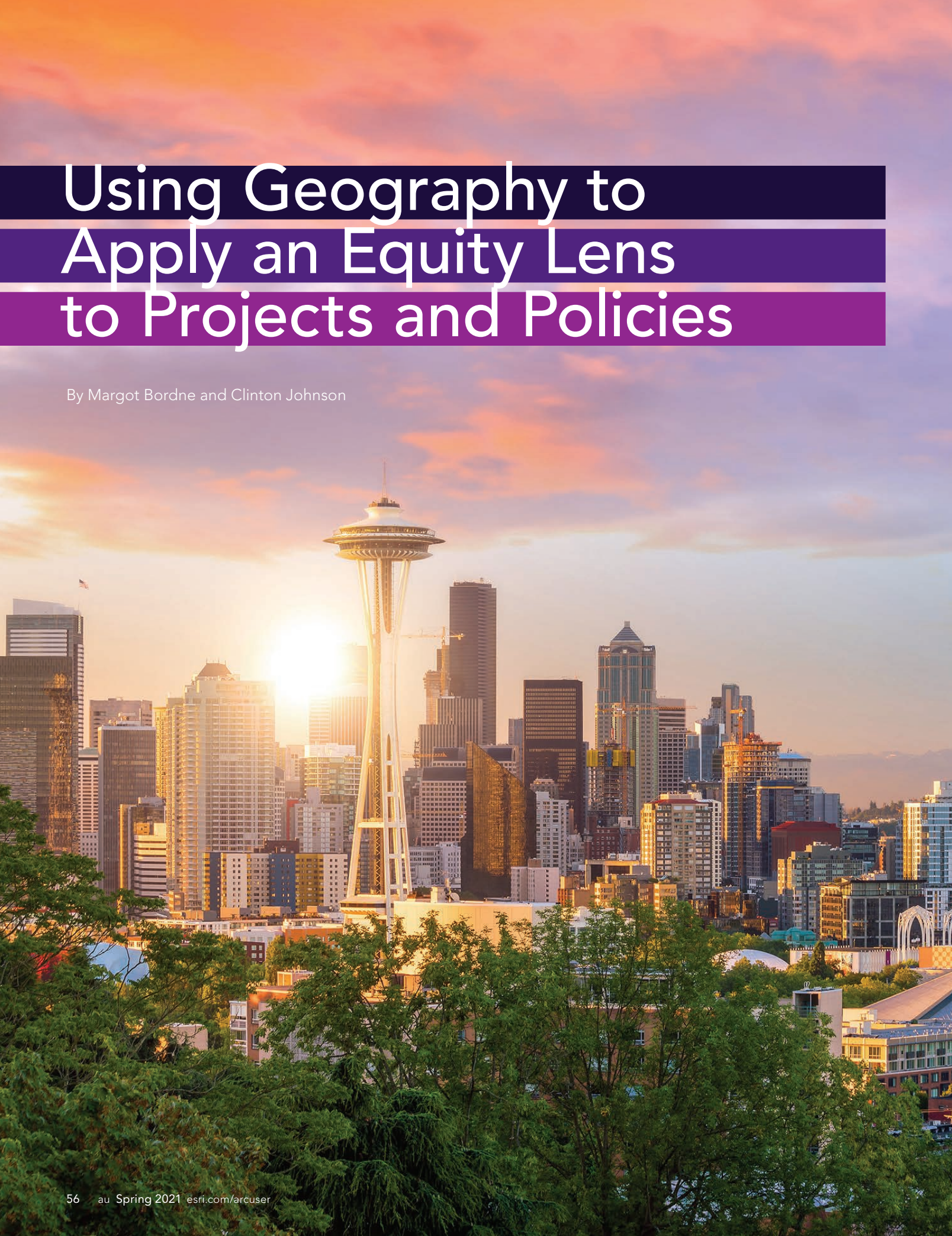
By Breece Robertson



Bold conservation goals are required to save special places in the United States from being adversely changed forever. In *Protecting the Places We Love: Conservation Strategies for Entrusted Lands and Parks*, conservationist and geospatial designer Breece Robertson delivers a vision for success and clear guidance for conservation groups, both large and small. Conservation advocates and professionals at small-to-medium-sized land trusts, conservation organizations, and park agencies are the target audience for this book. The examples included come from the work of land protection organizations across the globe. These strategies support species, habitats, and natural resources as well as healthy, livable communities that are climate resilient and socially cohesive. Robertson's book provides a vision, strategies, and resources that can take conservation efforts to the next level. She has more than 20 years of experience building and leading strategic initiatives that combine cutting-edge technologies, research, and planning to support progress in the park, conservation, and environmental fields. Esri Press, 2021, 280 pp., ISBN: 9781589486164

Using Geography to Apply an Equity Lens to Projects and Policies

By Margot Bordne and Clinton Johnson



Over the past decade, leaders in King County, Washington, have emerged as innovators in the fight for equity and social justice (ESJ) in local government. They have found new ways to use data to shape more equitable policies and track progress over time. And an unassuming county department is leading the charge—the King County GIS Center. This center's small team, with leadership and support from Greg Babinski, uses geography to fuel progress.

In late 1960s Detroit, a young Babinski first learned about geography against a backdrop of social unrest and racial inequity. One of his teachers was William Bunge, a controversial figure who pioneered the use of applied geography for social justice.

Bunge co-led what he called geographic expeditions—not outward to the far-flung reaches of the earth, but inward to his own urban environments of Detroit, and, later Toronto. The goal was to understand people's lived experiences and see how someone's location contributed to their quality of life. He partnered with Gwendolyn Warren, a young Black woman who helped surface and map racial inequities in Detroit.

At the time, Bunge's approaches led to his being labeled a communist sympathizer, losing his job, and living in exile in Canada. But Babinski never forgot what he learned from Bunge, taking many ideas with him as he navigated a career that eventually led him to King County, in Washington state.

Leveraging Geography for Equity in King County

Babinski began working at the King County GIS Center in 1998. Since then, he's witnessed a growing realization of the need to focus on equity and social justice and recognized geography and GIS were the best tools available to do that work.

Babinski recalls an early project in which the county planned to purchase an abandoned rail line and convert it into a recreational trail for community use. The project came with a hefty price tag—$100 million. County executive Ron Sims came to the GIS team and asked for a geographic analysis of the project. Whom would it impact, and how many recreational trails and parks were already in the area? The team did the analysis and made a crucial discovery—the area was affluent and already had the highest concentration of trails and parks around. With that awareness, the county decided not to spend the money, shifting its focus and budget to other projects where people would benefit more.

Later, Sims asked county demographer Chandler Felt to research how the demographics of residents affected their success in life. The disturbing results showed that—depending on where they lived—life expectancy for King County residents could vary by as much as 10 years and they experienced differences in health and income. The areas with the lowest life expectancy were also the areas with the most people of color. This shocking discovery helped forge Babinski's drive to improve equity.

"Race and the place that you're born or where you live shouldn't be a predictor of your ability to thrive and succeed in life," Babinski said. "Right now, they are."

These experiences and analyses evolved into the practice of applying an equity lens to every potential project and policy in King County with the aid of spatial analysis. Babinski began believing that geography can help government leaders answer the question: Where is the need greatest?

GIS Best Practices for ESJ

What other questions can geography help leaders answer? How else can GIS be used to promote equity? Babinski, the King County GIS Center team, and other King County leaders began working to expand a framework that others could learn from and use.

In 2018, the King County group helped host an equity and social justice track at the annual conference for the Urban and Regional Information Systems Association (URISA). The session was standing room only, and the buzz was long lasting, with passionate professionals deciding to form a workgroup to further the cause.

In 2019, Babinski was awarded an EthicalGEO Fellowship through the American Geographical Society to develop a fleshed-out set of GIS best practices for ESJ. Alongside a core team, he began the work of creating a formal document that would spark conversations, influence critical thinking, and be improved over time. The guiding principles included focusing efforts upstream, targeting the underlying causes of inequity rather than the symptoms. This means using GIS to examine policies and systems rather than outcomes. He also wanted to establish an ESJ life cycle by identifying problems, exploring solutions and alternatives, and tracking progress year over year.

Franklin and Babinski evolved their best practices into the half-day Intro to GIS for ESJ workshop the King County GIS Center staff presents to other city leaders. At first, they offered an afternoon course, presenting to leaders from cities such as San Jose, California, and Seattle, Washington. As interest soared, staff soon had to add a morning time slot for people on the east coast. The course is now certified by URISA.

Taking Action for Equity in King County

While King County's impact on equity issues is evident in its thought leadership and knowledge sharing, the county has also been doing hard work within its own communities.

One salient equity issue the county is tackling is the digital divide. Not all community members have equal resources such as computers and Wi-Fi. With the COVID-19 pandemic further disconnecting people, county and school board representatives say it's more important than ever for families to have access to the internet. For many children, it's the only way to access their education. The King County GIS team used geographic analysis to pinpoint areas lacking coverage, sharing that information with service providers looking to expand.

In parallel with King County's work, City of Tacoma's senior policy analyst Alison Beason used GIS to create an equity index of the city's population, measuring digital equity and other characteristics such as livability and health. The team also contributed analysis to help city leaders decide where to allocate funds from the Coronavirus Aid, Relief, and Economic Security (CARES) Act—again by identifying areas with the greatest need.

Future Proofing Equity Work

Babinski points out that equity and social justice are long-term issues. They have persisted and improvement can only be measured over long time periods. Because of that timeline, spatial analysis must be executed consistently. He says the work must be done with a high degree of precision so that it stands the test of time.

"GIS for ESJ is not a one-year project," he said. "It's not a five-year effort. It's really generational, because if we want to break this cycle, so that race and place don't correlate with thriving throughout the course of your life, we've got to look at this over a generation or generations."

Beyond longevity, Babinski shares that ESJ work must stand up to critics and naysayers. He feels GIS is well positioned to assist in that goal—showing real numbers in a visual format (often on a map) that communicates viscerally with stakeholders and community members.

Babinski also seeks to inspire the next generation of geographers to take up the mantle of using GIS for equity. URISA is similarly focused on engaging young, up-and-coming geographers to do this work, through its Vanguard Cabinet of Young GIS Professionals and training opportunities such as the URISA GIS Leadership Academy.

While teaching a PhD-level GIS for Public Policy class at the University of Washington, Babinski noticed that many of his students' projects had a bent toward social justice issues. He shared the lesson he was taught in 1960s Detroit—that sharing the lived experience of the people in the community can spark change.

"Community input is not just nice to have; it's really critical to truly understand how members of the community perceive their own geography and how they perceive the things that the government is doing to it," he said.

After the death of George Floyd, many local governments have put more focus on social inequities, and some are duplicating what King County is doing. Multiple projects are under way, such as equitable housing in Houston, Texas, addressing inequality in Oakland, California, and examining driver's license suspensions in New York.

Babinski is one of many geographers and GIS professionals to adhere to a code of ethics, believing they have a duty to use technology (GIS in particular) for the benefit of all society. He has his own description of GIS, tying it fundamentally to the work of equity and social justice. In his words, "The GIS profession uses geographic theory, spatial analysis, and geospatial technology to help society manage Earth's finite space, with its natural resources and communities, on a just and sustainable basis for the benefit of humanity."

To learn more about how GIS helps people examine racial inequities, visit https://bit.ly/3chyysN.

> "Leaders in King County, Washington, have emerged as innovative in the fight for equity and social justice (ESJ) in local government."

About the Authors

Margot Bordne is an account manager on Esri's global business development team. She supports organizations across industries that leverage GIS to improve their operations and decision-making capabilities, with a focus on the use of GIS for advancing equity and social justice. Bordne also founded and leads Esri's Women's Enablement and Career Advancement Network (WeCan) and is currently working toward a master's degree in diversity and inclusion leadership at Tufts University.

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

Using Where to Answer *Why* and *How*

By Charlie Fitzpatrick

Roxana Ayala was introduced to GIS technology while working on a high school research project in 2013. GIS helped Ayala and her fellow students see their lived experience in a new light. This powerful technology helped her better understand the historically underserved neighborhood of Watts in the City of Los Angeles where she grew up, and Boyle Heights, another area of the city, where she went to school. Her connection to GIS has been guiding Ayala's career ever since.

"I still approach problems using the geospatial critical-thinking techniques I learned in high school."

Two Mentors and a Changed Life

Working in teams to investigate a social justice topic, students at the Math, Science, and Technology Magnet Academy at Roosevelt High School engage GIS in their service learning projects to build a deeper understanding of their community.

Empowered by GIS-based research on their local neighborhoods and city, students began to ask that all-important question: Why? Teachers note that their students develop a maturity and a confidence through GIS projects that change the way they think.

Alice Im and Mariana Ramírez, who both taught Ayala at Roosevelt High School, recall her as a bright student and a spirited, somewhat fearless kid. In Ayala, her teachers saw a smart teen who was always serious and engaged.

With their guidance, Ayala learned the power of plotting data-based analysis on a map in strikingly visual ways. Ayala's high school project focused on evaluating education inequalities. She saw the discrepancies in education, income, housing, health care, and environmental safety between her community and more financially secure neighborhoods.

"I love Roxy," said Im, an English teacher. "And I think Mariana will back me up on this…we have many, many students like this, where they are just so resilient and so capable of becoming these powerful, wonderful human beings."

"GIS helps them to really understand their community, so that their relationship with their community isn't a negative one, where they believe this is a terrible place that I need to escape," Im said. "Rather, it's like this is a really wonderful, beautiful place that has a lot of challenges, and that I can be a leader and I can transform it and take ownership."

Asking Why

Location intelligence made the student researchers even more alert to current events.

"Our students began to question the budget cuts that were happening systematically across the State of California," Ramírez said. "And they were noticing how California, having one of the richest economies in the world, was undercutting the educational system, and they were asking why."

Though currently pausing her teaching career to pursue a doctorate degree in education at the University of California, Los Angeles (UCLA), Ramírez is anxious to get back to teaching. She and Im believe that location intelligence from GIS can have a similar effect on students and teachers at other schools, especially in historically marginalized areas.

"There's not enough examples of communities like ours that are in working-class, people-of-color neighborhoods that are engaging in this type of work," Ramírez said. "So I think one of our goals as teachers and educators and researchers is to one day put out some work on this for the educator community."

Their students' work, however, already has drawn attention. In 2013, Ayala and three other

high school classmates presented their findings at the Esri User Conference in San Diego, California. Their work inspired GIS users from around the world. Since then, the students from Roosevelt High School have made an annual trip to the Esri campus in Redlands, California, to share how GIS enhances their understanding.

As Ayala entered the University of California, Irvine, her skill with GIS, a technology few of her peers even knew about, opened new opportunities for her. She frequently used GIS in courses she took on her way to earning a bachelor's degree in environmental science and urban studies. She also completed a summer internship at the University of Minnesota, using GIS to analyze manufactured homes across the United States and their vulnerability to environmental factors such as flooding and air pollution.

Her passion to make a difference has continued to drive her work. Ayala now conducts research and provides technical assistance at the American Council for an Energy-Efficient Economy (ACEEE), a Washington, DC-based nonprofit, 501(c)(3) organization that aids in advancing energy efficiency policies, programs, technologies, investments, and behaviors. She began at ACEEE with the assistance of the Roger Arliner Young (RAY) Diversity Fellowship Program. *[The RAY Diversity Fellowship Program supports conservation, energy efficiency, and renewable energy-related career pathways for emerging leaders of color.]*

She is most concerned with energy equity. "Clean energy-related efforts that are developed

↓ During the 2013 Esri User Conference, Roosevelt High School students (from left) Alexander Cosio, Stephany Ortiz, Uriel Gonzalez, and Roxana Ayala explain the analysis they performed using ArcGIS as part of a learning service project.

in an equitable, just, and fair manner can offer many benefits, especially to marginalized and Black, Indigenous, and people-of-color communities," Ayala said. "As we work to develop recommendations for policy makers, utilities, and other key stakeholders in the clean energy industry, we must ensure that these efforts reduce energy costs; promote the health, safety, and well-being of people; and work towards reducing carbon emissions that contribute to climate change." Last year, Ayala and her colleagues published *Expanding Opportunity through Energy Efficiency Jobs: Strategies to Ensure a More Resilient, Diverse Workforce*, a report that examines energy efficiency workforce development programs that emphasize diversity and inclusion.

The Value of a Geospatial Approach

"I still approach problems using the geospatial critical-thinking techniques I learned in high school," said Ayala. "It has become the foundation for my research method—looking for relationships and connections." In her policy work, Ayala said she makes a point of focusing on equity-centered strategies that will promote diversity, justice, and inclusion so that everyone has access to the benefits of programs and policies.

That underscores something her former teachers, Im and Ramírez, have noticed when their students talk about possible careers. "A lot of our very talented young people are saying, 'I would like to go into public policy, and I would like to go into work like that where I get to make certain types of decisions about how things are managed and how resources are distributed,'" Im said.

Ramírez added that when students get excited about turning research into policy and policy into action, they inspire their mentors. "We're constantly also growing and learning from them about their imaginings of how we can create a better future for youth and people of color."

GIS Maps the Way Back Home

GIS provided a career path that led Ayala to opportunities outside her neighborhood, but it has also provided a road back to that community.

"I struggled with outside factors and many systemic barriers to get to the place I'm at now," Ayala said. "People in my community lacked adequate resources but helped me in other ways. My success has been a community effort, with many mentors, friends, family members, and individuals that helped me along the way. I also worked very hard."

"I struggled with outside factors and many systemic barriers to get to the place I'm at now."

↑ Roxana Ayala

The school and community support she received helps Ayala see herself as someone who can give back to her old neighborhood. On a recent visit, she toured the area with her former teachers. Ayala pointed out polluted spots and food deserts but also beautiful murals that make her proud—and, in turn—make her former teachers proud.

Ramírez said that they all seemed to share a similar point of view shaped by GIS. "How can we create a better living and learning opportunity for all the youth that live here in my neighborhood? And how do we enrich this place for them and for their future?" she said.

Learn more about using GIS to teach K–12 students and the free teaching resources available from Esri at https://bit.ly/3t4c7ya.

About the Author

Charlie Fitzpatrick is the K–12 education manager at Esri. After being a formal student for many years, he taught social studies in grades 7–12 (mostly 8th grade geography) for 15 years. He also started teaching teachers to understand the patterns, relationships, and systems of the world using computers. He joined Esri as education manager in 1992, where he works with students, educators, and influencers across the nation. He and his colleagues work to provide software, instructional resources, and educator support for free to every school and club, so that learners of all ages can explore and understand the world, analyze information, make good decisions, and solve problems by thinking geographically using GIS.

Courses That Build Data Science Capabilities in Your Organization

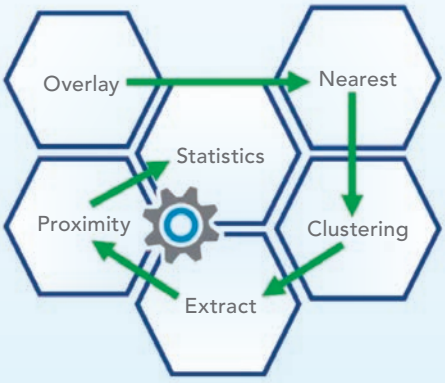
New foundational courses available from Esri Academy will empower GIS staff to answer complicated questions about the patterns and relationships that exist in the massive quantities of data now currently available for analysis.

Recognition of the value of both data science and spatial data science has grown tremendously in the last several years. Spatial data science employs methodologies and tools to extract nonobvious and useful patterns from data, enabling practitioners to make predictions. However, by incorporating geographic data and spatial analysis methods, spatial data science adds place-based context and greater insight to the practice of data science.

ArcGIS provides tools and workflows to use spatial data science methods to transform massive amounts of spatial data in many formats into actionable information that can improve the processes and decisions of organizations. ArcGIS Notebooks, built on top of the open-source web application Jupyter Notebook, has been implemented across ArcGIS to incorporate spatial data science capabilities and seamless integration with ArcGIS, while creating and sharing documents that contain live Python code, visualizations, and narrative text.

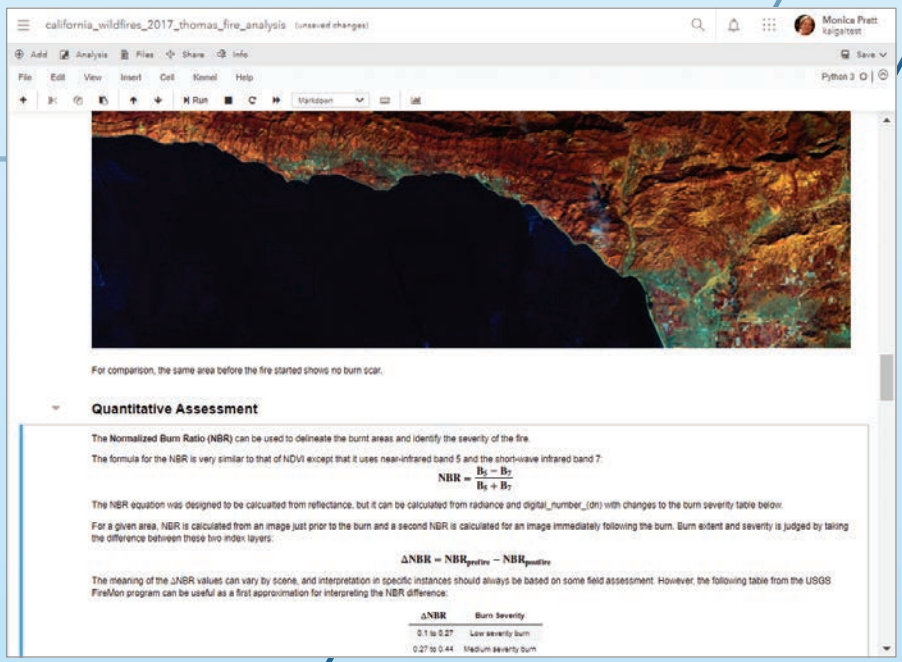
ArcGIS Notebooks is instrumental in performing the vital but formidable tasks required prior to analysis: data wrangling, cleaning, engineering, exploration, and visualization. These tasks transform, correct, and standardize data; devise the mechanisms needed for analyzing and gaining understanding of the data; and use that data for creating charts, plats, graphs, maps, and layouts.

By streamlining processes, making collaboration easier, and providing convenient access to any Python library, ArcGIS Notebooks lets GIS professionals bring far greater resources to bear on challenging problems as well as in automating and sharing work and building reproducible research.



↑ The spatial statistical capabilities in both ArcGIS Pro and Python and data science techniques combine in ArcGIS Notebooks to help users find answers in geospatial data.

↓ ArcGIS Notebooks can record entire workflows incorporating code, formulas, and visualization and make a wealth of Python libraries available while providing seamless access to ArcGIS tools and data.



ArcGIS Notebooks Basics and Data Science Workflows Using ArcGIS Notebooks, a pair of new web courses, will help get GIS professionals and data analysts started using ArcGIS Notebooks within ArcGIS Pro. These courses are available from Esri Academy. They provide the foundation needed for taking advantage of the data science tools and workflows in ArcGIS enabled by ArcGIS Notebooks.

ArcGIS Notebooks Basics explains how to use ArcGIS Notebooks in ArcGIS Pro to query features, perform analysis, geocode a location, and perform many other tasks. This course introduces the ArcGIS Notebooks interface and functionality for creating Python notebooks that perform spatial data analysis tasks.

Data Science Workflows Using ArcGIS Notebooks introduces data engineering concepts and the workflows needed to perform data engineering tasks using ArcGIS Notebooks in ArcGIS Pro.

Both courses are available from esri.com/training at no charge to those who are current on maintainence.

Organizational Support Is Key to Initiative's Success

By Suzanne Boden

Los Angeles County Metropolitan Transportation Authority (LA Metro) has undertaken an enterprise GIS modernization initiative designed to transform its business and build a better transportation future for the people of Southern California. Supporting LA Metro's own people during this transformation has been a key strategy in the success of this initiative.

At LA Metro, location is central to everything the organization does. Bus and rail lines serve distinct geographic areas, with routes and stops located to meet the needs of the public. Physical assets and incidents have unique locations. Access to accurate location data is essential for mission-critical workflows, including maintenance and safety.

Multiple business units use ArcGIS software, but historically GIS workflows have been siloed. Different departments used different ArcGIS products and versions of those products. This siloed environment made it difficult to share data, plan, and collaborate across business lines.

Solving the Silo Challenge

LA Metro engaged Esri Services to help it implement a location strategy that would standardize its enterprise GIS infrastructure and applications while delivering new capabilities such as digital asset inspection and real-time situational awareness. This new strategy would also streamline departmental workflows, increase operational efficiencies, and enhance communication and collaboration among multiple teams.

This location strategy is being implemented in three phases. Each phase impacts workflows across the organization. Enterprise-wide adoption of new tools and apps relies on many individuals changing how they perform their daily work. This creates a challenge for employees and managers alike.

Early on, the location strategy team identified that supporting the workforce throughout implementation should be a key strategy. Consequently, Esri's people-focused change management was included as a deliverable in the implementation plan.

LA Metro's Information and Technology Services (ITS) department is coordinating the location strategy implementation. Phase 1 activities included ArcGIS Enterprise and ArcGIS Pro deployments and the development of apps that support asset management and other high-priority workflows.

Anika-Aduesa I. Smart, ITS GIS program manager, leads the adoption strategy. As project plans were communicated to GIS teams, Smart detected apprehension. This is a common reaction when familiar technology and entrenched workflows are changed. Smart's goal was to devise an effective adoption strategy that would support both a successful phase 1 implementation and a healthy enterprise GIS ecosystem for the future.

"This was about building a community to deliver a cohesive business solution for everyone," she said. Because change management was included in the location strategy implementation plan, Smart had tools at her disposal to win sustained support for a new approach to GIS.

↑ Anika-Aduesa I. Smart
LA Metro ITS GIS Program Manager

A Turning Point

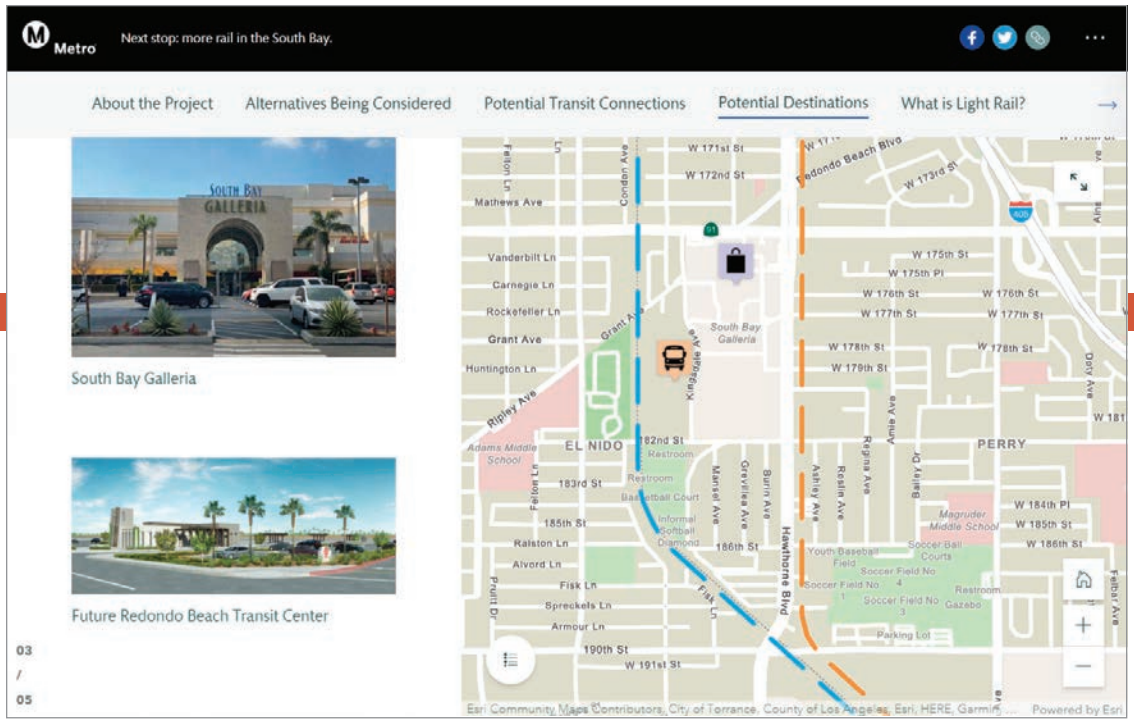
In fall 2020, Smart worked with Esri change management consultant Michael Green to deliver a customized, one-day virtual workshop called Preparing for Change. Workshop participants included GIS managers and professionals, project managers, and senior leadership from multiple LA Metro departments.

Smart understood that engaging these stakeholders would lead to a quicker pace of adoption after the phase 1 launch. In the longer term, this approach would promote wider adoption of GIS apps and technology.

"It was important for us all to be on the same page," said Smart. One goal was gaining consistent sponsorship for the implementation through increasing participants' awareness of GIS capabilities and business benefits. After establishing a common vision, participants encourage their employees to "think geospatial."

During the workshop, each participant was asked, "If every member of your organization would fully embrace and unleash the power of your geospatial strategy, what would the outcome look like for your business?"

This question sparked brainstorming around new GIS apps that could benefit each department. Participants spent the afternoon exploring change management activities, including stakeholder analysis, communication techniques, and resistance management.



← LA Metro's marketing department produced an ArcGIS StoryMaps story to communicate destinations that could be accessed by new transit service currently in the planning stages.

GIS for Everyone

Phase 1 of the location strategy implementation was completed at the end of 2020. The modern enterprise GIS infrastructure is now in place. Eleven departments are actively engaging with new ArcGIS apps.

Smart is committed to expanding adoption throughout LA Metro. She is marketing the value of GIS to departments that did not participate in phase 1. She's adopted the slogan GIS for Everyone and focuses on sharing the message that technology can enhance their work and improve decision-making.

Through outreach activities like "lunch and learns," Smart is broadcasting GIS team successes and building a network of GIS champions. These are classic change management strategies for maintaining momentum for change and reinforcing it so that new practices become embedded in the organization.

The hard work is paying off.

"People are more excited about GIS. It's literally catching on like wildfire," she said. Smart is working with the community relations department to integrate its data into the enterprise GIS. She is also working with the marketing department on a collaboration platform based on ArcGIS Hub. In addition to enabling easy access to information products that support marketing projects, the hub site will be a central location for LA Metro's various GIS teams to share their work and collaborate. Sharing and collaboration between teams did not happen prior to the location strategy implementation.

The Road Ahead

For phase 2, Smart wants to ensure that executive sponsors remain actively engaged. In a large, busy organization, maintaining executive attention throughout a complex technology project is challenging.

The location strategy implementation plan includes a change management retainer package that Smart will use to test-drive ideas with Green. He acts as a sounding board and adviser on how to best utilize change management techniques when challenges arise.

"In some ways, we're building the airplane while flying it," Smart said. "Change management is a solid framework, but it also gives us flexibility to innovate and address unique situations in our GIS environment. It's exactly in tune with what a successful GIS ecosystem should be: flexible and innovative." The communication framework has helped Smart gain valuable insight into executive engagement, assess how well the implementation is being received, and adjust her efforts as needed.

This approach has been successful. Bryan Sastokas, LA Metro's chief information technology officer (CITO), remains an active sponsor of the initiative and encourages department leaders to embrace geospatial capabilities.

Leading change management efforts to support LA Metro's location strategy has been a rewarding experience for Smart professionally. Her work has directly led to faster adoption of the technology and an increase in the number of GIS users. One of the most valuable outcomes of applying change management is that departments that once viewed ITS as trying to dictate technology use now view Smart's team as a valued partner for improving efficiencies and innovating with GIS.

The implementation focus has shifted to data governance, and Smart is optimistic that change management techniques will continue to serve her well as more LA Metro departments embrace a location strategy.

To learn more about the Esri course, Preparing for Change, visit https://bit.ly/2Oijx1E. For more information on LA Metro's initiative, contact Smart at SmartA@metro.net.

Digitally Transforming Field Data Capture to Save Sea Turtles

By Nick Duggan

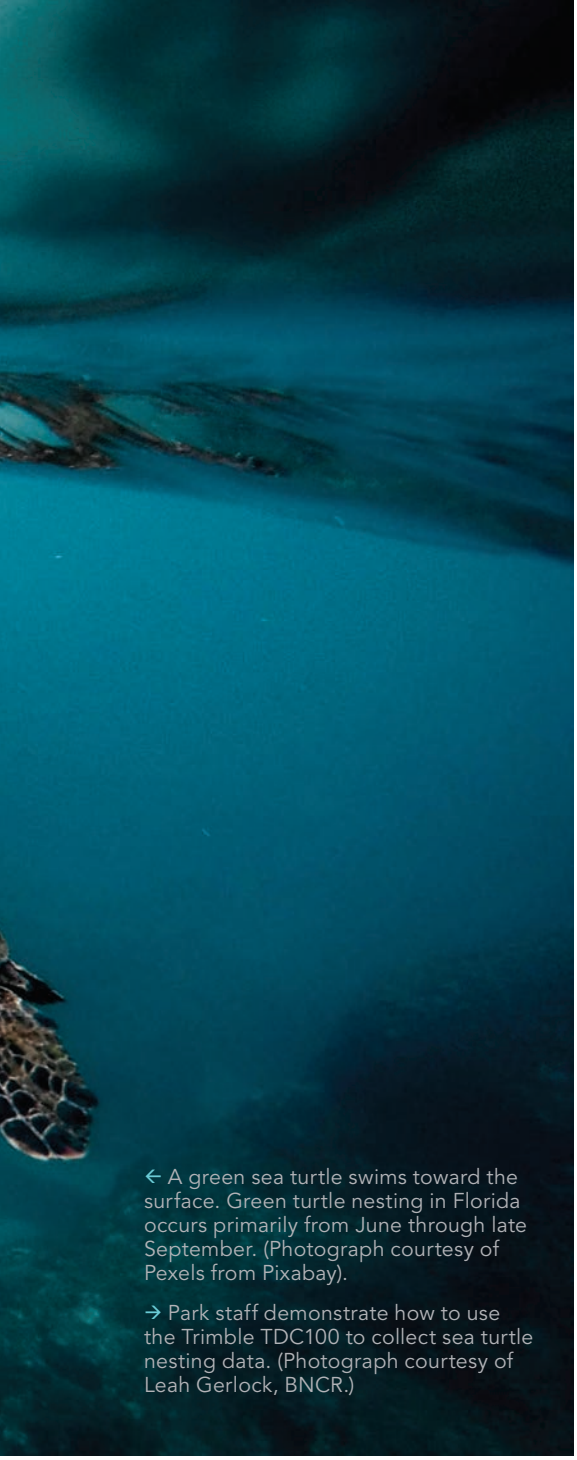
All five species found on Florida beaches—loggerhead, green, leatherback, hawksbill, and Kemp's ridley—are listed as either threatened or endangered under the Endangered Species Act.

For the past 40 years, between March and October, early risers along Florida's coastline may see groups of people walking the beach, heads down, and focused on the sand. They occasionally stop, kneel, point, and take notes. These people are data collection teams purposefully searching the beaches to find and identify evidence of sea turtle activity.

Over the past five decades, human activity has caused sea turtles to become endangered. For example, the population of Kemp's ridley turtles, the smallest and most endangered sea turtle species, has dropped from an estimated 42,000 in 1947 to about 700 in 1985. The numbers began to rebound in the 1980s. In 2003, the population of Kemp's ridley turtles was estimated at about 8,200 adult females, that foraged predominantly in the northern Gulf of Mexico.

In addition to negative impacts of commercial fishing and plastic waste, climate change has also become a significant threat to sea turtles as extreme weather events increase and the warming sand affects their eggs. To ensure these beautiful creatures don't become extinct soon, the Florida Fish and Wildlife Conservation Commission (FWC) regularly takes an inventory of species' numbers and nesting locations.

This important work has been carried out since 1979, when the FWC started the Statewide Nesting Beach Survey (SNBS) program to document the total distribution, seasonality, and abundance of sea



← A green sea turtle swims toward the surface. Green turtle nesting in Florida occurs primarily from June through late September. (Photograph courtesy of Pexels from Pixabay).

→ Park staff demonstrate how to use the Trimble TDC100 to collect sea turtle nesting data. (Photograph courtesy of Leah Gerlock, BNCR.)

turtle nesting in Florida. Another program, the Index Nesting Beach Survey (INBS), was added in 1989 to survey a subset of SNBS beaches. Designed to measure seasonal nesting, the INBS collects additional data such as nest inventories on 27 beaches statewide to help monitor the success of nests (or clutches) at each beach.

As a critical nesting ground for sea turtles. Florida hosts nearly 90 percent of the endangered Loggerhead species. Survey teams focus on five different species—loggerhead, green, leatherback, Kemp's ridley, and hawksbill—and record their activities. Until now, however, collecting this data has been a manual exercise using pen and paper and manually inputting data into spreadsheets.

"With this time-intensive process, it could take several months to tabulate all the data and produce essential reports that allow managers to identify widespread trends or problems," said Andrew Williams, a GIS technician in the Florida Department of Environmental Protection (FDEP) Bureau of Natural and Cultural Resources (BNCR) division, which compiles the collected sea turtle information from the Florida State Parks beaches and provides it to the FWC. "We also didn't consistently receive all the data acquired from the parks, and sometimes certain data was missing to complete a report."

That all changed in 2020 when the SNBS went digital statewide. Instead of the clipboards, pens, and paper, teams used Trimble handheld GNSS survey devices and ArcGIS Survey123 software to record sea turtle data. The change has not only given managers the opportunity to visualize and analyze activity in near real time, it led to an award made to the FDEP (and BNCR) with a Florida TaxWatch Productivity Award, a distinction that highlights efficiency gains in work.

The Case for Digital

The digital transformation began in 2017 with Williams and his colleague, Leah Gerlock, a natural resource specialist with BNCR and the statewide coordinator of sea turtle nesting data collection for the Florida Park Service (FPS). Having GIS backgrounds, they both knew they could make the data collection and dissemination process more streamlined and efficient with mobile devices and Survey123 field data capture software.

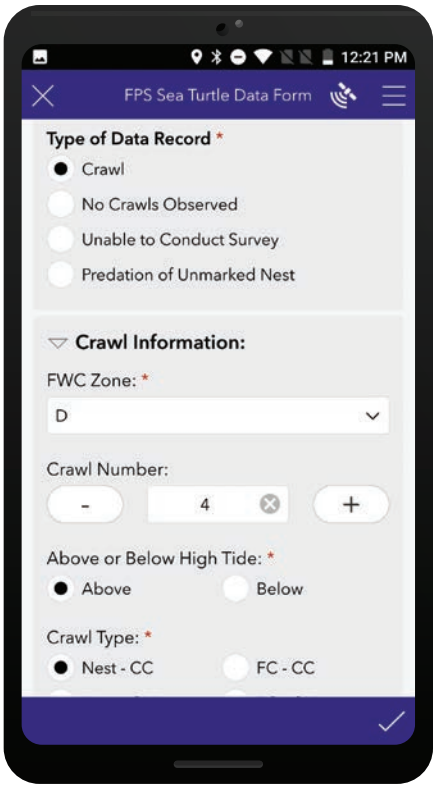
"With a GIS-based data collection app, we could capture data digitally as well as visually and display the information through the ArcGIS Online database, enabling specialists and managers to identify risks or issues in near real time," said Gerlock. "We couldn't provide that dynamic and timely data environment with paper and pen."

Equally important in acquiring GIS-ready field data was enhancing that data with consistent and accurate GNSS positions. Location data wasn't always captured in the past.

To cover the roughly 825 miles of beaches and 40 different state parks involved in the SNBS, BNCR would need from 50 to 60 mobile devices for data capture. The units would need to be rugged enough to cope with the weather, salt water, and a rocky and sandy environment, and still be powerful enough to run the Esri software efficiently and provide submeter GNSS

→ Field data was enhanced with consistent and accurate GNSS positions.

→→ Survey teams documented details with drop-down menus in the Survey123 application, which is more accurate and saves time.



accuracy. In addition, the devices needed to allow users to capture data offline to cope with mobile connectivity issues.

After testing and narrowing down several handheld devices and tablets, BNCR launched a test in 2018 using a Trimble TDC100 handheld GNSS data collector. Working in conjunction with the FWC, BNCR initially targeted only five parks. However, the parks' response was so enthusiastic, BNCR expanded the digital trial to 12 parks. Confident that the new digital survey app would provide the efficiency and precision expected, Williams and Gerlock trained a significant roster of individual park coordinators, staff, and volunteers on the Trimble-Esri system for the 2019 sea turtle nesting surveys.

Proving the Concept

FDEP's goal in 2019 was to survey as many state park beaches as possible using ArcGIS Survey123 and TDC100 devices. This included all 15 FPS index beaches. *[Index beaches are a smaller group of beaches within the larger group of beaches and more detailed data is gathered for these beaches.]* In total, FWC had about 200 people involved in the new digital surveys.

Once field teams determined their areas of interest, they used the built-in GNSS receiver in the TDC100 to establish a highly accurate location to ensure that the data collected met the required precision. Walking or driving all-terrain vehicles (ATVs) along the beach, surveyors searched the sand for signs of turtle activity, such as tracks known as crawl marks, left in the sand or nest predation. When activity was found, the location was recorded with 1-meter accuracy, and the details were documented using drop-down menus using ArcGIS Survey123. If surveyors observed no activity or were unable to conduct the survey due to extreme weather events, they also recorded that in the application.

The ease and intelligence of the customized Survey123 form greatly assisted data capture. Surveyors could confirm their location using an offline basemap included in the survey, and then choose the relevant data—crawl, false crawl, predation—to record. Based on the type of activity captured, Survey123 prompted users to provide additional detail, ensuring comprehensive attribute data. Preprepared customization of forms enabled teams to capture information more quickly ensure data collection was consistent in quality and content.

As data was collected offline, the program's park coordinator reviewed each

↓ A loggerhead hatchling. Loggerheads are the most common sea turtle found in Florida. Typically nesting from April to September, females return to their nesting beach every two years laying about 114 eggs in four different nests. (Photograph courtesy of Mike Brice from Pixabay.)

→ Loggerhead sea turtle tracks. (Photograph courtesy of FDEP State Park staff).

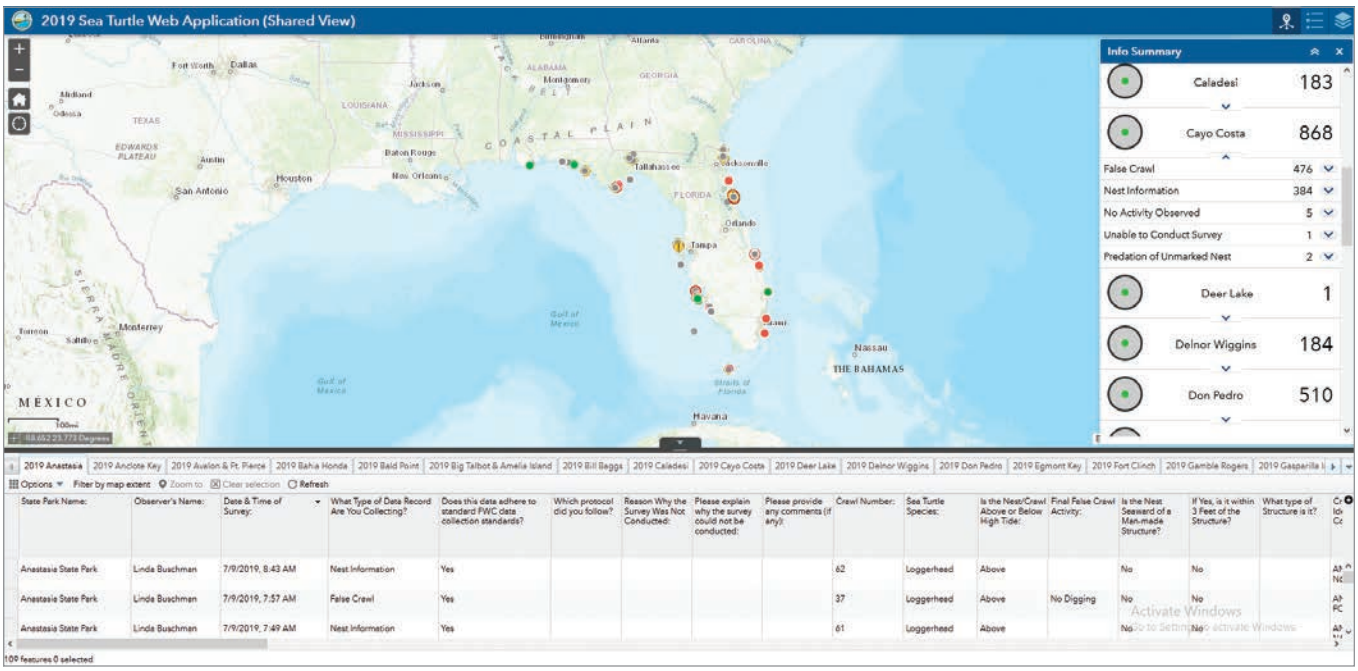
↓ When park coordinators submit new data, ArcGIS Online is immediately updated as well as the web map for that specific park.

day's data capture for quality control and then submitted the information to the database on ArcGIS Online for instant sharing and spatial viewing.

"We developed a standardized data collection form that met the needs of every state park," said Williams. "That allowed staff and volunteers to use the same simple, yet comprehensive interface and capture accurate and reliable sea turtle activity in just a few menu clicks. Paired with the Trimble TDCs, we're saving thousands of hours, and the data is more accurate."

Based on its success in 2019, BNCR expanded the Trimble-Esri system statewide for the 2020 season, equipping all 40 parks with the means and knowledge to capture data digitally. For the highest-density parks, it acquired nine Trimble TDC600 handheld devices to manage the vast data volumes.

For the 2020 surveys, several hundred people surveyed 219 beaches, covering approximately 839 miles of Florida's coastline. For the state park beaches, teams digitally collected 6,887 nests for all five species combined.



In the Know

In addition to the efficiency and accuracy gains provided by the mobile survey app, the dynamic accessibility and data analysis provided by ArcGIS Online significantly contributed BNCR's success. BNCR used ArcGIS Web AppBuilder to develop 40 customized, individual web maps for each of the 40 FPS parks. When park coordinators submit new data, ArcGIS Online is immediately updated as well as the web map for that specific park. This makes any new information available as soon as it's received or edited.

Using other customized web applications and widgets, park coordinators and managers can quickly analyze data and offer specialized information, such as how many loggerhead nests have been reported to date or if a particular rare species has been spotted. Data editing is much quicker and easier, and any data can be exported to create reports. It's a level of data sharing and visualization FOS has never had before.

The same is true for the BNCR and the FWC. With support from Aaron Koelker, a GIS systems project analyst with FDEP, Williams and his colleagues can use customized Python scripts to quickly compile and convert data into the various formats needed for each park's monthly report to the FWC. This customization saves substantial time. For the FWC, the responsiveness and completeness of the new data collection system has provided entirely new insight to help protect and support endangered sea turtles.

"With our new survey app, once the records are synchronized with the database, it is possible to see the most recent nests around the state and know when and where nesting is occurring," said Gerlock. "We can also identify when there has been an event involving a rare species in one of our state parks, or where there may be issues with predation. This has allowed FWC to stay more informed and provide assistance faster than ever before."

About the Author

Nicholas Duggan is a fellow of the Royal Geographical Society and a Chartered Geographer specializing in GIS, a writer, and an experienced user of Esri software. He has created solutions for national mapping agencies, renewable (offshore and onshore) and nuclear, property technology, 3D, and 4D, With more than 20 years in the geospatial industry, Duggan has a passion for innovation and exploring new technologies.

↓ The Florida sun rises on a beach that will be surveyed for signs of sea turtle activity, nesting activity.

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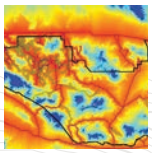

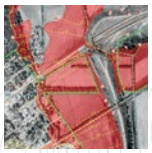

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