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Understanding Our Changing World through Web-Mapping Based Investigations

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Abstract

Maps have always been a rich source of information on a variety of topics in a medium requiring only a small amount of space. Today's web maps show more than simply the locations of physical and cultural objects. They also allow students to do more with them. They foster understanding relationships, linkages, and patterns inherent between and among such phenomena as ecoregions, land use, demography, watersheds, commerce, natural hazards, and social networks. With the evolution of today's mapping technologies into cloud-based platforms, educators and students as never before have a wide variety of data and tools at their fingertips that allow them to explore key issues of the 21st Century at scales from local to global. Students can upload their own data into these web maps alone or as part of citizen science projects, and share their maps with others in an online environment. These maps become multimedia-rich tools that students engage with while gaining critical thinking skills, career skills, and interdisciplinary content knowledge.

Keywords: Mapping, GIS, Spatial Thinking

1. Introduction

People have always been fascinated with investigating their home – the Earth. For centuries, maps have stirred imaginations and inspired explorations of the unknown. Maps are a rich source of information, showing spatial relationships between climate, vegetation, population, landforms, river systems, land use, soils, natural hazards, and much more. Maps help us investigate the "whys of where" the essence of scientific and geographic inquiry.

However, maps have never been confined to being useful solely for learning geography. Imagine an epidemiologist studying the spread of diseases, a scientist studying climate change, or a businessperson determining where to locate a new retail establishment. In each case, maps are important tools for studying these issues and for solving real problems in these disciplines. Furthermore, maps are of much greater use than simply indicating where things are. They explain far more than simply "what is where". They are keys to uncovering the reasons for the location, interaction, and changes occurring over, on, and under our planet's surface, and in addition, in social, cultural, and political networks that often cannot be seen or touched.

Maps were one of the first things that were placed on the web during the 1990s. Most of these maps were static documents that were digital versions of paper maps. However, over the past few years, maps have migrated into cloud-based environments that are running mapping services. Far from their static map predecessors, these new web maps are dynamic, customizable, and shareable. Because of these new capabilities, educators and students from a wide variety of disciplines are attracted to using them in their instruction, learning, and research. They are being used in inquiry-driven settings to foster content knowledge, the spatial perspective, and skills in critical thinking and data management that are applicable to a wide variety of careers.

2. What are web maps, and why are they important in society?

For many years, I worked in a building that housed the world's largest map collection – at the US Geological Survey's National Mapping Program in Denver. The 50 million topographic maps and thematic maps about everything from watersheds to earthquakes stored there were so voluminous that they required a seven hectare building for storage on shelves stacked floor-to-ceiling and on pallets that could only be raised with a forklift. The maps stored there represented countless hours of field and office research and production that spanned more than an entire century.

However, as rich in content as these and other paper maps are, they are limited in their effectiveness for several reasons. First, the Earth is constantly changing. These changes include those brought about by physical forces such as volcanic eruptions, river meandering, and glacial movement, and those brought about by human forces, such as urban growth and the alteration of the chemistry of the atmosphere. Still other changes result from a combination of human and physical forces. For example, soil erosion, a natural process, can be exacerbated by human agricultural practices. Coastal erosion may be hastened by sea level rise and climate change brought about by human impact on the biosphere. River flooding may be more widespread due to decades of construction of artificial levees along river banks. Second, paper maps are limited not only because the Earth is changing, but because the map themselves cannot be changed. Additional data cannot be easily added to them. Their scales, symbology, and map projections cannot be altered, and they can only be examined in one medium – by holding and viewing the paper that they are printed on.

Because of these limitations, maps have been converted for use in Geographic Information Systems (GIS) frameworks. Once in a GIS, the utility of these maps is greatly expanded and can aid in making decisions in today's changing world. These web maps are not simply digital versions of the paper they replaced, however. They are tied to rich databases containing attributes of the objects on the map. These attributes may include the real-time temperature of the wildfire at specific locations, the magnitude and depth of an earthquake that occurred five minutes ago, the dissolved oxygen in the water in a series of wells collected during a recent field study, the type of mineral being mined along a rock outcrop at a specific angle and geologic age, or the median age and life expectancy of a group of people in a specific region. These maps are also tied to powerful analytical tools. These tools allow people to perform such tasks as compute the least cost path for goods to flow from Point A to Point B, calculate the viewshed from a specific hilltop, determine how many tropical storms have passed within 50 kilometers of a specific island over the past 100 years, or calculate the mean center of a set of soil test points taken in the field.

Each one of these phenomena described in the previous section – from population to soil chemistry, from erosion to eruptions – change across space and across time. Not only these issues, but nearly all issues and problems in our world, in our regions, and in our communities, have this "change component". Change is at the heart of issues such as climate change, urban sprawl, crime, water quality, biodiversity loss, political instability, and natural hazards, just to name a few examples. This change could be measured over a few seconds, minutes, days, years, or millennia. To analyze change temporally and spatially requires maps that are dynamic. Today's decision-makers use dynamic web maps to solve problems on a daily basis. Over the past few years, these web maps have become much more than just tools on the analyst's tool belt: As more departments in an organization, such as a university, a government agency, a nonprofit organization, or a private business, realized how valuable maps and GIS were to their everyday decision making, they took steps to transform their organizations so that every department began to use the same common set of maps. As they did so, a curious thing happened: Web maps became a platform upon which organizations began to operate. And as more organizations in society began to operate this way, and as geotechnologies made their way into the everyday devices that people use, maps began to change how societies viewed and valued maps.

And because of this new paradigm in mapping, what has become of the map distribution facility where I used to work at the US Geological Survey? No surprise: Most of those maps have been sent to be recycled. In the past few years, if someone comes into the building and wants a paper map, it is printed on demand for that person from a digital file. And then in October 2013, the map store was closed, so everything had to be ordered electronically. The world has changed.

3. Why are web maps important in education?

At the same time as these societal trends were occurring, some educators and their students began to use web maps and geotechnologies to solve problems in their institutions. They no longer looked at maps as static documents that were useful only to find the locations of cities, countries, and rivers, but rather, as a part of the problem-based educational environments they were seeking to build. They found that using maps in this way was well aligned with their national educational standards and met their learning objectives (Kerski, 2003). Web maps began to be used in many subjects in which problems were being addressed and the locational component was important. These understandably included the disciplines of geography and Earth Science, but also, environmental studies, history, mathematics, chemistry, biology, literature, and other disciplines.

In addition, governments around the world have begun to recognize that geotechnologies, of which web maps are a part, are important technologies for societies to embrace. Therefore, educational institutions are being asked to educate their students in these technologies to fill the career positions in government, nonprofit organizations, academia, and private industry where they are critically needed. For example, geotechnologies were identified by the US Department of Labor (Gewin, 2004) as one of three major growth fields for the 21st Century, along with nanotechnologies and biotechnologies.

These geotechnologies are becoming increasingly difficult to ignore because they have become a part of our everyday lives. Indeed, as GPS-enabled mapping services have found their way into smartphones, tablet and laptop computers, vehicles, public transport, and many other everyday experiences, educators as never before can use common devices to open the door to these careers for their students. No longer is a dedicated computer laboratory required to teach and learn with these tools: Rather, students can bring their own devices and begin exploration right away. It should be noted that the instructor's role is still critical, however: It is the instructor that is helping guide the geographic inquiry process and preventing the process from being a random browse through data and maps. But at the same time, the instructors who are most successful with GIS are those who are open to learning the technological tools along with their students. The instructors who feel that they need to be the experts first before they can teach geotechnologies and spatial thinking to their students are hindered in their work and are not as successful (Demirci, Milson and Kerski, 2012).

Using tools in education may hasten the ability of educators to meet spatial learning challenges as identified in the National Research Council's (2006) report on GIS and spatial thinking across the primary and secondary curriculum. These tools can support standards-based inquiry-driven methods of teaching and learning, while providing basic analysis tools for exploring geographic or scientific data (Milson, Demirci and Kerski, 2012). They can be key in addressing skills identified by the Partnerships for 21st Century Skills initiative (LeVasseur, 2005) and in recommendations on the value of thinking spatially (Bednarz, 2004; Gersmehl and Gersmehl, 2006). They have also been linked to key skills essential for careers, including personal, academic, technical, and workplace competencies (DiBiase et al., 2010).

To be sure, teaching with web maps is not without its challenges. These challenges include those related to technology, to educational policy, and to society. On the technology side, challenges include the Internet bandwidth required to support dynamic web mapping through multiple browsers by multiple students working simultaneously. It also includes access to smartphones, tablets, and laptop computers. On the educational policy side, challenges include the lack of a home for "spatial analysis" in the curriculum. Inquiry-based interdisciplinary tools already have inherent difficulty finding a home. In this era of standardized testing, it is difficult to assess results from inquiry-driven methods, and consequently, those results are not as frequently tested, and those methods are not as frequently used. Geography is a natural fit for spatial thinking, but geography has struggled against competition from other subjects vying for a place in the curriculum and still regularly faces becoming reduced or eliminated by policymakers who have an antiquated or false notion of what geography is. Another problem is the lack of teachers who are trained in spatial analysis and with web-based mapping and geotechnologies. Similarly, robust bodies of curriculum based on these tools and methods and linked to national educational standards, while more voluminous than in the past, still are not in place in each country. On the societal side from parents and lawmakers are related notions that taking geography courses will not enable students to compete for the Science, Technology, Engineering, and Mathematics (STEM) positions that have received so much recent attention.

Because of these challenges, the adoption of GIS in primary, secondary, and university education proceeded at a slow pace from 1990 to about 2010. On the Rogers' (1995) diffusion of innovations curve, the educators using GIS during those two decades were the "innovators" and the "early adopters". However, a significant change occurred when GIS began to migrate to the web. The web reduced the number of barriers to educators seeking to implement spatial thinking methods and tools. No longer did they have to install software or fund, set up, and maintain a dedicated computer laboratory for this purpose. Now, the educator and student can analyze diverse phenomena – from population distribution to biomes to prevailing wind currents with an ordinary web browser.

Today, educators and their students have a wide variety of resources with which to enter the world of web mapping. Determining which resources and tools are most valuable and useful for the educational curriculum can be confusing. The following section focuses on a selected number of resources with which to start. It is not an inclusive list but is gathered from educators around the world from a study of best practices from 33 countries (Demirci, Milson and Kerski, 2012). More importantly, the following section also seeks to model for the instructor *how* to teach with dynamic web maps. It should be noted that the web maps alone do not transform education from rote memorization to grappling with problems and issues. It is the instructors who are dedicated to inquiry-driven and constructivist methods who accomplish that, modeling lifelong learning for their students. But the web maps are key tools to enable critical and spatial thinking.

4. Examining change over time using photographs and web maps

We are rapidly moving into an era where everything on the Earth that is changing, moving, or occupies physical space is monitored and imaged. Indeed, even our very homes and workplaces are becoming infiltrated with sensors of various kinds. As some of the earliest evidence of this movement, satellite images and aerial photographs are collected before, during, and after an Earth-changing event, such as a natural disaster. For example, hundreds of locations were photographed before and after Hurricane Katrina struck the Gulf Coast of the USA in August 2005. Digital Globe, other private satellite companies, the NASA-US Geological Survey's Landsat satellites, and airplanes commissioned by government agencies and private companies all collected imagery over the affected areas. These same resources make excellent teaching material to illustrate themes of coastal change and natural hazards. What makes these images even more powerful is that they are linked to specific locations on the Earth, and therefore can be mapped in the dynamic web mapping environment.

The pier, adjacent house on the beach, and the antebellum house adjacent to the beach are clearly visible in Figure 1 at Biloxi, Mississippi, taken in 1998. Figure 2 shows the same location on 31 August 2005, two days after Hurricane Katrina made landfall. As students grasp the impact that hurricanes have on people and the environment, these images can open a dialogue about natural hazards, public policy, and human-environment interaction, paving the way for further inquiry.

Educators in Geography, Earth Science, and Environmental Science have been using paper topographic maps and aerial photographs for years. Using these same resources inside a web mapping environment, such as through the use of Esri's ArcGIS Online platform (http://www.arcgis.com/home) allows educators and their students to examine local to global phenomena (Kerski, 2012).

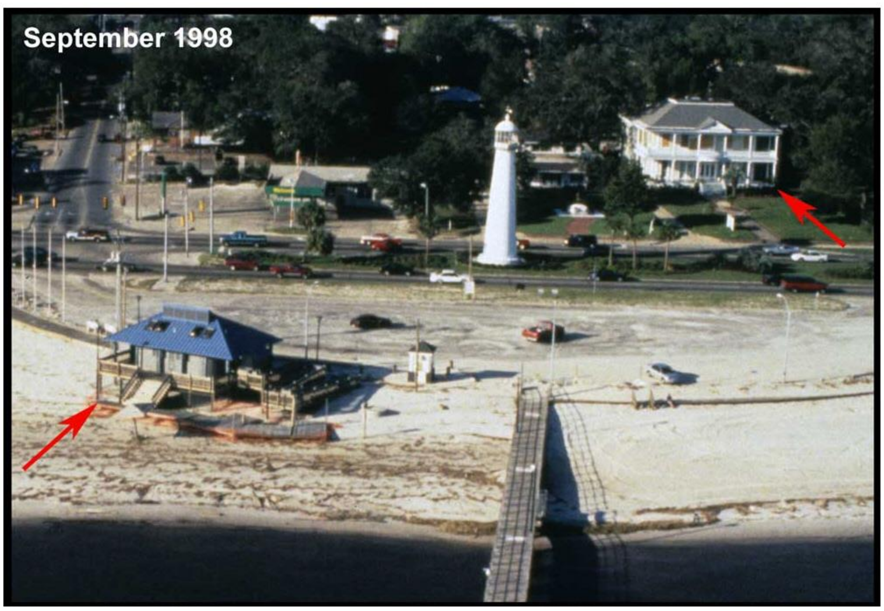

Figure 1. Oblique aerial image of Biloxi, Mississippi waterfront taken in 1998, before Hurricane Katrina. Before-and-after images can be viewed at: http://coastal.er.usgs.gov/hurricanes/katrina/.
Source: US Geological Survey.

Figure 2. Oblique image of Biloxi, Mississippi, USA waterfront in 2005, after Hurricane Katrina. Source: US Geological Survey.

They could begin by examining their school or university campus, and the adjacent neighborhoods. But they can use the same ArcGIS Online platform to examine such phenomena as where the river meanders of the Danube River flow into the Black Sea or to measure the slopes of ancient glacial lakeshores in Scandinavia versus those of North Dakota USA. They could use the same tools to assess the amount of urbanization in specific cities on every continent or measure the offsets of the rivers along both sides of the San Andreas Fault in the Carrizo Plain in California USA in a plate tectonics lesson. They could use the same tools to observe how metes and bounds survey systems established years ago in eastern North America and Europe affect current urban patterns and rural land use, compared to the Public Land Survey System in the Central and Western USA and in Canada. Working with this imagery can reinforce such content knowledge as glaciation, land use, agriculture, zoning, population, and plate tectonics.

These photographs can be added as multimedia to an ArcGIS Online map at specific points from latitude-longitude coordinates from where they were taken, or simply added in the general vicinity in which they were flown. Either way, they allow students to understand the phenomena not in isolation but in the context of their region, along with other themes represented by other map layers that can be added and analyzed in the same environment.

Because maps and images were compiled at different dates, these map layers can also be used to teach about landscape change. For example, examine the following aerial photographs from the US Geological Survey for three different years for a school in Colorado USA (Figures 3-5).

In 1995, the school appeared as two concentric circles.

The educator could ask students to determine what time of day the photographs were flown. With north at the top of each image, they can see that the 1995 photograph was flown in the morning and the 1999 photograph was flown in the afternoon.

Figure 3. Aerial photograph of a Colorado elementary school as it appeared in 1995.
Source: US Geological Survey.

Figure 4. Aerial photograph of a Colorado elementary school as it appeared in 1999.
Source: US Geological Survey.

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Figure 5. Aerial photograph of a Colorado elementary school as it appeared in 2002.
Source: US Geological Survey.

Next, the educator could ask students to determine whether the day of the photograph was a day when school was in session. School was in session during the 1999 image but not at the time of the 1995 image. Next, the educator could ask the students to determine why the 1999 image was so bright. This is because the school was under construction and renovation, and the resulting piles of soil and construction material reflected brightly in the photograph

By 2002, reconstruction of the school was complete. The school looked new. But, was it completely new, or were parts of the old building retained? Also, what happened to the trees around the old parking lot?

Students can also compare the aerial photographs to a topographic map of the same area in different periods (Figures 6 and 7).

Topographic maps are available digitally as a layer called "USA Topo" on ArcGIS Online, and also via the Libre Map Project (http://libremap.org). Topographic maps are typically older than the aerial photographs or satellite images that cover the same area, and thus the combination makes for an excellent resource to compare land use change over time. Even much older historical maps are often available online, such as those from the 19th Century from the Ordnance Survey in the UK (http://www.old-maps.co.uk/index.html).

In addition, some private companies and universities serve archives of historical topographic maps on the Internet. One such service (http://historical.mytopo.com) offers historical topographic maps for free download for much of the terrain from Maine to Ohio USA. NOAA's Office of Coast Survey's Historical Map and Chart Collection contains over 20,000 maps and charts from the late 1700s to present day. The collection includes some of the earliest nautical charts, hydrographic surveys, topographic surveys, geodetic surveys, city plans and Civil War battle maps, on: http://www.nauticalcharts.noaa.gov/csdl/ctp/abstract.htm.

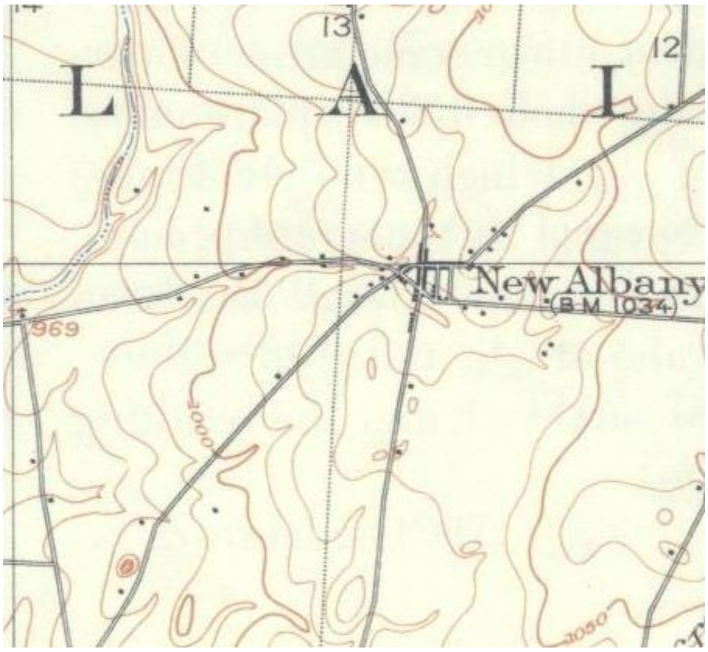

Figure 6. New Albany, Ohio USA topographic map from 1904.
Source: US Geological Survey.

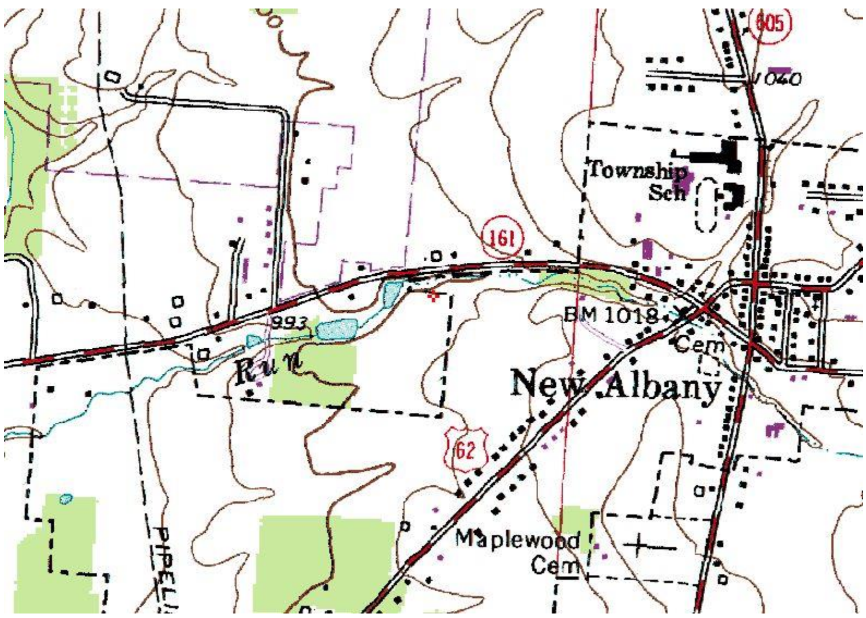

Figure 7. New Albany, Ohio USA topographic map from 1980.
Source: US Geological Survey.

Compare the topographic map of New Albany, Ohio, 1904 versus 1980. In 1904, New Albany was a crossroads of rural farm highways, but as it is not far from Columbus, Ohio, it has now experienced suburban growth from that city. Comparing maps such as these illustrates changes that could be examined in every community.

Using historical and current maps and imagery, students could answer such questions as the following: What has changed in my community or in other communities, and why has it changed? Were the changes because of natural forces or human-caused forces, or a combination? What will this area look like in 10 years? What will it look like in 100 years? What did the landscape look like when my parents or grandparents were secondary school students? Is the area changing more quickly or more slowly than other parts of my community, or other parts of my country or elsewhere in the world? Why? What is the land use like in my neighborhood? How does it compare to land use elsewhere in the world? What influence does population, climate, proximity to coastlines, or other phenomena have on land use? Can I estimate the population in the map or photograph of the area? What type of dwellings do people live in, and how do these dwellings compare in size and density to other parts of my community? How much terrain is visible at a resolution of 1 meter versus 2, 8, or 16 meters? How does detail change as the scale changes? What is the best scale at which to view a glacier, a school building, or a city? Examine aerial photographs taken in summer versus winter, spring, and fall. What are the differences in terms of vegetation and sun angle between those different seasons?

In a similar fashion, students can compare historical to current satellite images on the Esri Change Matters Viewer (http://changematters.esri.com/compare). This viewer uses Landsat satellite imagery. Because the Landsat satellites have been operating since 1972, over 40 years of change can be examined on the Earth's surface. Students can use the Change Matters Viewer to investigate the reasons for those changes. Furthermore, since Landsat imagery is typically delivered in the infrared wavelength, it provides an excellent introduction to the electromagnetic spectrum and remote sensing.

For example, the complex issues surrounding irrigation, agriculture, politics, climate, and internal drainage can be introduced and analyzed by comparing satellite imagery of the Aral Sea as it has shrunk over the past 40 years using the Change Matters viewer (Figure 8). Similarly, urban sprawl, coastal erosion, the construction of dams and reservoirs, the development of irrigated agriculture in Saudi Arabia, and other developments can be examined with this same tool.

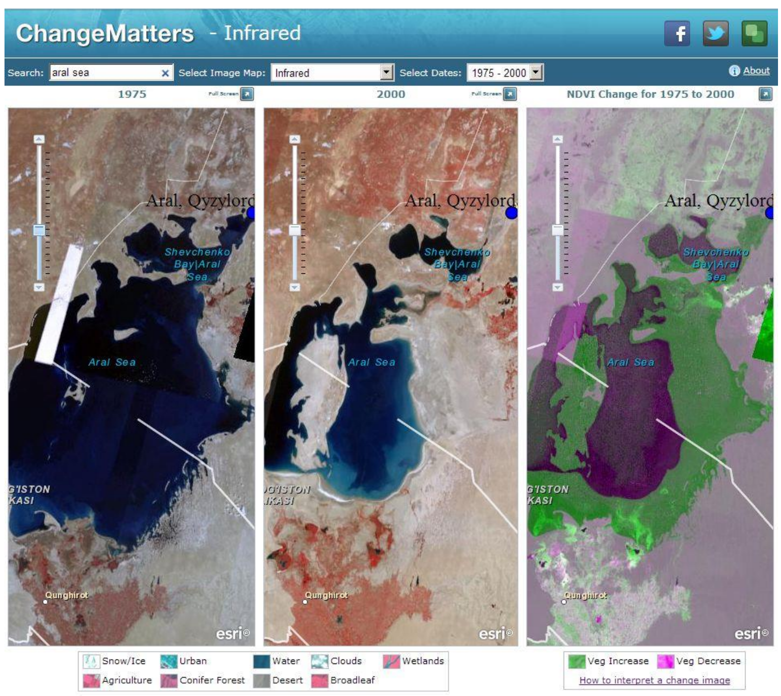

Figure 8. Aral Sea as seen from the Landsat satellite in 1975 (left) and 2000 (center) with changes between those two time periods (right).
Source: Esri and US Geological Survey.

5. Further Investigations Using ArcGIS Online

One of the most powerful web based mapping platforms to emerge is ArcGIS Online (http://www.arcgis.com/home). This platform supports local to global scale investigations with online mapping services placed onto the platform from local, regional, national, and international government organizations, private industry, academia, nonprofit organizations, and individuals. The base maps data is rich and detailed, including base layers such as satellite imagery, Open Street Map, topographic maps, and geologic maps. Thematic maps include watersheds, land use, ecoregions, voting patterns, median income, population growth rate, human health indices, natural hazards, energy, consumer preferences, and much more. Many of these data sources in this platform are updated in real time, ranging from Twitter feeds on current political situations to wildfires to weather to earthquakes to stream hydrographs and much more.

Students can map their own data onto the platform via a wide variety of sources. These range from simple map notes tied to points, lines, or polygons that students can add to maps, along with text, images, videos, and URLs. Data sources can also be from Excel spreadsheets saved on a local computer to spreadsheets that are online. Another mapable data source are track points from a field trip recorded with a GPS receiver or an app on a smartphone. Another capability is citizen science mapping: Through an "editable feature service", students can simultaneously be collecting field data via the ArcGIS app on their smartphones, while the data they are collecting populates a single web map in real time.

Mapped data can be classified and symbolized in a variety of ways. Mapped data can be analyzed spatially through tools such as overlay, buffer, and measures of centeredness and proximity. The tabular data associated with map features can be sorted and queried just as it can in an ordinary spreadsheet program. However, the results of the sort and query can be displayed on the map. Maps created through the platform can be created, modified, and shared. Unlike the former days of GIS, the sharing is accomplished by sending a colleague a simple URL. Maps can also be embedded as live web maps into web pages or blogs, or embedded in the same interactive manner into PowerPoint slides. They can also be published as many different types of applications, including those with terrain profiles of the landscape, or through comparing maps side-by-side through "swipe" technology, and through customized templates that are optimized for tablet and mobile devices.

In an example at the global scale, students can examine country data from the World Bank in ArcGIS Online (http://www.arcgis.com/home/webmap/viewer.html?webmap=5bbdd2f927fe4a5abc15beb71755208e) to compare demographic variables (Figure 9).

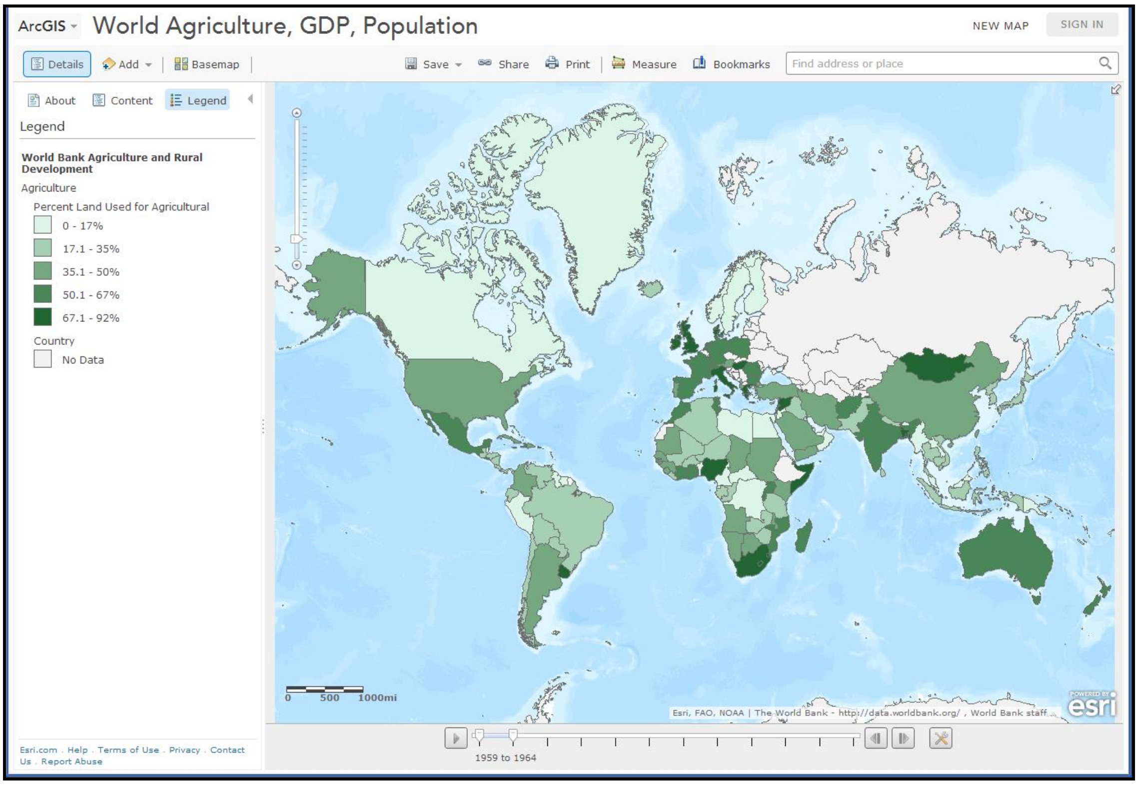

Figure 9. Percent land used for agriculture.
Source: World Bank and Esri.

What is the relationship between birth rate, life expectancy, and growth rate as shown on this map? How have these variables changed over time? By selecting specific countries and moving the arrow through resulting pop-up text box, the student has access to data from 1960 to the present. Alternatively, students can play the timeline underneath the map to see thematically how the pattern of specific variables change. Why do these variables change over time? Why do the variables for some countries change rapidly, while others do not exhibit change for some or all of the 53 years under study? Students can compare these data to Gross Domestic Product, and to agricultural variables such as the percent arable land, and crop and livestock production indices. Why do certain variables vary the same way? Why do others vary in opposite directions?

In another example of the use of ArcGIS Online in an educational environment, this time at a regional scale, is through the study of a proposed new road through the Serengeti (Figure 10). Students review articles and examine the map to understand the importance of the Serengeti, the distance to the Indian Ocean and Lake Victoria and to sources of supply and demand, and consider the pros and cons of constructing the road.

Students measure the length of each of the two road proposals and consider which biomes the roads would impact. The lesson accompanying the map is embedded in the map's metadata, and therefore the educator needs only to access a single URL for the map and the lesson (http://www.arcgis.com/home/item.html?id=2c1da31c0ffd4790ad2dec830d4d1eb3). The lesson includes links to background reading material and thought-provoking questions that require the student to think spatially and use the map as a source of investigation instead of a by-product of it. Upon the conclusion of the lesson, students use the map and the spatial perspective to present their argument, whether they are in favor of the road, not in favor of it, or whether they favor a different alternative.

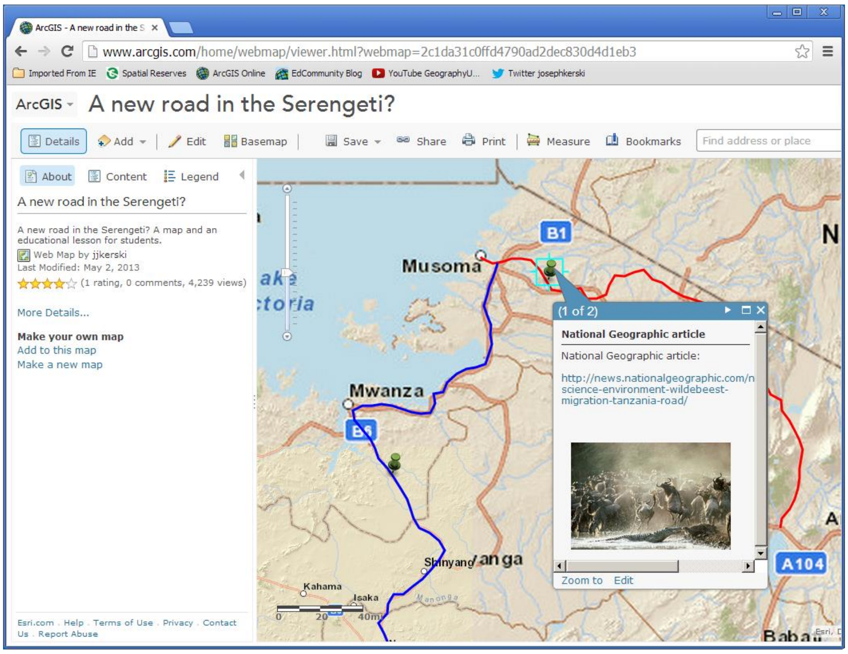

Figure 10. A new road in the Serengeti?
Source: Esri.

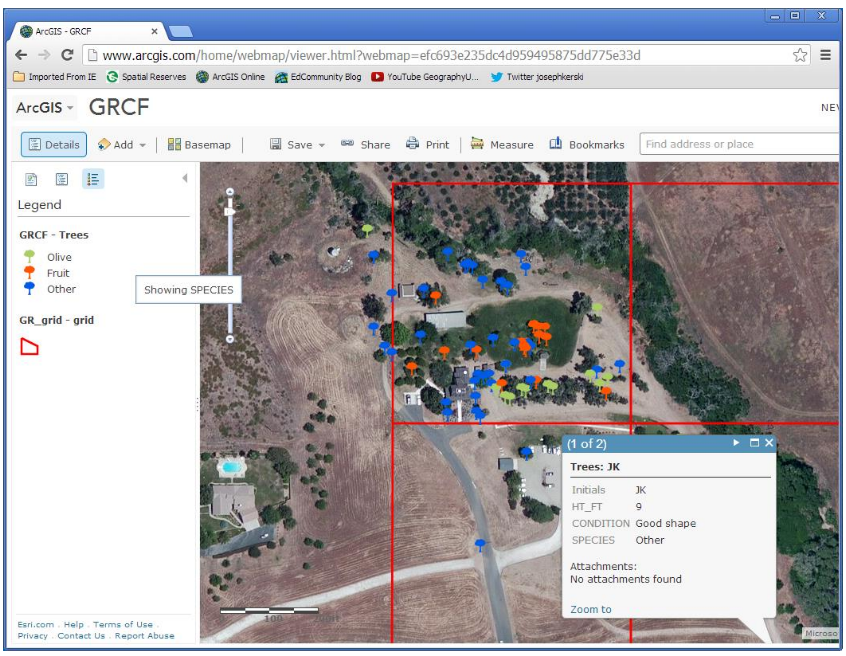

Figure 11. Mapping and analyzing trees from field-collected data.
Source: Esri.

In a third example of the use of ArcGIS Online in an educational setting, this time at the local level, consider the map created by a group of educators mapping trees in a county historical park (Figure 11). Educators gathered data on smartphones on tree height, condition, and species (http://www.arcgis.com/home/webmap/viewer.html?webmap=efc693e235dc4d959495875dd775e33d). They gathered the data using the ArcGIS app on their phones, entering the tree height, condition, and species while recording the position of the tree from the GPS on their smartphone. This is an example of the "citizen science" mapping referred to earlier. They also took a photograph of each tree and added that as another attribute for the data point they gathered.

As they collected the data in the field, the educators could see their own collected points appear on the map on their phones, but they also could see points gathered by their colleagues at the same time in the same park. In a similar way, students can gather data on tree species and height, litter, social zones, cell phone reception, light poles, and other data on their own school campuses, in their communities, or in local parks. If one of the points for whatever reason does not get added to the map while in the field, the map is also editable through a standard web browser. Using the web browser, the data can be added in the lab or in the field with a tablet or a laptop. When the project is finished, the educator who sets up the web map turns off the editing function of the map. The map remains interactive, but nobody can add data to it until the owner of the map turns the editing back on. Collaborative mapping efforts such as this can open new worlds to students in terms of working in teams, examining data, field methods, and critical thinking.

6. Telling Stories Through Maps

Maps have always been a powerful medium for telling stories. Today's web mapping tools place powerful storytelling abilities into the hands of every student. An easy-to-use and powerful set of these tools is the story maps platform (http://storymaps.esri.com). This platform enables students to tell their own stories, through text, video, audio, photographs, and live web maps. These stories can be used as an instrument by instructors to assess whether students have mastered specific content or skills. A gallery of existing story maps is available on a wide variety of topics, from the voyage of and origin of each passenger on the Titanic to historical hurricanes, the proliferation of cell phones globally, the ecological "footprint" of each country, the cost of food transportation, host cities for the Olympic games, and much more. New story maps appear daily.

More importantly, students can publish their own story maps using this same platform, either as web applications or by downloading and customizing the provided story maps templates[1]. Story maps are based on the Esri ArcGIS Online platform discussed earlier. Thus, when a particular map is updated, the story map based on that map is automatically updated. Story maps can be published as web applications on the Esri ArcGIS Online site or on the user's own web server.

For example, students can create a map of a particular field trip, and upload photographs or videos of their trip, in a short of time (Figure 12). This is illustrated and explained in an essay entitled *The 15 minute story map* (http://blogs.esri.com/esri/gisedcom/2013/07/26/the-15-minute-story-map/) about a map that was indeed created in 15 minutes.

To create this map, a track from a smartphone was collected, along with five photographs, and these and their captions were uploaded to the ArcGIS Online environment, where they were published into the story maps web application and shared with the public. The themes for photographs tied to story maps do not have to be the "walk along a harbor" as was featured in this map, but they could be about cloud formations, invasive species, incidences of graffiti, or the presence of historical homes. For example, in "Lost Detroit", a story map of famous abandoned buildings in that city was created to foster discussion about urban morphology, decay, and revitalization (http://www.josephkerski.com/storymaps/lostdetroit/).

The history and geography of specific villages or regions can be the themes of a story map, as was featured in the map for Bruges, Belgium (http://www.josephkerski.com/storymaps/brugge_shortlist/). This map was created from the downloadable templates that exist on the story maps web page.

[1] Story map templates can be downloaded and customized to meet specific needs, from the template gallery: http://storymaps.esri.com/templategallery/.

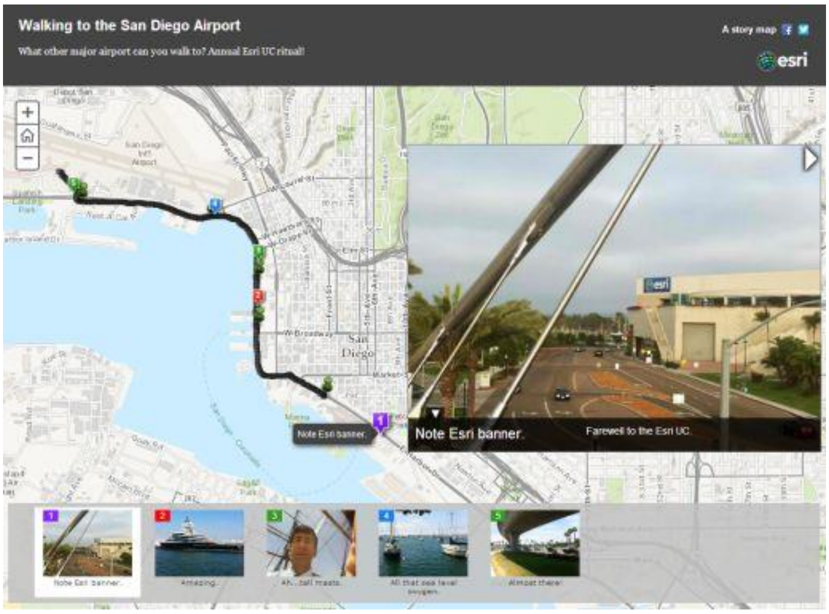

Figure 12. An example of a story map highlighting a walk along a harbor to an airport.
Source: Joseph Kerski and Esri.

Specific landforms ranging from sand dunes to barrier islands can be examined and measured, as was done in this study of 10 landscapes: (http://www.josephkerski.com/storymaps/10landscapes/). This map is linked to a lesson containing five questions on each landscape. What are landscapes and landforms? What forces created these landscapes and landforms in the past and continue to shape them today? What will these landscapes look like in 10, 100, or 1,000 years? Why[2]? This type of lesson has been core to geography and earth science teaching for decades, but web mapping technologies invite students to measure, to investigate, and to discover in more meaningful ways than those based on paper maps (Kulo and Bodzin, 2013).

7. Conclusions

Students can use these powerful web mapping tools and data to understand that the Earth is changing. Then, they can use the maps to begin to think scientifically and analytically about why it is changing. Asking the questions and being inquisitive are critical to the successful use of web maps and GIS in education. Through the use of these web mapping technologies, instructors can help students to begin analyzing the "whys of where" – the essence of geographic inquiry.

As useful as these web mapping are today, they will be even more useful in the future. In fact, web maps and the technologies that drive them are expanding by the day. This presents both an opportunity and a challenge. Educators and students using these tools must be flexible, adaptable, and willing to learn in a rapidly changing and sometimes unpredictable environment. The most important characteristic, however, in educators and students using these tools is to cultivate the habit of curiosity. Being curious about the world will help frame the questions to ask, and those questions will drive the data that needs to be gathered, the tools that are used, the conclusions drawn, and action that takes place.

Asking questions about the whys of where is not the end of the story, however. After using these web maps, students need to ask and

[2] For example, to see story maps that have been created on landforms, urban decay, and the history and geography of specific regions, see the story maps that the author has created on http://www.josephkerski.com/resources/web-maps/.

grapple with value-based questions. Should the Earth be changing in these ways? Is there anything we as a society can and should do about it? Is there anything that I should be doing about it? This captures not only the heart of spatial thinking, inquiry, and problem-based learning, but of education for activism – to make a difference in this changing world of ours.

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