Spring 2023

ArcUser

The Magazine for Esri Software Users

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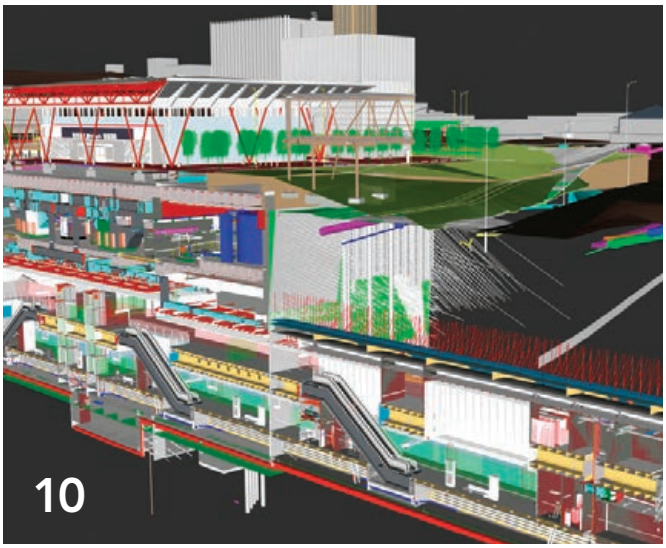
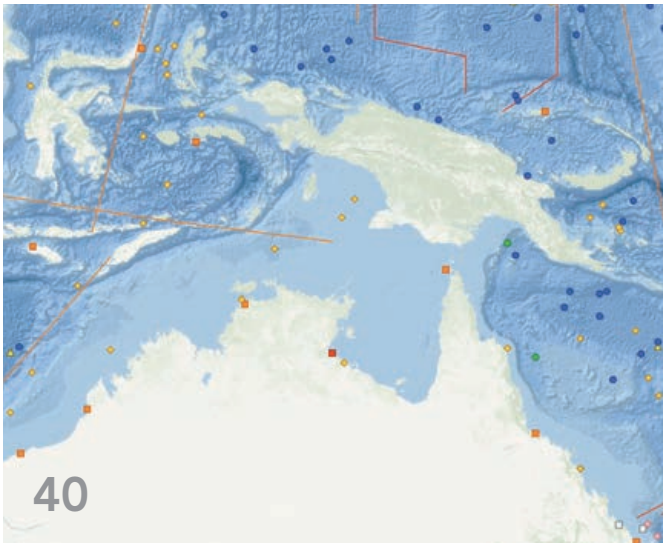


Focus



Special Section

End Notes

On the Cover

The Spilhaus World Ocean Map in a Square shows the Earth's ocean as a single, uninterrupted body of water. This projection is supported in ArcGIS. Learn more about it from this ArcGIS StoryMaps story: https://bit.ly/41lcJAL.

Seeing One World

The map on the cover of this issue shows the Spilhaus World Ocean Map in a Square, a world projection that emphasizes the extent to which the ocean dominates the globe, covering more than 70 percent of its surface. This map also lets us see the ocean as it truly is—one continuous body of water that wraps around all Earth's landforms.

Not only does the ocean dominate the Earth physically, but it is also a bulwark against climate and essential to the water cycle. In addition, the ocean helps feed the world and transport most of its goods. In short, the ocean is critical to the Earth's fate.

In addition to visualization, GIS provides many ways to see the ocean in more depth. GIS is helping fulfill the goal of the United Nations Decade of Ocean Science for Sustainable Development (Ocean Decade) by moving from the ocean we have to the ocean we need for the future we want.

Esri is participating in several Ocean Decade programs that are developing science to better understand and preserve the ocean. In addition to its role in a project to map the entire seafloor, Esri, along with 40 global partners, is involved in Digital Twins of the Ocean (DITTO), a program to create digital twins of the ocean that will not only increase understanding of current conditions but model future states and measure the potential effectiveness of mitigation efforts using specialized tools and artificial intelligence (AI) capabilities. DITTO is working to make ocean data available to all nations to better inform decisions.

Digital twins—initially employed to optimize manufacturing processes and the management of utilities, airports, and even cities—are increasingly being used to understand and sustainably manage portions of the natural world. With its 3D visualization and data integration capabilities, GIS is foundational to the creation of digital twins.

More broadly, GIS is the technology for applying the geographic approach, marshalling and analyzing data, producing and disseminating information, and gaining a more holistic understanding of the ocean. We need to see that the ocean's problems are the Earth's problems—it's all one interconnected, interdependent world.

Monica Pratt
ArcUser Editor

ArcUser

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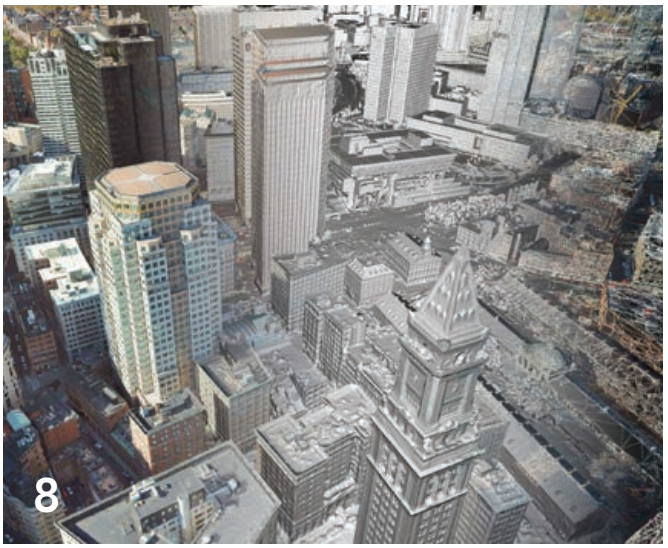
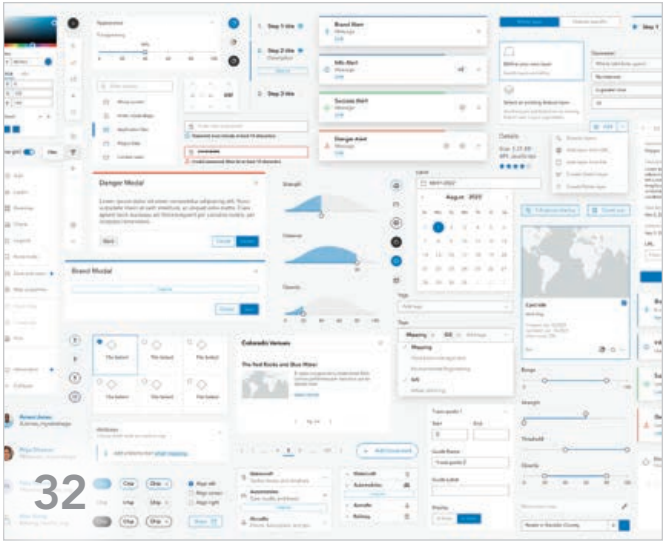
Departments





Briefly Noted

→ New Web App for Detecting Changes in Land

Sentinel-2 Land Cover Explorer (https://bit.ly/3lOqj7U), a web app available from ArcGIS Living Atlas of the World, delivers timely land-use/land-cover data using change analysis tools and data Sentinel-2 imagery.

The data captured in these observations enhances understanding of climate change and land use and improves emergency management response. Land use/land cover (LULC) maps are an increasingly important tool for decision-makers at local, regional, and national government levels around the world. These maps help inform policy and land management decisions around issues like sustainability, by contextualizing and quantifying the impacts of earth processes and human activity on the environment.

Built on ArcGIS API for JavaScript, Sentinel-2 Land Cover Explorer provides dynamic visual and statistical change by comparing annual slices of Sentinel-2 10 m land-use/land-cover data. Users can filter data by land-cover class and view statistical change by year, map extent, and class. They can select imagery renderings and download data for offline use.

Sentinel-2 archive data can also be accessed to visualize how the Earth's surface has changed over the last 14 months. The Time tool in the app, accessible at larger zoom scales, enables a temporal time slider and a temporal profile of different indexes for a selected point, such as NDVI (Normalized Difference Vegetation Index), NDMI (Normalized Difference Moisture Index), and Urban Index. With the Identify tool, users can access information on images and provide a spectral profile for a selected point.

The data is the result of a collaboration between Esri, Impact Observatory, and Microsoft. The data used by the app is supplied by Sentinel-2, a mission of the European Space Agency's Copernicus Programme. It consists of two polar-orbiting satellites that carry optical instruments that systematically acquire optical imagery at high spatial resolution over land and coastal waters. New Sentinel-2 images are added daily.

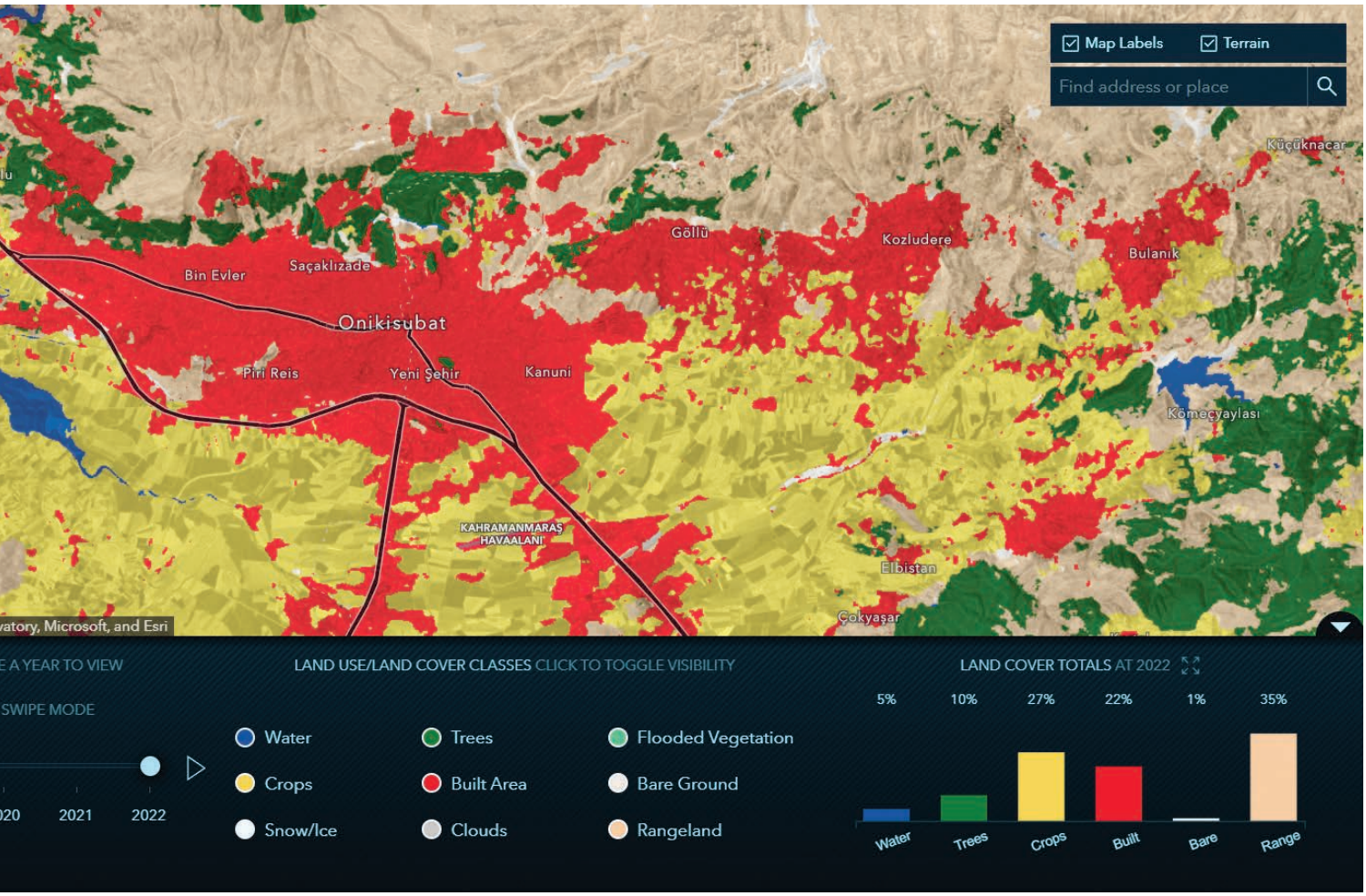
↓ Sentinel-2 Land Cover Explorer, a web app available from the ArcGIS Living Atlas of the World, delivers timely land-use/land-cover data using change analysis tools and Sentinel-2 imagery.

→ Agreement Makes NASA Data More Widely Available

Esri signed a Space Act Agreement with the National Aeronautics and Space Administration (NASA) to give the broader GIS community greater access to NASA's geospatial content. New datasets from nearly 100 spaceborne sensors that measure atmospheric health, land-based phenomena, and characteristics of the oceans are getting added to ArcGIS Living Atlas of the World. The agreement makes NASA data increasingly available to more than 10 million GIS users in ArcGIS and Open Geospatial Consortium, Inc. (OGC)-based formats.

→ Esri Joins Effort to Share Interoperable Open Map Data

To help build interoperable open map data, Esri joined the Overture Maps Foundation, a collaboration founded by Amazon Web Services (AWS), Meta, Microsoft, and TomTom that aims to give geospatial developers and professionals access to reliable map data under an open data license. Esri will help curate data from its well-established Community Maps Program that contributors have chosen to share as open data and will make Overture data available through its ArcGIS software and other services.



A Foundation for Digital Twins: ArcGIS Reality

Digital twins have become an increasingly critical tool for many industries. ArcGIS Reality, a new suite of photogrammetry software products released by Esri, helps create the foundation for digital twins on scales ranging from local to global.

More than just a visualization, a digital twin is a virtual representation of an object, process, or system that bridges the gap between the physical and digital worlds. By providing high-resolution maps and 3D models of construction sites, complex cityscapes, or entire countries layered with geospatial information give organizations a better understanding of the world.

A digital twin can accelerate innovation, build consensus, and save time and money by iteratively modeling changes. By testing system components or the function of an entire system, digital twins provide a better understanding of processes and the impacts of proposed changes. By creating a feedback loop between design and production, a digital twin saves time and money. In addition, troubleshooting malfunctions can be done inexpensively in a virtual world.

This need to capture reality as the foundation for digital twins is expanding the aerial imaging market, which is expected to grow from $1.4 billion in 2017 to more than $4 billion by 2025. The ArcGIS Reality suite of photogrammetry software products helps create digital twins through reality capture workflows that generate a digital representation of the world at any scale and extent. These products can turn drone and aerial imagery into visually stunning and highly accurate maps and 3D models. The ArcGIS Reality suite includes ArcGIS Reality Studio, ArcGIS Reality for ArcGIS Pro, Site Scan for ArcGIS, and ArcGIS Drone2Map.

ArcGIS Reality Studio

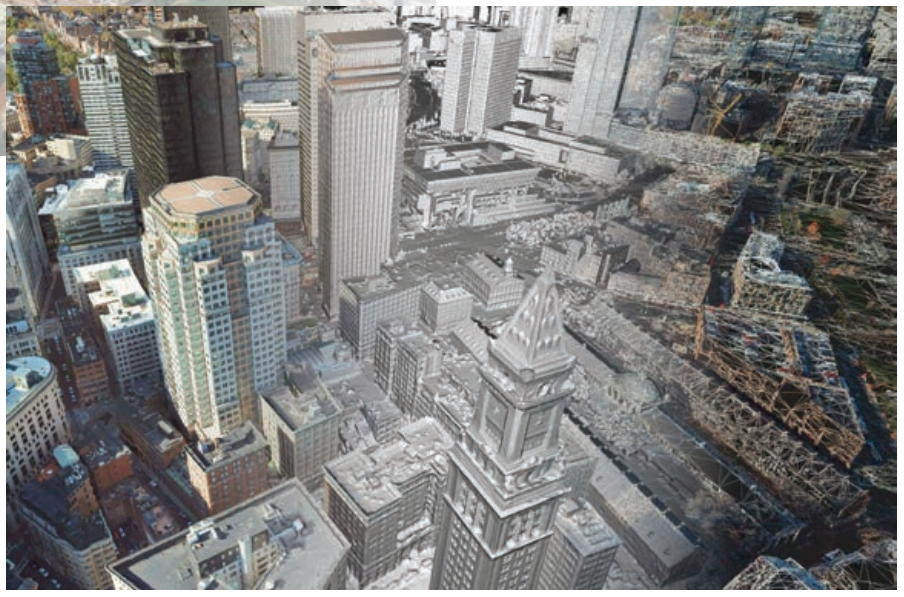
ArcGIS Reality Studio, a new standalone advanced photogrammetry application optimized for precision, speed, and simplicity, can be used to create the foundation of 3D digital twins. Align large collections of images captured by multicamera sensors across multiple flights to create highly accurate true orthos, 3D meshes, and point clouds. An intuitive mapcentric 3D interface provides automated processing workflows for the efficient creation of survey-grade products. Easily collaborate and share data within GIS technology and mapping systems for photo-realistic visualization and analysis.

↑ Imagery data provided by ©Vermessung AVT-ZT-GmbH

↗→ Images generated from 3D meshes processed by ArcGIS Reality using imagery data provided by ©Bluesky Ltd.

This solution is optimized for precision, speed, and simplicity. By processing large or multiple-day captures in a single project, it accelerates data processing. Automated workflows can create true ortho and 3D meshes for entire cities and countries without requiring manual post-processing edits. It provides a best-in-class aerial triangulation and processing engine that produces accurate, photorealistic, and performant true ortho and 3D meshes.

ArcGIS Reality Studio workflows automatically determine optimal parameters at each processing step to reduce the learning curve. Images are easily located in the context of a map. Outputs can be immediately used in ArcGIS or third-party mapping systems so that data won't require reformatting for use by customers.



ArcGIS Reality for ArcGIS Pro

This new extension for ArcGIS Pro lets users input images from drones or crewed aircraft to generate 3D outputs for reality mapping. It provides reality mapping tools that allow GIS professionals to create the foundation for digital twins and provide data for analysis in ArcGIS.

With this extension, ArcGIS Pro can generate photo-realistic true orthophotos, point clouds, and 3D meshes from drone and aerial imagery in-house. Processing and outputs are seamlessly integrated with ArcGIS, so they're immediately ready for analysis, visualization, and incorporation into workflows such as automated object detection and feature extraction.

Because ArcGIS Reality for ArcGIS Pro is camera agnostic, it supports a wide range of drone and aerial sensors and eliminates the need for separate solutions for drone and aerial imagery. Both types can be processed in one project.

Site Scan for ArcGIS

Now part of the ArcGIS REality family, Esri's cloud-based end-to-end reality mapping software for drone imagery is designed to simplify drone program management, imagery data collection, processing, and analysis. It maintains a complete picture of drone inventory and flight history with automatic fleet management. Drone data can be directly published to ArcGIS, so it is available for drone analytics such as object detection and the application of artificial intelligence (AI).

ArcGIS Drone2Map

This intuitive desktop application processes and analyzes drone images without the need for an internet connection. The accurate 2D and 3D representations of the real world generated can be easily shared using ArcGIS. Site Scan for ArcGIS uses the same processing technology as the rest of the ArcGIS Reality family.

Together, the products in the ArcGIS Reality suite enable interaction with a digital world layered with geospatial data that provides greater context for decisions. To learn more about Esri's ArcGIS Reality, visit go.esri.com/About_ArcGIS_Reality.

A Digital Twin Guides Underground Rail Expansion

By Terry Bills and Ian Koeppel

In Brisbane, the most rapidly growing city in Australia, a digital twin and a virtual reality program guide the design and construction of an underground railway.

The team tasked with designing the first underground railway under the heart of Australia's fastest-growing city knew it would be a delicate task, fraught with infrastructural peril. The project's scheduled completion was less than two years away. It required tunneling several stories under Brisbane's teeming metropolis and constructing expansive subterranean stations. What could go wrong?

At the outset, no one knew that the effort would involve an ingenious application of GIS, the creation of a detailed and up-to-date 3D model of the underground project and the city above it, and an immersive digital twin to bring the project to life.

A Rapidly Growing Queensland

The Queensland government conceived the Cross River Rail project as a way to alleviate population pressure. By 2036, the South East Queensland metro area is projected to add another 1.5 million residents (a number that by itself would make it Australia's fifth-largest city), pushing the region's total population to nearly 5 million.

The Cross River Rail project will deliver a new 10.2 kilometer (km) line through Brisbane's inner city, featuring twin 5.9 km tunnels running under the Brisbane River and the central business district (CBD). Four new underground stations will be built as part of the AU$5.4 billion project, in addition to the upgrade of eight existing stations.

Most of the new metro residents will live outside of Brisbane but within commuting distance. Many of the new jobs, however, will be in the Brisbane CBD, on the north bank of the Brisbane River.

Current rail infrastructure is insufficient to handle the increase in CBD-bound train traffic that will be necessary to handle these commuters. Cross River Rail will add twin tunnels under the river and four additional underground stations to handle this demand.

A Bigger, Better Model

The Cross River Rail Delivery Authority, the Queensland government agency overseeing the project, sought advice from colleagues on the other side of the world soon after the project was announced. Crossrail, a construction project in London that launched in 2009, has similar aims. The project is creating new tunnels and

10 new underground stations throughout Central London.

Crossrail involves construction beneath a metro area even denser than Brisbane's, with extremely narrow margins to avoid damaging existing underground infrastructure.

By the time Cross River's plans were beginning, Crossrail had been under construction for almost seven years. The Cross River team contacted its British counterparts and asked what, if anything, they would do differently if they could start over.

"They basically said, 'We would have built a bigger, better 3D digital model sooner,'" Vine said. Crossrail then offered three steps for building the perfect GIS-driven digital twin:

1. Create a common data environment.
2. Stipulate that all contractors use the same standards in their 3D architectural models so that they can all be combined into a single model for the project.
3. Make the model immersive.

An Expansive Mission

For starters, Crossrail recommended that Cross River create a common data environment for all work. Any project-related dataset, no matter what the format should be in a central repository. That included GIS, building information modeling (BIM), volumetric data, and photogrammetry (a three-dimensional coordinate measuring technique that uses photographs).

In recent years, GIS technology has become adept at integrating BIM models and other project-related data formats into a GIS environment. BIM models are 3D architectural models that describe and depict the things being built or dug, while GIS adds contextual awareness for those things. Rather than considering BIM models as just inert objects floating in space, the people involved in a project can visualize what's around them. In GIS they can see how each structure fits into the infrastructure aboveground (such as paths, roads, and light poles), underground (the pipes and lines that connect utility services) and the natural world (landscaping, groundwater, and even wildlife and biodiversity considerations).

The advice also helped Cross River handle a broad mandate. When Queensland's government created the Cross River Rail Delivery Authority, it required the agency to be responsible not just for the railway itself, but also for planning and assessing the project's economic impact.

Cross River Rail will add twin tunnels under the river and four additional underground stations to handle this demand.

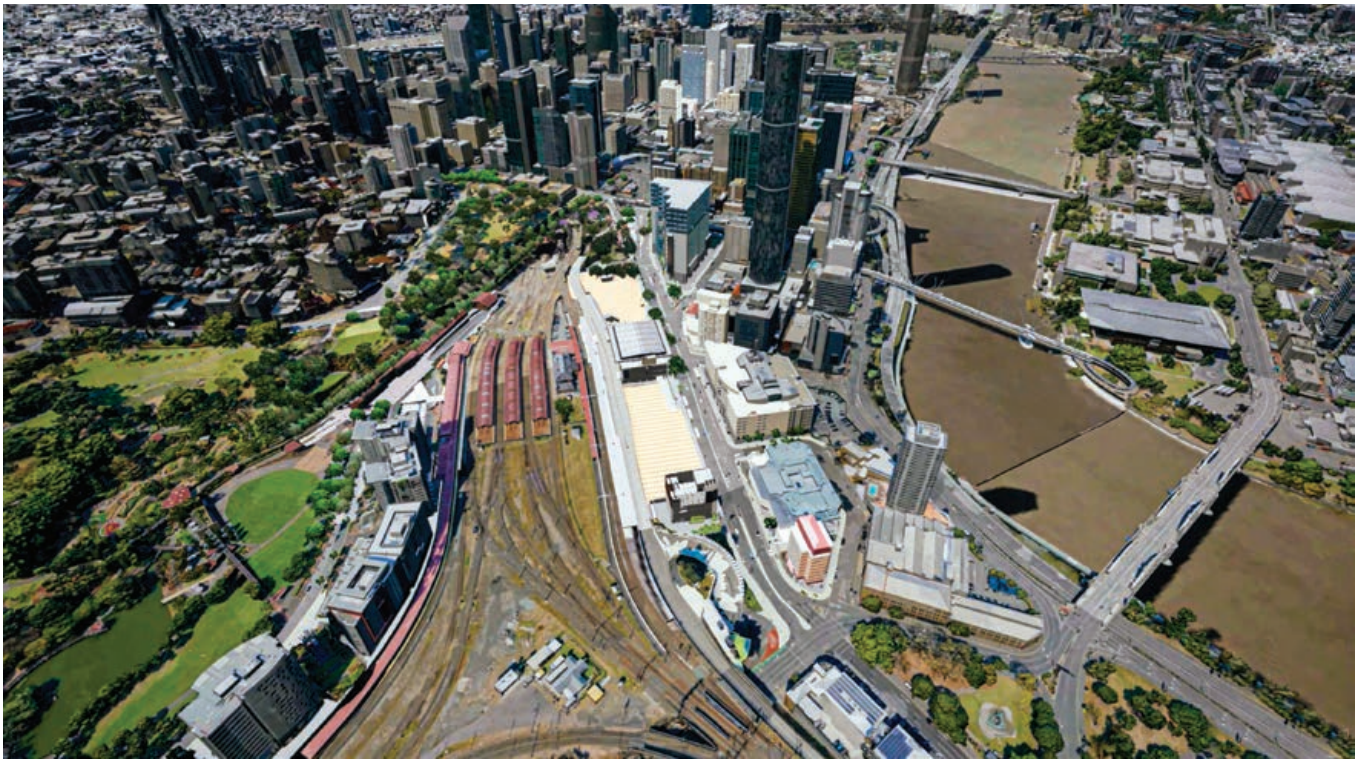
There was a good reason to include this mandate in the agency's charter. Although Cross River anticipates future developments in the region, its location means Cross River will also influence those developments.

"Cross River Rail is going right under the CBD, so the area around the stations is already prime land where the city will grow next," Vine said.

Everything in Federation

Crossrail's second piece of advice to Cross River related to BIM data coming from the project's many contractors and

↓ Brisbane, the most rapidly growing city in Australia, is using a digital twin and a virtual reality program to guide the design and construction of an underground railway.



↑ Workers enter the Roma Street cavern to conduct an inspection.

subcontractors. Crossrail staff urged Cross River to create a "federated" BIM model. That meant combining the disparate BIM information into a single BIM file that depicts everything. For that to happen, Cross River needed to ensure that every contracting entity was using exactly the same data formats, standards, and protocols.

"What the Crossrail team didn't realize until it was too late is that all their contractors were telling Crossrail how they were going to submit their BIM models—it was baked into the contracts," Vine said. Crossrail indulged their contractors and realized later that they should not have done that.

The Australian team used Unreal Engine so that anyone could be virtually transported inside the place they were set to build.

Rail Games

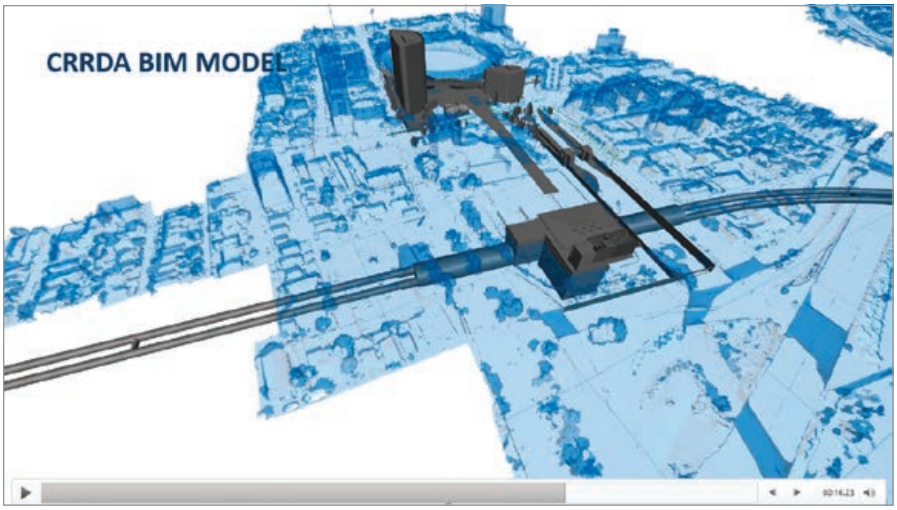
Crossrail's third recommendation is "the party piece, the one everybody loves," Vine said, because it's about making the model immersive. "They told us they should've put all their data into a game engine and turned it into virtual reality."

Putting BIM models into Unreal Engine, a 3D gaming tool, allows engineers and other stakeholders to experience each station before they build it. The Australian team used Unreal Engine so that anyone could be virtually transported inside the place they were set to build.

"So, we have a federated BIM model of all the stations and all the tunnels, and GIS land mapping in 3D," Vine said. "But then we put it all into Unreal, crank the magic gaming engine handle, and it gives us back a single virtual reality."

The result is 17 kilometers of immersive railway infrastructure that can be explored—like a first-person game—on a screen manipulating a web scene or with a virtual reality (VR) headset. The Cross River team even built a virtual reality theater using a five-way projection system, so many people can explore the project together.

The virtual reality component transcends mere flash, providing a way for nontechnical stakeholders—people not directly involved in the design and construction of Cross River—to view the project as it proceeds. It also gives those who are part of the design team the kind of visual assessments that even the most detailed 3D BIM model cannot provide. As one example, Vine points to the Roma Street station, where teams are experimenting with ways to install a massive art exhibition space on a concourse wall, trying and testing different ideas virtually before they finalize the design and build it.



↑ A federated BIM model for Cross River Rail brings together project-wide details for the whole project.

The Digital Twin Expands to Capture All of Brisbane

Cross River's commitment to the common data environment signaled a shift from the usual relationship between GIS and BIM on this kind of large infrastructure project. In the past, GIS would have provided crucial support by providing context for 3D architectural BIM renderings. Given the mandate to document economic development around the train stations, Cross River elevated the importance of GIS. To depict those aboveground areas, Cross River would require skillful 3D maps, including data gathered by lidar sensors to capture engineering-grade measurements.

That, in turn, led to another requirement. The aboveground data would also require context.

If the goal was to understand how the stations would affect economic development in the CBD, it didn't make sense to map just the area around them. A map of the entire CBD was required. Everything would need to be layered perfectly so that everything underground lined up exactly with everything aboveground.

The result is a 3D land layer that shows lots, utilities, and other pertinent visual information. Cross River's use of 3D even includes material designed in consultation with Brett Leavy, a self-described "cultural heritage digital Jedi," who uses advanced VR technology to re-create precolonial Brisbane. Leavy's input, Vine explained, has helped ensure that the project honors and remains respectful of indigenous peoples.

"We went from, it's all about building a railway, to ah, it's also about rebuilding the city," he said. "We ended up making a 3D model of Brisbane, because it was impossible to do one without doing the other."

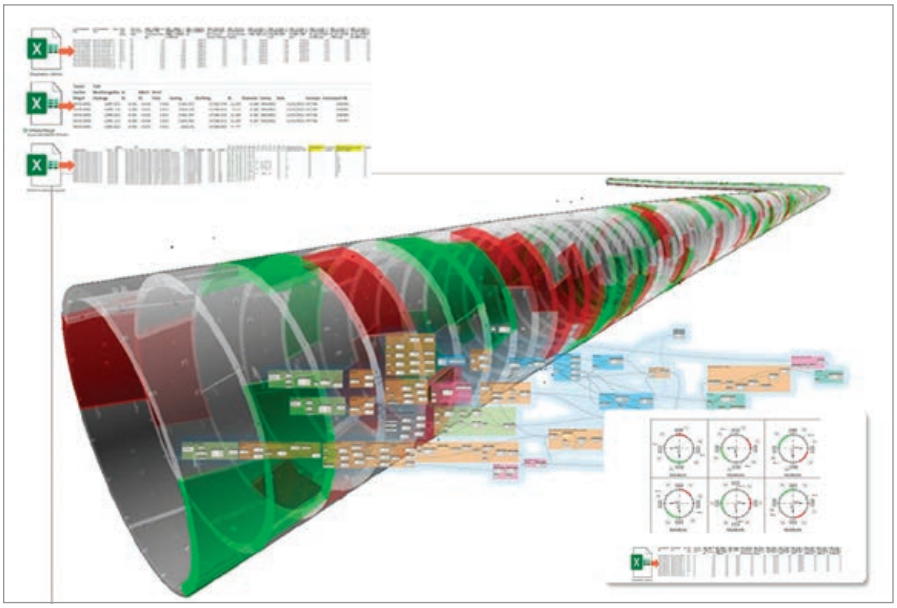
A Twin Without End

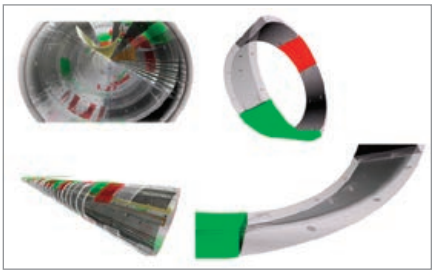
The Cross River digital twin is a continuous work in progress. As designs are finalized and construction proceeds, a staircase or tunnel that existed as a single item in a contractor's initial BIM submission becomes one with thousands of individual components in the federated BIM model.

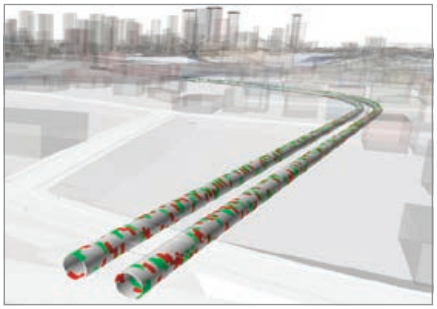
Beyond just the Cross River project, there's no reason the digital twin can't continue to grow in perpetuity, evolving with Brisbane itself. "We have a running joke about Cross River Rail, that the more you look at it, the bigger it gets," Vine said, noting that after the project began, the city was selected to host the 2032 Summer Olympic Games.

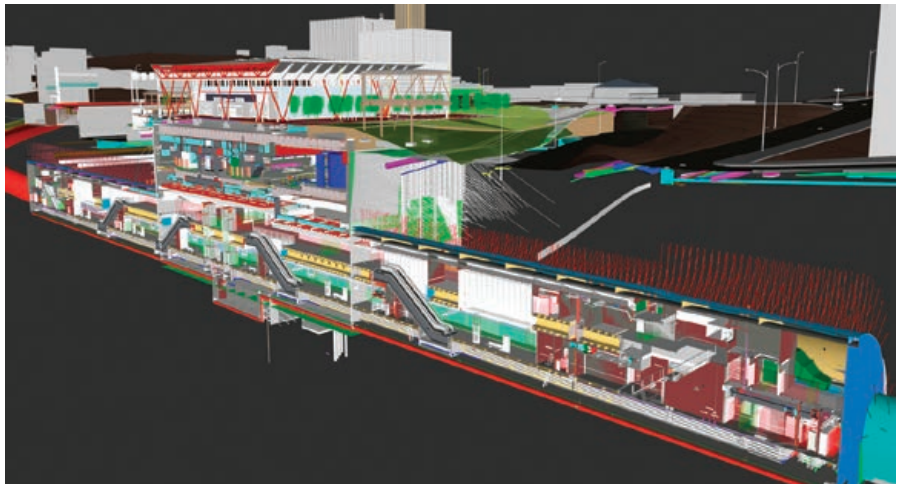
"We have an opportunity to take what we've done here as part of building a railway line and stretch it to include everything we're going to need to build for the

↓ For tunnel work, the components and sequencing of parts require close tracking.









↑ The Roma Street cavern shows the complexity of the two-tunnel subway line.

← This BIM model shows the level of detail required to guide construction.

Olympics," said Vine.

Vine foresees the twin being a tool for operating the system in addition to its value in design, construction, and project management. "We realized we've built a digital twin that will help run the railway," he said. "So, there's almost a whole second chapter waiting to be written."

About the Authors

Terry Bills, the global transportation industry director at Esri, is responsible for all transportation infrastructure segments worldwide. He has more than 25 years of experience in transportation, working on planning, policy development, information technology and GIS. He has been a principal planner for a large regional transportation planning agency, as well as the president of a GIS and transportation consulting firm. He earned two master's degrees from the University of California, Los Angeles, where he was also a doctoral candidate.

Ian Koeppel leads Esri international business development for transportation markets in Europe. He is a cultural geographer and resides in the Loire-Atlantique region of France. Before joining Esri in 1998, he was regional sales manager at Etak (now TomTom), managing consultant at Accenture, and director of management information systems at the City of New York Department of Parks & Recreation. Koeppel also coauthored a book, *Struggle for Space: The Greening of New York City, 1970–1984*.

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New Map Style Helps See the Future of Housing in Utah

The GIS team in the Utah office of Colliers International created a map style that more effectively communicates data on housing growth while saving the team map production time.

Colliers International provides expert real estate and investment advice to clients in 63 countries. Since 1998, Colliers Utah has provided investment sales, landlord and tenant representation, property management, and valuation services throughout the state. The Utah office operates in one of the fastest growing states. According to the US Census Bureau, Utah's population has increased by more than 46 percent in the last 20 years. Specifically, the Wasatch Front in northcentral Utah and St. George in the southwestern region are some of the fastest-growing areas in the US.

Developers in Utah face challenges because of the limited space for new construction. Because of these geographic constraints, gaining insight into when and where the next site development should go is crucial. Developers rely on real estate brokers to quickly provide data that is as accurate as possible to make future purchase decisions.

Support for Decisions

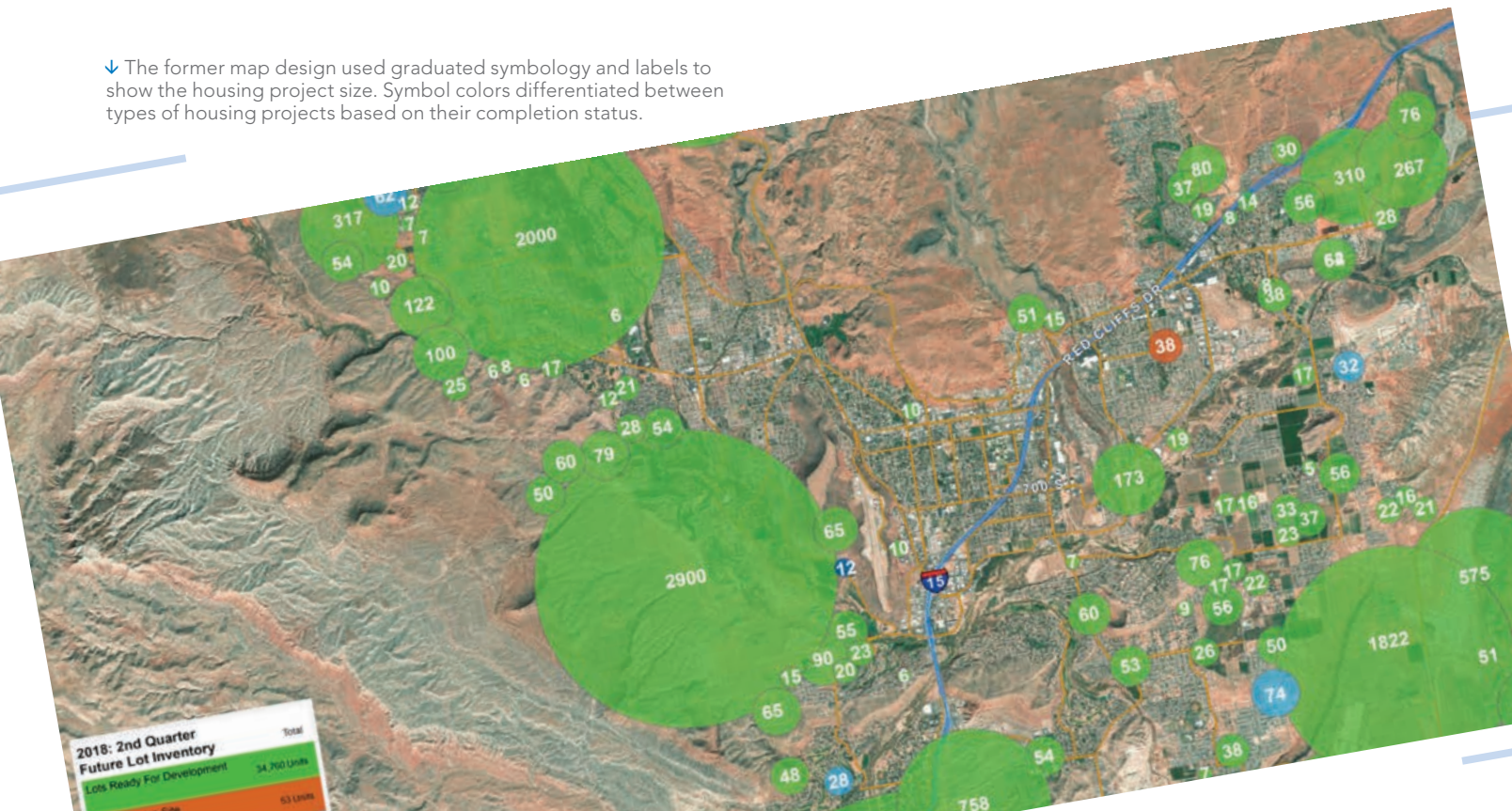
To help clients and brokers stay abreast of construction trends, the GIS team at Colliers Utah provides maps and datasets that have proved critical to the company in winning business over local competitors.

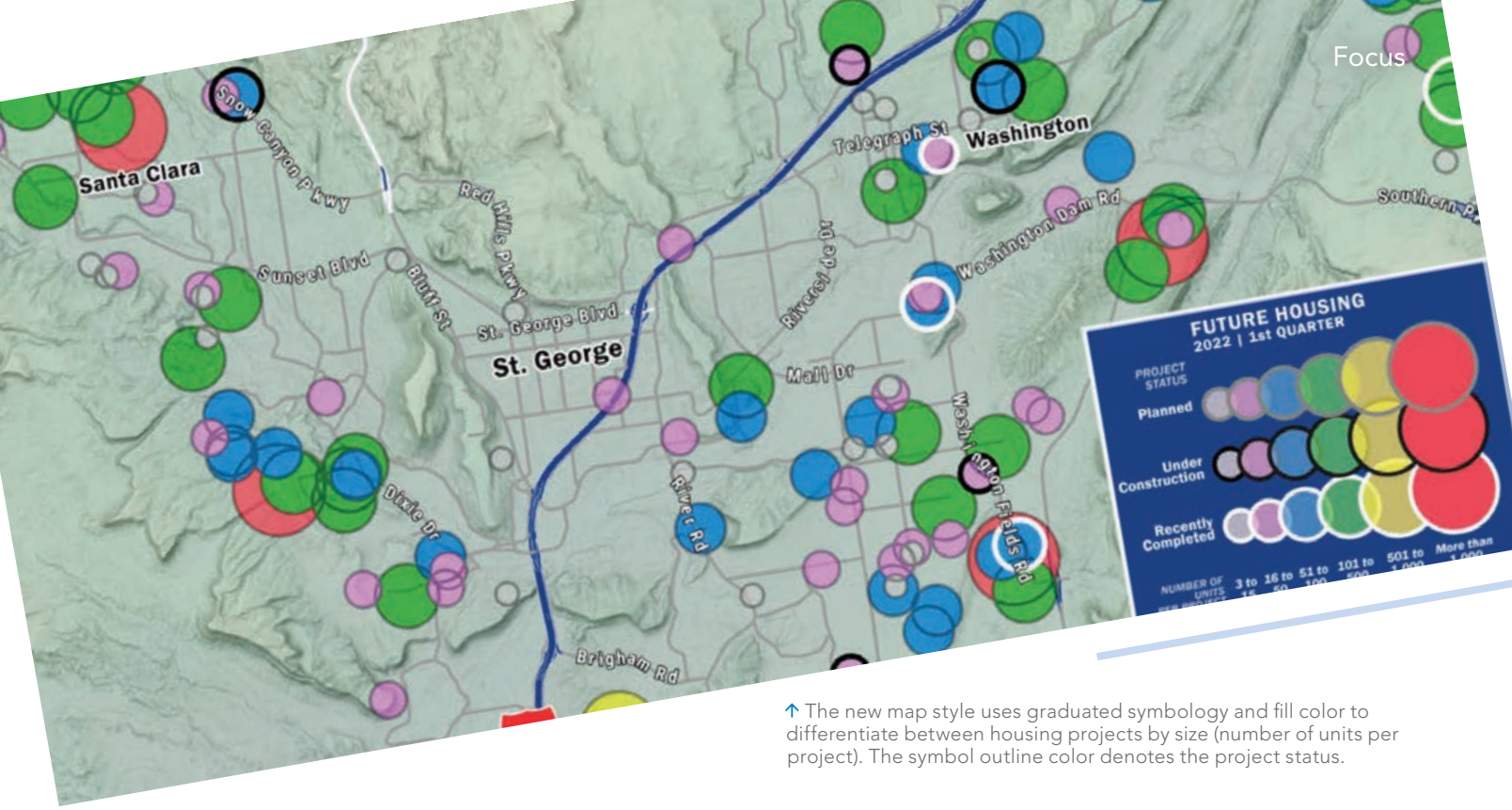
Kate Wright and Ernie Cottle, GIS analysts at Colliers Utah, see future housing projects as key economic indicators for growing commercial real estate markets. With this data, the GIS team provides valuable support to more than 200 commercial real estate brokers involved in marketing and investment decision-making.

The GIS team, managed by Tyler Crocker, wanted to improve map visuals to provide brokers with a product that was less complicated to use and easy for clients to understand. Colliers Utah real estate brokers use map visuals in client pitch meetings and marketing materials. Wright and Cottle saw an opportunity to fine-tune several map solutions to better showcase their GIS toolset to stakeholders.

"We need maps that are informative and present accurate data. But we also need them to be aesthetically pleasing, something that can be inserted into a flyer or incorporated into a pitch presentation and look attractive as a marketing piece," Wright said. "What has been great about using Esri products is that we can accurately

↓ The former map design used graduated symbology and labels to show the housing project size. Symbol colors differentiated between types of housing projects based on their completion status.





↑ The new map style uses graduated symbology and fill color to differentiate between housing projects by size (number of units per project). The symbol outline color denotes the project status.

map the data that we're trying to display and also make it look attractive in an all-in-one dedicated program."

The Colliers Utah GIS team eventually landed on a simple yet dynamic map style. While the map continues to be tweaked and refined, the complete visual overhaul in its stylization was a significant breakthrough.

The new map style presents the data in a format that is simple and easy to understand. It combines graduated circles, fills, and strokes to identify housing projects by their size and status. Now brokers, their teams, and clients can easily see where housing developments will be built in an area. Maps can be viewed online or downloaded as static images when needed.

This represents a substantial improvement over previous versions of the map, which required a complex legend and a full-page reference sheet to explain symbols and other map elements to help figure out what was being presented on the map.

Using Esri products and third-party data for local real estate and housing information, the team has furnished insight into the market that brokers value. ArcGIS Experience Builder lets the team transform data into web apps without writing code. With Experience Builder, the site gives users better ways to interact with data than would be possible using a report or static map image.

Greater Adoption and Impact

With the new map style, brokers can help clients make more informed investment decisions in the high-growth market. Since the Colliers Utah GIS team rolled out new maps, team members have noticed positive impacts because of their work.

"When we implemented our new map style, we saw our time generating new maps drop by nearly 75 percent," said Cottle. This allows the team members to focus on collaborative efforts in map design and marketing.

They have seen greater adoption of the tools among real estate brokers. For example, brokers who at one time were hesitant to use these tools are now incorporating their maps in their marketing and presentations. Having these reports in a presentation provides a competitive advantage over other brokers. The GIS team at Colliers Utah attributes this to the much easier visualizations.

Preloading their data into web apps in Experience Builder has empowered real estate brokers to view and obtain the data they need on their own. This has allowed the team to spend more time building new GIS tools.

Interest in the new maps is growing outside the organization. A few national fast-food chain restaurants and retailers in the local Utah market have used future housing data to help decide on potential store locations. Executives and planners were able to use this data to see more potential store locations in rural areas of Utah that are projected to develop rapidly, according to planned housing data. The data points to significant housing increases in the coming years and opportunities for new store locations.

Other retailers have layered the future housing data from the Colliers Utah GIS team on top of maps that show high-traffic street corners. Predicting where housing is going to be built, along with traffic data, has allowed businesses to be a step ahead in selecting future store sites.

Continued Improvement

The Colliers Utah GIS team has set a goal of improving the map and supplying additional relevant housing information. For example, the team has responded to requests for data on multifamily housing projects and rental units. These new datasets are expected to provide a more complete picture of the future of housing in the area. With the ability to refine this new map with new data and analysis, the GIS team can make its tool a go-to source for relevant data about the future of local housing markets and help Collier stay ahead of the competition.

GIS Aids Housing Equity

In response to the opaque rental housing market in Beirut, Lebanon, a university research lab created a database of rental information contributed by tenants and shared it with home seekers, tenants, researchers, and housing advocates through an online map.

In Beirut, the civil war and the repeal of rent control have led to high rent prices that aren't aligned with renters' ability to pay. In some cases, the tight housing market has forced tenants to sign leases spanning multiple years, often paying years in advance.

As the capital and largest city in Lebanon, Beirut has a host of housing concerns that have been exacerbated by population growth. With recent stabilization in the region, property management companies and property owners have flocked to neighborhoods of Beirut and transformed them to attract tenants willing and able to pay higher rents. This has displaced those with lower incomes, compelling them to move to areas that are further away from the city center and jobs.

In this period of housing uncertainty, many residents and potential renters need access to rental market information. The lack of transparency in the rental market has generated severe inequities among city dwellers. This situation has especially disadvantaged the most vulnerable social groups, who often pay high rates for substandard units. The lack of information about housing quality and pricing has increasingly become a substantial hurdle for those looking to rent.

Rental Data in Geographic Context

To improve the situation for renters, the Beirut Urban Lab built the City of Tenants, an online platform based on a database of tenant-contributed information and visualized using GIS to map that information.

The Beirut Urban Lab is an interdisciplinary research lab that was founded in 2018 in the Maroun Semaan Faculty of Engineering and Architecture (MSFEA) of the American University of Beirut. The lab has been collaborating with scholars, researchers, institutions, public agencies, activists, professional groups, grassroot collectives, and local communities on multiple interdisciplinary projects. These projects rely on mapping as an analytical research method and effective communication tool.

With the City of Tenants, the Beirut Urban Lab could integrate data about rental conditions such as rent prices, and neighborhood characteristics within a location-based context. The lab had built an accurate basemap, the Beirut Built Environment database, that includes footprints, property boundaries, roads, sewer networks, and Electricité du Liban's official neighborhood divisions for the city. It will be updated regularly with layers to reflect ongoing research and data collection.

With the Beirut Built Environment database as a foundation, the City of Tenants incorporates ArcGIS Survey123 and ArcGIS Experience Builder to collect data about the occupancy status of rental units. A web app, built using ArcGIS Experience Builder, allows the data collected to be displayed in a compelling web application on a single screen. It contains embedded ArcGIS Dashboards modules and has been optimized for Arabic and English. Its functionality extends to desktop and mobile devices, and a hub site brings together spatial and environmental characteristics.

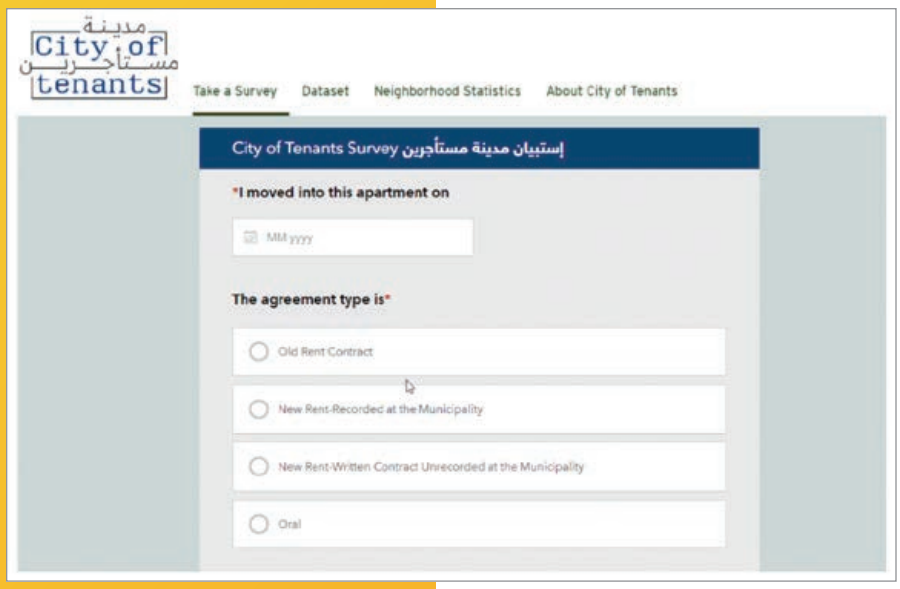
The rental data is anonymously collected, using ArcGIS Survey123, from current tenants living in neighborhoods in throughout Beirut. Users quickly answer questions in the form and the collected data is immediately uploaded to the ArcGIS system. Tenants provide their email addresses to access the survey. Researchers and other professionals use the data to explore urban trends in Beirut.

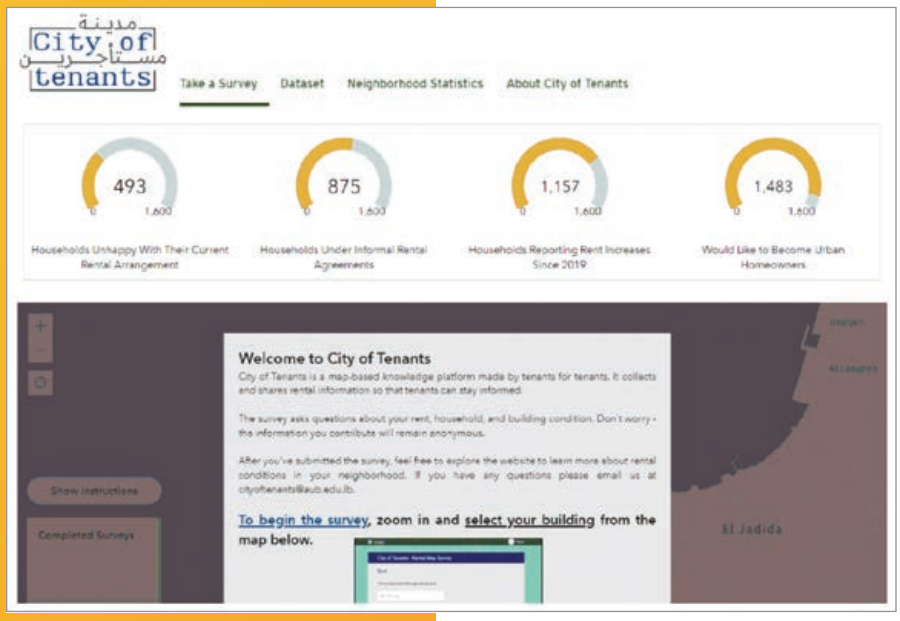
With the City of Tenants geoportal, tenants and researchers can log rental costs in relation to housing conditions for rented-out units. This information, shared in an accessible and clear form, improves home seekers' knowledge on existing housing conditions and can help counter the ongoing reliance on asking prices, which are often inflated.

"The mapping component is an integral part of the City of Tenants platform. It allows for georeferencing of the data, which in turn provides critical insights about the correlation of rent and neighborhood characteristics," said Mona Fawaz, professor of urban studies and planning for the American University of Beirut and cofounder of the Beirut Urban Lab.

A Better View of City Housing

The City of Tenants platform launched with 1,800 data points collected between December 2021 and December 2022. Data collection is ongoing. Market visibility is a necessary first step toward the formulation of responsive public policies for the rental sector that will ultimately serve the goals of housing justice. Policy makers can also rely on the City of Tenants platform to understand gaps in the rental market, price





↖ Tenants enter their rent information into an ArcGIS Survey123 form.

← The ArcGIS Experience Builder app has embedded ArcGIS Dashboards modules.

↙ The City of Tenants app has been optimized for Arabic and English.

gouging, and other factors when creating public policies.

Readily available data on modes of payment, rent prices, apartment sizes, building conditions, number of occupants, and the age of housing helps tenants—both current and future. With more and better rental information, tenants reduce the time spent searching for adequate housing options and more effectively negotiate with property owners. Access to publicly available rental market data empowers potential renters' decision-making to create more favorable rental conditions for themselves.

"We are still in the analysis phase of this project, but we are collecting information across 20 variables including cost and type of utilities, currency of rent payment, and formality of agreement, and others," said Fawaz.

Data collected thus far indicates that rents for similar apartments in similar locations vary substantially. Fifty percent of responding households reported relying on oral contracts, and another 15 percent have written contracts that were not recorded at the municipality. Households are heavily burdened by rent. The cost of rent and basic services such as electricity, water, and building services raised that burden to 95 percent of income for households surveyed. Consequently, these households depend on financial aid or help from relatives to make ends meet.

In the future, the Beirut Urban Lab hopes to expand the City of Tenants to other cities in Lebanon. The lab further hopes to develop the platform so that data is automatically updated based on data gathered via ArcGIS Survey123.

Using GIS to Promote Appraisal Transparency and Efficiency

Chatham County, North Carolina, had more than 46,000 parcels that needed to be properly and accurately assessed for tax purposes. The county created an all-in-one solution for its tax department's recent real property tax reappraisal process using GIS.

Counties are required to regularly undertake general reappraisals. This involves a tremendous amount of tax administration and appraisal work. Once properties have been assessed, value notices are provided to property owners. Property owners have the right to appeal the county's assessed valuation and request a reappraisal. Reappraisals can be a major public relations issue.

To effectively deal with requests for reappraisal, Chatham County decided to provide property owners who disagreed with valuations easy-to-use tools for exploring real estate data. County appraisers also needed a comprehensive appeals management platform to efficiently navigate the appeals process.

Rethinking the Appeals Process

To generate the best solution for managing appeals, the tax department reached out to the county's GIS department for a comprehensive solution to visualize, track, and manage comparable sales and appraisal information for its internal appraisal process. To improve government transparency, it was important that this solution was readily available to property owners after the county's tax office sent change-in-value notices.

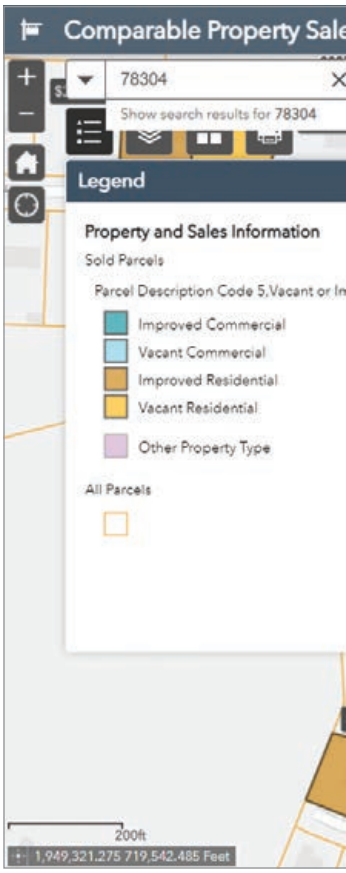
The GIS department used ArcGIS Online extensions to implement a solution for collecting photos of properties, creating a dynamic online tax appeals form, an operations dashboard, and a comparable sales application.

The first step was the creation of the Fieldwork Photo Collection tool using ArcGIS Survey123. It would be used by contract reappraisal staff for collecting current property photos. The tool also helps staff organize multiple photos for parcels. To capture parcel ID and property address information, more than 100,000 photos were taken in the field. The photos were used to validate data entry and identify errors.

Assessors needed current photos of each property to support change-of-value notices. Having all the photos in one place made it easier to keep an accurate record of the property reappraisals and improved overall field efficiency.

Each year, following the countywide reappraisal process, all property owners receive a change-of-value notice, which provides a new assessed value. This new value can be challenged by the property owner, who makes a tax appeal. The tax appeals form was created online using ArcGIS Survey123. One advantage of adopting this online form was that forms can be filtered to identify duplicate submissions and find errors.

Typically, the valuation appeals process is lengthy. With the new system, an appeals form is automatically sent to assessors so they can immediately start working on it, which speeds the process. Submitted appeals forms populate a dashboard application that appraisal staff use to centrally manage the appeals process. With the appeals dashboard, the tax department can view appeal submission information, assign appeals to appraisal staff, and update the status of appeals in real time.



The Comparable Property Sales mapping application (https://bit.ly/3XgBQSy) was launched in 2021 just before change-of-value notices were sent. Using this tool, a property owner could easily find sales of similar properties to support a request for reappraisal. This interactive comparable sales application provides easy access to meaningful sales information.

Improving Productivity and Transparency

Within a few years, Chatham County has been able to leverage GIS technology to better serve its residents and optimize its internal processes. The appeals form and dashboard have improved customer service and tax department efficiency. Many property owners have expressed satisfaction with the new appeals process.

The Comparable Property Sales

mapping application has improved tax department transparency to property owners. The ArcGIS Survey123 appeals form has reduced redundant appeal submissions and saves time during the appeals process.

"The process designed by our GIS department using Esri products provided a visual map outlining the parcels with appeals and the status of the appeals. Staff were able to track all comments and attach all the documents to each parcel, which resulted in time savings when processing appeals. We also experienced a reduction in paper since the appellants were able to upload all documents and complete the online application form," said Jenny Williams, tax administrator, Chatham County.

Chatham County continues enhancing the tax department solution for real property to make it more efficient. The county is taking steps to develop a public tax reappraisal hub site that will work in conjunction with the tax department. The site will promote awareness of the improved transparency in the tax reappraisal process.

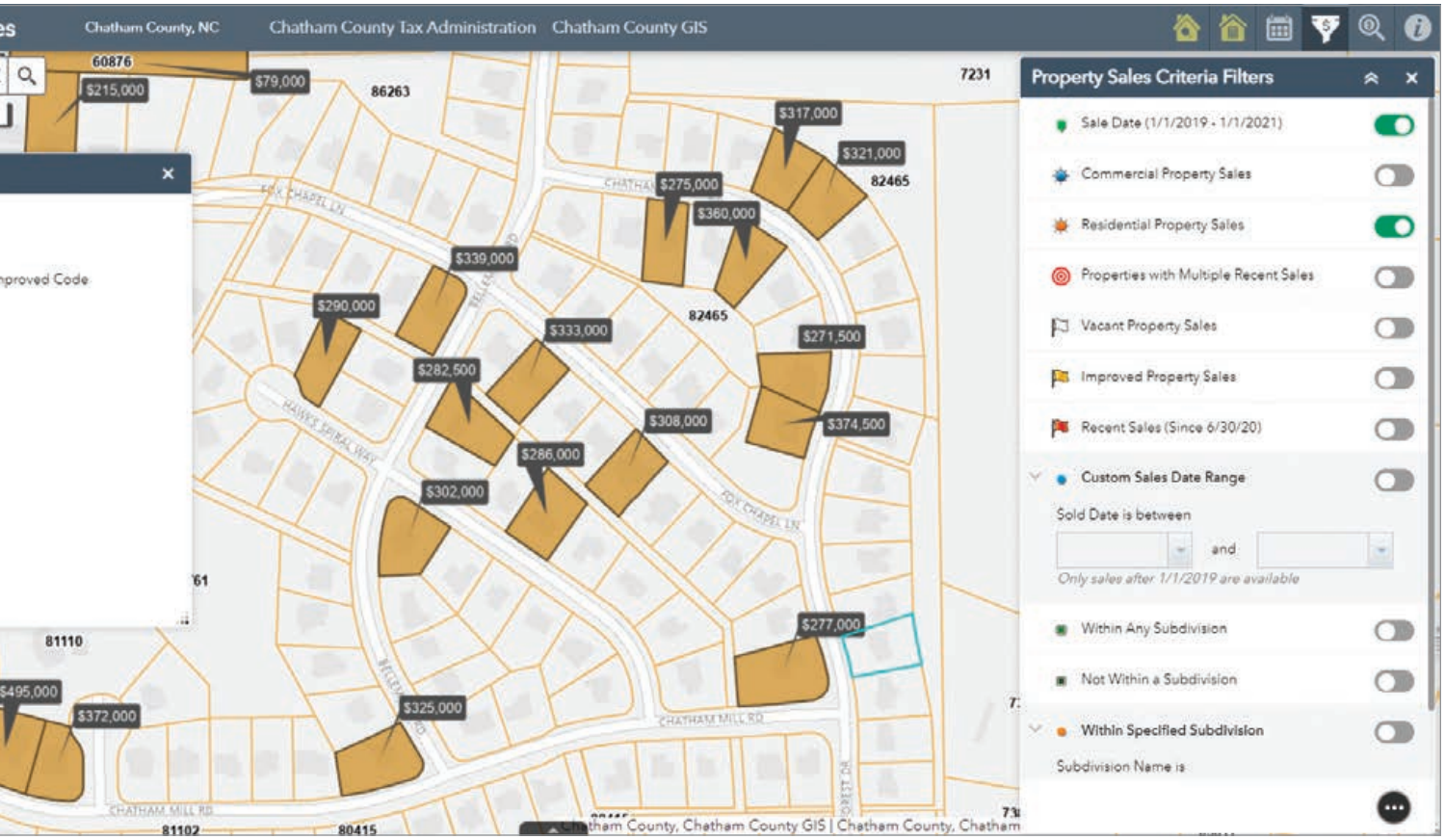
"GIS technology empowered tax department *[staff]* to take ownership of their data and allowed them to take it to the next level," said Nick Haffele, MIS and GIS director for Chatham County.

Chatham County's solution can be easily replicated by other county tax departments that are looking to streamline the appeals process. The county has also been encouraging other departments to use GIS to improve their work.

> "GIS technology empowered tax department *[staff]* to take ownership of their data and allowed them to take it to the next level."
>
> Nick Haffele
> MIS and GIS Director
> Chatham County

In response to the success Chatham County had with the Real Estate Appraisal division, the Personal and Business Property divisions have requested an online appeals system for their operations. The GIS department is currently in the process of developing similar solutions for them according to Lucian Stewart, applications solutions engineer at Chatham County.

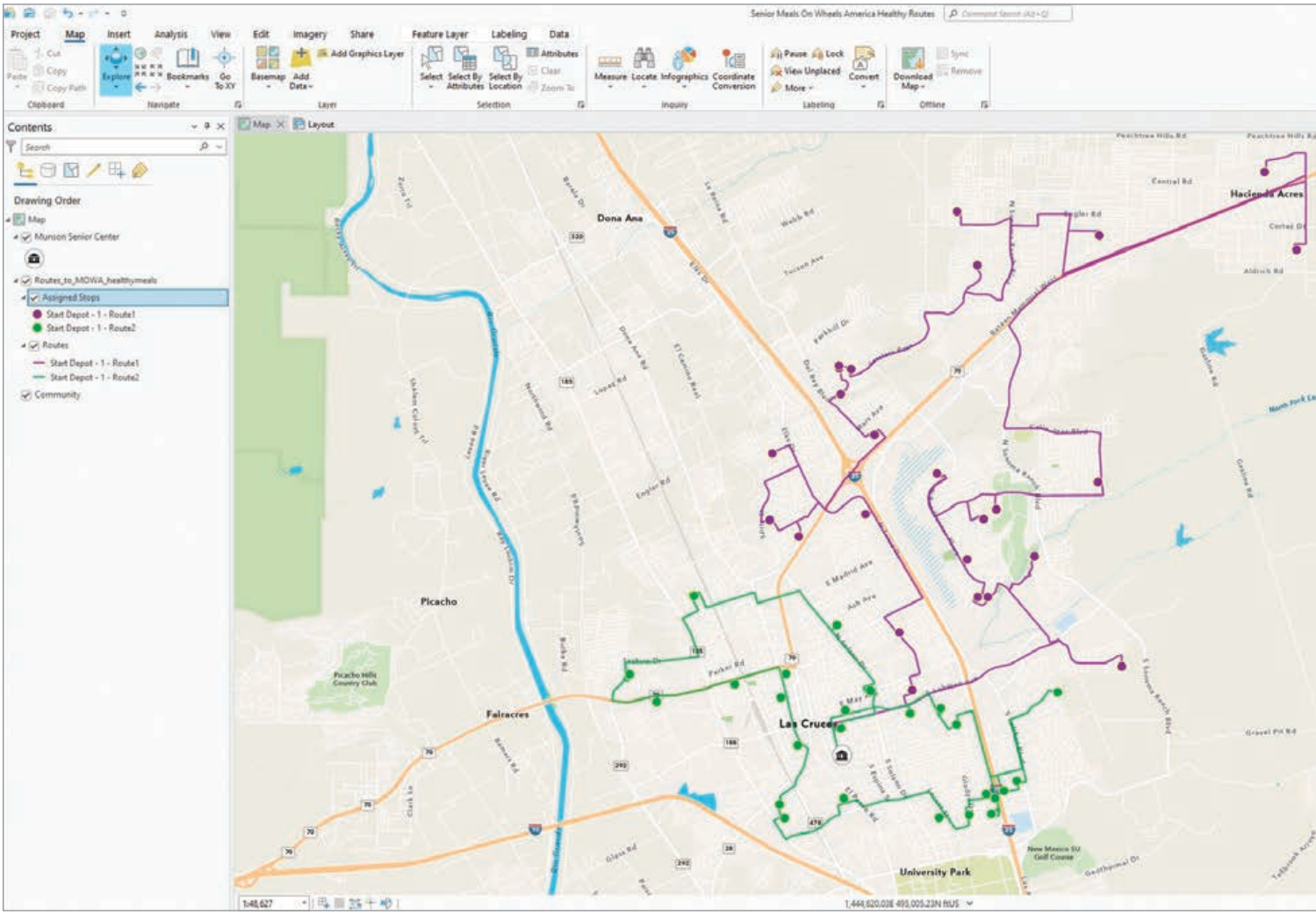
↓ The Comparable Property Sales mapping application lets a property owner easily find sales of similar properties to support a request for reappraisal.



Las Cruces Uses the Power of *Visualizing Its Data*

By Suzanne Boden

GIS manager Courtney Granite seeks to instill a collaborative approach to data management and sharing at the City of Las Cruces, New Mexico. The city is the state's second-largest city and home to New Mexico State University. Partnering with Esri to deploy an adoption strategy helped her build consensus for change and a growing enterprise mindset across the city.



A self-described "data person," Granite is passionate about using location intelligence to inform decision-making. Las Cruces has a decentralized GIS model that is coordinated through Granite's team and housed in the Community Development department.

Her team supports GIS staff and users in other departments, including utilities, economic development, public works, quality of life, public safety, parks and recreation, and the city manager's office. The GIS team also provides reporting that supports departmental metrics and performance management initiatives and helps leaders measure progress on the city's strategic comprehensive plan, Elevate Las Cruces.

Granite stepped into her current role in October 2019. From the beginning, she wanted to encourage an enterprise approach to information and GIS.

"I came from IT and very much a data-focused background," said Granite. "I wanted to grow *[the GIS program]* with an emphasis on data governance rather than the old-school way of doing things."

The "old-school way" included fielding myriad requests for GIS maps and data. Each department worked with its data in a silo, which made it a challenge to access and report all relevant data to support decision-making.

In conversation with Esri senior training consultant Tosca Hoffmann, Granite described her vision for broader use of GIS and collaboration across teams and city programs. Hoffmann told Granite that other GIS managers she worked with had similar goals. GIS awareness and data silos are common challenges, and Esri has created an adoption strategy practice to help organizations overcome these barriers.

Building a Playbook to Grow GIS Adoption

With her interest piqued, Granite met with Esri consultant Lyndal Brookhart. The two agreed that an adoption management playbook engagement would help advance Granite's vision for Las Cruces.

Granite approached the city's GIS steering committee. After explaining the current state of GIS practice and the need for change, she asked the committee to assign staff to participate in playbook meetings. The committee could see the value of making changes that would help report on data in a way that made sense, increased standardization, and built trust in enterprise information.

With the steering committee's approval, the adoption management playbook moved forward. Granite felt it was important to bring as many departments into it as possible. Representatives from 10 city departments participated in seven working sessions facilitated by Brookhart. After talking through what they were trying to achieve and why it was critical to the city's future, they brainstormed specific approaches and the steps that would be needed to accomplish their goals.

"We had close to 20 people involved from across all the key functional areas of the city—and they showed up and were present and contributed. This initiative was owned by everybody," said Granite.

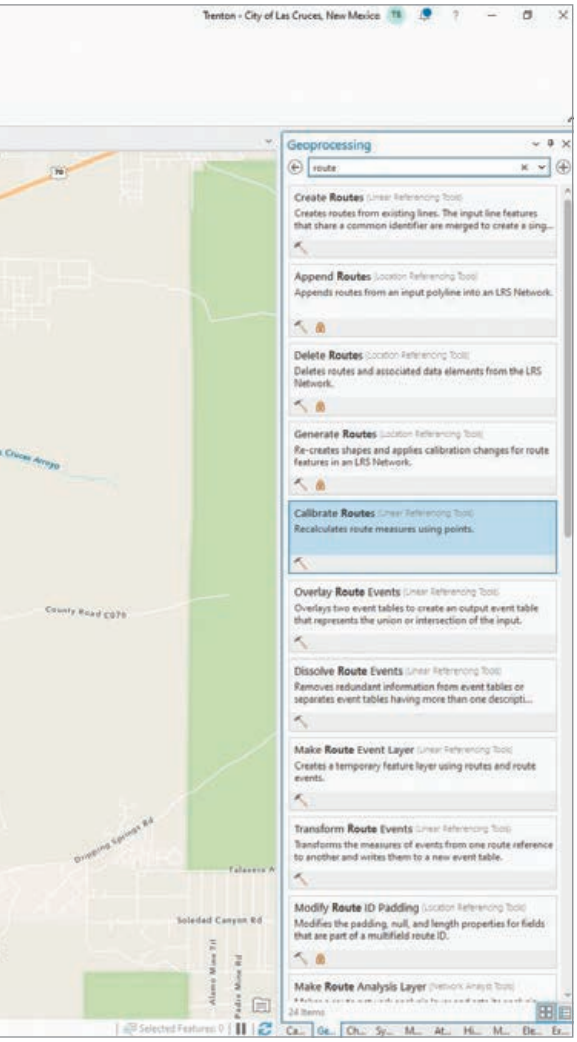
To reinforce the importance of the effort and its collaborative spirit, the group named their initiative Connect Las Cruces: Empowering GIS Modernization Across the Enterprise. They also crafted a big opportunity statement in the Las Cruces adoption management playbook that encapsulates the initiative's benefits: "We can positively support our livability, prosperity, and environment by leveraging location intelligence technology that supports critical decisions. By increased cross-functional department and community data-sharing practices, we can better understand where we are, who we are, and how we grow together."

The group tasked a smaller adoption management team to implement the playbook. Five participants, including Granite, were assigned to this team. Brookhart facilitated discussions that resulted in the development of a solid plan. "We agreed the action items were very doable," said Granite.

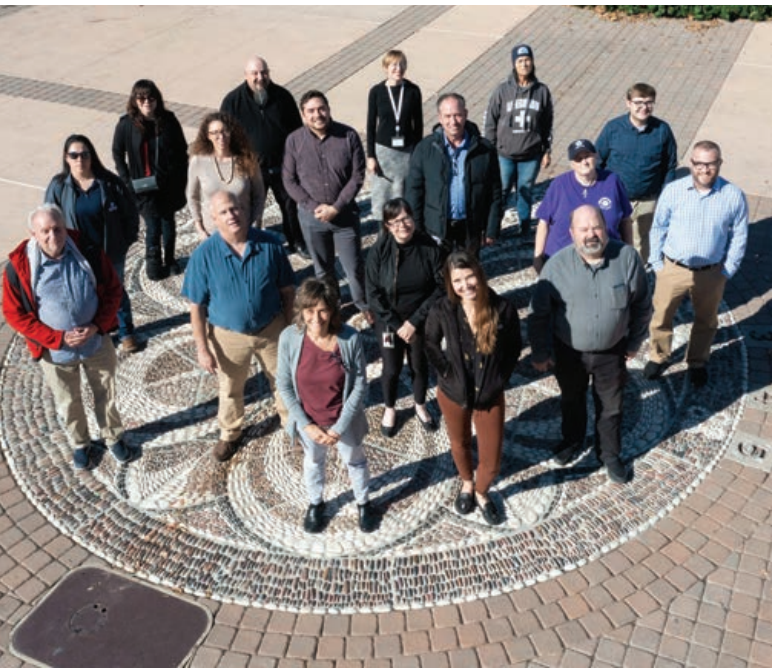
Communicating the Vision

When the playbook engagement began in spring 2022, Las Cruces had 230 active ArcGIS users, which included GIS professionals, light users, and staff who viewed web maps and apps. By the end of 2022, there were 380 active users—an impressive growth of 39 percent.

To achieve that growth, Granite deployed the playbook's communications strategy and set out to convince department leaders—key influencers for change—that location intelligence could improve decision-making and enhance



← A Connect Onsite workshop participant was able to quickly apply the training and produce this map, which supports the city's meal delivery program. (Map courtesy of City of Las Cruces, GIS team.)



↑ The Connect Las Cruces initiative sparked significant GIS adoption among city staff. The images show the proportional growth in GIS usage before and after Connect Las Cruces launched. (Photos courtesy of City of Las Cruces.)

their operations. Department by department, she met with managers and program staff to gain their interest and build a desire to do more with GIS.

She framed her presentation every time using a key theme: "the power of visualizing your data." Every time, she explained how GIS could improve the workflows and programs supported by the department and each user role within the department. Her goal was to inspire everyone with a clear picture of what could be—a future in which location intelligence infused decision-making would drive efficiencies and smart resource allocation. This would help make Las Cruces an even better place to live, work, and do business.

"I wanted the change network to understand the importance and outcome of making a commitment to the plan—how it would take us to the next level and the benefits we would gain," stated Granite.

Engaging End Users

Because Las Cruces has an Esri Small Government Enterprise Agreement, many city employees have access to ArcGIS software. Encouraging a self-service model for GIS is a key goal of Connect Las Cruces.

During the playbook sessions, the team identified workforce development as an important strategy to grow GIS skills and build excitement among the staff to use GIS. To execute this strategy, the team deployed an in-house training initiative named Connect Onsite, which authorized city staff to attend GIS-related training courses four hours a month over a period of four months.

Connect Onsite launched in October 2022 with four one-hour, hands-on workshops designed to grow foundational skills in GIS-based enterprise best practices that aligned with departmental workflows. GIS technician Alejandro Samaniego helped create and deliver the workshops.

"My personal goal was to inspire more interest in GIS," said Samaniego. "I felt like if it was your coworker showing you what they do with this program, how they use it, and giving examples of how useful it could be, it would inspire participants to apply GIS to what they do."

Introducing a fun activity helped set Connect Onsite up for success. The adoption management team decided a virtual, story-based scavenger hunt would attract interest and increase workshop participation. The team devised a series of questions for scavenger hunt participants to answer using a web map. The activity introduced GIS terms and taught participants how to identify features, add points, create simple data, and follow routes and lines. Those who accurately completed the monthly scavenger hunts were entered into a drawing for a prize.

"It's all about training and getting them inspired to use GIS," said Samaniego.

Connect Onsite Delivers Success

Workshop participants were asked to bring project data so they could immediately apply the training to their own work.

"What we saw was pretty remarkable," said Granite. "The people who really put the time in to be engaged got a lot out of it."

One participant from the Quality of Life Department brought data for the meal delivery program she supported. Her goal was to reduce food waste resulting from delays in delivering the meals. In the workshop, she learned how to create a map of city streets and overlay the meal delivery locations. Then she worked with a GIS staff member to optimize delivery routes. Delivery drivers with deep knowledge of city streets and traffic patterns helped further optimize the routes. By including the drivers, everyone involved with the program was empowered to improve it—a tangible example of the benefits of GIS,

collaboration, and "the power of visualizing your data."

"The meal delivery program was able to transition from using a third-party solution to an internally supported tool," said Granite. That success sparked interest from another department.

"Risk Management staff noticed *[the Quality of Life employee]* working on her map and her enthusiasm for the data," Granite said. "Now they're interested in attending a future session because they can see how it would be applied to some of their scenarios and the data they're utilizing."

Another success occurred after three police department employees attended a workshop. They brought data for projects they needed to complete and a week later, Granite received a phone call from a deputy chief requesting a customized training session.

"Maybe they used GIS in the past, but they weren't using it to its full potential," she said. The deputy chief now mandates that his team use GIS to help solve crime in specific areas of the city.

After completing the in-house training, some participants wanted to continue growing their GIS skills. Hoffmann works with Granite to provide Esri course recommendations for those employees. Overall, Granite and Samaniego are very pleased with the impact of the training.

Painting Their Own Canvas

Building on the Connect Onsite success, Granite and Samaniego are on a mission to enable more employees to confidently apply GIS tools themselves.

"I want GIS to be a change agent for the city, a catalyst for creative thinking and innovative workflows that utilize GIS to report on and share data and information," said Granite. "Historically, people came to the GIS department and asked, 'Hey, GIS, can you do *[this task]* for us?' Of course, we can, but we want subject matter experts to be empowered through training and access to software tools to paint their own canvas and make informed decisions using the data that matters to them."

Samaniego concurred. "When someone requests a task, for me it's just a task," he said. "But if they know how to use the program and it's their own work, they're going to have a higher investment in the outcome and be more creative. By giving everyone the tools, the products we put out as a city will improve because we're all working on what we care about rather than simply completing tasks."

Building Communities of Practice

While the number of GIS users has grown significantly since Connect Las Cruces started, Granite hasn't set a target.

"I'm a data person so I like numbers, but this is about providing a service to others and helping them see the value of using the technology."

Asked about her next step, Granite answered, "I think what I'm really looking for is to continue making connections. This year, we plan to offer a communities-of-practice program. One will focus on GIS, and another will be around data science. If we can develop these internally and in the community, then I will have met what I think is a good goal."

She is well on the way to achieving her goal. Her team is helping forge a regional GIS community of practice. Several agencies, including Doña Ana County, Mesilla Valley Metropolitan Planning Organization, New Mexico Land Conservancy, and the Mesilla Valley Regional Dispatch Authority, have expressed interest. She wants to see how they can better share and make use of data. "Connecting with GIS and data professionals from different agencies is going to really help us," said Granite.

> For more information on Connect Las Cruces, contact cgranite@lascruces.gov.

About the Author

Suzanne Boden is the training marketing manager at Esri, where she champions the value of lifelong learning and the people and organizations that apply GIS to accomplish big goals. When not working, she's practicing sustainable gardening in Southern California.

USING GIS TO MAP THE WAY TO HOUSING EQUITY

By Keith Cooke

The topic of zoning reform has gained momentum exponentially over the last few years. As more communities find that their ability to deal with the housing shortage is hindered (or all but blocked) by their existing policies and dated zoning ordinances, demands from the public, developers, and elected and appointed officials to change this situation continue to grow.

Reforming a zoning ordinance is neither quick nor inexpensive. To address this, US Department of Housing and Urban Development (HUD) has received $85 million in funding for the Yes In My Backyard competitive grant program as part of the $1.7 trillion spending bill approved by Congress in 2022. This program will likely begin by April of this year.

At its core, zoning reform is about modernizing an organization's development strategy (particularly housing) to meet the modern needs of its residents and to correct previous failed policies. Many people want more choices than half-acre single-family lots or very high-density apartment complexes. A lack of housing supply only serves to hinder the availability of affordable housing, which in turn limits the economic mobility of its residents, particularly those of disadvantaged communities and young professionals.

There will be inherent pushback from this because…well, it's change. That's not a political statement. People on the left and the right (and in the middle) are resistant to change. But this isn't a political issue. It's about enabling a community to create the housing and other developments its residents want and need that a legacy ordinance simply cannot provide.

Yes, some residents will still want a traditional single family residence (SFR) home. Some will be happy living in loft apartments downtown. I do not think it's wise to outlaw either of those types of development for a myriad of reasons I won't go into here. Zoning reform can open the door to more diverse types of housing, such as cottage courts, townhomes, duplexes, and flex houses.

The American Planning Association (APA) recently released its *Equity in Zoning Policy Guide* (https://bit.ly/3XrvEam), which helps planners and government leaders identify the ways zoning regulations can be changed to meet the needs of historically disadvantaged and vulnerable communities. I was naturally drawn to the section of this guide that deals specifically with the zoning map.

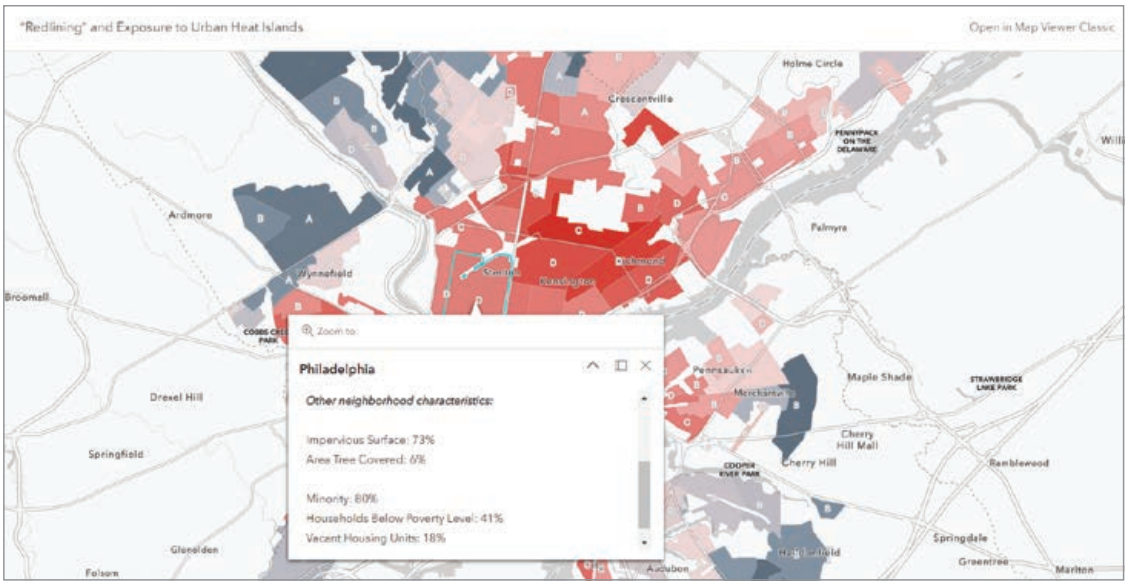
I've spoken many times in this space about the necessity of taking a geographic approach to planning, and creating equity in zoning policy is an example of this. Let's look at how GIS is a mission-critical tool for the zoning map policies recommended in the Zoning Map Policy sections of the APA guide.

Zoning Map Policy 1 states, "Those recommending neighborhood-wide or area-wide changes to the zoning map should reflect the demographic composition of the community and should include representatives of historically disadvantaged and vulnerable communities." This is the first step in applying the geographic approach to planning—understanding neighborhood characteristics.

Because understanding precedes action, planners must have access to updated demographic, socioeconomic, and business data before they can start making changes to zoning policy. Within the ArcGIS system, this is done through ArcGIS Community Analyst or ArcGIS Business Analyst Web App. These web-based applications provide access to more than 2,000 variables to help optimize zoning and resource allocation decisions, giving planners a place to start implementing a data-driven approach to zoning policy.

Zoning Map Policies 2 and 3 in the APA guide focus on the necessity of civic inclusion. Simply put, zoning policy changes do not exist in a vacuum and cannot be successfully amended behind closed doors. They require input from all residents, regardless of their ability to be at an in-person meeting. Today's public requires multiple ways to engage with government. In GIS, this is done through ArcGIS Hub, which provides easy access to planning initiatives.

This means that planners are not only communicating proposed changes but getting regular feedback from residents in a way they can effectively map and analyze. Civic inclusion is a must if a planning department wants to create a genuine partnership between itself and the residents it serves.



← A valuable free resource for planners is Esri Maps for Public Policy, which provides curated content such as this map showing historical redlining policies.

Zoning Map Policies 4 through 9 deal with addressing redlining, health risks, and access to services in disadvantaged neighborhoods. Again, GIS provides the level of analysis and understanding that is required for a data-driven and geographic approach.

Esri Maps for Public Policy (livingatlas.arcgis.com/policy/overview/) is a free resource available to planners and government leaders to address these issues using a geographic approach. This site provides curated content that can be viewed separately or added to an existing zoning map. Planners can view maps showing historical redlining policies, exposure to urban heat islands, Justice40 tracts, air quality, access to broadband, and data on many other issues.

In addition, the Social Equity Analysis solution can be used to understand community characteristics, analyze community conditions and actions, and generate an equity analysis index. Like other ArcGIS Solutions, it comes with an ArcGIS Online subscription and is fully supported.

Zoning Map Policies 10 and 11 deal with revising maps to remove barriers to equity. GIS provides the tools for conducting scenario planning to identify and remove those barriers. Specifically, ArcGIS Urban allows planners to play out different zoning reforms and measure the impacts of these changes. These scenarios could include:

- How would increasing housing density improve access to housing and consequently, improve affordability?
- What impact would reducing minimum lot sizes in a neighborhood make?
- Where could we focus allowing accessory dwelling units (ADUs) and what would that do to the housing supply?
- What will the impact be on housing, jobs, tax revenue, and overall economic mobility if we altered zones to accommodate transit-oriented development?
- What if we eliminate parking requirements for certain types of zoning?

GIS can answer all these questions in minutes or hours instead of weeks or months and do so in a more cost-effective way. This geographic approach to planning is a proven process that can provide the framework for your organization's zoning reform efforts. If you have questions, please feel free to reach out to your Esri account team, email at planningteam@esri.com, or visit esri.com/planning.

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 level in Alabama and North Carolina. Prior to this role, he was an Esri account executive for 15 years, who worked with more than 100 local governments.

Five Reasons to Use ArcGIS Monitor

By Derek Law

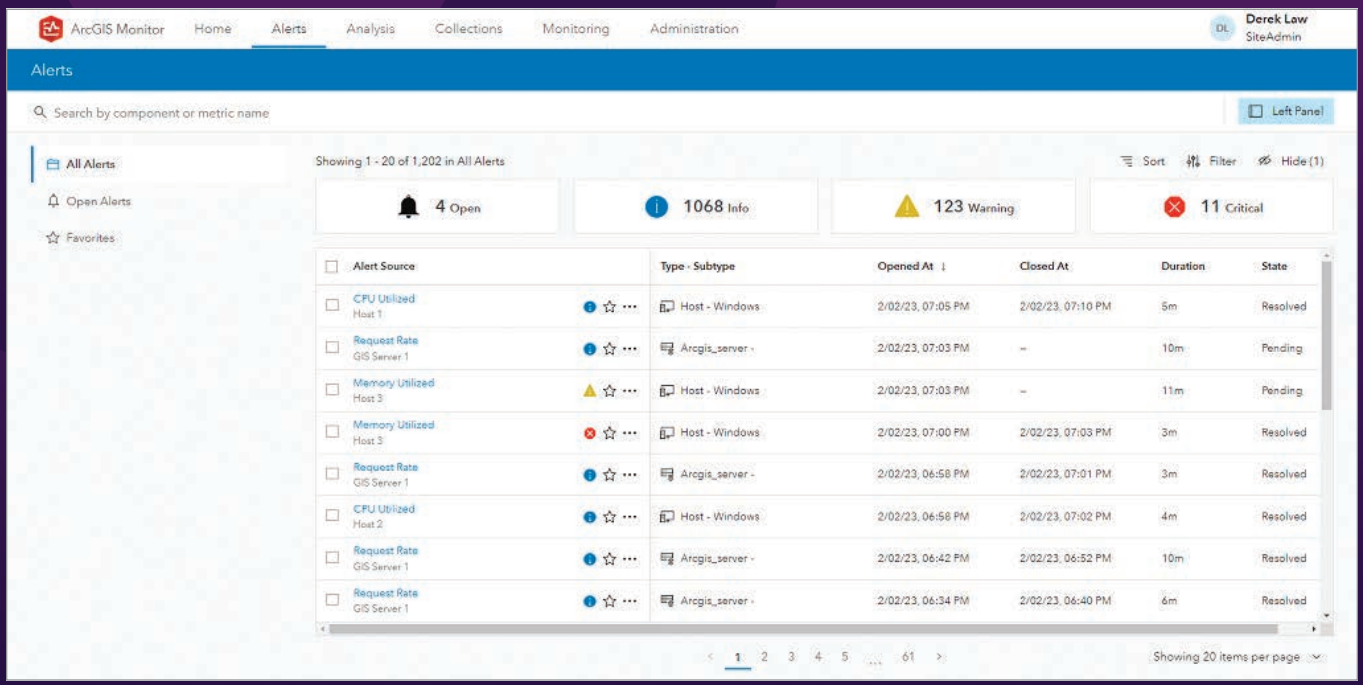
Move from reactive to proactive when managing ArcGIS Enterprise with a tool that provides insight through reporting, visualization, and alerts.

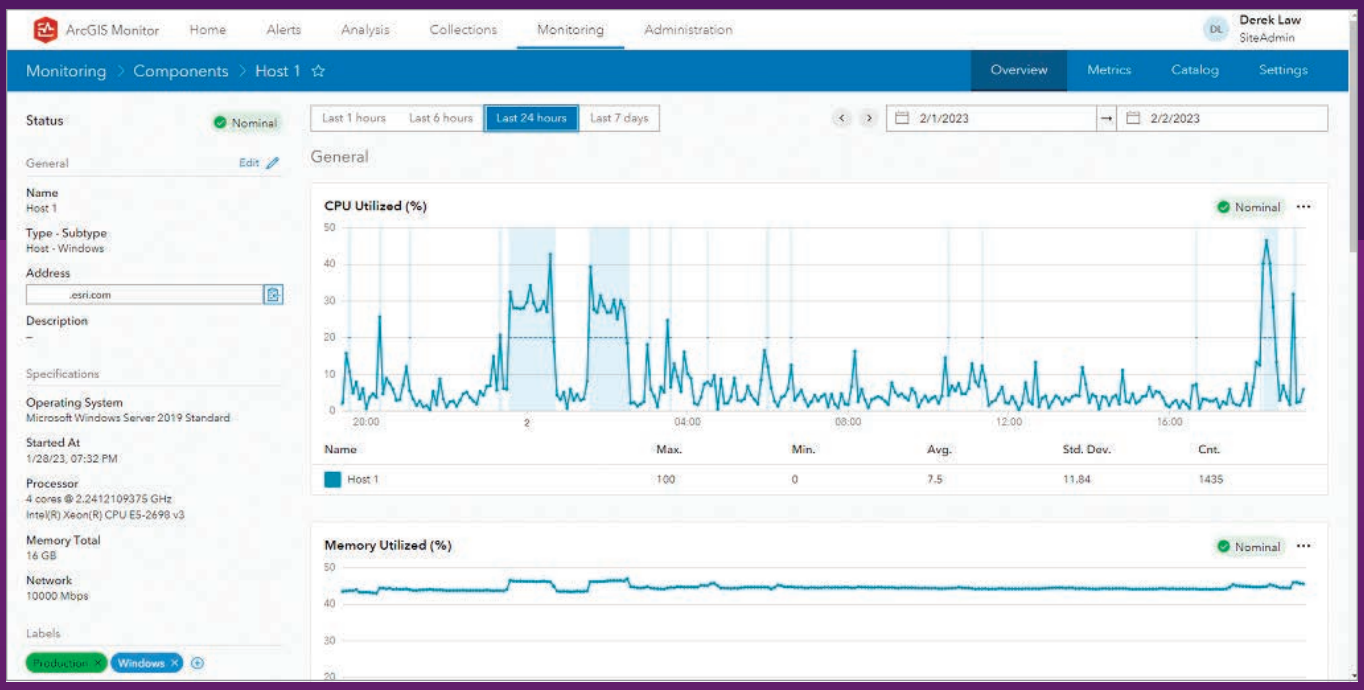
ArcGIS Enterprise is the foundational software system for GIS, powering mapping and visualization, analytics, and data management. It enables organizations to deploy an enterprise GIS in their own infrastructure on physical machines, virtual machines, or cloud environments.

Administrating and maintaining an enterprise GIS can sometimes be challenging, especially if an organization lacks IT expertise or as enterprise GIS capabilities scale and grow over time. ArcGIS Monitor, a tool for holistic monitoring of ArcGIS Enterprise and its underlying infrastructure, collects data and information on an enterprise GIS deployment and provides managers and administrators with effective alerting and reporting.

Distinct from other third-party system monitoring solutions, Monitor was designed specifically for ArcGIS. It was developed based on the experiences of Esri Professional Services staff members who help organizations deploy and manage enterprise GIS implementations. Before it became an official Esri product, Monitor was used for several years in successful Esri consulting services projects. This article lists the top five reasons you should implement ArcGIS Monitor in your organization.

↓ ArcGIS Monitor can track system health threshold values that vary for different components and depend on the organization's enterprise GIS business and IT requirements.





↑ Managers and administrators can define the metrics that are meaningful to them and configure custom data visualizations

1 Optimize Enterprise GIS and Monitor Its Health

Enterprise GIS components—such as GIS servers, enterprise portals, databases, and host machines—can be registered with Monitor. Once registered, Monitor collects data metrics about different attributes for each component.

Over several weeks or a month, system activity trends and patterns can emerge that can guide managers and administrators with rightsizing the system. This information ensures enough system resources, such as computer processing units (CPU) and memory, are allocated to each component of the enterprise GIS and its infrastructure so that it will run efficiently. By collecting data metrics about various enterprise GIS components, Monitor provides a holistic view of the entire system and its framework.

Monitor also provides the ability to configure alerts and notifications on enterprise GIS components to check for system health. For example, an alert could be configured on a GIS server when its instance saturation percent is high, indicating that more instances (i.e., system resources) are needed to handle the incoming service requests. It could be further refined to trigger only when the 90 percent threshold is reached multiple times in the same week.

When triggered, an email or text message can be sent to a manager or adminstrator when components reach or exceed defined threshold values for system health so they can be proactively managed. Alerts also assist with resolution efforts—in this example, it would mean adding more instances to the GIS server.

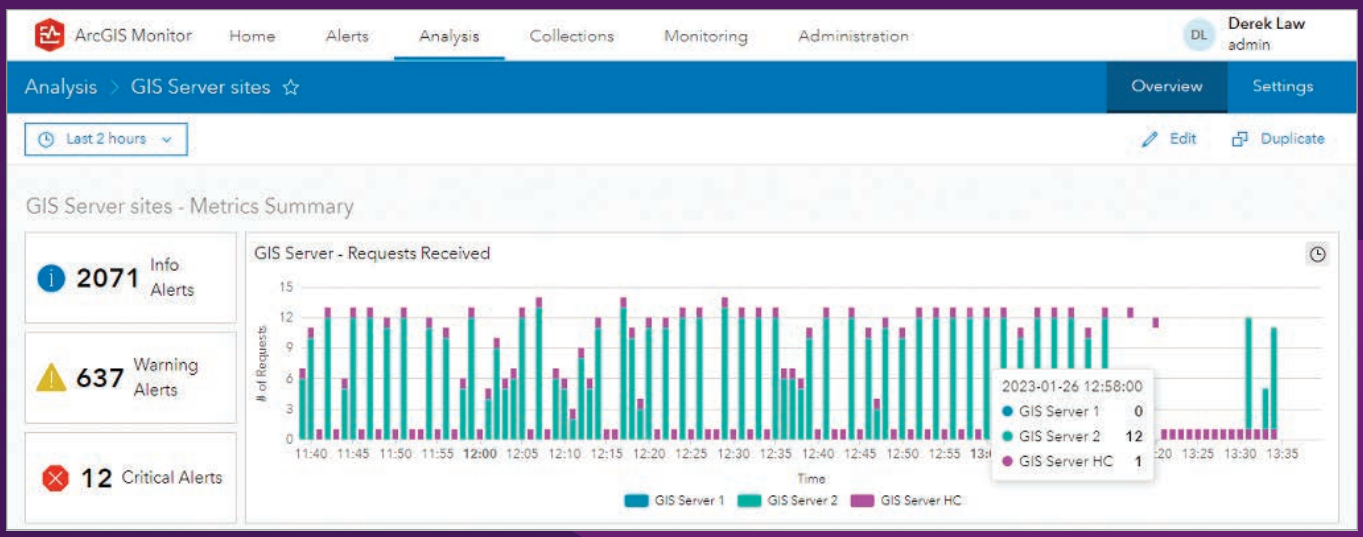
System health threshold values vary for different components and depend on the organization's enterprise GIS business and IT requirements. Other examples of monitoring system health include when a web service has a high response time (i.e., the system is slow), when a host machine has frequent high CPU usage, or when a component does not return data metrics when queried because it is unavailable or offline. Monitor supports multiple alerts and notifications for different enterprise GIS components and their attributes. Alerts and notifications can be configured to meet the specific size and needs of an organization.

2 Troubleshoot Performance and System Issues

One of the challenges with IT systems is downtime. When a system outage occurs, it affects productivity and—potentially—revenue. According to *Cost of Data Center*, a report published by the Ponemon Institute in January 2016, the average cost of downtime to an organization is $9,000 per minute. It is therefore important to resolve and minimize system issues as much as possible.

An enterprise GIS deployment varies depending on an organization's size, business needs, and IT requirements. Some organizations might have a single GIS server while others may have a multi-machine GIS server deployment across multiple locations. A GIS server could also utilize multiple data sources (i.e., databases and geodatabases) powering its web services.

When performance and system issues occur, it can be challenging to determine and isolate the causes, especially for larger



↑ By collecting data metrics from registered enterprise GIS components and storing this data in an internal database, ArcGIS Monitor provides enterprise GIS managers and administrators with an archive of enterprise GIS activity.

deployments. Monitor helps managers and administrators troubleshoot performance and system issues within a single application. It can be used to investigate common performance issues such as system overload due to high traffic volume and network bottlenecks and to check the availability of resources. While Monitor does not automatically resolve these problems, it provides diagnostic tools that help you track down the possible sources of the issue.

For example, a web editing application might have a performance issue due to slow response time, which can cause frustration for end users when the app is not working properly because of the delay. Monitor can help determine where the performance issue is occurring. Is it at the application tier, the feature service tier, or the database tier? Managers and administrators can examine the data metrics of the components that support the web editing application and check for indicators in the components' activity history for possible reasons for the slow response time. By identifying potential performance and system issues early—before they become critical—Monitor can prevent or minimize system downtime.

3 Generate and Collect Quantitative Data Metrics and History

Monitor collects data metrics from registered enterprise GIS components. It stores this information in an internal database that provides enterprise GIS managers and administrators with an archive of enterprise GIS activity.

This archive is beneficial because it provides a history of system activity, usage, and performance. This data can be examined to address questions related to trends and patterns of use such as:

- Which enterprise GIS components have the most activity?
- Which web services are the most active?
- Are web services more active during specific time periods?
- Are some web services mostly inactive? (Perhaps they should be changed or retired.)
- Which Enterprise portal items are the most active?

This data can be used for justifying additional system and IT resources and anticipating high traffic events such as emergency weather response or government elections. It also helps planning for enterprise GIS growth and predicting system resource needs when new components and GIS capabilities are added.

In addition to preconfigured data metric charts for enterprise GIS components, Monitor offers an option to configure custom data visualizations. This allows managers and administrators to define the data metrics they are interested in and how they are visualized.

Data metrics, collected and used within Monitor, can also be accessed outside of Monitor as feature services. These feature services can be registered with Enterprise portal and accessed by ArcGIS client apps. This means that collected data metrics can be viewed in apps such as ArcGIS Dashboards and ArcGIS Experience Builder so they can be shared with management and other enterprise GIS stakeholders.

4 Improves Communication between GIS, IT, and Stakeholders

In many organizations, typically the GIS department manages enterprise GIS, while the IT department manages the rest of the systems and services. Monitor is a great tool that enables GIS staff members who might not have IT expertise to better communicate with their organization's IT personnel.

Because it collects data on common system properties of enterprise GIS components and provides quantified data metrics (as

discussed previously), Monitor uses terms and concepts that are familiar to the IT staff. This authoritative information about performance, health, and usage of enterprise GIS provides operational awareness of enterprise GIS to IT and management in a language that they can easily understand.

Since Monitor collects and records data metrics over time, it can be particularly helpful in determining if appropriate system resources have been allocated to support enterprise GIS needs. If they have not, GIS staff will have the empirical evidence needed to validate system resource requests to IT, management, and other enterprise GIS stakeholders.

> "No issues reported by end-users is a good thing."
>
> **Eddie Fung**
> GIS Data Coordinator
> City of Calgary

5 Promote Enterprise GIS End User Satisfaction

A key responsibility of enterprise GIS managers and administrators is to ensure that the system is working efficiently and meets the needs of the organization. The quote above succinctly summarizes this objective. This responsibility applies to an enterprise GIS of any size in any industry. When enterprise GIS efficiently addresses demands, end users are satisfied. By leveraging Monitor to address issues before they become critical, managers and administrators can proactively manage the system to meet their goals and keep end users happy.

Conclusion

Monitor complements and strengthens your enterprise GIS deployment by providing a holistic view of the entire system and its infrastructure.

About the Author

Derek Law is a senior product manager for ArcGIS Monitor at Esri. Based in the Redlands, California, office, he's involved with requirements gathering, software development, and product marketing. He's worked for more than 20 years as a GIS professional and has worked with many domestic and international clients. Follow him on Twitter: @GIS_Bandit and on Mastodon: mastodon.world/@GIS_Bandit

Organizations that Benefit from ArcGIS Monitor

These are some organizations that have used ArcGIS Monitor to cut down on outages, trouble shoot problems, optimize performance, and improve end-user experiences.

"City of Calgary Monitors System Health with Enterprise GIS Optimization Tool" (https://bit.ly/3X12eQn)

"Houston Public Works Manages Enterprise GIS with Performance and Optimization Solution" (https://bit.ly/3jtuYU2)

"Stark County in Ohio Improves System Health with Enterprise GIS Optimization Solution" (https://bit.ly/3YnYDgh)

"Forsyth County Monitors Enterprise GIS with Optimization and Management Solution" (https://bit.ly/3Rv9wKR)

"The Utility of ArcGIS Monitor" (https://bit.ly/3HPWX9I)

Use Calcite to Easily Create Beautiful User Experiences

By Julie Powell and Kitty Hurley

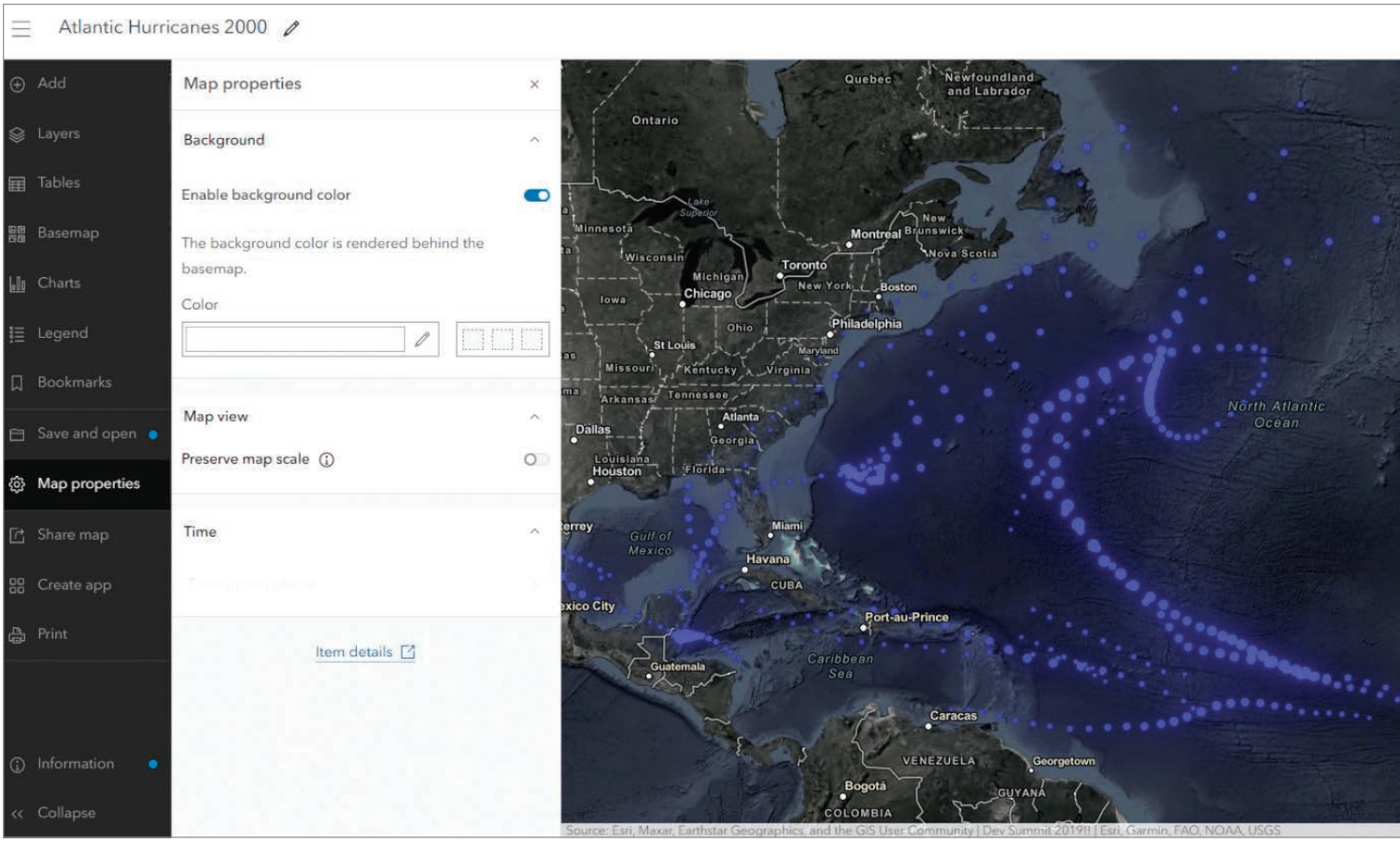
Calcite Design System 1.0 was released in January 2023. Using Calcite, developers can create beautiful, user-friendly, and consistent experiences across applications with minimal effort. Calcite includes configurable web components along with iconography, a UI kit, and usage guidelines containing best practices.

Calcite is used by Esri product teams to create consistent, on-brand Esri experiences across ArcGIS products. Using Calcite, you can create a cohesive user experience across your applications by implementing the patterns and established best practices native to ArcGIS products. It will let apps you develop that will be integrated with the ArcGIS ecosystem offer the familiar ArcGIS experience while showcasing your own brand and style at the same time.

By default, UI components use the ArcGIS color palette, font, and component shape. Theming in Calcite allows you to integrate your own style or company branding in your app. You can easily customize component color, font, and other styles where applicable.

Recent enhancements to the design system include consistent and predictable component API patterns, improvements to

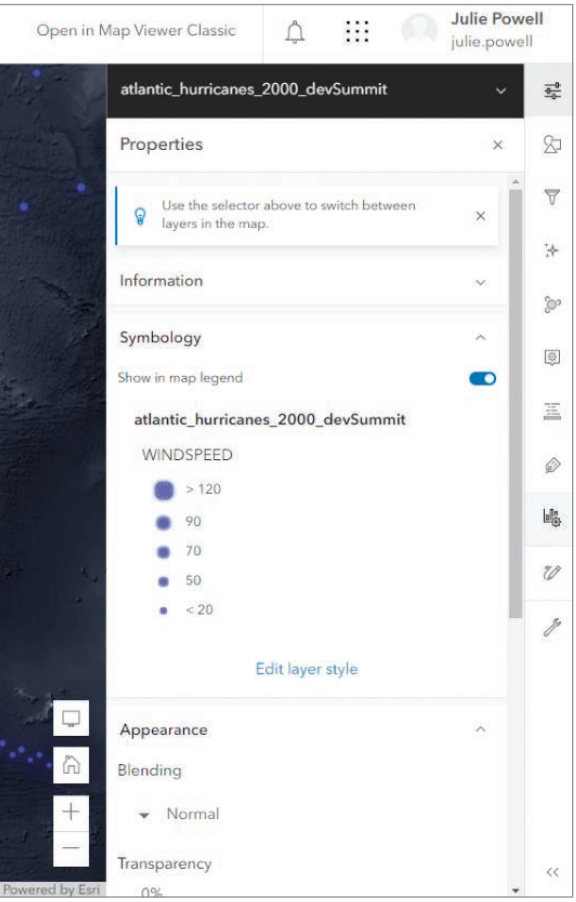
↓ Calcite is used throughout ArcGIS web-based products such as Map Viewer in ArcGIS Online.

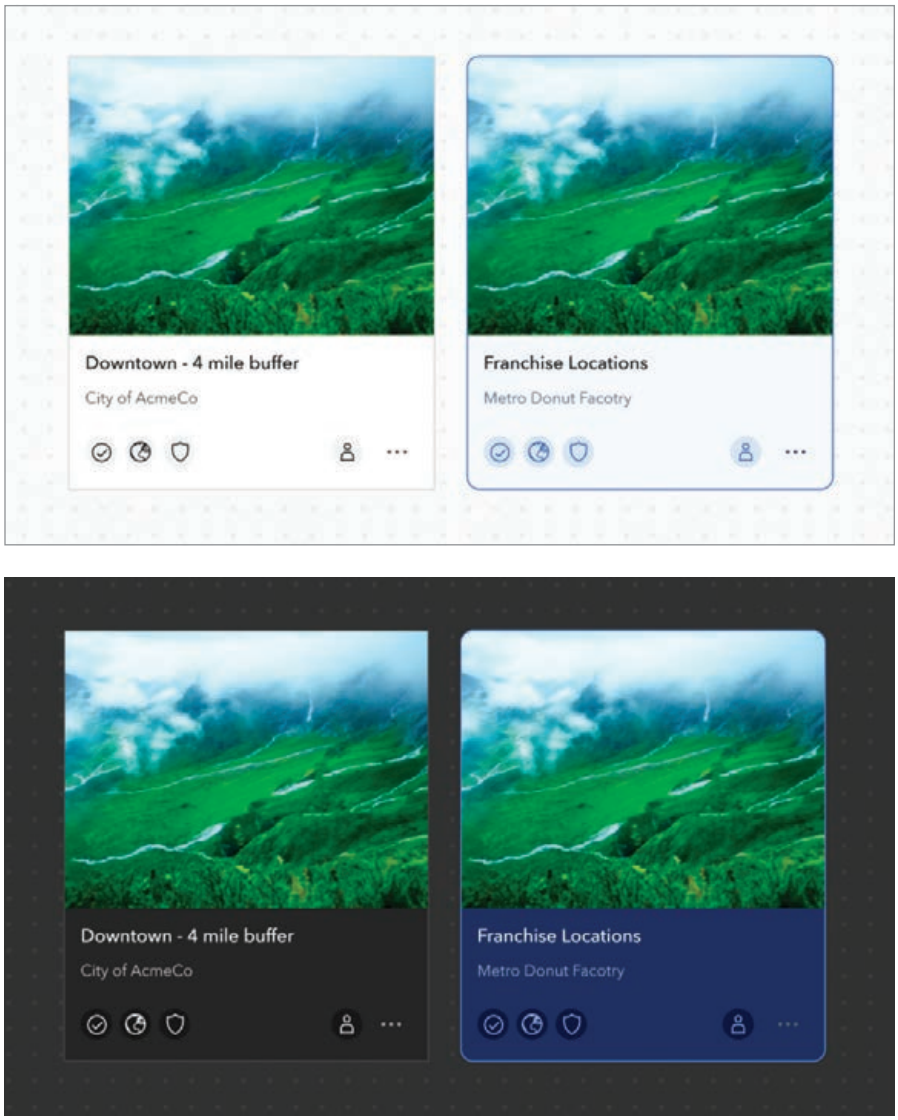


accessibility, localization, and a component preview experience. This release also includes an in-depth guide that covers topics such as best practices, how to build apps with Calcite, and a brand-new Figma UI kit.

Consistent Component API

Because Calcite is the result of a broad collaboration between Esri design and development teams, this naturally resulted in some differences in implementation between components. During the transition to the production release, Esri defined strict rules for component implementation and programming patterns. To provide a standard API across components for developers, changes were made to some of the components' APIs. As a result, apps built with previous beta releases will likely need code updates to match API changes. Consistency updates span the following areas:





↑ Calcite defaults for colors and modes can be overridden to match your brand.

- Naming, events, and property patterns
- Focus and blur events
- Options and methods for floating elements
- Disabled and read-only properties

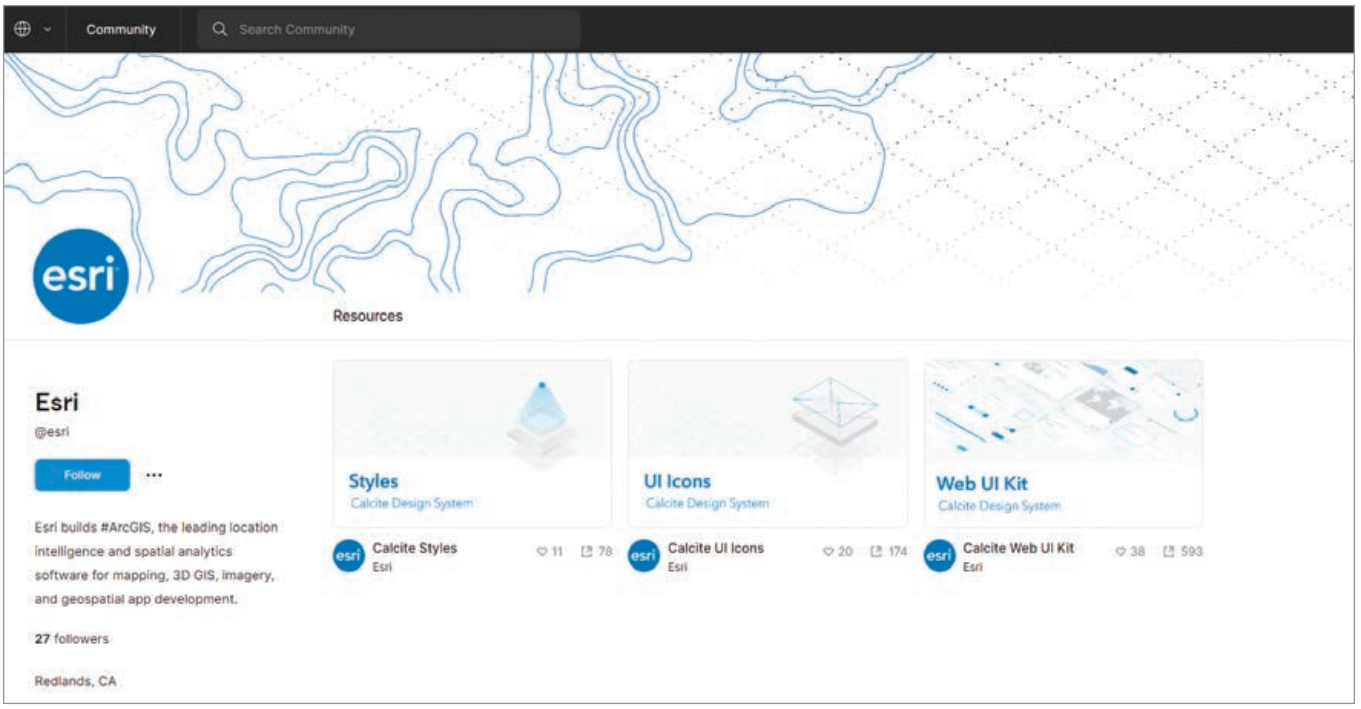
See a full list of breaking changes between releases in the change log (https://bit.ly/3jxe6vt).

Accessibility

Delivering accessible software is a top priority for Esri. Calcite components leverage W3C accessibility standards to ensure the applications and experiences you create are usable by a wide range of audiences. Calcite undergoes third-party accessibility audits to help identify key areas for improvement. In the last year, many updates have been made to Calcite around accessibility including

- The ability to automatically reduce motion based on user preference
- Improved keyboard interaction
- Enhanced assistive technology support such as requiring labels, setting of roles, and Accessible Rich Internet Application (ARIA) attributes
- High contrast support

Esri introduced a new guide that includes accessibility guidelines that outline additional steps you can take to ensure a diverse audience can navigate, understand, and use the solutions you build. Accessibility is an ongoing and incrementally improving project for Esri product teams, and accessibility advancements will be documented



↑ Figma web UI kit

with each release. Check out the release notes (https://bit.ly/3RsqREe) for more details about accessibility updates.

Localization

Calcite components support localization. That means the language used within the UI can be adapted for a specific language and culture. Localization includes support for changing the display language, regional formatting, utilizing numbering systems, and right-to-left (RTL) bidirectional content. With this release, components now have built-in translations for all supported Esri locales in addition to other localization-related enhancements. Learn more in the localization documentation standards (https://bit.ly/3Y0wZWO).

Calcite components are framework agnostic. This means Calcite can be used with any framework.

Framework Integration

Since Calcite components are built on W3C web component standards, they are framework agnostic. This means Calcite can be used with any framework. This release adds improvements to the components when working with virtual document object model (DOM) environments. Resources such as new and updated framework example apps and a guide topic about in integrating Calcite with web frameworks aid implementation. Developers can also use the Calcite Components React wrapper provided to easily use Calcite in apps built with React.

Calcite Resources in Figma Community

You can now access the Figma web UI kit, styles, and UI icons from the Esri Figma Community (www.figma.com/@esri) and stay up-to-date with the latest Calcite Figma resources. Resources will be updated with each major Calcite release. You can also use the Figma Community to ask questions and make suggestions related to Calcite Figma resources.

Figma Web UI Kit

Version 1.0 introduces the Calcite Figma UI kit that designers and developers can use to design their apps inside the Figma environment using Calcite. Design your app inside Figma and be confident that your design will exactly match a web app built with Calcite components.

The new UI kit will sync to Calcite releases. It offers improvements over the beta version. It has been architected with component properties, nested instances, and preferred instances; improved auto layout; support for light and dark modes. It comes with defined frame architecture and naming conventions, and it includes sticker sheets and examples of common component configurations and component usage guidelines.

Note that Figma, a popular design tool, is not an Esri product. Visit the Figma website (www.figma.com) to learn more.

Documentation Site Updates

The documentation site has been updated with more information on best practices, enhancements for exploring and configuring components, and updated resources for getting started quickly.

Each component page has an interactive sample that lets you explore the various

ways in which a component can be configured. Many components were updated to expose new ways for interacting with the component. You can explore a variety of recommended patterns for a given component. Adjust the default Calcite theme variables and preview your brand or application colors within the component. You can visually preview and toggle the visibility of slots within components.

Getting Started Resources

The new guide helps you determine which Calcite component build format is best for your workflow. The new tutorials teach the basics about web components. Because web components are a native browser standard, many technical concepts necessary to develop with Calcite components are not specific to the library. However, to help developers quickly come up to speed on the key aspects of working with web components, Esri added a core concepts guide.

Release Naming

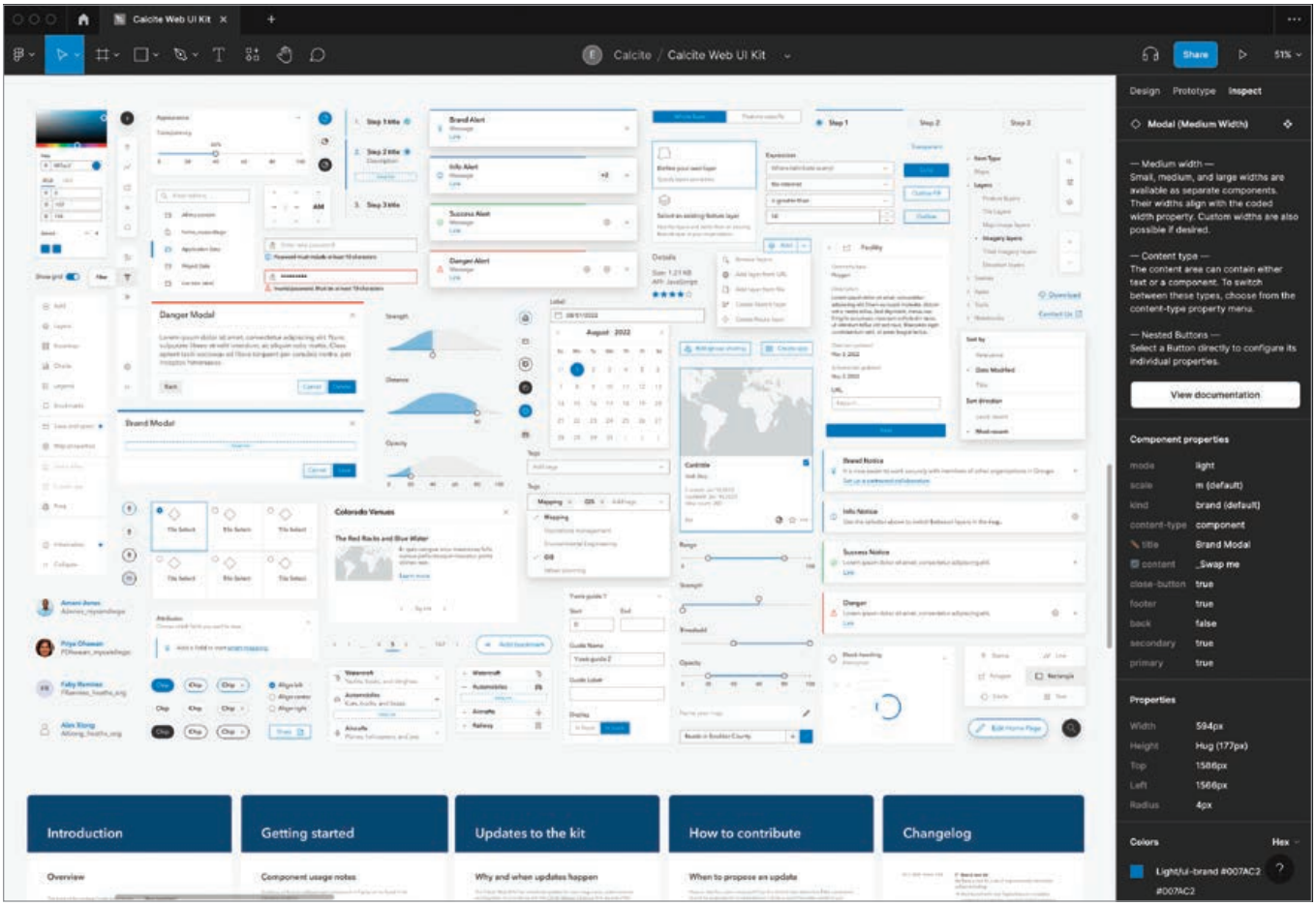
Calcite releases use semantic versioning, which indicates the type of change in a release using the format: MAJOR. MINOR.PATCH. Major versions change incrementally when there are breaking changes. Minor versions change incrementally for new capabilities and enhancements. Patches change incrementally for bug fixes. Calcite will continue to evolve and expand with new components and resources for building great applications.

About the Authors

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

Kitty Hurley is passionate about web map accessibility and bringing the web and maps to wider audiences. She is a product engineer who is focused on the Calcite Design System. She enjoys exploring Minnesota's wilderness and has a goal to visit every major league baseball across America.

↓ Build your web app with Calcite components using the Calcite Figma UI Kit within Figma.



Using ArcGIS Maps SDK for JavaScript in Virtualized Environments

By Andy Gup

Virtualized environments provide certain advantages for organizations such as allowing multiple users to simultaneously share hardware resources through virtual machines (VMs). These systems can scale from a few workers to hundreds sharing resources from one or several host servers.

There are various considerations for using ArcGIS Maps SDK for JavaScript (JavaScript Maps SDK) in these environments including tuning your Virtual Desktop Infrastructure (VDI) and designing your visualizations for best performance. This article introduces basic tuning concepts. For information on designing visualizations, see the Resources section at the end of this article.

Tuning VMs for Web Mapping Applications

Tuning, or sizing, your VDI involves allocating resources to individual VMs. It has options and considerations that are very similar to purchasing dedicated physical hardware, such as a laptop or desktop. However, VM architecture is significantly different, and its performance characteristics can vary widely. A conceptual overview comparing a laptop or desktop computer to a VDI in shown in Figure 1.

For VMs running applications built with the JavaScript Maps SDK, attention needs to be focused on allocating enough virtual memory (vRAM), virtual CPU (vCPU), and virtual graphics processing (vGPU) to meet or exceed the JavaScript Maps SDKs system requirements (see https://bit.ly/3mt8ALC for those requirements). Esri also recommends consulting with your VDI manufacturer for the latest best practices for tuning your environment.

No One Size Fits All VDIs

Sizing virtual machines for your web mapping users, based on the system load created by the applications used for daily tasks, ensures that each user will have adequate vCPU, vRAM and vGPU available to them. For example, users who are focused primarily on data entry will place a significantly lower workload on the host server as compared with users who work on web mapping visualizations. In this oversimplified scenario, data entry worker VMs could be allocated fewer hardware resources than VMs for users doing graphic intensive work.

When VMs are not sized correctly for JavaScript Maps SDK applications, end users notice poor performance such as high latency and stuttering or even reduced rendering quality. This is typically the result of the browser only being able to deliver low frame rates, also referred to as frames per second (FPS). There are a variety of reasons for low frame rates including high vCPU usage, no vGPU, older and slower hardware in the host server, slow network, improperly configured VMs, and even older browser versions that may have WebGL performance bugs.

Graphics Acceleration

Applications built with JavaScript Maps SDK use WebGL for graphics acceleration to provide rich and immersive visualization capabilities in the browser. Many common business applications also take advantage of graphics acceleration, including Google Chrome, Microsoft Edge, Microsoft Outlook, and Microsoft PowerPoint. These types of applications often provide the best user experience when run on machines that have a physical GPU or vGPU.

Most modern computers come with a GPU. Specifically designed to offload graphics processing from the CPU, a GPU lets the CPU focus on nongraphics-related tasks.

However, these applications also work on VMs that do not have a vGPU, but this requires additional vCPU and vRAM for each user to make up the difference in processing power and avoid performance slowdowns. A CPU is less efficient than a GPU when handling graphics processing because it must also simultaneously handle all the other tasks assigned by the operating system.

Minimum Requirements

Inadequate virtual processing resources can occur within an individual VM or on the host server when there are too many users accessing finite resources. It takes time to research these issues to identify performance bottlenecks and then resolve them. As mentioned previously, the JavaScript Maps SDK system requirements also apply to virtual machines. Esri recommends that VDI implementations have a physical GPU in the host server and allocate vGPU resources and a minimum of two vCPUs for each VM. The vCPU allocation also ensures that the configuration aligns with the minimum requirements for using Chrome and Edge browsers in virtual environments. If virtual resources are allocated below the minimum hardware requirements, users should expect performance degradation.

Performance Analysis Tools

There are many tools and best practices that can help tune a VM for best performance when using JavaScript Maps SDK applications. It's important to use a variety of tools to get a complete picture of how fast or slow the VM is performing compared to physical laptops and desktop computers.

Many organizations deploy tools for performance monitoring for the entire VDI. However, that may not always give enough information to quantify the end user's experience in an individual VM while running a specific web application. It depends on how the VDI is configured.

VMs typically do not work like a stand-alone computer with a single user. This is because the host server's hardware resources are being shared with other users. For example, if the host server is overprovisioned, then individual VM performance may fluctuate depending on resources available on the host server at a specific time. Overprovisioning is a scenario where the VDI is configured to promise fixed server hardware resources to too many users, resulting in performance slowdowns for everyone. And since VM usage is variable throughout the day, it can be challenging for IT staff to implement a perfect solution.

The following is a sampling of common end-user tools that give insight into how individual VMs are performing. These tools include Microsoft Windows Task Manager, Google Chrome DevTools, CPU benchmark and browser benchmarks tools.

Windows Task Manager

This handy tool has a performance tab that lets you determine the CPU type, number of vCPU cores, and vRAM allocated to a VM. You can also measure CPU and memory utilization over time. Allocation for VMs, vCPU, and vRAM is dependent on how it's configured in the VDI. However, this configuration is not a guarantee of physical resource availability on the host server. You can use Task Manager to take measurements while going through common workflows with your web mapping application. Then you can compare measurements taken at various times during the day, or even compare them to other VMs that are similarly configured.

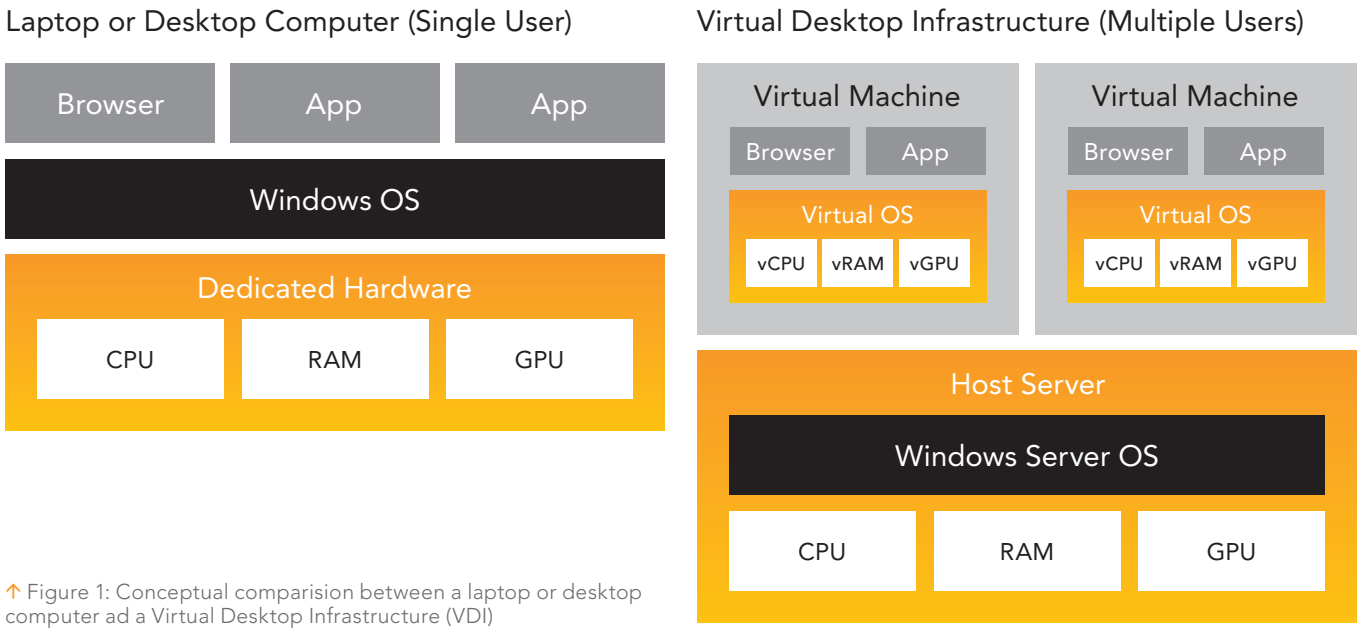
CPU Benchmarks

There are industry-standard CPU benchmarks tools, such as CPU Benchmarks from PassMark, that can give an approximation of how well a vCPU configuration compares to the relative speed of hundreds of other dedicated, physical processors that have run thousands of benchmarks. In general, better results indicate faster performance. Keep in mind, there isn't an exact translation between virtual and physical hardware, and the benchmarking results from a VM are only an approximation of its physical world equivalent.

Always research the benchmark manufacturer's documentation to understand how to interpret results. For example, if the test results indicate the vCPU is on the low end of the spectrum, such as the equivalent of a 2009, two-core CPU, that VM most likely won't perform as well with visually intensive tasks as it would with static web pages that don't involve web maps.

Chrome DevTools

These tools are well documented (https://bit.ly/41OLVJM) and can provide detailed insight into how JavaScript applications perform by finding coding errors, measuring request/response times, and capturing detailed memory snapshots. These tools are crucial for tuning web mapping applications as discussed in the next section.



↑ Figure 1: Conceptual comparision between a laptop or desktop computer ad a Virtual Desktop Infrastructure (VDI)

→ This screenshot shows a VM testing slightly above the average world benchmark for performance.

Browser Benchmarks

There are also browser benchmark tools, such as Basemark Web 3.0 (https://bit.ly/3Zphk43), that can be used to provide insight into how the browser itself is performing within the VM. This type of tool can help uncover browser bottlenecks, because it removes the web mapping application from the equation so that you can focus on pure system performance.

Web Mapping Application Tuning

In addition to tuning VMs, your geospatial data and JavaScript Maps SDK applications should be designed with performance in mind. Just as it is possible to have too few VM resources, due to basic physics it is also possible to create a mapping application that will perform poorly on the most powerful physical machine in your organization.

Esri has provided lots of information about improving your data as well as designing your application for the best visualization performance. Here are several key resources:

- "Enhancements for Mapping More Data, More Efficiently in the Browser" (https://bit.ly/3IX3ZbZ)
- "Techniques for visualizing high-density data on the web" (https://bit.ly/3kPKoma)

Conclusion

VMs often perform differently than dedicated, physical computers. Virtualization introduces additional considerations for tuning both the VM and your web mapping applications. VMs should be configured to the same system requirements as a physical computer including having access to a GPU for the best visualization performance. In addition to designing your web mapping applications for best performance, Esri recommends that you use a variety of commonly available tools to analyze and benchmark VMs to uncover potential configuration bottlenecks.

Additional Reading

- "Optimize Chrome Browser on virtual desktops" (https://bit.ly/3ArSCFa)
- *The Top Four Reasons Windows 10 VDI Needs GPUs*, a NVIDIA ebook (https://bit.ly/3IOXyb4)

About the Author

Andy Gup spends a lot of time outdoors. When he is not on a mountain somewhere, he is a senior product engineer for ArcGIS Maps SDK for JavaScript. Gup works on ES modules, third-party JavaScript frameworks, and other cool mapping-related goodies.

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SUPPORTING THE SCIENCE THAT SAVES THE OCEAN

By Monica Pratt

In March 2023, a global agreement of tremendous importance to the future of the ocean was signed. The United Nations (UN) High Seas Treaty, signed by 193 nations, marks the first step toward establishing policies to reverse biodiversity loss and ensure sustainable development. It creates a framework for protecting the high seas, an area that encompasses two-thirds of the ocean that is located outside of national boundaries and largely beyond most governance.

In the words of UN Secretary-General António Guterres, this treaty is "crucial for addressing the triple threats of climate change, biodiversity loss, and pollution." This agreement is further evidence of a growing appreciation of the importance of ocean and the need to protect it.

A Little-Known and Underappreciated Realm

While the surface of the Earth, its moon, and even planetary neighbor Mars, have been mapped with a high degree of detail, just six years ago only 6 percent of the Earth's seafloor was mapped to a comparable degree of detail. The ocean—which covers more than 70 percent of the Earth's surface—has remained largely unexplored, barely mapped, and poorly understood.

Of all the plants, animals, and fungi found on Earth, a quarter of them live in marine environments. Scientists of the National Oceanic and Atmospheric Administration (NOAA) have estimated that 91 percent of species found in the ocean remain unclassified.

More important, the ocean's contributions to the sustainability of the planet are greatly underappreciated. It is difficult to overstate the ocean's importance. The well-being of the ocean is inextricably bound up with the world's water supply. While only

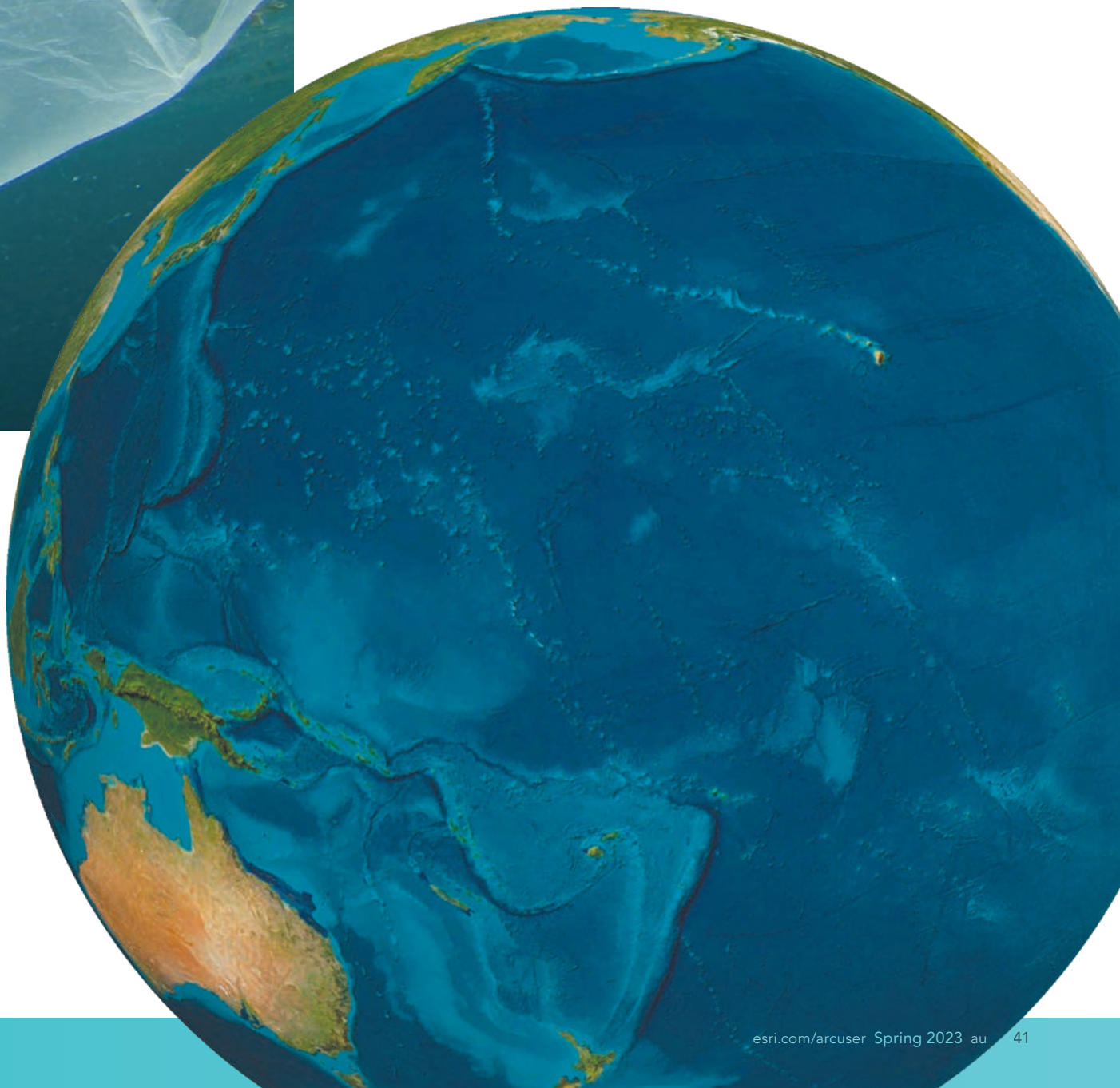
→ The ocean—which covers more than 70 percent of the Earth's surface—has remained largely unexplored, barely mapped, and poorly understood.

2.5 percent of water on Earth is freshwater, the ocean stores of a vast majority of the planet's water (96.5 percent) and provides evaporated water to the water cycle so that it can be circulated around the globe.

Called the world's greatest ally against climate change, the UN states that the ocean generates 50 percent of the world's oxygen while absorbing 25 percent of all carbon dioxide emissions and capturing 90 percent of the excess heat generated by those emissions. This carbon sink is a crucial buffer against climate change impacts.

The ocean also plays an increasingly important role in feeding the world. The nearly 10 million tons of fish caught annually significantly contribute to meeting the needs of a constantly growing population. According to the Food and Agriculture Organization of the United Nations (FAO), the global consumption of aquatic food has increased by more than five times over the last 60 years. The ocean is also the main method of transporting the world's goods. Marine shipping carries approximately 80 percent of world trade.

← The ocean is assailed by debris ranging in size from microplastics to abandoned fishing gear.



Many Threats to the Ocean

The well-being of the ocean and its inhabitants are threatened in many ways that include rising ocean temperatures, pollution, overfishing, and seabed mining. As concentrations of greenhouse gases have risen, the concentrations of heat at the sea surface and in the top 700 meters of the ocean and additional warming for the top 2,000 meters have increased overall during the past 30 years. With this temperature change have also come sea level rise, coastal land loss, and coastal flooding. Increases in carbon dioxide levels in the ocean have resulted in higher acidity levels in the ocean. Increased ocean temperatures and acidification both adversely affect marine species and ecosystems.

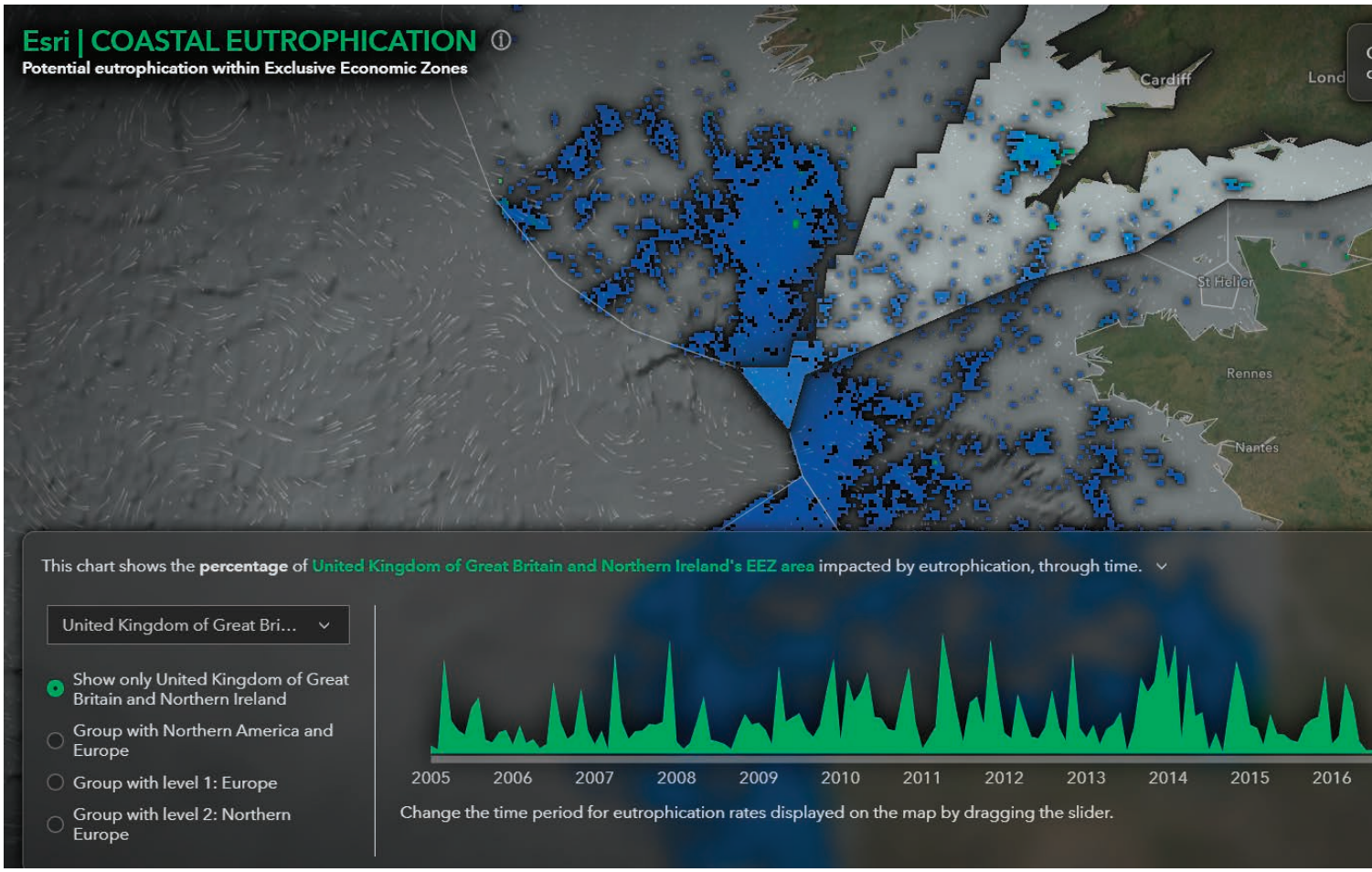
The ocean is assailed by many sources of pollution. Debris, from microplastics as small as 5 millimeters to abandoned fishing gear, is a highly visible form of pollution. The National Institutes of Health estimates that 10 million metric tons of debris are dumped into the ocean annually. Nonpoint pollution from sources, such as septic tanks, farming operations, timber harvesting, and manufacturing chemicals, are more difficult to measure. More easily identified, point source pollutions from events, such as oil spills, discharges from factories, or water treatments, are easier to identify but just as detrimental.

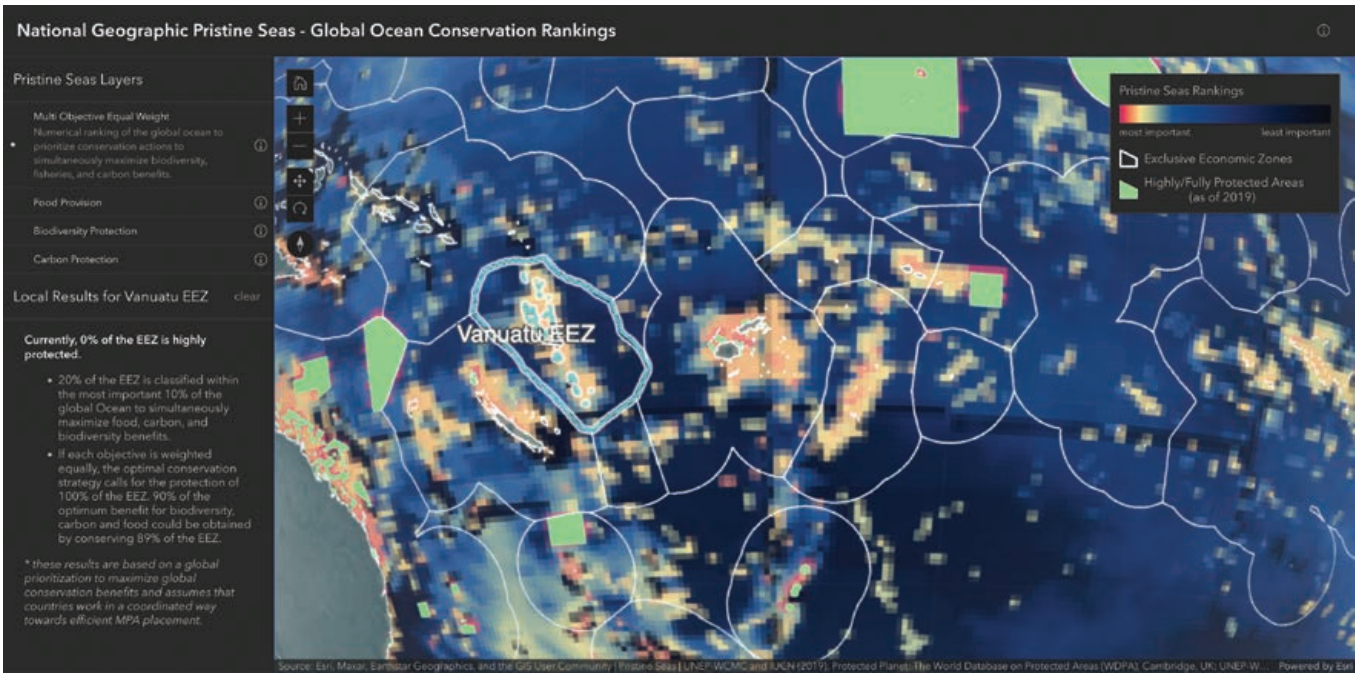
As the demand for food from the sea to feed a growing world population increases, unsustainable fishing practices are having a growing and negative impact. The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species includes 1,550 species of marine plants and animals that are at risk of extinction. *The State of World Fisheries and Aquaculture 2022*, a report by the FAO noted that the percent of the fishery stocks fished within sustainable levels has decreased from 90 percent in 1970 to 64.6 percent in 2019. In addition, many more species are depleted by large-scale commercial fishing practices that inadvertently catch fish and other sea life that are discarded.

In recent years, commercial mining of seabed minerals is posing a new threat. Of 50 essential minerals, 37 of them are found in the ocean. One of the first deep mining projects is proposed for an area off Papua New Guinea, following several years of exploratory drilling. These excavation activities promise to be profoundly disruptive to marine life, ocean health, and the lives of those in the region who depend on the ocean for their livelihoods.

Esri and The Science of Where

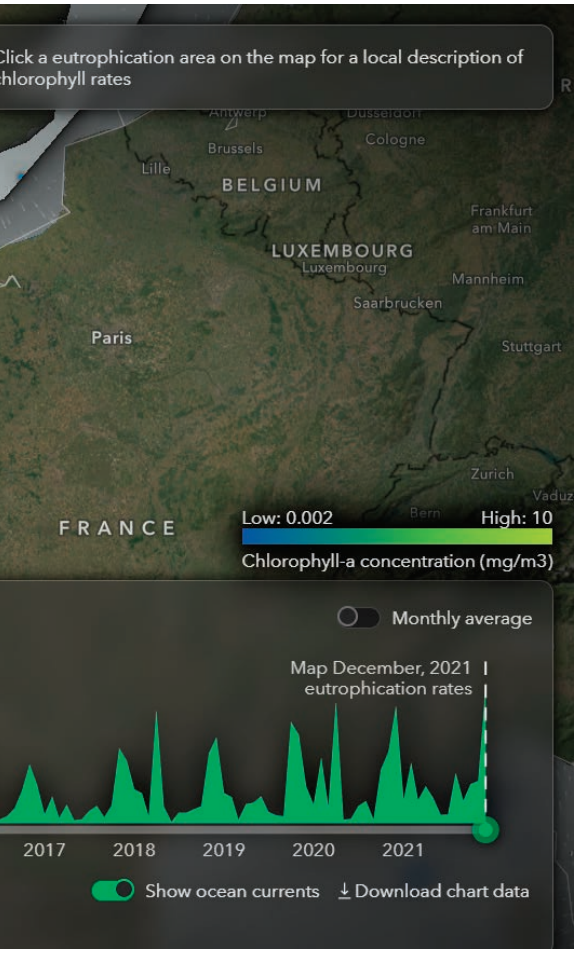
During closing comments at the 2022 Esri Ocean, Weather, and Climate GIS





↓ The Coastal Eutrophication app makes information about the impacts of ocean pollution from land-based activities more accessible.

↑ This web app developed by Esri and Pristine Seas will let policy makers weigh the trade-offs between loss of biodiversity, the depletion of food resources, or the release of greenhouse gases by oceans to arrive at more equitable solutions.



Forum, Esri president and cofounder Jack Dangermond shared a little about the company's founding. "Esri was started with this idea 53 years ago, not far from here, to basically build an organization in a very modest way that would apply rational thinking and science to environmental protection and land-use planning."

Esri's ongoing commitment to the environment and science has been summarized by Esri chief scientist Dr. Dawn Wright. "Science underpins everything that Esri produces. We're very excited about all the things that we're doing across all of the environmental sciences. This is embedded in what we do, to strengthen the foundation of our software and services; to research, publish, communicate, and serve alongside the scientific community; and to inspire positive change in society."

Esri is engaged in efforts to further scientific research and preserve the ocean. In 2012, Esri hosted the inaugural Esri Oceans Summit, which brought together academic and research institutes, government agencies, nonprofit organizations, consultants, and ocean-related businesses that use GIS in the marine environment. This event kicked off the Ocean GIS Initiative, which has sought to increase the extent and quality of seabed mapping and improve support for multidimensional data and analyses.

In succeeding years, the event has evolved into the Esri Ocean, Weather, and Climate GIS Forum. Esri has contributed to the significant progress that has been made on the goals outlined in the Ocean GIS Initiative. It has combined the ocean basemap with the Esri's world elevation services to develop a comprehensive land and sea service, supported development of vertical time-dependent data transformations, and enhanced the integration of numerical models.

Not only is science foundational to the development of Esri's technology, but as an organization, Esri and Esri staff members are actively involved in scientific research. This includes participation in several programs that are part of an ambitious UN initiative dedicated to better understanding and preserving the ocean.

A Plan for the Ocean

Recognizing that threats to the ocean are escalating and the ocean plays an essential role in sustaining the Earth, the UN declared 2021 to 2030 the United Nations Decade of Ocean Science for Sustainable Development

(Ocean Decade). The goal of this ambitious and wide-ranging plan is to move from "the ocean we need for the future we want" through developing ocean science that will provide a better understanding of marine ecosystems, inform policy to reverse its decline, and support actions for sustainably managing the ocean and achieving the UN 2030 Agenda for Sustainable Development. Through an alliance of scientists, resource providers, governments, businesses, and industries, the Ocean Decade Alliance hopes to revolutionize humanity's relationship with the ocean.

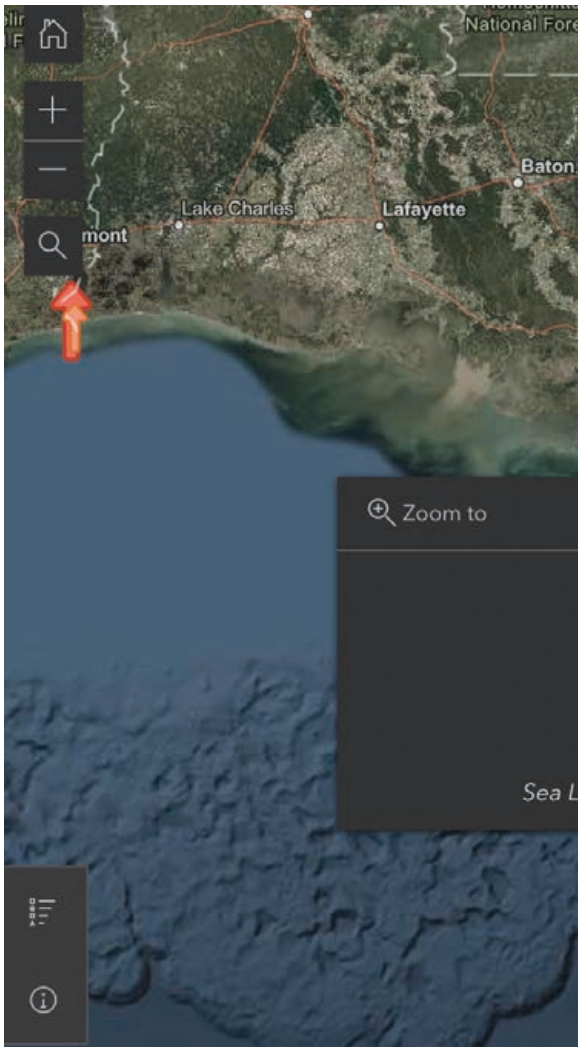
Esri is participating in several Ocean Decade programs:

- Seabed 2030, led by the Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO); and the promotion of Seabed 2030 and Ocean Mapping by the United States, which is led by NOAA.
- Digital Twins of the Ocean (DITTO), led by the GEOMAR Helmholtz Center for Ocean Research Kiel and Kiel University.
- The Deep Ocean Observing Strategy (DOOS), which is led by the Scripps Institution of Oceanography.
- Early Career Ocean Professionals (ECOP), led by the Ocean Decade Informal Working Group for Early Career Ocean Professionals.

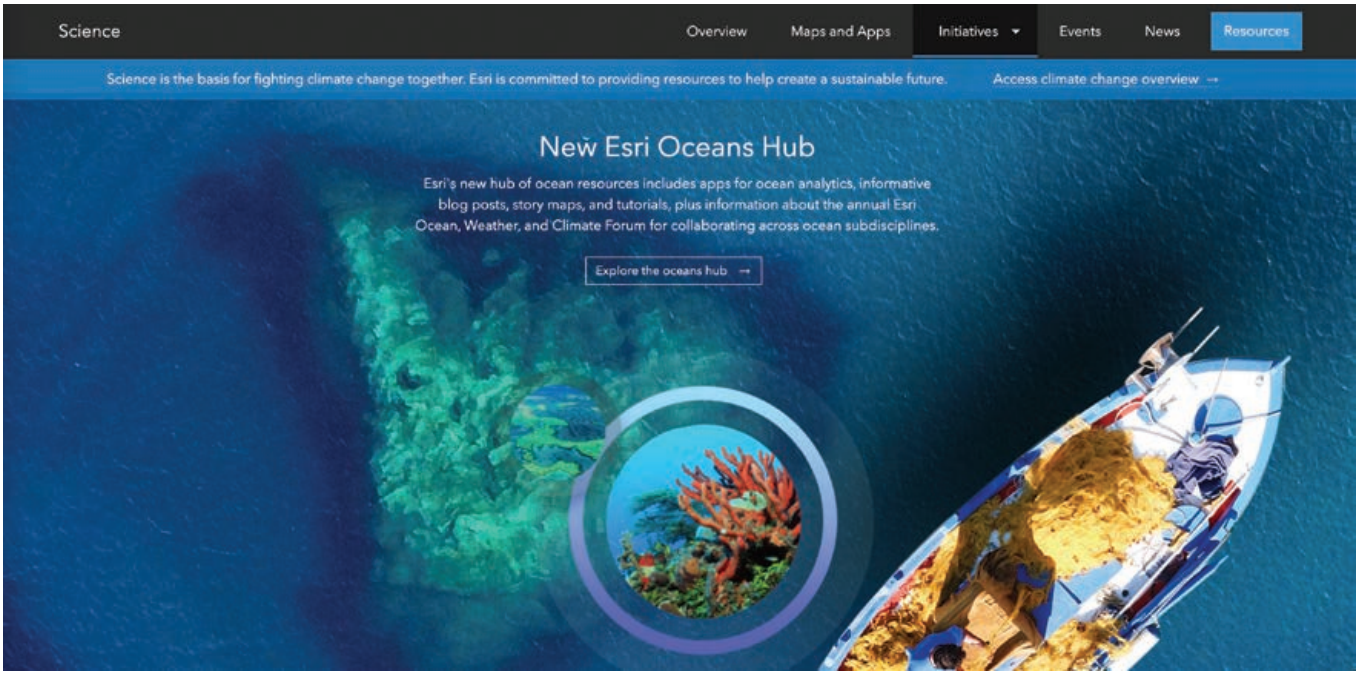
Esri is also a member of the Ocean Decade US Nexus, a program of the US National Ocean Decade Committee of the National Academy of Sciences that communicates news about US efforts related to the Ocean Decade.

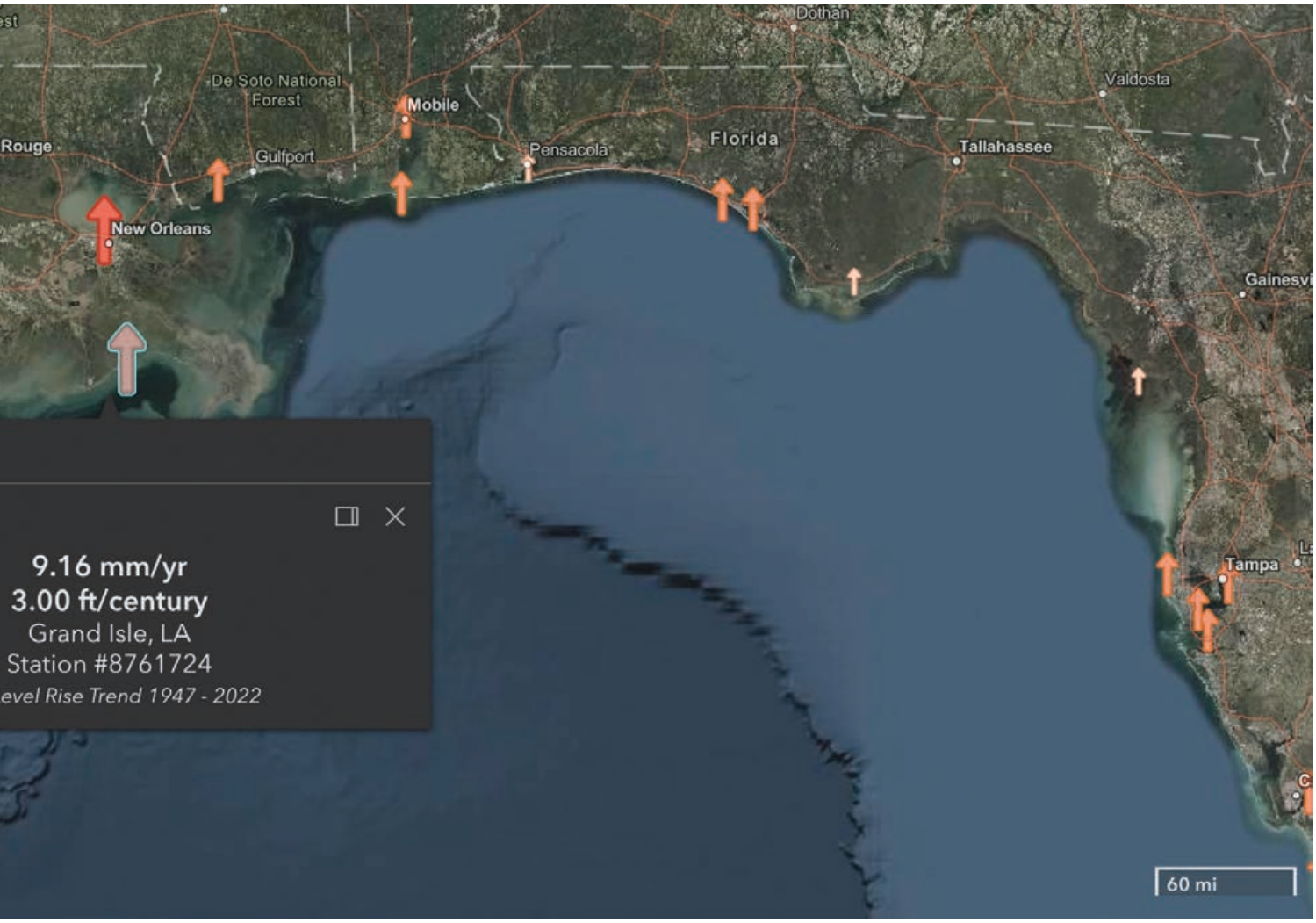
Mapping the Ocean Floor

The Seabed 2030 Project was one of the first actions of the Ocean Decade. It is a global initiative to map 100 percent of the ocean floor to modern standards by 2030. When the project first launched in 2017, only 6 percent of the seabed was mapped. Seabed mapping supports the UN Sustainable Development Goal (SDG) 14: Life Below Water and is vital for the navigational security, safety, and economic health of countries around the world. A detailed knowledge of bathymetry is required to maintain the hundreds of thousands of square miles of cables that enable telephone communications, public and private data transmission, and the internet. The GEBCO digital map being built now covers more than 20 percent of the seabed, and



↓Visit the New Esri Oceans Hub to access ocean analytics apps and blog posts, story maps, and tutorials ocean science.





↑ The Sea Level Rise ArcGIS Hub makes resources for understanding coastal flooding and sea level rise available.

research vessels are continually expanding the area mapped.

Esri, a partner in Seabed 2030, has been contributing to this project by promoting the project's vision within the wider geospatial community. As a partner, Esri is involved in the collection of bathymetric data and sharing solutions developed for ocean mapping and bathymetric data management.

Digital Twins of the Ocean

Esri is part of a global network of 40 partners working on DITTO, a Ocean Decade program to make ocean data and information technology accessible to "all nations, stakeholders, and citizens." To realize the program's goal, Esri and its collaborators developed the Ecological Marine Units (EMUs), a 3D digital ocean model, which includes 50-year volumetric averages of ocean temperature, salinity, dissolved oxygen, and nutrients.

Digital twins of the ocean will provide a digital framework for marine data, modeling, and simulation that utilizes artificial intelligence (AI) and specialized tools for manipulating, analyzing, and visualizing marine information. This program is developing digital twins of the ocean that will be shared to support ocean science and asking what if questions when examining use cases and developing best practices and governance policies that promote sustainability. With a digital twin of the ocean, not only can the current ecosystem be more thoroughly understood, but its future state can be modeled based on scenarios such as the effectiveness of sea level rise mitigation efforts.

Telling the Story of Data

DOOS, which has been endorsed as an Ocean Decade program, is an international organization that coordinates the observation, exploration, mapping, and modeling of deep ocean baseline conditions and the effects of climate change and human disturbances. This information is essential to promoting a healthy, resilient, and sustainably managed deep ocean. DOOS also promotes early career researchers to aid them in developing into leaders in ocean science.

The overarching goal of DOOS is the promotion of a deep ocean community that spans disciplines and fields. Consequently clear, engaging, and meaningful communication that facilitates collaboration between members of the scientific community and translates scientific advancements to the public and policy makers is essential.

The visualizations available in GIS via maps, dashboards, and ArcGIS StoryMaps help tell those data stories.

Implement DOOS (iDOOS), also an Ocean Decade program, seeks to build a network of networks that includes undergraduate institutions, as well as industries, nonprofit organizations, and governments across disciplines and communities related to the field of deep ocean observing (i.e., the ocean below 200 m depth). The project also funds six Early Career Researchers (ECRs) who are coleaders in each iDOOS working group. Esri chief scientist Wright is a coprincipal investigator on the iDOOS science translation working group. The entire project is run as a hub site using ArcGIS Hub.

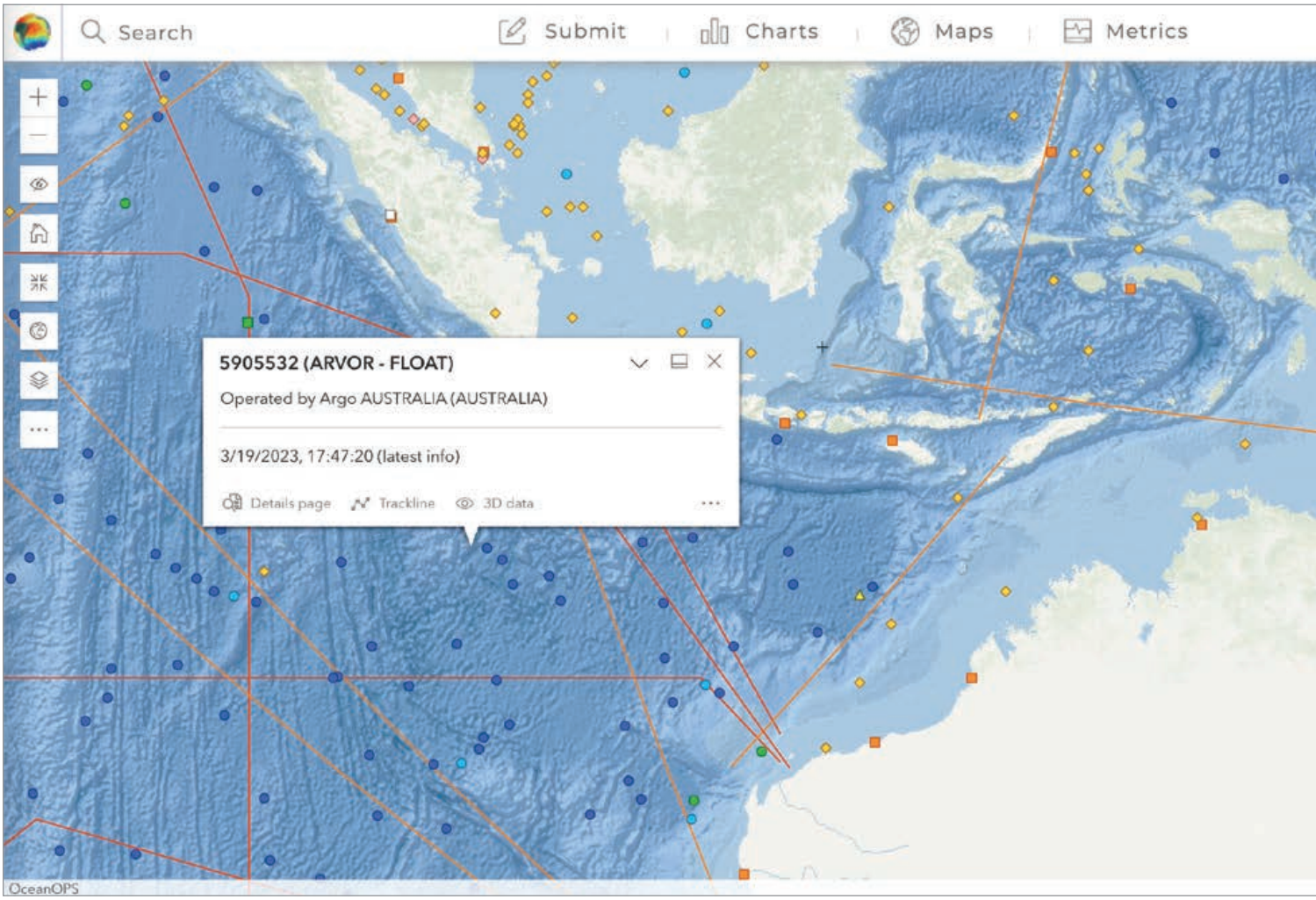
Informing Action

In addition to its work on projects and initiatives associated with the Ocean Decade, Esri is working with the UN and other organizations around the world to build the geospatial infrastructure that will drive science and its application to address the world's problems. It is only through better understanding of the ocean and its critical and complex role in the functioning of Earth's systems, can both ocean and Earth be preserved.

In partnership with GEO Blue Planet, the ocean and coastal division of GEO that connects information on the ocean and coastal areas with society, and the United Nations Environmental Programme (UNEP), Esri has created an index for coastal areas showing where excessive accumulation of plant nutrients cause eutrophication. Information on the potential for eutrophication in exclusive economic zones (EEZs) contained in this index is made available through the Coastal Eutrophication app. Information about the impacts of ocean pollution from land-based activities is now more accessible and can be used to support informed decision-making to help reach SDG 14.

OceanOPS, a joint center of the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, provides monitoring, coordinating, and integrating data services and metadata for a network of global oceanographic and marine meteorologic observing communities. The

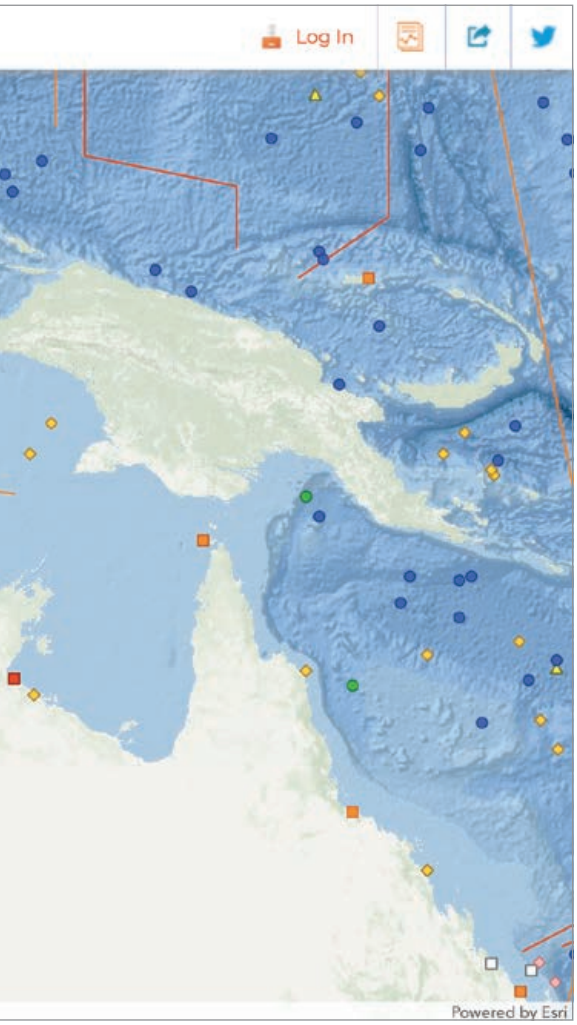
↓ The OceanOPS dashboard, built with help from Esri, makes available the data from the thousands of floats that monitor ocean and coastal conditions.



Science Applied to Real-World Challenges

GIS for Science is a three-volume series published by Esri Press and written for professional scientists, citizen scientists, and anyone who is interested in science, geography, and conservation. The chapters in *GIS for Science,* Volume 1: *Applying Mapping and Spatial Analytics; GIS for Science,* Volume 2: *Applying Mapping* and *Spatial Analytics;* and *GIS for Science,* Volume 3: *Maps for Saving the Planet* show how the geographic approach and geospatial technologies are being applied to meeting the challenges of climate change, loss of biodiversity, natural disasters, and other pressing issues on both land and sea. The strategies presented can inspire applications and research across other disciplines.

A companion site, gisforscience.com, makes related data and other resources available. Each volume is linked to a technology showcase illustrating how advances in science can be leveraged to affect change in the world. Purchase print editions from Esri Press at esri.com/en-us/esri-press/overview or other book sellers.



OceanOPS dashboard, built with help from Esri, makes available the data from the thousands of floats that monitor ocean and coastal conditions.

Balancing Sustainable Factors

In March 2023, Esri participated in the eighth annual Our Ocean Conference. The conference brings organizations together to ensure protection of the ocean through managing marine resources responsibly; growing sustainable blue economies and tourism; and creating marine protected areas (MPAs) where damaging activities are banned and marine life thrives.

Since 2014, Our Ocean Conferences has attracted commitments worth approximately US$108 billion. At the 2023 conference, Esri announced a commitment with the National Geographic Society's Pristine Seas to develop a web application that shows to new global conservation rankings that assess, monitor, and improve MPA management. For more than a decade, Pristine Seas has worked with local communities and governments to create 23 of the largest MPAs in the world. Learn more about the work of Dr. Enric Sala, a National Geographic Explorer in Residence, on Pristine Seas from this ArcGIS StoryMaps (https://bit.ly/409UI7i).

There is no perfect solution to stop the loss of biodiversity, the depletion of food resources, or the release of greenhouse gases by oceans. Effective policies balance these requirements. Sala's work has developed rankings of these factors to arrive at more equitable solutions. The web app (https://bit.ly/3A1jyLP), developed by Esri and Pristine Seas, will let policy makers weigh the tradeoffs between factors using tools that yield results that are easier to interpret.

Independently, Esri has created the Sea Level Rise ArcGIS Hub (sea-level-rise-esrioceans.hub.arcgis.com/) to make resources for understanding coastal flooding and sea level rise. This portal, which brings together apps, stories, and documents, was based on work Esri did creating the Climate Mapping for Resilience and Adaptation (CMRA) in 2022.

The Most Effective Approach Is a Geographic One

The ocean is fragile and is threatened by many forces. However, more than anything else, the ocean is threatened by our ignorance of it. Through its use of the geographic approach, GIS offers the best technology for gaining a more holistic understanding of this complex environment through the collection, analysis, and modeling of data about the ocean and the continued development of new research methods.

In dealing with the accelerating effects of climate change, Dangermond has said, "Time is not on our side, but technology is." He believes that GIS professionals and scientists from different fields are creating information products that will affect the behavior of organizations. Using GIS, this information can be effectively shared between scientific researchers and communicated to policy makers and the public, enabling decisions that will help sustain the ocean and Earth.

About the Author

Monica Pratt is the founding and current editor of *ArcUser* magazine, the executive editor of *ArcNews* magazine, the editor of *Esri Globe* and the head of the Publications team at Esri. She has been writing on technology topics, specializing in GIS, for more than 30 years. Before joining Esri in 1997, she worked for newspapers and in the financial industry.

High-Quality Field Descriptions *Make Mapping Easier*

By Diana Lavery

Making a map is a great way to visualize quantitative data because it shows the data values in combination with location intelligence. However, making a map requires understanding the attributes being mapped. If descriptions of those attributes are a few clicks away, that significantly decreases the time the mapmaker needs to understand the attributes.

The field descriptions of feature layers in ArcGIS Online are a structured place to communicate all details of attribute fields, including:

- Definitions
- Sources
- Vintages
- Units

Expressions for Calculated Fields

These descriptions help analysts navigate the ever-growing corpus of data by putting this field-specific documentation as close to the field as possible. This limits the amount of time analysts need to search for documentation. Analysts use this information to ensure they're using the right attributes for their purposes.

Many layers in ArcGIS Living Atlas of the World, such as American Community Survey hosted feature layers, USA Census 2020 Redistricting layers, Bureau of Labor Statistics Monthly Unemployment layer, County Health Rankings 2022, and Justice40 Tracts, include long field descriptions.

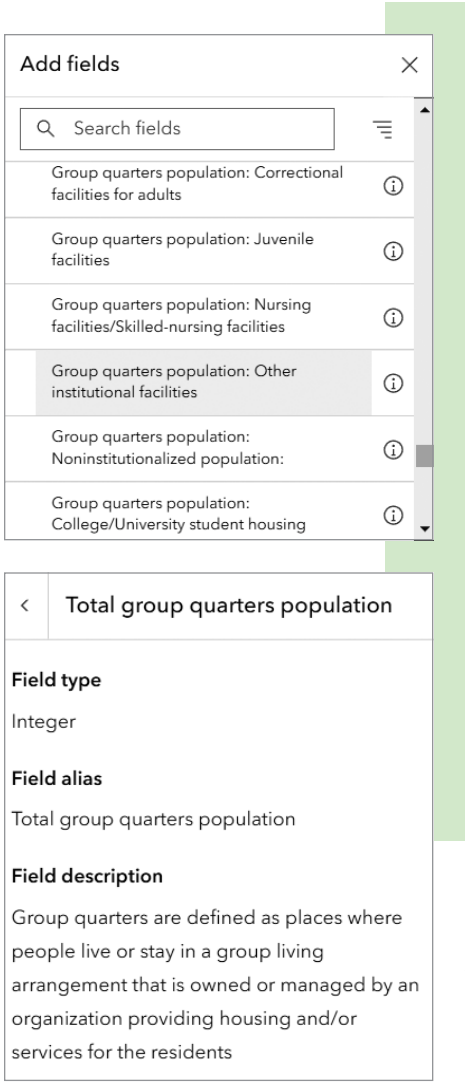
Learn Definitions

GIS analysts know that GIS can help shed light on complex topics, like climate change, social justice, and economic development, by visualizing opportunities to intervene. Those complex topics often come with a specific vocabulary that allows subject matter experts to describe details efficiently. Unfortunately, to the layperson, this language can sound like industry jargon. One example of this jargon is the phrase "group quarters population." It's defined as people living in group-based settings such as college dorms, military barracks, correctional facilities, or assisted living homes.

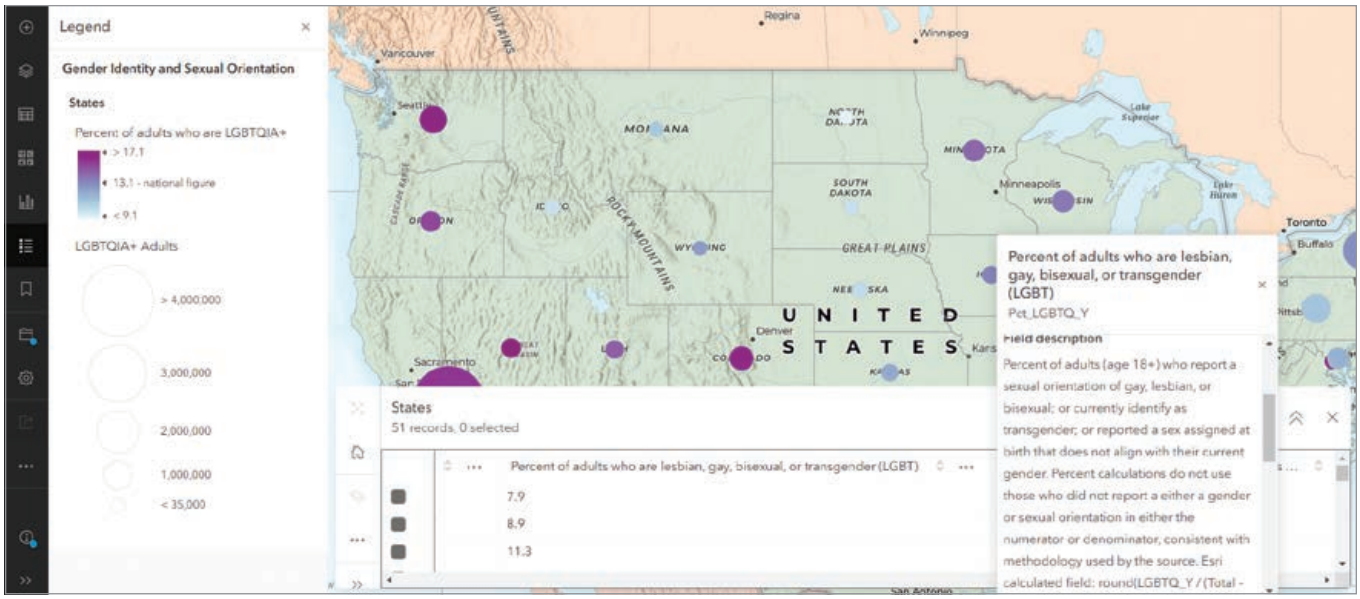
By opening the USA Census 2020 Redistricting Tracts layer in Map Viewer, you can see a field displayed as Total group quarters population in the fields list for styling the map. The i information button provides the definition:

"Group quarters are defined as places where people live or stay in a group living arrangement that is owned or managed by an organization providing housing and/or services for the resident."

Another useful type of definition included in the field description—when appropriate—is one for coded values. For example, every census block, block group, tract, and county are contained in a state (or state equivalent if in Washington, DC, or Puerto Rico). This state is a field on the layers for lower levels of geography. Similarly, these codes are also contained within a census division. The coded values for the attribute division range from 0 to 9. In this case, the description serves as a codebook that exposes which division each value corresponds to.



← Open the USA Census 2020 Redistricting Tracts layer in Map Viewer, select a field, and click the i information button to view field definition.



↑ Open the attribute table for the layer, click more options (…) and choose the i information button to access information about a specific field including the field description.

One click on the i information button gives a better understanding of these topics. Not leaving Map Viewer to get the definitions on another website saves time. The layer provides the definitions you need in the field descriptions.

Learn Expressions for Calculated Fields

I find that working with calculated fields can be cumbersome and time-consuming, because sometimes my own calculations don't match what I'm seeing on the layer I'm working with. I want to see the formulas used, since knowing exactly how a field was calculated can be extremely helpful.

For example, the Living Atlas Gender Identity and Sexual Orientation layer does not include those who did not report certain characteristics in either the numerator or denominator of percent calculations. You can explore the field descriptions by opening the attribute table, clicking … (more options) in the header for the specific field in the attribute table and choosing the i information button to access information about a specific field including the field description. The formula used for the field can be viewed. With that information, I have greater trust in an attribute than when I wasn't replicating the values, and I don't need to leave the Map Viewer and read through a methodology document from the source. My question was answered in a few clicks.

Learn Sources, Vintages, and Units

Some datasets are valuable in part because they bring together information from multiple sources. While it is very useful to have different types of information in one unified layer, it can raise questions about sources and vintages. However, the field description is an ideal place to store this type of attribute-specific metadata. For example, each year the Robert Wood Johnson Foundation undertakes the herculean task of combining several sources and updating each with the latest vintage data available to produce its County Health Rankings. This results in a very informative layer that provides attributes on topics such as obesity, smoking, child poverty, and mammogram screening.

If I'm interested in underlying sources and vintages of the data used in this layer, I will look at the layer's item page. However, much of this information on sources will differ depending on the attribute. To find out the underlying source and vintage of an attribute, all I have to do is click the Data tab on the item page. This brings me to the attribute tables, and from there, I hover over the field I want to learn more about, in this case, percent low birth weight.

Hovering over the column exposes the field description, which includes source information. The source for data on low birth weight is the National Center for Health Statistics—Natality files for years 2014–2020. This field description also notes that low birth weight is defined as weight less than 2,500 grams, and that it's 20 percent of the Health Outcomes ranking.

For large GIS projects, there are dozens of fields that have detailed information associated with them. Here the fields list on the item detail page can be extremely helpful. In the Data tab, simply switch from Table view to Fields view. Try the List option or the Table option to discover which one works best for your needs. I find the List option is the most ideal because it displays all field information (including field descriptions) in one place.

Field Descriptions Are Visible in Many Places

From the previous examples, you probably noticed that field descriptions are available in many places in ArcGIS Online. Get to them within the Map Viewer's symbology options, viewing the attribute table within Map Viewer, and in the Data tab of the item page. Exposing the field descriptions in multiple user experiences makes viewing the descriptions just a few clicks away from whatever you're doing. Next time you're working with a layer in ArcGIS Living Atlas and have a question about an attribute, check for a field description.

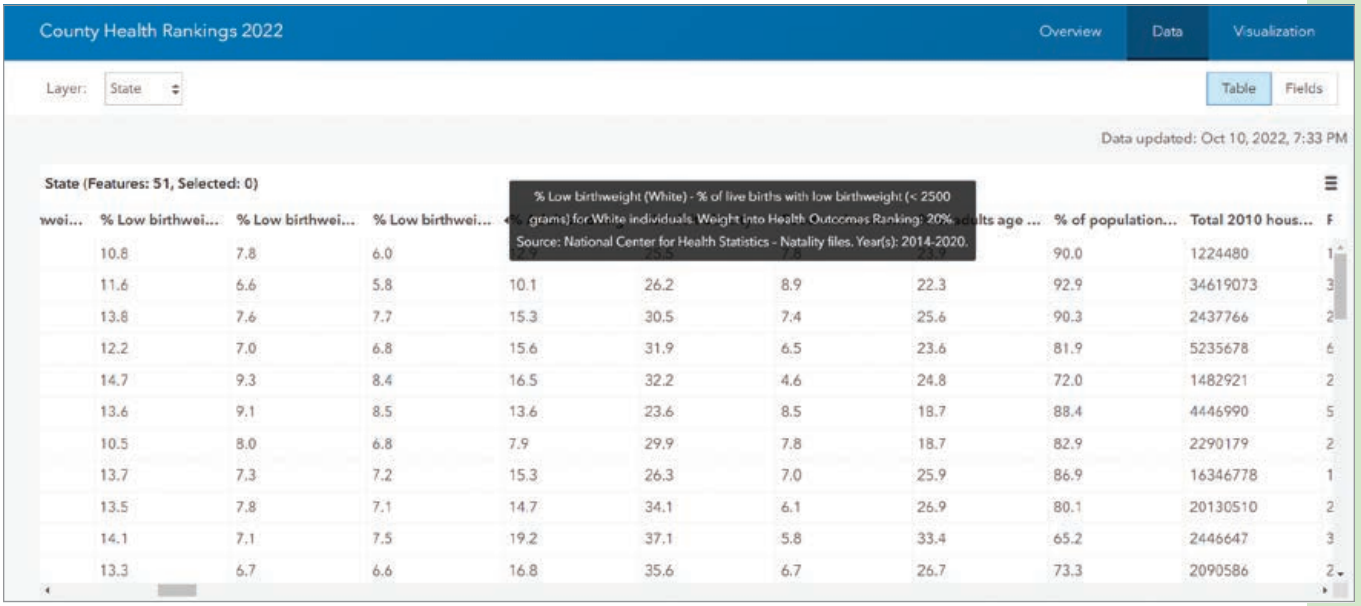
Include Long Field Descriptions on Your Feature Layers

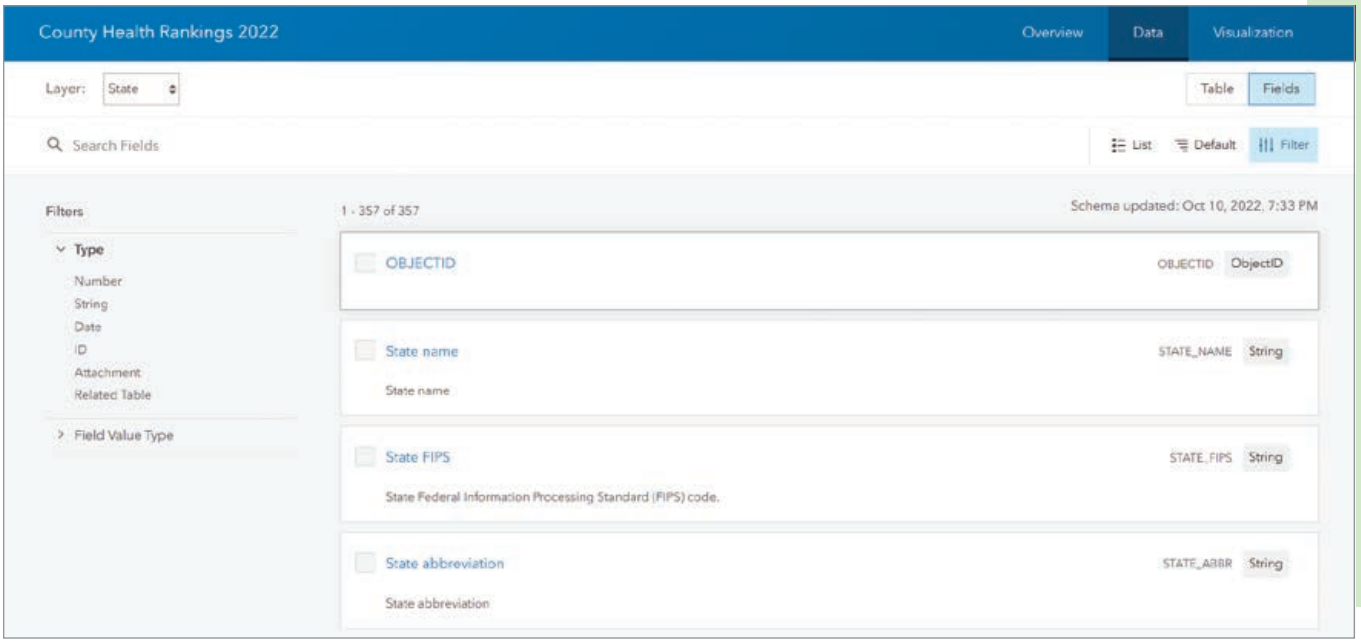
In most large organizations, the analysts who publish layers are different from the analysts who use the layers for mapping. And the people who create dashboards, apps, and stories can be different. Are you publishing feature layers for your organization that others use downstream in a workflow? Consider including long field descriptions on some of your layers in this case.

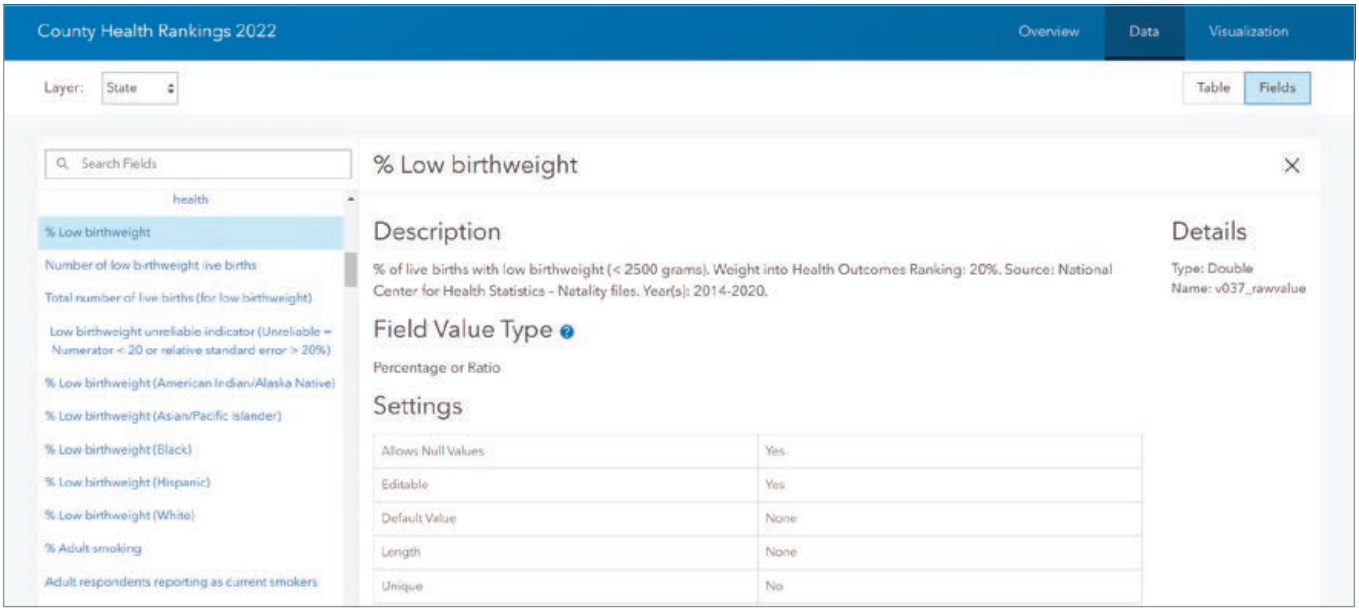
From an organizational perspective, analysts are creating a high-quality institutional asset that can avoid misinterpretation of data, which reduces costs. From an individual perspective,

↓ To find out the underlying source and the vintage of an attribute, click the Data tab from the item page to access the attribute tables. Hover over the field to learn more about an attribute including any formulas that have been applied.

↓↓ Use the fields list on the Data tab to access field information when using layers that have a large amount of detailed associated information.







↑ From the item page, click Data > Fields and change from Table view to List view, then click on the field to edit.

analysts are providing answers to specific questions about various fields in a self-service style, which reduces questions piling up in analysts' inboxes.

Creating Descriptions

The most time-intensive part of creating field descriptions will be writing out the descriptions themselves because that can involve looking through codebooks, metadata in data warehouses, information across multiple sources, and other kinds of technical documentation that may or may not be well organized. Since the main goal of field descriptions is to communicate information about the field, it can be worthwhile to ask people who use the map layers you create what they need to know about the attributes. You can ask questions such as:

- Is the source the most important thing to put first?
- What definitions are needed?
- Do we include formulas?
- Do any acronyms need to be spelled out?

When they write descriptions for a handful of fields, analysts will quickly realize that it takes dedicated time. If creating field descriptions for every single field seems overwhelming, start with the fields that generate the most questions. Which attributes generate the most questions?

The actual mechanics of applying the field descriptions are easy for the item's owner. It can be done manually through the ArcGIS Online graphical user interface (GUI), or through a scripted process. A scripted process is most ideal when editing many fields.

Applying Descriptions Manually through the GUI

From the item page, click Data > Fields > to change from Table view to List view. Then click the field you'd like to edit.

By opening the USA Census 2020 Redistricting Tracts layer in Map Viewer, you can see a field displayed as Total group quarters population in the fields list for styling the map. The i information button provides the definition.

If you're working with multiscale layers, make sure the desired layer is selected in the drop-down option. If your layer contains many fields, use the search bar to search within the fields. Or use the filter options to filter by field type. The character limit for adding descriptions manually through the user interface is 500.

Applying Descriptions through a Scripted Process

If you'd prefer a scripted process to save time and reduce the potential for human error, I highly recommend AliasUpdater (https://bit.ly/3XPXf5P), a Python script created by Esri staff member Lisa Berry. It was designed to help you update the aliases and descriptions for hosted feature services.

You'll need a Microsoft Excel table containing the field names, desired aliases, and desired descriptions. This script also allows for assigning other options including attribute field type, decimal places to display, and comma separators. The character limit for adding descriptions through a scripted process is 1,064.

Recap

Field descriptions help clarify confusion around definitions, units, sources, vintages, and more. Many layers in Living Atlas contain field descriptions for all attributes. This helps analysts learn more about what exactly they are mapping in just a few clicks. Adding field descriptions to your own layers is straightforward.

About the Author

Diana Lavery (she/her/hers) loves working with data. She has more than a decade of experience as a practitioner of demography, sociology, economics, policy analysis, and GIS. Lavery holds a bachelor's degree in quantitative economics and a master's degree in applied demography. She is a senior product engineer on ArcGIS Living Atlas of the World's Policy Maps team. She enjoys strong coffee and clean datasets, usually simultaneously.

Give REST a Rest

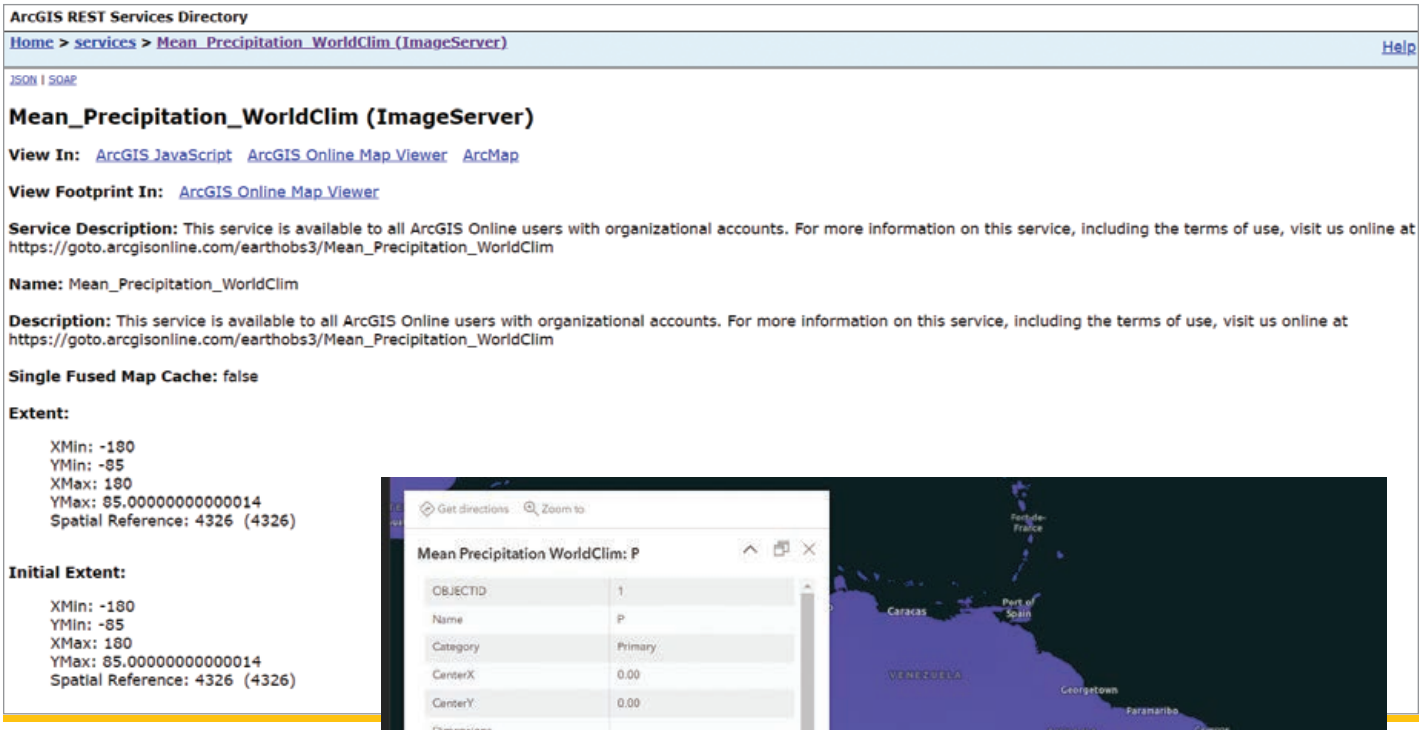
By Dan Pisut

Using the REST service URL to build maps and apps is no longer a best practice. Learn about all the benefits of using an ArcGIS Online item to build maps instead.

How many of us have used Add Data from Path with a REST endpoint or Add layer from URL with the REST endpoint when building a map in Map Viewer in ArcGIS Online?

It's the typical pattern we were taught to use with Web GIS: find the REST endpoint and then copy and paste it into your project. But when you do that, you're just making life more difficult for yourself.

What most people don't realize is that an item hosted on ArcGIS Online is very different from a service (or REST endpoint). You can think of an item as a specific configuration of a service. There can be many different configurations of a service,



ArcGIS REST Services Directory

Home > services > Mean_Precipitation_WorldClim (ImageServer) Help

JSON | SOAP

Mean_Precipitation_WorldClim (ImageServer)

View In: ArcGIS JavaScript ArcGIS Online Map Viewer ArcMap

View Footprint In: ArcGIS Online Map Viewer

Service Description: This service is available to all ArcGIS Online users with organizational accounts. For more information on this service, including the terms of use, visit us online at https://goto.arcgisonline.com/earthobs3/Mean_Precipitation_WorldClim

Name: Mean_Precipitation_WorldClim

Description: This service is available to all ArcGIS Online users with organizational accounts. For more information on this service, including the terms of use, visit us online at https://goto.arcgisonline.com/earthobs3/Mean_Precipitation_WorldClim

Single Fused Map Cache: false

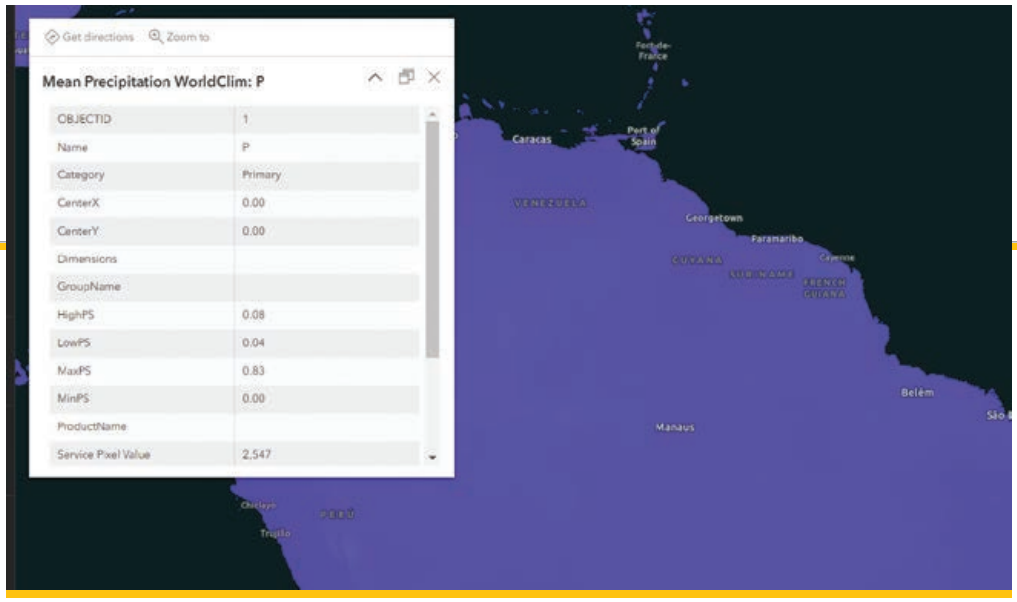
Extent:

XMin: -180
YMin: -85
XMax: 180
YMax: 85.00000000000014
Spatial Reference: 4326 (4326)

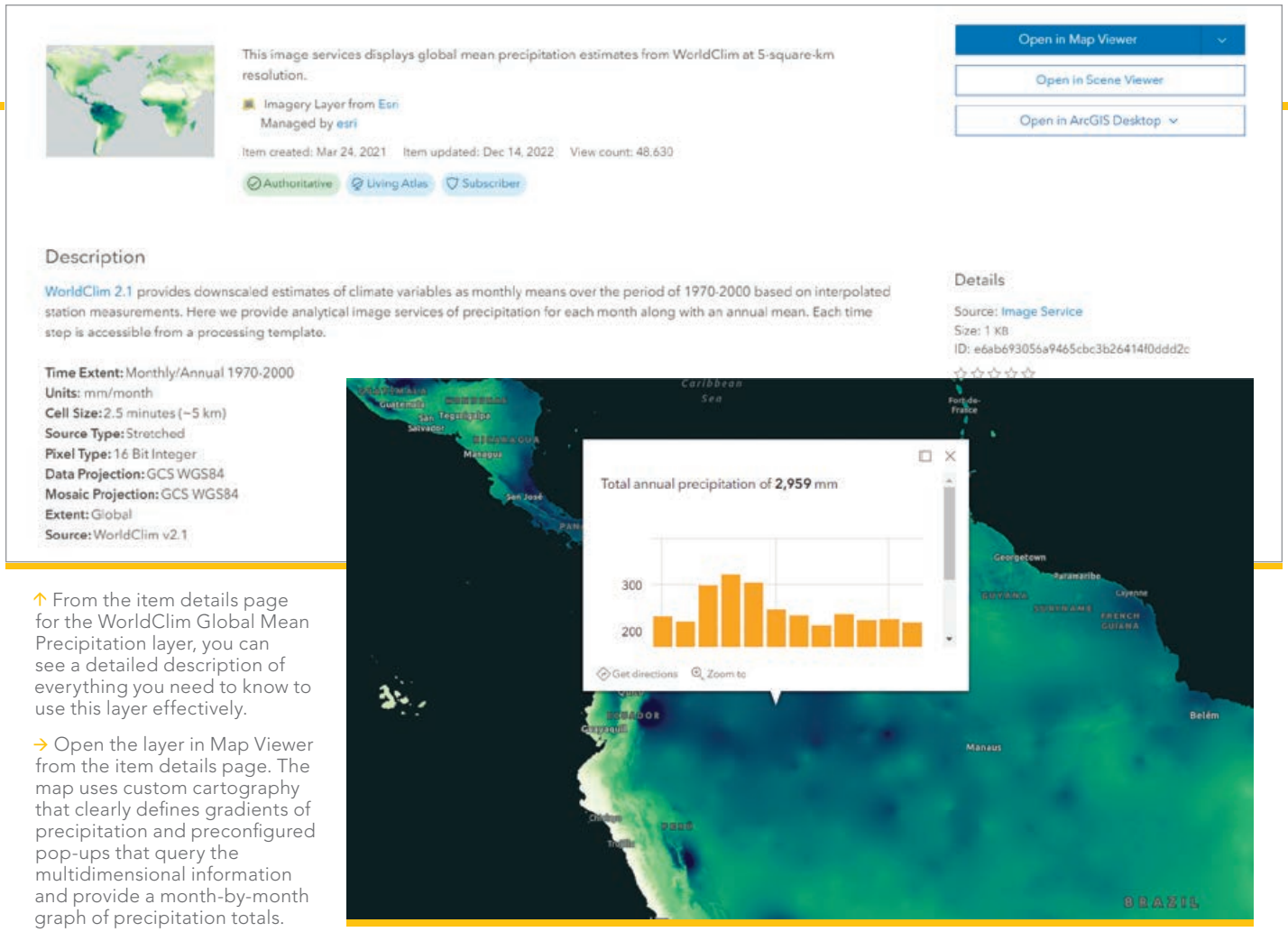
Initial Extent:

XMin: -180
YMin: -85
XMax: 180
YMax: 85.00000000000014
Spatial Reference: 4326 (4326)

↑ There's not much useful human readable metadata in the service URL for the WorldClim Global Mean Precipitation layer.



→ When you open the service via the REST endpoint in Map Viewer, the map uses the default rainbow color ramp, so it displays as a purple blob. Pop-ups display the default raster value which is not very informative.



↑ From the item details page for the WorldClim Global Mean Precipitation layer, you can see a detailed description of everything you need to know to use this layer effectively.

→ Open the layer in Map Viewer from the item details page. The map uses custom cartography that clearly defines gradients of precipitation and preconfigured pop-ups that query the multidimensional information and provide a month-by-month graph of precipitation totals.

and each has a unique ID that can be used to easily access the item anywhere in ArcGIS. These unique configurations can add additional valuable information to the baseline service, such as

- Custom cartography
- Configured pop-ups
- Improved metadata and provenance
- Raster functions
- Views (subsets of feature layers)

A Tale of Two Layers

The WorldClim Global Mean Precipitation layer (https://bit.ly/3Y70FRb) in ArcGIS Living Atlas of the World provides a good example.

Using the REST URL Service

There's not much useful human readable metadata in the service URL. Sure, information can be added while publishing a service, but it is not displayed in a user-friendly manner. Not to mention, it's much easier to later edit an item description.

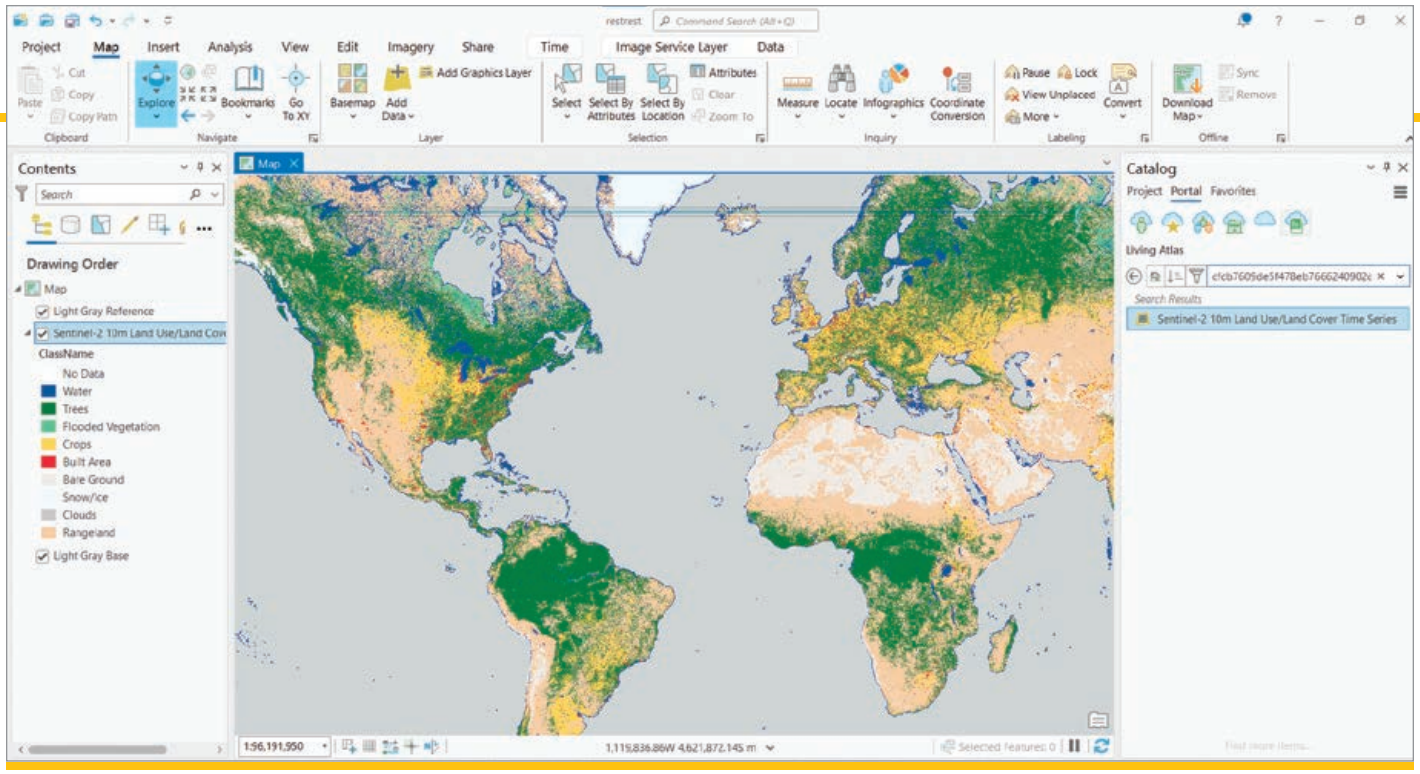
Open the service for the WorldClim Global Mean Precipitation layer in Map Viewer. You will see it uses the default rainbow color ramp, and given the range of the data and its distribution, the map displays as a purple blob. When you click the map, the pop-ups display the default raster value, which is not very informative.

In addition, you can't see the connection between this layer and the detailed item description. When you click Information in Map Viewer, you're sent back to the ArcGIS REST Services Directory entry for the REST endpoint rather than the item description for the layer. While you may understand the layer information in the REST directory entry, someone who uses your map may not, so you're putting them at a disadvantage.

Using the Item Instead

From the item details page for the WorldClim

You can think of an item as a specific configuration of a service.



↑ Opening the layer in ArcGIS Pro from the item details page will also display customized cartography and pre-configured pop-ups.

Global Mean Precipitation layer, you can see a detailed description of everything you need to know to use this layer effectively. Open the layer in Map Viewer in ArcGIS Online or ArcGIS Pro from the item details page, and you'll see custom cartography that clearly defines gradients of precipitation. Preconfigured pop-ups are customized to query the multidimensional information and provide a month-by-month graph of precipitation totals. And when this item is added to a map and saved, you can easily get back to that detailed item description by clicking Information.

A Better Way

So how should I be adding layers?, you might ask. Instead of the REST URL, use the item ID. Every item has an alphanumeric string in its URL; that is its item ID. For the Sentinel-2 10m Land Use/Land Cover Time Series layer in ArcGIS Living Atlas, the URL is www.arcgis.com/home/item.html?id=cfcb7609de5f478eb7666240902d4d3d.

To use this layer in a map, copy the alphanumeric string cfcb7609de5f478eb7666240902d4d3d and paste it when adding a layer from ArcGIS Living Atlas in Map Viewer or paste it into the Catalog search box for Living Atlas in ArcGIS Pro.

In some cases, there isn't an item for a service, and that's another pattern that people need to embrace! Luckily, creating one is pretty simple.

If you published from ArcGIS Pro into an ArcGIS organization portal, or if you uploaded a file directly to ArcGIS Online, you are lucky because you already have an item. It just needs to be configured. In Map Viewer, adjust the cartography, configure the pop-ups, and add any aliases in Map Viewer and then right-click the layer and choose Save. Any customizations you made will be saved to the item (but not the service).

There is another important reason for using items. As a map publisher, you can help you support your users by alerting them to changes to layers or their planned retirement via the item page tags and labels. See "A Process for Deprecating Maps and Layers" (https://bit.ly/3ymv8AB)

Instead of the REST URL, use the item ID.

About the Author

Dan Pisut leads development of ArcGIS Living Atlas of the World environmental content, which includes information about Earth's land, ocean, atmosphere, and ecosystems. Prior to working at Esri, he worked at National Oceanic and Atmospheric Administration (NOAA) for two decades, leading data visualization efforts for research, communications, and education.

GIS Bookshelf

Managing Our World: GIS for Natural Resources

By Geoff Wade and Matt Artz

Managing Our World: GIS for Natural Resources is a collection of real-life stories about natural resource organizations successfully using GIS to increase efficiency and sustainability using the geographic approach. Organizations working in the agriculture, forestry, mining, energy, pipeline, and renewable energy sectors have used GIS to increase profitability, improve environmental protections, and expand societal benefits. A collection of online resources, including additional stories, videos, new ideas and concepts, and downloadable tools and content, complement this book. Esri Press, 2023, 184 pp., print ISBN: 9781589486881 ebook ISBN: 9781589486898

Moving Forward: GIS for Transportation

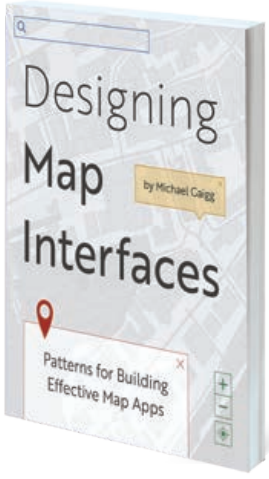
By Terry Bills and Keith Mann

Geospatial analytics, real-time dashboards, and mobile applications are driving new, more efficient workflows and paving the way for innovative, cost-effective solutions for transportation agencies. Case studies in *Moving Forward: GIS for Transportation* describe how ports, airports, transit authorities, and departments of transportation around the world have implemented GIS to visualize and analyze data for operational efficiency, safety and security, asset management, and planning and sustainability.

GIS and location intelligence are helping transportation organizations strengthen their ability to maintain roads and highways, railway systems, and other vital infrastructures. Esri Press, 2021, 120 pp., print ISBN: 9781589486928, ebook ISBN: 9781589486935

Designing Map Interfaces: Patterns for Building Effective Map Apps

By Michael Gaigg



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

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

Be Your Own Leader and *Own Your Career*

By Rosemary Boone

Sid Pandey is the chairperson of the Urban and Regional Information Systems Association (URISA) Vanguard Cabinet and GIS senior consultant at Deloitte. In this interview, he shares valuable insight and some tools that will help you take stock of yourself, find mentors, take ownership of your career, and shape its direction.

Q: How did you get your start in GIS?

A: At Penn State, I initially pursued a degree in environmental systems engineering in the College of Earth and Mineral sciences, since I had a big interest in sustainability and building homes off the grid. A lot of the prerequisite courses in my college involved human geography and physical geography, which I really enjoyed. Even though I cared so much about sustainability, the more I went through the major, the more I realized it's not the right path for me.

I spoke with my adviser, and she said, "You like technology, computers, and the geography classes you've taken—have you considered GIS?" I took an introduction to GIS course and absolutely loved it! That class did a good job showing how to use geospatial technology to not only make maps but apply science and technology to use in positive and impactful ways. I ended up switching my major to geography and never looked back.

Before I graduated, I applied to internships and landed a part-time job as a GIS technician for nine months. It was in this role where I had the opportunity to attend *[the Esri]* Federal GIS Conference and connect with the Esri YPN.

Q: What insights can you give to someone entering a GIS role out of college?

A: It's different from college because the data is not as clean, the workflows are not as straightforward as they are in your labs, and you have to figure out things on your own. In my college program, I learned a lot that carried over nicely to my next career, but there were things I felt like I hadn't fully grasped yet until I entered my GIS career. One of them was how to effectively describe what I do in GIS within the organization and how to communicate effectively what I need from people. When you enter in your GIS career, you may work with people who are not spatial thinkers and even folks who are *[not]* tech savvy overall. So, you may need to learn how to effectively describe what you need from people in different ways both to do your job and to help them understand how they can better help you.

I feel as though a lot of people just starting their careers can easily get tunnel vision. They're just happy they got their new job or internship and, when given a task, they put their head down and work. While there isn't anything wrong with that, it is important to take the opportunity to reflect on how you fit into the rest of your organization, and know what other people are doing, to get an idea of where else you can get involved and what else you can learn.

When I started at Dewberry, my main mission was to help develop FEMA *[Federal Emergency Management Agency]* flood insurance rate maps. It was great—I got to make cool maps at work. However, after a while and after listening to the interesting work many of my colleagues were doing, I began to want to do more.

I was fortunate that my team encouraged me to talk to other people in the company to learn about what they were doing. In those conversations, I would provide my own ideas and to my surprise, I found that most people were very receptive to hearing my thoughts and letting me help. This is where I learned that it's important to take a step back to look at the bigger picture of seeing *[how]* you fit in the ecosystem of your organization and not being afraid to speak up and share your thoughts and ideas. You never know when one of those ideas will turn into your next project or opportunity!

Q: Was there anyone who helped you as a mentor?

A: Yes! Many people throughout my career so far. I got a lot of mentoring from people outside of my organization. Coming into Dewberry, I was already a member of the Maryland Geographic Information Committee, and through that organization I got to meet a lot of people and observe how they interact with their coworkers and their organizations. I saw how they would explain what they do and how they pitched ideas to other folks, and then I would try and bring that back to my own organization.

I also had informal *[mentoring from]* people across my organization who've been very supportive. When I hear something interesting in a meeting, a lunch and learn *[session]*, or see something interesting on our company intranet, I always try to make an effort to reach out to my colleagues to learn about it. I encourage you to do the same! It can be as simple as saying, "Hey, I'm really interested in/have questions about what you do and want to learn more." It's from those organic, informal conversations about others' projects and what they do that you can learn a lot. Take the opportunity to ask questions and get advice from them and build a relationship with them. It's important to find your allies in an organization—people who will think of you for new opportunities and look out for you—and this is a great way to do it.

Q: How can someone take the initiative to gain mentorship opportunities?

A: First, you need to think through what it is you need or are looking for. Do an assessment of yourself. What are your strengths and weaknesses? Understand who are the people around you (either in or outside your organization) who can offer something that will help you fill the gaps and reinforce the strengths you have.

Then, reach out and connect! As I said earlier, you can reach out directly to people around you or find a mentorship program. Both URISA's Mentoring Network and Women+ in Geospatial have great programs.

Take that initiative to regularly meet with someone or multiple people to pick their brain and come up with a basic agenda. Much of mentoring happens informally, but having a rough idea of what you want to talk about can be helpful.

Get a diverse group of mentors at different levels, such as people who are above you and peers at your level as well. Give yourself as many perspectives as you can.


Sid Pandey

Q: What can someone do in college to get their name out there?

A: Most conferences have opportunities to be a student volunteer, such as Esri and URISA conferences. If you're able to be a student volunteer, you will get the opportunity to network or even be a moderator for a session *[presentation]*.

You can also join an organization that has student memberships,

↑ Pandey with some members of URISA's Vanguard Cabinet at the 2022 Esri User Conference (from left to right) Kendal Price, Frank Romo, Pandey, Rachel Layko, and Megan Young.

like the American Association of Geographers *[AAG],* the Urban and Regional Information Systems Association *[URISA],* the United States Geospatial Intelligence Foundation *[USGIF], and the* American Society for Photogrammetry and Remote Sensing *[ASPRS].*

There are also competitions out there you can *[participate in by submitting]* projects you've worked on, such as ArcGIS StoryMaps competitions and poster competitions for various conferences. Take the chance and put your work out there. You may be surprised with how much positive feedback you receive! There are things you can take advantage of during your school breaks too. There are tons of local GIS meetups not tied to organizations. It's so much easier to get involved now with so many informal opportunities like those I mentioned.

Q: What training opportunities do you recommend?

A: I suggest assessing what kind of training you need first and then working with your school, workplace, or other resources to see what training you have available to you. Many times, you will find you have access to LinkedIn Learning, Esri's virtual training campus, and more. Public speaking also tends to be a big thing that people want to work on, so try checking out your local Toastmasters group to help. They're going to help you to learn and practice presenting at a conference or meeting and in smaller settings.

LinkedIn has great training courses, one of which is email writing. I've seen folks struggle with email writing and *[understanding]* what is a casual email versus professional *[email].*

Try and participate in a speed networking event at a conference or meetup you might be attending as well. This is a great way to practice your networking skills.

Q: How can someone get involved with URISA?

A: Many people will find themselves in a one-person GIS department, and others will find themselves in a large GIS organization. Whatever the case, when you're thinking about career growth, you're going to need people to help *[you]* gain more perspective, and an organization like URISA can do that. At URISA, it's like having a GIS family where everyone welcomes you and is willing to talk and share their perspective with you.

Also, I recommend getting involved in an organization like URISA in the beginning of your career. It can start small and grow over time. URISA and other organizations have a variety of committees that are focused around different topics, so you can meet various people and get noticed. People recognize the contributions you're making even if they're small in the beginning. People wait too long to get involved in leadership opportunities because they think they need 10 years of experience to be a leader or manage anything, and that's just not the case. Most organizations just need someone who's enthusiastic and cares, and the rest you'll learn on the job.

Get involved, meet people, and find ways you can contribute, and then take the chance to be a leader, because it's a safe space to test the waters and make mistakes. They're not going to kick you out, deduct your pay, or make you lose your job. You're just going to learn! What better place to do that where there's no negative impacts?

Q: Overall, what is your best advice for other young pros?

A: Don't let your position within your organization or *[limited]* years of experience hold you back. Get involved early and stay involved consistently throughout your career. You don't have to be the expert in the room—just be willing to learn and to help where you can. You'll be glad you did!

We sometimes hesitate to raise our hand or put ourselves out there because we are afraid of looking like the expert when we may not feel like it, or of making a mistake. I've felt this way before but have found that it's extremely important to do what you can to push past those feelings. It doesn't require taking big steps to do it; you can take things at your own pace and grow from there. Take the opportunity to share an idea in your next meeting, share a project you're working on using social media (even if it's still in progress), or share an idea or tip/trick that you found helpful on your company's intranet or your team's group chat.

The more you put yourself out there, the more you will build yourself as a resource or subject matter expert, and the more opportunities you will create for yourself.

→ Learn more about the Esri Young Professionals Network (https://bit.ly/3j5zOqq).

The more you put yourself out there, the more you will build yourself as a resource or subject matter expert, and the more opportunities you will create for yourself.

About the Author

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

University Professor Blends GIS and Conservation Medicine

Before students at Tufts University finish the Master of Science in Conservation Medicine (MCM) program from the Cummings School of Veterinary Medicine, there's one requirement they may not have anticipated being key to their future careers: a GIS course.

The MCM program brings together veterinarians, physicians, ecologists, and conservation professionals committed to addressing urgent issues being faced by the planet. The program studies habitat use conflicts, habitat conservation, emerging and resurging diseases, environmental contamination, ecosystem and climate change, wildlife management, biodiversity loss, and ecosystem function degradation.

"The problems our students aim to solve are inherently spatial by nature, requiring GIS and spatial analysis skills to fully understand and investigate the scope of the problem," said Carolyn Talmadge, Data Lab services manager and Tufts and course director for the Cummings School of Veterinary Medicine. Initially, there was no dedicated GIS course, just workshops and guest lectures. "But as we all know, you can't truly get a handle on GIS in one, three-hour course," she said.

In 2016, Talmadge was a recent graduate of the Tufts Civil and Environmental Engineering master's program and a GIS specialist at Tufts. She secured approval from both the research technology director and MCM program leadership and developed a semester-long GIS course called GIS for Conservation Medicine. "I am now teaching the course for the eighth year," she said, "and it is one of the most popular and highest-rated courses in the program."

As the Data Lab services manager, Talmadge works for the research technology team in Tufts Technology Services. She manages Tufts Data Lab, the interdisciplinary research and computing labs that provide methodological and technological support for all aspects of the geospatial and data science workflow. In addition, each year she hires and supervises 14 graduate and undergraduate students who work as Data Lab assistants. She also writes and coordinates GIS learning resources, creates maps for faculty publications, and provides advanced consultations. Her teaching duties include specialty workshops and in-class guest lectures on geospatial technologies, GPS data collection, GIS, cartography and design, ArcGIS StoryMaps and other ArcGIS Online products.

Inspiring Students to Innovate with GIS

"Carolyn teaches GIS like someone who has found their passion in life and puts so much effort at making sure her lessons are clear, manageable, and fun for people," said Talmadge's former colleague Madeline Wrable, a solutions engineer for imagery and remote sensing at Esri. "It's clear she cares about her students' success and that their passions are met."

Wrable has seen firsthand how Talmadge guides students and Data Lab assistants throughout their learning journeys. Whether she is breaking down how to use GIS to meet a specific challenge, contributing to an email list to share job postings with students and alumni, or building helpful tutorials, Talmadge is "there for someone every step of the way," Wrable said.

When Talmadge was awarded Tufts' Outstanding Contribution to Education Faculty Award in 2019, one of her former students observed that Talmadge had opened up a world of GIS and spatial analysis and was invaluable as a source of guidance, motivation, and mentorship during the MCM program.

↓ Carolyn Talmadge, Data Lab services manager at Tufts University

↑ Talmadge works with a former colleague and lab assistant Madeline Wrable.

Talmadge's encouragement has helped her students and peers find GIS positions with organizations such as the Smithsonian Institution and other museums, the Massachusetts Institute of Technology, Harvard University, the World Bank Group, the US Department of Defense, and the Food and Agriculture Organization of the United Nations, as well as various conservation programs. Many former students have returned to Tufts to give guest lectures in her course.

"There are so many entry points to GIS, especially with the wide array of tools that Esri has available," said Talmadge. "My goal for the class is to first provide the motivation for learning GIS before teaching the skill itself. I also want my students to know GIS is not as scary as they think it's going to be. They can have a lot of fun with the data and software while having a tremendous impact on the research and work being done in the conservation realm."

Building a Conservation Medicine Curriculum

When building her course, Talmadge acknowledged that students enrolled in the MCM program varied widely in their level of comfort with technology and data analysis. "Some know that GIS is critical for what they want to do, while others have never heard of GIS in their life and are nervous using computers, let alone data analysis software," said Talmadge.

To secure student buy-in, Talmadge focuses her course using Tufts Clinical and Translational Science Institute (CTSI) One Health Program. One Health is a collaborative, multisectoral, and transdisciplinary approach to optimizing health outcomes by leveraging resources at the local, regional, national, and global levels. This approach recognizes the interconnection between people, animals, plants, and their shared environment.

"My course covers a range of applications and focuses on using geospatial tools to investigate environmental health, animal health, wildlife management, and public health issues facing us in today's world," said Talmadge.

Talmadge's goal is for students to see the utility of GIS in every assignment and how it could pertain to their research or career interests. "I do my best to make the class engaging and accessible yet try to motivate and challenge them to think about how they can use these tools and spatial analysis to address and solve the problems they are most passionate about," said Talmadge.

During each class session, Talmadge builds on the skills students learned the previous week and divides class time between lecture and application. She uses hands-on activities to reinforce the concepts learned in the lecture.

"I strongly prefer to do live GIS activities with the students rather than having them work through tutorials on their own in class

> "But as we all know, you can't truly get a handle on GIS in one, three-hour course."
>
> **Carolyn Talmadge**
> Data Lab Services Manager
> Tufts University

↑ Talmadge and students from the GIS for Conservation Medicine course in the Master of Science in Conservation Medicine (MCM). program in fall 2021

because, as we know, GIS offers a number of different ways to achieve the same outcome. When we are completing the activity together, I can explain why we are doing something specific, walk through the pros and cons of this method versus other approaches we've learned, and share helpful tips for getting around the software or visualizing the data," said Talmadge.

Doing live activities allows Talmadge to start with a refresher on what students learned the previous week and add onto it. Live activities also allow students to ask questions, troubleshoot together, and bond.

Each activity uses a different scale, addressing challenges at levels from the neighborhood level to the global. These activities demonstrate various applications, methods, and data sources commonly used in conservation work. These sources include International Union for Conservation of Nature and Natural Resources (IUCN) data; Global Forest Watch data; or faculty-collected data, such as turtle nesting sites or soil samples.

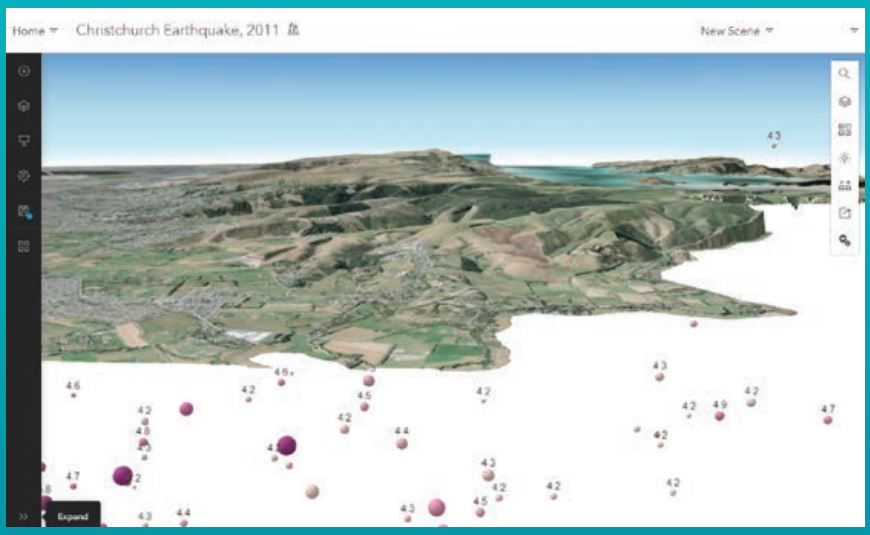
"We go into these activities using real case scenarios and datasets instead of showing *[students]* how to use a tool on a random piece of data, so they are completing these activities with a purpose and goal," said Talmadge.

Key to her instructional philosophy is emphasizing cartography, design, and communication in the course. "It is so important for the students to learn how to communicate and visualize the data efficiently and effectively in order to deliver their intended message. Understanding design and cartography concepts is a huge part of communicating spatially, and as such, both skills are an important component of my course," said Talmadge.

Throughout the course, students use ArcGIS Online and ArcGIS Pro to make high-quality maps, gain knowledge in database management, and perform data cleaning and spatial analysis. A favorite assignment is collecting field data using ArcGIS Survey123 on a subject of interest such as wildlife sightings, invasive species, or habitat degradation.

Classwork builds toward a final GIS analysis project. For this project, students choose the topic and build an engaging and informative poster. Many posters

↓ Madison Bolduc, an MCM student, was awarded first place in the Spatial Analysis Using ArcGIS StoryMaps category at the Esri User Conference for this entry.



New Hands-On Modules Added

ArcGIS Labs, a new e-Learning format, has been added to the Esri Academy catalog. These self-paced learning modules emphasize hands-on practice through step-by-step exercises.

These labs, which typically take from one to a couple of hours to complete, are another flexible option for growing your GIS knowledge and ArcGIS skills. Each lab includes one or more scenario-based exercises, the data needed to complete it, a quiz to measure your understanding of the workflows taught, and a certificate of completion for successfully passing the quiz.

As with other Esri Academy web courses, you'll need to already have access to the software used in the lab exercises. Course topics range from Working with Charts and Reports in ArcGIS Pro to Building an App in ArcGIS Online to Expand Food Access to Visualizing Multidimensional Data Using Voxels in ArcGIS Pro. Explore interesting topics and new ArcGIS workflows while building valuable skills that will advance your GIS career goals. Modules will continue to be added.

Visit Esri Academy (esri.com/training/) and try an ArcGIS Lab today.

created by Talmadge's students have won recognition at the Esri User Conference Map Gallery competition. In 2022, MCM student Adina Zucker, who recently started a position doing GIS work for the National Park Service, placed first in the Communicating Science Spatially category. In 2021, another MCM student, Madison Bolduc, who is now the GIS manager for the Biodiversity Research Institute, was awarded first place in the Spatial Analysis Using ArcGIS StoryMaps category.

Improving and Expanding the Curriculum

"Nothing makes me more excited than seeing my students excited about GIS and all of its possibilities," said Talmadge. "Their GIS success motivates me each year to keep improving and expanding the class, keeping it relevant with the newest technology and important tools they should know entering into the GIS and conservation fields."

Even for those who don't go into GIS career fields, Talmadge hopes her students leave with beneficial job skills such as understanding what design qualities make good or bad maps and visuals, how to evaluate data sources and methodologies, how to collect and organize data, and how to communicate findings effectively.

In looking at future development of her course and, more generally, GIS in conservation efforts, she believes there is room to expand the application of GIS to include incorporating GPS data collection and drone technologies. In 2020, the MCM program introduced a course called Drones—Unmanned Aircraft Systems (UAS) for Field Data Collection, Mapping & Analysis, in response to increased interest in geospatial technologies. Talmadge believes that as GIS becomes a more integrated practice in conservation, the results of field studies will become accessible to the public and open pathways for interdisciplinary collaboration.

"GIS is such a powerful tool and doesn't require one to be a computer expert or advanced data analyst. My goal is for every student to walk away excited about GIS and understand how they can use it in their future careers and in a variety of One Health applications," said Talmadge.

A Roadmap to Success for Students

By Alexa Vlahakis

The San Bernardino County Superintendent of Schools (SBCSS) office worked with the Southern California county's school districts to create a website that uses a GIS portal to provide comprehensive information and helps better prepare students for college and the workplace.

With more than 20,000 square miles, San Bernardino County has the largest geographic extent of any county in the United States. Its 33 school districts serve the educational needs of a diverse population of nearly 400,000 K–12 students. SBCSS acts as an intermediate service agency between the California Department of Education and San Bernardino County school districts.

The county's school districts have partnered with SBCSS to support data management and analysis that provide oversight using such metrics as standardized test scores, graduation rates, and college acceptance rates. Previously each school district managed its own datasets and shared them with various educational partners as printed reports. Information was duplicated, and the lack of standardization made collaboration difficult.

"We're all out there making these same reports repeatedly," said John Massie, program manager for assessment, data analytics, research, and evaluation at SBCSS. Each district report looked different, and districts had no standardized way to communicate. These paper-based reports had spreadsheets and few visuals.

"We'd make a report on this and show some people, present it, and then the report sort of just goes to die; it never gets to live on," said Massie. A tangible and persistent record of presentations was not maintained so that it could be referenced in the future.

↑ San Bernardino County, which has the largest geographic extent of any county in the United States, has 33 school districts that serve a population of nearly 400,000 K–12 students.

There was no technology infrastructure to streamline the acquisition of information, maintain historical records, and support communications across districts and regions within the county. Paper-based processes also made it difficult for district staff to effectively apply to the state for more resources. Parents found it challenging to access the information they needed to make decisions regarding their children's futures.

SBCSS county superintendent Ted Alejandre advocates locally, statewide, and nationally for policies and resources to help districts prepare students for college and the workforce. In response to this situation, the county districts and Alejandre strategized with staff, parents, and the public on how to provide easy access to the educational data critical to meet the unique needs of every learning community.

More than seven years ago, San Bernardino County stakeholders developed and implemented the Cradle-to-Career Roadmap (https://c2c.sbcss.net/en) using a collective impact approach to achieve the countywide vision. This roadmap website provides a one-stop resource for families to track important milestones for their children to gauge student progress and offers resources to community members. The site links to reports on childhood and young adult development and resources available from the California Department of Education and other educational organizations.

With the development and implementation of the Cradle-to-Career Roadmap website, there was potential for GIS to enhance the integration with the state's systems to share data more accurately and consistently. The GIS-based open data portal was developed to share information and statistics. It gives district staff, parents, and students access to reports and data.

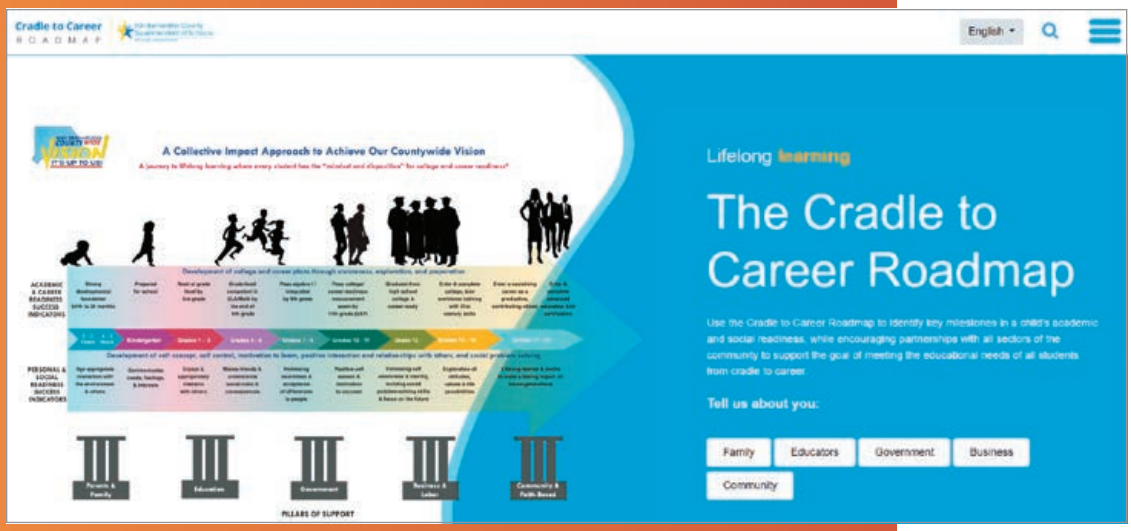
"Providing an open portal where residents, schools, government, and community agencies can access data to help inform decision-making about educational and career attainment and opportunities is a crucial priority," said Alejandre.

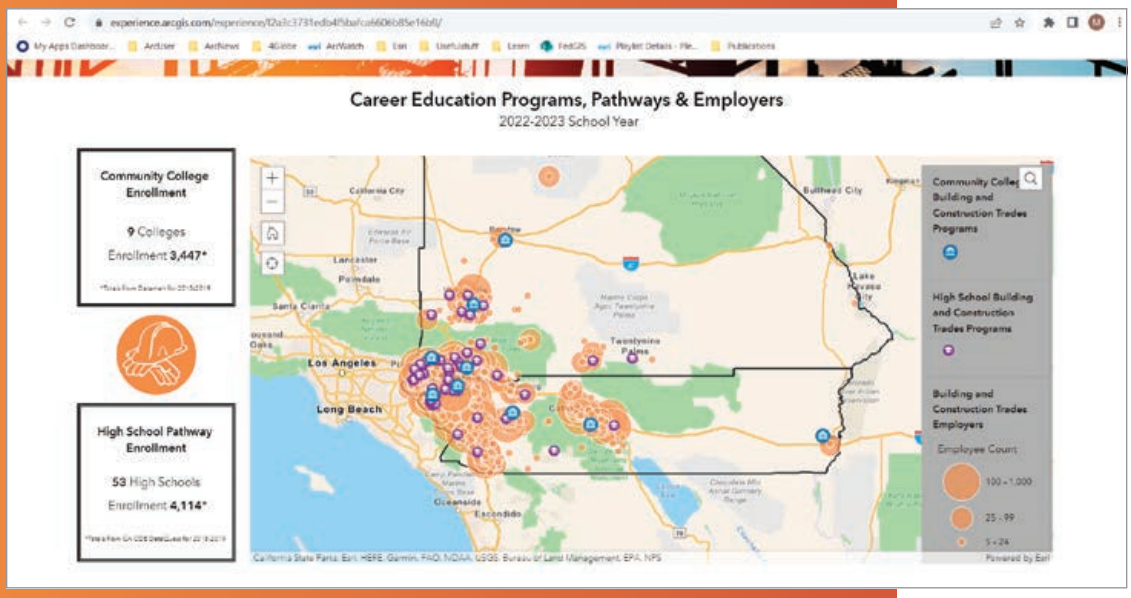
Through the partnership, the districts and SBCSS streamline data into one open data platform that uses GIS for sharing information, building awareness, data analysis, and reporting. The open data portal uses ArcGIS for Power BI and ArcGIS Dashboards to display information.

"*[The technology]* is super versatile. We can embed Power BI visualizations. It blends so nicely with the geospatial maps; *[the hub site]* is a nice place to hold everything," said Massie.

The data portal allows viewers to easily access information and answers to the common school districts questions such as:

- What is the high school graduation rate?
- What is the economic status of families in the district?





↖ The Cradle-to-Career Roadmap website provides a one-stop resource for families to track important milestones for their children to gauge student progress and offers resources to community members.

↙ The GIS-based open data portal gives district staff, parents, and students access to reports and data such as this visualization of data of career education locations and employers, which was built using ArcGIS Experience Builder.

- How many students does the county serve?

The hub site can provide links to much more detailed, interactive reports and display trends over time that update automatically. The additional capability with GIS allows the county to integrate data and make changes or provide solutions for students and families based on data. In the past, the school districts couldn't respond as fast to student and family needs, but with the data integration, county and district leaders are able to support students in near real time and follow historical trends.

School districts can gather data faster and more efficiently thanks to the automation provided by GIS tools. Massie often shares with school districts what they can do with the data from the site. Since the data portal's implementation, districts evaluate their performance in comparison to other districts in the county. They can also view their data over time.

The portal provides access to all the data in one location and eliminates the need to visit several state websites and combine data. With the open data portal, districts can monitor student performance and create comparative graphs for their presentations to local governing boards and community groups.

"It's a self-service thing. Districts don't have to ask us to make graphs for them; they can pull all the data they need. We aren't slowing them down," said Massie.

Alejandre remarked, "I am proud of the range and accessibility of data that is available through the SBCSS open data portal and Cradle-to-Career platforms, so that the public has access to information that can spur academic success for students."

About the Author

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

A NATURE-BASED SOLUTION TO HUMAN-ELEPHANT CONFLICT

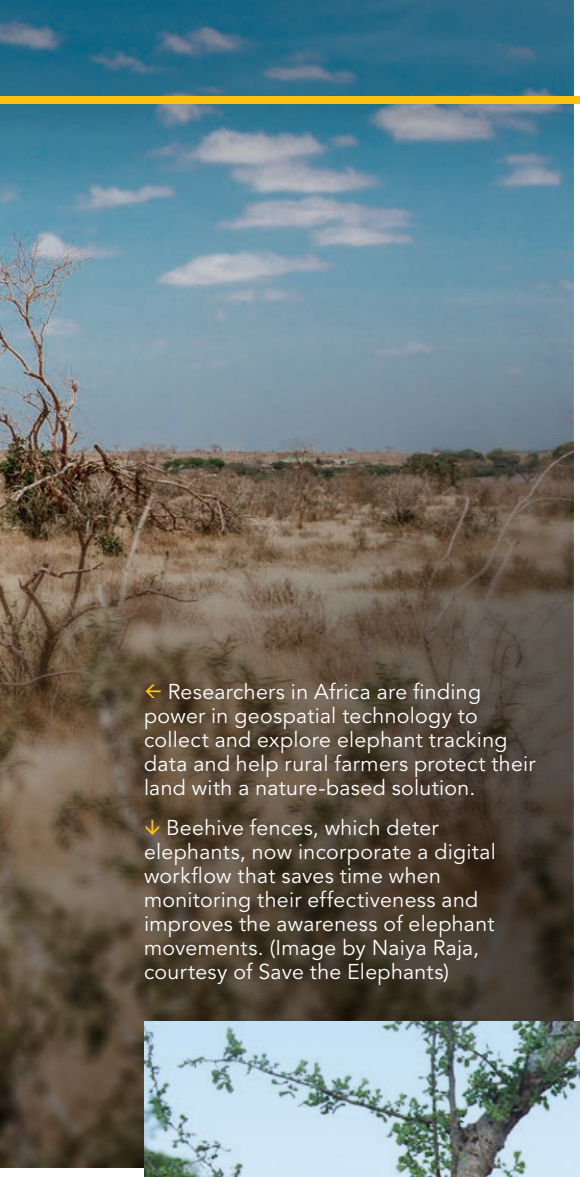
By David Gadsden

An ancient African folktale tells of elephants that are afraid of honeybees. In 2006, researchers proved that these tiny insects can indeed help save the world's largest land mammal.

In Kenya, most wildlife live in land outside of protected areas. This can cause conflict between animals and people. For example, farmers' crops suffer devastating damage when hungry elephants trample their fields, often at night. Farmers want to protect their livelihoods, homes, and families, while elephants need to eat.

Lucy King, who heads the Human-Elephant Co-Existence Program for Kenya-based Save the Elephants, experimented with playing recordings of swarming

↓ Conflicts between animals and people can happen when hungry elephants raid farmers' fields.



← Researchers in Africa are finding power in geospatial technology to collect and explore elephant tracking data and help rural farmers protect their land with a nature-based solution.

↓ Beehive fences, which deter elephants, now incorporate a digital workflow that saves time when monitoring their effectiveness and improves the awareness of elephant movements. (Image by Naiya Raja, courtesy of Save the Elephants)

African honeybees near elephant herds and witnessed that these huge animals quickly ran away. That observation was the basis of a creative solution that saves elephants' lives by using beehives to redirect elephants before they interact with humans. Elephants are afraid of honeybees and avoid them because bees sting them in sensitive areas around their trunks, eyes, and the inside of their ears.

The Elephants and Bees Project, devised by Save the Elephants, reduces elephant crop raids by helping farmers build beehive fences that discourage elephants. Project team members plant regenerating trees, such as *Commiphora*, as posts and suspend beehives or dummy hives between them. The trees and hives are linked by wire to form fences. When elephants strike the hives or the wires that connect them, the hives swing and bees come out buzzing, scaring the elephants away. Using trees instead of wood posts creates a long-term solution because trees provide natural shade and support for beehives.

King's team worked with farmers to install beehive fences around portions of their farms. Beehive fences bring other benefits. Not only do farmers sleep soundly knowing the African honeybees are active at night, but bees pollinate crops, and farmers can sell honey from the hives. Today, beehive fences protect farmland in 23 countries. As the project has grown, researchers have used GIS and remote sensing to monitor fences more effectively and gather data on elephants.

Creating a System within a System

Founded in 1993, Save the Elephants has used geospatial technology to track elephant movement across African landscapes for nearly three decades. Today,

the organization hosts Africa's largest elephant-tracking database. But as GIS capabilities evolved, so have the organization's goals and practices.

"When we started working with Esri's tools, we were putting elephant tracks on a map. Over time, we were able to do advanced analysis to understand migration corridors and use models to see where elephants are most likely to be at certain times of the year," said Festus Ihwagi, a senior scientist and research manager with Save the Elephants.

Tsavo National Park, Kenya's largest national park, is home to the country's largest elephant population, with more than 12,000 residing there. Save the Elephants staff are in constant communication with the farmers who live between the east and west sections of the 8,000-square-mile park.

After beehive fences were built around farms, staff began visiting to ensure that the fences were working, spot maintenance issues, and catalog elephant encounters. This data collection allows for ongoing research, monitoring, and problem-solving.

To monitor farms and fences, a team of GIS officers initially visited farmers with handheld GPS devices and manually recorded information about human-elephant conflicts. That information, which sometimes included hand drawings of elephant movements into and around the farms, was digitized at the office.

"There was a lot of work that went into data collection between the handhelds and digitizing and maintaining all the other records that come with that data," said Gloria Mugo, a GIS officer and remote sensing scientist who joined the Elephants and Bees Project in 2016.

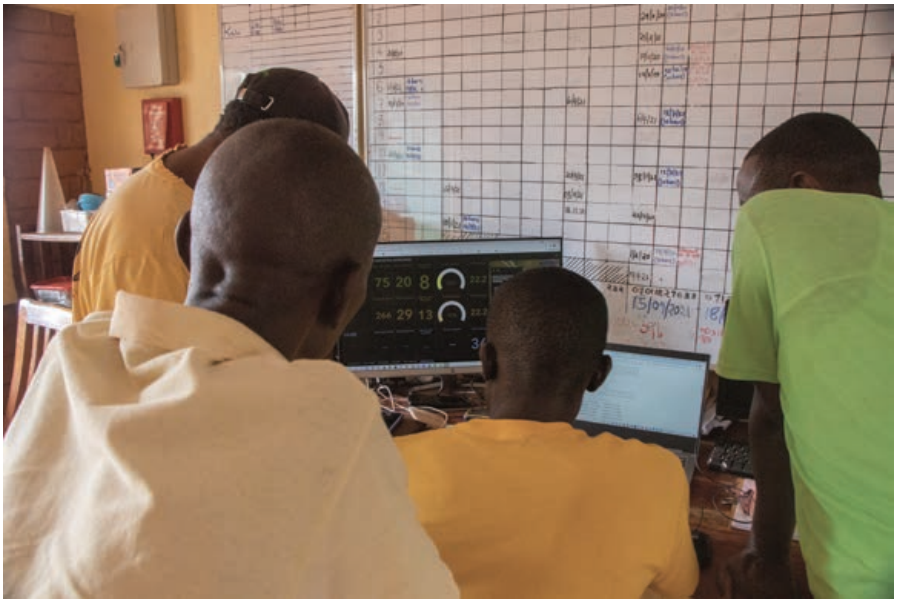
Mugo and the other officers saved time by deploying ArcGIS Survey123, a GIS app that works on smartphones and tablets. After digitizing questionnaires, the officers could visit farmers and collect data in real time. The result, Mugo said, was transformative. "It slashed our working time from around 80 hours a month to about 16 hours." The time saved using automation allows researchers to explore other methods and technology applications that can advance the organization's mission.

As data comes into the office from the field, staff ensure that records are properly analyzed and stored. Reporting is also much easier, giving staff more time for analysis rather than data entry.

Data collected with ArcGIS Survey123 is then visualized with ArcGIS Dashboards. Together, these tools convey information about elephant movement, crop raids, and beehive fence maintenance. The collected data is hosted and visualized with a single system, making it easier to see which regions might need enhanced support and optimal locations to expand the program. As a result, the Elephants and Bees Project

→ Measurement and location data for elephant tracks was previously gathered using pen and paper. (Image courtesy of Save the Elephants)

↓ The team looks at a dashboard that displays data collected from the field. (Image by Robyn Brown, courtesy of Save the Elephants)



increased the number of farms in the beehive fence program. In Sagalla, a community in Voi, Kenya, beehive fences protect 47 farms, up from 30 farms.

New Methods of Understanding Elephant Migration

GIS officers with Save the Elephants use geospatial tools to efficiently track elephant movement and understand migration patterns and behavior. With the time saved by using geospatial tools, Mugo and the Elephants and Bees Project staff can focus on other important work.

While beehive monitoring is still key to their efforts, officers have also trained farmers in conservation agriculture methods and built a women's enterprise center where local women can generate alternative income by selling baskets they weave and other items.

King and her team have also produced a Human-Elephant Coexistence Toolbox, which shares strategies from across Africa to help communities hoping to resolve human-elephant conflict. "The toolbox has instruction manuals for many methods you can use to deter elephants—not just beehives. Other places are dealing with these conflicts, and we've been able to communicate to a wider audience so that people can learn from these tools and methods. No one method will work everywhere, and new learnings from the field will feed back into the toolbox," Mugo said.

The toolbox includes details on elephant

↑ Today, beehive fences protect farmland in 23 countries and help preserve elephant populations.

behavior and the animal's importance in the ecosystem, as well as provides information on farm protection methods, elephant-compatible farming practices, habitats, and guidance for living near elephants.

To benefit elephant diets, Mugo is researching whether specific plants are attractive to elephants, using imagery and remote sensing technology. She recently published a paper confirming that Copernicus Sentinel-2A imagery can be used to visualize vegetation species distribution.

Project team members collect data on the movement of elephants using handheld GPS while following elephant footprints. Overlaying elephant track data with vegetation helps identify which plants bull and family groups prefer. Remote sensing expands research possibilities because officers don't have to be on-site to collect data.

Ihwagi and Mugo see remote sensing as a promising way to understand the nuances of elephant behavior continent-wide. Paired with GIS, it gets them one step closer to realizing their dreams of seeing Africa's elephants repopulated and understood as a crucial species of the continent's biodiversity.

"The communities, people, governments, and stakeholders who are involved in trying to protect these elephants need to visually see data and information, which is something we can't do without GIS," Mugo said. "It helps us get to a point where we have a higher understanding of all the systems that are interconnected."

About the Author

David Gadsden is the director of conservation solutions and administers the Esri Conservation Program. For more than 30 years, this program has made Esri's GIS technology available to nonprofit and nongovernment conservation organizations globally. Gadsden, who joined Esri in 2002, has more than two decades of experience helping organizations use GIS in humanitarian and conservation work. He has also served as a technical adviser to the United Nations, the US Department of State, and the Bill and Melinda Gates Foundation. An applied geographer, he writes articles and blog posts about using geospatial technology to advance the conservation of biodiversity, climate resiliency, and sustainable development, and providing equitable access to nature.

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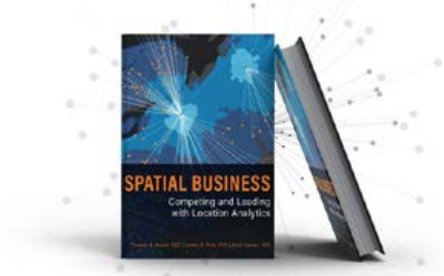

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