

# ArcUser

The Magazine for Esri Software Users

The First Global,  
Data-Driven, and Truly  
3D Ocean Map 10

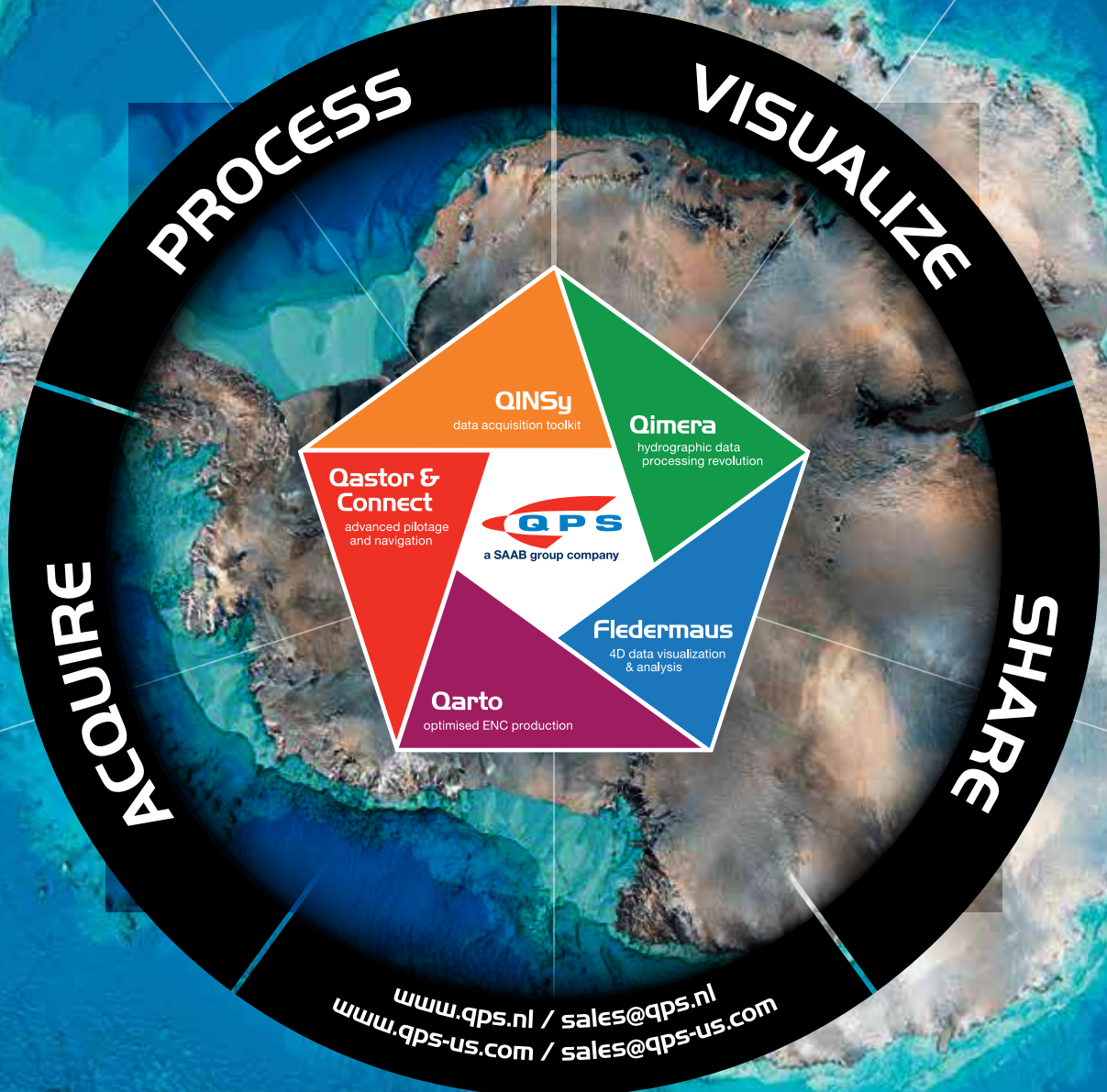
Planning the City of Tomorrow  
in 3D 12

She Sees a Better World 32





a SAAB group company



Antarctica by Martin Jakobsson (Stockholm University)



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### On the Cover

The Ecological Marine Units project establishes a 3D point mesh framework spanning 52 million points and global measurements of six key variables of the ocean's water column over a 50-year period. Read the article on page 10.

# The Science of Where: Our Promise

I am excited to share with you Esri's renewed emphasis on our brand, its meaning and its promise. We have captured our long history, our values, and mission in a new tagline, "The Science of Where," which we feel represents Esri's essence.

From its earliest days, Esri's values have been rooted in purpose and service and a mission to inspire positive change. For nearly half a century, we have relentlessly pushed the boundaries of geographic science and opened the world to the possibilities of powerful geospatial technologies.

With the advent of the digital transformation, we stand on the edge of a new technological frontier. The release of Esri's ArcGIS 10.5 is The Science of Where, in action. With ArcGIS 10.5, we provide the next generation of GIS that will simplify and amplify the work of our users everywhere. Together with our user community, we are pioneering a common visual language that combines mapping and advanced analytics to connect real-time data to the people and organizations that need them most—you, our users.

The Science of Where, is the perfect representation of our past, our present, and our future because The Science of Where, is—quite simply—what we do. It's also what our users do too, every day. Our users around the world practice The Science of Where, by mapping the ocean floor; by making organizations smarter; by implementing retail location strategies; by building strong, resilient economies. They understand and embrace the knowledge and commitment to make these kinds of projects really work, which is something you will see again and again as you read the stories featured in this issue of *ArcUser*.

The Science of Where, is the science of digital transformation, the science of exploration and navigation, the science of commerce and ecology. It's the science of insight and innovation. It inspires us and drives us to offer the most high-powered, high-performance mapping and analytics capabilities in the world.

The Science of Where, is the context layer for all of our content and visualization capabilities. It streamlines the spatial analysis of geographic and enterprise data through intuitive maps, charts, and graphs.

The Science of Where, is our brand. Our brand is our promise. It reflects our commitment to geoscience and to innovating the great technologies that harness it so that our customers can continue to create the maps that run the world.

Please join me in embracing The Science of Where, as an articulation of our joint mission to make the world a better place.

Warm Regards,



Jack Dangermond

# ArcUser

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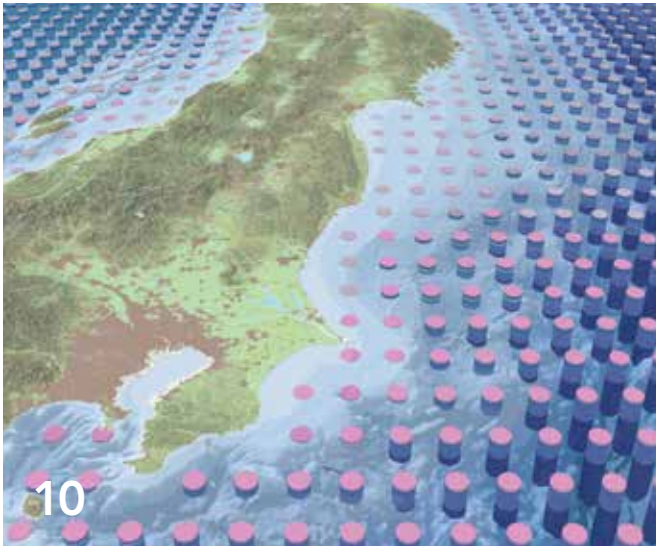
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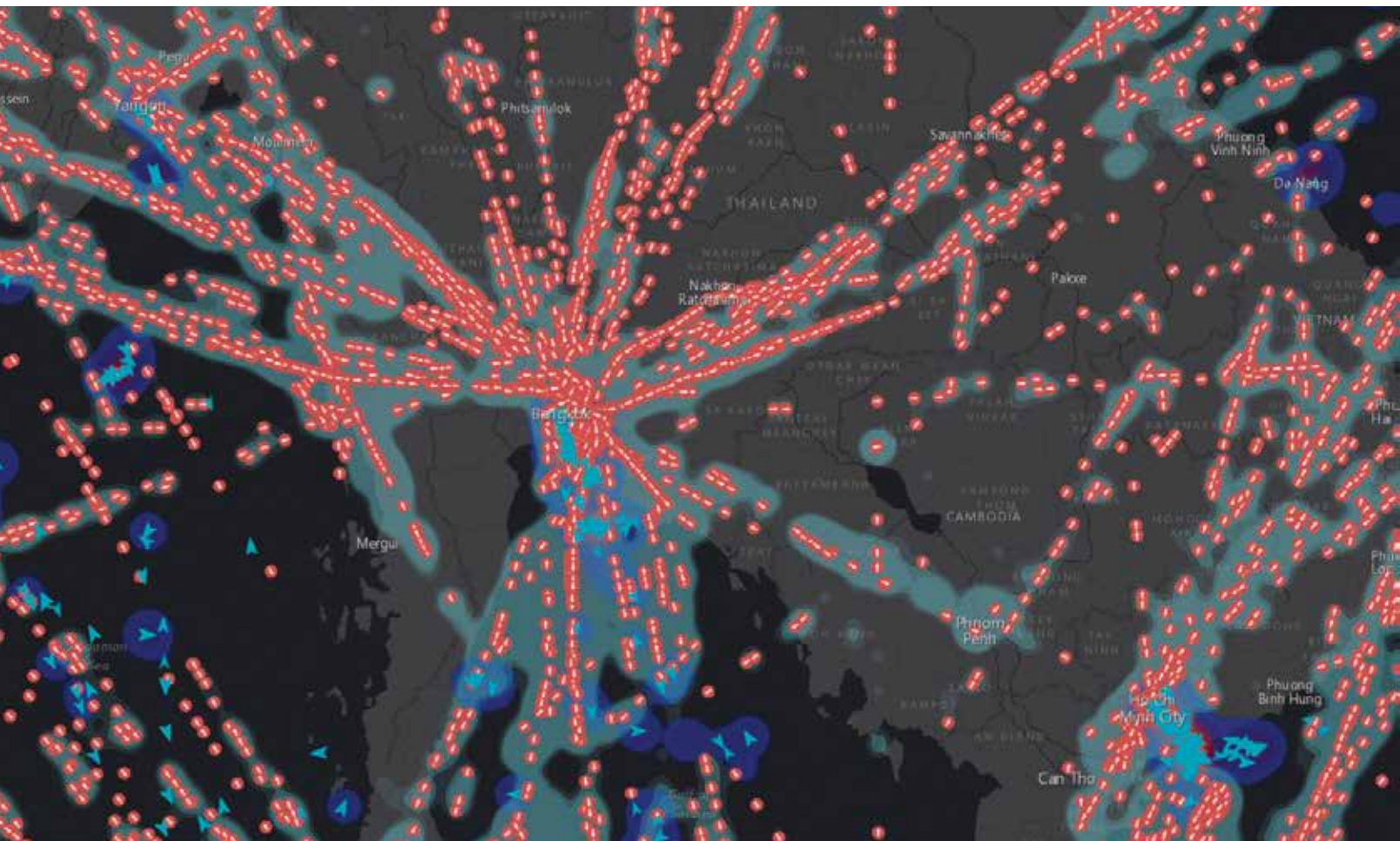
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# Greater Analysis and Collaboration with ArcGIS 10.5

ArcGIS 10.5 provides new capabilities that enhance analytical and problem-solving and makes it easier to connect to and integrate many types of enterprise data with ArcGIS. The most significant change with the ArcGIS 10.5 release is ArcGIS Enterprise. ArcGIS Enterprise is the new name of the ArcGIS for Server product family that includes ArcGIS Server, Portal for ArcGIS, ArcGIS Data Store, and ArcGIS Web Adaptor.

The first step when getting started with ArcGIS Enterprise is to create a base ArcGIS Enterprise deployment. A base deployment is the configuration of the four software components—ArcGIS Server, Portal for ArcGIS, ArcGIS Data Store, and ArcGIS Web Adaptor—that is a functional Web GIS that resides in your infrastructure. The base deployment can be configured with all components on a single machine or with components distributed across multiple machines

in a multitier configuration. ArcGIS Enterprise can always be deployed with high availability.

## Server Roles

From the single ArcGIS Server software component, you can license the specific server capabilities that your organization needs through server roles. At ArcGIS 10.5, there are five server roles:

ArcGIS GIS Server, ArcGIS Image Server, ArcGIS GeoEvent Server, ArcGIS GeoAnalytics Server, and Esri Business Analyst Server. The five server roles of ArcGIS Enterprise provide an off-the-shelf solution that feels completely custom. Each server role added to the base ArcGIS Enterprise deployment can be scaled independently. ArcGIS Enterprise can be deployed on any infrastructure that meets the minimum system requirements so it can be architected to align with any organization's technology road map.

### ArcGIS GIS Server

This role captures everything ArcGIS for Server was in prior software releases. It provides the same service types and has the same analytical capabilities. ArcGIS GIS Server is offered in Basic, Standard, and Advanced editions and at the Workgroup level. Users will still be able to extend and customize the functionality of ArcGIS GIS Server through Esri-built extensions or through custom written server object extensions and interceptors. It powers Web GIS behind a firewall, but it can also be used in dedicated server sites to support specific functions for an organization, such as mapping and visualization and maintaining workload separation for optimal system performance.

### ArcGIS Image Server

At ArcGIS 10.5, ArcGIS Image Extension for Server has been replaced by

ArcGIS Image Server. It provides everything ArcGIS Image Extension for Server offered but also introduces Raster Analytics. By harnessing the power of distributed and parallelized computing, Raster Analytics can produce pervasive, full-resolution raster/imagery output in a fraction of the time previously required. Users can run simple raster analysis tools or can chain together analytical functions to create raster models to answer even the most complex questions. Whether the data resides in a data center or the cloud, Image Server has many options for connecting to existing raster and imagery libraries.

### ArcGIS GeoEvent Server

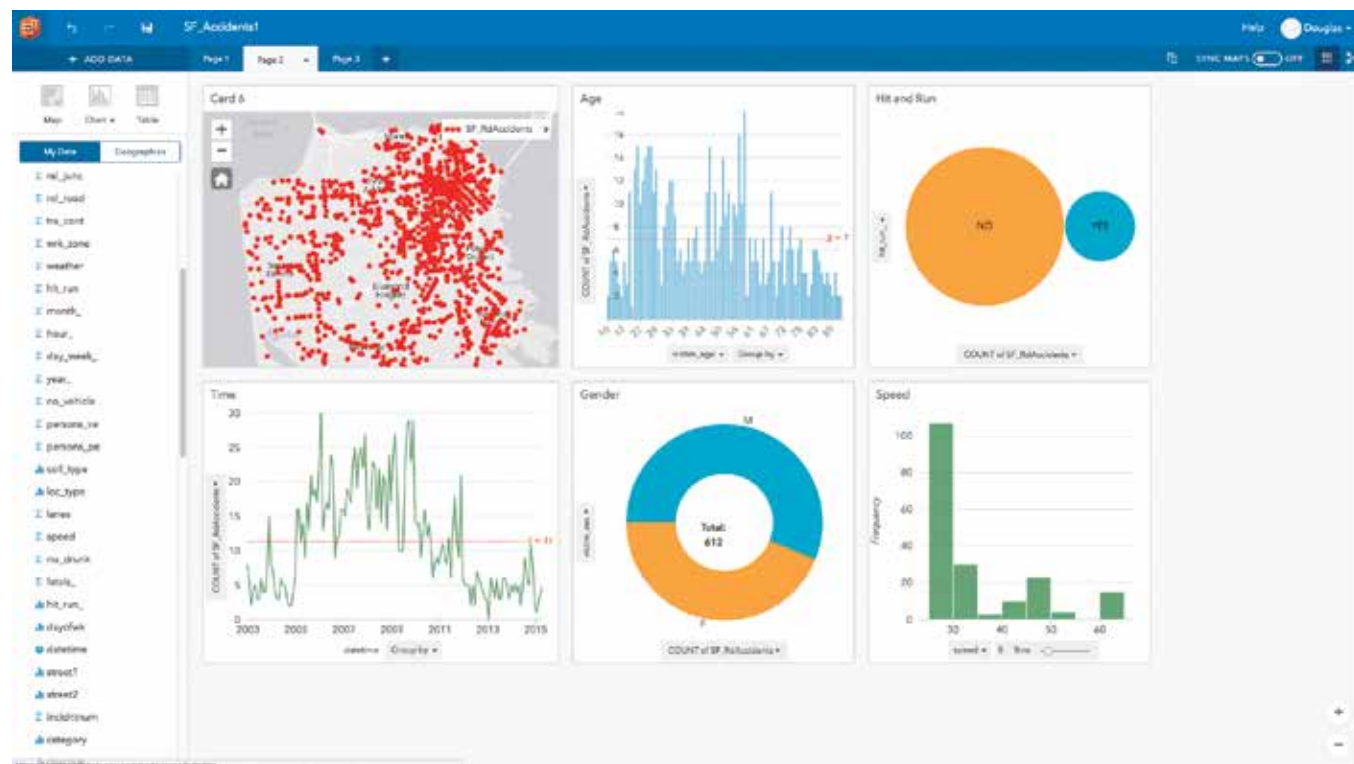
Replacing ArcGIS GeoEvent Extension for Server, which was available in previous releases, ArcGIS GeoEvent Server serves the same purpose and has the same analytical horsepower. ArcGIS GeoEvent Server is designed to handle high-volume, high-velocity real-time and streaming data. It provides solutions through on-the-fly analysis and dynamic aggregation of large datasets, which makes data visualization simple. When connected to the base ArcGIS Enterprise deployment, ArcGIS GeoEvent Server can archive data to the spatiotemporal data store for further data analyses.

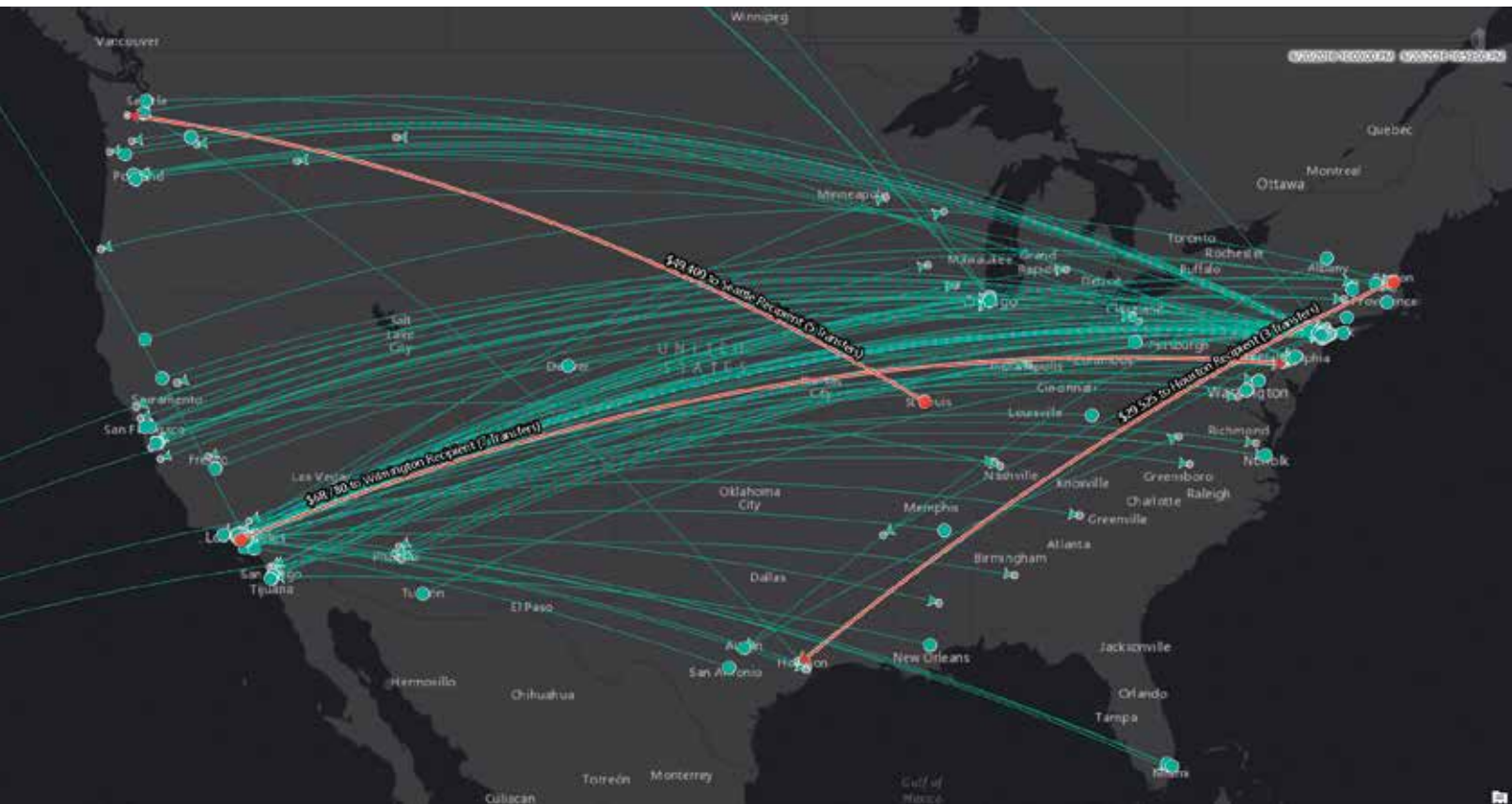
### ArcGIS GeoAnalytics Server

ArcGIS GeoAnalytics Server makes its debut at the 10.5 release. It is

← ArcGIS GeoEvent Server powers fast, real-time data mapping and analytics, from any sensor, device, or social media feed.

↓ New with ArcGIS Enterprise, Insights for ArcGIS enables simple drag-and-drop data exploration and analysis, including maps and charts.





↑ The new ArcGIS GeoAnalytics Server accelerates batch analytics on massive datasets, reducing processing time from days to minutes.

designed to handle the analysis of massive datasets. GeoAnalytics tools are a subset of Esri geoprocessing tools that use distributed and parallelized computing to run space-time analyses on extremely large datasets. These tools can be executed using the Portal for ArcGIS map viewer, ArcGIS Pro, the ArcGIS Server REST API, or from the new ArcGIS API for Python. ArcGIS GeoAnalytics Server can connect to data from the Hadoop Distributed File System (HDFS), Hive, local file shares, and data from within ArcGIS Enterprise, including using the archived spatiotemporal output from ArcGIS GeoEvent Server as input. Because ArcGIS GeoAnalytics Server uses the base ArcGIS Enterprise deployment to write and store analytical output, it is easy to use and share the resultant layers and data.

### Esri Business Analyst Server

Esri Business Analyst Server is an Esri solution package that has been turned into a server role. Unlike the other server roles, Esri Business Analyst Server includes a bundle of specialized tools, data, and apps. Esri Business Analyst Server content is specially curated and proprietary to Esri. It allows users to target specific markets and enrich the data analysis process. Custom tools and applications make analyzing, generating, and exploring business intelligence data easy. Full integration with the base ArcGIS Enterprise deployment means that all business intelligence data remains safely behind the firewall.

In addition to the server roles, ArcGIS Enterprise differs from its predecessor ArcGIS for Server by delivering Esri-curated Living Atlas of the World content behind the firewall. Using the base ArcGIS Enterprise deployment, an administrator can configure Portal for ArcGIS to include Living Atlas content, which includes imagery, demographics and lifestyle data, historical maps, and base-maps. An administrator can decide which Living Atlas resources to make available to the organization to align with the organization's business priorities.

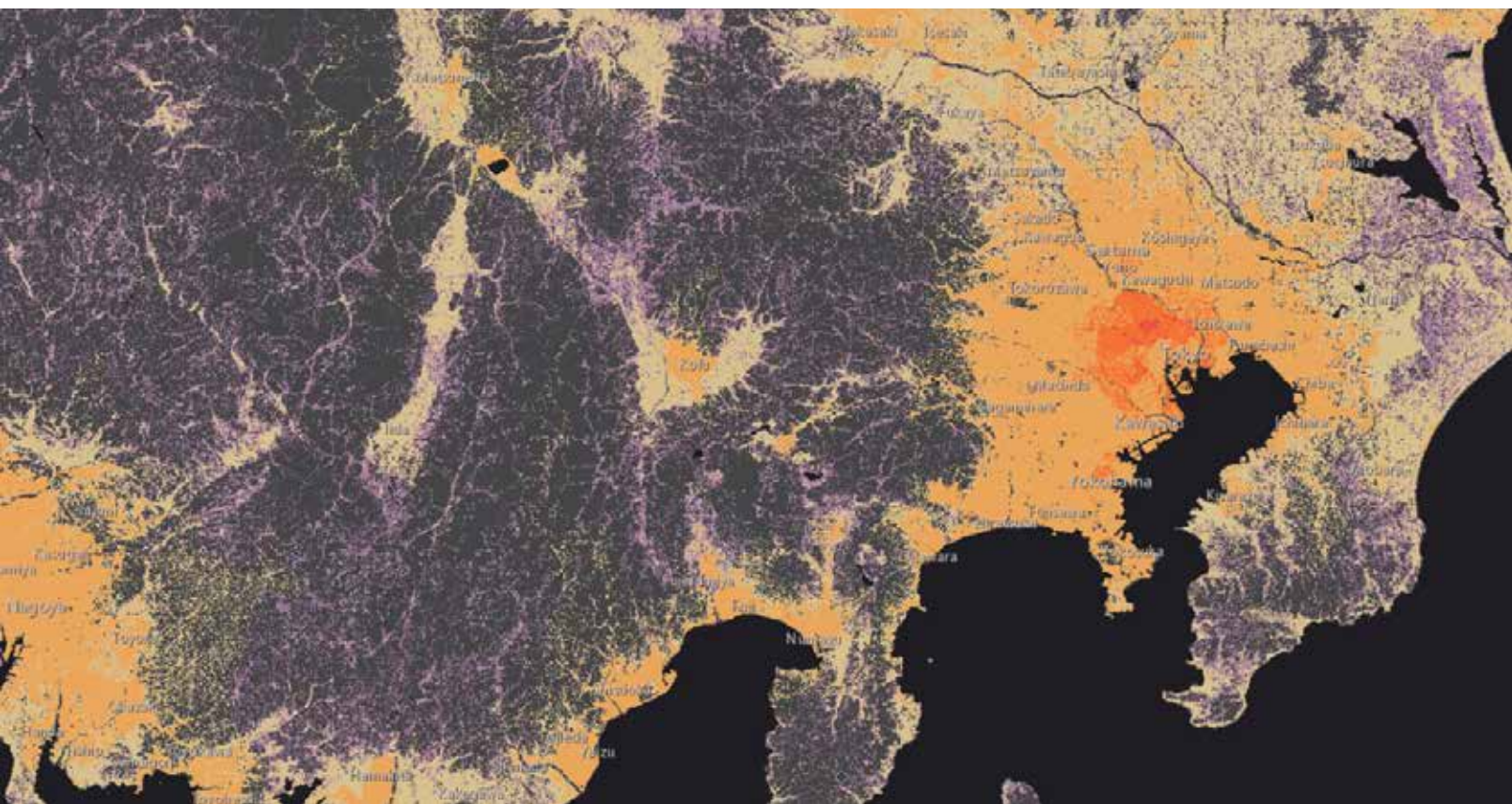
### Extending Collaborative Capabilities

ArcGIS 10.5 is designed for full integration with Web GIS. Web GIS provides a centralized location for an organization to share data, analyses, and information. Esri offers two paths to Web GIS: ArcGIS Enterprise and ArcGIS Online. The choice will depend on whether an organization wants to manage the infrastructure behind its Web GIS.

If everything should be kept behind an organization's firewall and software installations and deployments are handled in-house, then ArcGIS Enterprise is the choice. If it makes more sense for the organization to have Esri manage the scaling, updating, and overhead of its Web GIS, then ArcGIS Online is the choice.

With the release of ArcGIS 10.5, the collaborative capacity of Web GIS has been expanded. New with ArcGIS 10.5 is the concept





↑ Access the Living Atlas of the World—including world traffic and demographics—through ArcGIS Enterprise.

of distributed Web GIS, in which content is shared between multiple, independent Web GIS implementations. The first wave of distributed Web GIS—portal to portal collaboration—is unveiled at ArcGIS 10.5. portal to portal collaboration uses the Portal for ArcGIS component to share content between two or more ArcGIS Enterprise deployments.

In addition to greater collaborative capabilities in Web GIS, the apps offered by ArcGIS 10.5 give better connectivity between the office and the field so an organization can gain new information from its data.

### Interactive Data Discovery and Exploration

Insights for ArcGIS, debuting with ArcGIS 10.5, is an innovative web-based app that provides interactive discovery and exploration of both spatial and nonspatial data. Insights can incorporate data from enterprise databases, such as SQL Server and SAP HANA; geodatabases; Microsoft Excel spreadsheets; and any data that can be brought into ArcGIS as a feature layer.

Insights uses a smart, graphical user interface (UI) that analyzes data as it is added and recommends appropriate data exploration tools and visualizations. Insights projects are managed in workbooks that include data connections, iterative analysis, visualizations, workflows, and the information produced by analysis. Workbooks contain pages for collecting related content. On a page,

data is visualized on cards as maps, charts, and tables.

Cards are the primary way to interact with Insights for ArcGIS. Analysis happens dynamically. The connected nature of the card interface provides on-the-fly synchronization between data views. Create, update, and compare maps, charts, and tables; draw buffers; aggregate numeric data across any geography; apply spatial tools; and slice and summarize data by any field—all using cards.

The app automatically tracks and diagrams workflow steps. This makes analysis workflows repeatable and verifiable. Integration with ArcGIS Enterprise lets Insights workbooks be shared and viewed across the organization.

### Tools for Developers Too

ArcGIS is code free by design. Everything from running analyses to creating web apps can be accomplished without writing a single line of code. However, ArcGIS 10.5 has many GIS tools for developers, programmers, and data scientists. It introduces ArcGIS API for Python, which provides new options for scripting and automating analysis and administrative tasks within the ArcGIS platform. It is especially useful when applied to ArcGIS Online or ArcGIS Enterprise. ArcGIS API for Python integrates well with Jupyter Notebooks and the SciPy stack and includes modules that allow display and modification of maps directly from Jupyter Notebooks.



# The First Global, Data-Driven, and Truly 3D Ocean Map

Oceans are critical to the well-being of Earth and its inhabitants. They are the repository of almost all the water on the planet; impact climate and weather; are a major source of food, and are the highway upon which global shipping travels. Yet, remarkably little is known about oceans. Only 5 to 10 percent of oceans have been explored in any detail.

To ameliorate this situation, the Group on Earth Observations (GEO), an intergovernmental partnership that seeks innovative solutions to global challenges, commissioned a global map of Ecological Marine Units (EMUs). This map will support the wise use of ocean resources and the preservation of environmental resilience by providing a framework for understanding processes and detecting change.

Released in September 2016, the EMU project was created through an innovative public-private partnership led by Esri and the United States Geological Survey (USGS) in collaboration with NatureServe, the Marine Conservation Institute, the University of Auckland (New Zealand), GRID-Arendal (Norway), Duke University, the Woods Hole Oceanographic Institution, the National

Institute of Water and Atmospheric Research (NIWA), the United States National Oceanic and Atmospheric Administration (NOAA), and the United States National Aeronautics and Space Administration (NASA).

The EMU project establishes a 3D point mesh framework spanning 52 million points and global measurements of six key variables over a 50-year period of the ocean's water column. The creation of EMUs was a big data project. EMUs are composed of an aggregation and computation on an unprecedented scale. Climatology data was extracted at  $\frac{1}{4}$  degree by  $\frac{1}{4}$  degree (approximately 27 kilometers x 27 kilometers at the equator) intervals at variable depths before being spatially analyzed and clustered using a multivariate statistical method and then verified by leading oceanographers.

The result is a standardized, rigorous, and ecologically meaningful set of ocean ecosystem units that may be used as a basemap with other GIS overlays produced by various organizations for climate change impact studies, biodiversity priority setting, economic and social valuation studies, research, and marine spatial planning.

In describing the unique value of EMUs, Dawn Wright, Esri chief scientist who led Esri's efforts on the project said, "The strength of EMUs is that they differ from existing maps of marine ecoregions or biogeographic realms by being globally comprehensive, quantitatively data driven, and truly 3D. Rigorous statistical clustering produced 37 physically and chemically distinct volumetric regions where the chemical properties most likely to drive ecosystem responses are readily available to all interested MPAs [*marine protected areas*], conservation-minded organizations, academic institutions, or citizen scientists. With these insights in hand, individuals can gauge indicators of positive or negative trends and use data to make informed decisions that preserve marine environments."

← The EMU project establishes a 3D point mesh framework spanning 52 million points and global measurements of six key variables over a 50-year period of the ocean's water column.

↓ EMU Explorer apps were developed so the EMUs and the original NOAA *World Ocean Atlas* data could be explored using a web browser or mobile device.

The authoritative *World Ocean Atlas* produced by NOAA is the primary data source for EMUs. EMUs are an open, accessible data source that can serve as the basis for further marine spatial research by giving scientists and conservationists better access

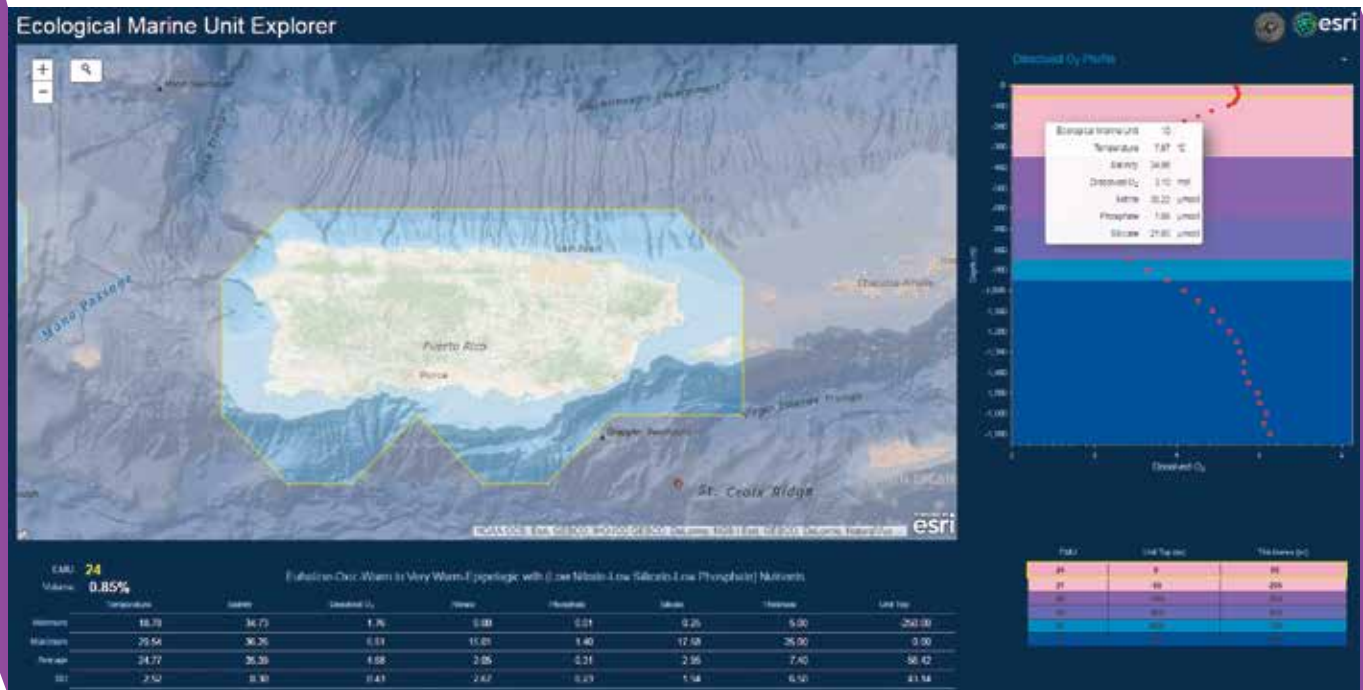
the connection between human actions and environmental effects.

Although the EMU Explorer apps and EMU layers were made available in the Living Atlas of the World in 2016, the project continues. A global delineation of Ecological Coastal Units (ECUs) at a much finer spatial resolution, as well as global ecological freshwater ecosystems (EFUs), is planned.

The creation of EMUs is a tremendous step toward the goal of not only comprehensively mapping the ocean but also understanding how the earth works. EMU complements the Ecological Land Units (ELUs) released in 2014. ELUs defined and modeled

science through apps such as Survey123 for ArcGIS; and participating in the Federal Geographic Data Committee Open Water Data Initiative. To improve access to rasters stored in the cloud, Esri contributed to the open-source Geospatial Data Abstraction Library (GDAL) implementation of Meta Raster Format (MRF) and made its patented Limited Error Raster Compression (LERC) technology freely available to the geospatial and earth sciences community. Esri Press has published books, such as *Ocean Solutions*, *Earth Solutions*, Second Edition, that promote the use of GIS for scientific research.

EMUs grew out of a collaborative effort.



to knowledge regarding marine ecosystems.

The Ecological Marine Unit (EMU) Explorer apps were developed so the EMUs and the original *World Ocean Atlas* data could be explored using a web browser or mobile device. Analysis of the entire water column is inherently a 3D application and EMU Explorer apps provide that third dimension, making complex data more understandable and thus making it available for use in the classroom and the field.

By providing ready access to this data, EMU Explorer is a powerful educational tool that can be incorporated into classroom and laboratory exercises, illustrating

terrestrial ecosystems as unique combinations of bioclimate, landform, geology, and land cover. ELU data can be explored using the Eco Tapestry app in a web browser and as layers in the Living Atlas of the World.

EMUs and ELUs are part of Esri's continuing efforts to develop the framework and tools that support basic and applied science. These efforts spring from Esri's commitment to develop GIS technology that promotes understanding the earth in ways that are profound and lead to action.

Just a few of these efforts: including scientific Python modules with ArcGIS; developing an R-GIS community; promoting citizen

The insights produced by this effort would not have been possible without valuable input from a large team of contributors. Esri hopes this collaboration will not only continue but also grow, and it encourages scientists to expand EMUs with their own data to make possible a more current and comprehensive picture of the oceans. Access to web services and related products for use in related projects is available [www.esri.com/ecological-marine-units](http://www.esri.com/ecological-marine-units). Download the EMU data from [esriurl.com/emudata](http://esriurl.com/emudata). See current information on the project at the EMU community on GeoNet ([geonet.esri.com/groups/ecological-marine-units](http://geonet.esri.com/groups/ecological-marine-units)).



# Planning the City of Tomorrow in 3D

By Jim Baumann, Esri Writer

The Internet has provided a connected, digital environment that allows much of the world's population to enjoy the benefits of exchanging a wide variety of information for commercial, scientific, and social activities. This connectivity also spawned the vision of a smart community—a community in which information technology (IT) plays a major role in the decision-making process and provides an improved quality of life for its residents.

## IT Solutions for Systemic Problems

Today, the maturation of information technology, particularly improvements in computer speed, real-time monitoring and feedback, device independence, and the integrating capabilities of GIS as a platform, is transforming the smart community from a theoretical concept into reality.

This transformation comes none too

soon. World population is predicted to be 9.7 billion people by 2050, and two-thirds of those people will live in cities. This huge increase in population will significantly strain the services required by urban dwellers.

In China alone, 350 million people are expected to move into cities during the next two decades, according to Wu Hongbo, undersecretary for the United Nations Department of Economic and Social Affairs. "Clearly, such massive changes will pose social, economic, and environmental challenges, while also creating tremendous opportunities," said Hongbo.

Population growth necessitates increased public transportation capacity, expanded utility services, more affordable housing, better educational opportunities, and a greater emphasis on public safety. The common thread linking these services is the need for integrated planning and analysis.

## Applying a Global View to Local Issues

Cities have long suffered from a lack of comprehensive planning, unsustainable development, and the ineffective use of resources. Ongoing efforts undertaken throughout the world to better understand the complex dynamics of urban life seek to create sustainable cities in the future.

For many years, the Fraunhofer Society, Europe's largest application-focused research organization, has analyzed the expansion of population worldwide and its impact on resources. Its research is used to develop solutions for the problems inherent in unsustainable growth and apply these lessons to future development.

In 2010, the society launched Morgenstadt: City of the Future. The goal of this initiative is to develop and implement technologies for future cities that are climate adapted, carbon dioxide neutral, and energy efficient.

← Cologne is on a major European river so flooding is an ever-present danger. Using Esri CityEngine to model existing flood data provided the visualization of flood inundation levels in Mülheim Süd.



In Phase 1 of the project, the society evaluated Berlin, Copenhagen, Freiburg, New York City, Singapore, and Tokyo to determine sustainability best practices and their impact on the quality of life based on emerging technologies and new business models. By analyzing the six cities on-site in-depth and from the viewpoint of different disciplines, the Fraunhofer city teams identified the main action fields for sustainable development for each of the six cities. These action fields show how these cities are addressing challenges and opportunities to better understand strategies and priorities adopted by the six cities. Eighty-three defined key action fields for sustainable development were represented in the Morgenstadt model's core.

Applying the results from Phase 1, the society then launched City Lab to test the use of different innovative information and communication technologies to determine their effectiveness in helping the city of the future be more livable and resilient. Fundamental to the project is the society's belief that interdisciplinary collaboration lies at the heart of urban innovation. Participating cities are implementing projects that include the analysis of the link between sustainable mobility and energy

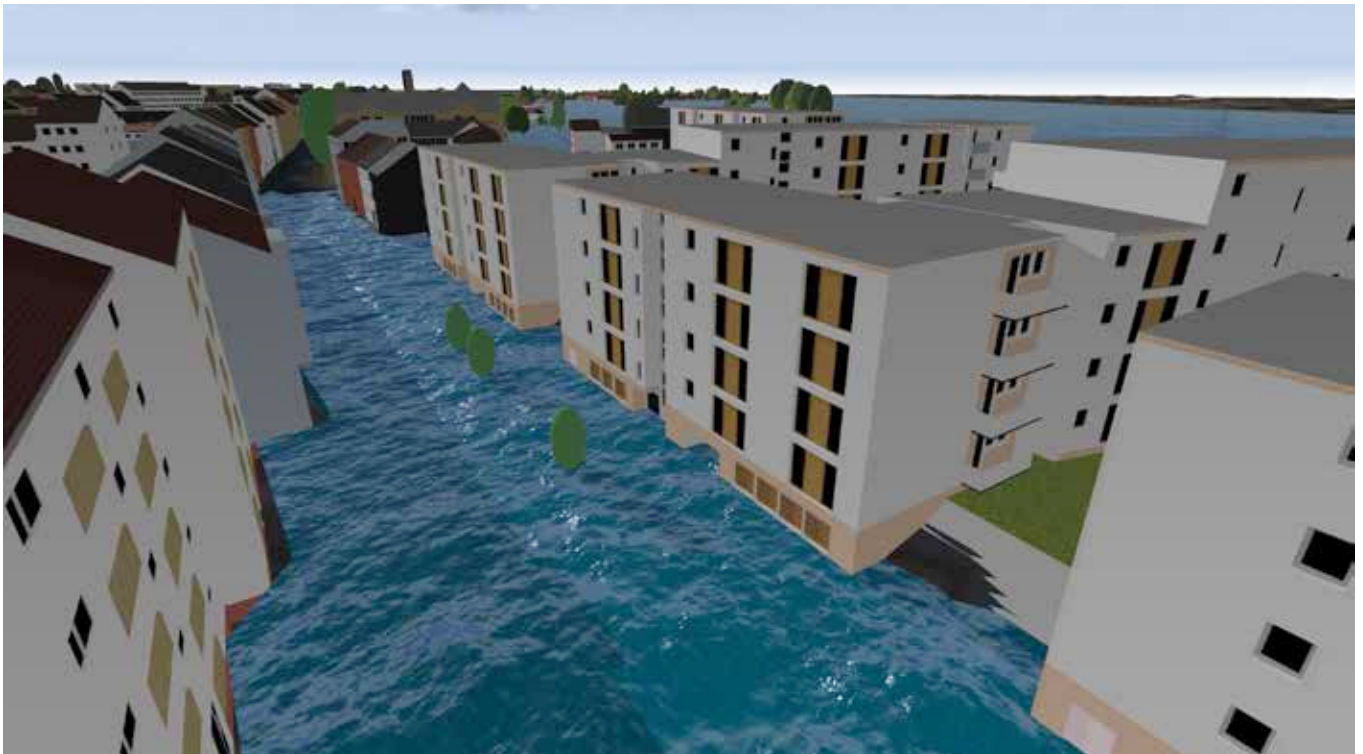
consumption and the use of sensors to collect data in real time for the development of data-driven services.

### Reimagining Mülheim Süd

Cologne is a major German city on the Rhine River. Its history stretches back 2,000 years to its founding as a Roman outpost in the Rhineland. In 2012, the city was selected to implement a Morgenstadt Phase 2 project that examined the best methods to revitalize the aging industrial, commercial, and residential district of Mülheim Süd and transform it into a new and sustainable community in the next 20 years.

The proposed design was developed by a consortium of architects and urban planners, including BOLLES + WILSON, ksg Architekten und Stadtplaner, and KLA Kiparlandschaftsarchitekten, which were selected through a competition organized by the City of Cologne. The design incorporates residential, commercial, and recreational areas within a green infrastructure to provide a safer, more attractive, more enjoyable, and healthier environment for those living and working in the area.

Jörg Schaller used Esri CityEngine to complete an interactive 3D model of the design to visualize planning alternatives



for Mülheim Süd. (Schaller is professor at the Technical University in Munich; the owner and director of the German environmental consulting group Prof. Schaller UmweltConsult GmbH (PSU); scientific director of Esri Deutschland Group GmbH; and cofounded Esri Deutschland in 1979.) CityEngine is a software modeling package for urban planning that is integrated with ArcGIS technology.

"We used GIS technologies combined with geodesign planning methodology to support the implementation of a holistic approach to sustainable urban development," said Schaller. "This also includes an emphasis on green infrastructure, which is a requirement of our national government. Our model follows the guidelines of Cologne's smart city initiative, within the framework of the Fraunhofer Society's Morgenstadt project."

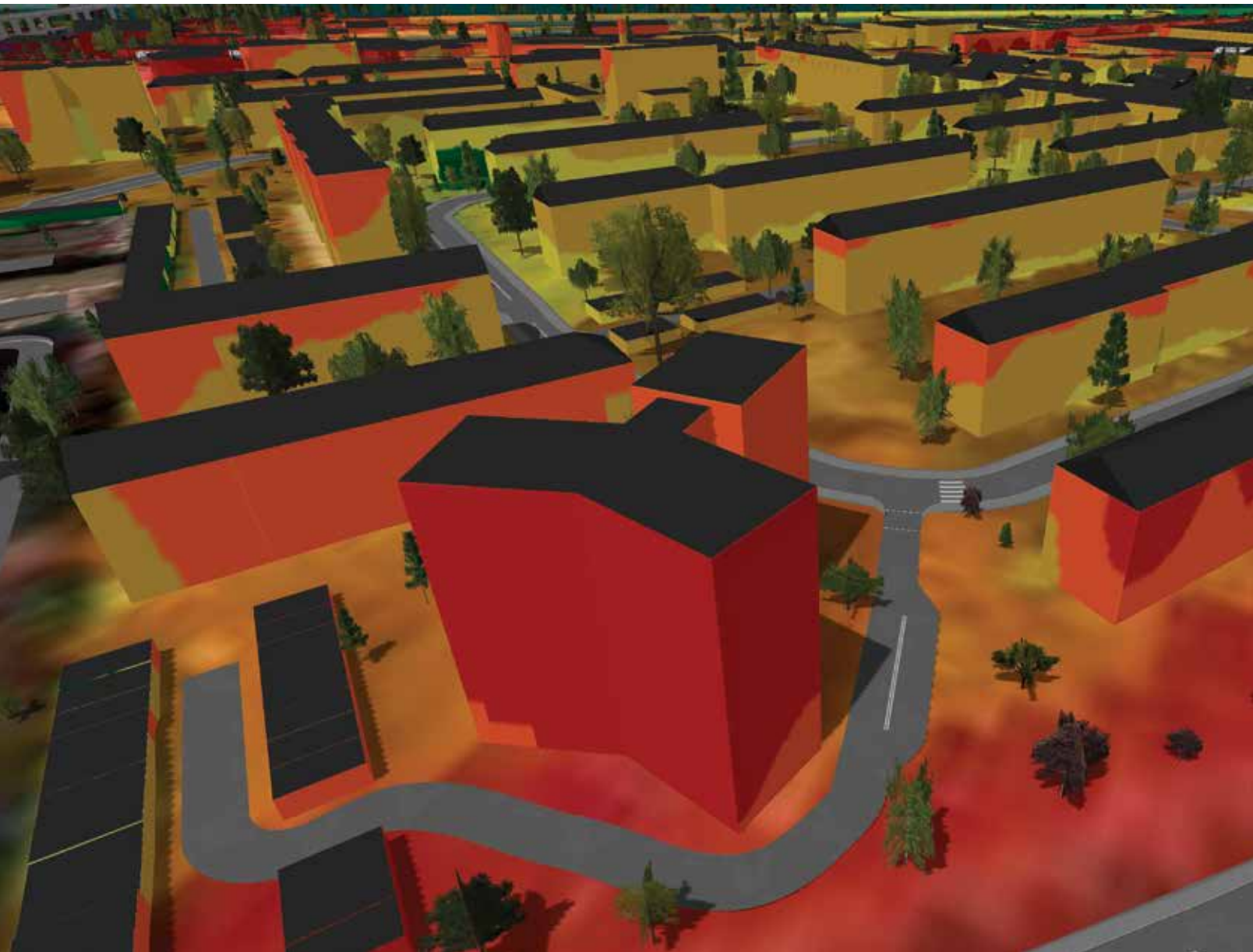
### Developing an Interactive 3D Model with CityEngine

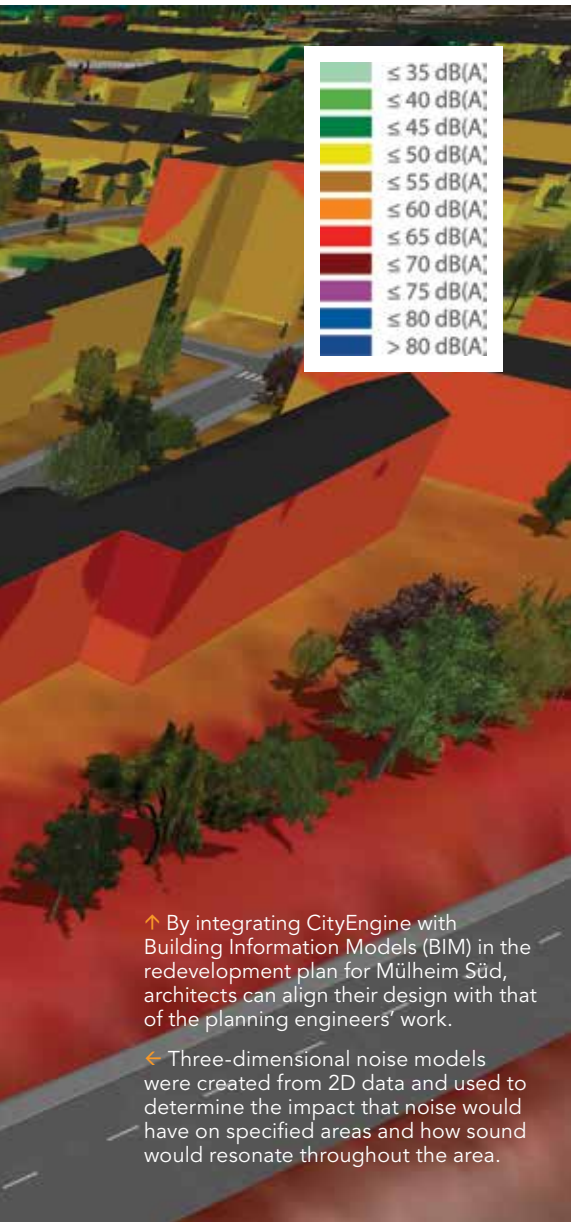
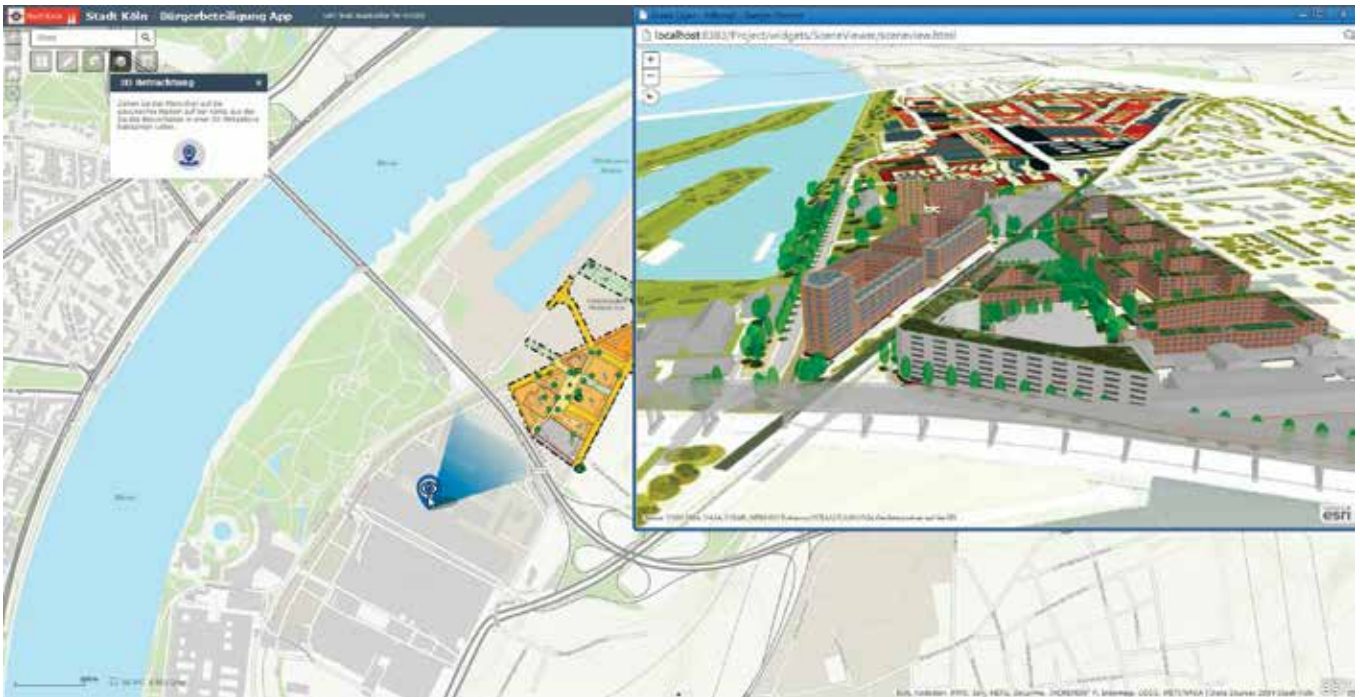
Many datasets were needed by PSU to complete the project. The City of Cologne provided a digital terrain model (DTM); digital surface model (DSM); cadastral data; high-resolution orthophotos; aerial photos; Building Energy Specification Table (BEST) and Energy Performance Certificates on the buildings that are currently in an old residential quarter of the project area; master plan document; development plans; environmental data; and models for flooding, air pollution, noise, and traffic, as well as related statistical data.

"Other input included lidar elevation data and a BIM [*Building Information Modeling*] data, all of which we integrated with CityEngine to develop our 3D model of a redeveloped Mülheim Süd," said Schaller. "Including the BIM with CityEngine allows

architects to align their design with that of the planning engineers' work, which can't be done with BIM alone. In future development stages, the 3D model of the entire district can be used for the city planning process, public participation initiatives, and energy and environmental modeling." PSU used these datasets and models, combined with the plans and sketches of buildings, walkways, parks, and other features proposed by the architects and urban planners, to create detailed 3D models to support a new master plan of a revitalized Mülheim Süd. These models take into consideration several environmental factors.

Because Cologne is on a major European river, flooding is an ever-present danger. Using CityEngine to model existing flood data provided the visualization of flood inundation levels in Mülheim Süd. "The process was fairly straight forward," said





↑ By integrating CityEngine with Building Information Models (BIM) in the redevelopment plan for Mülheim Süd, architects can align their design with that of the planning engineers' work.

← Three-dimensional noise models were created from 2D data and used to determine the impact that noise would have on specified areas and how sound would resonate throughout the area.

Schaller. "We first created water surface raster files from water level data and the DTM. The raster files were then vectorized and tiled. This allowed us to include them as layers in CityEngine. We could then display potential flooding at various levels and its impact on the streets and buildings in Mülheim Süd."

Reducing sound levels in cities is another major consideration when improving the quality of life for residents and workers. Together with Esri partner n-Sphere from Switzerland, PSU spatially modeled potential noise levels in Mülheim Süd using CityEngine and ArcGIS Geostatistical Analyst with the 2D noise level data provided by the city.

Three-dimensional noise models were created from the 2D data and used to determine the impact that noise would have on specified areas of the previously created building facades and how sound would resonate throughout the area. With related statistical information, it is possible to determine how many people would be affected by the different noise levels in different development scenarios.

Energy conservation is also an important factor in a smart community. For each building within a selected district quarter in Mülheim Süd, a BEST table was created by the SmartCity Cologne initiative. This is

required by the European Union's Horizon 2020 plan for promoting low energy consumption and indicates the building's energy needs for heating, lighting, and hot water. Each 3D building model in the selected quarter was color-coded by its actual energy consumption and its potential energy saving in the future scenarios.

Central to the SmartCity Cologne initiative is citizen participation. An online citizen participation app was developed by PSU and the company 52°North that gives residents the opportunity to evaluate and comment on the redevelopment proposals. It will be available soon at the SmartCity Cologne website ([www.smartcity-cologne.de/](http://www.smartcity-cologne.de/)). This helps the city engage with its residents as it continues its smart community development.

"3D GIS technology is a powerful design platform to support the planning and implementation of sustainable urban development," concluded Schaller. "It is a very cost-effective method because 3D municipal designs can be efficiently created, and changes to those designs can be easily made if required by city planners. In addition, while all cities are different, the workflow and tools we have developed can be employed by other communities by using their own data models for noise levels, energy consumption, and so on."

↓ A tornado that hit the Powdermill Nature Reserve in southwestern Pennsylvania, June 2012 provided a research opportunity for studying the effects of management practices. Because of the extent of the study area, UAVs were used to supplement on-the-ground monitoring.

# Turning Adversity into Opportunity

By Jake Slyder, Julia Carr, and Matt Mercurio

When disaster strikes, few people consider themselves lucky to be in the storm's path.

After a tornado struck southwestern Pennsylvania's Powdermill Nature Reserve on June 1, 2012, the environmental research center of the Carnegie Museum of Natural History found itself in just that position. Following large storms that damage forests, land managers interested in balancing economic concerns with environmental stewardship must decide if, and how, to perform salvage logging.

Recognizing this valuable research opportunity, Powdermill's GIS lab sprang into action to map storm damage on the reserve. Once the extent of the damage was assessed, the research team decided to split four large (10–20 acre/4–8 hectare) damaged areas in half, randomly assigning half to be logged and half to be left as is to compare how these areas respond to management decisions.

As the scientific value of these study areas became clear, researchers flocked to the

project, some coming from as far away as the Czech Republic. GIS became increasingly valuable for allocating limited space and efficiently collecting and managing data generated from multiple field surveys by these researchers.

## UAVs Supplement Field Methods

While field surveys provide detailed information on the status of various taxa, the GIS lab needed to develop a current picture of the forest structure across the entire site that could be used as a framework for organizing research. Although remote sensing seemed a logical choice because it offered repeatability and coverage, much of the available geospatial data lacks either the temporal or spatial resolution to be very informative.

For example, Landsat has a 16-day cycle that makes recent data available, but its 30-meter resolution is insufficient for studies at the scale required. Conversely, county

aerial imagery flights provide finer spatial resolution in visible bands but are only collected every three years. Pennsylvania has a solid baseline of lidar data from 2006 to 2008, but there are currently no plans for additional flights.

Given these limitations, the team turned to an emerging tool, unmanned aerial vehicles (UAVs), to supplement on-the-ground monitoring. Their ease of use and affordability have quickly made UAVs valuable data collection tools for conservation, forestry, and other fields.

While raw images or video from a UAV can be helpful for getting perspective on the affected area, the team used Drone2Map for ArcGIS to process an array of nadir images captured above each study area into 3D data (i.e., point clouds, digital surface models) that provide valuable structural information.

The team at Powdermill's GIS lab used 3D data from August 2015 flights to highlight the stark differences across salvaged,



unsalvaged, and unaffected forest. Despite the potential value in using UAVs, several challenges were associated with applying traditional workflows, such as those built around lidar data, to photogrammetrically derived 3D data. For example, photogrammetry requires at least two common points between images. Lidar requires only a single ray to measure a feature or surface elevation, making it a much better choice to ground model, even with canopy coverage.

While testing a new UAV in preparation for summer monitoring, the team thought of a novel way to circumvent this major limitation. In deciduous forests, UAV imagery captured before the leaves emerge can provide a clear picture of both the ground and the trees below the canopy and be combined with the summer data to provide a more complete picture of the forest. The results obtained from processing these leaf-off images were surprising: a dense point cloud with nearly 1,200 times higher point density than the available lidar data. Individual trees were clearly visible.

Given the tremendous detail of this point cloud, the group sought to create a workflow to use this data for forest inventories that would automatically extract multiple forest parameters. Although methods for extracting trees from lidar point clouds exist in the scientific literature and are available through third-party software, the

team wanted to explore using ArcGIS for Desktop with the ArcGIS Spatial Analyst and 3D Analyst extensions.

The logical starting point was the creation of a tool that would locate and identify each tree in the point cloud. To account for hilly terrain, the team converted the LAS files to a single point feature class and calculated point height above ground using a digital elevation model (DEM). [LAS is an industry-standard binary format for storing lidar data.] Because the best available DEM had comparatively coarse resolution, the team wanted to try classifying the ground points within the point cloud since the ground was clearly visible in the point cloud.

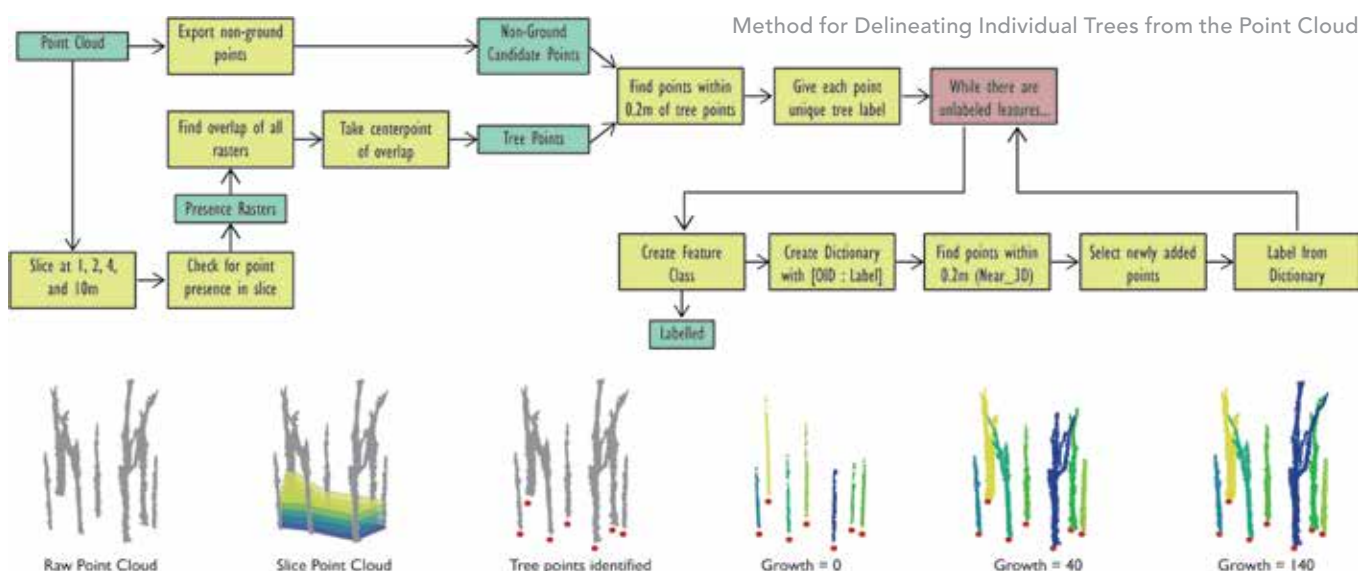
### Integrating a New Data Type into Existing Workflows

Though the photogrammetric point clouds share the same file type and are similar in appearance to lidar, they are produced by different processes. Photogrammetric point clouds lack fields, such as return number, intensity, and class code, that are generally present in processed lidar data. Any tool that uses these lidar-specific fields may not function as expected when run on photogrammetric LAS files.

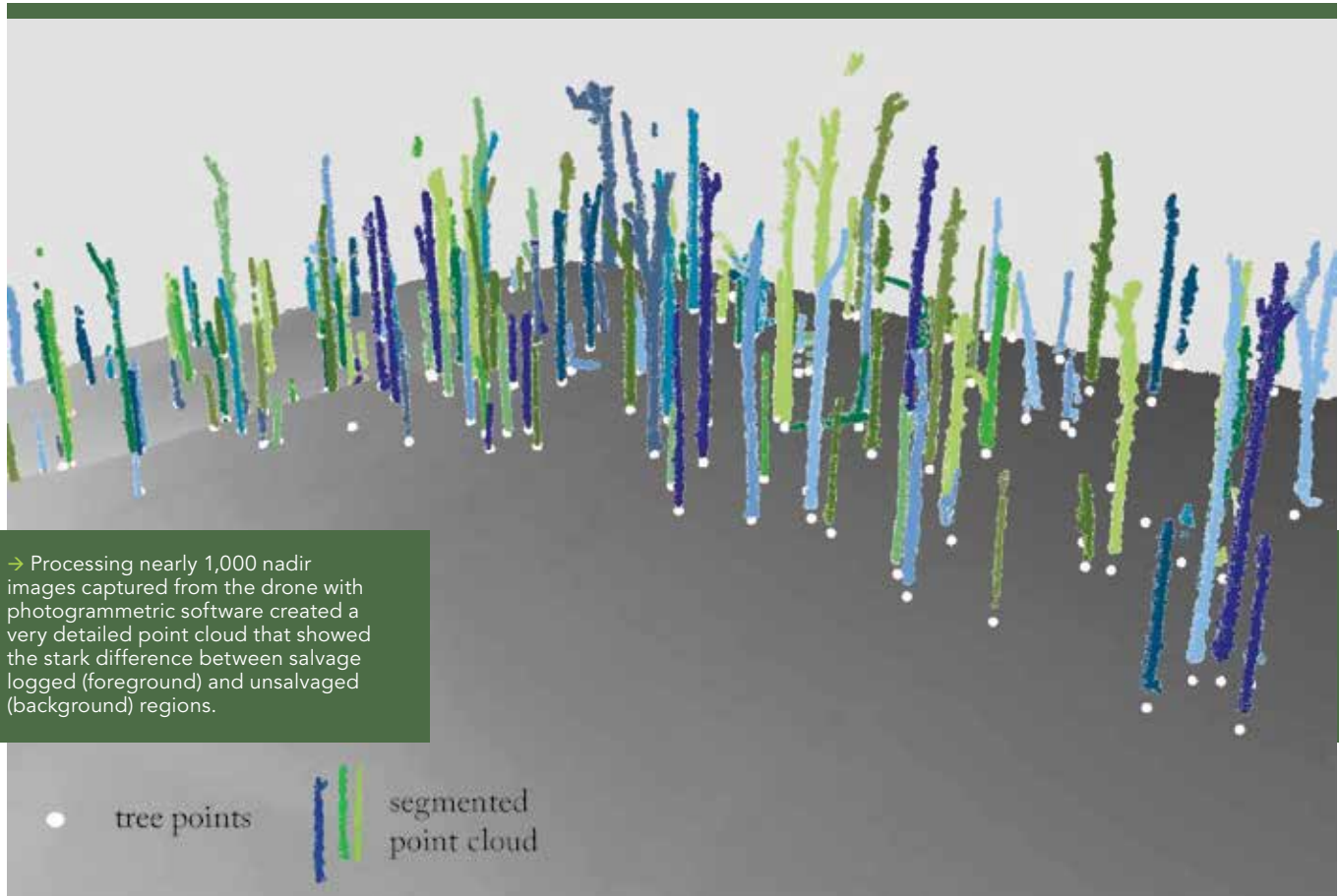
Consequently, the team—anticipating these difficulties—used the Classify LAS Ground tool available with the ArcGIS 3D Analyst extension on the unclassified

point cloud. The tool often performed well, but it periodically left large areas unclassified. On closer inspection, the team found that unusually large surface anomalies often marked the start of unclassified areas. They found a workaround by first running the tool with a mask that excluded these difficult areas followed by a second run reusing ground points from the first run. Once the preliminary work was done, the team could begin extracting usable information from the dense cloud of points.

Many existing methods for delineating vertical features such as trees start by identifying a local maximum. This approach does not work well with deciduous trees that have large, sprawling canopies and several high points. Instead, the team identified each tree from the bottom up and took advantage of the tree's vertical trunk. Since a tree trunk extends from the ground up to the canopy, unlike woody debris or other vegetation, the team sliced the point cloud into three height classes between 1 and 10 meters; rasterized each layer, assigning values of 1 for presence and 0 for absence to each cell; layered the three rasters; and used the Raster Calculator in the ArcGIS Spatial Analyst extension to summarize the cell values for all three layers. The result was a final raster in which all cells with a value of 3 represented tree locations and were converted to a tree point feature class.



↑ Two tools were used for tree identification and delineation. The first tool locates trees (tree points) by testing for the presence of points within different height classes. The second tool “grows” trees by labeling points closest to the tree point and iteratively searching within a narrow 3D search window for already labeled points.



→ Processing nearly 1,000 nadir images captured from the drone with photogrammetric software created a very detailed point cloud that showed the stark difference between salvage logged (foreground) and unsalvaged (background) regions.

At first blush, the results looked promising, but the team realized that a more rigorous accuracy assessment was necessary. Using the Create Random Points tool, they manually established 40 assessment plots totaling ~1.26 hectares (3.1 acres). Leveraging the linked map and scene capabilities of ArcGIS Pro, the team could inspect the point cloud and manually map each tree in the assessment plots. After this tedious work, the team was pleased to find that the custom tool accurately mapped the location of 97 percent of trees without additional fieldwork.

### Seeing the Trees from the Points

The accurate tree point locations, combined with a canopy height model, provided the team with tree location and height. However, the clear forms of the trees within the dataset suggested the possibility of extracting additional forestry parameters such as estimates of tree volume and basal area, so—bolstered by this early success—the team further explored the dataset.

Team members quickly realized that they were in for a challenge. Performing geoprocessing and making measurements on individual masses of points would require delineating individual trees from the mass of non-ground points. Manual delineation was out of the question due to the large focal areas (100+ acres/40+ hectares in total) and the small size of the team. Instead, they needed to come up with a series of logical steps to consistently delineate trees.

Initially, they considered assigning all above ground points to the nearest tree. This proved to be unsatisfactory because large, spreading tree crowns sometimes overlapped. While more computationally intensive, an iterative growth approach could circumvent this major issue.

After setting the starting point for each tree based on the previously mapped tree points, the team tried searching for above ground points in a small 3D envelope to allow each tree to “grow” only if there were additional points nearby. Unfortunately, a nearly continuous mat of unclassified points

near the ground meant that the iterative loop would not stop at the base of the tree, even with a small search window.

To get around this problem, the team tweaked the tool to slice off all points within a meter of the ground before the loop started. After the iterative growth portion of the tool finishes, the low points are added back, and the trunk is extruded down to the ground. The level of complexity within the study area, characterized by a high density of debris that was leaning or downed after the storm, created low expectations that the tool could consistently delineate trees from the point cloud.

The team returned to the earlier assessment plots to manually delineate each visible tree in ArcGIS Pro and was pleased to find that for 315 trees (composed of 395,097 individual points), there was a 91.6 percent correspondence between the automatic tool and manual delineation. The results were even more encouraging after manual inspection, when they found that just 10 or so problematic trees resulted in many of the delineation errors.



→ After processing each point cloud with the custom ArcGIS toolset, the ground was removed, and each tree was given a unique feature ID, which can be used as a case field to make summaries or additional geoprocessing much easier at the tree level.

## Plans for Additional Development

After some ups and downs and many trips back to the drawing board, the team now has a custom set of tools that allows it to collect leaf-off imagery and process this into forest inventory data within a matter of days, which greatly reduces the manual fieldwork to collect this type of data. Moreover, saving the flight records to repeat the same flights in the future will allow all the project partners to monitor sitewide change over time in unprecedented detail.

While fieldwork will still be required, the UAV has quickly established itself as a valuable tool for the scientists studying this important land management issue. Seeing the value in these same approaches for other researchers and conservation groups, the team plans to share its work via a custom toolbox once the code has been cleaned up. The team also plans to push further with this technology, adding more multispectral sensors with repeat flights during the spring and fall seasons to attempt to classify

individual tree species types in this diverse forest. UAVs certainly have the potential to revolutionize geospatial data collection, and—with some creativity—these tools and their resultant data can work well within the existing ArcGIS infrastructure.

For more information, contact Jake Slyder, GIS research scientist, at the Carnegie Museum of Natural History at [slyderj@carnegiemnh.org](mailto:slyderj@carnegiemnh.org).

## About the Authors

**Jake Slyder** is a research scientist and manager of the GIS lab at the Carnegie Museum of Natural History, based at Powdermill Nature Reserve.

**Julia Carr**, a recent graduate of the geology program at Brown University, is planning to pursue a doctorate in tectonic geomorphology in fall 2017.

**Matt Mercurio, GISP**, spent 17 years as a GIS professional in nonprofits and local government before cofounding two geospatial technology companies in 2015.

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# Getting Ready for the

# Big One

By Jim Baumann, Esri Writer

On June 7, 2016, at 8:03 a.m., a 9.0 magnitude earthquake, centered 70 miles off the Oregon coast, violently shook the Pacific Northwest from Northern California to southern Canada for about five minutes. Because the earthquake's epicenter occurred deep in the crustal plates beneath the Pacific Ocean, tsunami waves as high as 40 feet formed and struck the coast about 20 minutes after the initial earthquake jolt. The other side of this wall of water surged west, taking 10 hours to reach the Japanese coast 5,000 miles away.

Fortunately, this is not the description of an actual disaster but the scenario for an emergency response exercise called Cascadia Rising. It was organized by the Federal Emergency Management Agency (FEMA) to test the readiness of emergency responders in the Pacific Northwest region for a major earthquake similar in size to the one that struck Japan in 2011. The multiagency exercise was staged June 7–10, 2016, and included more than 165 organizations in Oregon, Washington, California, Idaho, and Canada.

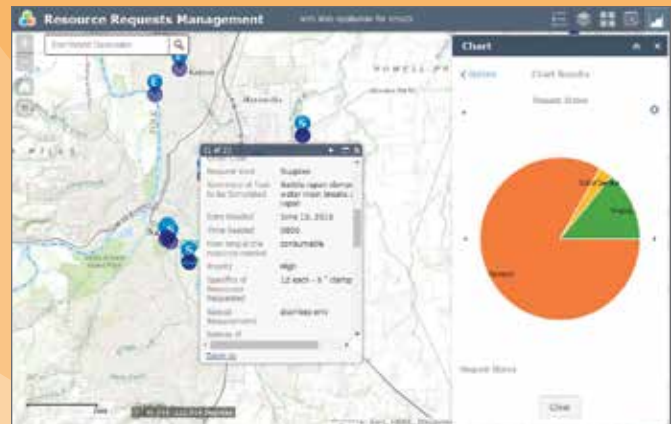
The City of Salem, Oregon, which participated in the exercise, activated its Emergency Operations Center (EOC) and mobilized its EOC GIS team. It used ArcGIS as a geocommunication platform for collaboration, resource allocation, and damage assessment.

"The exercise was about simulating the first week after a catastrophic 9.0+ earthquake and resulting tsunami striking the area," said Susan Blohm, GIS manager for the City of Salem, Oregon. "It was a multistate event that required the activation of EOCs throughout the Pacific Northwest region."

## Overdue for a Major Event

The Cascadia subduction fault zone stretches approximately 800 miles along the western coast of North America from Cape Mendocino in northern California to Vancouver Island in British Columbia, Canada. The offshore Juan de Fuca plate is being shoved under the North American plate. The subduction zone is named for the Cascade Mountain range, which includes active volcanos. It is part of the Pacific Ocean's Ring of Fire, where the majority of the world's largest earthquakes occur.

Chris Goldfinger, a professor at Oregon State University (OSU) and an expert on subduction zone earthquakes, indicates that the last major earthquake occurred on the Cascadia subduction zone on January 26, 1700. An extensive study authored by Goldfinger and other OSU researchers concluded that there is a 40 percent chance of a major earthquake occurring in the southern margin of the Cascadia fault zone during the next 50 years that will be similar in intensity to the 2011 Japanese event. The research also indicates that earthquakes in this region occur every 240 years on average, making the next one already about 75 years overdue.



↑ The status of emergency facilities and school status and the most current damage estimates were communicated via an Operations Dashboard.

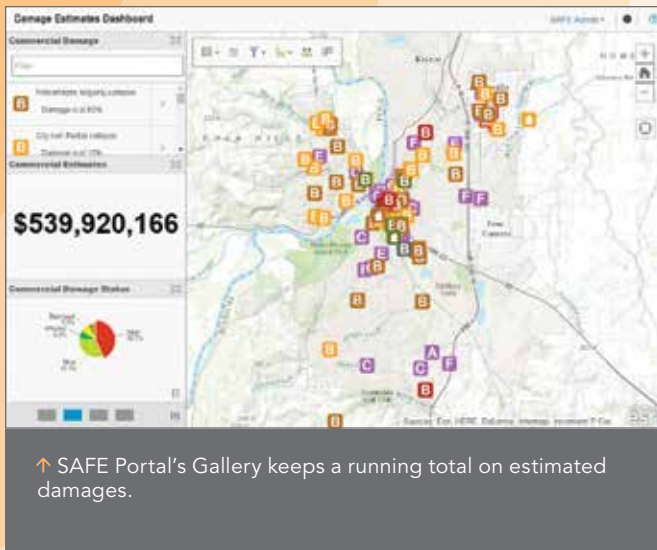
## Testing Real-Time Collaboration

"All of us in this region that are involved in emergency operations are well aware of the potential devastation from a 9.0 earthquake and the fact that it could strike at any time," said Blohm. "Our fundamental goal for the exercise was to participate in a meaningful, collaborative way. We accomplished this by creating the Situational Awareness Framework for Events Portal, successfully implementing Portal for ArcGIS with 100 temporary ArcGIS Online user licenses that we distributed throughout our local area."

"Because of the low learning curve of ArcGIS Online, training wasn't necessary, and we were very satisfied with the results," said Blohm. "We were able to quickly stand up a working prototype of an expanded local emergency services network for data management, visualization, and resource sharing. In addition, we supported the overarching objectives for the exercise established by the Oregon Office of Emergency Management (OEM) that included operational communications, public health and medical services, mass care services, situational assessment, critical transportation, and operational coordination."

According to Dan Brown, the city's GIS technical lead, SAFE Portal was not only the technology platform but also the geocommunication platform for collaborating in real time. "I am looking forward to using SAFE Portal to further strengthen our city, county, transit, schools, health, and business community to use the power of Web GIS and to go beyond the limited use of paper maps."

Salem allocated its ArcGIS Online licenses to facilities in the city

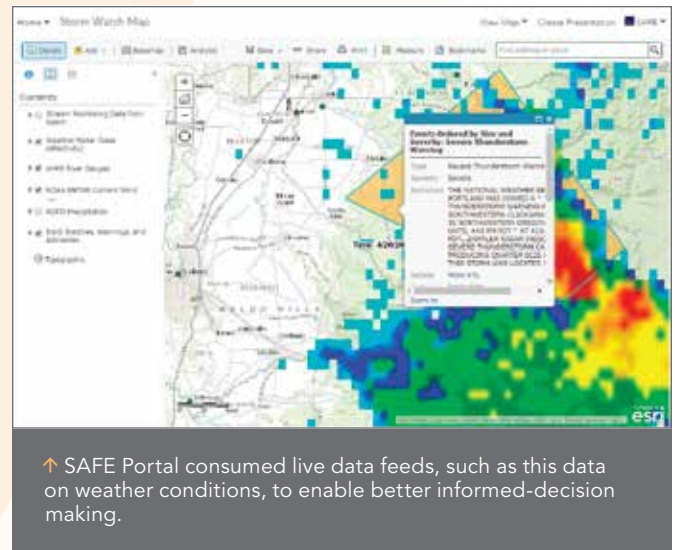


as well as cities within Marion County where it is located. This distribution of software licenses to other jurisdictions—the Red Cross, Citizen Emergency Response Teams (CERT), the local hospital, and others—allowed those organizations to interactively share information directly related to Oregon OEM's objectives with the Salem EOC in real time.

Emergency 911 calls, as well as other critical resource requests, were reviewed to determine the appropriate response based on needs, resources, and locations. In addition, they could share and exchange resources with one another. The locations of all mass evacuation and response shelters, such as hospitals, were available through the portal. Field teams recorded damage assessments with Collector for ArcGIS and attached related photos to their reports. Transportation networks were assessed and GIS used to identify alternative routes for transporting critical goods and providing services to the most vulnerable populations.

By coordinating operations through Portal for ArcGIS, information was shared in real time between participants, local EOCs, the state, and federal organizations such as FEMA.

"We developed an effective application for damage assessment for the exercise," said Blohm. Each damaged property's value was obtained from the county assessor's records. Teams in the field estimated the percentage of a property that sustained damage. This percentage was applied to the assessed value to estimate the cost of damages. For example, the loss for a house valued at \$300,00



that was 50 percent damaged was estimated to be \$150,000.

"We kept a running total of property damage displayed on the EOC dashboard so that it could be readily reported to FEMA, because when you reach a certain financial threshold, you can request federal emergency disaster relief assistance including financial relief funding," said Blohm.

### Bringing All the Data Together

Online content was an important part of developing the big picture at the EOC. The city not only displayed the information it was collecting in the field but also looked at seismic activity from the US Geological Survey, weather patterns from the National Weather Service, and local citizen vulnerability based on the US Census Bureau data.

"We included many authoritative data providers in our data feeds to take advantage of their live streaming data services so that we could deliver a comprehensive, real-time common operating picture for our EOC," said Blohm. "The beauty of ArcGIS Online is its ability to easily bring all of that data together to display it and, more importantly, share it."

"At the city of Salem, we embrace using ArcGIS as a platform. Without that, I don't think we would have had the success we did on this exercise," concludes Blohm. "You have to use all of the different components of the platform in order to have a complete picture and develop a successful EOC program. This was a fast-track project and we were able to stand it up quickly and easily."

# GIS Enhances Construction Surveying

By Michael P. Parkinson, GIS Manager, FSC, INC.

GIS integration into construction surveying has provided the multidisciplinary engineering firm FSC, INC., and its clients with a powerful new tool that enhances data management, project management, quality control, and cost reduction.

Construction surveying provides the critical link between exact design engineering and precise on-the-ground layout of industrial facilities. Industrial construction facilities often require deep foundations that transfer building loads farther into the earth than shallow foundations. The vertical structural element of a deep foundation is generally referred to as a pile. A pile is typically a column of strong material, such as steel-reinforced concrete, that is sunk deep into the ground to provide underground structural support.

The specifications for piles depend on the geotechnical characteristics of the ground as well as design aspects of the facility. To achieve engineering load capacity and overall strength of the facility foundations, optimal placement of support piles—both horizontally and vertically—is paramount.

At multiple project sites, FSC, INC., provided precise construction layout as specified by detailed engineering piling plans. These piling plans are designed with multiple pile types, each with strict engineered specifications and a unique location. To ensure the precise layout location of each pile, survey-grade GPS equipment is used to mark the location where each pile will be installed. After initial layout and installation, survey-grade GPS equipment is again used to verify that the as-built location for each pile falls within an allowable tolerance.

One such project site alone contained more than 21,000 data points. The need for a GIS solution quickly became apparent. FSC, INC.'s GIS department developed a custom geodatabase to manage and store the tremendous flow of spatial data coming from each project site.

Initial pile locations were transformed from an assumed grid coordinate system

to a real-world coordinate system for use in GIS mapping applications. Attribute tables were populated and used to track pile specification details and installation information such as installation status, installation date, and as-built measurements.

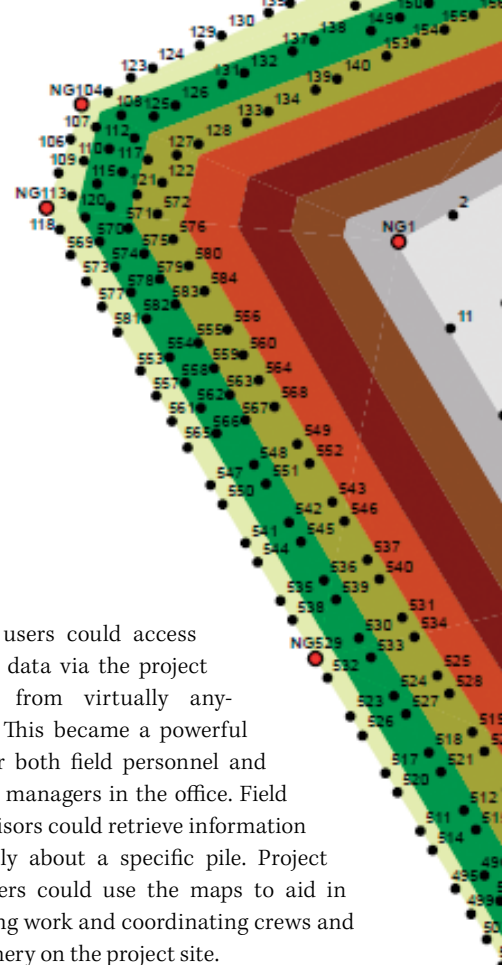
Because work was performed six days a week at each site, daily edits were necessary to provide up-to-date information on the project progress to various project stakeholders. FSC, INC., also published the database to a GIS service using ArcGIS for Server. This service could be consumed by other GIS users in ArcMap.

A more flexible method for sharing information with non-GIS users was also needed. The GIS team developed and hosted a user-friendly GIS web application, a project viewer, with Geocortex Essentials. Produced by Esri Platinum Partner Latitude Geographics, Geocortex Essentials allows quick and effective deployment of web applications.

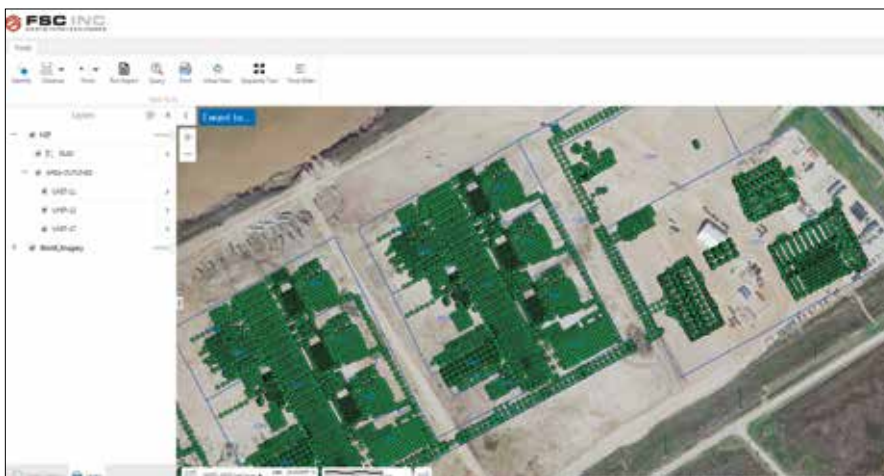
End users could access project data via the project viewer from virtually anywhere. This became a powerful tool for both field personnel and project managers in the office. Field supervisors could retrieve information instantly about a specific pile. Project managers could use the maps to aid in planning work and coordinating crews and machinery on the project site.

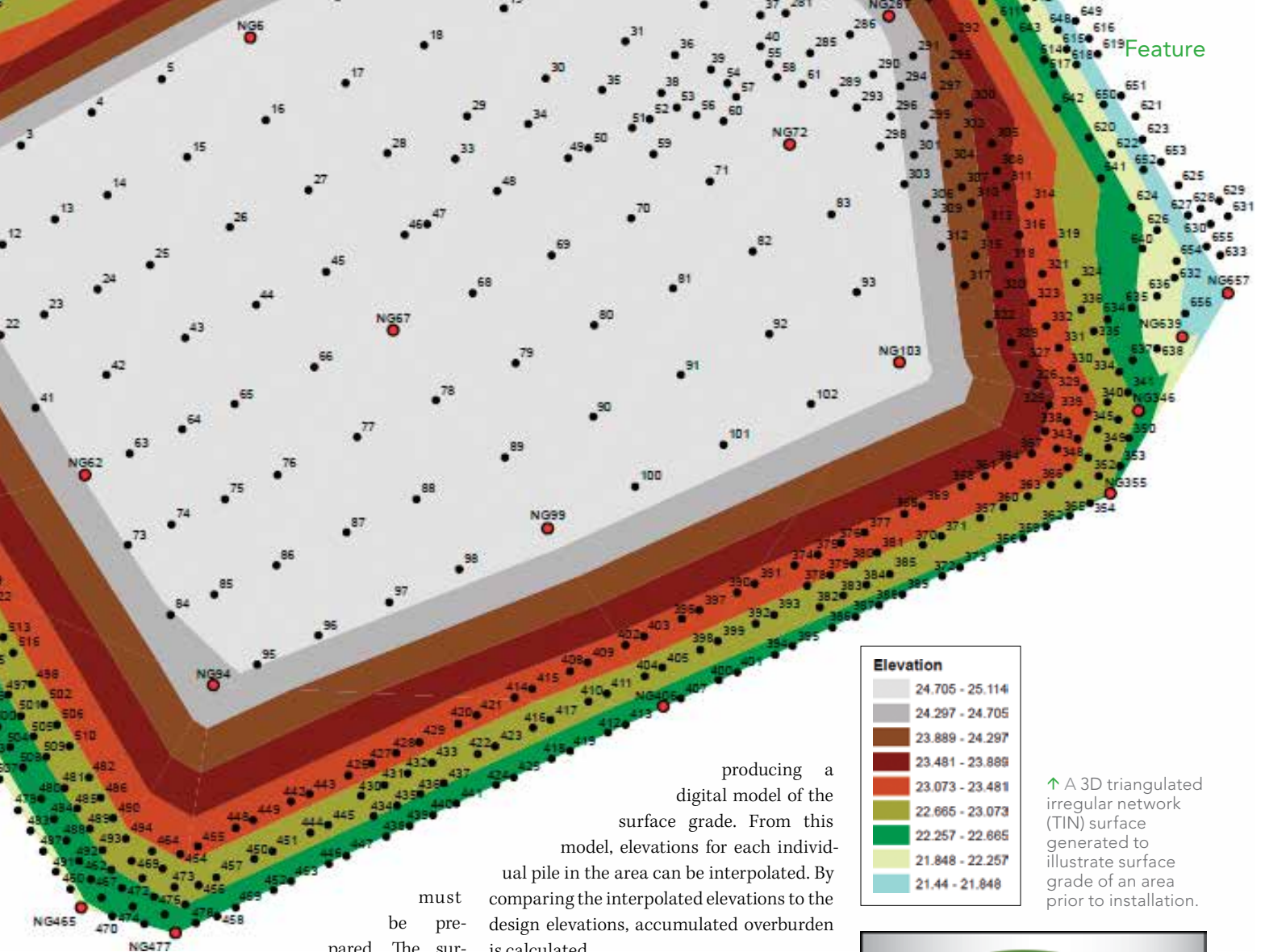
The project viewer was also used to archive and retrieve as-built documentation needed to verify that installed piles met all tolerance requirements. Because the flow and accessibility of information was streamlined, project decision-making efficiency improved dramatically.

In addition to precision pile layout and as-built verification, FSC, INC., used tools in ArcGIS to help calculate grade overburden. Before piles are installed, the project site surface



✓ The project viewer was used to show installation progress and analysis to the project stakeholders.





must be prepared. The surface gradient is a critical component of correctly installing a pile, since each pile must be installed to a specific, predetermined depth.

If too much surface material is present, additional construction material must be added to the pile to bring it to the correct elevation. For a large site, excess materials can add up quickly and cost the client hundreds of thousands of dollars.

To recoup these costs, excess grade allowances are outlined in project contracts. However, calculating and documenting these costs can be tricky. Traditionally, a topographic survey is performed, and the excess grade is calculated by averaging the planned elevation and grade elevation differences in each series of piles. But by utilizing tools in the ArcGIS 3D Analyst extension, a much more accurate assessment can be made.

A 3D triangulated irregular network (TIN) surface is generated based on natural ground elevations derived from GPS measurements,

producing a digital model of the surface grade. From this model, elevations for each individual pile in the area can be interpolated. By comparing the interpolated elevations to the design elevations, accumulated overburden is calculated.

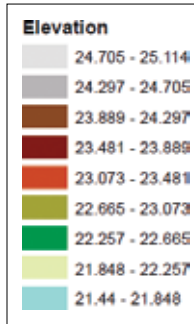
This method yields significantly more accurate results than traditional methods of calculation, thus allowing the client to recoup more of the costs incurred from additional materials during the installation process.

Implementation of these practices allows FSC, INC., to offer more comprehensive and robust services, making the company more appealing to clients for future construction projects.

For more information, contact [mparkinson@fscinc.net](mailto:mparkinson@fscinc.net).

### About the Author

**Michael Parkinson** has a bachelor's degree in geography from Texas A&M University. He was a GIS mapping designer for Phillips 66 Pipeline Company before joining FSC, INC., as a GIS manager. His current areas of expertise include database management, web application design, pipeline mapping, and unmanned aircraft systems (UAS) data collection for surveying and engineering.



↑ A 3D triangulated irregular network (TIN) surface generated to illustrate surface grade of an area prior to installation.

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# Cultivating Relationships, Planting Ideas, and Harvesting Dreams

By Trisha Brush, Director of GIS, Planning and Development Services of Kenton County, Kentucky

Growing up on a farm, I realized that farming is a full-time job, even if my father called it *hobby farming*. Farming involved the entire family working together as a team.

Farming is a risky business that depends mostly on one element that cannot be controlled: the weather. Consequently, farmers leave nothing else to chance. Every move is intentional and strategic. Methodical planning and refinement enable farmers to gain the greatest yield possible. There is a time to reap and a time to sow. Perfect timing is everything.

Are you calculating every move you make in building your GIS? Are there times when lack of personnel, funding, or hardware determine your path? Do you feel like your GIS shop is affected by multiple “weather patterns” outside your control?

I will share my GIS farmer strategy for calming the storms of newly elected officials, looming budget cuts, and uninformed citizens. Let’s look at the life cycle of a GIS farm.

## Crop Selection

Selecting your crop is a critical decision to make for your GIS shop. Do you want your team to be the go-to for emergency management analysis, cadastral CAD science, or mapping? These are just a few of

the directions you could pursue. There is a myriad of paths your GIS troop can explore. By determining your geospatial focus, you can calm the storms before they arrive. For example, if a high-profile or mandated course is the emphasis of the division, budgeting could be less of a concern. Take the proper time and be purposeful when planning the route for your location intelligence legion.

## Cultivating Relationships and Land Preparation

In farming, you need to prepare the land with a plow, a disk, or a harrow. In GIS, the concept is similar. As a GIS leader, you need to find GIS champions in your organization, town, or community. This is the time for you to get the lay of the land. Who is on the geospatial side of the fence? This is the crowd you appeal to when preparing the ground to start sowing your geospatial seeds.

At this point, the timing is perfect for you to start learning about your supporters’ interests so you can tell them how GIS can be used to harvest their dreams. Just like soil, some relationships need cultivating. Interpersonal communications play a *big* role in GIS farming, and that is something they don’t teach you in Intro to GIS 101.

## Planting Ideas

Once you have declared your direction and know the topography, it is time to start

planting seeds. If you have a squad of emergency analysts, the seed to sow could be an appreciation of the need to establish an addressing authority in your jurisdiction. This seed could be sown with the local fire chief, the chief of police, mayor, county administrator, and dispatch and emergency manager—to name a few. It takes lots of seeds to make things grow. If you are a good farmer, your seed propagates other folks’ ideas.

## Irrigation and Fertilization

Choosing where to sow the seed is mission-critical to the success of your team, but the seed will need some water and fertilizer to grow. You need to apply just enough water to sustain—but not flood—it. Knowing exactly when and how much fertilizer is needed to grow the idea is truly a science. Fertilizer, in this case, may consist of statistics, maps that show irregular data, or documentation of how a workflow has gone wrong.

Growing an idea can take months—sometimes years. This means that this part of the farming life cycle will need to be repeated as needed. It could create what a programmer would call a loop. You may need to hit the Escape key to exit a loop and reevaluate the importance of the seed you planted. Perhaps you examine a new way of planting—such as the no-till method—to encourage growth. If you get caught in fertilization-and-irrigation paralysis, you can always look for a fresh perspective and new seeds to plant.





## Harvesting Dreams

There is nothing better than reaping what you sowed by gathering success stories and harvesting dreams. Realizing the precise time to collect the fruits of your labor is key. The idea should be ripe to shell, shuck, or pick. Stockpile too early or too late and you could get little or no return on your crop. Harvesting at just the right time produces the highest yield. When harvesting dreams, make sure you share the victory with all the champions who supported the dream and brought it to fruition.

## Climate

Several years ago, our 25-year-old GIS was under attack. Elected officials claimed that GIS was “just bells and whistles.” Even today, that attack still resonates with my team and me.

One morning I sat down with an elected county official. While sharing stories over coffee about the valuable role of GIS in emergency siren placement, handling voting precinct redistricting, and settling school district boundary disputes, it became clear that the official knew nothing about the involvement of GIS in these vital projects.

This was the turning point. This is when I became a GIS farmer and began my crusade to meet with elected officials and municipal dignitaries to relate to them GIS stories so they can understand the workhorse role that GIS plays behind the scenes. Stories of

the daily uses of GIS in dispatch, school bus routing, public works, and planning have enlightened them. They now realize the indispensable part GIS plays in routine—but critical—workflows.

Here are a couple of dreams my team recently harvested. An elected city official was seeking funding to study a street intersection realignment. A city administrator from a local city asked my team to prepare a story map about that intersection. Using this story map, the city successfully lobbied the state legislature for funds to perform a study on the intersection. The city, which was awarded a quarter of a million dollars for the design of the intersection, believes the story map was, “a key tool” that enabled it to receive the funding.

In our jurisdiction, there are 34 cities in two counties that manage road projects. This area is served by six utilities. Local utility partners wanted a management system that coordinated street cuts. Over the last seven years, the GIS-based right-of-way system has saved the participants more than \$200,000 by synchronizing paving improvements and also easing traffic congestion. By using the farming methods that I have outlined here, these successful seeds grew into harvestable dreams with great yields and measurable return on investment (ROI).

## Keep Sowing Seeds

As a GIS farmer, I find myself sowing seeds

more than any other chore. You never know where a seed will take hold. Sometimes the soil is fertile where you thought nothing would grow. Sometimes seed selection will be critical because the soil is less fertile. Knowing the lay of the land will aid you the most when you are just starting GIS farming, but sometimes ignorance doesn't hurt either.

Mostly it comes down to risk, relationships, and refinement. Farming is a risky business, so you need to be strategic and purposeful. Build relationships. Understand the needs of the community and your champions. With refinement, you will produce a bumper crop of fruitful geospatial projects. I hope my advice on how best to do these farm chores will assist you in harvesting your geospatial dreams.

## About the Author

**Trisha Brush, GISP**, is the director of GIS for Planning and Development Services, Kenton County, Kentucky. Brush has 19 years of experience managing geospatial technologies and has served on state GIS boards in Kansas and Kentucky. In 2003 she founded and served as president of the Kentucky Association of Mapping Professionals. She has a bachelor's degree in geography and a graduate-level GIS certificate, both from the University of Cincinnati. She has a master's degree in business administration from Baker University, Overland Park, Kansas.

# What Makes an Enterprise GIS Successful?

By Adam Carnow, Esri

A successful GIS implementation requires more than just technology. Whether or not a GIS is successful largely depends on motivated people. These people are committed to managing change and effectively applying the technology in a sustainable manner while following best practices. An assistant city manager once told me, “whether or not our GIS implementation is successful is not a technology problem; it’s a people problem.”

## Become a Leader

Two key elements of a successful GIS are vision and leadership. If you are a GIS manager, you need to be more than just a manager. You need to be a leader in your organization. You need to awaken your organization—and the public—to the capabilities and benefits of the use of GIS. This means you need to market the benefits of GIS to colleagues and the public.

Let them know that GIS can do more than make maps. Let them know that spatial analysis can provide insight that is not accessible with any other technology and that it can be used easily by anyone. This critical insight can help anyone make better decisions, be more efficient, and therefore save money and time.

To realize this vision of a location platform successfully supporting your organization’s business, you need to understand how GIS can contribute to your organization’s success. Talk to leaders in your organization to understand their vision and their problems, then deploy sustainable GIS solutions that directly align with their vision and help solve their problems. Provide these leaders with solutions they can use themselves—solutions such as web-enabled, operational dashboards. Making executives GIS users will let them understand the value of GIS. It will elevate your standing in the organization as well as elevate GIS to a mission-critical, enterprise business system.

A successful GIS also needs a living strategic plan. No enterprise IT system can be successful without an effective strategic plan. This plan need not be a voluminous document that takes a huge effort to create only to gather dust on a shelf. It can be as simple as a matrix showing which GIS capabilities have been deployed to which departments.

It should identify target areas for GIS expansion, prioritize those areas, and show they will be implemented in phases as appropriate solutions that meet organizational needs. The key is constantly updating the plan so it stays relevant and effective. This plan should align with the IT strategic plan as well as the overall organizational strategic plan.

Effective governance is another key to a successful GIS. This means that you must have an organizational structure that allows GIS to be as effective as possible. You do not want process to get in the way of progress.

One key is that there must be executive sponsorship for GIS. There should also be a GIS steering committee made up of executives who can make business decisions related to GIS. This would include decisions on whether or not a GIS solution should be developed using commercial off-the-shelf (COTS) technology or a custom solution developed by authoring code. This steering committee should also prioritize the GIS projects based on their value to the

organization so GIS professionals work in a manner that is sustainable and well aligned with the organization’s mission.

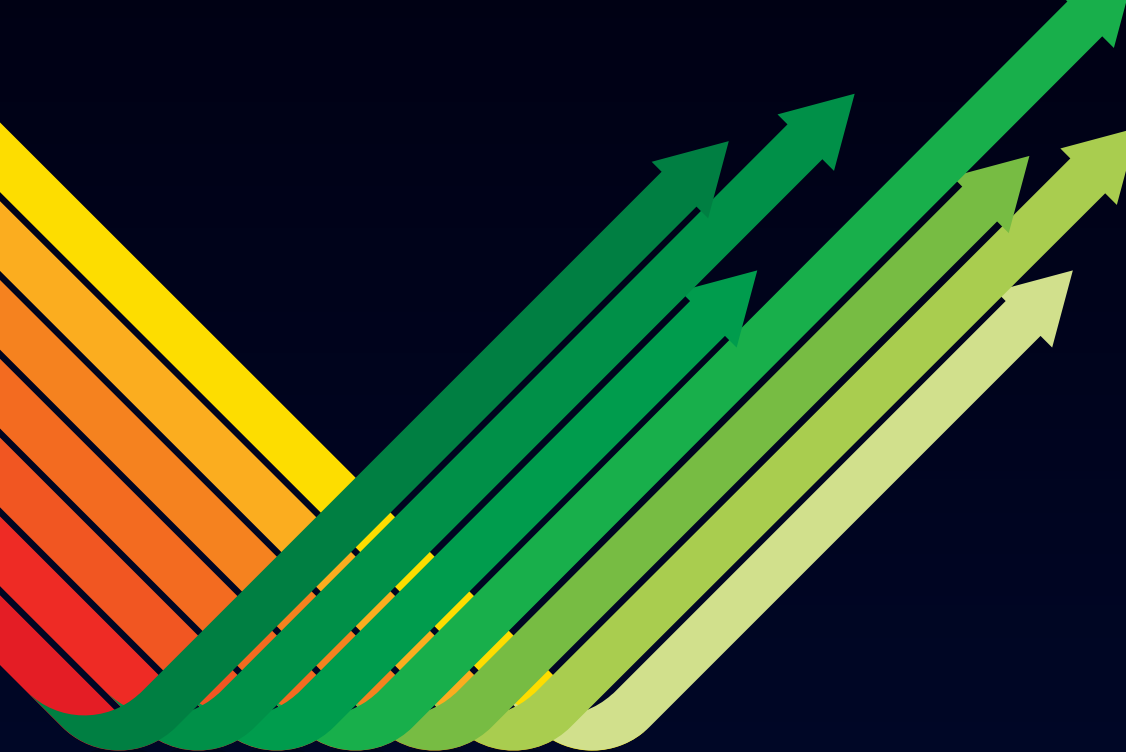
## Embracing Change

As ArcGIS evolves, so too does the approach used to implement it. To keep up with the accelerating rate of technology change, adopt change management. Embrace change and make it part of your daily work. If you do not consciously commit time to change management, you will not effect any change. Change is tough, but it cannot be ignored. Effectively and constantly managing change is fundamental to a successful organization.

You need to do this by participating in ArcGIS beta programs. A Esri Developer Network subscription will let you try out the new capabilities of the latest versions of ArcGIS and learn how they can benefit your organization’s work.

If your ArcGIS implementation is to be successful, the apps that people use must be engaging. With the widespread acceptance in our personal lives of smart mobile devices, like phones and tablets, and their app ecosystems, the expectations of end users have permanently changed.

No longer are people willing to read a manual or take a class to learn how to use an app. They won’t use apps that replicate the desktop with lots of layers to turn on and off and toolbars full of tools. Apps need to be focused; intuitive; and work on any



device, anywhere, at any time.

With the spread of smart mobile devices, work takes place wherever and whenever the worker decides, so your GIS apps need to be ready to work and as easy to use as any other app. The goal is to give everyone alternatives that use the latest and most authoritative data and processes, but to keep those alternatives in a known, controlled, and secure environment. ArcGIS includes apps that can easily be configured and tools for creating apps without writing code. Become familiar with them and use ones useful to your organization's workflows.

The last key to a successful GIS implementation is good people. GIS is rapidly changing technology, so it is critical that GIS professionals get annual training. Maintain a living workforce development plan that creates an educational pathway for the GIS users in your organization based on their responsibilities.

A GIS manager needs business management skills as well as technological and IT skills. As a GIS manager, you need to market your team's capabilities to the leaders of your organization. You also need to develop and maintain a business plan and change management plan as part of the GIS strategic plan.

These skills must be acquired for your program to be successful. You also need to learn how to run an enterprise IT system, implementing service-level agreements,

system architecture design, enterprise system integration, security, and project management.

### Don't Do It Alone

No successful GIS relies exclusively on internal resources. Implementing and maintaining an effective enterprise GIS requires outside assistance, so plan for getting assistance from Esri and/or its partners. Assistance from external, experienced professionals will increase the likelihood of success, minimize risk, and reduce the project timeline.

Esri offers many resources to help make you successful, so take advantage of them.

- Read the white paper *Architecting the ArcGIS Platform: Best Practices*, available from [esri.com](http://esri.com).
- Read columns by GIS managers in every issue of *ArcUser* magazine.
- See Managing GIS blog posts on *Esri Insider*.
- Join and participate in the Managers in GIS LinkedIn group.
- Attend the GIS Managers' Open Summit at the Esri User Conference.
- Contact your Esri account team. Your success is their job.

### About the Author

Adam Carnow is an account executive with Esri who manages large local government GIS customers in Florida, Georgia, and North Carolina. For more than 20 years, he

has been applying GIS and related spatial technologies to complex, award-winning projects across the globe in the realms of planning, transportation, and environmental sciences for both the public and private sectors. He holds a bachelor's degree in geography and a master's degree in urban and regional planning from the University of Florida, and he is a certified urban planner (AICP) and GIS Professional (GISP).

## Monitor Your GIS Platform





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# Start Cooking with the ArcGIS Chef Cookbooks

One of the ways to quickly reduce your workload and simplify maintenance of your GIS is to write scripts that automate common administrative tasks. If you think scripting is writing complicated batch files or shell scripts that are difficult to maintain, let me encourage you to use the ArcGIS Chef Cookbook. It will make your life easier. This article introduces (or reintroduces) you to a relatively new scripting and automation technology—Chef.

What is Chef? Technically, Chef is both a company (see [www.chef.io/chef/](http://www.chef.io/chef/)) and an automation platform for working with your infrastructure in the cloud, on-premises, and in hybrid environments. Chef has lots of components, but this article will focus on cookbooks. The cookbook is the fundamental building block of Chef. It is used to define what you're going to do to automate a task. A cookbook contains recipes that are the actual scripts. Recipes can accomplish very simple tasks, such as installing or uninstalling software, or they can be used to perform more complex tasks, such as assembling and configuring multiple software components across your network so they all work together.

The Esri Server team has been using Chef for several years to quickly configure virtual machines on-premises and in Amazon Web Services (AWS). As you can imagine, Esri runs ArcGIS software in many

➤ Listing 1 shows a simple recipe that you could use by opening it in a text editor and replacing "domain.com" with the domains you use for ArcGIS Server and Portal for ArcGIS.

➤ Listing 2 shows how the recipe would look if your domain for ArcGIS Server is `yosemite.esri.com`, your `admin_username` is `smokey1`, and your `admin_password` is `onlyUcan4527`.

Listing 1

```
{
  "arcgis": {
    "server": {
      "domain_name": "domain.com",
      "private_url": "https://domain.com:6443/arcgis",
      "web_context_url": "https://domain.com/server",
      "admin_username": "admin",
      "admin_password": "changeit",
      "is_hosting": true
    },
    "portal": {
      "domain_name": "domain.com",
      "wa_url": "https://domain.com/portal",
      "admin_username": "admin",
      "admin_password": "changeit"
    }
  },
  "run_list": [
    "recipe[arcgis-server::federation]"
  ]
}
```

Listing 2

```
arcgis": {
  "server": {
    "domain_name": "yosemite.esri.com",
    "private_url": "https://yosemite.esri.com:6443/arcgis",
    "web_context_url": "https://yosemite.esri.com/server",
    "admin_username": "smokey1",
    "admin_password": "onlyUcan4527",
    "is_hosting": true
  }
}
```

## Listing 3

```
"portal": {  
  "domain_name": "yosemite.esri.com",  
  "wa_url": "https://yosemite.esri.com/portal",  
  "admin_username": "smokey2",  
  "admin_password": "preventFF7843"
```

↑ Listing 3 shows how this would work for the portal section of the recipe.

different environments to test it, improve its performance, and support customers. Using Chef has saved considerable time and effort and has reduced the stress of constantly installing, uninstalling, updating, and maintaining all Esri machines running ArcGIS. Chef has proved to be a dependable and repeatable solution for automating ArcGIS deployments.

Earlier this year, Esri created a collection of Chef cookbooks for ArcGIS and made them available to all ArcGIS users at the Esri repository on GitHub. Each cookbook has a set of useful Chef recipes that work with different aspects of the ArcGIS platform, including ArcGIS Server, Portal for ArcGIS, ArcGIS Data Store, ArcGIS Web Adaptor, ArcGIS GeoEvent Server, and ArcGIS Pro.

To get started using Chef and the ArcGIS Cookbooks, you will need to have the following items:

- The setup and valid authorization files for the ArcGIS software stored in a folder on the machine you're working with.
- An SSL certificate issued by the certification authority for the domain. (Note: If you don't define a CA-cert, this tool will generate and use a self-signed certificate for testing purposes.) Note that self-signed certificates are not supported by Portal for ArcGIS. Your organization probably already uses CA-signed certificates from an organization like Verisign, Thawte, or DigiCert, and a web server expert in your IT staff can help you acquire a signed certificate.
- The Chef Client to run recipes. You can download and install the Chef Client

↓ Listing 4 shows how you would modify the webgis-windows.json file. You provide the version of your software, the path to your keystore, the keystore\_file, keystore\_password, and the correct path to your setup and authorization files.

Listing 4

```
arcgis": {
  "run_as_user": "arcgis",
  "run_as_password": "Run_As_Pa$$w0rd",
  "version": "10.5",
  "iis": {
    "keystore_file": "C:\\keystore\\mydomain_com.pfx",
    "keystore_password": "changeit"
  },
  "web_adaptor": {
    "setup": "C:\\ArcGIS\\10.5\\WebAdaptorIIS\\Setup.exe",
    "admin_access": true
  },
  "data_store": {
    "setup": "C:\\ArcGIS\\10.5\\DataStore\\Setup.exe"
  },
  "server": {
    "admin_username": "admin",
    "admin_password": "changeit",
    "setup": "C:\\ArcGIS\\10.5\\Server\\Setup.exe",
    "authorization_file": "C:\\ArcGIS\\10.5\\Authorization_Files\\Server.prvc",
    "keystore_file": "C:\\keystore\\mydomain_com.pfx",
    "keystore_password": "changeit"
  },
  "portal": {
    "admin_username": "admin",
    "admin_password": "changeit",
    "admin_email": "admin@mydomain.com",
    "security_question": "Your favorite ice cream flavor?",
    "security_question_answer": "vanilla",
    "content_dir": "C:\\arcgisportal\\content",
    "setup": "C:\\ArcGIS\\10.5\\Portal\\Setup.exe",
    "authorization_file": "C:\\ArcGIS\\10.5\\Authorization_Files\\Portal.prvc",
    "keystore_file": "C:\\keystore\\mydomain_com.pfx",
    "keystore_password": "changeit"
  }
},
"run_list": [
  "recipe[arcgis-server::system]",
  "recipe[arcgis-server::iis]",
  "recipe[arcgis-server::server]",
  "recipe[arcgis-server::server_wa]",
  "recipe[arcgis-server::datastore]",
  "recipe[arcgis-server::portal]",
  "recipe[arcgis-server::portal_wa]",
  "recipe[arcgis-server::federation]"
]
}
```

## Listing 5

```

"arcgis": {
  "version": "10.4",
  "desktop": {
    "setup": "C:\\ArcGIS\\10.4\\Desktop\\Setup.exe",
    "install_dir": "C:\\Program Files (x86)\\ArcGIS",
    "install_features": "ALL",
    "software_class": "Viewer",
    "seat_preference": "Fixed",
    "desktop_config": true,
    "modifyflexdacl": false
  }
},
"python": {
  "install_dir": "C:\\Python27"
},
"run_list": [
  "recipe[arcgis-desktop]"
]
}

```

← Listing 5 shows a simple recipe for installing and authorizing ArcGIS software

appropriate for the operating system you're working with at [www.chef.io/chef/install/](http://www.chef.io/chef/install/).

- The appropriate ArcGIS Cookbook. There are separate ArcGIS Cookbooks for ArcGIS Desktop, ArcGIS Pro, ArcGIS Server, and ArcGIS GeoEvent Server. Download and extract the appropriate ArcGIS Cookbook from [github.com/Esri/arcgis-cookbook/releases](https://github.com/Esri/arcgis-cookbook/releases).

ArcGIS Cookbooks were designed so you don't have to write scripts—just modify existing recipes and files to automate simple tasks.

The listings that accompany this article demonstrate how easily you can modify and use recipes. Listings 1 to 4 show how to use an ArcGIS Cookbook recipe to federate an ArcGIS Server with Portal for ArcGIS, a task you can do manually but one that can be automated with Chef. You can use this recipe not only for your initial configuration but later when you have added another ArcGIS Server to your deployment. After making changes to the recipe and saving them, use the Chef Client you installed to run the script by typing "chef-solo -j C:\chef\roles\webgis-windows.json" at the prompt (C:\) in the command prompt window and pressing Return.

If you don't have ArcGIS installed on a laptop or PC, you might want to try the simple recipe shown in Listing 5 for installing and authorizing ArcGIS Desktop.

To learn more about using the ArcGIS Cookbook, visit the [arcgis-cookbook](https://github.com/Esri/arcgis-cookbook/wiki) wiki on GitHub: <https://github.com/Esri/arcgis-cookbook/wiki>.



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→ Madison Vorva, a senior at Pomona College in Southern California, combines her passion for conservation and human rights with technology to effect real change.

# She Sees a Better World

By Citabria Stevens, ArcNews Editor

## Madison Vorva, who goes by Madi, has accomplished a lot.

She campaigned to get the Girl Scouts to stop using unsustainable palm oil in their cookies. She convinced Kellogg's, leading producer of cereal, cookies, crackers, and savory snacks, to agree to a deforestation-free policy for all its products.

She has studied land rights in Colombia, traveled to Cambodia to make a short documentary on a politician fighting for victims of land grabs, and observed how palm oil farming affects local communities in Malaysia and Singapore.

She is a United Nations Forest Hero and was honored at the Teen Choice Awards. She sits on the board of the Jane Goodall Institute (JGI).

She recently hosted a television program to show kids—especially girls—how fun and important science and technology are. She's developing GIS-based curricula to get youth more involved in service learning.

She's currently working on her thesis.

Her undergraduate senior thesis.

Madi is only 21 years old.

### Campaigning to Make Palm Oil Sustainable

As a Girl Scout trying to earn her Bronze Award, she and her friend, Rhiannon Tomtishen, put together an awareness presentation about why orangutans are endangered.

"I was really inspired by Jane Goodall," recalled Vorva. "I had seen an IMAX movie of her and was like, I want to be her when I grow up!"

The two friends learned that one of the biggest threats to these primates is the deforestation that is occurring to make room for palm oil plantations. Given that palm oil is in about 50 percent of packaged grocery store products, the girls felt they had to do something. They created orangutan week at their school, hosted palm oil-free bake sales, and put on a middle school dance to raise money for conservation.

Then one day, Vorva flipped over a box of Girl Scout cookies and saw that palm oil was an ingredient.

"That was really shocking because I'd sold the cookies since I was in first grade," she said.

That year, she and Tomtishen sold magazines instead of cookies. They'd planned to boycott the baked goods until the Girl Scouts stopped using palm oil in them, and they started a petition on change.org to get others to join in. They even attended a conference for Dr. Jane Goodall's Roots & Shoots program, which inspires kids around the world to create community action projects, to see if Goodall would sign the petition.

"But she actually changed the language on the petition," said Vorva. "It said, like, 'I'm not going to buy Girl Scout cookies until the palm oil is taken out,' and she rewrote it [to say] 'unless it's from a sustainable plantation.'"

In addition to signing the petition (along with 70,000 other people), Goodall got Vorva thinking about sustainability and what that meant. The girls reached out to





↑ As Girl Scouts, Vorva and her friend, Rhiannon Tomtishen, set out to discover why orangutans were endangered and quickly found out that palm oil—an ingredient in Girl Scout cookies—contributed greatly to their plight.

↓ Vorva had her lightbulb moment with GIS when she geocoded all the petition signatures from her Girl Scouts campaign and saw for the first time where supporters were located.

the Rainforest Action Network, Union of Concerned Scientists, and other similar organizations to partner with them on the campaign. That's when Vorva started to realize that palm oil farming not only threatens orangutans but is also linked to the displacement of indigenous communities and child enslaved labor.

Part of the Girl Scouts' mission is to advocate respect for the earth and encourage using resources wisely. Vorva and Tomtishen remained members of the organization throughout their campaign and worked to change it from within. They started a Rainforest Hero badge and sponsored art projects to help girls learn about the palm oil issue and its connection to deforestation. Soon, the girls were a running a nationwide campaign.

When Girl Scouts USA agreed to meet with Vorva and Tomtishen at their headquarters in New York five years later, it was big news—on the front page of the *Wall Street Journal* and in *Time* magazine as





← Vorva, speaking to the Roots & Shoots leadership council at Esri in 2016, likes the way GIS allows kids to map projects they are passionate about and see that they're part of larger movements.

well as on ABC, NPR, and CBS. “It was all over the place my sophomore year of high school,” recalled Vorva.

Girl Scouts’ subsequent change in its palm oil policy was the first time policy change was driven by girls in the organization’s 100-year history. The Girl Scouts chose to offset its use of palm oil by purchasing certificates from the GreenPalm program.

“That was really, really exciting,” said Vorva. “But it was also discouraging because they didn’t make sure their palm oil was from sustainable sources.”

So she decided to go bigger.

Kellogg’s, based in Vorva’s home state of Michigan, owns one of the two companies that bake Girl Scout cookies. So Vorva and her team—with support from hundreds of thousands of people—began communicating with Kellogg’s to persuade the company to use deforestation-free palm oil. Not only did Kellogg’s comply by announcing in 2014 that it would implement a deforestation-free policy for all its products, but Wilmar International, which trades 45 percent of the world’s palm oil,

also agreed to adopt a deforestation-free landmark policy.

“Now, 90 percent of the world’s supply is bound under these deforestation-free commitments,” said Vorva. And most American companies currently have a sustainable palm oil policy of some kind in place.

“Then I went to college!” Vorva exclaimed, throwing this timeline into sharp relief.

### That Lightbulb Moment

College is where David DiBiase, Esri’s director of education, global business development, and Vorva met. They were both attending a talk about GIS being given by Esri founder and president Jack Dangermond at Claremont Graduate University in Southern California.

Vorva was a student at nearby Pomona College. GIS had piqued her interest when she was in the JGI’s Roots & Shoots program. JGI uses maps and geodesign to work with surrounding communities to rehabilitate forestland and protect chimpanzee habitats.

“The community mapping model for

Roots & Shoots is for kids to make observations wherever they are and start figuring out, ‘What are the real needs in my community for people, animals, and the environment,’ and ‘What are the real resources [that] could help me with the problem I’m trying to solve?’” said Vorva.

Her lightbulb moment had come during an introduction to a GIS course she took in college. She geocoded the petition signatures from her original campaign with the Girl Scouts.

“It just, like, blew my mind to be able to say for the first time, ‘This is where everyone was from, this is the most concentrated ZIP code for petition signatures,’” she said. “I wish I had known that was out there when I was younger because you can visualize your impact so much easier. One of my biggest challenges the whole time driving an awareness campaign was [answering the question], ‘How are you reaching people?’ And if we had had a map of social media when the topic was trending, that would have been a great tool to show, like, this is producing real results.”

When Dangermond began talking about Esri's ConnectED initiative, which donates ArcGIS Online subscriptions to schools across the United States, Vorva thought, "This is so cool. We didn't have anything like this!"

Dangermond identified DiBiase as the person responsible for making the massive project possible, so Vorva decided to make his acquaintance before jetting off to a meeting.

"I wrote [DiBiase] this letter and passed it down to him in the audience, sort of introducing myself and why I was really passionate about this community mapping, service-learning module," she said. A few weeks later, DiBiase called Vorva, telling her that he hadn't received a note in class since he was in grade school. But he was obviously impressed.

"Imagine meeting Jane Goodall as a 20-year-old woman," he reflected.

"Imagine the idealism. Imagine the determination. Imagine the principles. You'd be meeting Madi if you met Jane as a 20-year-old." DiBiase asked her to speak at the 2015 Esri Education GIS Conference, which takes place just before the Esri User Conference in San Diego, California.

In her presentation, Vorva told the audience how she came to realize the encompassing nature of conservation work—that it wasn't just about protecting one species but that it included land-use and deforestation issues, required community engagement, and had political and economic ramifications.

"She absolutely blew the room away, she was so poised and her story was so inspiring," remembered DiBiase. "People were in tears at the end."

↓ Vorva was honored at the Teen Choice Awards in 2015 for her environmental activism and conservation work.



### Simplifying Complexities with Maps

Vorva had realized the difficulties of implementing a plan to source sustainable palm oil because the supply chain is complex. The fruit is harvested at an oil palm plantation and sent to a mill and then to a refinery. Many plantations send fruit to one mill, and milled fruit is sent to different refineries so companies have no idea where the palm oil they purchase originally came from.

"If you don't know where the palm oil's coming from, how can you claim that the actual plantations are adhering to these guidelines and rules? How do we ensure that traceability component?" questioned Vorva.

She realized that GIS could help her visualize the tangled supply chain, and she is working on that now with her partners. What Vorva perhaps didn't realize right away, however, was how imperative maps were to digging deeper into the genesis of the issue she'd been involved in for nearly a decade.

"My initial passion was conservation," she said. "And then I realized that conservation is a very people-driven thing." She saw this when she traveled to Colombia as a sophomore in high school to observe a community that was coming back to its land after being driven out to make room for what ended up being a failed palm grove.

She saw it in 2014 when she went to Cambodia to make a short documentary about Mu Sochua, a democratic opposition leader who helps indigenous communities fight for land rights. She saw it when she



went to Malaysia and Singapore last year to find out why palm oil is so prevalent in that part of the world and how its production affects politics, economics, and public health.

"When we were in Malaysia, these people didn't have maps, and they were going to court to fight for their land rights," she recalled. Some nonprofits were trying to use community maps to show the tribes' historic and traditional boundaries, but Vorva noticed that some of the basemaps being used were taken from old colonial maps.

"That's why I've gone back to mapping," said Vorva. "The people who should be

able to decide what happens to their community resources are people who are from those places. And oftentimes, they don't have [formal] land rights and they're using maps that are completely outdated—or they don't know how to use them." That's why she thinks conservation groups should focus on community-centered mapping when helping people fight for their land.

### Spreading GIS to the Next Generation

Vorva also thinks that community-based mapping can help kids get more involved

with service-learning projects.

"A map and GIS can help you visualize the world," she said.

She remembers being young and working on a project that felt so immense. "It was a lot of responsibility and also just hard," she said. "I would be on the ground in Colombia and it was an intense position to be in to have to see these really gross human right abuses. [...] And then having to represent that and explain in a two-minute NPR interview why the average American consumer buying Girl Scout cookies should care. It was a lot of responsibility for a kid."



← As a cohost of television show *FabLab*, Vorva got to shoot at the 2016 White House Science Fair and interview some of the top young scientific talent in the United States.

to mentor a lot of kids." Which is important to her, considering she's had so many mentors throughout the years. "I get to do that now through Roots & Shoots—inspire other kids and...connect them to different groups," she said. "That's the best part."

She also did this as a host of *FabLab*, a 2016 television show on FOX that aimed to motivate girls to take more of an interest in science, technology, engineering, and math (STEM). Through the show, she attended the 2015 United Nations (UN) Climate Change Conference (COP21) in Paris and shot videos explaining to kids what the UN does. She also filmed at the 2016 White House Science Fair, highlighting the top young scientific talent in the country.

"The show allowed me to kind of combine my how-do-we-make-the-world-a-better-place [*mindset*] and my interest in tech," she said. "I was always talking about how we should talk about maps."

Vorva believes so wholeheartedly in the power of maps that her senior thesis seeks to expand the use of GIS among young people. "It's a GIS lesson for high school students," she said. "I'm creating, like, a case study of what the Jane Goodall Institute has done with geodesign."

She's putting together introductory lessons on monarch butterflies to help kids understand why the species is threatened. She wants them to see how land-use changes have decimated their habitats. Then she wants the kids to use GIS to figure out the best places to plant milkweed (the only plant these caterpillars and butterflies use for food and shelter) in their communities to contribute to the national corridor being established.

"What she's doing is really sophisticated," said Char Miller, director of the environmental analysis program at Pomona College and Vorva's thesis adviser. "It's not just about the tool [*GIS*]. It's also [*about*] how you show those cool things to young people and engage them."

"She's totally plugged into...youth leadership and conservation, so having that—plus an idea of how to use GIS to solve problems—that's tremendous," said Rob Stauder, product manager for GeoPlanner for ArcGIS at Esri, who helped Vorva work on her thesis project during her internship

at Esri over the summer.

"She recognizes GIS as an instrument or a modality that can help people change their views of the world," echoed DiBiase. "She believes that the ability to use GIS—and geodesign in particular—has the potential to make a lifelong impact on the students who work with it."

## Mapping Change

GIS has certainly affected Vorva. And although she's not entirely sure what she will do after she graduates in May 2017, GIS will almost certainly play a role in her future endeavors.

"No matter what, I'm going to keep working on these kinds of projects," she said. "I feel just as driven to do something as when I was 11." Vorva also wants to continue inspiring kids to pursue their own passions and use GIS to perceive their effectiveness.

"I want younger people to have those lightbulb moments, like, 'Oh, I can apply GIS for x, y, or z'—just like I did," she said. "That's what excites me...to show them that [*GIS*] is a way to visualize what they're doing."

## Reach GIS Professionals, Managers, and Developers

Advertise in *ArcUser* and reach more than 450,000 people who are actively using GIS and Esri technology in their organizations.

[esri.com/arcuser](http://esri.com/arcuser)  
or [ads@esri.com](mailto:ads@esri.com)

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She knows how young activists feel.

"These problems are really big, and kids can be overwhelmed," she reflected. "Being able to map your project and see that you're part of a much larger movement—that's why I got excited about [*GIS*]."

And that is why she's trying to make young people more aware of the technology. Part of her role as a board member for JGI is to increase GIS use within the Roots & Shoots platform.

"I get to Skype into classrooms frequently and introduce the community mapping model," she said. "I've gotten

# Get Ready to Launch Your Online Web Map Gallery

By Jonathan Gross and Darcy Phelan-Emrick, Baltimore City Health Department

A web map gallery on ArcGIS Online showcases the work of your organization. The authors provide best practices for creating and launching your own web map gallery so you can share your work throughout your organization and raise the profile of your GIS program. They also include tips that will help you make the most effective use of mapping products in your organization.

At last, you are ready to take the big step of releasing an online web map gallery for your organization using ArcGIS Online. This article describes what we learned when we launched a map gallery for the Baltimore City Health Department ([www.baltimorecity.gov/healthmaps](http://www.baltimorecity.gov/healthmaps)) using ArcGIS Online. In these eight tips, we share the lessons we learned. We hope they will inform your processes and make publishing your own gallery a successful venture.

## 1 Define the purpose of the map gallery.

Clearly define the purpose of the gallery. It should align with your organization's mission. The Baltimore City Health Department wants all Baltimoreans to benefit from knowledge, access to health services, and an environment that will enable healthy living, so the map gallery supported that mission.

You should be specific and involve your main stakeholders. Always ask who are the audiences for your gallery are. How do you expect your audiences will use your maps? Engage stakeholders as early as possible to make sure your efforts are parallel with their efforts.

Our stakeholders are Baltimore City residents and the senior leadership of the Baltimore City Health Department. The goals of our map gallery are

- To provide the public with interactive maps and spatial analyses of health and health-related topics.
- To update data and tools available to the public on our website.
- To increase awareness of health-related topics, problems, and potential solutions and help move Baltimore City toward public health action.



↑ The web map gallery template includes several different ways to display and sort maps. Include all relevant metadata for your gallery so users can view and find your maps and apps easily.

## 2 Create a written plan.

Putting together a written plan will help coalesce your ideas for the map gallery. The plan can be brief and should describe the logistics of the gallery, the personnel and costs associated with it, the process for creating and reviewing it, and the number of maps in the gallery and frequency with which maps will be published and updated. The plan should have a timeline for potential projects in the short, medium, and long term and should include a brainstorming section. Even if you are not asked to provide a plan, having one to reference and revise will be helpful. Solicit feedback on the mapping projects that interest your leadership.

Our map gallery plan is brief, but it has grown since its inception. We update it regularly, refer to it often, and use it to brainstorm new ideas. It is our compass. Our list of map projects is structured as a timeline with three different project lengths.

**Short term**—Estimated two-week turnaround time or less for one map

**Medium term**—Three to four weeks

**Long term**—Four or more weeks

*Tip: Esri evangelists recommend using the phrase “spatial analysis” instead of “mapping” when speaking to others about your plan. Mapping implies something more passive—just placing items on a map—while spatial analysis is more active and informative.*

## 3 Develop a product line.

Define the types of maps and map-related products you will offer. Many people have not been exposed to sophisticated map products, such as Esri Story Maps apps, so they may not appreciate the potential of these products at first. People are familiar with Google Maps but can't imagine much else.

There are several ways to address this. Show them examples of maps that you've created. Invite them to explore the Esri Story Map Gallery or the Esri Web Application Template page. Have them look at Esri's GitHub repository. Esri also offers a map gallery template

and examples from organization home pages and portals as well as tips for configuring galleries in *ArcGIS Blog* posts.

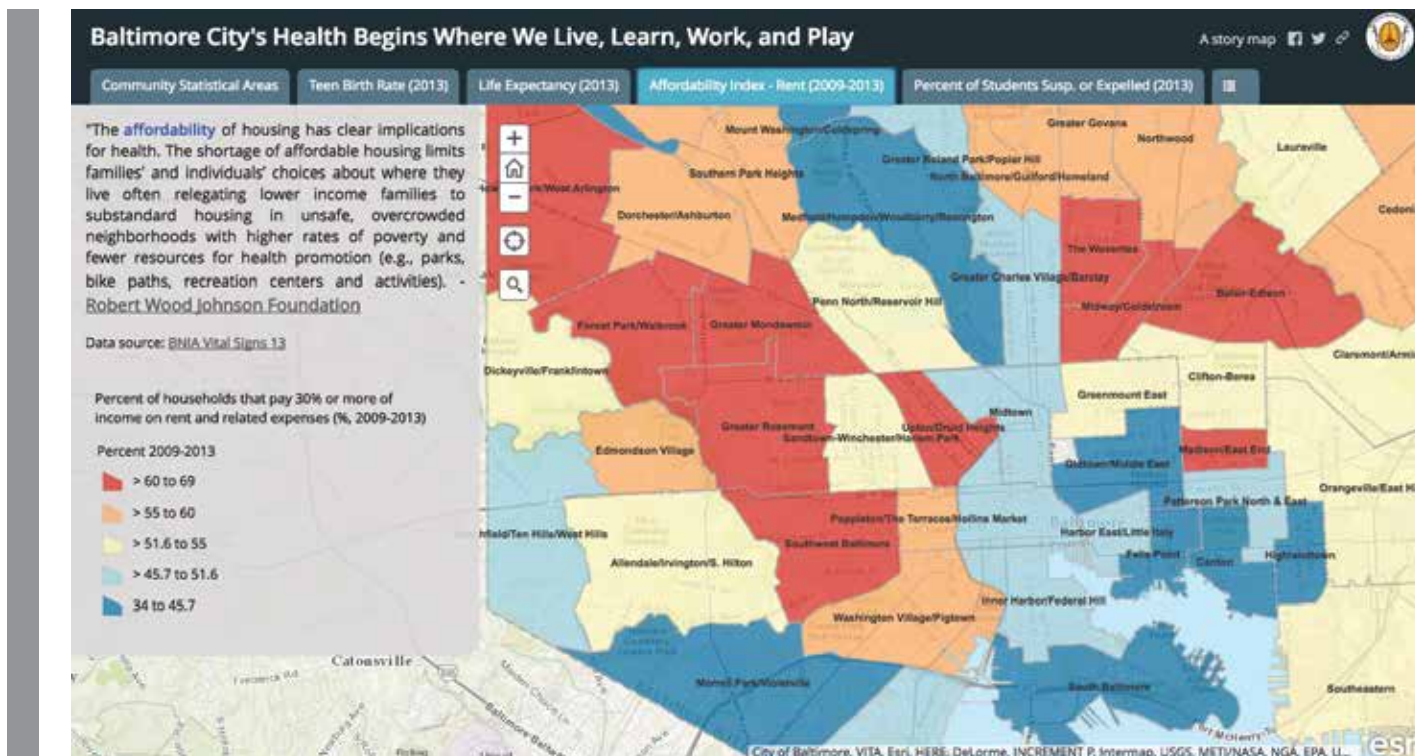
Consider which of these types of maps and map products will be attractive to your target audience:

- **Descriptive maps** show location, phenomena, area, counts, rates (of disease for example), risks, or protective factors or can demonstrate spatial analysis and hypothesis generation. This type of map can reveal patterns and trends and make use of spatial statistics and regression.
- **Esri Story Maps apps** combine maps with text, images, and video to form a compelling narrative. They can also be used as a directory for services to assist in finding the nearest location of a specific type (hospital, clinic). They can also locate assets, maps, services, or organizations.
- **Routing maps** can show how to get to a location and how long it will take for a given mode of transportation.

Esri has templates to accommodate many types of maps, and the list is growing. Take time to understand the differences between a simple map, a web map app, and customized web maps (with or without additional programming). Consider your organization's current and future internal capacity to create maps, which staff members should be responsible, and which staff members are skilled enough to modify existing templates as needed. You may want to use field collection and crowdsourcing apps such as Collector for ArcGIS and Survey123 for ArcGIS. We hope to incorporate these apps into our work in the future.

If feasible, use a variety of templates in your gallery. The six maps in

↓ The Baltimore City Health Department's map gallery helps increase awareness of health-related topics.





↑ Baltimore City Health Department maps provide the public with spatial analysis of health-related data.

our gallery use the Story Map Series (twice), Story Map Journal, Filter, and Time Aware map templates. We have also embedded a map within a map. (For information on embedding a map in a map, see the *ArcGIS Blog* post “Embedding a Story Map within a Story Map.”)

When choosing a template, ask yourself which map template is most appropriate for the goals of your map and does the template match your data in terms of form and function?

In your map gallery plan, you may want to include a short paragraph describing ArcGIS Online, noting its ability to be viewed on any computer or mobile device (smartphone or tablet) and security features such as password protection of maps prior to publication.

You could also develop a checklist for your organization that covers map elements, the development of standard templates, and your practices for publication. We’ve found that such a checklist ensures standardization and facilitates the review and release process. We developed our checklist based on our personal map design preferences, an *ArcUser* article entitled “Make Maps People Want to Look At: Five primary design principles for cartography” by Aileen Buckley (Winter 2012) and the article “What All Good Maps ‘Should’ Have,” available from the Western Washington University website.

## 4 Verify that you can release this data.

As you develop your map gallery plan, recognize that geospatial data is inherently specific and revealing, so the way you share information should be an important concern for your organization. Make sure you are following best practices for your field and GIS. For data that is

confidential but aggregated, there are multiple considerations. Should this data be publicly released? Does it follow applicable laws and regulations? Is it statistically valid? Does it avoid stigma? When appropriate, include disclaimers or limitations about the accuracy of a map.

For our initial online maps, we chose to use existing open data sources such as Open Baltimore, the Maryland Department of Planning, and the Baltimore Neighborhood Indicators Alliance to highlight relevant health challenges in Baltimore City. In the meantime, we are working on longer-term projects using health data that will be aggregated. Prior to release, all maps are reviewed by several layers of leadership including our public information officer (PIO).

## 5 Encourage feedback.

Feedback makes your map better. Every map and map gallery should go through an informal or formal feedback and review process before publication, whether it is for internal use or public release. Assemble a small group of coworkers (both GIS and non-GIS users) who can provide feedback via e-mail or a brief online form (e.g., Google Forms). Consider asking questions such as “How easy was the map to use on a scale of 1 to 5?” or “What suggestions do you have for improving the map?”

The process of internally reviewing and promoting your map will provide valuable feedback before publishing. We have found the process to be helpful because it reveals errors both big and small, and it is generally not too time-consuming. This process will often uncover mistakes that can be easily fixed and will improve the user’s experience.



## 6 Craft a rollout plan.

Creating a rollout plan will help facilitate mapping workflow and publication. Consider doing a soft launch first so that you can troubleshoot small errors and (hopefully) avoid larger ones. Create a social media toolkit and one-pager to share with your PIO and the press. Also, reach out to your network of map professionals at partner organizations for their help with publicity and sharing your map gallery and maps. When you have developed at least three or four maps for a public gallery, consider sharing them with the media to kick off the gallery.

Some additional suggestions could include:

- Working with your PIO on a national or local news story. In our case, a local Fox News affiliate wrote a short story and embedded the maps in its website for readers.
- Work with your PIO to explore the possibility that a civic or tech organization will write or blog about your map gallery.
- Ask your local, state, or federal GIS or open data agency to host a link to your map gallery.
- Promote the map gallery via your organization's social media accounts.

Don't forget to promote your map internally. Include an announcement about the map gallery in newsletters and create slides for leadership that can be distributed at community meetings or other types of events. Include the map gallery in your online and printed reports.

If you find this kind of promotion challenging, try to remember that if your map gallery has operational value, failing to promote it internally will mean it won't garner enough users to make a difference. For map galleries with public audiences, keep in mind that if your organization's staff are unaware of the gallery, they could be caught off guard when interacting with stakeholders and the public.

## 7 Engage your leadership on how to use maps.

You may be charged with briefing your organization's leadership on how to use maps and map products. Further, your leadership may want to use those same maps to help them communicate with other stakeholders. Possible uses of your maps include:

- Public or stakeholder meetings to demonstrate a problem and/or its solution
- Decision making and planning by your organization, government agencies, community groups, and the private sector
- Conversations with funders
- Funding applications and reports
- Evaluating and monitoring a program or project

In addition, it is also important to brief members of your leadership on the map gallery's accomplishments and bring its needs to their attention as appropriate. Maps are a compelling way to break down silos within and between agencies.

## 8 Make feedback easy to give.

We recommend creating a separate specific organizational email account for map viewers to send feedback and adding this email address to the maps and map gallery. Metrics that monitor the hits on a map gallery is useful, but ultimately qualitative feedback is more important. You need to understand who is being informed by your maps and what actions are undertaken as a result of that information.

*Tip: Keep a running list of map ideas as more ideas begin to surface so as not to forget them.*

### Conclusion

We hope our lessons learned will be helpful as you begin to develop or refine your own map gallery. Be sure to check the Learning Plans specific to development on Esri's new training page. Our map gallery will continue to be an important component of work at the Baltimore City Health Department. We are also seeking to develop it further with business and nonprofit partners in a recently launched Baltimore TecHealth Initiative—Transforming Engineering for Civic Health.

For more information, contact Jonathan Gross, epidemiologist for the Baltimore City Health Department, at [Jonathan.gross@baltimorecity.gov](mailto:Jonathan.gross@baltimorecity.gov).

### About the Authors

**Jonathan Gross** is an epidemiologist in the Office of Youth Violence Prevention at the Baltimore City Health Department. He collects, analyzes, and maps data for all the office's programs including Safe Streets Baltimore, an outreach and conflict mediation program designed to reduce gun violence. Most recently, he launched the Health Department's interactive web map gallery at [www.baltimorecity.gov/healthmaps](http://www.baltimorecity.gov/healthmaps) that includes spatial analysis of the 2015 homicide epidemic. His background includes a master's degree of public health in epidemiology from the University of Michigan, Ann Arbor, and a graduate certificate in geographic information systems from Johns Hopkins Advanced Academic Programs.

**Darcy Phelan-Emrick** is the chief epidemiologist at the Baltimore City Health Department. She leads the department's efforts to use existing data sources and new data collection tools to assess public health needs and inform policy development and assurance. She is a faculty member at the Johns Hopkins Bloomberg School of Public Health, and she teaches the introductory epidemiology course of the Johns Hopkins Undergraduate Program in Public Health Studies. Phelan-Emrick earned a doctorate in public health and a master's degree of health science in epidemiology at Johns Hopkins University. She has held prior positions at the New York City Department of Health and Mental Hygiene and the New York Academy of Medicine.

# 10 Essential Steps for Story Map Success

By Bern Szukalski, Esri Chief Technology Advocate

Esri Story Maps apps are easy to author, but you'll likely need to put in a little extra effort to craft a truly great one. Like playing the guitar, it's easy to learn the F, C, G, and E chords and start strumming away. But if you want to become a true virtuoso, it will take some thought, study, and preparation—even practice. Here are 10 steps for success that will help you build awesome story maps.

## Before You Begin

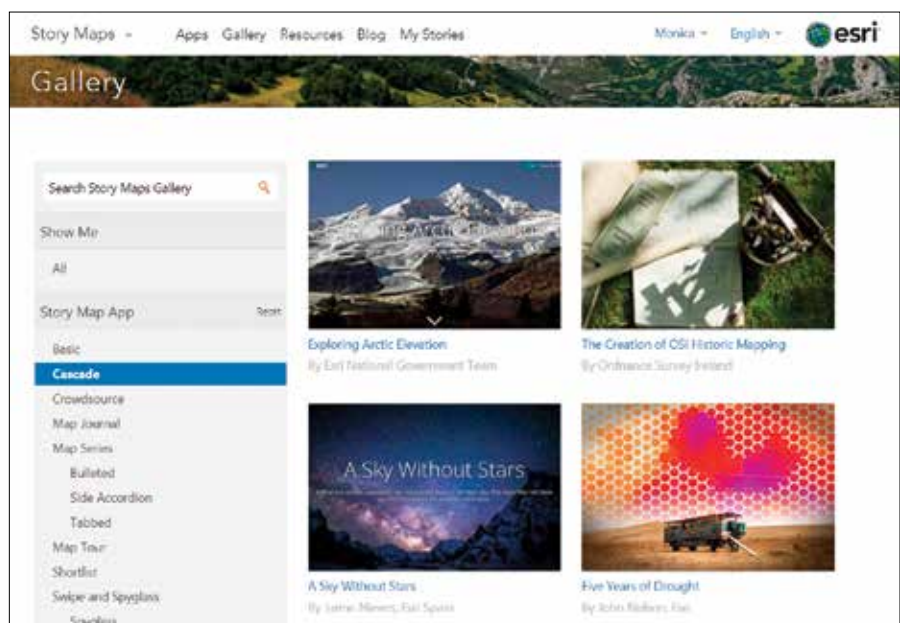
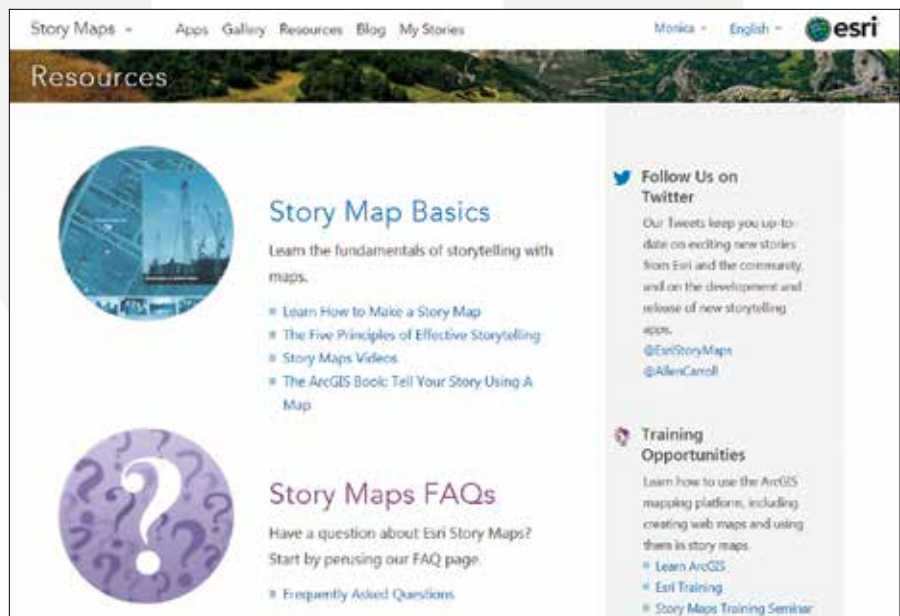
The Story Maps website (storymaps.arcgis.com) is the best place for information and resources that can help you author great story maps. Bookmark it. From galleries to featured story maps to blog posts and tutorials, it's where you should go to learn and start to build your stories.

## Step 1: Envision Your Story

A great story map requires inspiration, an idea, and some thought. Think about how you want those ideas and inspiration to unfold. Envision how a viewer might experience your map. Sure, you can dive right in, but spending a little time mulling things over will make it easier to organize your story, hone it down to the essential elements, and find the right story map to bring your story to life. Which brings us to Step 2.

## Step 2: Choose the Right Story Map App

There are a number of story map apps to choose from, and most include different layout options. Which is the best one to tell your story and unfold it in a compelling way? Answering that question will require some review and perhaps some experimentation—perhaps even repeating





↑ Flickr is great for photos and can provide your images at different sizes and resolutions as a built-in capability, and Story Maps are smart enough to fetch the appropriate size from Flickr.

Step 1 until you are satisfied.

How can you find the right story map? Here are a few suggestions: Browse the Gallery at the Story Maps website and be inspired by what others have done. Filter the gallery by choosing a story map type and see what each can offer. You can also filter by subject, industry, format, and author. Just scroll down and look along the left side and choose.

Use the Create Story option to guide you to the right app. You'll find the Create Story button on the Apps page. After you click it, you can either click Pick an App from a catalog of choices with concise, single-sentence descriptions or click Ask the Pros to be guided to a story map by answering questions about your story and how you want to tell it.

### Step 3: Craft the Story Components

A great story map includes great maps and multimedia and narrative text that is both interesting and informative. A great map is visually appealing, simple, focused on the story, and performs well.

All these attributes require a bit of tradecraft. You'll find lots of resources in the ArcGIS Online help and *ArcGIS Blog* to help you learn how to make great web maps that perform well. Don't overlook those little details. Make sure your pop-ups are configured, the layer names make sense, and the symbols are clear and well chosen.

↗ The Story Maps website ([storymaps.arcgis.com](http://storymaps.arcgis.com)) is where you should go to learn and start to build your stories.

↗ Browse the gallery at the Story Maps website and be inspired by what others have done.

Media (photos and videos) should also be optimized for web use. Make sure image sizes are appropriate for the way they will be used in your story map. Using a 5 MB photo is never a good idea in a web app, especially when it will be used as a thumbnail.

Media storage should also be considered. Flickr is great for photos and can provide your images at different sizes and resolutions as a built-in capability, and the Story Maps apps are smart enough to fetch the appropriate size from Flickr. If you're storing your images elsewhere, you may need to do the resizing and optimization work by hand.

Your text and narratives, including the title and subtitle, should be clear and compelling. Avoid using jargon and acronyms that might be confusing to viewers unfamiliar with the topic. Use a tone and style that lure viewers in and engage them so they will continue the journey through your story.

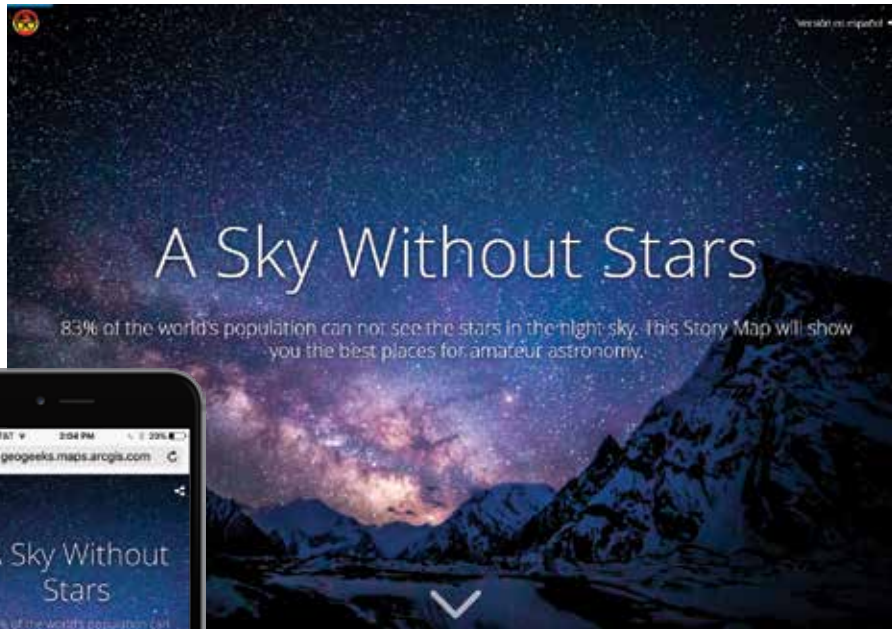
### Step 4: Build It

You've got ideas, maps, and media. You have given some thought to the best story map to use. Now it's time to take a first cut.

Launch the Story Map builder. It will guide you through the steps. Although it almost always delivers the best results, don't be afraid to challenge the defaults and experiment. As you build, it you'll know what works and what doesn't. When you've finished your first pass, squint hard and scrutinize your work. Then move directly to Step 5.

### Step 5: Refine and Simplify

Take a step back and consider the story's merits. More importantly, consider, its shortcomings. What works? What doesn't? Are



↑ It's always a good idea to test your story map in environments different from the one in which it was authored.

you missing maps or graphics or do you have too many? How can your story be enhanced?

Think about the narrative. Is there too much or not enough? Keep refining it to see how you can improve the overall result.

Don't be afraid to consider another story map if you find yourself wrestling with the one you've chosen.

Whether you're on a mission to highlight the plight of endangered species or showcase your city's improvement projects, too much information or a lengthy story can cause your viewers to tune out, lose interest, and become distracted. Simpler is always better, and simplicity will increase the odds your story will be viewed from beginning to end.

### Step 6: Repeat

Go back to Step 5, and repeat it as necessary.

I repeat: Go back to Step 5 and repeat it as necessary.

### Step 7: Get Fresh Eyes to Review Your Story

So you think you've created a prize-winning story map. You are sure it will be highlighted at the next Esri User Conference. You are enthralled by your clever work. You love your maps, your media, and your narrative.

But—swallow hard here—your opinion really doesn't count.

The goal is to tell your story before an audience larger than you, its proud author. Before unleashing your story map on the world, have others take a look at it. Wear your thick skin. That map or graphic you worked on for hours and are so happy with might be the first thing that someone else looks at and says, "huh?" Those main stage actions that you puzzled over for an eternity might leave your viewers confused.

Having others who don't have your personal investment in

the story provide a review is invaluable. Toughen up and listen to what they say.

### Step 8: Test on Different Monitors, Devices, and Browsers

It's always a good idea to test your story map in environments different from the one in which it was authored. You may have authored it using your awesome Apple 27-inch Retina display, but your audience might be viewing it on a dusty 4:3 monitor, bargain tablet, or an old Droid with a cracked screen. While story maps are responsive and will accommodate any size, that two-sentence description on your large monitor might mean scrolling for those less fortunate. Think about the size/device sweet spot for your target audience.

Try your story map in different browsers. While the story map will work in any browser, there may be issues with some of the media you've chosen to include. It's also a very good idea to clear your browser cache and

test the story map as an anonymous user. Clearing browser cache will reveal images that are too large and other web bottlenecks. And testing as an anonymous user will shake out any access issues.

### Step 9: Go for the Green

While logged into ArcGIS Online, use My Stories to view all your story maps. You'll find My Stories at the far right along the top of the Story Maps website. Think of it as a lens applied to your ArcGIS Online content. It not only lists your story map apps, it also has some really great tools to help you manage and share your story maps.

Use My Stories to check for subscription or premium content, maps, images, or media that are not available. Click Check Stories or just click the title of the story map for a thorough inspection. If something is amiss, you'll get the red flag noting the issues and

↓ Your story map deserves a broader audience, so share it widely: Tweet it, blog it, or post it on Facebook.



offering tips for how to remedy them. When everything checks out, you'll get a green banner.

*Tip: Set Delete Protection for the maps and other items used by your story map that are stored in your ArcGIS Online account so that they're not accidentally removed. Check the box for Delete Protection in the Settings tab in the Item Details pages and click Save.*

## Step 10: Socialize and Share

Congratulations! You've got a great story to tell. Now it's time to socialize and share it with others. Your story map might be only for internal use, but it's still important to share it.

Make sure you've got a great thumbnail. It will be an essential part of your story's appearance in ArcGIS Online and when you socialize it. Click on the default thumbnail on the Item Details page to replace it.

Your story map deserves the accolades of a broader audience. Add it to your organization's home page gallery. Email it to your

colleagues. Most story maps are public, so add the link or embed the story map on your website. Add it to your blog, Tweet it, and post it on Facebook. Share it widely.

## Some Final Words

Making story maps is easy—like learning those basic guitar chords. The hardest parts—and the parts that elude even seasoned GIS professionals—are telling the right story for your audience, developing the correct narrative, and getting the best media and maps you can. Following the steps suggested in this article can help you put your best story map forward.

## About the Author

As the chief technology advocate and product strategist at Esri, **Bern Szukalski** is focusing on ways to broaden access to geographic information and helping users succeed with the ArcGIS platform. Follow him on Twitter at @bernszukalski.

# Fill Out Your Profile and Be Somebody

Your ArcGIS Online user profile is the way the rest of the ArcGIS Online community learns about you and determines the value and veracity of your shared items and groups. Creating an informative profile is a best practice whether you're making maps and apps for others in your GIS department, for users across your organization, or the public.

## Do It Now

After getting your account, one of the first things you should do is create a good profile. After signing up, you'll be presented with your account information. It will be blank. It's a good idea to complete your profile when you first sign on. However, you can change your profile anytime by clicking My Profile in the drop-down under your name after signing in to your account.

## What Is a Good Profile?

A good profile includes pertinent information about you or the group or organization you represent. Things you can include in your profile are a good thumbnail, some information about you, your roles and responsibilities in your organization (if appropriate), and contact information.

If you are an official representative of an organization, including the organization's logo with your profile is a good idea. When

you share items on behalf of a company or organization, you may want the organization to be the recognized source instead of yourself or some other individual.

In that case, create an account representing the organization. The administrator for your organization can transfer ownership of items as needed to that account. Note that ArcGIS terms of use prohibit sharing of account logins, so this must be a separate account.

## Make Sure It's Visible

Ensure that your profile will be visible to others by clicking the radio button next to Everyone (public) under Who can see your profile? in the account settings. That way, no matter how you share your items, others will know about you and the organization you represent.

*Note: Your administrator may not allow you to control these settings.*

## Make Your Profile Look Good

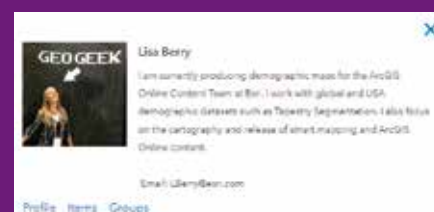
You can format your profile for easier reading by inserting carriage returns. While the profile editor does not currently support WYSIWIG editing or HTML, you can add carriage returns and other special characters using HTML decimal codes (the codes

used in HTML to get special characters to display). The codes for carriage returns (&#10;) and line feeds (&#13;) are useful for improving profile formatting.

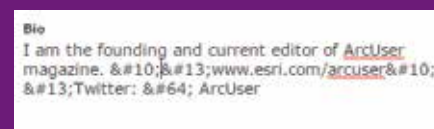
## It's Never Too Late

You can edit and update your profile at any time, so it's never too late to add or improve your profile to let others know who you are and who you represent. This will provide context and reassurance to others who might want to use your shared items.

For more information, see the ArcGIS Online help topic [Manage profile](#).



↑ This profile provides context for and confidence in the content shared.



↑ Use HTML decimal codes to format the text in your profile.



### What you will need:

- An ArcGIS Online for organizations account
- ArcGIS Pro

# Efficient Geocoding with ArcGIS Pro

By Mike Price, Entrada/San Juan, Inc.

**Public safety organizations** rely on reliable, repeatable incident mapping of address-based data. Some agencies have created in-house geocoding using locally developed E911 points and street files. Other agencies subscribe to location-based services that use commercially provided street data. A typical fire/emergency medical service (EMS) provider could respond to 100 to 300 incidents per one thousand residents, which might result in 20,000 incident responses or more in one year.

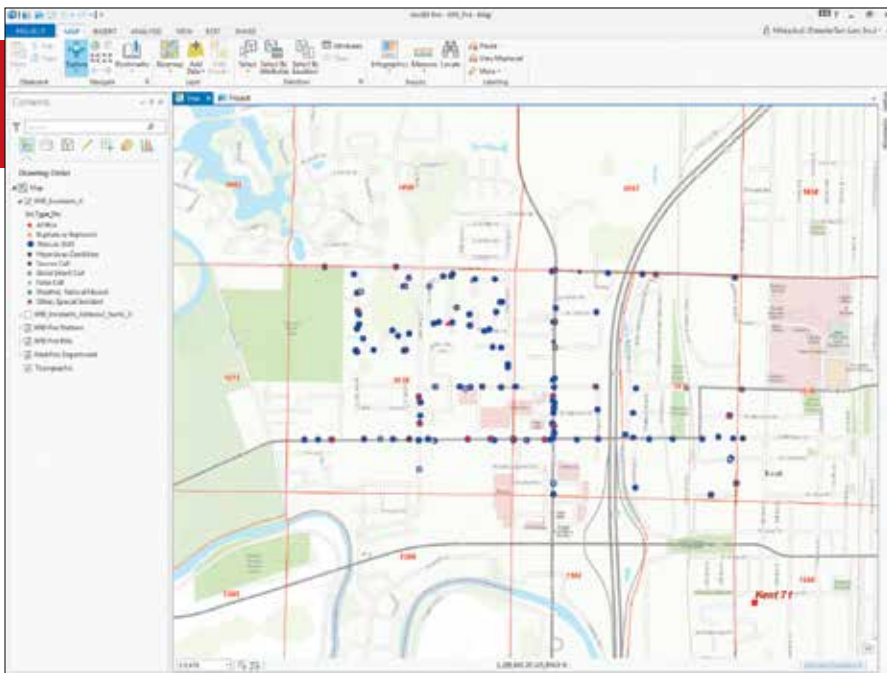
This total might include multiple

responses to the same house, convalescent care facility, or large apartment complex. Since one address may be involved in many responses, it is not necessary to geocode each response record. Instead, street addresses may be summarized, which creates a much smaller address set. By geocoding the summary set, joining longitude and latitude coordinates back to the parent incident table, and creating and saving an XY response dataset, many points can be mapped by geocoding many fewer records. As always, the key to success involves clean,

standardized address assignments.

Esri provides several ways to geocode addresses with online services. For several years, ArcGIS Online has included an ArcGIS World Geocoding Service that provides an effective multiple field geocoding service. It includes the ability to edit and re-geocode complex addresses. ArcGIS Pro includes many tools to perform custom and standard ArcGIS Online World Geocoding Service tasks.

Geocoding using the Online World Geocoding Service requires a current ArcGIS Online subscription and uses service



✦ In this exercise, emergency response data is summarized by street address to consolidate multiple reports with the same address so that many more points can be mapped by geocoding fewer records.

✦ Change the coordinate system to NAD 1983 Washington StatePlane North FIPS 4601 (US Feet).

ArcGIS Online organization account. To begin, install ArcGIS Pro on your mapping computer and verify that you have an ArcGIS Online license. Log in to ArcGIS Pro. When ArcGIS Pro starts, choose Create a new project using the Map.aprx template. Use \KFD\KFD\_AGOL, the same KFD root folder used for the ArcGIS Online exercise, to create a new project folder just under KFD. Name the project and its project folder KFD\_Pro.

## Add Data and Change the Basemap

In ArcGIS Pro, inspect the tabs at the top of the workspace that expose ArcGIS Pro functionality.

1. Click the MAPS tab and choose Basemap to change the default Topographic basemap to OpenStreetMap.
2. Click the Add Data button and navigate to \KFD\KFD\_AGOL\.
3. Select Data—Add data to the map and select Kent Fire Department.lyr.
4. Zoom the map extent to the extent of the Kent Fire Department.lyr.
5. Select Data—Add data to the map and select KFD Fire RDs.lyr, and Kent Fire Stations.lyr. **Do not** load the KFD Incidents.lyr.

This exercise uses the same reference data as “Optimize Online Geocoding.” Kent Fire Department.lyr showing the fire district boundaries layer, was created in Washington State Plane North American Datum (NAD83) North and will be used to set the coordinate system in future tasks.

In “Optimize Online Geocoding,” the underlying dataset was populated. Near the end of this exercise, the KFD Incidents.lyr will be used to symbolize the incidents. Verify that the data links are valid for all three layers and that you see eight fire stations and a fire district boundary.

credits. Forty credits are needed to geocode 1,000 addresses. A single ArcGIS Online account includes 100 annual service credits. Credits remaining at year’s end do not carry into the following year.

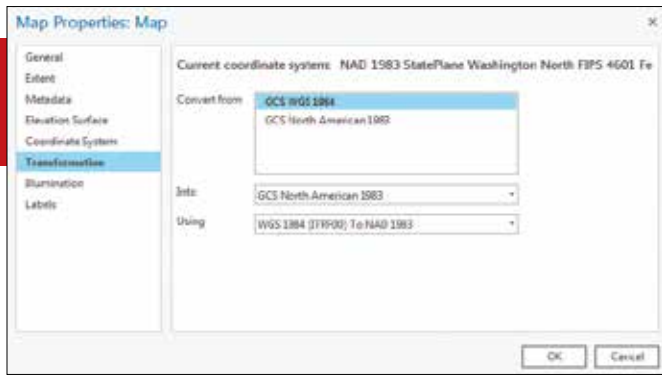
This exercise uses actual response data from the Kent Fire Department in Washington state for two response districts in downtown Kent. It teaches a simplified workflow for posting more than 1,000 incidents to a map in ArcGIS Pro.

The Kent Fire Department has used address geocoding for many years and has applied a

current, standard addressing schema. The addressing schema is referenced in National Fire Protection Association Standard 950 *Standard for Data Development and Exchange for the Fire Service* and is supported by the Federal Geographic Data Committee (FGDC) in FGDC-STD-016-2011, *United States Thoroughfare, Landmark, and Postal Address Data Standard*. You can read these documents to learn more about addressing standards.

## Create a Project in ArcGIS Pro

ArcGIS Pro is web based and requires an



← Select Transformation and verify that Convert from is set to GCS WGS 1984, Into is set to GCS NAD 1983 2011 transformation, and Using is set to WGS 1984 (ITRF00) To NAD 1983 2011.

↓ Summarize all incident addresses by right-clicking the Address2 field in the KFD\_Incidents\_XY table and choosing Summarize.

## Consider Coordinate Systems and Transformations

Change the coordinate system to Washington State Plane NAD 1983 North US Feet.

1. Right-click Map (the data frame) in the table of contents (TOC) and choose Properties. Choose Projected coordinate system > State Plane > NAD 1983 (2011) (US Feet) > NAD 1983 (2011) StatePlane Washington North FIPS 4601 (US Feet).
2. Select Transformation and verify that Convert from is set to GCS WGS 1984, Into is set to GCS NAD 1983 2011 transformation, and Using is set to WGS 1984 (ITRF00) To NAD 1983 2011.

When they were originally defined, the North American Datum 1983 (NAD 1983) and the World Geodetic System 1984 (WGS 1984) were equivalent. To minimize coordinate changes, NAD 1983 is tied to the North American, Pacific (for Hawaii, Guam), and Marianas tectonic plates. WGS 1984 is tied to the International Terrestrial Reference System (ITRF), which is independent of tectonic plates. Over time, the two coordinate

systems have become increasingly different. ArcGIS Pro provides a higher-quality transformation that will be used for this exercise. Unless it is changed, the geocoding reference data will be in WGS 1984 geographic coordinates.

## Preparing Incident Data for Geocoding

To convert incident data stored in a Microsoft Excel spreadsheet, click Add Data and navigate to KFD\_AGOL\XLSFiles\. Open KFD\_Incidents.xls, and select KFD\_Incidents\$. Once added, right-click on it and open this worksheet. Sort the Address2 field in Ascending order to preview duplicate addresses. Many of the 1,028 records reference the same address. These records can be summarized as one geocoding record.

## Export Incident Data in Excel to a Geodatabase Table

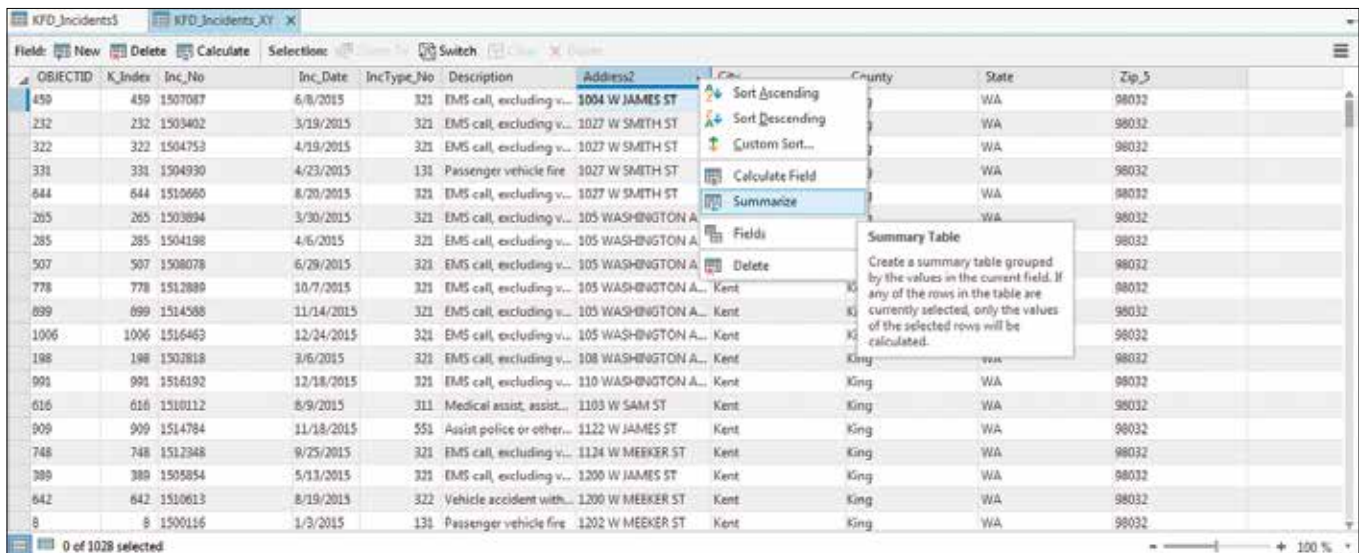
To protect the original data format before summarizing on the Address2 field, export the worksheet as a geodatabase table.

1. With the KFD\_Incidents\$ table visible, click the menu on the right side of the table (three horizontal bars) and choose Export. Export KFD\_Incidents\$ to the KFD\_Pro file geodatabase as KFD\_Incidents\_XY. Click Run.
2. Open KFD\_Incidents\_XY and verify that it contains all 1,028 exported records.
3. Notice that each duplicate Address2 record contains the same values for City, County, State, and Zip\_5. If they did not, additional steps might be required to edit or perform additional rematching steps.
4. Remove KFD\_Incidents\$ from the TOC and save the map.

## Summarize Address Field

To summarize all incident addresses, right-click the Address2 field and select Summarize.

1. Make sure the Input Table is KFD\_Incidents\_XY and set Output Table to KFD\_Incidents\_Address2\_Sum\_1\_XY.
2. Under Statistics Fields, select City,





← Geocode the addresses in the KFD\_Incidents\_Address2\_Sum1\_XY layer using the default GeocodeServer XY provider and setting the values for field names and aliases.

↓ Create two new fields in the KFD\_Incidents\_XY table to store X and Y coordinates.

(KFD\_Incidents\_Address2\_Sum1\_XY), the summarized field (Address2), and the summary (Sum1). It identifies the dataset as a table only (XY). Although it is long, it is very descriptive.

Open the summary table added to the project and explore the data. Sort Count\_Address2 in descending order and preview repeated response addresses. Notice that the summary table contains only 129 unique addresses, compared to the source table, KFD\_Incidents\_XY, which contains 1,028 responses.

## Geocode Addresses

Geocoding the summary addresses, calculating their coordinates, joining coordinates back to the response table, and posting an XY event theme results in a considerable savings immediately. By saving the geocoded coordinates in a reference table, they can be assigned to records in future years so that only new addresses will need to be geocoded.

In the TOC, right-click KFD\_Incidents\_Address2\_Sum1\_XY and choose Geocode Addresses.

In the Geoprocessing pane in Parameter, make sure the Input Table is KFD\_Incidents\_Address2\_Sum1\_XY.

For Input Address Locators, click the dropdown and select the <https://geocode.arcgis.com/arcgis/rest/services/World/GeocodeServer>, the default GeocodeServer XY provider.

A list of standardized field names and aliases will appear. In that list, set the following values:

- Set Address to Address2.
- Skip Neighborhood.
- Set City to FIRST\_City.
- Set Subregion to FIRST\_County.
- Set Region to FIRST\_State.
- Set Postal to FIRST\_Zip\_5.
- Skip Postal Ext and CountryCode.
- For Output Feature Class, put KFD\_Incidents\_Address2\_Sum1\_X, storing them in KFD\_Pro.gdb.
- **Do not click Run.**

The reference geocoding data is stored in WGS 1984, a geographic coordinate system. Although the ArcGIS Pro geocoder will calculate decimal degrees longitude and latitude values for all points, point output to the

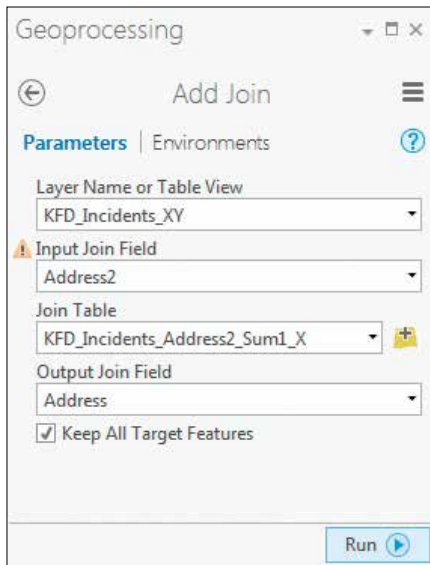
County, State, and Zip\_5 and use the Statistics Type FIRST.

3. Click Run.

Remember, these fields must contain identical content for each unique address string. Save the summary output in KFD\_Pro.gdb as KFD\_Incidents\_Address2\_Sum1\_XY. This naming convention references the source table

OBJECTID	New Field	Date	IncType_No	Description	Address2	City	County	State	Zip_5
1	Create a new field in this table.	/2015	311	Medical assist, assist...	1615 W JAMES LN	Kent	King	WA	98032
2		/2015	321	EMS call, excluding v...	24420 64TH AVE S	Kent	King	WA	98032
3	3 1500026	1/1/2015	321	EMS call, excluding v...	627 W TITUS ST	Kent	King	WA	98032
4	4 1500041	1/1/2015	321	EMS call, excluding v...	24420 64TH AVE S	Kent	King	WA	98032
5	5 1500053	1/2/2015	321	EMS call, excluding v...	233 5TH AVE S	Kent	King	WA	98032
6	6 1500091	1/2/2015	321	EMS call, excluding v...	1401 W MEEKER ST	Kent	King	WA	98032
7	7 1500105	1/3/2015	322	Vehicle accident with...	W MEEKER ST & WA...	Kent	King	WA	98032
8	8 1500116	1/3/2015	131	Passenger vehicle fire	1202 W MEEKER ST	Kent	King	WA	98032
9	9 1500117	1/3/2015	321	EMS call, excluding v...	1603 W JAMES LN	Kent	King	WA	98032
10	10 1500119	1/3/2015	611	Dispatched & cancel...	1603 W JAMES LN	Kent	King	WA	98032
11	11 1500156	1/4/2015	321	EMS call, excluding v...	6123 S 242ND PL	Kent	King	WA	98032
12	12 1500174	1/5/2015	321	EMS call, excluding v...	24420 64TH AVE S	Kent	King	WA	98032
13	13 1500191	1/5/2015	321	EMS call, excluding v...	615 W HARRISON ST	Kent	King	WA	98032
14	14 1500210	1/5/2015	321	EMS call, excluding v...	1411 W SMITH ST	Kent	King	WA	98032
15	15 1500213	1/6/2015	311	Medical assist, assist...	24420 64TH AVE S	Kent	King	WA	98032
16	16 1500222	1/6/2015	321	EMS call, excluding v...	620 W JAMES ST	Kent	King	WA	98032
17	17 1500230	1/6/2015	321	EMS call, excluding v...	1711 W MEEKER ST	Kent	King	WA	98032
18	18 1500292	1/7/2015	321	EMS call, excluding v...	1313 W MEEKER ST	Kent	King	WA	98032
19	19 1500322	1/8/2015	311	Medical assist, assist...	233 5TH AVE S	Kent	King	WA	98032

Visible	Read Only	Field Name	Alias	Data Type	Apply Trust	Highlight	Number Format	Domain	Default	Length
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	OBJECTID	OBJECTID	ObjectID	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	K_Index	K_Index	Double	<input type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Inc_No	Inc_No	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Inc_Date	Inc_Date	Date	<input checked="" type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	IncType_No	IncType_No	Double	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Numeric			
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Description	Description	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Address2	Address2	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	City	City	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	County	County	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	State	State	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	Zip_5	Zip_5	Text	<input checked="" type="checkbox"/>	<input type="checkbox"/>				2147483647
<input checked="" type="checkbox"/>	<input type="checkbox"/>	LonDec84	LonDec84	Double	<input type="checkbox"/>	<input type="checkbox"/>				
<input checked="" type="checkbox"/>	<input type="checkbox"/>	LatDec84	LatDec84	Double	<input type="checkbox"/>	<input type="checkbox"/>				



↑ Set the two new fields to Data Type Double.

← Join the KFD\_Incidents\_XY table to the KFD\_Incidents\_Address2\_Sum1\_X to add the summarized geocoded addresses to all the incidents.

local State Plane coordinate system can be specified in the Geoprocessing pane; choose Environments.

1. In the Output Coordinate System drop-down, select Kent Fire Department.
2. Omit Output CONFIG Keyword.
3. Click Run to geocode 129 summarized address records.

## Review Geocoded Addresses

All records should be matched. If you needed to rematch to fix ties or unmatched records, you would click Yes to start the rematch process button and explore the Interactive Rematch wizard. You would zoom to the first geocoded record and inspect the list of candidate sites. If you approved the first candidate highlighted in cyan, you would do nothing. If you saw a better candidate, you would select it and rematch.

KFD\_Incidents\_Address2\_Sum1\_X will be added to the map. Preview geocoding results on the map. All 129 points should map

just northwest of Station 71, in or near FD 1516 and FD 1517.

4. Right-click on this layer in the TOC and choose Attribute table to open and inspect the KFD\_Incident\_Address2\_Sum1\_X table.
5. Locate longitude and latitude fields (X and Y). These fields contain WGS 84 geographic coordinates that will be joined to the KFD\_Incidents\_XY table. Remember the position of these fields in the table.
6. Clean up the map. Remove the KFD\_Incidents\_Address2\_Sum1\_XY table. Close but **do not** remove the KFD\_Incidents\_Address2\_Sum1\_X feature layer. KFD\_Incidents\_XY should be the only open table. In the next steps, new fields will be added to this table, a tabular join created, and new fields calculated. A simplified project, combining standardized layer and field names, minimizes the chance for error.

## Create Longitude, Latitude Fields in Incidents Table

Verify that only the KFD\_Incidents\_XY table is visible and active. The next steps will create two new fields in KFD\_Incidents\_XY to store coordinates.

1. In the upper left corner of the KFD\_Incidents\_XY table, click New Field to open the field dialog box.
2. Go to the last Field Name field (after Zip\_5) and enter LonDec84 for Field Name and Alias and set the Data Type to Double.

To see another way to add a field, go to the ribbon and click the FIELDS tab. In the Changes section, click the New Field button

and enter LatDec84 for name and alias and set Data Type to Double. When finished, check your work, and click the Save button in the Changes group. In the table area, close the Fields dialog box and note the new <Null> fields in the KFD\_Incidents\_XY table. Save the project.

## Join Geocoded Attributes to Incident Table

1. In the TOC, right-click KFD\_Incidents\_XY and choose Joins and Relates > Add Join. Complete the Add Join wizard by making the following changes:
2. Assign Address2 to Input Join Field.
3. Set the Join Table to KFD\_Incidents\_Address2\_Sum1\_X.
4. Scroll down the drop-down for Output Join Field and set it to Address (**not Address2**).
5. Check the box for Keep all Target Features.
6. Click Run to execute the join. Inspect the joined KFD\_Incidents\_XY table. Locate the X and Y fields containing longitude and latitude in decimal degrees. Save the project.

## Calculating Coordinates Using Joined Data

Now to populate the LonDec84 and LatDec84 fields with the values in the X and Y fields.

1. In the KFD\_Incidents\_XY table, locate and right-click the LonDec84 field and select Calculate Field.
2. In the Calculate Field wizard, confirm the Input Table is KFD\_Incidents\_XY table and LonDec84 is the Field Name.

Scroll down through the Fields list and select X. Double-click X to preview the calculation formula. Leave all other areas with default values and click Run.

- Populate the LatDec84 field in the same way. Right-click the LatDec84 field, choose Calculate Field, select Y as the Field, double-click to preview the formula, and click Run.

Make sure LonDec84 and LatDec84 contain the values from the X and Y fields.

The join is no longer needed, so right-click KFD\_Incidents\_XY in the TOC and choose Joins and Relates > Remove All Joins. Save the project.

## Posting, Symbolizing, and Exporting Incidents

- Right-click the KFD\_Incidents\_XY table in the TOC and choose Display XY Data to

invoke the Make XY Event Layer wizard. Make these changes to the wizard:

- Make sure the XY Table is KFD\_Incidents\_XY.
- Set the X Field to LonDec84 and Y Field to LatDec84.
- Set the Layer Name to KFD\_Incidents\_XY\_Layer.
- Leave the Z Field blank and leave Spatial Reference as CGS\_WGS\_1984.
- Click Run to execute the XY Event Layer tool.

The new XY layer will be added to the map. Inspect the points on the map and open its table to verify that it contains 1,028 records. Save the map again.

## Export XY Incident Data to a Feature Class

In the KFD\_Incidents\_XY\_Layer attribute

table, verify that no event layer records are selected and note the IncType\_No field. Although this field supports symbology in the KFD\_Incidents.lyr file, symbolize Incident and Address2 summary points to confirm that all points have mapped properly.

- In the TOC, right-click KFD\_Incidents\_Address2\_Sum1\_X and choose Symbology. In the Symbology wizard, click the symbol and select the red Circle 3 symbol.
- Next open the symbology for KFD\_Incidents\_XY\_Layer and select the black Cross 1 symbol. Explore the map and verify that all incident points align with Address2 summary points.
- In the TOC, right-click KFD\_Incidents\_XY\_Layer and choose Data > Export Features. In the Copy Features Parameters dialog box, keep KFD\_Incidents\_XY\_Layer as Input Features and set Output Feature Class to KFD\_Incidents\_X in KFD\_Pro.gdb.
- Click Environments in the Geoprocessing pane. Use the Kent Fire Department feature class to set the Output Coordinate System to NAD 1983 (2011) StatePlane Washington North FIPS 4601 (US Feet).
- Accept all other defaults and click Run. Turn off the other Incident layers and inspect the KFD\_Incidents\_X (exported points). Click the Copy Features dialog box and click the yellow warning triangle to read the message. Save the map again.

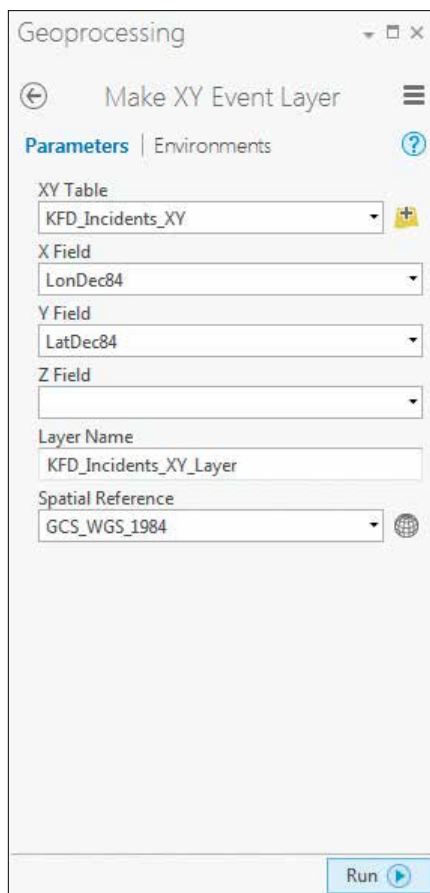
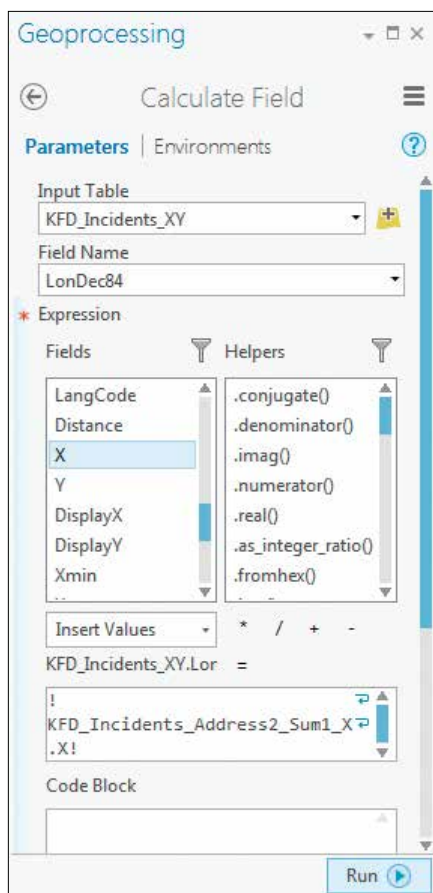
## Mapping Incidents by NFIRS Type

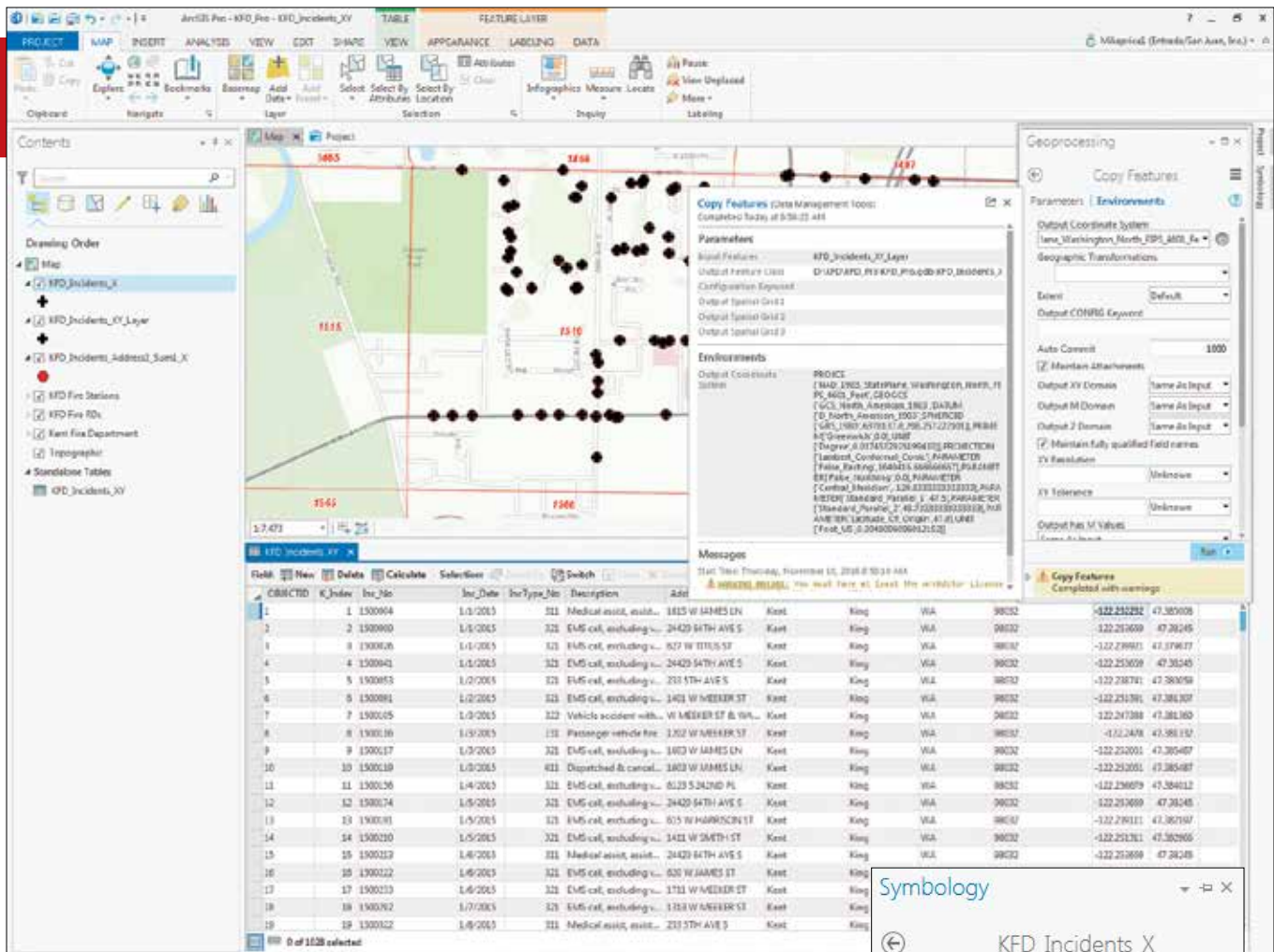
To use the National Fire Incident Reporting System (NFIRS) coding to symbolize the incident types, import layer symbology.

- In the TOC, right-click KFD\_Incidents\_X and select Symbology.
- In the Symbology pane, click the three

←← After tables are joined, use the Field Calculator to populate the LonDec84 field with values from the X field.

← Once the KFD\_Incidents\_XY table has the X and Y values, make an XY Event layer.





↑ Export the XY Incident Data to a feature class.

→ After importing the National Fire Incident Reporting System (NFIRS) coding using the symbology in KFD\_Incidents.lyr, use symbol layer drawing to move the large symbols in Group\_2 to the bottom of the drawing order.

- horizontal bars on the right side and choose Import symbology.
- For Symbology Layer, click the folder icon and navigate to KFD\_Incidents.lyr in KFD\_AGOL\GDBFiles\WASP83NF and select it.
- Set Type to VALUE\_FIELD with both Source and Target Fields set to IncType\_No. Click Run to execute and inspect the mapped symbology.
- Many incident types are Rescue, EMS. To move the large blue Rescue, EMS symbols to the bottom of a stacked set, right-click KFD\_Incidents\_X and select symbology again.
- Click the three bars at the top of the pane and select Advanced.
- Expand Symbol layer drawing, check the Enable symbol layer drawing box, and Move Group\_2 (containing Rescue, EMS

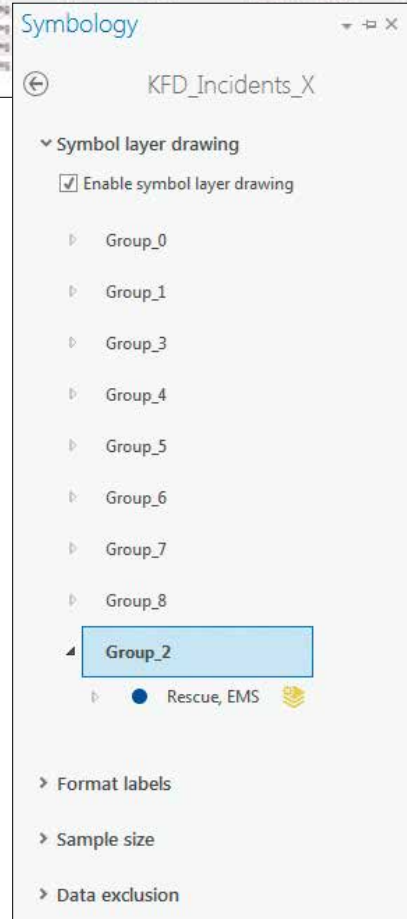
- incidents) to the bottom of the stack.
- Close Symbology and any open tables and save the project.

### Summary

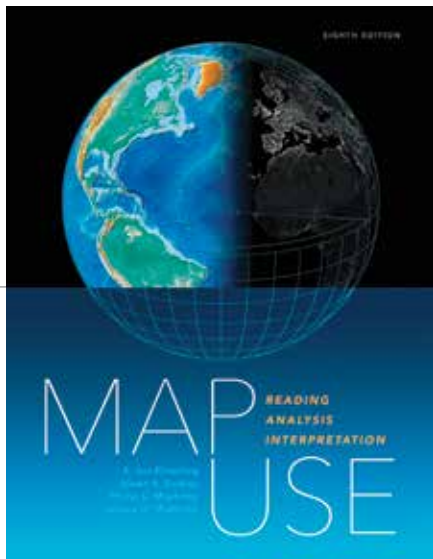
This ArcGIS Pro exercise required geocoding only 129 unique address records to map 1,028 incidents because incidents that were at the same address were summarized. Consequently, only four ArcGIS Online credits were consumed. Before you geocode, remember to standardize addresses so you can efficiently summarize them.

### Acknowledgments

Special thanks again go to the Kent Fire Department and the Kent Regional Fire Authority for the opportunity to use their partially synthetic fire station, response, boundary, and incident data in this exercise.



# The Primer for Using Maps Effectively



The eighth edition of the classic cartographic text, *Map Use: Reading, Analysis, Interpretation*, is now available from Esri Press.

Since its first edition, *Map Use* has been written specifically for the map user rather than the mapmaker. Although people work with maps every day, many don't appreciate all the powerful ways maps can be used.

"Reading a map is probably the most common use of maps. You look at a map, you read the content off it, and you learn something new," said coauthor Aileen R. Buckley, a research cartographer at Esri. "But maps can also be analyzed. You can make measurements and calculate statistics using information that's on maps."

While written mainly for students enrolled in college-level cartography or map use courses, the book also serves as an excellent resource for cartographers and professionals who work with GIS, remote sensing, and imagery. People who use maps for scientific research, navigation, and recreation also will find *Map Use* to be a perfect go-to reference. Esri president Jack Dangermond has called the 650-page textbook "a comprehensive primer for using maps effectively."

*Map Use* teaches map fundamentals—what maps are; the types available; what they portray; the purposes they serve; and how to read, analyze, and interpret them. It is divided into three major sections: map reading, map analysis, and map interpretation. Today, that analysis is often done using GIS. "While the focus in past editions was on using paper

maps to do analysis, this edition focuses on mapping information using digital analysis, primarily through GIS," Buckley said.

A new chapter on map design basics explains how to define the map's audience and theme, craft a clear and concise message, choose the right map projection, use proper symbolization, make the map legible, use color effectively, and design maps for the web. It was added to deepen readers' understanding of what goes into making a well-crafted map. "If you understand how a map is made, you will better understand how to use it," said Buckley.

"I think readers will appreciate the chapter on map design replete with illustrations of both well- and poorly designed maps, intentionally created to show the difference between good and poor design," said *Map Use* coauthor A. Jon Kimerling, professor emeritus of geosciences at Oregon State University in Corvallis.

In addition to a wealth of illustrations—nearly 600 full-color maps, photographs, and graphics—this edition has a 44-page glossary that reflects the latest terminology in mapping, cartography, spatial analysis, imaging, land surveying, instrumentation, and the mapping community.

Additional coauthors of the book were Phillip C. Muehrcke, professor emeritus of geography at the University of Wisconsin Madison, and Juliana O. Muehrcke, founding editor of the journal *Nonprofit World*. Esri Press, 2016, print ISBN: 9781589484429 and e-book ISBN: 9781589484696.

# SPORTS, TELEVISION, AND POP CULTURE INSPIRE MARK GALLANT'S STORY MAPS



If an Esri Story Maps apps all-star team is ever assembled, Mark Gallant will certainly be in the lineup. Since 2013, the EntertainMaps.com founder, who is based in Ottawa, Canada, has been churning out a steady stream of compelling story maps that are so good he makes it look easy.

**Gallant is a storyteller**, and his medium is Esri Story Maps apps. He won second place in the 2016 Esri Storytelling with Maps Contest in the Culture/History/Events category for his story map Making Waves: The Evolution of Ska! Gallant was selected as the winner of Esri Canada's App of the Month for July 2016 for Old Ottawa: A Capital Uncovered, which contextualizes historical photos of features, events, and settings on a map of Canada's capital.



Mark Gallant, a GIS professional working for the Canadian federal government by day, creates story maps on topics ranging from sports to pop culture.

He also received second place in the 2015 Esri Storytelling with Maps Contest in the Culture/History/Events category for Ottawa's Eyewitness: Thomas Burrowes that explores the rich history of Canada's capital. Gallant's EntertainMaps website explores various popular culture topics. It features story maps including Off to the Races: NASCAR's Biggest Tracks; Jurassic Park: Lights, Camera, Hawaii; and Seinfeld: A Map about Nothing.

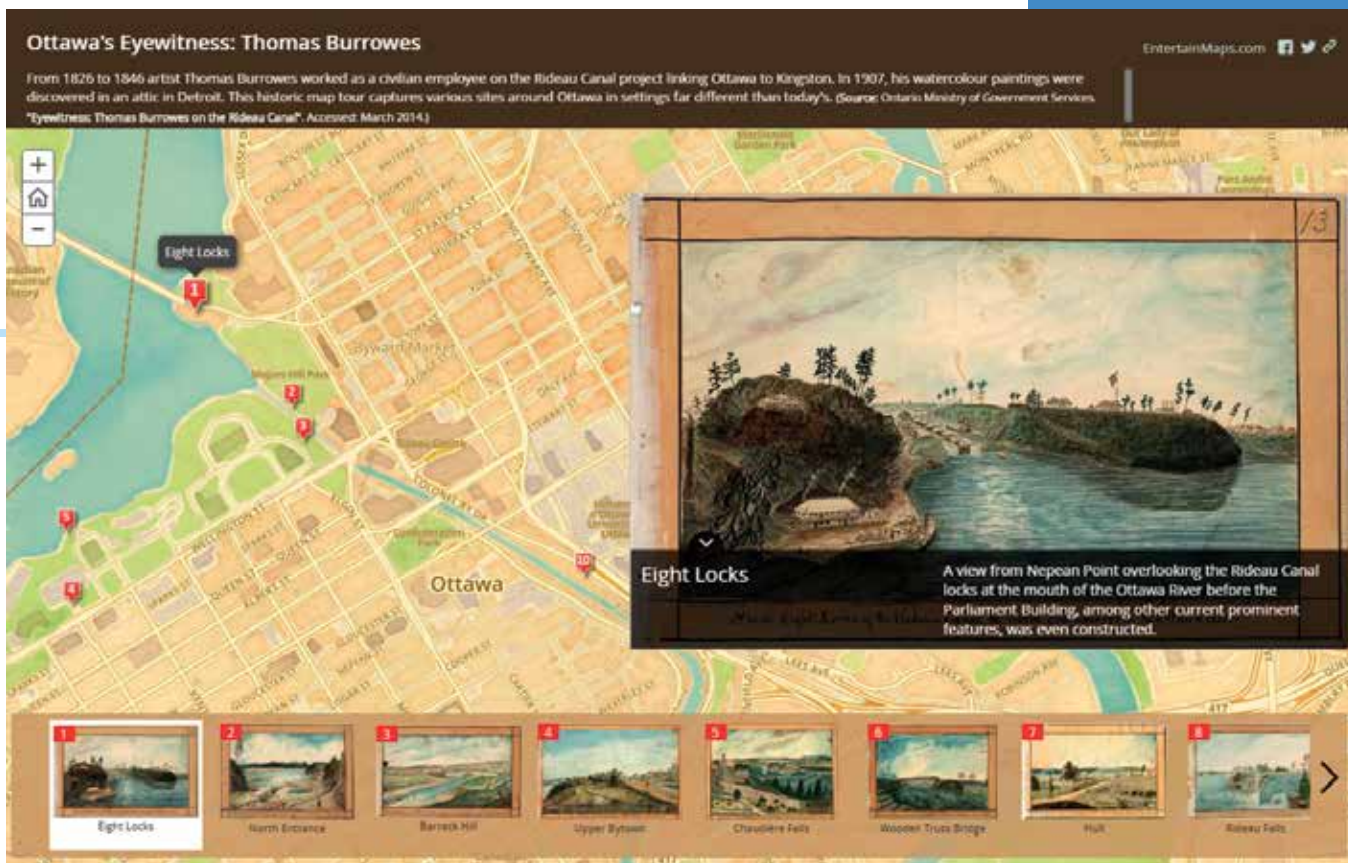
Esri Canada spoke with Gallant to find out what inspired him to start EntertainMaps.com and how he created the Old Ottawa story map. He also shared tips for first-time story map creators.

**Esri Canada:** You currently work as a GIS professional within the federal government, so EntertainMaps.com is something you do as a hobby. What inspired you to start this venture?

**Gallant:** My goal is pretty simple: I want to promote geographic understanding and reach new audiences that aren't normally exposed to geography. I started working with ArcGIS Online a few years ago—when it was launched—to keep my Web GIS skills sharp. Once I realized I had built over 20 apps, I decided to assemble them in a gallery and give it a domain name.

**Esri Canada:** Why did you feel that pop culture, such as ska music—which you feature in Making Waves: The Evolution of Ska!—would be a good fit for your work to engage people in geography and GIS?

**Gallant:** I find GIS is often used to present subjects like land use or weather patterns—things that fall within the traditional focus of geography—which I don't think capture the interest of the general public. So I go for topics that are outside the norm that people will recognize on the maps on my website. Also, I look at enough traditional geography stuff at work throughout the day, so when I'm at home, I'd rather spend time on something different.



**Esri Canada:** It sounds as though one of the goals of your project is to help promote the benefits of GIS to a nontraditional audience. Why is that important to you?

**Gallant:** Yes, that's right. I think that sometimes people don't look at things in a spatial sense. For example, when I see historical photos, people often just present the photo; they don't show where it *[was taken]*. The goal of my project is to place things like photos and videos in a spatial context. This way, they're learning the *what* and the *where*. To put this in context for a project like the Old Ottawa story map, people can make a connection with an old photo and the street they walk on every day.

**Esri Canada:** How do you pick the topics for your story maps?

**Gallant:** I have five questions that I ask myself before starting.

1. Is location relevant to the story?
2. Is there a variety of places or features?
3. Is good-quality media available?
4. Can things be explained in a simple manner?
5. Would somebody other than me be interested in viewing it?

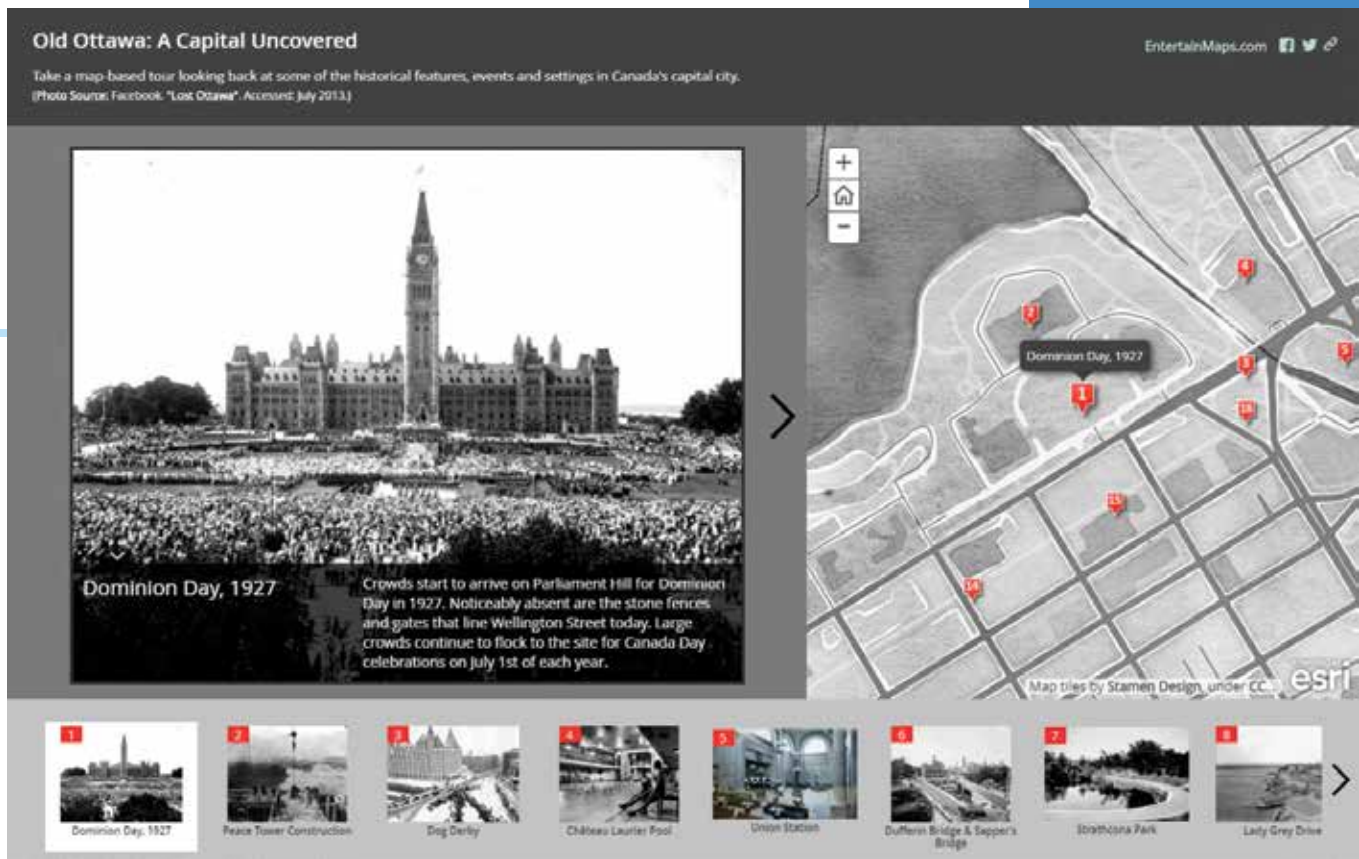
If the answer to all these questions is *yes*, then I'm likely to pursue it as a topic.

**Esri Canada:** Why did you choose to use Esri Story Maps templates as the starting point for your apps?

**Gallant:** First, they're very easy to use. The maps are hosted online, so I don't have to get into web hosting. They're constantly enhanced as they consume quarterly updates from ArcGIS



Ottawa's Eyewitness: Thomas Burrowes is a story map that explores the rich history of Canada's capital through a series of watercolors.



Online. Also, story maps are built with responsive design, so I don't need to make multiple designs for mobile devices. Finally, because they're easy and straightforward, I believe they effectively help the presentation of my topics.

**Esri Canada:** Your story maps are characterized by a clean, simple appearance and intuitive functionality. How did you develop your story map skills?

**Gallant:** When I first saw ArcGIS Online, I thought it had enormous potential to help GIS grow in the web environment and with presentation techniques. So I spent a lot of time learning ArcGIS Online because it was new. It didn't even exist when I was in university. I enhanced my skills building story maps by adhering to a strict set of limitations such as keeping it simple and not presenting more than 20 points on a map.

**Esri Canada:** Moving to the Old Ottawa: A Capital Uncovered story map, what led you to create this app? Are you a history buff?

**Gallant:** I wouldn't say I'm a history buff—I would say I'm more of an Ottawa buff. I'm from Ottawa. I've only ever lived in Ottawa. I studied geography here, and I was always paying attention to the layout and design of the city. I've always been interested in how the city has evolved over time.

I first saw the photos presented in the story map featured in a news article about Lost Ottawa, a Facebook research community. I visited the page and began sorting through the photos. I thought if I could pick enough photos of locations in Ottawa that look different than what's there today, I would really have something that would lend itself to a story map.



Old Ottawa: A Capital Uncovered provides context for historical photos of features, events, and settings on a map of Canada's capital.



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**Esri Canada:** Why did you choose the Esri Story Map Tour template for this particular tour?

**Gallant:** I think that the Story Map Tour template is probably the best for a sequential presentation of points of interest or different places. It also limits how text is displayed, so the reader isn't spending too much time reading at different points, which I thought would be appropriate for this topic.

**Esri Canada:** The basemap has a great, antiquated look to it that suits the theme perfectly. How did you create it?

**Gallant:** That's a custom basemap that I made using a web program called Stamen Map Stack. It allows users to take data from OpenStreetMap.org and then manipulate it in terms of its color, transparency, and texture. On the basemap for this app, I'm using a style called Watercolor, and I made it black and white so it looks like an old, dusty map.

**Esri Canada:** What's the response been like for this Story Map Tour app?

**Gallant:** It's been somewhat popular. Right now it has over 3,000 views. It usually gets more views around Canada Day.

**Esri Canada:** Last question: What advice would you give budding story mappers out there?

**Gallant:** Think about your topic for a while before you actually make the story map. I think about mine a lot before I start working on them, maybe for a week or two. I would also encourage people to look at different examples before you make your first one. And spend time [with] ArcGIS Online learning the ins and outs of Web GIS. Spend time looking at little snippets of code. Even though story maps are easy to create, I find the more time people spend learning ArcGIS Online and learning a little bit of HTML and JavaScript, the better their story map skills will become.

To find out more about story maps and start authoring your own, visit the Esri Story Maps website.

← Because story maps are built with responsive design, Gallant doesn't need to make multiple designs for mobile devices.

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# The Many-Faceted Career of Sarah Williams

By Jim Baumann,  
Esri Writer



↑ Sarah Williams has applied her knowledge and passion for geography and design to solving problems all over the world.

**From making maps** that have influenced public policy and hung in a fine art museum in New York to pioneering the mapping of transportation systems in Africa to tracking down ghost cities in China, Sarah Williams has applied her knowledge and passion for geography and design to solving problems all over the world.

Williams is currently an assistant professor of Urban Planning at the Massachusetts Institute of Technology (MIT) in the Department of Urban Studies and Planning, where she is also the director of the Civic Data Design Lab. While she is involved in many projects, Williams regularly teaches introductory and graduate-level GIS courses. In her courses, she uses ArcGIS technology and focuses on its analytical and geoprocessing capabilities.

"I emphasize design in all my classes," said Williams. "I tell my students that ultimately the maps they create will be judged on

whether they are readable. If your map highlights the story you want to tell, you will have a greater chance to convey the message contained in the data you used to create it. Good design helps make the map more accessible to the viewer."

## Informing Public Policy from MOMA's Gallery Walls

In 2006, Williams joined a team from Columbia University to create Million Dollar Blocks. This design project analyzed spatial information from the urban areas of six cities throughout the United States to determine which neighborhoods had large numbers of residents who have been incarcerated.

The project used Bureau of Justice Statistics data, which included each prisoner's previous residence and criminal offense and the cumulative cost of incarceration. In addition to Williams, other Million Dollar Blocks team members included Laura Kurgan, Eric Cadora, David Reinfurt, and Leah Meisterlin. The project is a collaboration between the Justice Mapping Center, the Spatial Information Design Lab, and the JFA Institute.

The analysis highlighted (at the city block level) those neighborhoods where former residents had been incarcerated for so long that their prison maintenance costs exceeded one million dollars. The visualizations were created with ArcMap.

"This was the first project that I worked on in which map data visualizations raised public awareness and produced a positive outcome," said Williams. The maps, in an exhibition called Design and the Elastic Mind at New York's Museum of Modern Art (MOMA), were seen by policy analysts. This prompted the analysts to use the maps to support the Criminal Justice Reinvestment Act of 2010. The act allocated \$25 million for job training programs for released inmates.

"The real strength of these visualizations is that they allow people to examine a social concern in a new way, which can prompt a better understanding of that issue. This is what I call creating a space for public action."

"On the surface, the Million Dollar Blocks maps, simply show the neighborhoods where prisoners come from. But in fact, they graphically depict a need for after-school programs, drug prevention clinics, and job training courses," said Williams. "I think that if we could spend \$1 million on social programs in these neighborhoods, we could have a lasting impact on them."

## Digital Matatus Keeps Nairobi Residents Moving

Shortly after completing the Million Dollar Blocks project, Williams teamed up with The Earth Institute at Columbia University to develop the first freely available GIS database for transportation and planning for Nairobi, Kenya. The resultant Nairobi Free the Data project helped policy makers, urban planners, and community

stakeholders obtain the spatial data they needed to make informed decisions about the future development of the city.

“The datasets we created are available to all, which adds value to them because others can use the data for their own research and planning,” said Williams. The files were ingested into Google Maps and OpenStreetMap.

Williams returned to Nairobi in 2013 to begin work on the Digital Matatus project. Matatus, a Swahili colloquialism, is the name of the city’s extensive, semiformal bus system. It means *three* and refers to the typical cost of a ride (three cents) in the 1960s.

With more than 130 operators that serve hundreds of routes throughout the city, the system is very complicated to document and analyze. Working with the University of Nairobi, Williams developed a cell phone application to capture digital information about routes that was subsequently used for analytical purposes, as well as creating an easily understood, stylized route map for commuters similar in design to subway maps. The methodology developed by Williams has been replicated in other cities that have semiformal bus systems similar to Matatus.

“Semiformal bus systems are the most common form of public transportation in the developing world,” said Williams. “You will

find them throughout South America, Asia, Africa, and many other areas. Providing a method to map these transportation systems allows greater mobility for urban dwellers that rely on them.”

The data developed for the Digital Matatus project was accepted for uploading into Google Maps. It was also used for the creation of transit apps by local technology companies so commuters would have bus route information available to them on smartphones.

“Basically, we visually surveyed and plotted the existing routes of the Matatus system and then laid a grid over our plot so we could develop a simplified map that was easy to understand for those using it,” said Williams. “We wanted to show residents how comprehensive the system was and how to use it beyond the one or two routes they regularly traveled. It was also very useful for the operators of the routes because it allowed them to identify both redundancies and gaps in the various lines. They were then able to consolidate some lines, as well as create new ones, and it showed them how they could further develop the system through more considered planning rather than the existing haphazard method.”

The template and workflows developed for the project used open-source tools and methodology with the General Transit Feed System (GTFS) as its standard. The paper map for commuters was

↓ Maps designed by Williams for an exhibition called *Design and the Elastic Mind* at New York’s Museum of Modern Art (MOMA) prompted policy analysts to use the maps to support the Criminal Justice Reinvestment Act of 2010.



created using ArcGIS and Rhino software. The raw data files are distributed in the GTFS and shapefile format. The files have reportedly been downloaded more than 300 times by organizations all over the world for transportation planning and implementation purposes. Williams hopes to create a resource center to further disseminate information on developing GTFS feeds.

Williams worked with the Center for Sustainable Urban Development at Columbia University; the Civic Data Design Lab at MIT; the University of Nairobi's School of Computing and Informatics; and Groupshot, a design and research firm, to complete the project. The Rockefeller Foundation provided a grant to support this effort.

### Looking for Ghost Cities

Currently, Williams is working on a project in China to determine unoccupied residential areas that are often referred to as ghost cities in the popular press. These may be symptomatic of overbuilding in the Chinese real estate market. To find them, Williams needed data about the location of amenities, such as shopping malls, gas stations, restaurants, and hair salons, as well as city populations and transportation networks. Places without these amenities within a certain proximity could indicate that no one lives there.

Unfortunately, the availability of data is often restricted by the

Chinese government. Williams's solution was to use the APIs for Chinese social media sites to scrape data that mentions consumer services. The social media sites used included Sina Weibo (a microblogging site akin to a hybrid of Twitter and Facebook), Dianping (a publisher of consumer reviews) and Baidu (the Chinese version of Google Maps). She analyzed the data from these sites to estimate amenity locations and nearby city populations.

Williams indicates that the accuracy rate in her initial work is 70 percent. She is refining her model to increase its accuracy. The project is sponsored by The Samuel Tak Lee Real Estate Entrepreneurship Lab, housed in the MIT Department of Urban Studies and Planning.

"In this project, we are investigating land use by the interaction of individuals with social media, which allows us to draw conclusions about broader real estate and urban issues in China," said Williams. "The idea behind the project is to determine risk and opportunity within the Chinese real estate market."

### Looking into the Future

"Eighty percent of all data is privately accumulated and maintained," concluded Williams. "Often it is automatically collected from our mobile devices. Williams believes that while this data could be

↓ A map of the semiformal bus system in Nairobi, Kenya, was produced by the Digital Matatus project.





← Williams worked with The Earth Institute at Columbia University on the Nairobi Free the Data project, which helped policy makers, urban planners, and community stakeholders obtain the spatial data they needed to make informed decisions about the future development of the city.

This might be accomplished by aggregating the data and stripping some personal information from it.

“Consciously or unconsciously, we willingly give social media data away on a daily basis. It’s a matter of how that data is used that becomes the issue,” said Williams. “It would be very beneficial if new data collection and visualization tools were developed that allowed the public to more easily gather

very valuable for services such as emergency response or analyzing traffic patterns in real time, it is locked away, for the most part, because of privacy concerns. She sees the need to develop policies and procedures that protect the individual’s personal data rights while allowing public access to this data when it is needed.

data through social media channels and then present it to support community issues. While there seems to be a general belief that the rise of big data is going to change the world, I don’t believe it will happen unless the data is collected and synthesized into tools that can be used for the public good.”

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# Mastering Geodesign ONLINE

By Carla Wheeler, ArcWatch Editor

The avatar of a student focuses a red laser simulator at a digital map of Lee County, Florida, in a virtual classroom. He stands with the avatars of fellow students and faculty as he points out where land could be developed near mass transit and urban services and reduce development in areas better suited to agriculture. “Don’t take anybody’s eye out now,” joked a faculty avatar. “I’ll try not to,” the student avatar said with a chuckle before continuing his presentation.



↑ The avatar of a student focuses a red laser simulator at a digital map of Lee County, Florida, in a virtual classroom with the avatars of fellow students and faculty during a presentation.

**Welcome** to the cloud-based environment for teaching geodesign at the Pennsylvania State University (Penn State) World Campus, where students learn to make what the university calls “geospatially oriented” design decisions. Students can earn two online degrees: a 35-credit Master of Professional Studies in Geodesign degree or a 14-credit Graduate Certificate in Geodesign.

Students collaborate on assignments and make final presentations to faculty and

classmates in a 2D/3D virtual classroom that provides an immersive environment. Students and faculty also communicate using other Internet-based communication tools such as Skype and Yammer. It’s the next-best thing to being together in one room.

“All our courses are offered online, so people can participate from wherever they are—they don’t have to relocate,” said Kelleann Foster, director of the Stuckeman School of Architecture and Landscape

Architecture at Penn State and the faculty leader of the school’s geodesign program. “So much is happening in the cloud now that it has actually become easier to deliver the program online.”

The online geodesign program was designed for people who work in diverse fields—such as transportation planning, landscape architecture, sociology, hydrology, and urban planning—and who want to use what Foster calls “spatial problem solving” in design decisions.

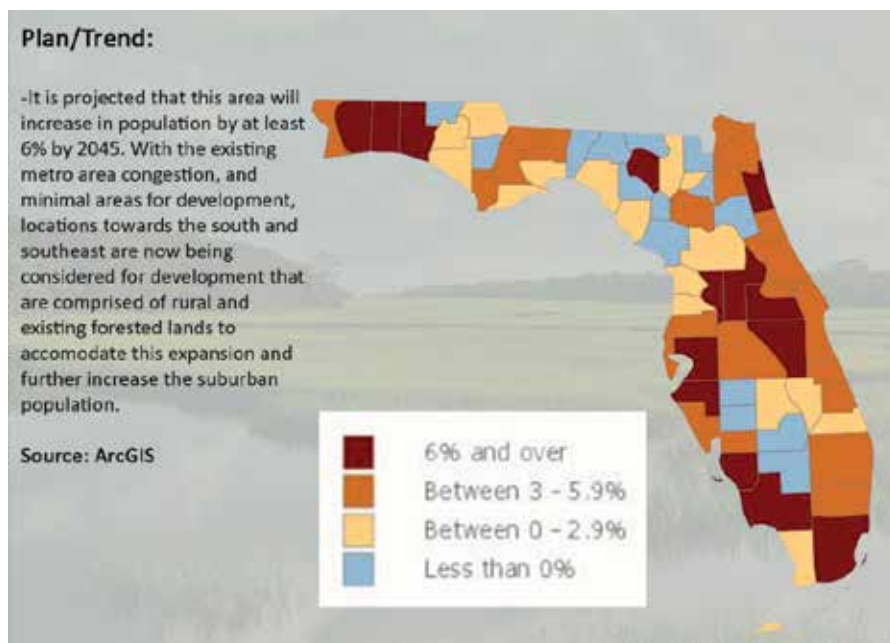
“It’s geared toward working professionals who want to acquire new skills, advance their [careers], or shift gears,” she said. The time commitment is from 15 to 20 hours per week, Foster said. The Graduate Certificate in Geodesign program takes about a year to complete, while the Master of Professional Studies in Geodesign program usually takes from two and a half to three years.

The online education program is giving Greg King, a GIS consultant from Brisbane, Australia, the opportunity to earn a master’s degree in geodesign from a top school—even if that school is 9,424 miles away in State College, Pennsylvania.

“I’m not aware of any geodesign degrees in Australia,” said King. “Online education works well for me. With my work commitments, being able to study and complete assignments when I have time is the best option. I currently have one class meeting each week, which is fine. But more than that would be a challenge.”

“What I think is so powerful about geodesign is [that] once you know this process, it’s transportable.”

Kelleann Foster  
Faculty Leader of Penn State’s Geodesign Program



↑ Students have to understand the plans and trends in their assigned regions and strategically intervene to improve the plans.

### Real-World Geodesign

The class format eliminates challenges, but the assignments are challenging. Students dive in and work on scenarios based on real-world issues that cry out for creative, thoughtful, and scientifically sound geodesign solutions. Recent class assignments have included deciding where to place transit-oriented development (TOD) in Florida and evaluating alternative routes and plans for improving US Highway 64/Corridor K in the Ocoee River Gorge area of Tennessee.

The students use GIS to evaluate their design scenarios. For an assignment for Geodesign Studio I: Rural/Regional Challenges, Penn State faculty member Michael Flaxman stipulated that the students create TOD proposals for various areas of Florida. “[TOD means] the placement of residential and mixed-use development that decreases the total vehicle miles driven and increases the use of public transit,” said Flaxman.

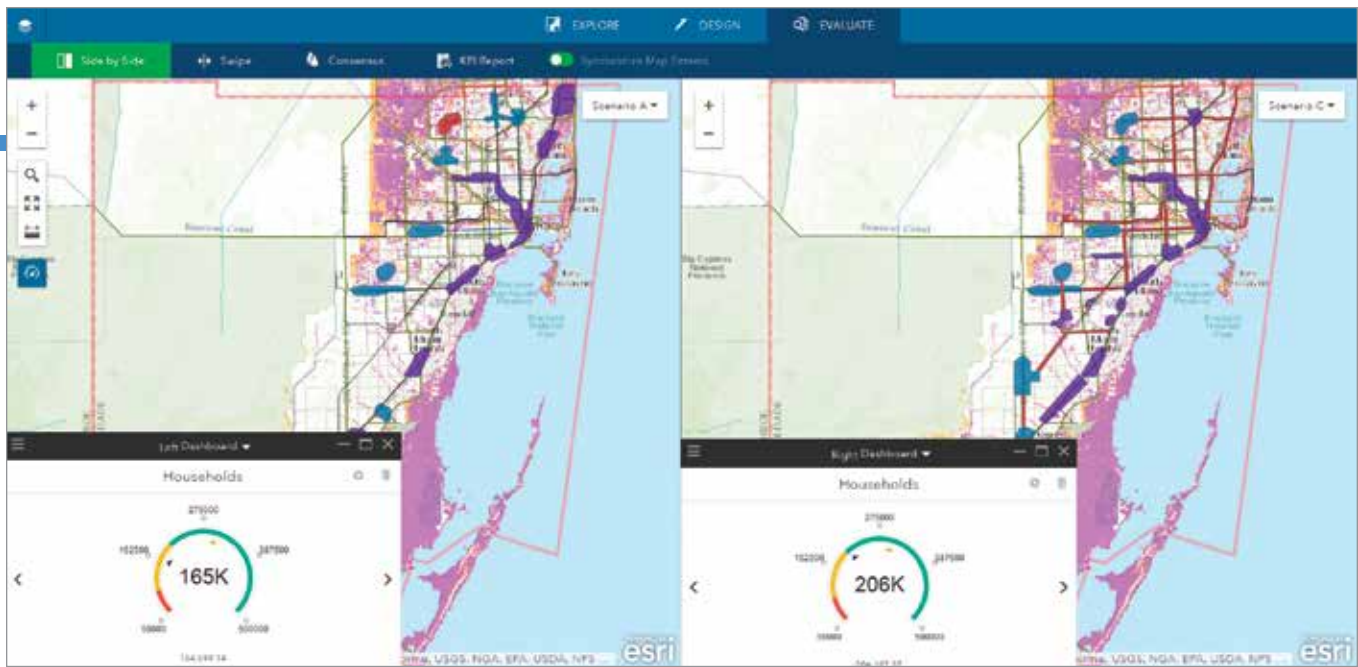
Shannon McElvaney, a master’s degree

student, used modeling and analysis tools in ArcGIS for Desktop, ArcGIS Online, and GeoPlanner for ArcGIS to determine where TOD should be located in Miami-Dade County, Florida, in 2040. He took into account the 330,000 households that the county projects will require transportation options by then and the probability that the sea level will be higher.

“The question was, ‘where can we grow?’” said McElvaney. He had to factor in many constraints: protecting green infrastructure, accounting for projected sea-level rise, and land that was unsuitable for development. Using sea-level rise projections available online from The Nature Conservancy, McElvaney brought that data into GeoPlanner for ArcGIS and mapped it. The map he created showed the land in his study area that would be covered by water in the future due to a projected three-foot rise in sea level. This would mean big trouble for portions of Miami Beach and a military base to the south.

“I couldn’t believe how drastic it was and how much land it overtook,” McElvaney said during his final online presentation. He finally decided to develop a bus rapid transit system farther inland and create mixed-use development along that route rather than putting in a fixed rail system that may be threatened by the rising sea level.

Flaxman said he was impressed with the work done by McElvaney and the other students in the class. “The primary [objective] was to become comfortable with



↑ The areas on Shannon McElvaney’s map in lavender indicate land in the study area that would have a 75 to 100 percent chance of being three feet underwater.

large problems and large spatial scales,” said Flaxman, who also has taught at Massachusetts Institute of Technology (MIT) and owns Geodesign Technologies Inc. in Berkeley, California. Students had to understand the plans and trends in their assigned regions and strategically intervene to improve the plans. “They came up with some good design solutions that faculty wouldn’t have thought of,” Flaxman said.

### A Well-Rounded Education

The Penn State geodesign program is not meant so much to turn out a cadre of geodesigners as it is to give people in their chosen

↓ Kelleann Foster, director of the Stuckeman School of Architecture and Landscape Architecture at Penn State, is also the faculty leader of the school’s geodesign program.



professions the skills to lead a geodesign process, according to Foster.

“They don’t have to be a GIS expert. They have to understand GIS,” Foster said. “They don’t have to be a design expert, *[but]* they have to understand the design process.”

Flaxman agrees. “Those with the *[geodesign]* training are going to do their traditional jobs better,” he said.

Both the certificate and master’s degree programs require geography courses as needed, along with classes on geodesign history, theory, principles, and models. The master’s degree students also take Geodesign Studio I and II and complete a capstone experience that involves preparing a student-selected, peer-reviewed geodesign project and then either presenting it in a formal venue such as a conference or author an article about it for a professional publication.

Whether students leave the Penn State World Campus with a master’s degree or certificate, Foster hopes they will carry with them a thorough understanding of a design process that includes gathering input from stakeholders, obtaining and analyzing data related to the issue, evaluating design proposals, and studying the consequences and implications of each proposal based on a set of criteria that is established early on in the process.

“What I think is so powerful about geodesign is *[that]* once you know this process, it’s transportable,” said Foster. “You can apply it to many different situations. And even as the technology changes and evolves—which, it does, every year—you will know how to plug the newest technology and newest ways to acquire the data into this framework in order to go forward with decision-making and *[getting]* the rapid feedback on the impacts and potential consequences.”

The days of working in a vacuum on a design project without collaborating with the public, decision-makers, and experts in other fields are long gone. “That is so old-school, especially with place-based projects,” she said. “You have to be able to understand how to work with a variety of people. To ask the right questions and get the right information from them is essential to the outcome.”

Otherwise, design proposals can turn into dinosaurs. “We have a lot of beautiful plans that sit on shelves because they weren’t part of a process that people were brought into and *[where people]* understood the value of the outcome,” Foster said.

For more information about the Penn State Master of Professional Studies in Geodesign and Graduate Certificate in Geodesign programs, visit [worldcampus.psu.edu/geodesign](http://worldcampus.psu.edu/geodesign) or contact Kelleann Foster at [geodesign@psu.edu](mailto:geodesign@psu.edu).



# Geodesign Education Goes Global

José Francisco Rivas Valencia owns a land development company in Colima, Mexico. He lives 7,600 miles from Greg King, a GIS consultant based in Brisbane, Australia.

Yet Rivas and King meet once a week in an online virtual classroom—sometimes as computer avatars—as they pursue a Master of Professional Studies in Geodesign degree from a school located thousands of miles away from both of them: Penn State World Campus, based in State College, Pennsylvania.

In its broadest sense, geodesign combines the art of design with the science of geography to incorporate stakeholder input, creative design techniques, rigorous methodologies, spatial analysis, and mapping. A practitioner uses geodesign methodology to find the most suitable, environmentally friendly, and sustainable option for real estate development, agriculture, wildlife conservation, transportation, flood control, and many other applications. ArcGIS for Desktop, GeoPlanner for ArcGIS, and ArcGIS Online are used in these programs. They help students analyze data and visualize the impacts of their designs.

Interest in geodesign has spiked in the last several years. Not only does Penn State offer geodesign degrees and certificates, but the University of Southern California (USC) and the University of Wisconsin, Madison, also offer geodesign programs. The Geodesign Summit, held at Esri headquarters in Redlands, California, and the Geodesign Summit Europe attract hundreds of people. *[The Geodesign Summit will be held January 24–26, 2017.]*

Penn State has designed a program that takes advantage of online education, which is being increasingly embraced by universities. The students and faculty use Skype, Yammer, and 3D immersive collaboration software, such as Terf, to communicate and collaborate on joint class assignments or review each other's work.

Rivas and King created avatars that bear a remarkable resemblance to their real selves. Last spring in a 3D classroom, they used these avatars when presenting their final projects for a course. Avatars of fellow students clapped after each presentation and listened to feedback from their instructors. Students find the virtual conversations to be a very valuable part of the class. King thought the avatars brought a sense of realism into the classroom. *"[It's] almost like actually being in a discussion with someone personally,"* he said.

Penn State's online geodesign education program was designed for the working professional like Rivas and King. Each man keeps a busy schedule and sought out an online master's degree program in geodesign. King opted for an online geodesign degree program rather than taking an individual, elective geodesign course at a nearby college that was offered as part of a degree program. *"Without Penn State offering geodesign as part of the World Campus, I wouldn't have the ability to study geodesign,"* King said.

The program offers an opportunity to learn a planning and design methodology that takes into account the design proposal area's environment, factors such as social and economic sustainability, and

the people who live there. It also adds spatial analysis into the equation. King said he learned a design principle long ago that stressed that the design of an entity can't occur in isolation. *"As every building/entity/community interacts with its surroundings, the design process needs to involve the surrounding areas,"* he said.

King works for an engineering firm that encourages innovative planning and design for any project. He hopes that he will gain a better understanding of how GIS results are interpreted for design purposes. *"As geodesign is a new discipline, getting involved now lets me contribute to its development. Opportunities like this are quite rare,"* King said.

*"This geodesign program has all of what I was looking for: balance between theory and practice, an innovative approach to the urban planning and design process, a new perspective on the online teaching process, and time flexibility,"* said Rivas.

Rivas owns Ryval Constructora, a construction company in the City of Colima, located south of Puerto Vallarta and about 62 miles inland from the Pacific coast of Mexico. His firm focuses on land development and establishes joint ventures with other companies and housing developers, which build the homes. Rivas wants to use geodesign methodology and tools to pursue sustainable land development practices in the city and the state of Colima. *"We have a very small state and a small city but with a lot of urban challenges and opportunities due to strategic location in our country,"* Rivas said.

He said that housing in Colima is often being constructed with no balance between different types of land use, no projection for economic development of the surrounding areas, and no consideration for creating a sense of community among the inhabitants. *"I think it is urgent to change this development model,"* Rivas said.

A geodesign methodology will help Rivas' team, local officials, consultants, would-be clients, and the people who live nearby to better collaborate, resulting in social, environmental, and economic sustainability.

*"Of course, as a company owner, I look forward to profits,"* said Rivas. *"But I am also aware of social responsibility, and I am sure that if the planning and design process of my developments undergo a collaborative process ... the final product will be highly profitable, not just for my company but also for the community and the whole city."*

Unlike King, Rivas was a GIS novice before taking the master's degree courses. *"I really had no experience actually getting information into a GIS nor analyzing and processing it to generate new data,"* he said. *"This has been a great learning process for me and, of course, a challenging one. But in the end, I am learning the great capabilities of GIS software and what it can contribute to the collaborative geodesign process—customizing maps and information that allows everyone to understand the actual problems, propose ideas, and look at possible what-if scenarios."*

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# Geodesign in the Desert

By Veronica Nixon, GIS Specialist, Desert Botanical Garden



**Creating accurate maps** has always been part of exhibit planning at Desert Botanical Garden in Phoenix, Arizona. As the technology of cartography has advanced from hand-drawn maps to GIS, the garden has begun employing geodesign to create truly extraordinary exhibits.

Desert Botanical Garden, located in the heart of the Phoenix Valley, is within the northern reaches of the Sonoran Desert. The garden exhibits more than 20,000 desert-adapted plants that range from ancient towering saguaros to delicate succulents. Detailed maps of these plants are brought together with utility maps and other GIS layers in a map used by desktop and mobile GIS technologies to plan the exciting trail renovations and seasonal art exhibits that enhance and protect Desert

Botanical Garden's valued plant collections.

The garden staff use geodesign methodologies to optimize the placement of art installations, new utility lines, and hardscape near collections of precious plants while protecting plants from hazards such as root compaction.

Geodesign is a specific form of landscape design. It earns the prefix *geo* because it changes the environment at a geographic scale. It is informed by geospatial technologies including GIS. While the garden's 138 acres are—admittedly—at the smaller end of the geographic scale, the density and value of its historical plant collections, combined with its miles of underground irrigation lines and other utilities, produce a design challenge that necessitates the use of geospatial technology.

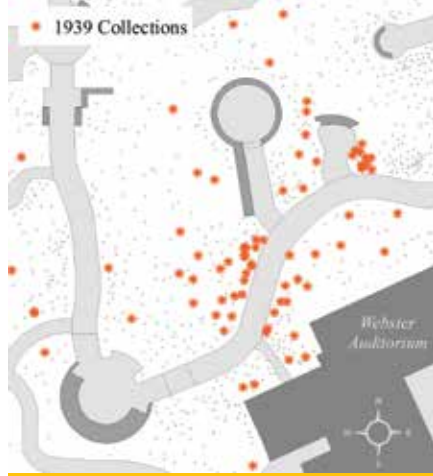
As a GIS specialist for Desert Botanical Garden, I create and manage spatial information about plants, built structures, hardscape, and underground utilities. In my role as a member of the garden's Living Collections team, I map the plant collections for our GIS-linked plant database at [livingcollections.org](http://livingcollections.org). The plant database was developed by Desert Botanical Garden and Missouri Botanical Garden to harness the power of GIS and scale up our plant collections management work. The GIS capabilities of our plant database make it possible to keep our plant records accurate and up to date during extensive garden renovations.

To do geodesign, I use my geospatial toolkit: ArcGIS for Desktop; ArcGIS for Server; ArcGIS Online; Collector for ArcGIS,



← The *Field of Light* exhibit glows in the dark at Desert Botanical Garden. Photo by Adam Rodriguez.

↓ Desert Botanical Garden uses ArcGIS to maintain its detailed plant database and orchestrate the movement of plants during landscaping projects so that precious historical and research data is retained with each plant.



a mobile mapping and data collection app; and high-accuracy surveying equipment. Our GIS data is stored in a versioned geodatabase. It supports web mapping and lets people in multiple departments edit

maps and attribute data.

I use ArcGIS for Desktop to perform spatial analyses and create cartographic products such as landscape design overlays that allow us to view exhibit plans on top of existing utility lines and plants.

I use the Collector for ArcGIS app, loaded on an Apple iPad mini, to collect data. Several staff members use the Collector for ArcGIS app on iPads to edit GIS layers in the field. My iPad has become indispensable. I carry it in my tool belt whenever I head outside to update our plant map with information on recent plantings.

### Geospatial Technology Helps Visualize the Plan

The Mexican giant cardons (*Pachycereus pringlei*) in our historical plant collection date to the garden's opening in 1939. They are the stars of the Sam & Betty Kitchell Heritage Garden that debuted in 2016. The cardons were collected on the Baja California Peninsula by our first director George Lindsay. Now nearly 35 feet tall, the cardons were only 4 feet tall when they were brought to the garden in 1939. They may one day grow to be more than 60 feet tall. Generations of visitors to the garden have viewed the cardons, as well as many other original plantings such as paper spine cacti and toothpick cacti.

Designing the Sam & Betty Kitchell Heritage Garden exhibit around invaluable plants, such as the cardons, posed an interesting challenge. We wanted not only to bring the garden's history to life by gathering all the plants of historical significance in one location but also better exhibit the plants already present in the space. New plantings, hardscape, and irrigation lines had to be positioned carefully around and among some of the oldest, largest, and most beloved plants.

During the planning and construction phases of the project, the location of each plant had to be carefully tracked. This ensured that the correct plants were included in the exhibit while other plants were moved to new locations in the garden. It was especially important to safeguard precious identification and collection data for the plants that were moved.

While walking through the garden and inspecting each plant, our team used iPads to review historical plant records in



↑ GIS specialist Veronica Nixon applies geodesign methodologies using high-accuracy surveying equipment and ArcGIS software.

our cloud-based plant database. These records tell us when a plant was accessioned into our collection, who donated the plant, and if it was collected in the wild.

We used a custom form in the Collector for ArcGIS app to record an assessment for each plant. Approximately 1,000 plants in the half-acre exhibit area were evaluated. If a plant was part of the heritage collection, it was kept in its current location. If it was not, it was transplanted to another part of the garden. These plants were remapped in their new planting beds using the Collector for ArcGIS app. New plant locations were automatically synced with our plant database, ensuring that our plant records were up-to-date.

Landscape architects create beautifully detailed renderings to help staff imagine what finished landscapes will look like. ArcGIS for Desktop and survey GPS allow us to go one step further and mark the locations of features from the construction plans on the ground in their future location. I georeference overlaid digital architectural designs onto a current map of the garden. Once the architectural drawing is georeferenced, our staff selects features that they want to see laid out on the ground. A feature might be the planned location of a pathway that needs to be inspected. After exporting the selected points to a survey GPS, I use a GPS stakeout routine to navigate to each location with subcentimeter accuracy and insert marker flags into the ground.

This technique enabled our curator of the Living Collections and our director of planning and exhibits to evaluate design elements and features in situ well before actual construction began. For example,



↑ Preliminary geodesign and mapping work kept volunteers and rare plants safe during the installation of the eight-acre Bruce Munro *Field of Light* exhibit. Photo by Greta Somers.

we used this technique to strategically place our Cardon Plaza, a focal point of the heritage garden, so that visitors can photograph the full 35 feet of the nearby Mexican giant cardons.

Reviewing preliminary designs on the ground well before construction reduces the chance of construction delays due to belated discovery of plant-design conflicts and guards against future harm to the plants. The desert-adapted roots of cacti are longer and shallower than those of other plants. In the case of the Sam & Betty Kitchell Heritage Garden, the hardscape had to be designed to protect the roots of the existing cardons and saguaros from possible compaction.

### Modeling the Complex Bruce Munro *Water-Towers* Installation

During the 2015–2016 season, Desert Botanical Garden displayed a collection of eight works by artist Bruce Munro, known for his work in the medium of light. Munro’s works are large scale, and two of the installations required geographic planning.

The *Water-Towers* installation was composed of 58 towers of glowing water bottles. The installation covered a quarter of

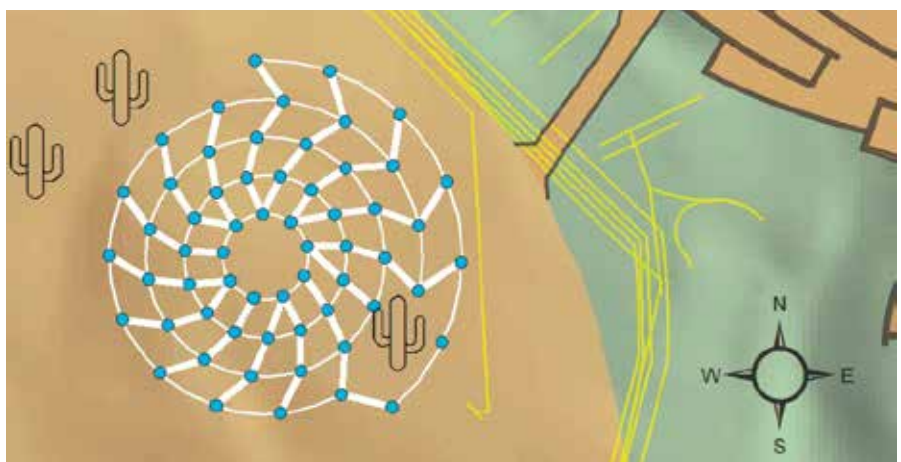
an acre and had to be positioned carefully in an area of the garden that has saguaros, a wash, and critical underground utility lines. I worked with our exhibitions manager and facilities manager to convert the layout specifications for the Munro *Water-Towers*

installation into a scale model in the GIS. Map layers depicting saguaro root zones, topography, and underground utilities were then loaded onto the GIS map. These landscape features constrained where the art exhibit could be placed.

Finally, the *Water-Towers* model was rotated and shifted to produce three different configuration options that would protect the root zones of the three neighboring saguaros, avoid underground utilities, and minimize grading work while maximizing accessibility for guests. The configuration that the exhibits staff chose was then transferred to the GPS to be marked on the ground, and *Water-Towers* was installed. The result was an incredibly engaging and beautiful display that did not negatively impact its built or natural environment.

### Intricate Details of Bruce Munro’s *Field of Light*

Miles of delicately colored fiber-optic lines fed into 30,000 frosted bulbs across eight



↗ Desert Botanical Garden staff carry out landscape lighting audits using Collector for ArcGIS prior to nighttime exhibits.

↘ Layout specifications for the Bruce Munro *Water-Towers* installation were converted to a scale model in ArcMap to select the best location for the exhibit with respect to saguaro root zones, topographic features, and underground utilities.

↓ The Bruce Munro *Water-Towers* exhibit at Desert Botanical Garden was created using stacked water bottles and fiber optics and sited using GIS. Photo by Adam Rodriguez.



acres of the garden's butte to bring the Munro *Field of Light* exhibit to life each night. The fiber optics drew light from 60 light boxes distributed across the area. Staff and volunteers worked together to thread the fiber-optic lines across the ground between the approximately 4,000 cacti and desert plants that populate the north side of the butte.

Our complete plant map, maintained in the GIS, was used by our Living Collections team to query and visualize the plants located where the exhibit would be installed. Care was taken during the design and installation process to protect the endangered Nichol's Turk's Head Cactus (*Echinocactus horizontalonius* var. *nicholii*), a very small cactus that can easily be overlooked.

Cacti, despite their tough appearance, are extremely fragile and slow-growing plants. Therefore, staff and volunteers took the utmost care not to damage any cacti during the installation. The detailed plant map enabled the team to modify where the light sources were placed to avoid being near the endangered cacti without creating visual gaps in the light display.

The Living Collections team collaborated with the exhibits staff to guarantee the safety of the plant collections—as well

as of staff and volunteers—while installing the exhibit on the steeply sloping butte. Detailed maps visualizing the slope, access routes, plant density, and location of each Nichol's Turk's Head Cactus were created in ArcGIS. These maps were heavily utilized by the team when planning and installing the *Field of Light* exhibit. Merging technology with exhibit planning made it possible to bring about the truly outstanding visual delight of this artistic endeavor.

### Enhancing the Evening Experience

Subtle lighting along the paths makes the garden an enchanting place to visit after sundown. Throughout the garden, 1,400 individual lighting fixtures line the pathways, illuminating plants and art installations. Each light is strategically placed and directed to ensure the safety of guests while accenting the dramatic forms of desert plants at night, adding a subtle layer of enchantment to the mood.

Behind the scenes, staff maintain the landscape lighting system to ensure that no area of the garden goes dark. Landscape lights are inventoried using the Collector for ArcGIS app on iPads to locate all landscape light fixtures, particularly when plants grow

over them. Using the Collector for ArcGIS app, staff add and remove landscape lights in the GIS and mark any lights that are out so that our electrician can find and repair them during the day. This map-based audit was a technological breakthrough for our landscape lighting maintenance work.

The lighting audit is carried out most efficiently during the hour of dusk. That is when our lights come on but when there is still enough light to spot fixtures with bulbs out. Last fall, I worked with our site operations staff to carry out a complete landscape lighting audit prior to the opening of the nighttime exhibit *Bruce Munro: Sonoran Light at Desert Botanical Garden*. The complete audit ensured that the landscape lighting system was fully functional before opening night.

Geodesign and geospatial technologies have proved useful in the installation of exhibits over the past two years. The Desert Botanical Garden looks forward to discovering even more applications for GIS software, web maps, and geodesign methods as we look ahead to the creation of our children's garden.

For more information, contact Desert Botanical Garden GIS specialist Veronica Nixon at [vnixon@dbg.org](mailto:vnixon@dbg.org).

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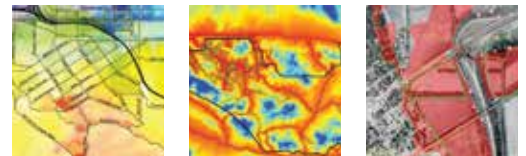
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