

ArcUser

The Magazine for Esri Software Users

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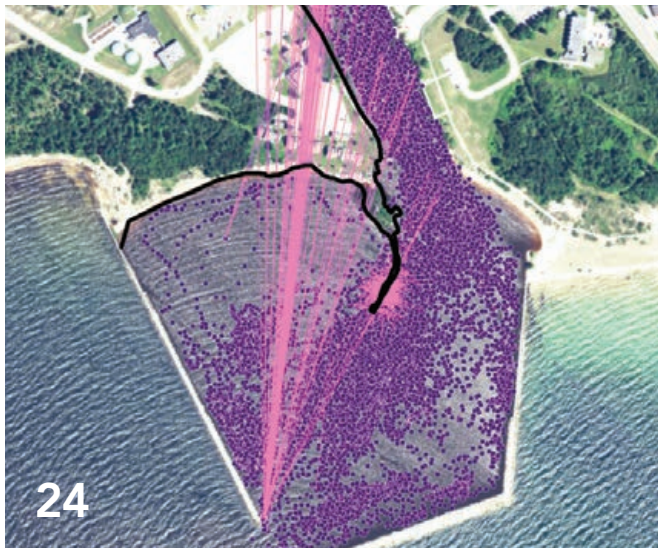
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On the Cover

The cover features an elevation-tinted, multidirectional hillshade of the area around Reno and Sparks in Nevada. It was one of the many cartographic products generated by Washoe County, Nevada, after processing a terabyte of lidar data.

A Clearer View of What Is Important

“The universe is full of magic things, patiently waiting for our senses to grow sharper.”

Eden Phillpotts, from *A Shadow Passes*, 1919

It seems that a century later—thanks to GIS—our senses have grown sharper. GIS lets us look beneath the surface and perceive the relationships, patterns, and dependencies of our world. These are realities that would remain hidden in the absence of the geographic framework and integrative powers of GIS. With this knowledge, we can move from a reactive to a proactive approach when facing challenges at scales—both spatial and temporal—that range from global to local and from epic to daily.

Articles in this issue vividly illustrate this. The National Geospatial-Intelligence Agency uses satellite imagery and hydrologic modeling to study the risk to human populations posed by the sudden release of millions of cubic meters of water when a glacier-created dam, melted by the effects of climate change, fails. A GIS team at the University of Arizona, tasked with assessing the effects of legislation that would rapidly dispose of federal landholdings, shared its GIS-based analysis and made its findings more accessible using an Esri Story Maps app. By moving from a paper-based, manual workflow to one that is digital and uses field apps linked to the city’s GIS, the City of Fort Worth, Texas, now knows the condition of its streets, storm drains, and other assets and the status of its work orders in near real time, saving the city time and money while providing its residents with a higher level of service.

The ability of GIS to support evidence-based and results-oriented processes has expanded with the Esri Geospatial Cloud. Web connectivity, combined with elastic cloud computing, lets organizations access a wealth of geographic information and harness powerful analytical tools that incorporate artificial intelligence, and then share the information products generated as maps and lightweight apps. Furthermore, the geospatial cloud enables a geodesign approach to policy that takes a long-term view, iteratively models various policies, assesses their consequences, and promotes collaboration to help us better protect what is important to us.

Monica Pratt
ArcUser Editor

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Editorial

Editor Monica Pratt

Contributors Jim Baumann, Carla Wheeler, Citabria Stevens

Technical Adviser Paul Dodd

Copyediting Linda Thomas

Design

Creative Director James Hitchcock

Designer Doug Huibregtse

Illustrator Dan Gill

Photographers Eric Laycock, Eric Johnson

Print Coordinator Lilia Arias

Advisory Board

Corporate Marianna Kantor

Products Damian Spangrud

International Dean Angelides

Marketing Communications Jeff Brazil

Industries Damian Spangrud

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Editorial Inquiries

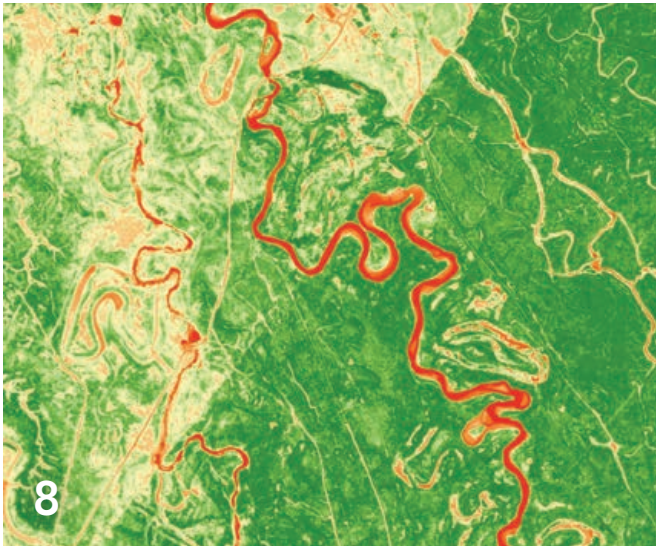
Monica Pratt, ArcUser Editor
380 New York Street
Redlands, CA 92373-8100 USA
arcuser_editor@esri.com

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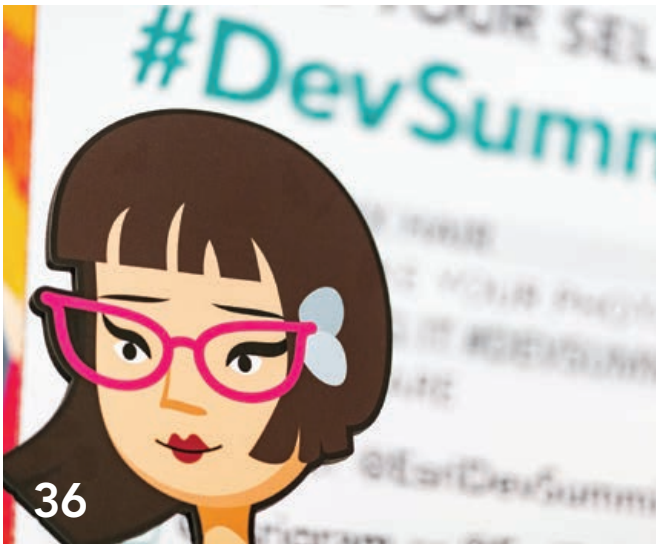
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Five Great Things about ArcGIS Pro 2.3

ArcGIS Pro 2.3 is the biggest release of the software so far. It incorporates many user requests received through the ArcGIS Ideas website. While the list of both new and improved functionality is long, these five improvements will help you do more in ArcGIS Pro.

1 The startup experience is simpler and quicker.

As many users have requested, you can start ArcGIS Pro without first creating a project. A project can always be created later if necessary. Opening ArcGIS Pro without a project can facilitate the data management workflows you may have previously used in ArcMap.

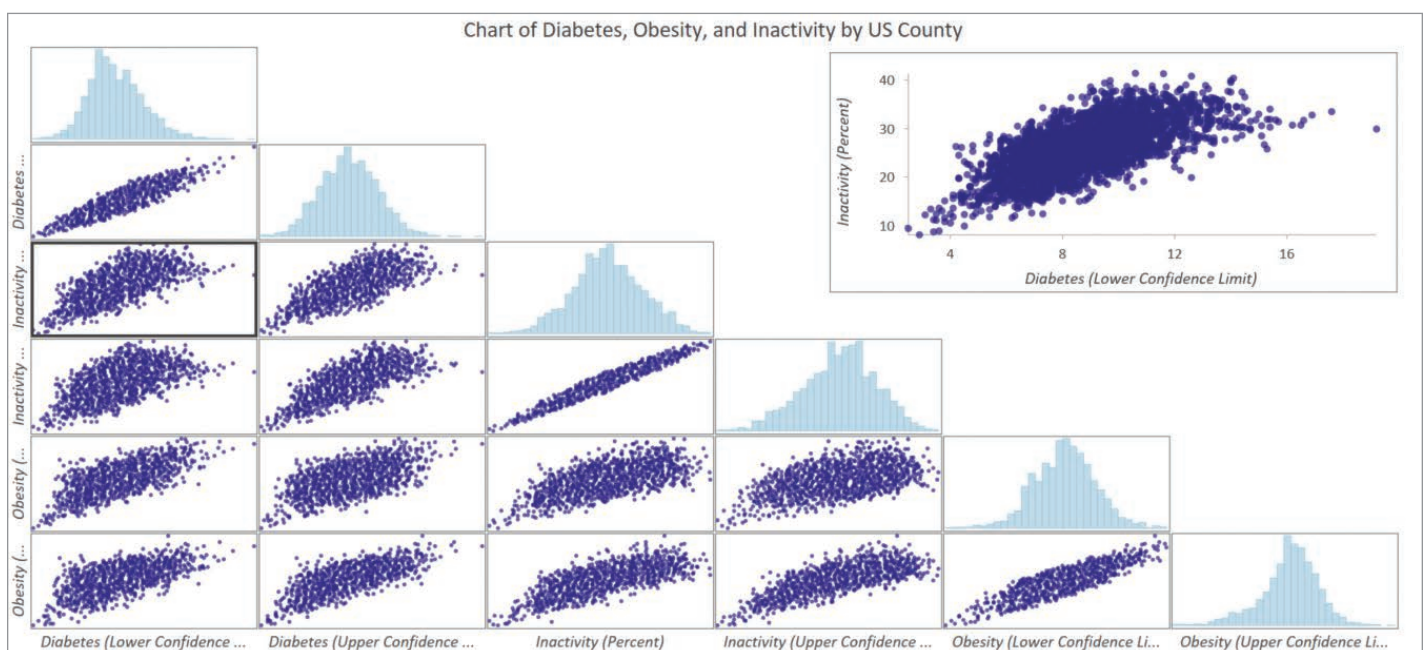
You can pin frequently used projects and project templates to the startup page so they will always be readily available. Pin as many as 50 projects. Conversely, you can configure ArcGIS Pro to always open the same project.

Double-click ArcGIS Pro maps (.mapx), map packages (.mpkx), layouts (.pagx), map layers (.lyrx), and layer packages (.lpx) items from Windows Explorer to open them directly in ArcGIS Pro.

2 Spell check text elements in your layouts.

Correct flagged misspelled words individually or view all misspelled words in the Check Spelling pane. Add words to a custom dictionary.

↓ The new scatterplot matrix chart type lets you visualize bivariate relationships between combinations of multiple number variables.





↑ Deep learning tools support image classification and object detection workflows.

3 Charts are easier to manage and format and now include scatterplot matrix charts.

Chart visual formatting controls are now on the Chart Properties pane. Save custom themes so you can apply them to other charts. Charts are listed below a layer's symbology in the Charts section in the Contents pane on the List by Drawing Order tab. The new scatterplot matrix chart type lets you visualize bivariate relationships between combinations of multiple number variables. Scatterplot points can also be sized using a third numeric variable to create a bubble plot.

5 Visualize data and perform new analysis in ArcGIS Business Analyst.

With the Business Analyst extension for ArcGIS Pro, visualize data and key indicators using the beautiful, custom infographics that incorporate your own data, Esri Demographics data, and the results of analysis using the new Calculate Market Penetration and Create Trade Area Rings tools.

4 Image classification and object detection tools use deep learning.

The new Deep Learning toolbox contains three geoprocessing tools in the ArcGIS Image Analyst toolbox that support image classification and object detection workflows. These tools use deep learning models generated by deep learning frameworks such as TensorFlow, Microsoft Cognitive Toolkit (CNTK), and Keras.

Introducing the Spectral Index Library in ArcGIS

By Vinay Viswambharan and Julia Lenhardt

The ArcGIS Spectral Index Library introduces a streamlined option for visualizing your imagery using spectral indices. Spectral indices are combinations of the pixel values from two or more spectral bands in a multispectral image. Spectral indices are designed to highlight pixels showing the relative abundance or lack of a land-cover type of interest in an image.

The most common index is the Normalized Difference Vegetation Index (NDVI), which provides an indication of abundance of vegetation by comparing the different reflectance values of the red and near-infrared bands (normalized such that the minimum value is -1.0, and the maximum is +1.0). There are many other indices that have been developed, using a variety of spectral bands to highlight different phenomena, such as vegetation, water, snow, and soil.

Spectral indices are most commonly applied in ArcGIS using raster functions.

Out-of-the-box functions, such as NDVI, Soil Adjusted Vegetation Index (SAVI), and Enhanced Vegetation Index (EVI), are available. The Indices button on the Imagery tab in ArcGIS Pro provides a handy shortcut to a predefined list of about 20 indices that are designed to process data locally.

Users can also implement their own band ratios and combinations using the Calculator or Band Arithmetic raster function.

The ArcGIS Spectral Index Library offers ready-to-apply spectral indices using raster functions that are easy to use.

[See also "Imagery Superpowers—Raster analytics expands imagery use in GIS" in the spring 2018 issue of ArcUser.]

ArcGIS Spectral Index Library

ArcGIS Online houses the Spectral Index Library, which contains raster function templates for a variety of well-known indices. For each index, there are typically

two raster function templates: one that produces a single-band image in floating-point format that's appropriate for analysis and a second that applies a color ramp or color map to generate a colorized image intended for visual representation.

These raster templates can be applied to your imagery in ArcGIS Pro or in the Map Viewer in your ArcGIS Enterprise portal. The library of functions is accessible through the public ArcGIS Online group ArcGIS Spectral Index Library. You can join the group for easy access to the indices.

Within ArcGIS Pro, these spectral indices can be applied to local imagery, applied to imagery from an image service, or you can transmit the definition of the index to the server. Transmitting (or uploading) the definition of the index to the server is advantageous because the server performs the processing on the source data and returns only the more compact index back to the client, increasing performance.

How Do You Benefit from the Spectral Index Library?

ArcGIS Pro natively provides multiple ways to apply indices. These options include the Band Arithmetic raster function (available through the Raster Functions pane), the Indices gallery on the Imagery tab, or using the Calculator raster function to manually implement your own custom algorithm.

However, in addition to ease of access and convenience when applying these indices using the Spectral Index Library, there are three other benefits:

1. The Spectral Index Library selects the

appropriate bands for you. The Band Arithmetic function requires you to know your imagery bands or imagery wavelengths to use the function out of the box to apply spectral indices.

2. With the Spectral Index Library, you can easily perform server-side processing without having to modify or tweak any parameters. The built-in system functions cannot be used for server-side processing unless you pick the index, specify the band numbers or wavelengths, define the raster variable, and explicitly save the Band Arithmetic function as a custom function template. The functions provided in the indices gallery can only be applied on the client and cannot be used for server-side processing. Without the Spectral Index Library, you must know what you are doing and go through multiple steps to apply a server-side index.

3. The visual indices in the ArcGIS Spectral Index Library have a custom stretch and a color map to render the visual products intuitively. These custom parameters are specifically tweaked for each index for better visualization of specific phenomena.

The big benefit of using the Spectral Index Library is convenience. Select your imagery, pick the spectral index from the library, and click Apply. Voila! You have the product you desire. It's that easy.

➔ What can you spot in NDVI (top image) that you can't spot in the true color image (bottom image)?



About the Authors

Vinay Viswambharan is a product manager on the Imagery team at Esri with zeal for remote sensing and everything imagery.

Julia Lenhardt is a product engineer on the Raster team. She has been with Esri since 2014 and has a background in remote sensing and GIS for environmental research. In addition to image analysis, she has a passion for music, running, good food, and animal welfare.



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Briefly Noted

→ Esri Launches R&D Center in New Delhi, India

Esri opened a new R&D Center in New Delhi, India in March 2019. The New Delhi team includes data scientists, enterprise developers, product engineers, and GIS analysts, is working on data science, deep learning, and geospatial artificial intelligence (GeoAI) solutions to revolutionize spatial analytics and help overcome some of the world's biggest challenges. The team will also develop the next generation of Esri's ArcGIS Enterprise based on a microservices architecture.

Esri's worldwide network of 15 research and development centers stretches from Beijing, China, to Zurich, Switzerland, to Melbourne, Australia. As part of its acquisition of indoor positioning system (IPS) provider indoo.rs in February 2019, Esri opened an R&D center in Vienna, Austria, that is focused on developing cutting-edge IPS capabilities.

These centers are evidence of Esri's commitment to advancing location intelligence technology. "By locating strategic R&D centers around the globe, we are able to continue to engage talent worldwide to expand the capabilities of the Esri Geospatial Cloud," said Esri president Jack Dangermond. To learn more about the Esri R&D Center in New Delhi, visit esri.com/newdelhi.

→ Mapping the Great Indoors

In February 2019, Esri acquired indoo.rs, GmbH, a world leader in indoor positioning system (IPS) software, and announced ArcGIS Indoors, a new mapping product that enables interactive indoor mapping of corporate facilities, retail and commercial locations, airports, hospitals, event venues, and universities.

Mapping, managing, navigating, and planning indoor spaces is a rapidly emerging market that promises to decrease costs, increase safety, and provide a better workplace experience for inhabitants. The IPS market has skyrocketed in recent years, and integration of IPS technology will benefit all levels of an organization.

The acquisition will provide users of Esri's ArcGIS platform with embedded IPS location services to support indoor mapping and analysis. A former Esri partner, indoo.rs has worked with organizations such as international hub airports, major rail stations, and corporate headquarters. Existing indoo.rs customers will now have access to ArcGIS, adding powerful GIS software to indoor mapping applications.

The indoo.rs headquarters will serve as a new Esri R&D center based in Vienna, Austria, that will focus on cutting-edge IPS capabilities and provide support for IPS functionality in ArcGIS Indoors and across the ArcGIS line of products.

ArcGIS Indoors provides floor-aware 3D maps and focused apps that support owner/operators, maintenance and service personnel, security staff, employees, and visitors. The initial release of ArcGIS Indoors will include the indoo.rs IPS capability to enable ArcGIS Indoors mobile apps to work with iBeacon-based IPS systems, which provide "blue dot" accuracy on mobile devices. ArcGIS Indoors supports other IPS formats, such as Apple's indoor position service, and will add support for other IPS providers in coming releases.

For more information about ArcGIS Indoors, visit go.esri.com/indoors.



→ ArcGIS Security Updated

To implement the highest security standards across its entire suite of products, Esri is using the most robust, widely accepted security protocols, including Transport Layer Security (TLS) for privacy and data integrity. The ArcGIS platform uses the TLS protocol as a key component of its security for web and service API connections, including connections between other Esri software products.

In April 2019, Esri required TLS 1.2 connections for ArcGIS Online services. For some users, action was required to ensure continued access to ArcGIS Online services. Esri released patches and instructions on updating existing software to support these connections.

ArcGIS Pro is already TLS 1.2 enabled, while ArcGIS Desktop required a patch or configuration change to support TLS 1.2 connections. For workflows that access ArcGIS Online basemaps, story maps, ArcGIS Living Atlas of the World, hosted items, or other ArcGIS Online services or host a GIS portal with ArcGIS Enterprise that connects to ArcGIS Online, the software that accesses ArcGIS Online will need to support TLS 1.2 connections to those services. In addition, ArcGIS apps, custom apps, or third-party apps built on ArcGIS Runtime SDKs that access ArcGIS Online from desktop or mobile devices will need to support TLS 1.2 connections.

If your organization is raising its network security requirements to demand TLS 1.2 or later and disabling previous TLS and SSL versions, ensure that your software and operating system environments are updated to support those new internal IT requirements with TLS 1.2.

Visit support.esri.com/tlsproducts for a list of affected products and information on actions you may need to take. To stay up-to-date on security, privacy, and compliance-related announcements for the ArcGIS platform, subscribe to the RSS feed in the ArcGIS Trust Center at Trust.ArcGIS.com.

→ Jack Dangermond Honored in the Netherlands

Esri president and founder Jack Dangermond was appointed an Officer in the Order of Orange-Nassau in a ceremony that took place on April 2, 2019, immediately after he spoke at the Geospatial World Forum. Jan Hamming, mayor of the Dutch city of Zaanstad, made the presentation on behalf of King Willem-Alexander of the Netherlands.

This honor recognizes Dangermond's special merit in the national and international geo world. The Order of Orange-Nassau was established in 1892, and it is not often given to someone who lives outside the Netherlands. However, Dangermond's worldwide work combined with his work in the Netherlands with the National Planning Service in Zwolle, the Kadaster, and many other organizations—along with his special ties to the Netherlands as the birthplace of his parents—were factors in bestowing this honor.


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Geospatial Technologies Help Mitigate the Risks of Climate Change

By Jim Baumann, Esri Writer

The National Geospatial-Intelligence Agency (NGA), among its many responsibilities, is studying the effects of various climate change phenomena throughout the world.

Originally founded in 1996 as the National Imagery and Mapping Agency, the NGA has provided geospatial intelligence (GEOINT) mapping services to the nation's intelligence agencies for more than 20 years. The NGA uses information on the effects of climate change for civilian outreach efforts, such as rescue operations and rebuilding in the wake of natural disasters and humanitarian crises, and for strengthening national security efforts.

One result of climate change is the ongoing melting of glaciers throughout the world. As a glacier recedes, a glacial lake system is formed. Water ponds either

behind the glacier forming an ice dam or in front of the glacier forming a moraine built from rock debris that was transported by the glacier. Moraines, like ice dams, are mostly made of ice and therefore susceptible to melting and failure. When glacier-created dams fail, large volumes of lake water empty in only a few hours and surge downstream in an event known as a glacial lake outburst flood (GLOF).

NGA is currently studying the GLOF phenomena in Patagonia, which encompasses the southernmost tip of South America and parts of Argentina and Chile. The area is divided by the Andes Mountains.

The Argentinean side features grasslands and deserts, while the Chilean portion is known for its glaciers, fjords, and ice fields. The southern and northern Patagonian ice fields comprise the largest mass of ice in the southern hemisphere outside of Antarctica.

Global warming has caused the Colonia Glacier in Patagonia to retreat about 2.5 kilometers during the past 30 years, while the nearby Nef Glacier has retreated 1.8 kilo-meters. Both glaciers have contributed to the water contained in the vast glacial systems that feed Chile's largest river by volume, the Rio Baker. Located in the Patagonian ice fields, the river in turn

← The bottom of Cachet Dos Lake five days after a glacial lake outburst flood (GLOF) drained its basin.

flows into Cachet Dos Lake, which has had 20 catastrophic GLOF events during the past 10 years due to the recurring melting of the ice dam that contains it.

The refilling and discharge of the lake is ongoing. As water pours into the lake from the glacial systems, a tunnel begins to form at the base of the ice dam that ultimately undermines it and releases all the water contained within it. The tunnel subsequently collapses and freezes over again, the lake refills, and after a time another tunnel forms in the ice dam and the water is once again expelled.

The calculated discharges from the lake range from 2,000 to more than 15,000 million cubic meters of water per event. These discharges flood the Rio Baker/Rio Colonia basin, often killing the inhabitants living downstream as well as destroying

infrastructure in its path.

"A number of universities, as well as the USGS [US Geological Survey] and the NGA, have studied the Colonia glacier and its recurring GLOF events for several years," said Manuel Castro, human geography analyst at the NGA. "Unfortunately, the phenomenon occurring at the Colonia Glacier and Cachet Dos Lake is rapidly becoming prevalent in many other parts of the world, which creates a need to better understand it.

The Colonia Glacier can be used as a proxy to study other glaciated zones that are inaccessible and the effects of climate change on the cryosphere. *[The cryosphere is that part of the earth that is so cold water is frozen solid.]*

What makes this area both striking and attractive for research is its magnitude. It is within the Northern Patagonian Ice Field,

One result of climate change is the ongoing melting of glaciers throughout the world.

which measures 4,200 square kilometers (km²), the second-largest continuous mass of ice outside the polar regions. Cachet Dos Lake is contained by a 437 km² glacier that holds back 200 million cubic meters of water that is released in a few hours when a GLOF occurs.

↓ Spatiotemporal dynamics of climate change are visible in areas like Patagonia. The Normalized Difference Water Index (NDWI) can efficiently detect surface water because water surfaces have a low reflectance in the near-infrared (NIR) spectral band. In contrast, vegetation is characterized by a high reflectance.

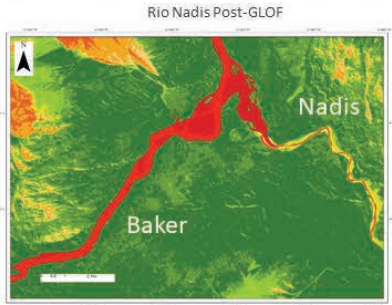
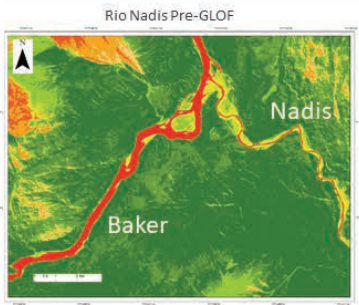
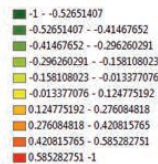
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The Proposal



Normalized
Difference
Water Index

$$NDWI_{10m} = \frac{p_3 - p_8}{p_3 + p_8}$$



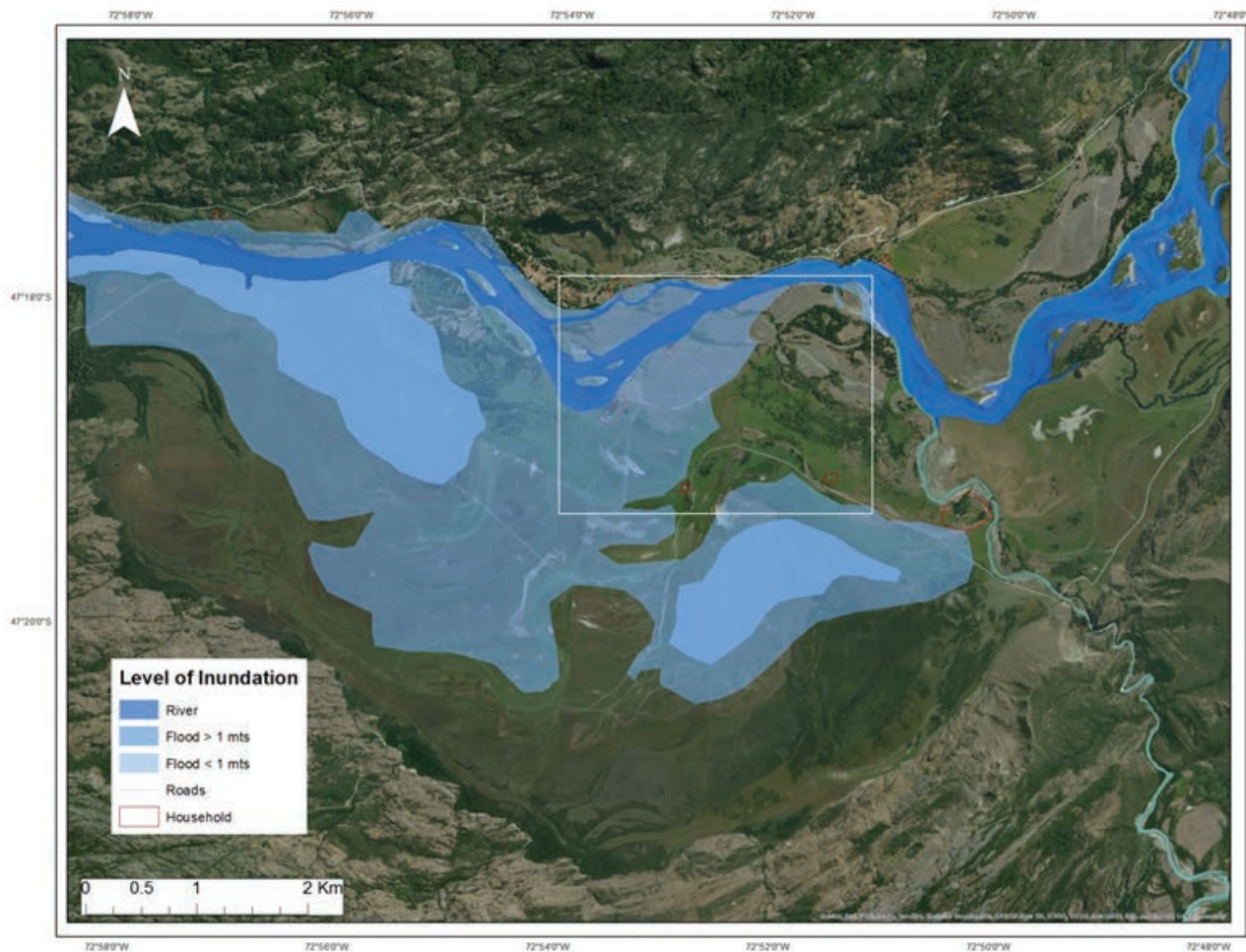
Band Number	Spatial Resolution (m)	Central Wavelength (nm)	Bandwidth (nm)
01	10	440	30
02	10	480	30
03	10	560	30
04	10	650	30
05	10	660	30
06	10	680	30
07	10	750	30
08	10	865	30
09	10	940	30
10	10	1240	30
11	10	1640	30
12	10	2130	30



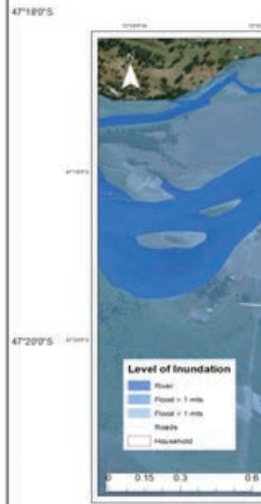
Photo: Andres Rivera



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Four properties are m
affected in Valle Gran
moderate flood. 60%
likely to be affected b
that connect Cochran
Impassable. Potential



Remediation Plan: Poter
Area in white box repre
is imminent. Further coo

↑ Cachet Dos Lake was completely drained after a GLOF. The lake's current depth is visible as well as its normal level.

The GLOF phenomena has the potential to affect populations throughout the world. The NGA is studying the Colonia Glacier because the methodology and models it is developing for its analyses can be applied to other places such as Alaska and Nepal. In addition, one of NGA's goals is to help national and international communities struggling with natural hazards by using its expertise in geospatial technologies.

"To research the GLOF events of the Colonia Glacier, I am using Arc Hydro to analyze the collected hydrologic data, HEC-RAS to model the hydraulics of the water flow, and ArcMap and ArcGIS Earth to process, visualize, and share the results." [Hydrologic Engineering Center

River Analysis System, or HEC-RAS, was developed by the US Army Corps of Engineers.] As part of the analysis, Castro used ArcMap to process electro-optical imagery obtained from Landsat satellites and obtain the Normalized Difference Water Index (NDWI) and map the area in the Rio Baker/Rio Colonia basin that is prone to flooding.

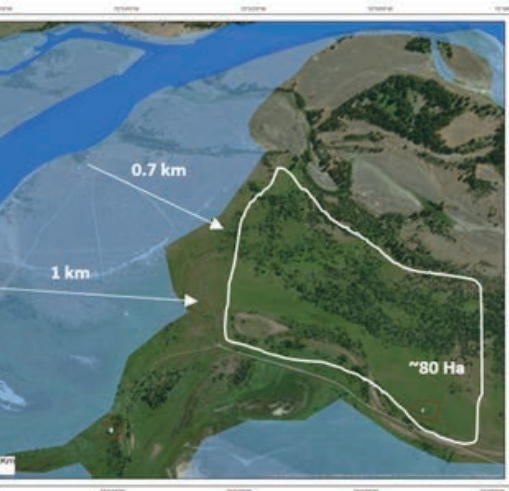
"First, I researched the Landsat imagery that included the Rio Baker/Rio Colonia basin and then compared those results with the dates of known GLOF events there," said Castro. "I was able to find a day during the summer of 2015 when there was limited cloud cover and the satellite had collected data only a few hours after the

outburst flood, so I got good imagery."

From the data indicating the extent of the GLOF, Castro created a 1,000-meter buffer around that part of the Rio Baker and the related basin and floodplain. He used the raster calculator in ArcMap to add NDWI calculations derived using the near-infrared (NIR) and shortwave infrared (SWIR) bands of the satellite imagery. To visualize the basin under normal conditions, he performed the same process using satellite data that was recorded eight days before the flood.

Castro plans to capture high-resolution imagery of key floodplain areas using an unmanned aerial vehicle and postprocessing the imagery using Drone2Map for ArcGIS.

most likely to be
de area with
of area is most
y GLOF's. Road
e with Colonia Sur
livestock loss



potential site for resources and livestock relocation.
resents a potential site for momentary assets relocation if inundation
ordination with local community is needed.

From this data, he will create a flood model that can provide a spatiotemporal representation of the Colonia Glacier GLOF. It will identify those areas that are most likely to flood and provide an estimate of the arrival time of the flood surges.

"Eventually, this work could provide the Chilean government or other stakeholder with the foundational methodology of how to operate a ground-based, high-definition survey lidar station across the Colonia Glacier and Cachet Dos Lake to collect 3D point clouds to define the shape of the glacier-water interface," said Castro. "Using near real-time data interpretation, this method can identify sudden drops in lake height as an early consequence of a GLOF with a simple change detection algorithm."

The data would be automatically

The GLOF phenomena has the potential to affect populations throughout the world.

uploaded to a satellite and accessed by researchers who would transmit a warning of an impending GLOF to local Chilean police. The lidar station will also allow the scientific community to collect valuable data about the Colonia Glacier that is important to researchers.

↓ A remediation plan is essential for measuring, modeling, and planning for the effects of a GLOF impact so that people who may be affected can be better prepared.



Story Map Promotes Better-Informed Federal Land Legislation

By Yao Jian and Emily Marderness

At the University of Arizona, a GIS team in the Advanced Resource Technology Lab in the College of Agricultural and Life Sciences was tasked with exploring the potential effects of national-level legislation that seeks to make federal landholdings more manageable by targeting lands that have been identified by the Bureau of Land Management (BLM) as “lands potentially suitable for disposal.”



← The University of Arizona team shared the results of its research on the proposed disposal of federal land as an Esri Story Maps app called “OUR LAND: The sale of federal land, accelerated” (OurLand.arizona.edu) to bring this information to a wider audience.

Locating the Data

The first step in understanding the effects of this ongoing legislation was to find out the total amount of land under consideration. The geospatial data for the land managed by each federal agency—BLM, USFS, FWS, NPS—is available from a public database provided by the federal government. Grazing allotments, municipal boundaries, cultivated land, and development areas data was also retrieved from public databases provided by the federal government.

Direct sources of this information were the BLM Resource Management Plans (RMPs). They are land management blueprints that are available as documents with text and maps through the online e-planning portal at eplanning.blm.gov. In some RMPs, parcels are clearly identified as potentially suitable for disposal because these RMPs have legal descriptions of the land tracts in the United States Public Land Survey System (PLSS) that include township, range, section, and the portion of the section.

The BLM Southern Nevada District Office,

Almost a third of the land in the United States is managed by the federal government. Federally owned land is mostly managed by four agencies: the Bureau of Land Management (BLM), the US Forest Service (USFS), the US Fish and Wildlife Service (FWS), and US National Park Service (NPS). These agencies are generally dedicated to the preservation of wildlife and ecosystems; recreation; and development of natural resources such as grazing, timber, and mining.

Historical transfer of land from federal ownership to railroads, other private owners, and states has left a patchwork of federal holdings. Proposed legislation such as the Hunting, Education, and

Recreational Development Act (H.R. 3333), or HEARD Act, seeks at the national level to reduce this fragmentation to make federal land more manageable. The HEARD Act proposes to require the BLM to sell 80 percent of this land over four years.

The project team exploring the effects of this legislation was led by Cody Sheehy, an award-winning videographer. Sheehy interviewed stakeholders and experts while the GIS team collected and evaluated existing geospatial data sources. Together they created an Esri Story Maps app called “OUR LAND: The sale of federal land, accelerated” (OurLand.arizona.edu) to bring this information to a wider audience.

which manages the BLM land in the Las Vegas Valley, partners with the BLM Lands, Realty and Cadastral Survey Program to make information about land sales publicly available through its website at blm.gov/snpplma. Since the Southern Nevada Public Land Management Act (SNPLMA) of 1998, the BLM has sold 35,000 acres at auction in the Las Vegas Valley. The field office also provided the team with the geospatial data to calculate how much land potentially suitable for disposal remains. The answer: 30,000 acres. While geospatial data was not available from any other state BLM office, individual field offices provided further details about the areas they manage.

The team asked how much land potentially suitable for disposal exists in each state and how much of this disposal land exists for the entire United States. From interviews and correspondence with BLM staff, it was clear that only the western half of the United States has a significant amount of land that could be affected by the legislation. There is a BLM office for each of the 12 western states (except for the Montana/Dakotas office) and one office for the whole eastern part of the United States. Because it is still receiving

its statehood and native settlement claims transfers, Alaska is a different story.

To determine the amount of affected land for the entire nation, it was necessary to acquire geospatial data for land designated as potentially suitable for disposal from the rest of the states. When contacted, some states provided data aggregated at the state level. The national BLM office responded to the team and explained that it had reached out to each state office in fall 2017 and aggregated the lands potentially suitable for disposal for the whole United States.

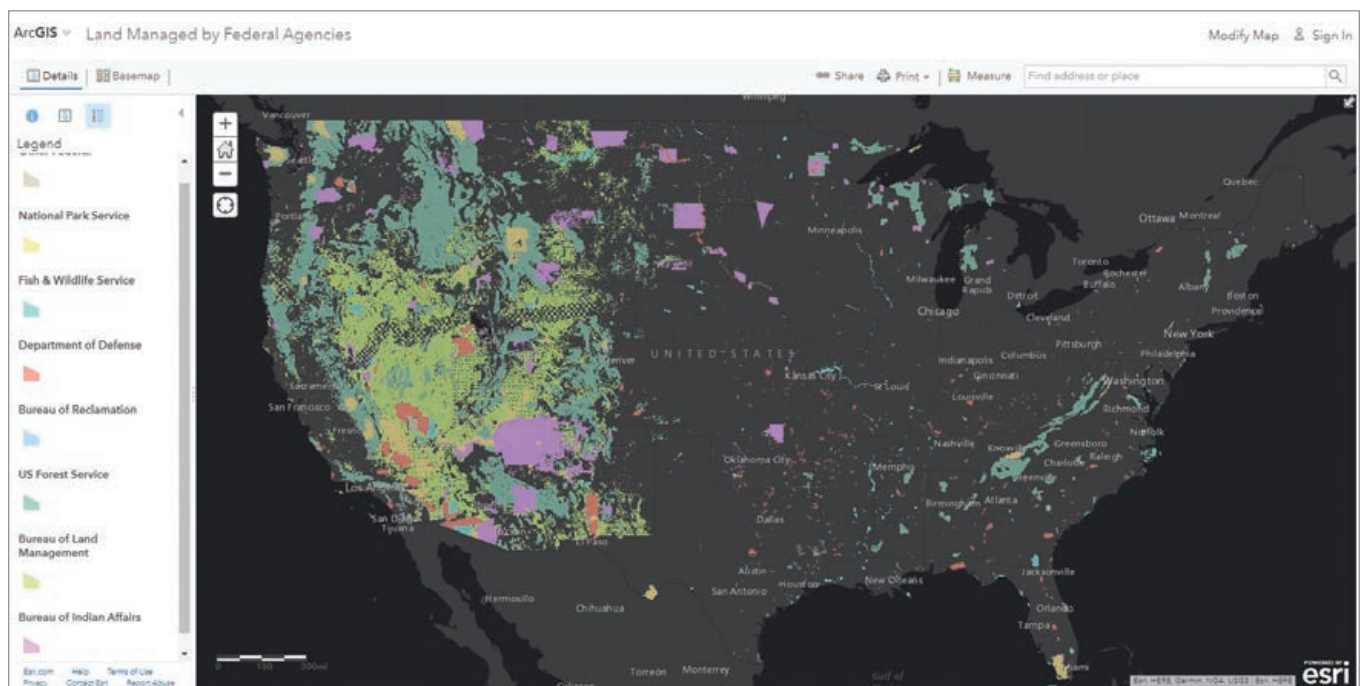
However, an officer from the Washington, DC, office informed the team that BLM headquarters had not finished quality checks to identify errors or omissions in the dataset. Also, not all field offices were included with updated information, solely on the basis of different timelines. The Las Vegas Field Office, for example, completed an RMP as recently as 2015, while the most recent RMP for a different Nevada field office is 1985. BLM staff reported that field offices are loosely required to update RMPs every decade. This inconsistency was a reality when using the data. In response to the variability in the published RMPs, the data had to be integrated before analysis.

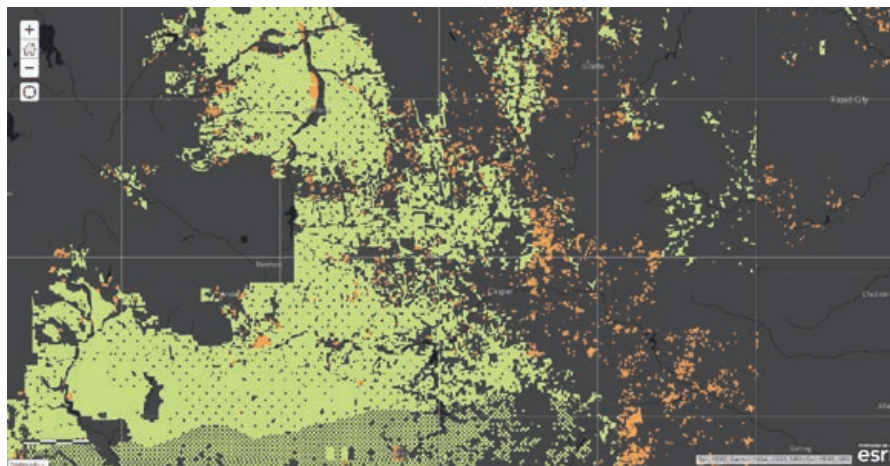
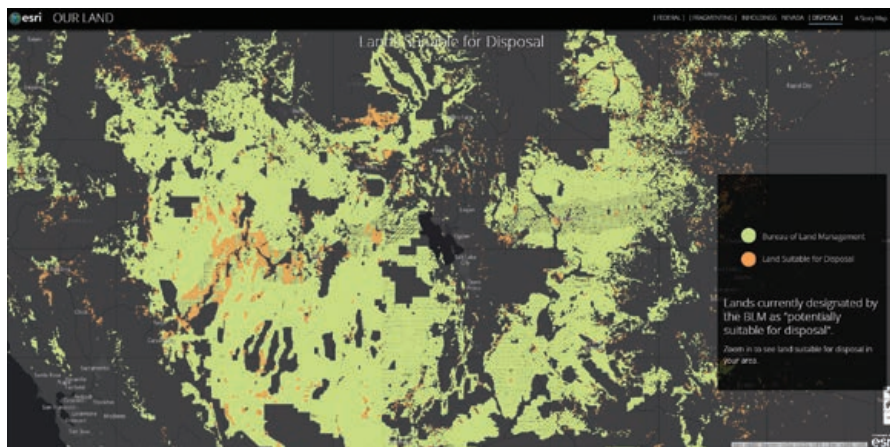
Finding the Real Parcels

Essentially, datasets for both BLM land and BLM parcels suitable for disposal came as multipart polygon feature classes because the method used to create those polygons, as well as the data itself, was not previously scrubbed and cleaned for analysis. To make the data ready for statistical analysis of the acreage for each land parcel and its proximity to surrounding land use, the Multipart to Singlepart tool was used several times to explode multipart polygons into single-part polygons. Taking BLM land polygons in Arizona as an example, all BLM land parcels were originally one large multipart polygon. After explosion, land parcels were split into 2,000 single-part polygons with shared attributes inherited from the “mother” polygon.

After exploding the BLM land feature class and BLM land suitable for disposal feature class, all single-part polygons were grouped by state boundaries for easier accessibility and reduced volume for data processing. At that time, the team discovered a significant number of seemingly invalid polygons by reviewing the attribute for BLM land and BLM land suitable for disposal single-part polygons state by state. In many cases, the polygons of BLM land

↓ Federally owned land is mostly managed by four agencies: Bureau of Land Management (248.3 million acres), Forest Service (192.9 million acres), Fish and Wildlife Service (89.1 million acres), and National Park Service (79.8 million acres).





↑↑ BLM lands (in light green) and lands that BLM identified as “potentially suitable for disposal” (in orange)

↑ Fragmentation of BLM land in northeastern Wyoming

suitable for disposal did not align with BLM land polygons. Some were too small to be valid polygons for land management agencies, and some were sliver polygons. Sliver polygons were probably caused when the original feature classes were created based on PLSS, which is widely used by federal land management agencies. To increase the accuracy of the statistical and proximity analyses of the data, these small and sliver polygons had to be eliminated.

After carefully reviewing attribute tables for BLM land and BLM land suitable for disposal feature classes for all states, the team agreed to eliminate any polygon that was less than one acre, since these parcels were potentially too small and fragmented for the BLM to manage. The team used the Thinness Ratio ($4 \times 3.14 \times (\text{Area} / \text{Perimeter}^2)$) to determine which polygons were potentially too thin to be valid and thus were sliver polygons. Any polygon that had less

than a 0.3 Thinness Ratio and less than five acres was manually examined and eliminated if it was a sliver polygon. Once sliver polygons were removed, the actual area could be calculated. The BLM currently has listed 10.7 million acres in this category, which is roughly the size of Denmark. Under proposed legislation, 80 percent of these acres would be sold within four years.

Besides the BLM parcel data, other spatial data used to support proximity analysis was processed for better usability. The grazing allotments feature class, obtained from the BLM Navigator website (navigator.blm.gov) was spliced by state boundaries. Categories other than development area and cultivated land were removed from the US Department of Agriculture Cultivated Land raster dataset. Development areas and cultivated land were then subset by state boundaries and vectorized for later proximity analysis.

Data Analysis

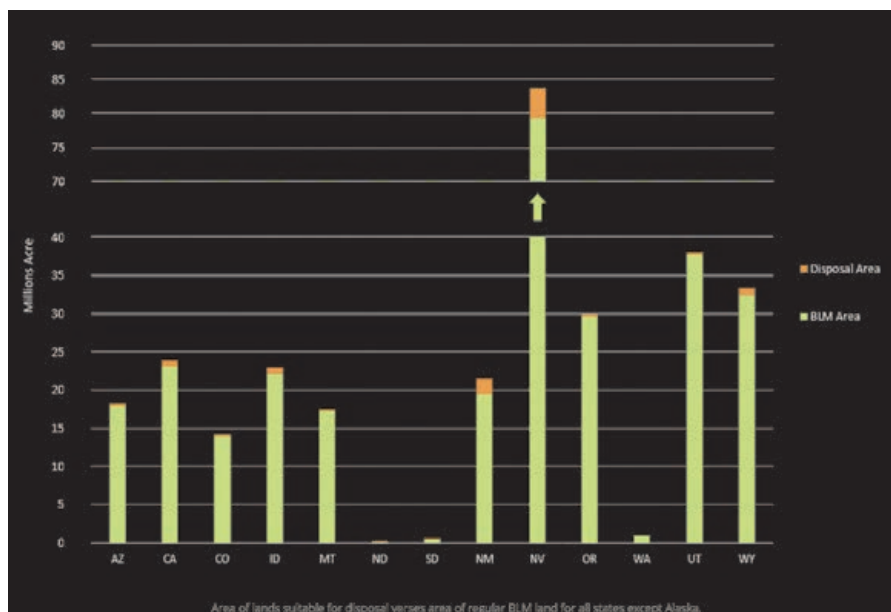
To characterize the relationship between BLM land and land suitable for disposal, both feature classes were overlaid with the municipal boundaries and grazing allotments for each state. The overlays, however, did not reveal the reason BLM marked those lands as suitable for disposal, other than most BLM land and land suitable for disposal is grazed and only a small amount is located within municipal boundaries. As a result, a more specific proximity analysis was performed to examine the distance from BLM land suitable for disposal to nearest developed area (e.g., roads, commercial and residential land use, and other infrastructure) or nearest agricultural area (cultivated land).

Efforts were made to perform a fragmentation analysis for BLM land and land suitable for disposal. Unlike many previous fragmentation analyses conducted from agricultural and ecological studies, the spatial extent of the study area became the main problem for applying existing algorithms. Although the team did not calculate fragmentation indices for all BLM land and land suitable for disposal, based on the manual inspection of dispersed spatial patterns, it is certain that fragmentation existed in both BLM land and land suitable for disposal parcels.

Key Findings

From the statistical analysis of the acreage of BLM land and land suitable for disposal, along with overlay layers with grazing allotments and municipal boundaries, approximately 19.15 percent of all land in the western United States (including Arizona, California, Colorado, Idaho, Montana, North Dakota, South Dakota, New Mexico, Nevada, Oregon, Washington, Utah, and Wyoming) is BLM managed, and only 3.58 percent is designated as potentially suitable for disposal. Approximately 88 percent of BLM land and land suitable for disposal are in grazing allotments. Only 1.05 percent of BLM land and 6 percent of land suitable for disposal are within municipal boundaries. The amount of most BLM lands suitable for disposal is small compared to all BLM land parcels in the western United States.

By comparing and contrasting the mean and median from the proximity analysis of distance from BLM land and land suitable for disposal to the nearest development



↑ The area of land suitable for disposal (orange) compared with the area of regular BLM land for all states (light green) except Alaska.

and agricultural land use, results indicate that, generally, lands suitable for disposal are closer to development and agricultural land-use areas than all BLM lands. Most lands suitable for disposal are closer to development (mostly roads), than agricultural land uses.

To increase comprehension of this analysis and encourage public discussion, the team created an Esri Story Maps app called “OUR LAND: The sale of federal land, accelerated” (OurLand.arizona.edu) that combines data-driven analysis and video journalism. The team believes presenting its research results in a story map will increase public awareness of details and impacts of ongoing legislation and landownership processes.

What's Next

Although the project did not include research on the market impact of disposing of 10.7 million acres within a few years, it provides enough evidence to open the door for those interested in the real estate market to start looking at the impact on both a local and national scale. The story map invites viewers to explore web maps in ArcGIS Online and take a closer look

→ Approximately 88 percent of all BLM land (including BLM land suitable for disposal) is located in grazing allotments. Photo from OUR LAND: The sale of federal land, accelerated.

at the land managed by federal agencies and—for the first time—lands potentially suitable for disposal. This dataset was previously unavailable because the BLM is in the process of aggregating that data nationally. Stakeholders also did not necessarily know what data to look at without the context that the story map provides.

While stakeholders can explore the potential impacts of accelerating the sale of federally owned land, GIS professionals can challenge the unsolved aspects of data analysis. The incompatibility of existing

fragmentation indices with a large study area prevents fragmentation analysis on BLM land and land suitable for disposal. It also encourages further study into developing new fragmentation indices and analyses, potentially using algorithms to analyze spatial distribution patterns of land parcels over a large study area.

Using GIS and a story map to create meaning and readable context from geographic data provides a fuller picture of ongoing federal land legislation and informs a wider audience of potential change in landownership and the real estate market.

For more information, contact Emily Marderness at emarderness@gmail.com, and visit the story map at OurLand.arizona.edu.

About the Authors

Yao Jian is a GIS specialist for the University of Arizona Advanced Resource Technology Lab who leads the data analysis for the Our Land Story Map project. He has a bachelor's degree in geography and urban and regional development from the University of Arizona. His focus is on cartography and GIS tool development for urban and regional planning use.

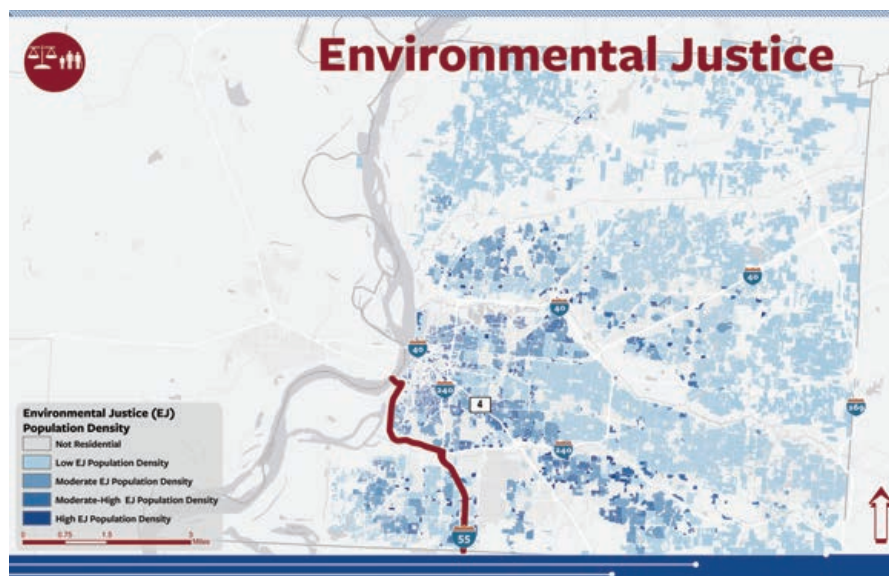
Emily Marderness is a GIS specialist for the University of Arizona Advanced Resource Technology Lab who leads data acquisition for the Our Land Story Map project. She has a bachelor's degree in geography from University of Arizona.



Public Outreach for Environmental Justice

By Chris McPhilamy, William Brewer, and Christian Snelgrove

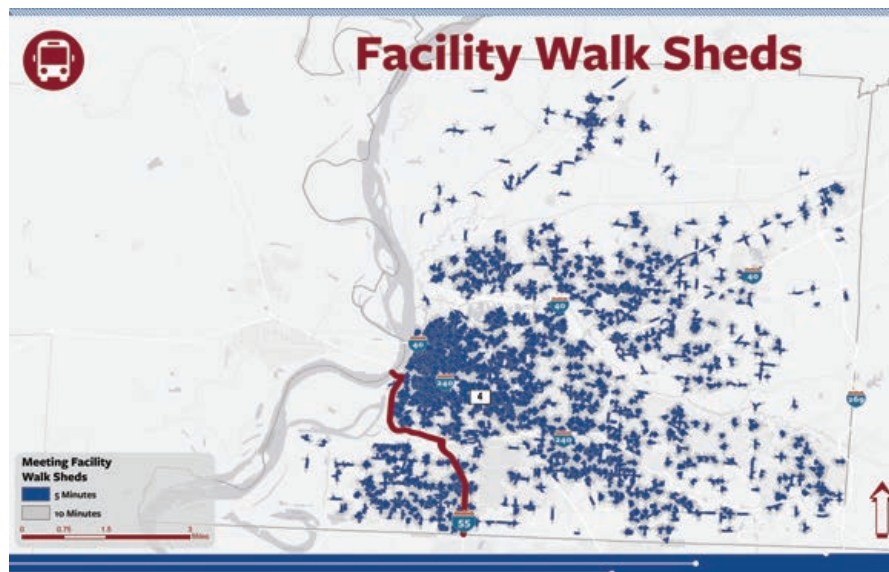
Staff members of the Data Visualization Office of the Tennessee Department of Transportation (TDOT) used Esri tools to identify ideal locations for meetings with the public about new transportation developments, with special emphasis on including vulnerable segments of the population who should be protected by environmental justice laws.



These vulnerable populations include minorities, impoverished people, zero car households, youth under 18, adults 65 and older, persons with disabilities, those with limited proficiency in English, and those with less than a high school education.

Executive Order 12898 was issued in 1994 to bring federal attention to the environmental and health effects of federal actions on vulnerable populations. The federal government was tasked with "identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." A year later, the US Department of Transportation (USDOT) finished its strategy for applying these principles to transportation. By ensuring that minority and low-income communities are meaningfully involved in the public engagement process, transportation benefits and burdens can more fairly be distributed among all communities.

TDOT has followed USDOT's lead, participates in these efforts, and is working to make sure that the voices of vulnerable populations are heard. A major focus of TDOT's public engagement process is gathering input from local stakeholders



▢ Dasymetric mapping allowed the redistribution of population data to parcels that had residential land use.

▢ Potential meeting location facilities were scored based on the number of bus stops that are accessible by selected walk times.

and incorporating it into planned changes for transportation corridors.

TDOT's planning and GIS practitioners play key roles in these efforts. The Data Visualization Office operates as part of TDOT's Long Range Planning Division. It acts as the analytical GIS hub for all spatial and nonspatial transportation data across the agency.

The Data Visualization Office staff wanted to produce a data-driven, scalable methodology that would be adaptable for either rural or urban analysis of population distribution. Outputs from this analysis could be combined with qualitative, localized knowledge possessed by TDOT liaisons and local stakeholders. This methodology was tested in a pilot project for the Interstate 55 (I-55) corridor.

Corridor studies done at the interstate level are particularly challenging due to the length of the corridors involved. For example, I-40 is a major east–west corridor that runs for about 455 miles. As part of these corridor studies, TDOT and its contractors are holding public engagement meetings in communities that will be affected by any ensuing transportation developments.

Identifying Optimal Meeting Locations

The Data Visualization team gathered data to measure how well each potential meeting location performed in two broad categories: demographic characteristics and accessibility. Each location received scores in the individual criteria that were weighted and compiled into a final score measuring that location's suitability for public engagement meetings. TDOT liaisons identified schools, libraries, aging population facilities, religious organizations, and public administration facilities as categories of potential meeting sites. Potential meeting facility data was derived from InfoUSA's 2018 US Business Data.

Demographic Characteristics

The team had limited resources available to determine the optimal locations for public engagement meetings. Ideal locations would have high population density, and a high proportion would belong to vulnerable populations and were assigned comparatively high weights.

Vulnerable populations were identified using block group-level data from the US Census Bureau American Community Survey. Population densities are typically calculated as uniform rates across an entire census boundary. To more accurately estimate where people were located, the team used the Intelligent Dasymetric Mapping (IDM) Toolbox developed by the Environmental Protection Agency (EPA). The IDM Toolbox contains a suite of tools written in Python that uses both ArcPy and arcpy.da functionality. *[These tools use dasymetric mapping, a geospatial technique that more accurately distributes attribute data assigned polygons, such*

Criteria	Score Method	Measures	Score	Weight
Demographic Characteristics	Population Density	High Population Density	5	15%
		Medium Population Density	3	
		Low Population Density	1	
	Environmental Justice	High EJ Population Density	5	30%
		Medium EJ Population Density	3	
		Low EJ Population Density	1	
Accessibility	Transit Stop Proximity	High Proximity	5	20%
		Medium Proximity	3	
		Low Proximity	1	
	Primary Interchange Proximity	High Proximity	5	10%
		Medium Proximity	3	
		Low Proximity	1	
	Secondary Interchange Proximity	High Proximity	5	5%
		Medium Proximity	3	
		Low Proximity	1	
	Congestion	Medium Congestion	5	10%
		High Congestion	3	
		Low Congestion	1	
	Walkability Index	High Walkability Index	5	10%
		Medium Walkability Index	3	
		Low Walkability Index	1	

↑ Combining multiple evaluation criteria, sites receive a score based on each of the weighted datasets.

as census block boundary data, by using information such as land-cover types to more accurately estimate where people live.]

Current parcel data maintained by the Tennessee Comptroller of the Treasury was inputted into the IDM Toolbox and used to redistribute population to parcels based on residential land use. Population was not assigned to parcels classified as vacant land, industrial, or other nonresidential land uses. Dasymetric mapping helped paint a clearer picture of not only where people lived but, combined with census data, specifically where environmental justice populations were concentrated.

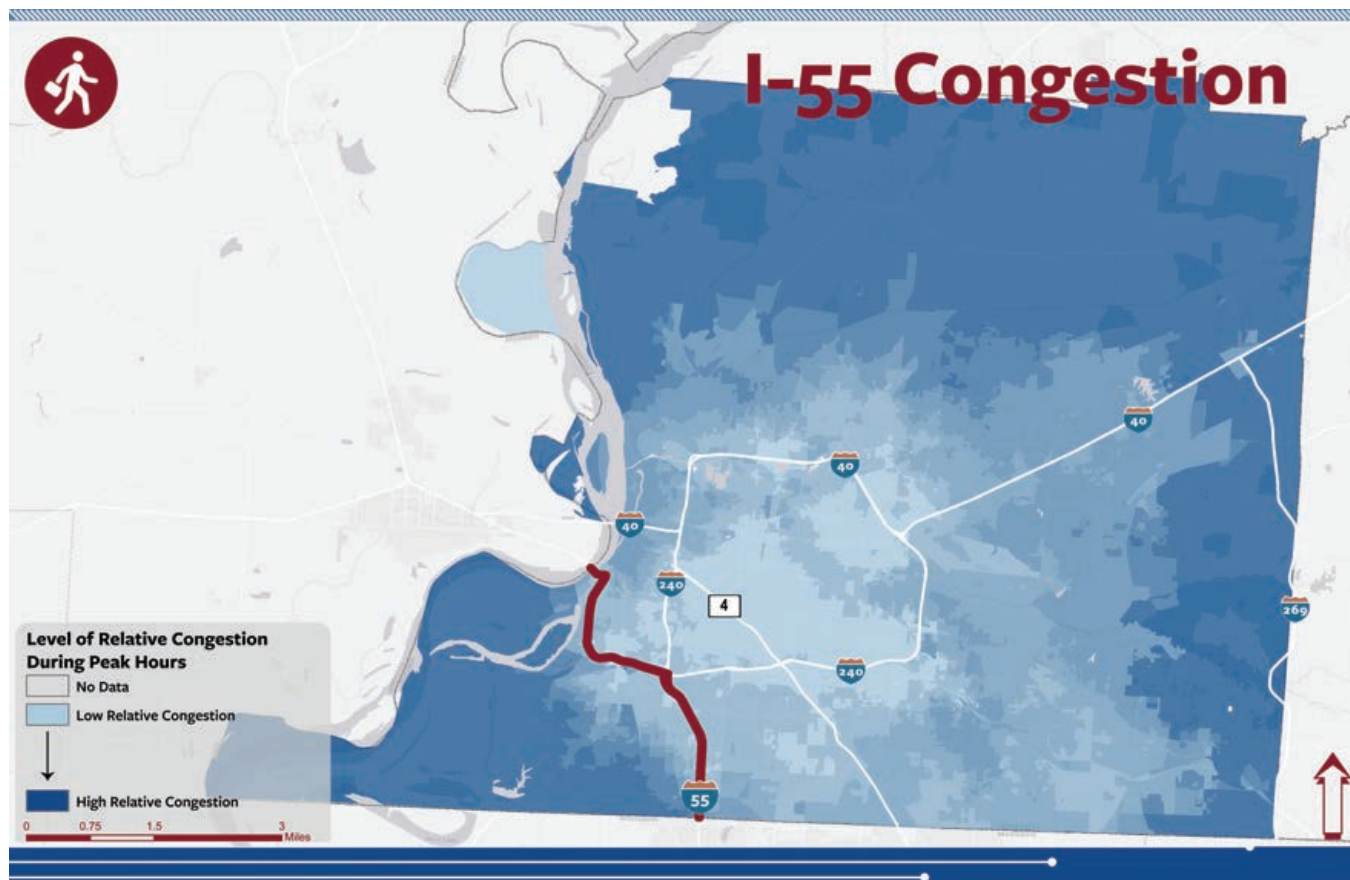
Evaluating the Accessibility of Locations

Once residential data was refined, the factors affecting accessibility to potential meeting sites were examined. Vulnerable populations typically rely on public transit and walking for transportation, so measures of walkability and accessibility by public transit were included in this analysis.

Because corridor studies are conducted on interstates, accounting for those who would be accessing potential meeting locations by car was relevant. In the pilot study, the team included a measure of how accessible these potential meeting locations were from interchanges along the I-55 corridor. Any congestion will affect accessibility, so a relative measure of congestion using job accessibility by car was included. Evaluating locations for their accessibility by both car and alternative modes of transportation helped identify locations that would serve people from all walks of life.

Transit Stop Proximity

Ensuring that populations that potentially could be adversely affected are adequately served was the focus of this methodology. Since these populations tend to rely on public transit, they are particularly vulnerable as transportation systems evolve. To address this, the Data Visualization team measured how accessible potential meeting locations were by public transit.



↑ Relative congestion was used to lower the rank of sites. Job accessibility was derived from data obtained from the University of Minnesota's Accessibility Observatory.

TDOT's Forecasting Office's HERE network data was used to create 5- and 10-minute walk sheds around each meeting facility. These walk times correspond to a quarter-mile and half-mile distances, respectively. Five minutes per quarter mile is a standard rate used in walk shed analysis.

Using ArcGIS geoprocessing tools, the number of bus stops in each walk shed was determined. A raw score was calculated for each potential meeting location. Two points were added to the score for each bus stop within a 5-minute walk, and one point was added for each bus stop within a 10-minute walk. Meeting locations were then rated on a scale of 1 to 5, based on these raw scores.

Creating a Walkability Index

Because the populations being targeted rely on walking in addition to public transit, the areas surrounding potential meeting locations needed to be evaluated for walkability. The EPA provides the Walkability Index.

This dataset measures how walkable each block group is, based on data from the 2010 Census. This national dataset also includes the underlying attributes used to calculate walkability. Some variables in this dataset include employment mix, occupied housing, street intersection density, and commute mode split. Each 10-minute walk shed was scored according to the Walkability Index(es) of the block group(s) it intersected with. The scores assigned to the walk sheds were then applied to their respective potential meeting locations.

Accounting for Interchange Proximity

Automobile accessibility was a factor. Optimal meeting locations should be easily accessible from the corridor in question. Consequently, interchanges were used as access points to meeting locations. In addition, people living near interchanges would be particularly affected by new developments along interstates and changes in ingress/egress to the corridor. Choosing meeting locations close to interchanges would help ensure that the populations surrounding the corridor were fairly represented.

Interchange accessibility was measured using the Tennessee's Statewide Travel Demand Model. By creating 5- and 10-minute automobile travel bands around each interchange along I-55, potential meeting locations could be scored based on how many 5- and 10-minute interchange travel bands they fell within. Like evaluating locations for proximity to public transit, two points were added for each 5-minute travel band, and one point was added for each 10-minute travel band. Meeting locations were again rated on a 1 to 5 scale based on these raw scores.

Measuring Congestion

The difference in job accessibility during peak versus nonpeak hours was used as a relative measure of congestion. Job accessibility for both intervals was derived from a dataset provided by the University of Minnesota's Accessibility Observatory. This dataset contains job accessibility counts at the census block level.

The Data Visualization team examined job accessibility based on a 30-minute travel time. For this analysis, *peak* was defined as between 7:00 a.m. and 9:00 a.m. and between 4:00 p.m. and 6:00 p.m. *Nonpeak* was defined as between 12:00 a.m. and 2:00 a.m. Census blocks that lost a higher percentage of job accessibility during peak hours versus nonpeak hours received lower scores.

Final Ranking of Locations

Each criterion was given an assigned weight. The score for each criterion is multiplied by its respective weight and then summed to calculate the final score for a location. This ranked list of possible locations for public engagement is meant to guide local planners rather than as an authoritative list. After it is given to the regional office, hand-selected sites from the community are incorporated and further refined using local knowledge of building occupancy, handicap accessibility, and locational site policies.

Conclusion

This unbiased and data-driven methodology has proved valuable in identifying meeting locations that serve populations that require environmental justice protection. It will continue to be used internally on other corridor studies. Studies for I-26, I-115, and I-75 have already been completed. Studies for I-40 and I-81 are under way and will be the first ones to incorporate both rural and urban analysis at a statewide scale.

The Data Visualization Office staff developed and documented this methodology, enabling TDOT's Office of Community Transportation (OCT) to make greater inroads with local stakeholders. Having a data-driven approach for allocating time and resources has proved immensely helpful to OCT staff. This methodology will serve as a blueprint for other site selection projects. The skills developed by the Data Visualization Office staff throughout this process will be used in the future, ensuring that vulnerable populations are fairly represented when new transportation development occurs.

For more information, contact Chris McPhilamy at chris.mcphilamy@tn.gov.

Acknowledgments

This article was produced under the direction of David Lee, PhD, assistant director of Long Range Planning at the Tennessee Department of Transportation. The authors acknowledge the University of Minnesota's Accessibility Observatory, the Environmental Protection Agency, and the US Census Bureau for providing data.

→ The qualified list of potential meeting sites was created and given to field offices to further refine with local knowledge.

About the Authors

Chris McPhilamy is a planning manager in the Long Range Planning Division at the Tennessee Department of Transportation. He oversees the Data Visualization and Forecasting Offices in the Data Management Office. He received a bachelor's degree in geography from Central Michigan University and a master's in geography from East Carolina State University. McPhilamy has held a GISP certification since 2009. He lives on a hill, rides bikes, and raises bees and chickens.

William Brewer is a planning supervisor in the Long Range Planning Division at the Tennessee Department of Transportation. As the supervisor of the Data Visualization Office, he manages the daily operations that involve interpreting complex transportation planning data in various methodologies, maps, and tools. Brewer received a master's degree in city and regional planning from Clemson University. His background includes comprehensive planning through public engagement, graphic design, GIS analysis, and zoning administration.

Christian Snelgrove, a planning specialist in the Long Range Planning Division at the Tennessee Department of Transportation, is a member of the Data Visualization Office. He bolsters the planning efforts of his division and local stakeholders by providing data and analytical support. He earned his bachelor's degree in geography and a certificate in GIS from George Washington University. He has an interest in computer hardware and is an avid reader.



Tracking Fish with ArcGIS Network Analyst

By Mark Dhruv

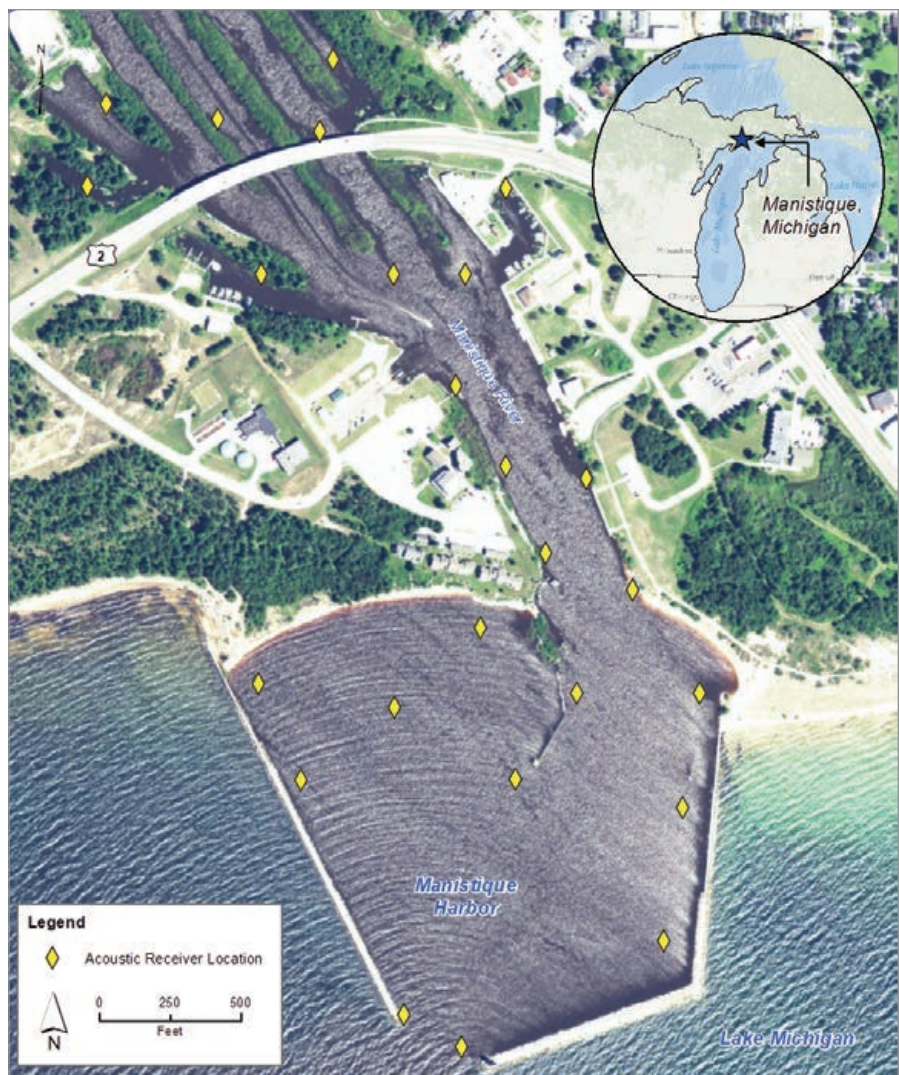
What if you needed to develop a route in an underwater environment rather than an existing network of streets?

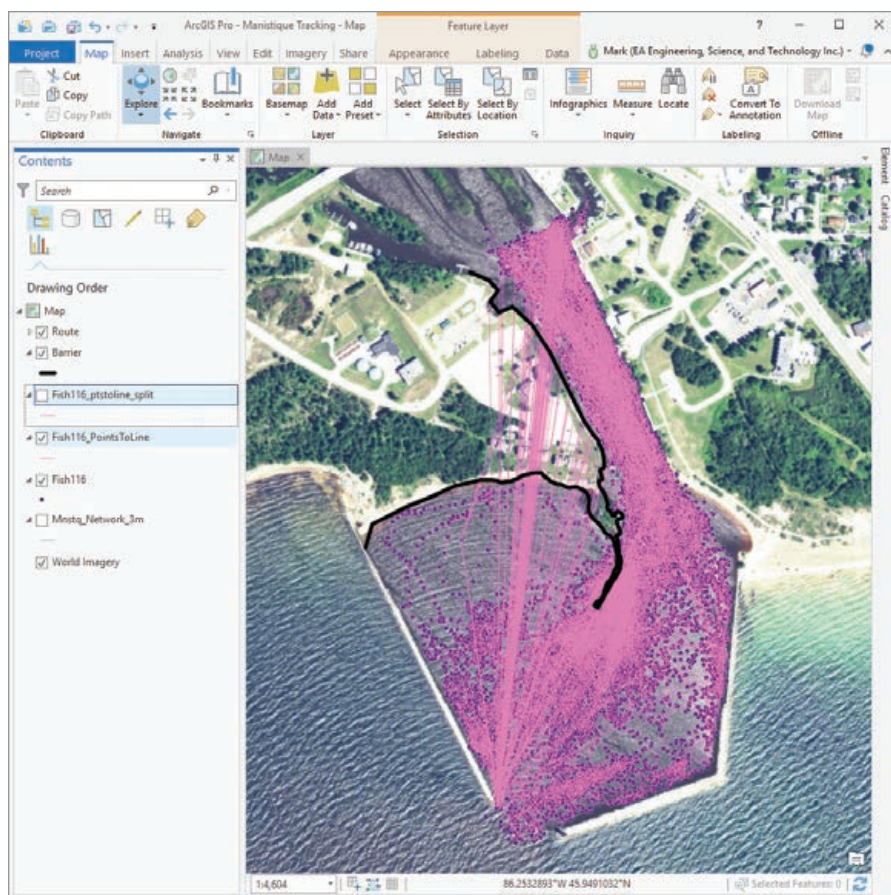
That is the problem that confronted Martha McCauley, a fisheries biologist with EA Engineering, Science, and Technology, Inc., PBC, as part of a fish tracking study of the common carp (*Cyprinus carpio*) in Manistique Harbor, Michigan.

With funding from the Great Lakes Restoration Initiative, a team of researchers from the US Environmental Protection Agency (EPA) Great Lakes Program Office, the US Army Corps of Engineers (USACE), Michigan Department of Natural Resources (MDNR), Biohabitats Inc., EA Engineering, and Lotek Wireless conducted a five-month study beginning in June 2016 to track the daily movements of carp in the harbor located at the mouth of the Manistique River. This was part of a study to establish the home range and residency of the carp population occupying the harbor. It would ultimately aid in locating polychlorinated biphenyl (PCB)-contaminated toxic hot spots in the harbor's bottom sediments.

These hot spots were a result of historical industrial discharges of PCB-contaminated waste into the Manistique River. Although PCBs were banned by the EPA in 1979, the impacts of the contaminated waste on the fish populations that live and forage in the

→ Markers show the locations of the 25 acoustic receivers in Manistique Harbor. The inset map shows the general location of Manistique Harbor.





← Line segments were generated between each position point to visualize gaps in point data. Any lines crossing a barrier would indicate missing points.

Manistique River can still be seen.

Carp are considered bottom feeders—they consume the organisms that live along the seafloor and therefore are more likely to ingest PCBs that have settled into the sediments. As a result, they are the most heavily contaminated fish in the harbor, which prompted the State of Michigan to issue health advisories against the consumption of carp in the lower river and harbor.

For the purposes of this study, the carp's PCB contamination level and their direct association with the sediment bed make them useful candidates to help the researchers identify those areas where PCB concentrations in the harbor bottom are high.

The study tracked the locations of 20 carp over five months to accurately depict their foraging areas. Each fish was implanted with a tiny acoustic transmitter that began emitting a signal once it was released back into the water. The tags produced a signal every five seconds that was picked up by an array of acoustic receivers

installed throughout the harbor.

When three or more receivers captured a tag's signal, the x,y location of the fish was triangulated, time stamped, and recorded with the fish's tag ID on the receiver's memory card. To keep up with the large number of data points recorded by the receivers and ensure everything was working correctly, McCauley and her team downloaded receiver data periodically throughout the study.

At the conclusion of the five-month study, more than 5.5 million unique positions had been captured and downloaded, resulting in a detailed but unwieldy dataset. To speed processing time for the ensuing data analysis, McCauley smoothed the dataset in Microsoft Excel by recalculating the points to produce a position every minute as opposed to every five seconds, reducing the number of points to just under a half million positions.

She further increased the dataset's manageability by exporting each carp's positional points as a unique dataset based on

the carp's tag ID. This allowed her to work with the data from one fish at a time.

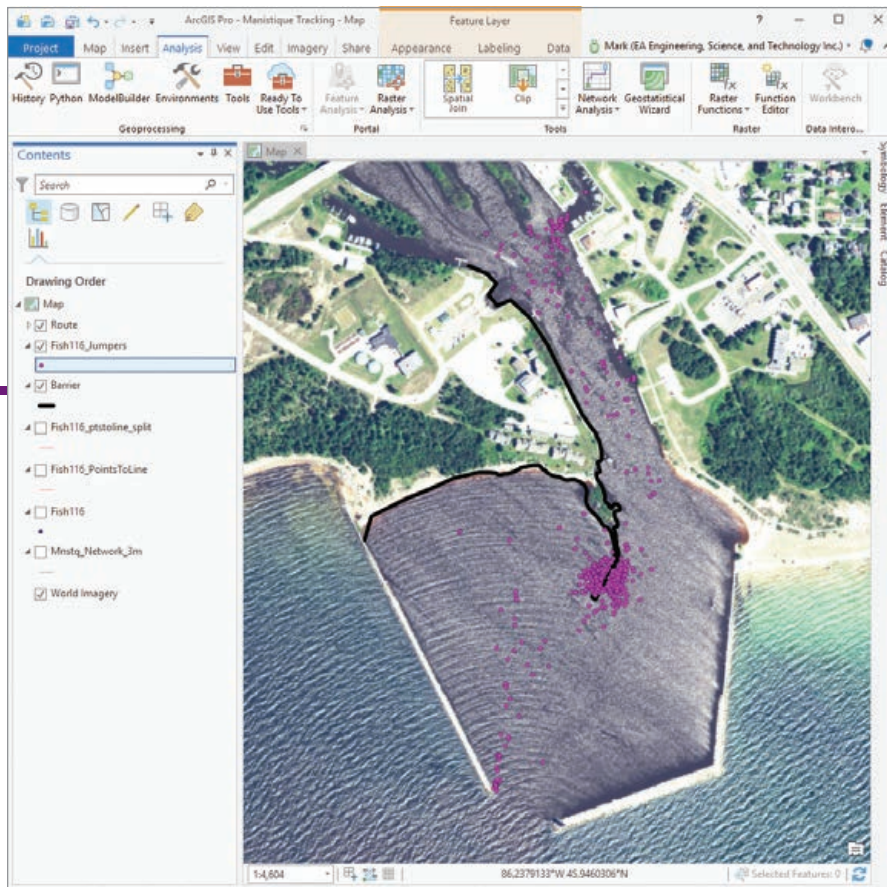
With an average of 23,000 points representing the minute-by-minute position of each fish, McCauley was ready to calculate the swim speed of each carp by using the difference in the x,y position between each consecutive point based on the time stamp. By understanding the fish's swim speed, she could deduce the behavioral patterns into feeding versus traveling behavior.

However, before she could begin the swim speed calculations, the data points would have to undergo a quality control process to ensure the accuracy of their locations. To view the data in spatial—rather than table—format, McCauley imported the points into ArcMap and plotted them based on each point's x,y coordinates using universal transverse Mercator (UTM) projection.

The resultant map showed a dense scattering of dots across Manistique Harbor, each dot representing a carp's location every minute over the course of five months. This allowed McCauley to identify erroneous positions (i.e., positions that fell on land or outside the harbor) and cull them from the dataset. The next step was connecting the points based on their time stamp. The resultant lines would reveal any gaps in positions that would skew the swim speed calculation.

Using the Points To Line tool in ArcToolbox, a massive spider web of lines was generated, covering the harbor and showing the fine-scale movements of an individual carp as it meandered around the harbor during the five-month study. With the lines displayed on an aerial image of the harbor, McCauley discovered where some fish appeared to “jump” back and forth over a large jetty that jutted southward through the center of the harbor.

Carp are not known as a particularly athletic fish, so the line jumps were likely a result of positioning errors that can occur in acoustically challenging areas, such as



✦ The endpoints generated from the selected lines that crossed the barriers. These points were then loaded as Stops in the ArcGIS Network Analyst extension.

✓ Wild common carp (*Cyprinus carpio*) were tracked to determine their home range.

the deep water adjacent to the rock wall jetty, or exceptionally rough water conditions. These lines would have to be altered to travel around the jetty rather than over it to provide the correct distance between points.

McCauley realized an automated process would be needed to correct the line path of many points. She turned to GIS analyst Mark Dhruv for help. He recognized this as a routing problem. The ArcGIS Network Analyst extension is a great tool for developing customized routes through complex transportation networks, but those are typically street and highway networks.

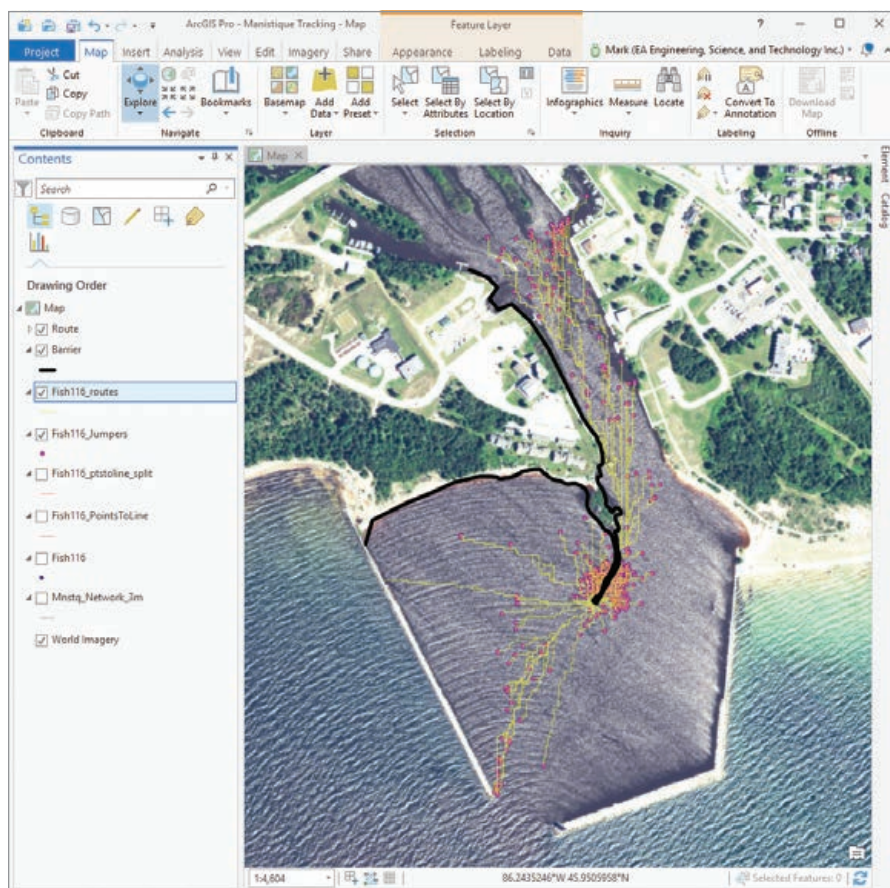
In this situation, Dhruv employed the ArcGIS Network Analyst extension to revise the segments that crossed the jetty. But before he could begin revising the routes, he needed to create a network layer, and the data would have to be prepped to reroute the “jetty jumpers” as a batch process.

In a typical land-based situation, the Network Analyst extension uses a predefined network, such as streets and highways, to find the shortest or a preferred distance between two points. By inputting a starting and ending point, the tool would create a line segment that adhered to the network layer with any routing variable factored in.

Using this same principle for the watery environment of Manistique Harbor, Dhruv developed a 1-meter by 1-meter grid with the jetty and surrounding landmass factored in. This would serve as the streets or network layer that Network Analyst could use.

Dhruv prepped the data for batch processing by parsing out the start and end points of the line segments that crossed the jetty. Using the spider web of lines initially created by McCauley, he cut the lines at each vertex to create individual segments. Using the Select By Location tool, he selected the





← These revised line segments were generated by the Network Analyst extension.

About the Author

Mark Dhruv began his 13-year-career at EA Engineering, Science, and Technology, Inc., PBC, as a GIS coordinator working solely on military contracts. When he became the GIS manager for the entire company, his role expanded to provide geospatial analysis support for many environmental projects. In 2011, he obtained his GISP. He has become a GIS liaison and mentor for a high school-based international research group that conducts climate change field research in the subarctic tundra of Canada. Dhruv received a bachelor's degree in marine biology from Texas A&M University at Galveston and a master's degree in environmental science and policy from Johns Hopkins University.

Karl Gustavson, Contaminated Sediments Lead, US Environmental Protection Agency, contributed to this article.

segments that intersected the jetty and exported them as a separate feature.

Using the Feature Vertices To Points tool, an endpoint file for each selected line segment was generated. These points could now be loaded in Network Analyst as stops to create the modified line that would bend around the jetty. This process was repeated for each of the 25 carp.

With the data prepped, Dhruv could run the Network Analyst extension. After activating the Network Analyst toolbar, he imported the 1-meter by 1-meter grid as the network dataset and used New Route to load the stops (start and end points of each track) and line barriers (the line layer that outlined the jetty and landmass). After clicking the Solve button, a new line segment was created that ran around the jetty. The length field, revised based on the generated revised segment, now accurately represented the distance traveled by the carp.

Dhruv used a spatial join to merge the revised segment endpoints with the original point data. A simple field calculation

replaced the jetty jumper length with the correct length. Now, with her quality control process complete and with a more accurate segment length between point time stamps, McCauley was able to begin her final analysis to identify potential PCB hot spots.

The 1-meter by 1-meter grid was developed to provide the network layer, but additional complexities, such as deeper channels used by fish or known feeding spots, could be added to the project so Network Analyst could be used to create a more realistic network layer.

As shown in this practical application, using Network Analyst to manipulate line segments around barriers isn't limited to data related to streets and highways. Using Network Analyst in this situation has revealed the extension's broader capabilities underwater or in any unique environment that requires navigation around barriers.

For more information, contact Mark Dhruv, GIS manager at EA Engineering, Science, and Technology, Inc., PBC, at mdhruv@eaest.com.

Share Your Story in ArcUser

Write an article for *ArcUser* magazine. Tell the GIS world how your organization saved money and time or acquired new capabilities using GIS. Share your GIS management insights or your expertise in extending the GIS functionality of Esri software.

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← The City of Fort Worth, Texas, makes smarter decisions based on its knowledge of asset conditions thanks to its digital processes.



Moving from Reactive to Proactive Management

In many cities, asset managers struggle to keep up with repairs such as fixing streetlights and potholes. Given the sheer number of required inspections and the precision and personnel needed to update records and paper maps, it's easy to see why many maintenance projects are long overdue or altogether neglected.

However, in Fort Worth, Texas, maintenance jobs are promptly executed. For example, unsightly potholes are replaced by shiny black asphalt within 48 hours. The city makes smarter decisions based on known asset conditions and saves time and money. The city's rapid response results from its extensive use of digital—rather than paper—processes for inspecting, maintaining, and managing its assets.

Updating GIS from the Field

Fort Worth covers 349 square miles. Ninety-three percent of its more than 874,000 residents commute to work. Repair and maintenance projects are constantly needed to keep the city operating smoothly. In a city of this size, staff must prioritize work orders based on factors that include traffic volume, public safety, and the efficiency of its crews. Forward-thinking cities like Fort Worth use GIS to ensure that prioritization is based on accurate data.

While the city has used GIS maps and data for some time, staff recently expanded its use of GIS. Fieldworkers now use GIS software on mobile devices to connect with the office. This move has improved communication and helps keep the city's shared map up-to-date.



GIS-Based Asset Management

Elizabeth Young, Transportation and Public Works business process manager for Fort Worth and a GISP, is implementing GIS-based asset management to help improve the city—one pothole, streetlight, and storm drain at a time. In 2009, Young began developing an inventory of assets around the city.

Traditional systems track asset conditions with hand-written paper maps, fieldwork, and intuition, making it difficult for a city to keep asset data accurate. However, Young transitioned Fort Worth to a comprehensive asset management program using GIS.

Having all assets tracked and managed in GIS helps improve real-time responses. For many businesses and cities with both fixed and mobile assets, this process can improve operational and predictive intelligence. Assets can be tagged with Internet of Things (IoT) sensors that feed their current status and send failure alerts directly to databases and fieldworkers' mobile devices. This saves time, reduces errors, and allows managers to track the health of assets in real time.

In the decade since it switched to digital maps and gained

up-to-date asset information, the City of Fort Worth has reduced its paper waste, according to Young. For example, storm water crews no longer need the more than 2,400 paper maps they previously used to locate storm drain inlet assets. Instead, they access maps and receive routing instructions to their next job on tablets. Teams discontinued paper daily crew reports that showed

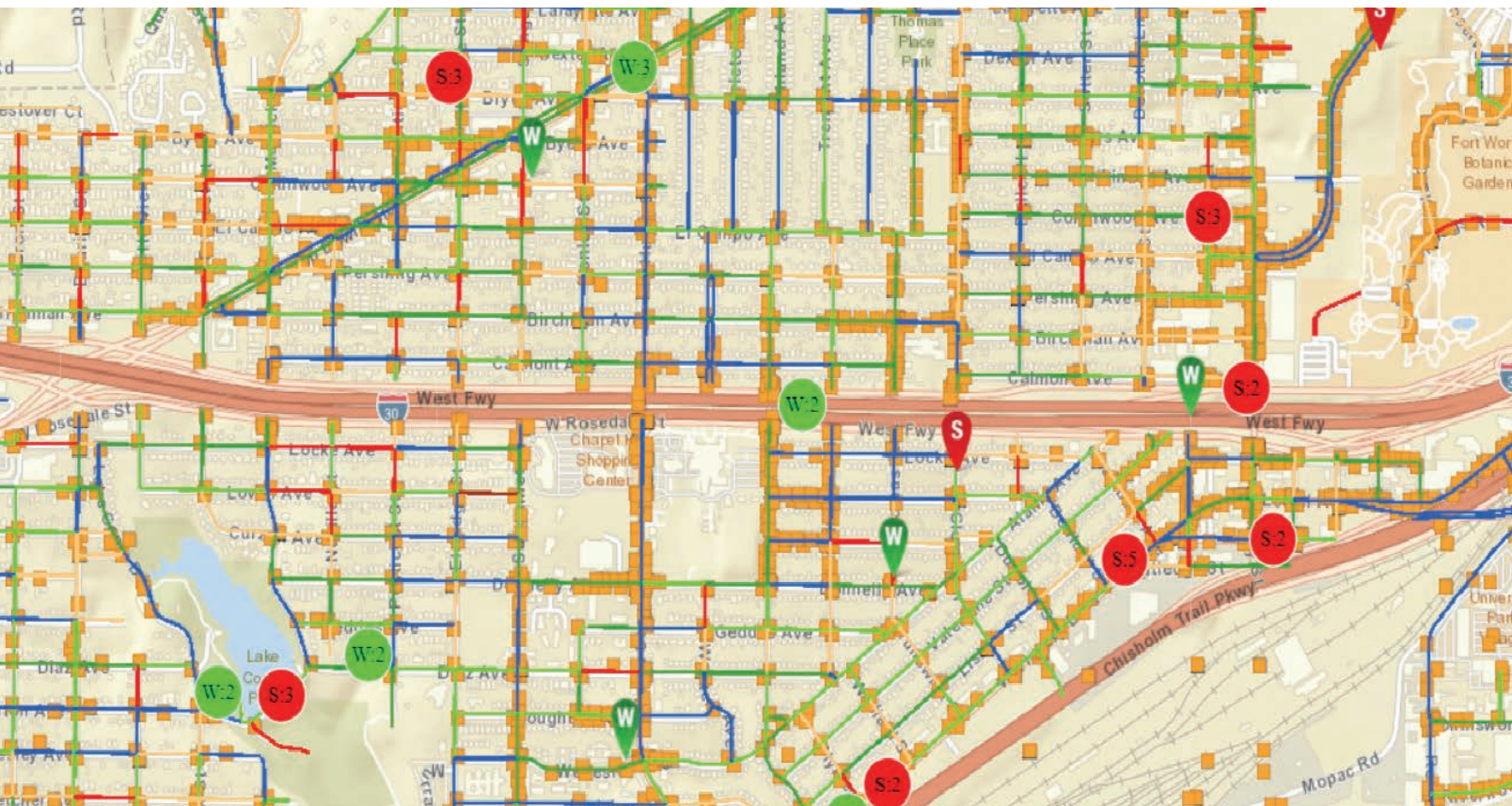
the breakdown of work accomplished for the day. This eliminated an estimated 1,000 sheets of paper annually. Storm water crews can now do markups directly on the map to show new or missing assets. Young said that backlogged data entry is no longer an issue. The new processes save the city roughly \$9,600 annually in the Stormwater Division in temporary employee costs and overhead.

The new
processes save
the city roughly
\$9,600 annually.

Proactive—Not Reactive—Planning

In Fort Worth, the shared awareness of modern GIS helps city managers make smarter decisions based on what they know about asset conditions. The system provides one access point for viewing, maintaining, and managing all assets.

↓ Digital mapping of assets has helped the city adopt a proactive approach to managing assets that uses data that is constantly updated from the field.



Before GIS, paper maps bred inefficiencies. For example, storm drain inlets need to be cleaned out, but with paper maps and work orders, the city didn't always know when the drains had last been cleaned.

According to Young, the city's long-term goal is to "go from being reactive to proactive" and prioritize projects better by understanding the condition of the asset so that better decisions can be made based on available funds.

Recently, all Fort Worth schools adopted new start and end times. Young's team had to update every School Zone sign in the city. Instead of sending several people to drive all over Fort Worth to find the signs, staff members used the data collected and managed in its GIS to identify in approximately 15 minutes the location of each of the 726 signs that needed to be changed. They then created work orders to spread the work across teams to accomplish this task efficiently.

Hands-On Leadership

Young immerses herself in almost every aspect of the city's asset management project. She is a hands-on, walk-in-your-shoes kind of leader. Since all field crews and office staff must learn and adapt to various platforms, software implementations, and information inputs, Young is committed to doing the same. She wants to hear the issues users have and learn how the technology is helping or can be improved.

"I've cleaned inlets. I've put on the boots, and I've been down there," she said. "I've been out there and built rapport with them already and gotten to know some of them—not all of them—but I'm a familiar face."

Young said working directly with fieldworkers lets her better understand the job. "It helps build a relationship and trust that allows us to better work as a team. It helps me to understand their everyday problems, either with technology or trials they may face while out in the field."

Preparing for Storms

The correct functioning of many assets managed in GIS, such as traffic signals and storm water collection assets, can be a matter of life or death. Texas weather can be extreme: drought one year, flooding the next. Because Fort Worth is prone to dangerous flooding, Young has focused much of her efforts on collecting asset data for storm water.



↑ Daniel Bookman, who works for the City of Fort Worth, can see labor reports, equipment usage, and materials used on maintenance projects while in the field.

Fort Worth started its storm water inventory in 2009 with the goal of recording the location of all culverts, drains, headwalls, weirs, channels, and dams. The inventory—now complete—feeds daily reporting of all repairs and inspections. With this system, Young and her team can see labor reports, equipment usage, and materials used. They can track cleaned inlets and identify those that still need inspection or maintenance.

Cities, especially those with unpredictable weather events, must be ready to contend with nature. Keeping storm drains clear of debris is a key activity that can mitigate risk and possibly avert disaster. Before GIS gave an interactive glimpse of the city's needs, asset management decisions were made based on intuition and experience. Now, decisions are data driven.

"We can go back and see where we've cleaned, how many times we've cleaned it," Young said. "We've moved from cleaning storm water inlets in the entire city every eight years to every three years. We can report on it and prove it because we've got the data behind it."

From Manager to Leader

If you lead a GIS team—or aspire to—make sure you head to San Diego, California, for the GIS Managers' Open Summit (GISMOS) on July 9, 2019.

This daylong interactive event, which runs concurrently with the 2019 Esri User Conference (Esri UC), helps people with a GIS background become successful leaders in their organizations. It will benefit not only current and future GIS managers but also business and technology strategists and decision-makers.

The format for GISMOS is relaxed and informal. You are not committed to staying for the entire event and may come and go as you please. Its content is coordinated with the Esri UC GIS Manager track, consisting of eight sessions on July 10 and 11.

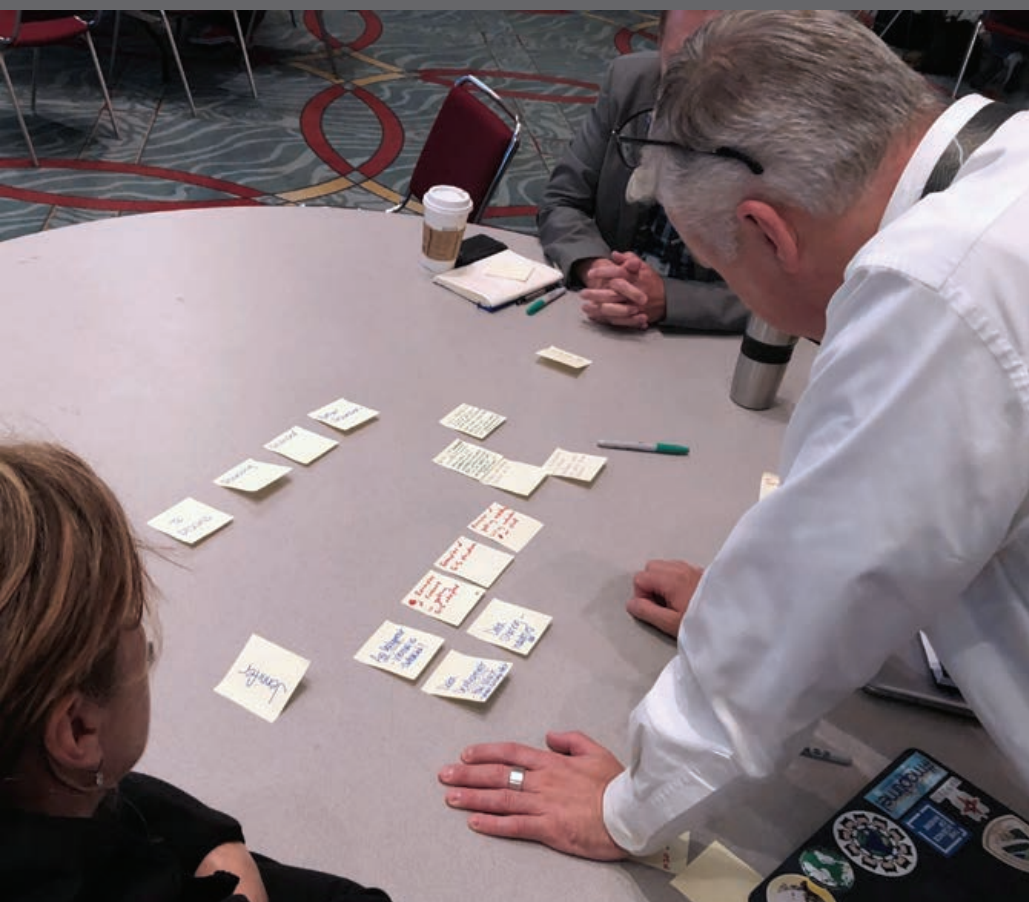
Not only does GISMOS feature

presentations on GIS management issues, it also focuses on participation, networking, and collaboration. The day begins with speed social networking. Your goal will be to meet between 15 and 20 people within 20 minutes. Additional networking breaks are sprinkled throughout the day.

Later in the day, you will join a small group and, using Lean Coffee methodology and lots of sticky notes to drive the discussion, will choose, prioritize, and explore topics that matter to you and the others in your group. The discussion of each topic is timed and voted on to keep things moving along.

Presenters at GISMOS have a strong handle on the business side of GIS and will share their knowledge and experiences with you.

↓ You help shape the discussion at the GIS Managers' Open Summit.



Summit Speakers

Adam Carnow

Esri community evangelist on "Surfing the GIS Waves to Success"

Carnow offers best practices and real-world examples showing how you can surf the waves of GIS evolution to success.

Eric Abrams

Geospatial administrator, Iowa Department of Transportation, on "Journey of a GIS Manager"

Abrams will show how to redefine traditional GIS, talk about the differences between centralized and federated GIS, and touch on how to leverage maturity models.

Brandi Rank

GIS manager, Thornton, Colorado, on "If You Aren't Managing, Who Is?"

Learn how you can spend your time leading change in your organization instead of doing technical chores.

Marvin Davis

GIS coordinator, Oak Hill, West Virginia, on "GIS in Rural Communities: How Oak Hill, West Virginia, Makes It Work"

The origin and organic growth of Oak Hill GIS will be examined to see how it can be used as a road map for other rural communities adopting GIS.

Last year, 300 people attended. While registration is free, space is limited, so register today at <https://bit.ly/2UsFkWC>. (You must be registered for Esri UC to attend this summit.)

Tips for GISMOS Participants

- ✓ Bring business cards.
- ✓ Get active on social media before and during the conference.
- ✓ Join the Managers in GIS LinkedIn group. ([linkedin.com/groups/3251417](https://www.linkedin.com/groups/3251417))
- ✓ Check out the Lean Coffee method before the conference starts so you can dive right into the discussion. (leancoffee.org)
- ✓ Attend a session of the GIS Managers track at Esri UC.

The High Cost of Low-Hanging Fruit

By Brent Jones

Low-hanging fruit refers to the obvious and easy things you do to achieve success or make progress toward a goal. It's the easy stuff. It's the things that always work.

Why is this a problem?

We all want the easy way to get the job done, but it's a problem because disruption sniffs out complacency. Low-hanging fruit is the target of disruption because it's easy. Advancing technology solves easy problems efficiently, so anyone can do it.

Relying on low-hanging fruit is well described in the book *Who Moved My Cheese?*, the often recommended (and ridiculed) book on change management. In it, mice who constantly seek security are upended by the possibility that they may lose it.

There is no security in the easy stuff. Relying on past patterns, regulations, and holding on to the status quo because "That's the way it's always been," and "We don't do that" are all ingredients in the recipe for obsolescence.

A senior vice president at a company I worked at many years ago said, "Don't worry about the phone ringing. It has always rung." That was true...until it wasn't. That company is now a shell of its former existence.

Complacency invites disruption and is the cousin of failure. I'm not saying you shouldn't pick the low-hanging fruit. I'm saying that if that's all you do, you're doomed.

Artificial intelligence (AI) and machine learning are real, and they're coming fast. What were once time-consuming human intelligence activities are becoming automated and combined with rapidly growing cloud capabilities. This will replace core workflows for many professionals such as lawyers, appraisers, assessors, accountants, and surveyors. Our ability to use AI with GIS and advanced spatial analysis capabilities are rapidly moving the dial. There's hardly an area that won't be touched as one business overtakes the core business of another.

This equals disruption. Are you ripe for disruption?

Probably.

We all are. Everything is changing and will continue to do so. Our cheese is getting moved, and our low-hanging fruit is being eyed by others. What do we do to prevent the disruption of our work? How do we prevent what Uber did to taxis from happening to us?

It's surprisingly simple. Transformation is disruption that you do to yourself. Disrupt your organization from the inside. Take the lead.

Build resilience to external disruption. Do this by staying current with your technology. Technology is moving ahead far more rapidly than it did just a few years ago, and the acceleration will increase.

Thomas Edison once said, "I start where the last man left off." Use this to your advantage. Don't reinvent the wheel. Use what's been done to leapfrog your organization ahead of where it is today. This requires a bit of work, but what worked in the past will probably not work long into the future.

Jack Dangermond, president and founder of Esri, has said many times, "Act like a startup." This means work lean, innovate, make mistakes, try new things, get out of your comfort zone, and do it quickly. These strategies are all important to defend against external disruption.

There is no better time than today to get started with your transformation. It will be more difficult next month, and more difficult the following month. I doubt it will stop.

Get started.

Network with peers, vendors, and suppliers. Attend a conference or webinar. Join an association committee. Look at which communities your peers are connected to.

I cut a quote by former IBM president Tom Watson, Jr., out of the newspaper and hung it near my desk for many years. It's perhaps more pertinent now than it was in the 1950s when he said it.

"Solve it. Solve it quickly, solve it right or wrong. If you solve it wrong, it will come back and slap you in the face, and then you can solve it right. Lying dead in the water and doing nothing is a comfortable alternative because it is without risk, but it is an absolutely fatal way to manage a business."

Your low-hanging fruit is being moved.

Move with it.

About the Author

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



Five Tips for Developers Who Work with Designers

By Rene Rubalcava

As developers, we can sometimes get deep in the weeds of our work. We're writing code, perfecting our next magnum opus. But don't lose sight of what you are trying to accomplish.

If you are lucky, you get to work with talented designers, perhaps building applications with a UI/UX designer or creating an application with a cartographer helping a map tell its story. This article shares five tips that will help you and your designer build something awesome!

1 Understand your goals.

Applications are not just born. They are made based on a set of requirements. You probably have a set of user requirements and features that you and the designer need to collaborate on. As a developer, it's tempting to just start banging away on your keyboard and try to prototype something quickly, but this is the part where you slow your roll, take a breath, and try to fully understand what you are going to build.

When working with a UI/UX designer, that person probably comes up with layouts and user interaction designs. When working with a cartographer, that person begins to craft the story of the map and has some ideas on how a user might interact with that map and explore it. The goal here is to know where you want to be before you start to go.

If you don't understand a design, ask for some clarification. Just as you may not always write unit tests for your code right away, a designer might whip up an awesome design without all the technical considerations because the designer may not even know them. That's okay. You can both help each other understand the end goals better. This isn't about you. It's about your users.

2 Don't be afraid to give input.

You may not know the ins and outs of semiotics as related to mapping, but that doesn't mean you can't have some valuable input on map design or building the UI/UX of an application. Have you used an app on your phone? Have you navigated a website to pay a bill? Then you are a user and you have some input. The worst that can happen is you learn something. If a design doesn't make sense to

you, ask. You'll either learn to understand it or improve on it. Both are positive outcomes.

My cartographic skills may not be the greatest, but I can still tell if a map isn't quite clear, so I can provide that feedback. Your designer is as hungry for feedback as you are. Be honest and constructive with your feedback. "This sucks" is not constructive or helpful. However, a comment like "That looks busy. I think there are too many labels visible at this scale," is constructive and useful.

Your designer is a designer for a reason. Your designer knows how to tell a story with a map or help users navigate an application. Your designer can also have some great (or at least definitely creative) ideas that can push the limits of what you can actually do.



3 Be honest about tech limitations.

It's really nice as a developer to say, "You bet I can do that, <insert language> can do anything!" But let's be honest—you know better. Your designer might want you to constantly rotate the labels on the map. That's a limitation, so speak up about it. (Okay, maybe you could do it, but let's be real.)

Remember, your designer is trying to come up with the best story or user interaction. Your job is to try and implement that to the best of your ability. If you really can't do it, be honest about that. It will save you and your designer a lot of headaches and frustration.

Notice I said can't do, not difficult to do. This isn't *carte blanche* to say no to everything because it may be difficult. If something is going to be difficult and require more time, you can decide together if the

effort is worth it or come up with a more viable solution. That's what collaboration is all about! Sometimes you need to push your limits. The challenge makes it fun, and you might even surprise yourself.

4 Respect the process.

Look, I don't care how much of a rock star you are. You're not going to get it right the first time. There are going to be lots of iterations on a project. Your designer will iterate the UI/UX or the design of a map. You will iterate on the implementations and any new limitations you need to consider. This whole thing is a process. You will continually review the work being done and try hard to produce something awesome.

Every time I build an application, I always think, I'm done, it's perfect, I can move on. Then my designer will test it and give feedback and I realize I have failed on every level. Okay, maybe not total failure, but the point is, you need to trust the process. Every project makes you a better developer, and your designer a better designer. Which brings me to my last tip.

5 Learn.

Take the opportunity to learn as much as you can when you have the chance to work with a designer. Trust me, it's incredibly valuable. For example, I constantly had to look up how to align text within an image, but once I had a designer walk me through how to add custom fonts to a page, I can now do it (almost) every time.

You may not always have a designer to work with on a project. When you don't, you can channel the wisdom of designers you have worked with. Designers want to learn from you so they can get a better idea of how far they can push the technology with their ideas in the future.

Designers and developers are both creatives who are full of ideas and eager to build. When you can work well together, you can build some awesome products. Go on, build something awesome!

About the Author

Rene Rubalcava is a product engineer on the ArcGIS API for JavaScript team. Read his blog posts on the *ArcGIS Blog*, and follow him on Twitter @odoenet.



Resources, Inspiration, and Support for JavaScript Geodevelopers

The [ArcGIS API for JavaScript](https://developers.arcgis.com/javascript) website (developers.arcgis.com/javascript) revamped with the 4.11 release, has features that will help inspire experienced developers and jump-start the efforts of new developers.

The home page has been redesigned to help you quickly find information about the API's capabilities and the resources available to learn about them. Go directly to the Tutorials, Guide, Sample Code, API Reference, and Showcase sections from the home page. The home page also has resources for exploring 2D and 3D visualization and building compelling apps.

The Guide takes you to the resources that will help you be a more successful developer, whether you are a veteran, newbie, or somewhere in between. For seasoned developers, more than 200 code samples provide examples of the full range of ArcGIS API for JavaScript capabilities. The sandbox in the Sample Code section has been updated with new functionality. The portal items and Esri modules are clickable and take you to the Details page for each item or the documentation for modules. Both are huge time-savers. The Showcase section, which is also new, is a collection of apps that show the API's capabilities with links to the code in GitHub, an explanation of relevant technology, and links so you can learn how to build the same capabilities in your apps.

If you are a new developer, the Start Learning section is designed to get you up and coding fast. Learn how to build a Hello World app using three easy steps on the Quick Start page. Short

tutorials in this section take about 10 minutes and teach a specific task. Tutorials are linked logically so you can master topics in a meaningful way. They are organized into topic folders, such as Developer Tooling or Building Your UI, and new topics have been developed to teach API core concepts. The small embedded table of contents in the pages for many topics will help you quickly navigate within a page.

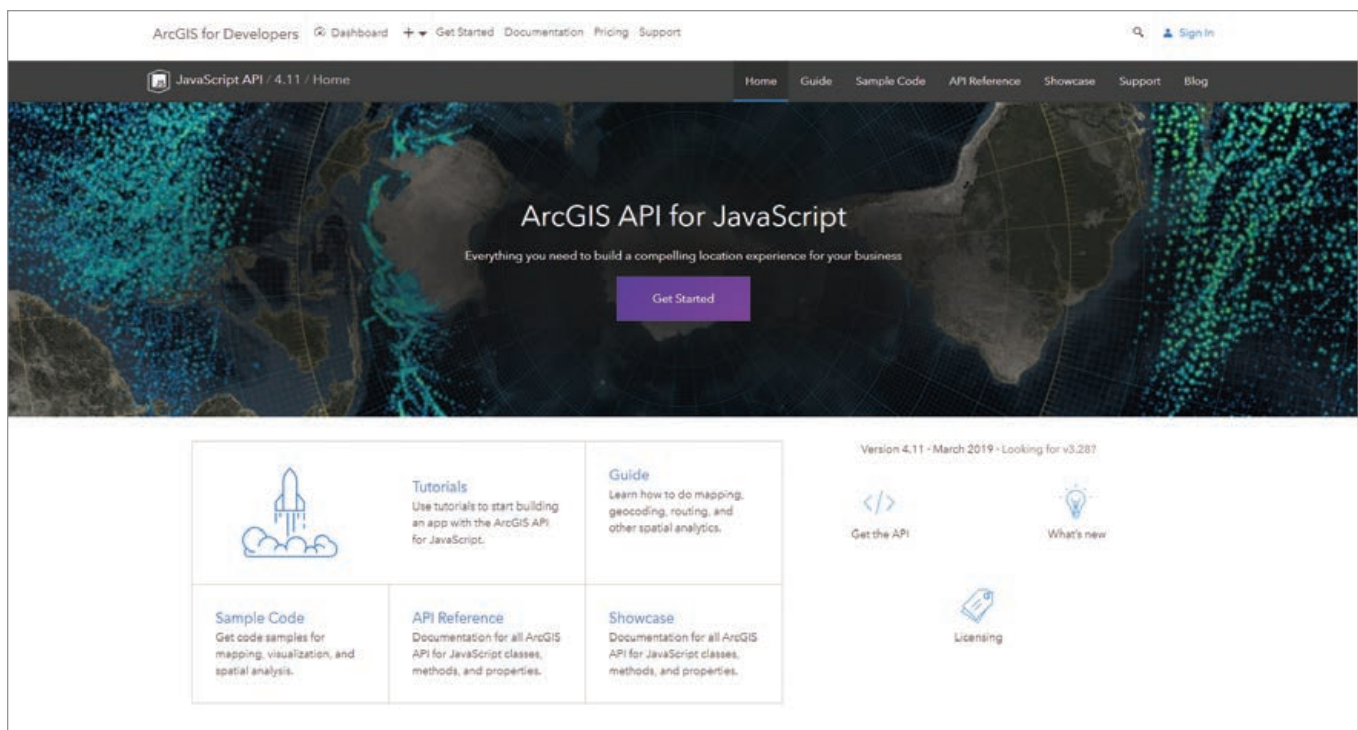
The Core Concepts pages will teach you about basic classes and concepts, so it's a perfect place to start for people new to the ArcGIS API for JavaScript or new to the 4.x version of the ArcGIS API for JavaScript. The three Core Concepts sections are: Maps and Views, Layers and Data, and Programming Patterns.

The General JavaScript Resources section helps you improve the HTML, CSS, and JavaScript skills you will need to be successful with web app development.

Stay current with ArcGIS development efforts with the links to the *ArcGIS Blog* and the ArcGIS JavaScript Twitter account on the Guide page.

The new Tutorials section has 22 tutorials that already exist on the ArcGIS Developers site, but now you can also access them from the ArcGIS API for JavaScript website. These step-by-step instructional guides will walk you through building specific functionality using CodePen. These tutorials contain explanations and links to relevant information on topics about the rest of the ArcGIS platform, such as ArcGIS Online and the ArcGIS REST API.

↓ The ArcGIS API for JavaScript website (developers.arcgis.com/javascript) was completely revamped with the 4.11 release.



A BETTER DEVELOPER EXPERIENCE

FOR THE MORE THAN 2,100 developers attending the fourteenth annual Esri Developer Summit (DevSummit), the relaunch of the ArcGIS for Developers program was one of the highlights. The event, held March 5–8, 2019, in Palm Springs, California, drew attendees who came to network, learn about the latest developments in ArcGIS, showcase their work, and interact with the hundreds of Esri development staff at the event.

In brief comments at the opening of the Plenary Session, Esri president Jack Dangermond and DevSummit MC and ArcGIS program manager Jim McKinney lauded the work of developers as both awesome and valuable. Dangermond emphasized Esri's shift to "focus on developers and making your lives better." In addition to incorporating developer feedback and constantly improving Esri's development tools, the ArcGIS for Developers program is more streamlined, flexible, and affordable.

CAPABILITIES DEVELOPERS NEED

The new features of this program were introduced by Euan Cameron, chief technology officer for the Runtime and Applications group at Esri during the Plenary Session. The ArcGIS for Developers program gives developers access to tools for native and web development that target mobile and desktop platforms and devices. These include the ArcGIS Runtime SDKs for Android, iOS, Java, .NET, Qt, and macOS; ArcGIS APIs for JavaScript and Python; and the REST API.

These tools help developers create interactive data visualizations in 2D and 3D using GPU-accelerated rendering and client-side analytics. Of course, geocoding, routing, and search capabilities can be incorporated in apps, as well as smart mapping and data-driven mapping that guide the creation of effective data visualizations. SDKs support apps that can work offline or in conditions of intermittent connectivity.

Data is vital to the success of apps. With any developer plan, developers get access to Esri's vector and raster basemaps, available in several ready-to-use styles and built with the best authoritative data available from leading providers and the Esri community. Vector maps can be easily customized using the ArcGIS Vector Style Editor. Esri also hosts a new vector basemap based on OpenStreetMap, which has unlimited map views per month, so there is no extra charge no matter how popular an application is. OpenStreetMap is constantly updated, and those updates are incorporated immediately as the changes are contributed. ArcGIS GeoEnrichment Service lets apps do more by supplying current demographic and business information by location. Data hosting can be handled by the developer or Esri. Esri hosting is private and secure.

QUICKLY PRODUCTIVE

ArcGIS developer tools let you do less and produce more. Maps and geocoding can be integrated into your app in just a few lines of code. Out-of-the-box widgets and components provide instant functionality, and app builders let you build apps without any coding. ArcGIS DevLabs are focused exercises that teach practical implementations of APIs and SDKs. Samples and open-source projects are available on GitHub.

AFFORDABLE AND EASY-TO-MANAGE PLANS

Existing developer subscriptions have automatically rolled over to the subscriptions in the new program. Free subscriptions become Essentials subscriptions with the same resources as previously. Paid developer plans are now referred to as Builder plans that allow commercial deployment and have pay-as-you-go pricing.

Manage your developer plan through a dashboard that organizes information on your credits and plan and provides access to tokens, keys, and the latest news on releases and learning resources. It can be

customized with your preferred APIs and SDKs so relevant suggestions and developer tips are surfaced.

Developers who are new to the program can start for free with the Essentials plan, which lets you build and deploy unlimited, non-revenue-generating apps using any ArcGIS API or SDK and the configurable apps and Web AppBuilder for ArcGIS. Host, query, and analyze your map data and style basemaps with one million basemap and geocode transactions per month. Beyond the 50 free service credits each month, pricing is pay-as-you-go.

With the Builder plan, you get unlimited commercial deployment of your apps, whether through sales or subscription. In addition to everything in the Essentials plan, this plan provides ArcGIS Online apps, ArcGIS Pro, ArcGIS Online, and Esri Technical Support. It can be purchased on a monthly or yearly basis.



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FIVE MYTHS



ABOUT LOCATION INTELLIGENCE

By Matthew Lewin

MYTH 2

IF YOU FOLLOW the tech industry, you've probably encountered the term *location intelligence*, but what does it really mean?

For some, it's about technology like GIS and mapping software.

For others, it's about analysis and spatial data.

And for others still, it's a business concept that refers to improved performance through better spatial awareness.

None of these are entirely incorrect. But they are somewhat incomplete. As a strategist, I spend a lot of time talking to people about their location intelligence questions, as well as clarifying some of their misconceptions. Here are five of the most common.

IT'S NOT AN ORGANIZATIONAL CAPABILITY.

If location intelligence is an ability, then you might assume that it's a uniquely individual one. After all, it's people that use the software, perform the analysis, and make the maps. Organizations, on the other hand, are simply the beneficiaries of these human abilities. Isn't it misleading to suggest that an organization—as a whole—possesses location intelligence? After all, what is an organization but a collection of individuals.

In truth, organizations do possess a distinct level of location intelligence. For individuals, location intelligence has a lot to do with understanding geography and business analysis and having access to tools to solve problems. For organizations, location intelligence is more about channeling and integrating the abilities of individuals to serve the interests of the organization. This is done by establishing effective location strategies, business practices, governance processes, and cultural norms. The best organizations then bake those elements right into the core business. In management consulting speak, they establish location intelligence as an organizational capability.

For instance, the British multinational oil and gas company BP took this approach in building its One Map program. Establishing One Map meant looking at how location intelligence could be leveraged across all BP's lines of business, including oil and gas exploration, production, transportation, refining, and retail. BP recognized that enabling such a large and diverse business through location intelligence required holistic thinking. It would require establishing a technology platform, governance, data-sharing practices, business applications, IT support, workflow automation, performance management, and branding and marketing. Essentially, BP elevated location intelligence to a true organizational capability.

MYTH 1

IT'S JUST GIS REBRANDED.

"Location intelligence— isn't that just GIS?" It's a common refrain, often made by a puzzled but well-intentioned IT manager. It's natural to assume that there's a strong connection between location intelligence and GIS. For years, many GIS software vendors have claimed to provide a platform for location intelligence. In fact, a Google search on the term returns dozens of pages focused squarely on the technology of GIS.

The truth is that GIS and location intelligence are distinct concepts. GIS refers specifically to technology. It's the software and hardware behind digital mapping and geospatial analysis. Think of GIS as the hard goods of the geospatial industry.

Location intelligence, on the other hand, refers to an ability—not a specific technology. An ability is a proficiency. It's a capacity to do something. The word *intelligence* itself is defined as "the ability to acquire and apply knowledge and skills." Location intelligence extends that definition into the realm of geography and business.

Put simply, location intelligence is the ability to derive business insights from geospatial information. Those with well-developed location intelligence abilities use GIS, maps, data, and analytical skills to solve real-world problems, specifically business problems. This is an important distinction. Location intelligence is primarily a business term that refers to solving business problems. GIS may be the technical foundation of location intelligence, but it's not the same thing.

MYTH 3

IT'S JUST ANALYTICS WITH MAPS.

Most literature discussing analytics unfortunately skips right over the concept of location, so it's no wonder that the analytics strategies of most organizations that I encounter do the same thing. A common perception is that—aside from seeing your work on a

MYTH 5

map—location doesn't really add much to an analysis. It's a complementary visual at best.

In reality, when you factor location into analysis, you open up a world of opportunity. Specifically, you make it possible to tackle a unique set of problems. Think about an offshore oil company trying to predict and monitor sea ice activity. Rogue icebergs or shifting ice floes, driven by global climate change, pose a tremendous risk to the safe operation of offshore oil rigs and shipping vessels. Mitigation of sea ice risk is inherently about predicting and its monitoring the location of sea ice: its size, shape, and speed and the consequences if it impacts an oil platform. This is a location-based problem that involves more than just plotting a location on a map. Making accurate predictions and formulating the best mitigating steps requires that an organization start the analysis with location as the core component.

Location intelligence lets you answer questions you couldn't answer in the absence of a geospatial context. And that goes far beyond plotting points on a map. Investing in tools, knowledge, and organizational practices is key to cultivating this ability.

MYTH 4

IT'S ONLY FOR SPECIALISTS.

Another common assumption is that anything "geo" is for experts. That includes geography, geomatics, geospatial analysis, and GIS. The sense is that geo is complex and a niche discipline. A map might appeal to a casual user, but real analysis is done by and for the benefit of professionals.

The truth is that geospatial tools and data are more accessible and intuitive than ever, which has resulted in a corresponding rise in nontraditional users. A survey of the geospatial analytics market published by *Geospatial World* in 2018 indicated that the fastest growing segments of geospatial technology are web and mobile GIS. A lot of the reasons for this trend are the ease-of-use improvements of the technology. This has resulted in an increase in adoption by nontraditional users. More than ever, we're seeing data scientists, policy makers, political analysts, and fieldworkers leverage location-based tools. We're also seeing many businesses integrate location intelligence at the executive level.

What this means for organizations is that to do great things with location intelligence, you don't have to be an expert. In many cases, you don't necessarily have to employ an army of geospatial specialists. A better strategy is to augment your existing business functions with easy-to-use and fit-for-purpose tools and technology.

IT'S NOT STRATEGIC.

A major oversight when it comes to location intelligence is its perception as a strategic enabler. An organization creates a business strategy to define how it will compete and win against its peers. A strategic enabler is any capability that significantly supports the strategy. Many organizations struggle to understand how location intelligence contributes in this way. How can location intelligence help organizations win?

The answer lies in understanding how a strategic advantage is created. A strategic advantage comes from having something valuable that would be difficult for competitors to replicate. A great brand, low-cost structure, and proprietary intellectual property are examples of high-level strategic advantages. These are potent assets because they protect the competitive position of the organization.

Similarly, anything that discourages customers from switching to competitors could be considered a strategic enabler. Rogers Communications in Canada uses location intelligence to improve how calls are routed to its service operators. Matching callers to agents is a notoriously difficult problem. To predict which agent is best suited to respond to a call, Rogers needs to consider many factors. These include a customer's intention and history as well as an agent's qualifications and experience. The company also needs to know the location of the caller to determine what phone or Internet issues might be relevant. All this information feeds into an artificial intelligence (AI) engine that predicts the nature of the call and routes it to the best agent to respond.

By automating this, Rogers has significantly reduced service time and improved customer retention rates. At a strategic level, it has helped Rogers protect revenue and its competitive position through superior customer service. If you're ever challenged with the comment that location intelligence isn't strategic, think about how an organization competes and all the advantages location-based insights can create.

ABOUT THE AUTHOR

Matthew Lewin is the director of management consulting at Esri Canada. His efforts are focused on helping management teams optimize and transform their business through GIS and location-based strategies. As a seasoned consultant, Lewin has provided organizations in the public and private sectors with practical strategies that enable GIS as an enterprise business capability. His interests lie at the intersection of business and technology. If you'd like to chat more about location intelligence, contact Lewin at mlewin@esri.ca.

Migrating Public Safety Workflows to ArcGIS Pro

By Mike Price

By Mike Price

What You Will Need

- Access to an ArcGIS Pro license
- ArcGIS Network Analyst ArcGIS Pro extension license
- ArcGIS Spatial Analyst ArcGIS Pro extension license
- Sample dataset downloaded from *ArcUser* website
- Unzipping utility

In the winter 2019 issue of *ArcUser*, “Mapping the Winter and Proposed Effective Fire Response” showed how to map the effects of adding additional responders and how these responders improved the effective response force (ERF) for stations in the Graham Fire & Rescue (GF&R) district in Graham, Washington. Through mapping staffing and deployment levels throughout the jurisdiction, this tutorial emphasized the importance of developing and maintaining an effective ERF throughout as much of the fire district as possible. A well-defined ERF is a critical part of an effective Standard of Cover (SOC).

GF&R used its ERF analysis to win a \$3.5 million grant from the Staffing for Adequate Fire and Emergency Response (SAFER) program. GF&R provides critical services to a rapidly growing resident population that has increased by more than 45 percent since 1990. This exercise mapped an existing deployment of 15 firefighters and modeled expanded deployments of 17 and 19 personnel. It emphasized creating and managing multiple ArcGIS Pro layouts by using prebuilt ERF polygon and raster layers. For more information on GF&R and the SAFER grant process, see "About Graham Fire & Rescue" in the winter 2019 issue of *ArcUser* magazine.

The previous exercise modified Pierce County streets and used ArcGIS Network Analyst to model 8-minute travel throughout the GF&R service area. The actual

staffing criteria included in GF&R's grant application was applied to the locations of six GF&R stations—five staffed by career firefighters and one staffed by volunteers.

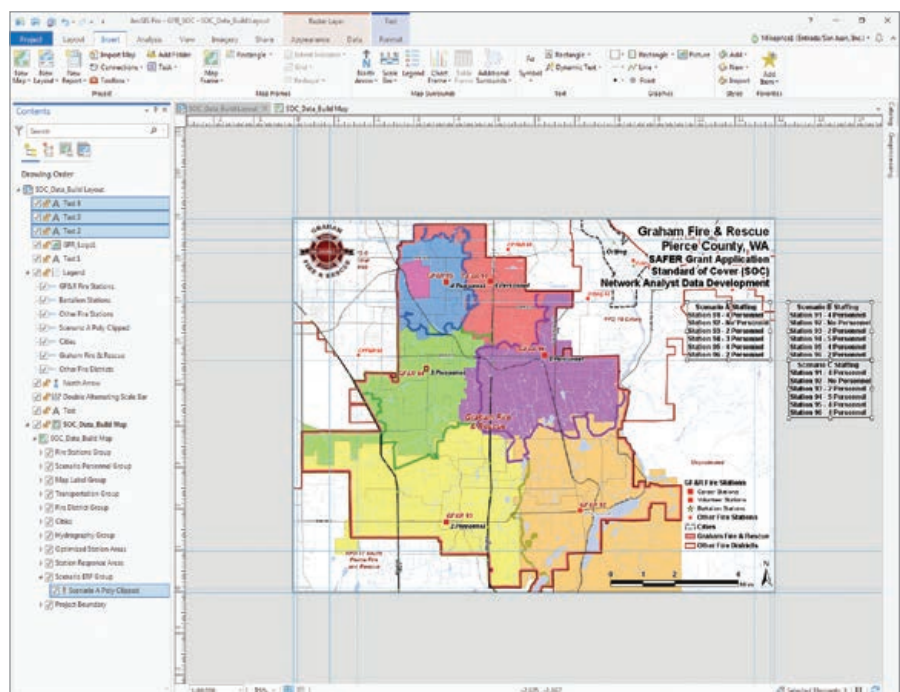
In this tutorial, you will take on the role of a GIS analyst and construct the datasets used in that analysis as well as output maps showing the results of the analysis. This exercise introduces many important ArcGIS Pro concepts and workflows using the Network Analyst and Spatial Analyst extensions for ArcGIS Pro. It re-creates, in ArcGIS Pro, a standard public safety modeling workflow that has been utilized in ArcMap for many years.

Getting Started

Go to the ArcUser website (esri.com/arcuser) and download the sample dataset, GFR_SOC.zip. The archive includes a dataset and supporting files for building the model. Extract it to a local machine.

Go to ArcGIS Online and verify that Network Analyst and Spatial Analyst extensions are available to your ArcGIS Pro license.

Start ArcGIS Pro, navigate to where you unzipped GFR_SOC, look in the GFR_SOC folder, and open GFR_SOC.aprx. The map opens in layout view. Open the Contents pane (if necessary). All data layers are



→ GFR_SOC.aprx opens in layout view with all data layers visible except Scenario A Poly Clipped.

→ Navigate to GFR_SOC\GDBFiles\WASP83SF\Transportation.gdb and open the Streets_ND feature dataset and add only Highways_Streets_ND, the network dataset.

visible except Scenario A Poly Clipped, located in the Scenario ERF Group near the bottom. This layer will represent the 8-minute staffing coverage used to create multiple maps. It is a template placeholder for the final ERF output. Do not remove it or try to repair its missing data source.

Notice that this layout includes three text blocks listing staff assignments at stations for three scenarios labeled A, B, and C. Scenario A defines the current 15-person staffing. Scenario B increases staffing by 2 to 17, and Scenario C adds 2 more personnel for a total response force of 19.

Switch to the map view and turn off the Optimized Station Areas and Station Response layers. Use the bookmark GFR SAFER 1:80,000 to navigate to the active project area.

Adding Data and Setting Environments

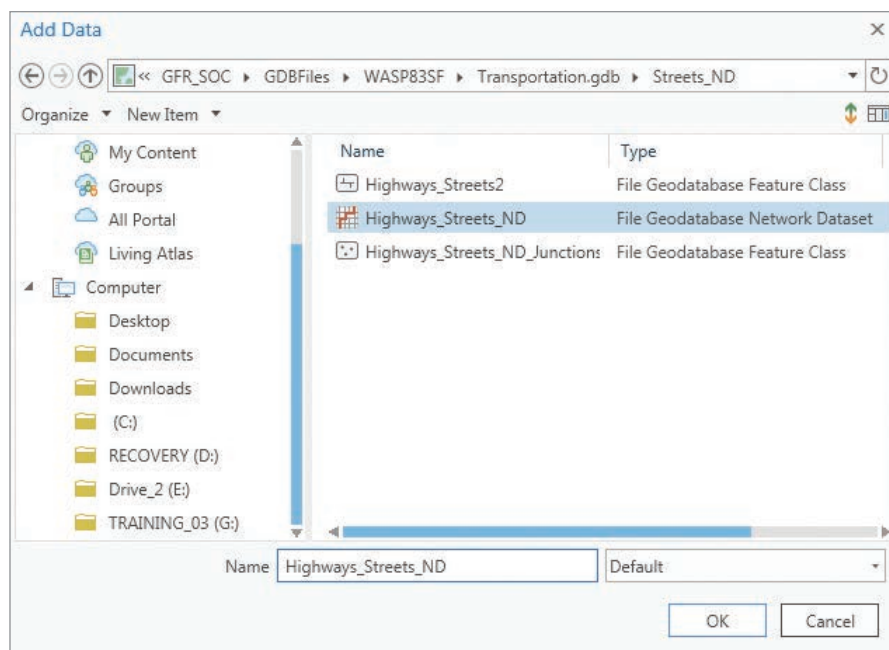
Click Add Data and navigate to GFR_SOC\GDBFiles\WASP83SF and open Transportation.gdb. Open the Streets_ND feature dataset and add only Highways_Streets_ND, the network dataset. Place Highways_Streets_ND in the Transportation Group, drag it to the bottom of the group, and turn it off.

Click Add Data again, navigate to GFR_SOC\GDBFiles\WASP83SF\Cartography.gdb, and open GFR_Clip_Grid. Place this raster at the bottom of the Contents pane and turn it off.

To set Environments, click the Analysis tab, then Environments. Environments are defined in ArcGIS Pro using many of the same modeling rules and parameters used in ArcMap. In the Environments pane, set the Current and Scratch Workspaces to SOC_Model.gdb. Set the Output Coordinate System to GFR_Clip_Grid. Set the Processing Extent and Snap Raster to GFR_Clip_Grid. Finally, set the Cell size to Same as Layer GFR_Clip_Grid. Save the project.

Creating 8-Minute Service Area Polygons

On the Analysis tab, open Tools. In the Geoprocessing pane, click Toolboxes, then



choose Network Analyst Tools > Analysis > Make Service Area Analysis Layer tool. Carefully set only the parameters listed in Table 1 and leave defaults for all other parameters. When done, click Run to create the 8-minute Service Area.

Loading Station Locations and Solving Service Areas

ArcGIS Pro uses a new procedure to load locations into Network Analyst solvers. Add GF&R fire stations to the 8-minute Service Area by choosing Tools > Network Analyst Tools > Analysis > Add Locations tool. In

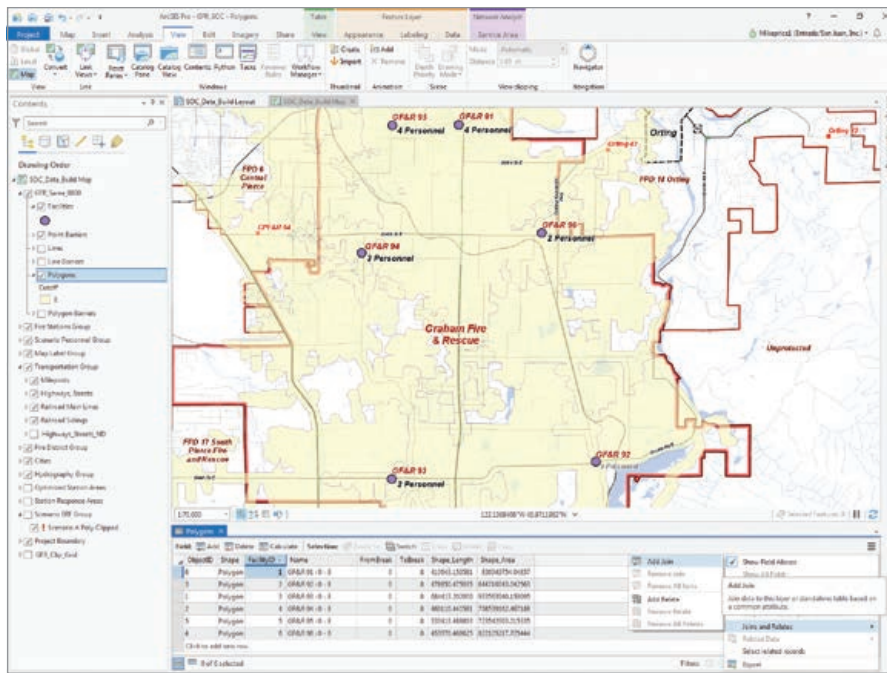
the Add Locations wizard, use Table 2 to set the parameters. Make sure Sort Field is set to INDEX. Make sure Append to Existing Locations is unchecked. When done setting parameters, click Run.

When processing is finished, verify that all six locations have loaded and that the data is sorted by Index. Save the project.

Choose Tools > Network Analyst Tools > Analysis > Solve tool. Set the Input to GFR_Sarea_0800, leave other Solve parameters unchanged, and click Run to generate 8-minute polygons. The polygons are added to the project. Save the project again.

↓ Table 1

Parameter	Value
Network Data Source	Highways_Streets_ND
Layer Name	GFR_Sarea_0800
Travel Direction	Away from facilities
Cutoffs	8 (delete all others)
Time Zone	Local time at locations
Output Type	Polygons
Polygon Detail	High
Geometry at Overlaps	Overlap
Geometry at Cutoffs	Disks
Polygon Trim Distance	600 Feet
Length_mi	Checked
Minutes	Checked



◀ In the Add Join pane, set Layer Name to Polygons, set Input Join field to FacilityID, set Join Table to GF&R Fire Stations, and set Output Join Field to INDEX.

above GFR_Clip_Grid, and open its attribute table. Turn off GFR_Sarea_0800. Save the project.

Converting Each Polygon to a Raster and Reclassifying It

Sort the attribute table for Sarea_0800_GFR by INDEX in ascending order. Find the OBJECTID_1 field. This field will be used to assign values to the initial coverage rasters. Save the project again.

In the attribute table, select the record for Station 91. In the Geoprocessing pane, use the Search box to find Polygon To Raster. In the Polygon To Raster window

- Set Input Features to Sarea_0800_GFR.
- Set Value Field to OBJECTID_1, NOT OBJECTID. This parameter is very important.
- Set the Output Raster to X and store it in SOC_Model.gdb.

Verify that Cellsize is managed by GFR_Clip_Grid (which was set in Environments). Click Run to create a temporary raster called x. Since it is temporary, there is no need to move it in the Contents pane. In the Geoprocessing pane, choose Spatial Analyst Tools > Reclass > Reclassify. When the Reclassify pane opens

- Set Input raster to X.
- Reclass field to VALUE.
- Under Reclassification, first row, Value is 4 (which is the value for OBJECTID_1) and set New as 1.
- Under Reclassification, second row, Value is NODATA and set New as 0. It is important reclassify NODATA to zero.
- Name the Output raster Sarea_0800_GFR_91 and store in SOC_Model.gdb.
- Click Run.

The output raster represents the 8-minute travel area for Station 91. Position it just above GFR_Clip_Grid in the Contents pane. Inspect its extent and verify that cells in the coverage area contain a value of 1 and all cells outside the coverage area contain a value of 0.

Remove the x layer and save the project.

For the remaining five station service areas, select each in the attribute table and repeat the steps to convert each

Enhancing and Inspecting 8-Minute Service Area Polygons

With SOC_Data_Build Map, go to the Contents pane and under GFR_Sarea_0800, open the Polygons layer attribute table. Dock the table at the bottom of the map frame.

Sort attributes by FacilityID in ascending order and click three bars in the table's upper right corner to open its menu. Select Joins and Relates > Add Join.

In the Add Join pane, set Layer Name to Polygons and Input Join field to FacilityID. This field is not indexed, so it displays a yellow caution symbol, and that is okay. Set Join Table to GF&R Fire Stations. Set Output Join Field to INDEX. Leave Keep All Target Features checked. Click Run. When completed, save the project.

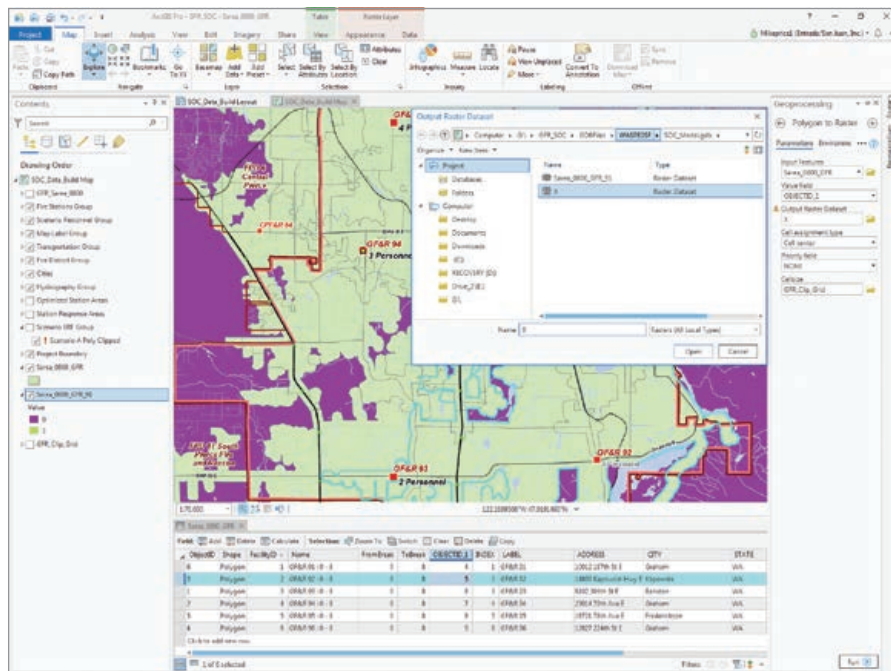
Inspect the joined attributes and sort again on FacilityID. The LABEL field should list in ascending order. Highlight the record for Station 91 and inspect its 8-minute travel area. It is located on an arterial street, so its southern travel capabilities are significant. Note the OBJECTID_1 field—it will soon become very useful. Clear the record selection for Station 91 before moving on.

Exporting Polygons

In the Contents pane, right-click Polygons and select Data > Export Features. In the Copy Features pane, set Input Features to Polygons. For Output Feature Class, save the output in SOC_Model.gdb and name it Sarea_0800_GFR. Click Run. When processing is completed, place GFR_Sarea_0800 near the bottom of the Contents pane, just

↓ Table 2

Parameter	Value
Input Network Analysis Layer	GFR_Sarea_0800
Sub Layer	Facilities
Input Locations	Fire Stations/GF&R Fire Stations
Field Mappings	Use Geometry
Field Name	LABEL
Search Tolerance	500 Feet
Sort Field	INDEX
Append to Existing Locations	unchecked



Take your time. Make sure the correct OBJECTID_1 for each record is the Value to reclassify on and 0 is set as New for NODATA. Delete the x layer after reclassifying each station's service area raster. Name each raster based on the station number. Save the project after creating each raster. Use the Favorites tab on the

Creating Effective Response Rasters for Three Scenarios

Remember Scenario A Poly Clipped,
the undefined feature class in the

Staffing by Station Number	91	92	93	94	95	96	Total	Scenario Raster Name
Scenario A: Current Conditions	4	0	2	3	4	2	15	Sarea_0800_GFR_SA
Scenario B: Initial SAFER Staffing	4	0	2	5	4	2	17	Sarea_0800_GFR_SB
Scenario C: Optimal SAFER Staffing	4	0	2	5	4	4	19	Sarea_0800_GFR_SC

↑ Table 3

Contents pane? Update it now to include the Scenario A solution by setting its data source. In the Contents pane, under Scenario ERF Group, right-click Scenario A Poly Clipped and choose Properties > Source and navigate to Sarea_0800_GFR_SA. Click OK and the layer updates. Since this layer now displays raster data, change its name to Scenario A Grid Clipped.

Data in Map View, Legends in Layout View

Click on SOC_Data_Build_Layout to see how the updated legend behaves. Notice that the legend reflects the Scenario A update and shows the correct name and legend style for Scenario A Grid Clipped. Save the project and return to SOC_Data_Build_Map.

Reopen the Raster Calculator in the Geoprocessing pane and model Scenario B ERF using the formula and output name from the ERF_Scenarios_A_B_C.rtf file. Repeat this process for Scenario C.

Check the results to confirm that Sarea_0800_GFR_SB contains 17 or fewer responders and Sarea_0800_GFR_SB includes at most 19 personnel.

ArcGIS Pro Legend Tricks

Wouldn't it be nice to borrow the Scenario A Grid Clipped legend for Scenarios B and C? In the Scenario ERF Group, right-click Scenario A Grid Clipped and select Copy. Move the cursor to the top of the Contents pane, right-click Scenario ERF Group, and click Paste twice. Rename them Scenario B and Scenario C.

Right-click Scenario B Grid Clipped, open its properties, and change its source

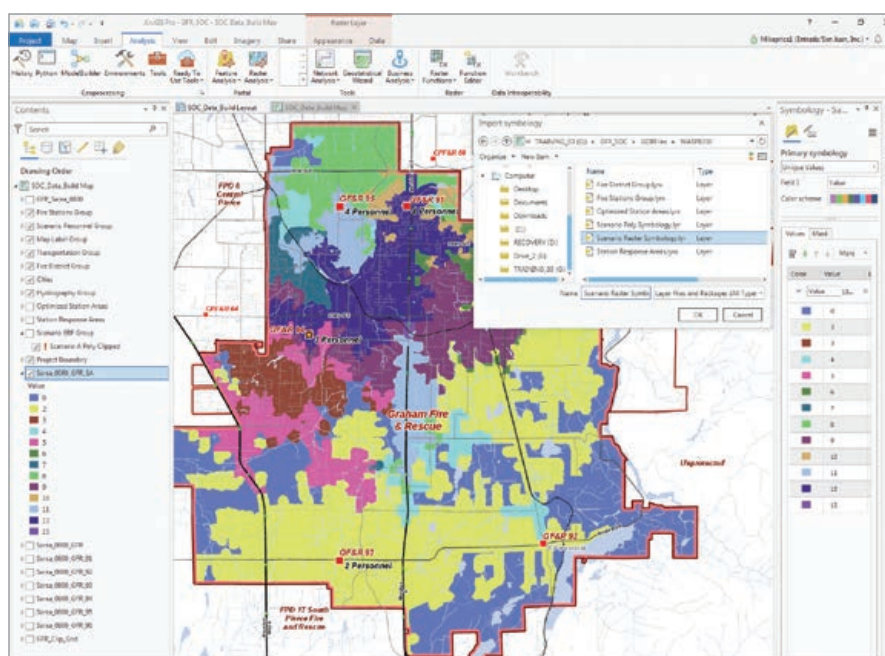
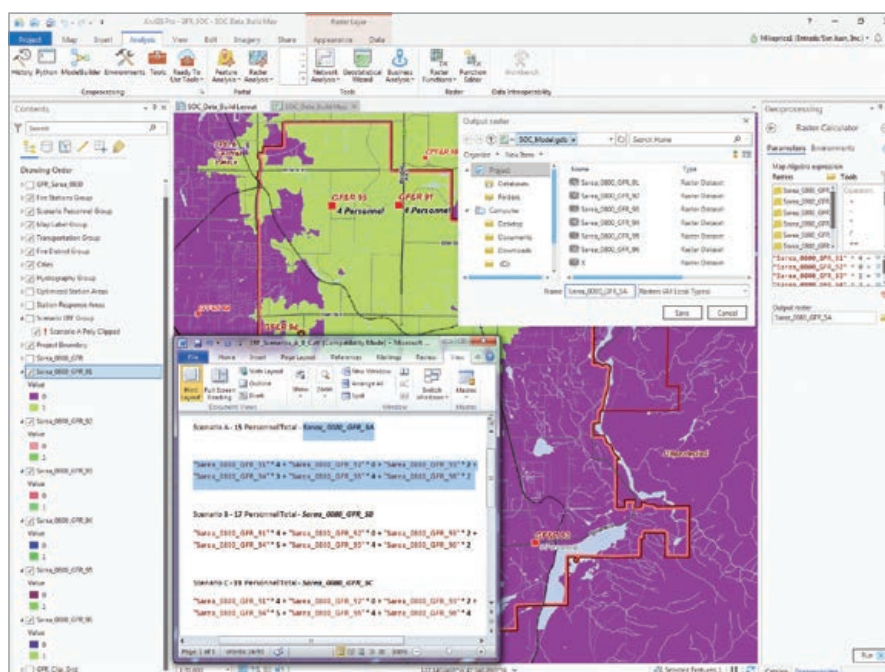
➤ Use the formulas in ERF_Scenarios_A_B_C.rtf to sum all raster calculations to model the scenario's total ERF coverage using the Raster Calculator.

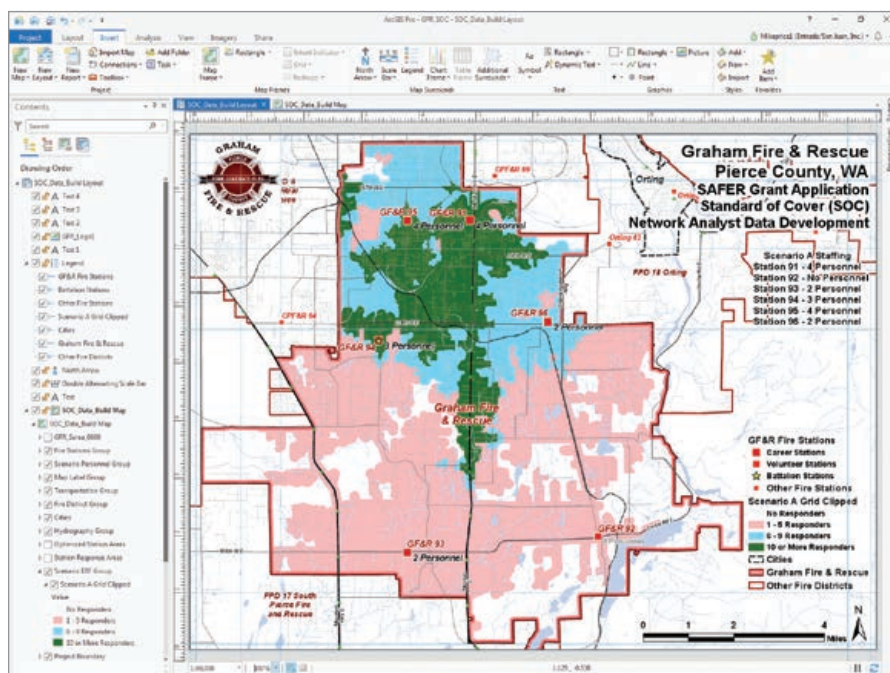
➤ Borrow the legend for Scenario A Grid Clipped for the Scenario B and Scenario C layers.

to Sarea_0800_GFR_SB. Repeat these steps for Scenario C Grid Clipped. Remove Sarea_0800_GFR_SB and Sarea_0800_GFR_SC from the Contents pane and save

the project.

Return to SOC_Data_Build_Layout and locate Scenario A Grid Clipped in the Legend group. Right-click this layer's





Return to SOC_Data_Build_Layout and locate Scenario A Grid Clipped in the Legend group. Right-click this layer's legend element and select Save As Default.

Swap the Scenario A staffing text block with the Scenario B staffing text block.

your hypothetical role as a GIS analyst—to develop your agency's SAFER application. At this point, you might consider other mapping and modeling options. A great next task would be to convert all three clipped ERF rasters to polygons and calculate their respective coverage areas.

Using polygons, you could compile recent incident points to show how many incidents fall into each responder count cell for all scenarios. You might also compile and rank residents and households for census block centroids by coverage and perhaps classify assessed valuation for protected parcels. You might use these maps and the underlying data to show local officials and residents how they are positively affected by increased levels of protection.

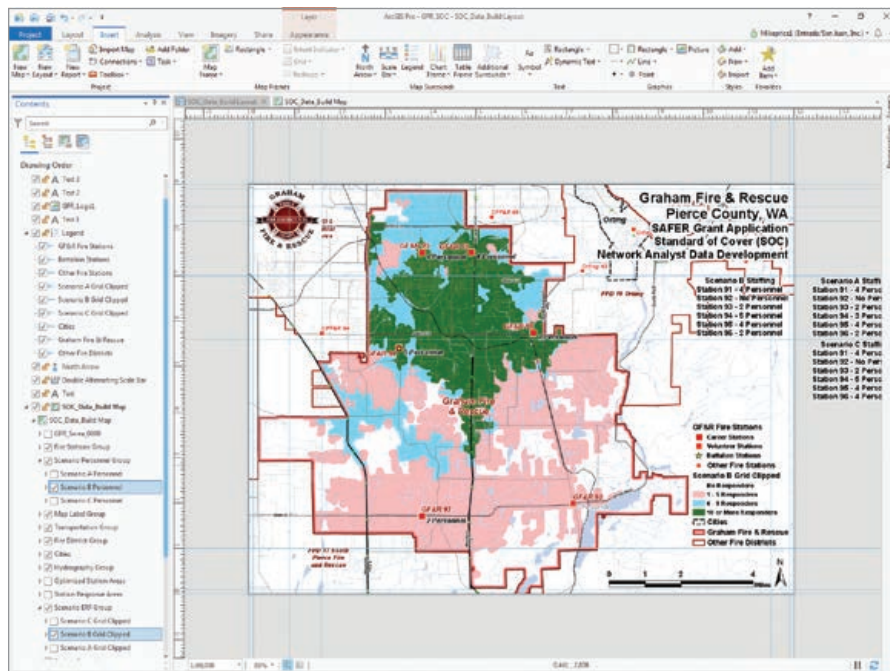
Summary and Acknowledgments

This has been a very interesting tutorial to create and document. It updates a traditional modeling workflow that used ArcView GIS 3.x and has transitioned with rapid changes in software and the world.

Congratulations to Graham Fire & Rescue for receiving a SAFER grant. Thanks again to the GIS data managers in Pierce County, Washington, for providing quality datasets that help represent real-world conditions. Special thanks to Oscar Espinosa, the assistant chief for Graham Fire & Rescue, and his fine staff for their commitment to deploying ArcGIS Pro right out of the box, even though they lacked experience with ArcGIS Desktop. We are learning lots from you, Chief Espinosa.

About the Author

Mike Price, the president of Entrada/San Juan Inc., was the mining and earth sciences industry manager at Esri between 1997 and 2002. He has been helping ArcUser readers understand and use GIS more intelligently since the magazine's founding. He is a geologist and has been a volunteer firefighter in Moab, Utah, for many years.



legend element and select Save As Default.

Return to the SOC_Data_Build_Layout, left-click and hold Scenario B Grid Clipped, and drag it into Legend. Repeat this process for Scenario B Grid Clipped and Scenario B Personnel (in the Scenario Personnel Group) visible. Turn off the Scenario A Grid and Personnel.

On the pasteboard slightly to the right of the active layout, locate the Scenario B

staffing text block. Swap the Scenario A staffing text block with the Scenario B staffing text block. Save the project.

On Your Own

Congratulations. By working this tutorial, you have created enough analytical and mapping materials to support a high-quality SAFER application. Export as a PDF or print Scenarios A, B, and C to share your work with senior staff as you continue—in

Make Your Work Easy to Find, Understand, and Use by Others

By Diana Lavery

You've put the finishing touches on your layer, web map, or configurable app. You're ready to share it with the world, right? Well...maybe you are if you've been updating your item's Details page as you've been working. If you're like me, you leave this important step until the end. Don't omit it.

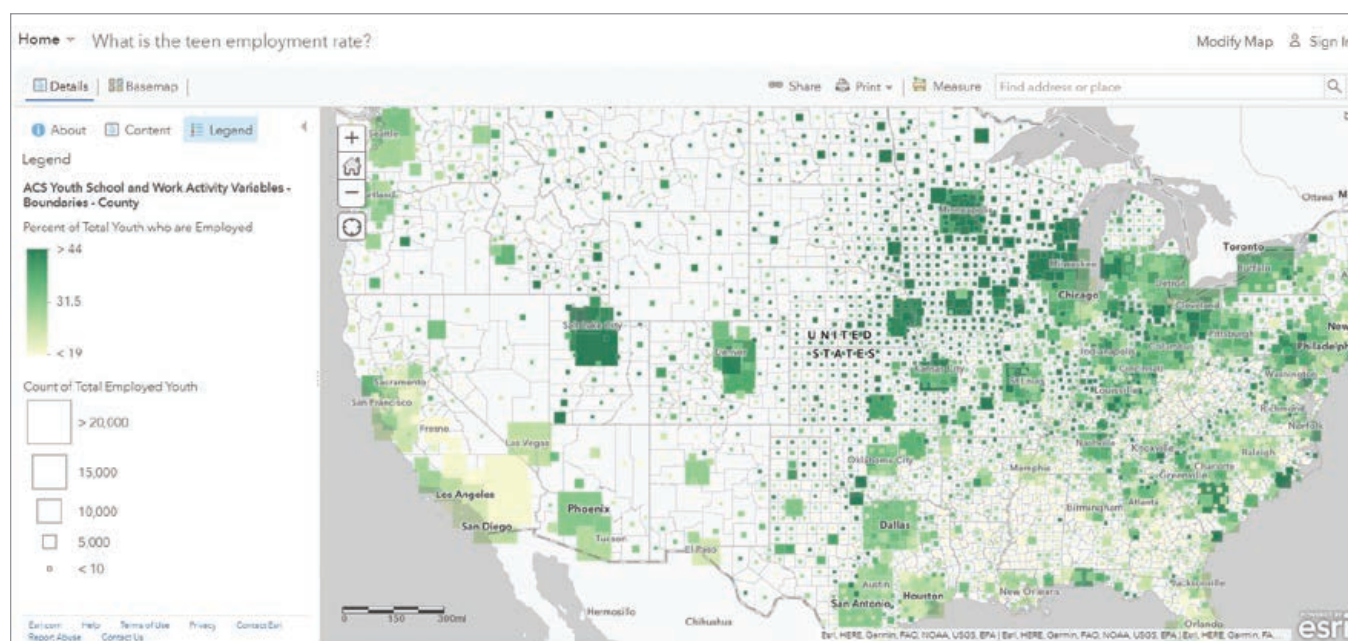
What Is a Details Page?

The Details page is the place where you let other ArcGIS users know what your item—your layer, web map, or configurable app—is all about. The title, the summary, and the description answer the question, what is this? in progressively more descriptive ways. The Details page is also the place to provide the source, the terms of use, any data footnotes or field definitions, and the general metadata that would be hidden when viewing the item.

Every ArcGIS Online Item Has a Details Page


↓ My map on the teen employment rate answers questions about youth, the workforce, labor supply, and even policy so these are great tags for this item's Details page.

Layers, web maps, scenes, configurable apps, story maps, even tables and images that have been uploaded to your ArcGIS account all have a Details page. A very common workflow is to first author a data layer, then create a web map from this layer, then display the web map along with some context in a configurable app or story map. The layer, the web



What are Children's Living Arrangements?

Overview



This map shows the predominant living arrangement of children by tract, county, and state boundaries. Percentages for each category in the pop-up. Data from American Community Survey.

Web Map by dianaclavery_uo

Created: Nov 29, 2018 Updated: Dec 5, 2018 View Count: 435

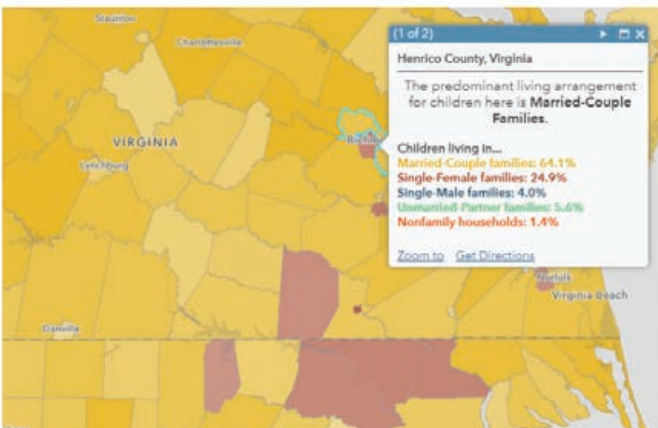
Living Atlas

Open in Map Viewer

Open in ArcGIS Desktop

Description

This map shows the predominant living arrangement of children by tract, county, and state boundaries. Percentages for each category in the pop-up.



Details

Size: 86 KB

★★★★★

Facebook Twitter RSS

Owner

dianaclavery_uo

Tags

household structure, children, living arrangements, American Community Survey, policy, demographics

Credits (Attribution)

Census Bureau's American Community Survey Table: B09008. The layers contain the most recent 5-year estimates available.



Diana Lavery @dianaclavery · Mar 4

Now available in @Esri Policy Maps site (esri.com/policymaps): Where are the Households with No Vehicle Available?



Where are the Households with No Vehicle Available?

This map shows where households are that have no vehicle available, and household size information is available in the pop-up. Knowing where residents are ...

urbanobservatory.maps.arcgis.com

2

5

map, and the app each have a Details page. Ideally, each Details page has been filled out—not just the Details page for the app. That way, the building blocks of your app—the layers and web maps—can stand alone. This can be helpful when a colleague or external GIS user wants to use a part of your app or story map.

ArcGIS Online provides some basic guidance on the page with the scoring bar. Rather than providing specific numbers, the scoring bar simply displays progress on a spectrum from low to high. If your page is scoring on the low side, it lists suggestions for top improvements.

Why Document Your Item?

Those who use your item will thank you! A complete Details page for every item not only makes your work easy to find, understand, and use by others but it also makes your item more credible. And it's required when nominating an item for inclusion in ArcGIS Living Atlas of the World and it makes your web map social media ready. For example, when I shared a map entitled "Where Are the Households with No Vehicles Available" on Twitter, the title, image, and blurb right from my Details page were picked up by Twitter.

↑ By taking a screenshot of this map with an open pop-up and using it in the Description section, I can communicate the legend and pop-up information at the same time.

↩ Completely filling out the Details page makes your web map social media ready with title, thumbnail, and summary. Twitter picked up the title, image, and blurb right from my Details page for this map.

Occupations Vulnerable to Extreme Heat

Overview

☆ Add to Favorites

Web Mapping Application by dianaclavery_uo

Created: Aug 17, 2017

Updated: Oct 9, 2017

View Count: 2,190

Living Atlas

Description

Agricultural workers and construction/extraction workers are vulnerable to extreme heat events, as well as some less obvious occupations such as manufacturing and food preparation.

Data in the tabbed map series are available at county-level and tract-level, data come from US Census Bureau's 2011-2015 American Community Survey, Table C24010. County-level data is visible at extents above 1:1,250,000 and tract-level data is available when zoomed in below 1:1,125,000.

Farming, Fishing, and Forestry Occupations include: first-line supervisors of farming, fishing, and forestry workers; agricultural workers; fishing and hunting workers; forest, conservation, and logging workers. (2-digit SOC = 45)

Construction and Extraction Occupations include: first-line supervisors of construction and extraction workers; construction trades workers; helpers, construction trades; and extraction workers. (2-digit SOC = 47)

Production (Manufacturing) Occupations include: first-line supervisors of production and operating workers; assemblers and fabricators; food processing workers; metal and plastic workers; printing workers; textile, apparel, and furnishings workers; woodworkers; plant and system operators; and other production occupations (2-digit SOC = 51)

Food Preparation and Serving Related Occupations include: chefs and head cooks; first-line supervisors of food preparation and serving workers; cooks and food preparation workers; food and beverage serving workers; and other food preparation and serving workers (2-digit SOC = 35)

Terms of Use

This work is licensed under the Web Services and API Terms of Use.

View Application

Share

Details

Size: 263 KB

API: JavaScript

Purpose: Ready To Use

★★★★★

Owner

dianaclavery_uo

Tags

occupation, counties, tracts, Extreme Heat, at risk, vulnerable, American Community Survey, agricultural workers, construction workers, extraction workers, food preparation workers, kitchen workers, production workers, manufacturing workers

Credits (Attribution)

US Census Bureau's 2011-2015 American Community Survey, Table C24010.

URL

http://urbanobservatory.maps.arcgis.cc

View

Six Tips to Document Your Item

1 Document as you work.

It's part of the process when publishing a layer or web map from ArcGIS Pro, as you're prompted for the basics such as title, tags, and summary before your item even exists in ArcGIS Online. Similarly, when creating a new item or adding an item from your computer, you are prompted for tags and a summary. You could skip this step in the moment, but by filling it out immediately, you will avoid having to go back and do it later. If you're unsure of what your final title or summary will be, that's okay. You can always edit it later.

2 Cite the original data source in the Credits (Attribution) section.

Be a responsible data user. Give credit where credit is due. Doing this makes your item look more trustworthy. Providing a link to the original data source in the Description section could inspire other users who want to build on your work. Besides, including the source moves that scoring bar toward the high end.

3 Think of someone who comes across your item online.

What information would you need to tell that person about your work? Why is this item valuable? Is there jargon or acronyms that are obvious to you that may not be so obvious to a lay audience? Are there any acronyms that you can spell out in the description? Are there any field definitions or data footnotes that should be noted?

↑ The Details page for this tabbed story uses the same colors used for each tab in the map for the description of each tab's content.

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4 Choose effective tags that make your item discoverable.

What question does your item answer? This can be a great place to start thinking about tags. For example, my map on the teen employment rate answers questions about youth, the workforce, labor supply, and even policy—those are all great tags. There might be reasons to use the geography level, such as census tracts or counties, as tags. Similarly, there might be a reason to include the source as a tag.

Review any tags that have been automatically generated. If you've performed analysis or geoenrichment, you will have automatically generated tags such as analysis result or enriched layer. While these tags are often helpful to the map author, they are not helpful to the viewer of the final web map or app, so delete them as appropriate.

5 Take the time to make a nice thumbnail.

This is especially important for top-tier content that you share publicly. A picture is worth a thousand words, right? For best results, the thumbnail should be 600 by 400 pixels.

6 Use markup, formatting, indentation, color, and images to your advantage.

It's easy to change the color of text in the Description section so that it can match your legend, or even add images.

Let's look at some tips for web maps, apps, and story maps.

Web Maps

My web map, What Are Children's Living Arrangements?, displays the predominant type of family by state, county, and tract. By taking a screenshot of this map with an open pop-up, hosting it as an image, and using it in the description, I can communicate the legend and pop-up information at the same time.

Apps and Story Maps

Occupations Vulnerable to Extreme Heat, a tabbed story map, shows four different categories of workers, one tab for each category, and then a final predominance map showing all four. The app's Details page uses the same color map as the ones used in the map for the details about each occupation category, with links to the authoritative source on occupation definitions.

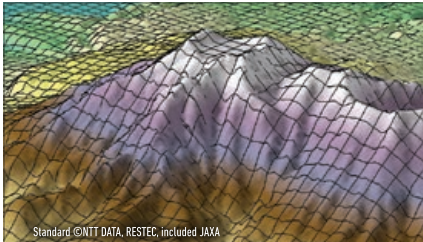
More Reasons to Love the Details Page

Up until now, I've discussed only the Overview tab. There's also a Usage tab that lets you track the number of views your item is getting. The Settings tab lets you turn on delete protection, mark the status, set the extent, and control the user experience for your item. For layers, a Data tab and Visualization tab let you do some quick checks without having to open the layer in a map. All the metadata on the Details page helps you as the item's creator and helps others collaborate across the entire ArcGIS platform.


For more information, visit the ArcGIS Online documentation topic "Item details."

About the Author

Diana Lavery loves working with data. She has more than a decade of experience as a practitioner of demography, sociology, economics, policy analysis, and GIS—making her a true social science quantoid. Lavery holds a bachelor's degree in quantitative economics and a master's degree in applied demography. She has been with Esri since 2017 as a product engineer on the Living Atlas and Policy Maps teams. She enjoys strong coffee and clean datasets, usually simultaneously. Follow her on Twitter at @dianalavery.




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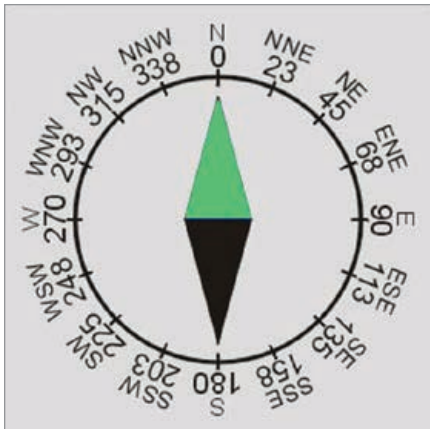
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Rotating Point Symbols in Web Maps

By Bern Szukalski



clockwise or counterclockwise, depending on how values are stored.

When rotating clockwise, angles are measured clockwise from the 12 o'clock position. When rotating counterclockwise, angles are measured counterclockwise from the 3 o'clock position.

Symbol Rotation Exercise

To follow along with this exercise, download the CSV file at <https://bit.ly/2NZbEd2>.

It includes webcam locations (these are dummy locations, not actual locations) as well as the direction the camera is pointing expressed as clockwise compass azimuths.

Step 1: Inspect the data.

Open the file using Microsoft Excel, Notepad, or another text editor. Note that the file contains locations in latitude-longitude and a direction that will be used to rotate the symbol.

↓ Under Change Style, click Symbols and choose an arrow. Check Rotate symbols (degrees) to choose the field and type of rotation.

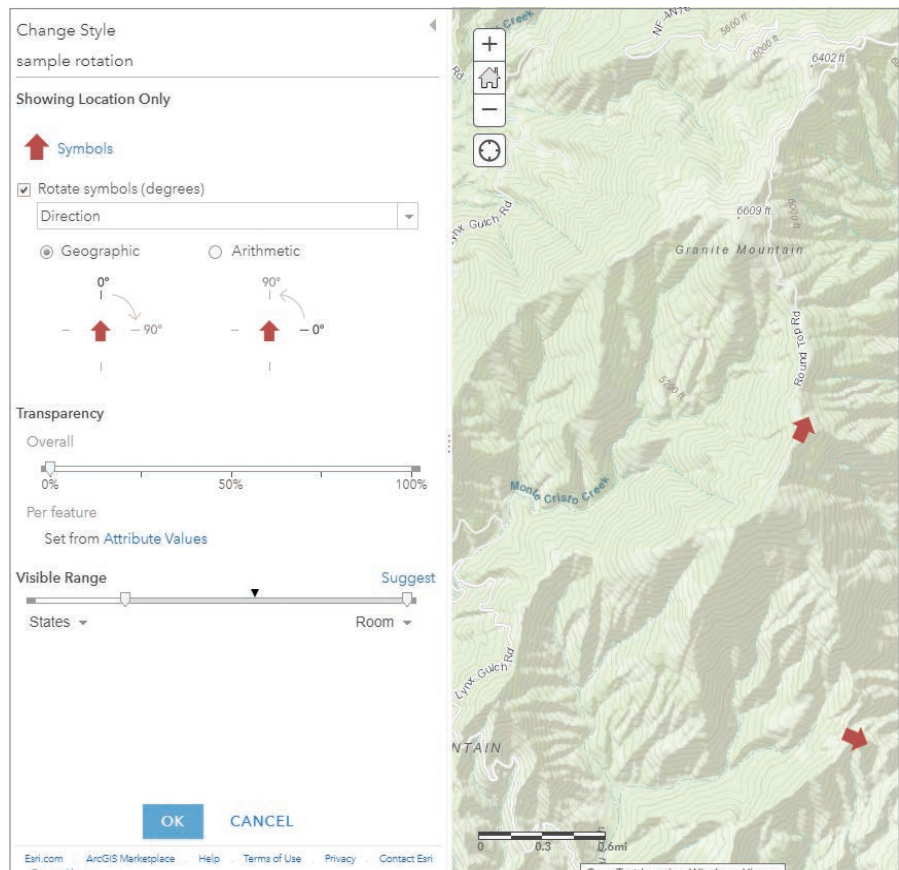


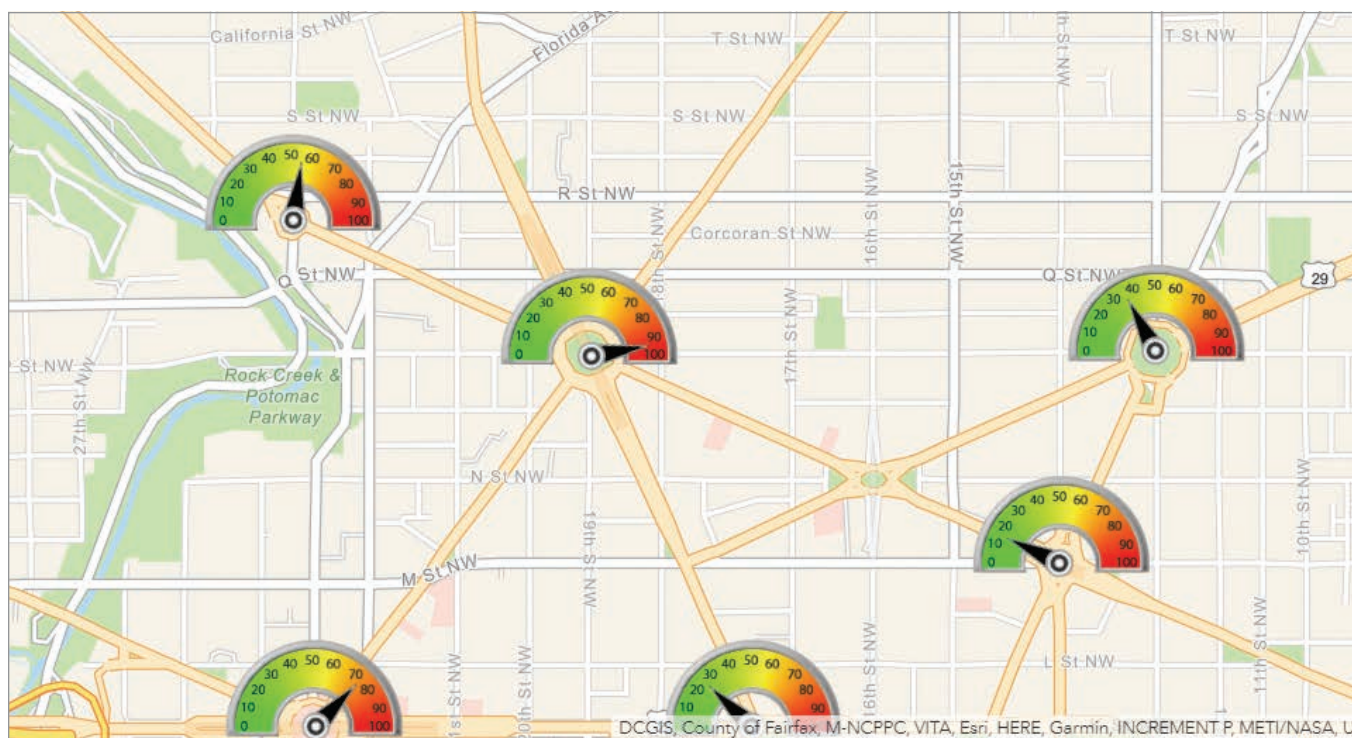
↑↑ Compass direction values are often used for rotating point symbols.

↑ Rotation angles are measured differently for clockwise and counterclockwise. Clockwise starts from the 12 o'clock position. Counter-clockwise starts from the 3 o'clock position.

Symbols can be rotated based on a numeric value. This is useful for showing which way a camera is pointing or a car is moving or the wind is blowing. To use rotation when displaying symbols, the data must have a field containing values that will be used for rotation.

Typically, those values are compass direction with clockwise values of zero at north, 90 at east, 180 at south, and 270 at west. Compass azimuths aren't required for rotating symbols. You can use any value that makes sense for your needs. You can set the rotation angles to be measured





↑ Symbols can be stacked to create a gauge and dial, using the symbol rotation to move the needle on the dial.

Step 2: Add the data to your map.

Add the CSV data to a new map. You can drag the file onto your map or choose Add > Add Layer from File.

Step 3: Change the style of the locations.

When you add the CSV file in the previous step, Change Style automatically opens. Choose Show location only, then click Options.

Step 4: Change the point symbols.

Click Options and then Symbols to change the point symbols. Choose an arrow symbol from the Arrows category. Since the rotation is stored as compass directions with zero pointing north (up), choose an arrow that points up. Change the symbol size as desired, then click OK.

Step 5: Rotate the symbol.

Check the Rotate symbols (degrees) box. From the drop-down, choose the field containing the values used for rotation. In this case, the field is Direction. The values are

already stored in the expected clockwise format described above, so Geographic (the default) is the correct rotation option. Save your style changes when finished.

Step 6: View the map.

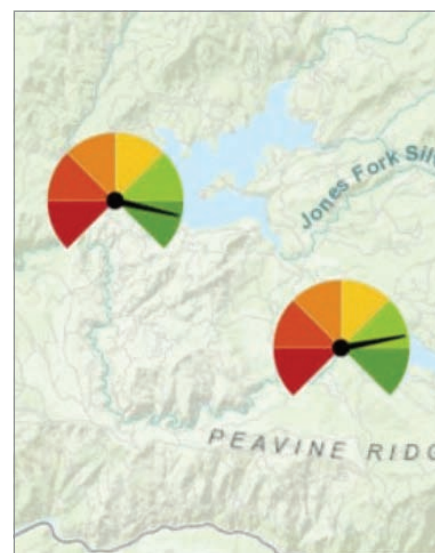
The map now displays the camera locations with the arrow rotated to show the direction of each camera.

Other Examples

Rotation can be applied to any feature layer in your map. Symbols can be stacked to create a gauge with a dial. Symbol rotation is used to rotate the dial. For more information, see "Creating dials and gauges using stacked symbols and rotation" (<https://bit.ly/2T1cel3>).

ArcGIS Arcade is an expression language built into ArcGIS Online that you can use to rotate symbols. For more information, see "Using Arcade to rotate symbols in web maps" (<https://bit.ly/2Xacg3C>) and the Arcade documentation.

For more information, see the "Change style" topic in the ArcGIS Online documentation.



↑ ArcGIS Arcade, an expression language, can also be used to rotate symbols. The dials are rotated to show reservoir capacity.

About the Author

Bern Szukalski is a tech evangelist and product strategist at Esri, focusing on ways to broaden access to geographic information and helping users succeed with the ArcGIS platform. On a good day, he is making a map; on a great day, he is on one. Follow him on Twitter @bernszukalski, or send him email to bszukalski@esri.com.



A Gentle Introduction to Spatio-Temporal Statistics

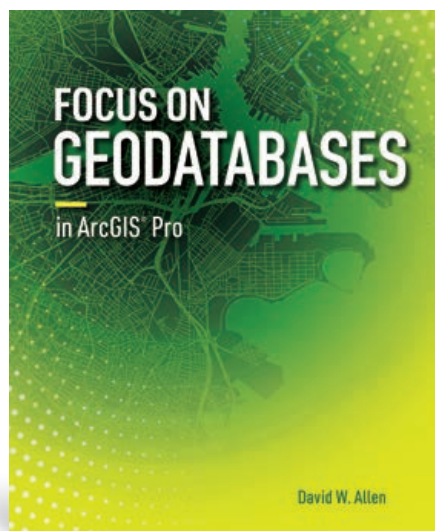
The dynamic nature of our world is being increasingly captured by sensors as big data. Much of this big data can be indexed by its spatial location and time stamp. *Spatio-Temporal Statistics with R*, by Christopher K. Wikle, Andrew Zammit-Mangion, and Noel Cressie, provides an accessible introduction to analyzing spatio-temporal data using the programming language R.

The format for each of its stand-alone chapters is an explanation of methodology followed by hands-on application of relatively mature models and methodologies. R was chosen because it is open source, has strong community support, and has many packages that can be used for spatio-temporal modeling.

This book assumes that readers have a background in calculus-based probability and inference and are comfortable with basic matrix algebra representations of statistical models. However, to support those with a less robust background in these subjects, technical notes throughout the book provide short reviews of these methods and ideas, and the appendix contains a brief refresher on matrix algebra. The exercises in this book assume prior knowledge of R and familiarity with Tidyverse, a collection of R packages designed for data science. To further aid with the exercises, helpful R tips have been included.

Spatio-Temporal Statistics with R is a down-to-earth and engaging introduction to the topic, rather than a comprehensive book on the subject. More advanced and technically trained readers may wish to look at a previous book on the same subject by authors Wikle and Cressie, *Statistics for Spatio-Temporal Data*; however, this book does not include software or coding examples.

Since increasing the number of people who are analyzing spatio-temporal data was a fundamental goal of the authors, a PDF of the entire book is available at <https://spacetimewithr.org/>, with support of the book's print edition publishers. The hardcover edition of this book was published by Chapman and Hall/CRC as part of The R Series in 2019, ISBN 9781138711136.



Geodatabase Best Practices Using ArcGIS Pro

Focus on Geodatabases in ArcGIS Pro, by David W. Allen, introduces readers to the geodatabase, the comprehensive information model for representing and managing geographic information across the ArcGIS platform. Allen steps readers through the process of creating the logical model, or schema, that is the foundation of a geodatabase; building and populating a geodatabase; extending data formats; creating and editing features; and working with topology. Each chapter includes not only an explanation of concepts but also hands-on, step-by-step tutorials; "Your Turn" sections; and study questions. An independent project reinforces these concepts. Each chapter emphasizes best practices in designing and implementing geodatabases to maximize efficiency and maintain data integrity while minimizing error and frustration.

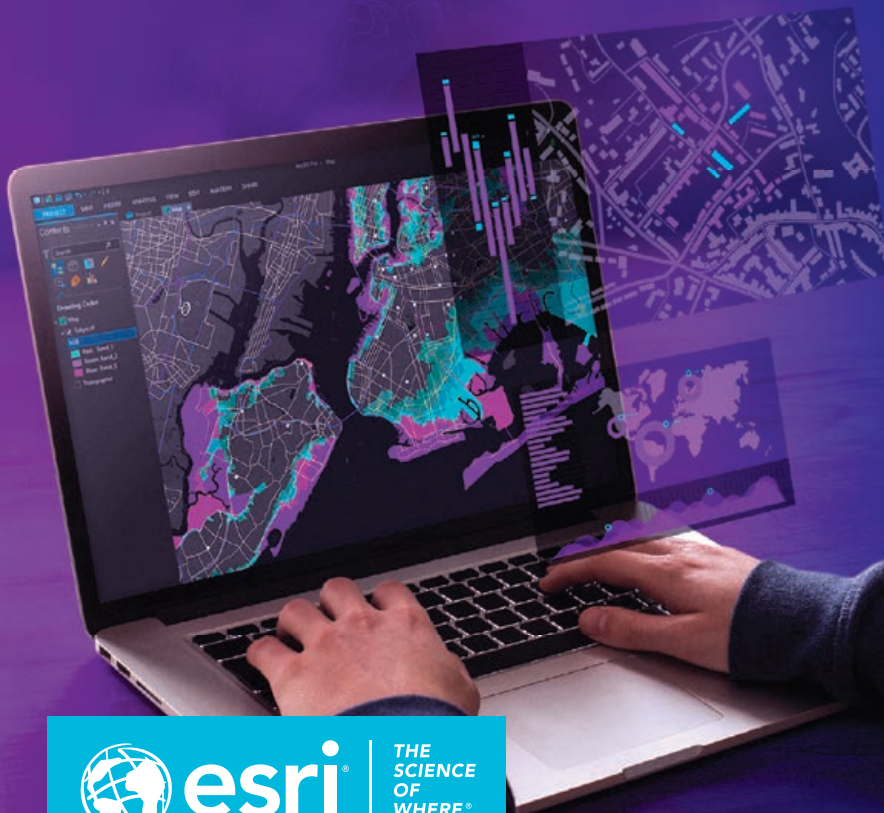
The author has been working in the GIS field for more than 35 years. For the last 30 years, he has worked for the City of Euless, Texas. He spent 18 years as an adjunct professor at Tarrant County College in Fort Worth, Texas, and now serves as the state director of operations for a volunteer emergency response group, developing databases and templates. Allen is the author of *GIS Tutorial 2: Spatial Analysis Workbook* (Esri Press 2016) and is a past contributor to *ArcUser* magazine. Esri Press, 2019, Print ISBN: 9781589484450.



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Lidar Shines in Northern Nevada

By Jay Johnson

Turning a terabyte (TB) of lidar data into ready-to-use GIS products can be quite challenging. In this article, I share the strategies I used to transform lidar data into GIS products to benefit Washoe County, Nevada.

In 2017, the United States Geological Survey (USGS) 3D Elevation Program (3DEP), in cooperation with the Nevada Bureau of Mines and Geology (NBMG) and local cooperators, flew a lidar mission to collect quality level 1 (QL1) and quality level 2 (QL2) LAS data across more than 1,500 square miles covering Reno, Sparks, Carson City, and surrounding areas in northern Nevada. Local cooperators included the Washoe County Regional Basemap Committee (Washoe County, City of Reno, City of Sparks, and NV Energy), US Forest Service,

Lyon County, and Storey County.

Deliverables for this project included classified LAS files, hydro-flattening break lines, digital elevation models (DEMs), digital surface models (DSMs), and intensity rasters. This project marked the first time the region has had such extensive lidar coverage, and the data received came with much promise as well as a number of challenges.

Moving Mountains of Data

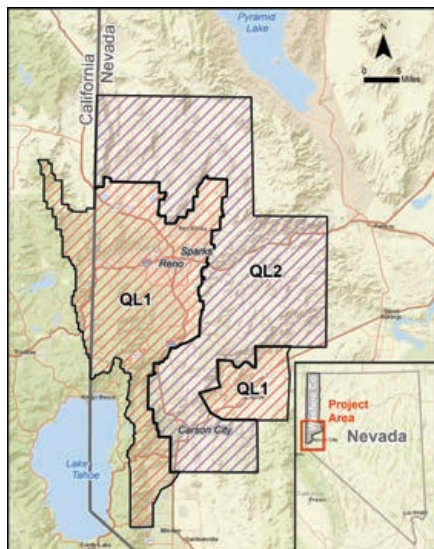
In July 2018, the data—2,025 QL1 and 2,478 QL2 LAS files totaling 27.9 billion points—was delivered to Washoe County's GIS program via a 1 TB external USB drive. It took a few weeks for network staff to make enough space available on Washoe County servers. At every step along the way, finding additional space for temporary files and managing intermediate products was a challenge. More than once, a batch process failed when it ran out of disk space.

One of the functions of Washoe County GIS is to respond to data requests. When engineering companies learned about the new lidar data, the county began getting requests for copies of the LAS files.

The lidar data was organized arbitrarily into 1,000-meter by 1,000-meter tiles that did not match the county's township, range, and section (TRS) boundaries. Since TRS boundaries are typically used to locate an area of interest (AOI) for routine data requests, staff had to determine the specific LAS files that intersected the AOI

a customer had requested and then copy those specific files.

To reduce this overhead, the county encouraged customers who were likely to make multiple data requests to bring in an external USB drive and get a copy of the entire dataset. A spare PC was dedicated to the hours-long copy operations so they wouldn't interfere with other work. However, there is a certain level of risk when connecting external hardware into any network.



← The project area included northern Nevada's three largest cities—Reno, Sparks, and Carson City—as well as areas of interest to federal agencies and other local cooperators.





← These contours, generated directly from the LAS files, are overly angular and do a poor job of representing the essential character of natural landscapes.

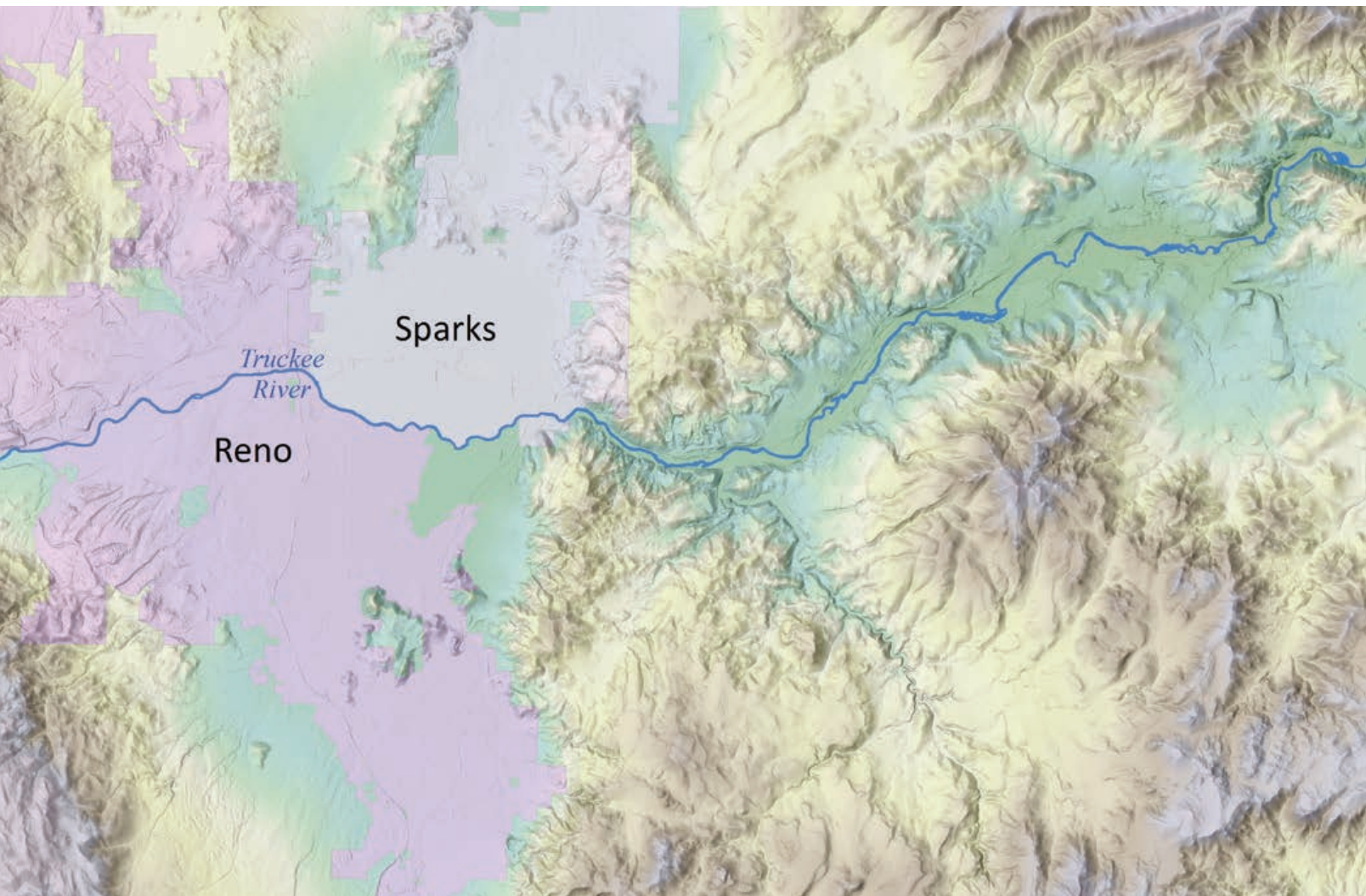
Organizations with prohibitions against this would need other solutions for making the data publicly accessible.

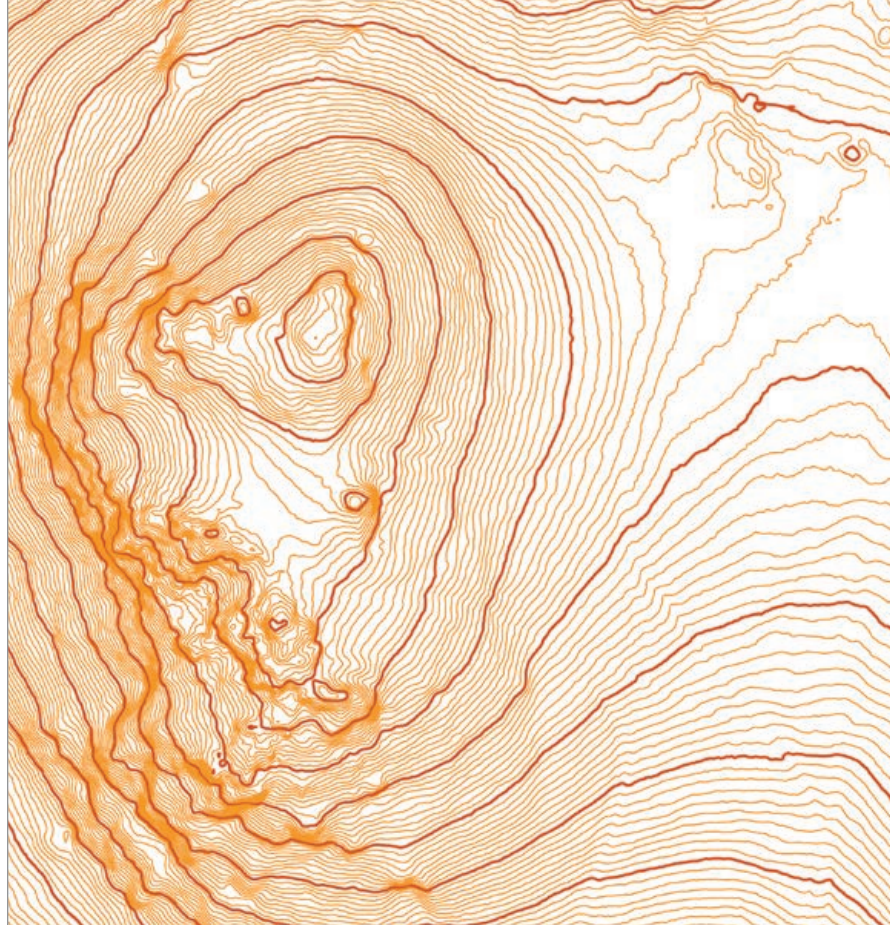
Creating Derivative Products

While many engineering firms are quite happy to deal with LAS point clouds (and may even prefer them over contour lines), plenty of users still need traditional contours. Producing contours from lidar data is nothing new, but there are a few steps in the process that can trip the unwary.

Typically, lidar-derived contours appear noisy or jagged, which some users find objectionable. Instead of creating contours directly from the LAS dataset, it's better to create them from a lidar-derived DEM. This introduces thinning and averaging into the process, resulting in better looking contours. (See ArcGIS help topic "Minimizing

↓ This elevation-tinted, multidirectional hillshade shows the Truckee River meandering through Reno and Sparks and clearly illustrates the dramatic mountain landscapes on all sides.





← Creating one-foot-interval contours from the lidar DEM minimizes high-frequency noise that is common in lidar data, producing contours that are aesthetically pleasing.

which to create contours, a mosaic dataset was built that referenced the DEM rasters for the QL1 and QL2 areas. Both QL1 and QL2 support a one-foot-interval contour.

A model, built using ModelBuilder in ArcGIS Pro 2.3, iterated through all section tiles and produced contours for each one. One big gotcha in this process: a single snap raster [which is used to align the cells of the output raster. Snap raster is set in the model's Environment Settings] must be used for all the contouring operations. If this isn't done, small differences in contour polyline outputs will result in edgematching errors between sections.

During the contouring operation, the output was reprojected into the State Plane Coordinate System used by Washoe County GIS. A z-factor of 3.2808 was applied to convert elevation from meters to feet. Because the contour operation created polylines within the minimum bounding box of the processing extent polygon, each contour feature class was clipped to the exact boundary of each section polygon to prevent overlaps in polylines between adjacent sections. Additional postprocessing included classifying the contours as either Index or Intermediate and exporting the finished contours to shapefile format for easy distribution.

Referenced Mosaic Datasets and Elevation Profiles

After creating a referenced mosaic dataset from the QL1-QL2 DEM, a multidirectional hillshade function was used to create a highly detailed hillshade for the entire project area. When set to 30 percent transparency and displayed over an elevation raster of the same DEM, this mosaic will improve Washoe County's cartographic products.

Elevation profile charts are also easily derived from the DEM. By interpolating popular hiking trails to a 3D line using the DEM as an elevation source, a profile chart of the elevation gain along the trail can be created. This information can easily be made available to the public to help them make appropriate choices based on the level of hiking challenge desired.

noise from lidar for contouring and slope analysis" for more information.)

Contours created from lidar tend to have an excessive number of vertices, which can lead to large shapefiles. Decisions in the data processing chain must balance accuracy preservation against the practical considerations of data storage and distribution. DEM tiles could have been created from the LAS data, which would have allowed smoothing and thinning to be

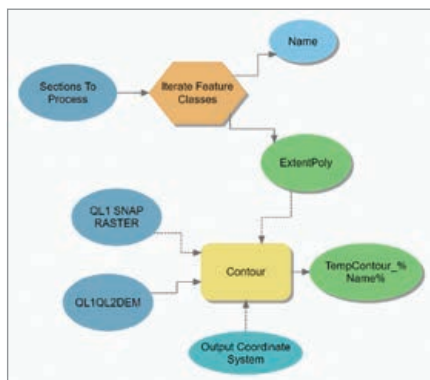
controlled to create a smoother DEM and more generalized contours with fewer vertices. However, by using the DEM tiles from the vendor, data manipulation was kept to a minimum and the output stayed true to the source data.

Repeat after Me, "Iteration Is Your Friend"

The amount of lidar data precluded processing the dataset all at once. Instead, a separate feature class of one-foot contours was produced for each of the more than 1,500 TRS sections covered by the lidar data. Significant portions of the lidar footprint extended beyond Washoe County's boundary and fell outside the section grid typically used. The Bureau of Land Management (BLM) cadastral reference grid (Public Land Survey System [PLSS] First Division) was used to build a polygon layer covering the entire project footprint.

Irregular BLM section boundaries left gaps between some sections. Nevada's "wide open spaces" have resulted in some strange PLSS boundaries. Editing the section boundaries ensured that all areas in the project had complete contour coverage. To create a single, seamless DEM from

↓ ModelBuilder was crucial to efficiently iterating through the data to create contour shapefiles for each of the more than 1,500-square-mile sections in the project area.



Roof Lines and 3D Buildings

Washoe County GIS traditionally maintains building footprints by heads-up digitizing from orthophotos. Lidar now provides an opportunity to not only update building footprints but also venture into the world of 3D buildings by creating 3D buildings for an area of suburban development where construction of new homes was in progress and for downtown Reno. There were no preexisting building footprints. The multipatch buildings were derived completely from lidar. The initial results are promising.

Science as Art

As a final example of the uses of lidar data in ArcGIS Pro, a 3D point cloud scene of downtown Reno was created. The lidar points were symbolized by elevation and modulated by intensity. Elevation shifts were symbolized from blue to green as elevation increased. Adding the modulation brings out contrasts in surface materials by increasing the brightness of high-intensity returns and reducing the brightness of

low-intensity returns. This technique lends the scene an almost photographic quality. This high-tech art was professionally mounted and framed and now decorates Washoe County's IT conference room.

Some Final Thoughts

There is plenty of value still to be extracted from the lidar data. Some of the potential tasks include merging the contours into a seamless dataset and creating simplified versions for use in web applications. I've barely scratched the surface of 3D visualization. Once I've finished generating the basic multipatch buildings, I look forward to adding textures to create more realistic 3D scenes.

Washoe County's experience as a cooperator in the 3DEP program has been very positive and allowed the county input to the final coverage area, a chance to review the pilot project deliverables, and quick access to the final data—all for a relatively modest financial contribution. If your community has the opportunity to participate

in a 3DEP project, I heartily recommend taking it.

For more information, contact Jay Johnson, Washoe County GIS, jjohnson@washoecounty.us.

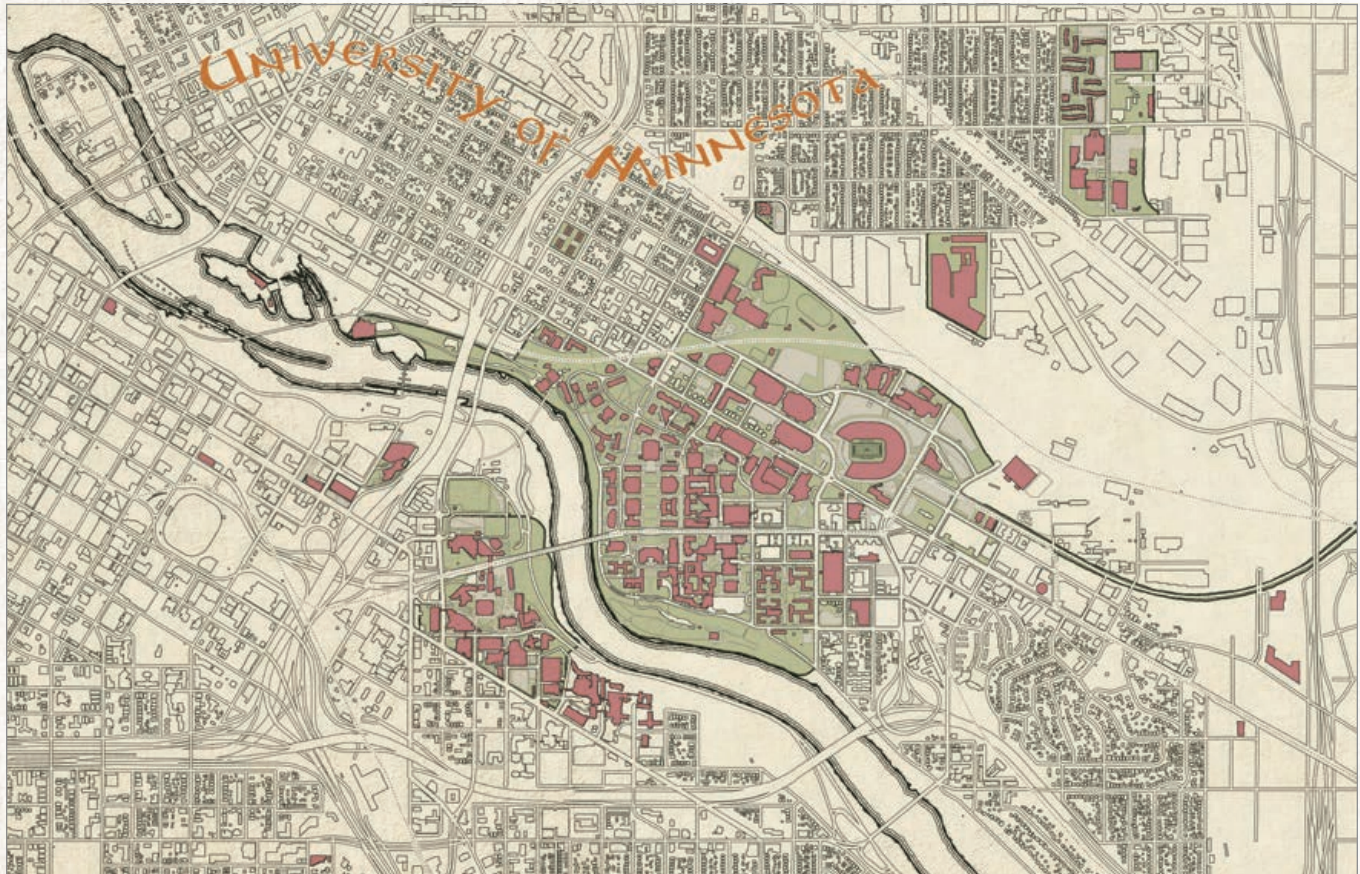
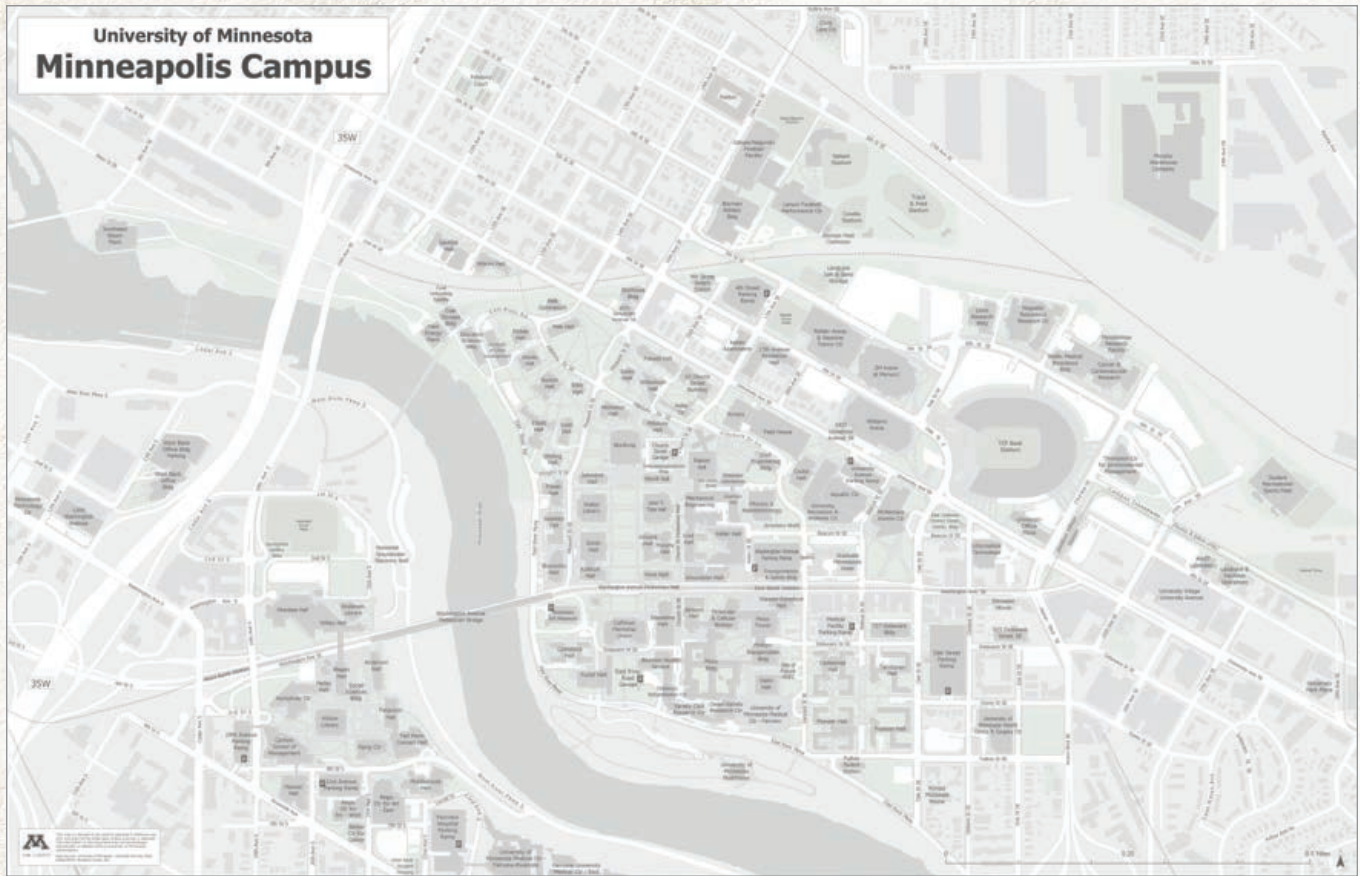
About the Author

Jay Johnson, a technology systems developer II, provides spatial analysis and visualization for Washoe County, Nevada, with an emphasis on emergency services and mobile data collection. He is happiest when hip deep in data and experimenting with new visualization techniques. Johnson received a master's degree in engineering (GIS) from the University of Colorado in 2002 and holds a Certified Mapping Scientist certification from the American Society for Photogrammetry and Remote Sensing (ASPRS).



↓ Scripts and tools from [ArthursLidarBuildingExtractionTools_10_04_2018.zip](#) were used to create 3D buildings in downtown Reno. Read "Arthur's Feature Extraction from LiDAR, DEMs and Imagery" by Arthur Crawford on GeoNet.





I decided I would allow myself an hour to generate each first draft—a time frame that would have been impossible for me to follow without the ability to apply existing styles. The MOOC had also given me the foundation to more adeptly navigate ArcGIS Pro, including working with the Symbology pane and layouts. On a deeper level, the MOOC also reinforced the idea of not accepting program defaults. This is something I already knew but that was easy to lose sight of when making similar maps all the time.

I first chose the Lord of the Rings-inspired My Precious style. I started with this one because I love fantasy novels. Who wouldn't want to see a Tolkienesque campus map?

Ultimately, I did not select this style because campus maps tend to be label heavy. After experimenting with labeling our campus buildings, it looked a bit crazy. Through the blog post, I learned that Nelson used the Aniron typeface on his Lord of the Rings-styled maps, so this is what I tried. It's such a cool look but way too intense for labeling buildings.

The following week, I made a campus map using the New Amsterdam style. I loved the clean lines and colors of this style, but in the end, it didn't work for me because labeling black buildings against a lighter background was too complicated. Label hardships strike again!

Next, I tried the Watercolor style. I enjoyed experimenting with it. However, the Watercolor style didn't feel quite right, particularly

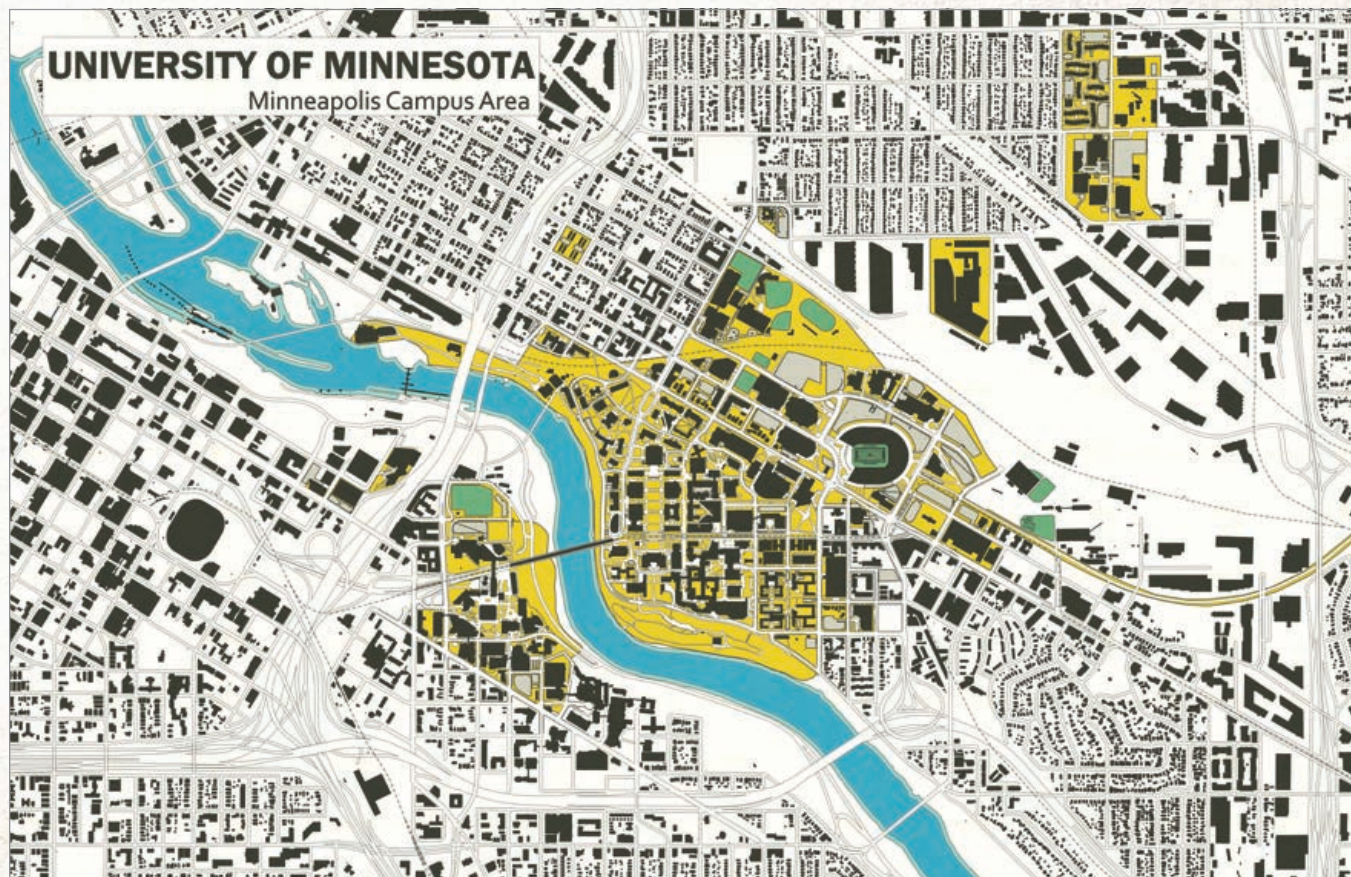


↖ This map, with the same extent and data as the George Washington-styled map, is typical of the type the mapmakers at the University of Minnesota make.

↙ My attempt at labeling a My Precious-styled map flopped.

↑ The My Precious-styled map wasn't selected due to difficulties in labeling using a suitably Tolkienesque typeface.

↓ The New Amsterdam-styled map was not chosen because labeling it would be difficult, especially against black buildings.



➤ Decorative elements were lifted from the original George Washington map that was Nelson's inspiration.

➤ The label for the Mississippi River is an example of Davison's Old_Ink_Font that I incorporated into the George Washington-styled map.

because the lines of the road and building edges looked too squiggly. I couldn't quite picture how the labels would work for this style.

It was fun to see our campus represented in such distinct styles: from fantastic to vintage to artistic, but finally, I stole the George Washington style. I thought this style had a great look for a campus map. It was very classy. I could imagine it hanging in a university office. I also felt that this style worked best with the scale and extent of the data as well as the size of the printed poster. After some initial research, I knew I could find an appropriate and complementary typeface for the labels and that they would be readable. For these reasons, this style was the winner out of the four that I tried.

Now that I had selected the style I wanted to use for the final map, it was time to add labels and the finishing touches. On the Library of Congress website, I found the original George Washington map that Nelson used as the inspiration for his style. I downloaded high-resolution clips of the north arrow and title area and then used Adobe Photoshop to lift those elements and add them as images to my ArcGIS Pro map.

For the labels, I found some old-timey-looking typefaces online, but they still looked too computer generated with a normal fill.

➤ Labeling was, once again, an issue for the Watercolor-styled map.



I needed some way to soften the edges. Some style hacking did the trick. I took the `BoundaryGradientOutlineFill` symbology from Nelson's style, changed the tint of the fill, reversed the order of the symbol layers, saved this reconfigured style, and used it as the polygon fill for my labels and other map text.

Stealing Nelson's style paved the way for my new life of crime. I also stole the `Old_Ink_Font` from cartographer Warren Davison, whose work was featured in Nelson's blog post "Not-So-Historic Survey Plan." This font is available for download from ArcGIS Online. I used Davison's font for the Mississippi River and a few other labels.

My boss and I sent a copy of the map to Swanson, who was thrilled with my vintage-looking map. He immediately went to IKEA to buy a frame for it (even though something antique and gilded might have looked better). This was a fun project for me. Next up: learning how

to create my own styles from scratch. (Mr. Nelson: a blog post with tips, please.) I am inspired to take the rest of our campus maps to the next cartographic level, too!

About the Author

After earning a master's degree in geography and a GIS certificate from City University of New York (CUNY) Hunter College, **Livia Betancourt Mazur** held GIS positions at the National Geographic Society and the New York City Department of Transportation. She currently works at the University of Minnesota. She has found that doing GIS work in such diverse environments has been both fun and challenging. When not at work, she enjoys reading sci-fi and fantasy novels, taking dance classes, and dabbling in interior design. She dreams of having a hobby alpaca farm one day.

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The only difference is that everything is done online. You will need to run an exam simulation to get familiar with the online testing environment and verify that your system meets the requirements. You must have access to a webcam and a private work space where you can take the exam. The work space should be free of distractions, notes, and any exam preparation materials. The proctor will use the webcam to visually scan your space before the exam starts.

Once you verify that your system meets the requirements, you can schedule a date and time for your exam on the Pearson VUE website and create a Pearson VUE login if you don't already have one. In some cases, a same-day appointment may be available.

On test day, you'll log in to Pearson VUE, select your exam, and proceed through the self-check-in process, then wait in the lobby for a proctor to connect with you. Once connected, your proctor will guide you through the process and launch your exam.

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GE●DESIGN TAKES ROOT

By Carla Wheeler

COMPARED TO the Esri User Conference—a big, bustling event about all things GIS that draws about 18,000 attendees annually—the Geodesign Summit is a small, understated affair. At this year's summit, held February 25–27, 2019, at Esri headquarters in Redlands, California, 225 people from 18 countries congregated to share geodesign projects and learn about geodesign concepts, methods, and technology.


While some commonalities exist between geodesign and GIS, there are differences, too. Geodesign combines the art of design, the science of geography, and input

from stakeholders to find the most suitable, sustainable, and environmentally friendly options for using space. That may be space for wildlife conservation, agriculture, development, transportation, and marine protected areas—to name a few examples.

Esri president Jack Dangermond, who earned a master's degree in landscape architecture from Harvard University's Graduate School of Design, has been a strong proponent of geodesign for years, helping organize the first Geodesign Summit in 2009. In marking the event's tenth anniversary, Dangermond said the practice is finally taking root in academia,

urban planning, conservation, some parts of government, and other areas.

"This idea of geodesign is becoming a movement, [though] it's subtle and in the background," he said in opening the 2019 Geodesign Summit. According to Dangermond, geodesign is part and parcel of the digital transformation that includes big data, artificial intelligence, the Internet of Things (IoT), and Web GIS. He urged audience members—many of whom were design or GIS professionals—to put their creative and technical talents to work to take on big issues such as climate change, sustainable development,



← A double-crested cormorant spreads its wings from the perch of a submerged sabal palm in the Rainbow River, which flows 5.7 miles from its headspring in Rainbow River State Park in Florida. Photo courtesy of Carlton Ward Jr.

and conservation, especially as the world population grows and resources become strained.

"The pace of change is accelerating at an exponential rate of growth. In some ways, it's threatening our natural world," Dangermond said. "We may not make it. That's why this meeting is so important. We need to grasp the problem and formulate action. You as human beings are the treasures here and not the technology. But we need to embrace digital transformation and leverage geospatial science to do geodesign."

While the creative aspect of geodesign is important, it's only one side of the coin. The other is what Dangermond calls the "geospatial infrastructure," meaning the content, services, and the GIS tools for mapping. Bringing *geo* together with *design* opens possibilities. "Applying the power of digital geography [*helps us*] envision what's possible, whether it's creating sustainable developments, making cities smarter, designing with nature in mind, or protecting biodiversity," Dangermond said.

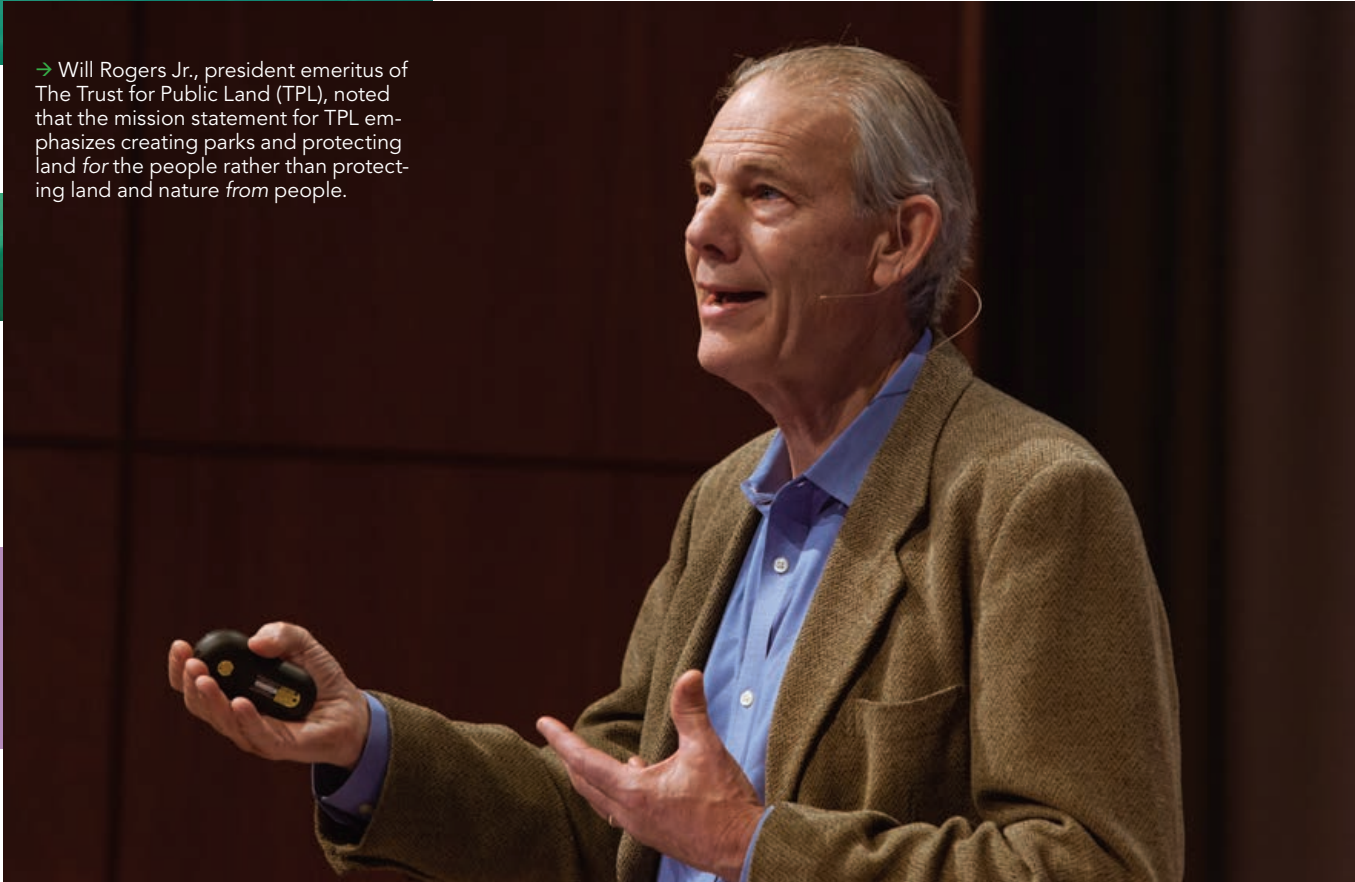
"I'm all about leveraging the power of geography to manage the world better and to make a difference."

DESIGNING FLORIDA'S WILDLIFE CORRIDOR

One person who is making a big difference is Carlton Ward Jr., an eighth-generation Floridian and conservation photographer whose work has been published in magazines such as *National Geographic*, *Smithsonian*, and *Audubon*. Ward founded Florida Wildlife Corridor, an organization that aims to protect, connect, and restore land and waterways that have been identified as conservation priorities in a green infrastructure network throughout Florida.

In his Keynote Address at the Geodesign Summit, Ward talked about how he uses photographs, videos, and maps to tell stories about what he calls "wild Florida," the ever-shrinking habitat for animals like the Florida panthers, black bears, bobcats, alligators, and birds such as cormorants.

"This is my Florida," he said as he showed photos of cowboys, oystermen, and Florida



→ Will Rogers Jr., president emeritus of The Trust for Public Land (TPL), noted that the mission statement for TPL emphasizes creating parks and protecting land for the people rather than protecting land and nature from people.



← Carlton Ward Jr., an eighth-generation Floridian and conservation photographer, said, "Without GIS, there is no context or call to action for the conservation stories I work to illuminate."

↓ Carlton Ward Jr. exploring a palm-studded tidal creek near Chassahowitzka National Wildlife Refuge during the 2015 Glades to Gulf Florida Wildlife Corridor Expedition. Photo courtesy of Carlton Ward Jr.

wildlife. Rather than go into ranching or politics, Ward became a conservation photographer. He has traveled to Gabon in Africa to study biological diversity and photograph 400 different species of animals and plants. "Working in Gabon gave me an appreciation for intact wilderness," he said. Eventually, however, wild Florida drew him home.

Ward, who has a master's degree in ecology, has kayaked, hiked, and ridden horses during two 1,000-mile expeditions throughout the state, all the while photographing the wildlife that roam and the people who work the land he holds dear. Ward has captured spellbinding

panthers. Only about 200 Florida panthers roam the state. "Wild Florida is still there, but it's hidden in plain sight, unseen, overlooked, or forgotten by most of Florida's 21 million residents and 125 million annual visitors."

Ward comes from a family of cattle ranchers and politicians. His great-grandfather, Doyle E. Carlton, was Florida's twenty-fifth governor. And his family's cattle ranch serves as a habitat for panthers and other



→ Green infrastructure tools are especially important for making land conversion and habitat loss real, both as past challenges and future threats.

photographs of panthers and black bears as they travel through protected areas, cattle ranches, orange groves, or other undeveloped private and public lands. "I can help the panther take his own picture," said Ward, who played a video of how he sets up the camera traps and then leaves his equipment behind in remote places.

During his presentation, Ward also displayed a map that traced the 500-mile journey of a bear named M34. The bear, fitted with a GPS tracking collar, traveled through south-central Florida over a two-month period. Although the animal was ultimately stopped and turned around by Interstate 4 and big housing developments nearby, Ward said the bear was able to travel that far thanks to a network of working farms and ranches that keep the public lands connected.

Ward says Florida's population increases, in net, by about 1,000 people a day. Housing for these new arrivals often gobbles up land. Ward says his organization's goal is to help grow his state's wildlife corridors and keep these areas intact so wildlife can move about unhindered and unhurt. Endangered panthers have been struck and killed by vehicles. About 30 panthers were killed in 2018.

On the brighter side, wildlife crossings have been built under some highways, allowing animals like panthers and black bears to avoid the onslaught of cars and trucks. In November 2016, Ward said a female panther traveled to an area north of Caloosahatchee River—something that had not been documented since the early 1970s. This showed a northward expansion of the panther's breeding habitat.

In a panel discussion after his talk, Ward told Dangermond and members of the audience that using imagery and a GIS framework can guide conservation stakeholders as they continue to expand the wildlife corridor. Ward is currently working on a



conservation photography project called Path of the Panther. The project collects donations to help elevate the story of the Florida panther and critical habitat needed to help save wild Florida.

Time is short, said Ward. Currently about nine million acres of the Florida Wildlife Corridor are protected, and there's an opportunity to conserve nearly seven million additional acres. "If we don't take action in the next decade, we are going to have some irreversible [environmental] damage," he said. "I am excited about the promise of the geospatial cloud to help create a universal framework and common language for land conservation and chart the course for protecting 30 percent of the planet by 2030 on the way to ultimately protecting half the planet."

GEODESIGN IN ACTION

During the three-day summit, dozens of presenters at the Geodesign Summit shared compelling stories of how they use geodesign and maps to make

better-informed decisions, often about land-use choices. They included Devin J. Lavigne, a principal and cofounder of the consulting firm and Esri partner Houseal Lavigne Associates, which specializes in urban design, community planning, and economic development. He showed how



→ A male Florida panther travels through an oak hammock at the edge of a cypress strand at Babcock Ranch State Preserve near Ft. Myers. Photo courtesy of Carlton Ward Jr.

Houseal Lavigne Associates is using Esri's community engagement software, ArcGIS Hub, and one of Esri's data collection solutions, Survey123 for ArcGIS, to gather feedback about the master plan for El Paso County, Colorado, from the people who live there.

ArcGIS Urban, a web-based GIS solution designed for urban planners that will be released this summer, was demonstrated at the Geodesign Summit. It lets planners visualize a digital twin of their community and keeps all citywide plans and projects in one place. With ArcGIS Urban, planners can create, manage, and share plans; visualize current projects; see zoning regulations in 3D; compare design scenarios; analyze the impact of their plans based on a set of built-in indicators; and engage with the public. Stakeholders, whether inside or outside of government, can share ideas about or weigh in on plans using the comment section.

Ken Schmidt, GIS administrator at the City and County of Honolulu, Hawaii, talked about doing geodesign with ArcGIS Urban. While still in development by Esri, the software is being put through its paces by several early adopters. Honolulu is using

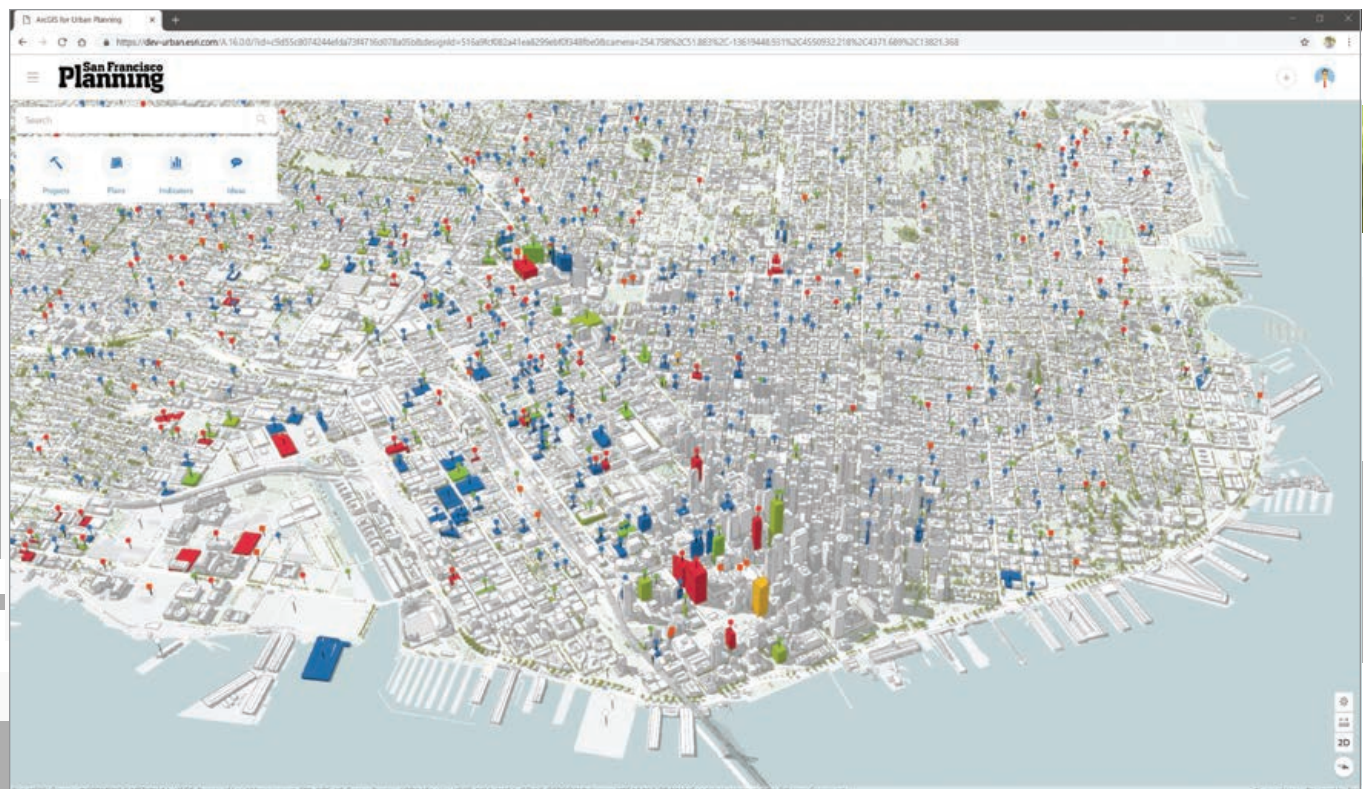
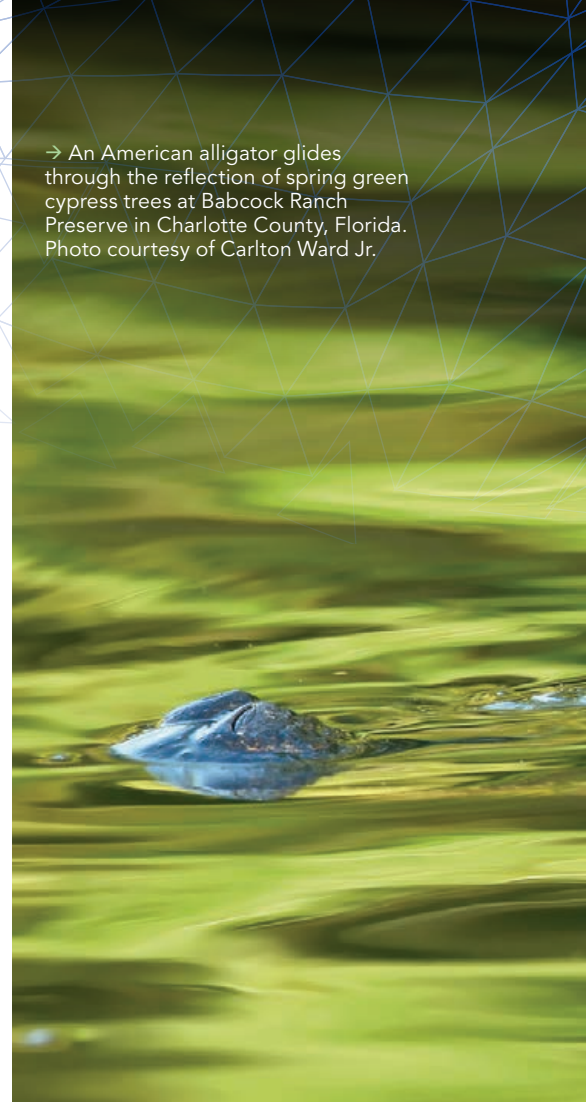
ArcGIS Urban to analyze how zoning changes in Honolulu could create opportunities for additional housing in an already highly urbanized area. Schmidt demonstrated the impact of adding five-story walk-up apartments in the Moiliili neighborhood compared to the currently permitted three-story walk-up apartments.

MAPPING LAND FOR PEOPLE

According to Will Rogers Jr., president emeritus of The Trust for Public Land (TPL), the mission statement for TPL emphasizes creating parks and protecting land *for* the people rather than protecting land and nature *from* the people. Since 1972, the nonprofit organization has worked on projects that have set aside more than 3.3 million acres for protection throughout the United States and has finished more than 5,400 parks and other conservation-related projects.

Maps have long been part of the equation to pinpoint areas that needed to be protected and decide which communities were most in need of parks. "Nonprofits like TPL exist to make a difference, and GIS has helped [the organization] make a bigger

→ An American alligator glides through the reflection of spring green cypress trees at Babcock Ranch Preserve in Charlotte County, Florida. Photo courtesy of Carlton Ward Jr.





“WILD FLORIDA IS STILL THERE, BUT IT’S HIDDEN IN PLAIN SIGHT”

difference,” said Rogers, during a talk he gave at the Geodesign Summit. “From day one, maps told the story—and Esri was a key and longtime partner and a supporter of our work.”

As GIS technology became more sophisticated, TPL brought Breece Robertson aboard in 2001 to lead its GIS program and develop mapping tools. She’s now

← With ArcGIS Urban, planners can create, manage, and share plans; visualize current projects; see zoning regulations in 3D; compare design scenarios; analyze the impact of their plans based on a set of built-in indicators; and engage with the public.

vice president and chief research and innovation officer at the organization. TPL’s tools quickly became more advanced. The organization can use GIS and demographic data to find out where parks are needed and who does not have access to them, Rogers said. For example, TPL found out that two-thirds of the children living in the city of Los Angeles were not living within a 10-minute walk (a half-mile radius) from a park.

TPL used GIS to help develop the ParkScore ranking system to evaluate how well cities are doing in providing easy access, amenities, acreage, and investment in parks for its residents. Currently,

Los Angeles has a ParkScore ranking of 66 out of 100 for large American cities, while Minneapolis, Minnesota, ranks No. 1. (See “Website Helps Discover, Explore, and Improve US City Parks” in the winter 2012–2013 issue of ArcNews.)

“None of this would have been possible without GIS and geodesign,” Rogers said.

The next Geodesign Summit will be held February 24–27, 2020 preceded by the International Geodesign Collaboration (IGC) held February 22–24, 2020. Both events will be held at Esri headquarters in Redlands, California.

Esri Corporate Headquarters

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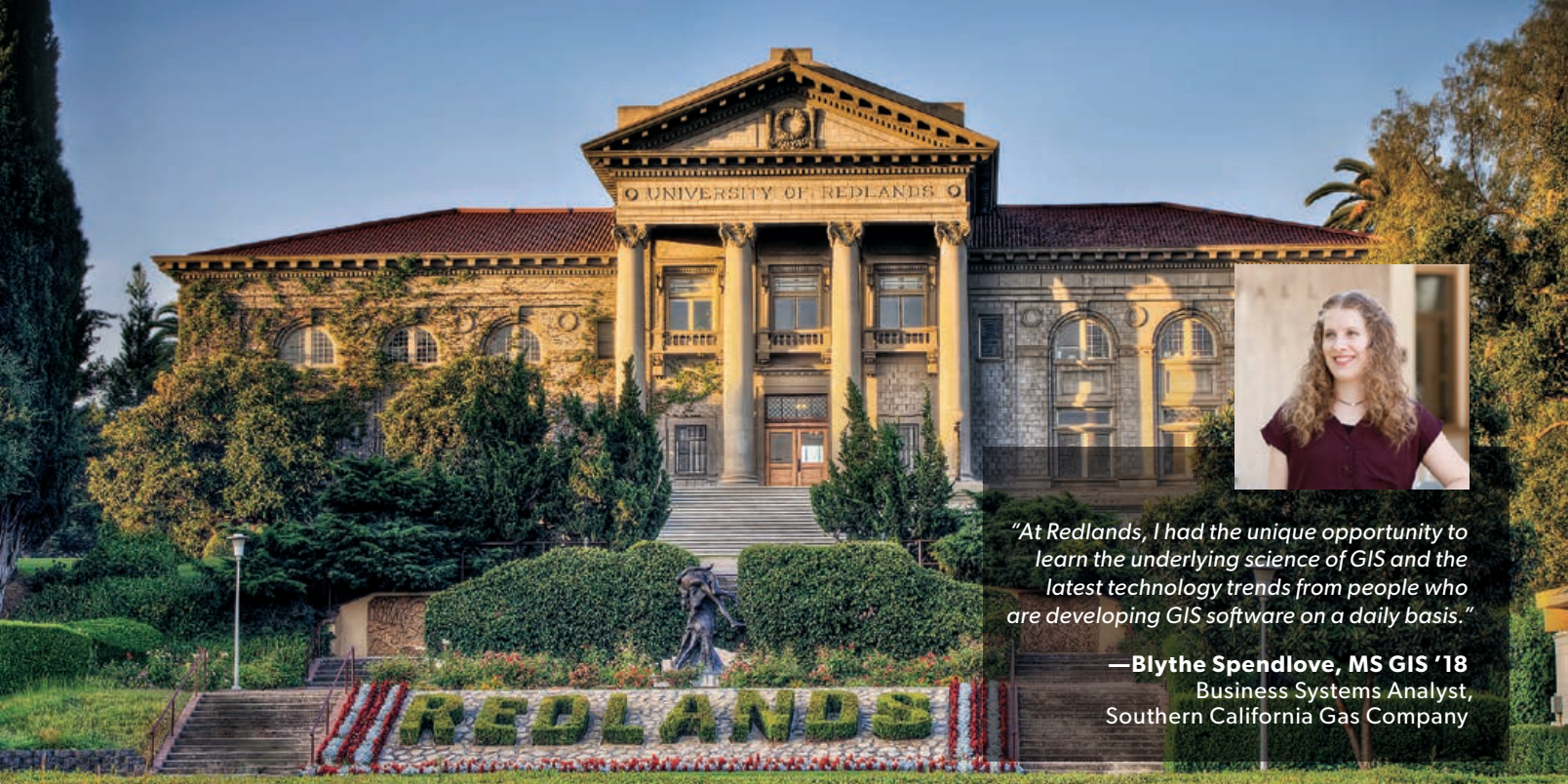
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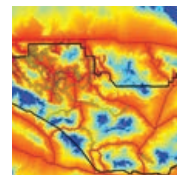
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