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Essays in Geography and GIS

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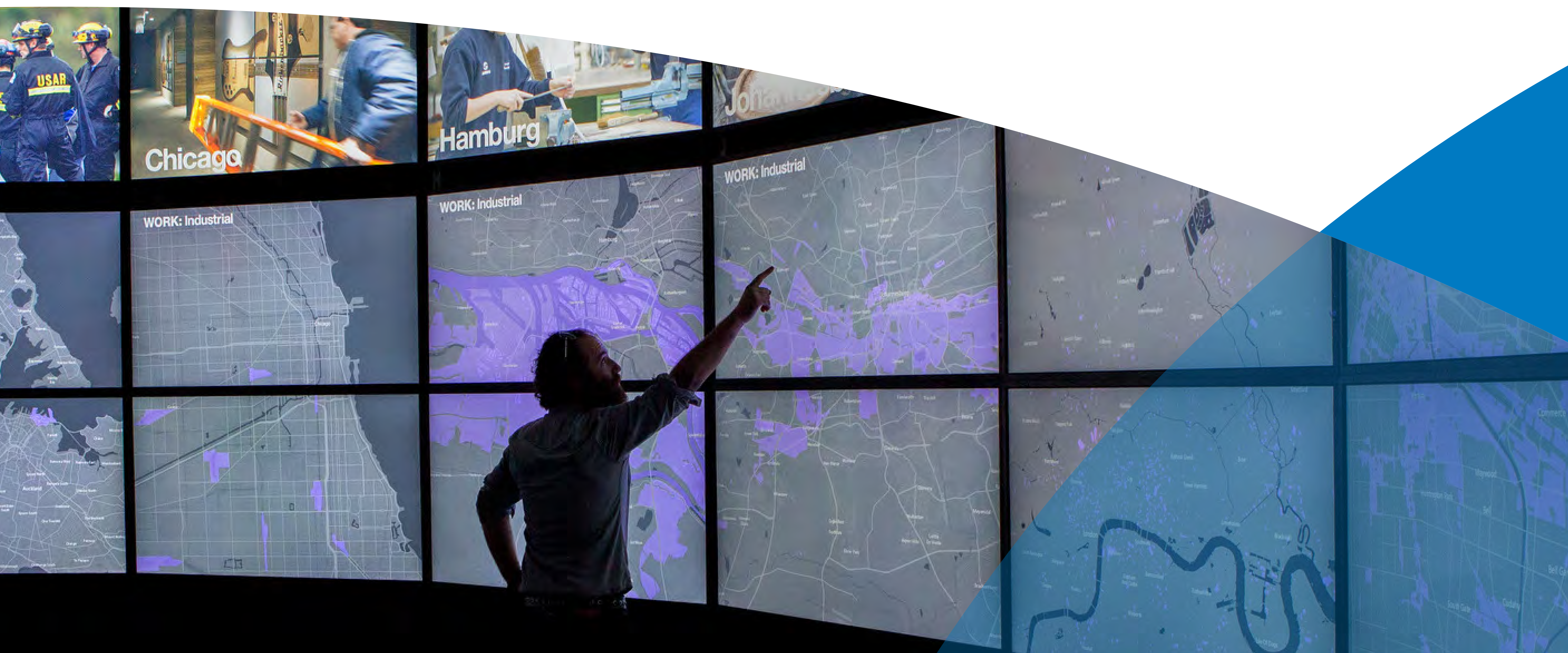

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There's More to Spatial Thinking Than You Think

David DiBiase, Esri

If you are a geography educator or GIS professional, you might say that "spatial thinking" is a way of reasoning about the world, facilitated by maps. However, if you are a science educator whose students need to make sense of 3-D molecular models or of cross-sections of a plant, "spatial thinking" is likely to mean something quite different. So, too, for cognitive psychologists who employ experimental methods to understand how people learn.

A recent Specialist Meeting on "Spatial Thinking across the College Curriculum" highlighted these different perspectives. The meeting's purpose was to "identify the current state of our understanding of spatial thinking, identify gaps in our knowledge, and identify priorities for both research and practice in educating spatial thinkers at the college level." Forty-three thought leaders were invited to participate, including those from Geography and GIScience, cognitive and developmental psychology, research librarians, and science education, history, landscape architecture, philosophy, and political science.

We were honored to represent Esri at the event. Our interest in a comprehensive approach to spatial thinking in education follows from the Esri Education Team's mission to *cultivate the next generation of GIS users and spatial thinkers*. As we pointed out in our recent essay "Envisioning the Spatial University," no college or university to our knowledge has included spatial thinking among its overarching objectives for general education, despite compelling evidence of its value. We approached the Specialist Meeting with high hopes that a consensus could be reached about how to realize spatial thinking in higher education. Ultimately, little consensus emerged about the broad nature of spatial thinking or about strategies for advancing it in higher education.

Why consensus eludes us

Why does consensus about spatial thinking remain elusive, seven years after the National Research Council's landmark publication of *Learning to Think Spatially*? We suggest at least four contributing factors:

1. Spatial thinking is a transdisciplinary habit of mind. Kindred disciplines span a dizzying range of scales, from subatomic to human to cosmic, as illustrated so effectively in the animation "The Scale of the Universe." Spatial thinking means different

things at different scales, and within different academic disciplines.

2. Academic disciplines are frequently based on different theories and constructions of knowledge. At times, social scientists may be content with anecdotal efficacy of GIS in fostering spatial thinking. Other disciplines marshal longitudinal research to demonstrate the relevance of spatial abilities to STEM careers. Still others are satisfied with nothing less than controlled experimental results.

3. Spatial thinking seems to be contested territory. Several disciplines vie for authority over its research agenda and curriculum design. Although geographers like Roger Downs have played pivotal roles in highlighting the relevance of spatial thinking across the curriculum, others note geographers tend to conflate spatial thinking with a subset of "geospatial" thinking skills.

4. A compelling value proposition for a discrete spatial thinking curriculum is elusive. No one at the meeting was able to satisfactorily address Bob Kolvoord's thought experiment, "what happens if we do nothing?"

Now what?

Many geographers are already convinced by recommendations of the *Learning to Think Spatially* report. We feel a sense of urgency about advancing geospatial thinking in higher education. Ambitious efforts to encourage geospatial thinking across the curriculum are underway at a few bold universities, including the University of Redlands, Harvard University, the University of California at Santa Barbara, and the University of Southern California. Esri encourages and supports these and related efforts elsewhere.

Do you see value in spatial thinking across the college curriculum and what role should GIS play in advancing (geo)spatial thinking at universities? We invite your comments, and hope you'll join us in continuing the conversation.

Thanks to Tom Baker, who co-authored this post.

About David DiBiase

David DiBiase leads the Education Team within Esri's Industry Solutions group. The Team promotes and supports GIS use to enrich teaching and learning at all levels, in formal and informal settings, domestically and internationally. Before joining Esri, David founded and led the Penn State Online GIS Certificate and Masters (MGIS) degree programs.

(This article originally appeared in the *Esri Insider* blog on 22 January 2013.)

The New Geographers

Matt Artz, Esri

> *"So many of the world's current issues—at a global scale and locally—boil down to geography, and need the geographers of the future to help us understand them."*
>
> —*Michael Palin*

"What is the capital of Madagascar?"

Unfortunately, that's what most people think of when they hear the term geography.

"It's boring," they say. "It's the study of useless information. It has no practical relevance to my life."

In fact, nothing could be further from the truth. Geography is one of the most interesting, vibrant, and dynamic fields of study today. It's also one of the most vital.

We think fondly of the great explorers who led challenging expeditions to the farthest reaches of the globe—to new continents, the poles, the tops of mountains, and the bottoms of the oceans. Through their explorations, they developed a new understanding of the world, and they came back to share their discoveries. Be they traders, hunters, adventurers, or scientists, all these explorers had one thing in common: they were geographers who learned about unknown places, people, and things and brought back information to share with the rest of the world.

Read inspiring stories about how new geographers are making a difference by applying GIS in their communities and across the world.

About 50 years ago, a new kind of geography was born, and it has opened up our world to advanced forms of exploration—not just treks to remote jungles or uncharted oceans but also research and analysis of the relationships, patterns, and processes of geography. Today, the new geographers use a combination of computers, satellites, and science to produce a much deeper understanding of how our world works.

While we know much more about the world today than ever before, parts of our world remain unexplored, and there are many important geographic problems left to solve: population growth, environmental degradation, loss of biodiversity, climate change, globalization, lack of sustainability, urbanization, health care access, poverty, hunger, and more. Although we have made tremendous progress in the last century, we still have a long way to go to develop a comprehensive understanding of our world. To solve these important geographic problems, we need the participation of everyone—not just administrators, scientists, and politicians. Everyone deserves a voice in these important issues.

Today, thanks to tools such as geographic information system (GIS) technology, virtually everyone can be a geographer. The tools to explore and examine geography in different ways are widely available, and anyone who uses them has the potential to make discoveries and easily share them with the rest of the world. This democratization of geography is leading to a better and more complete and more equitable understanding of our world, and it's creating additional dimensions in our relationships with each other and our planet. We are *all* new geographers.

We invite you to read our new e-book about how some of The New Geographers [PDF] are making a difference by applying GIS technology to the needs within their communities and throughout the world. These are people like you and me who are using new technology to make a difference and create a better world.

Their stories are inspiring. Yours could be, as well. We hope their stories will inspire you to join the ranks of the new geographers in making a difference in the world.

- Read The New Geographers [PDF]

About Matt Artz

Matt Artz joined Esri in 1989. In his current role as GIS and Science Manager, he helps communicate the value of GIS as a tool for scientific research and understanding. He writes extensively about geospatial technologies, manages the GIS and Science blog, and is the editor of GIS.com. Prior to joining Esri he worked as an Environmental Scientist at a large science and engineering consulting company, on such diverse projects as highway noise modeling, archaeological impact assessment, and chemical weapons disposal. His educational background includes an M.S. degree in Environmental Policy and Planning and a B.S. degree in Anthropology and Geography.

(This article originally appeared in the *Esri Insider* blog on 03 December 2012.)

Using GIS to Explain Geographic Reasoning

"Geo Learning"

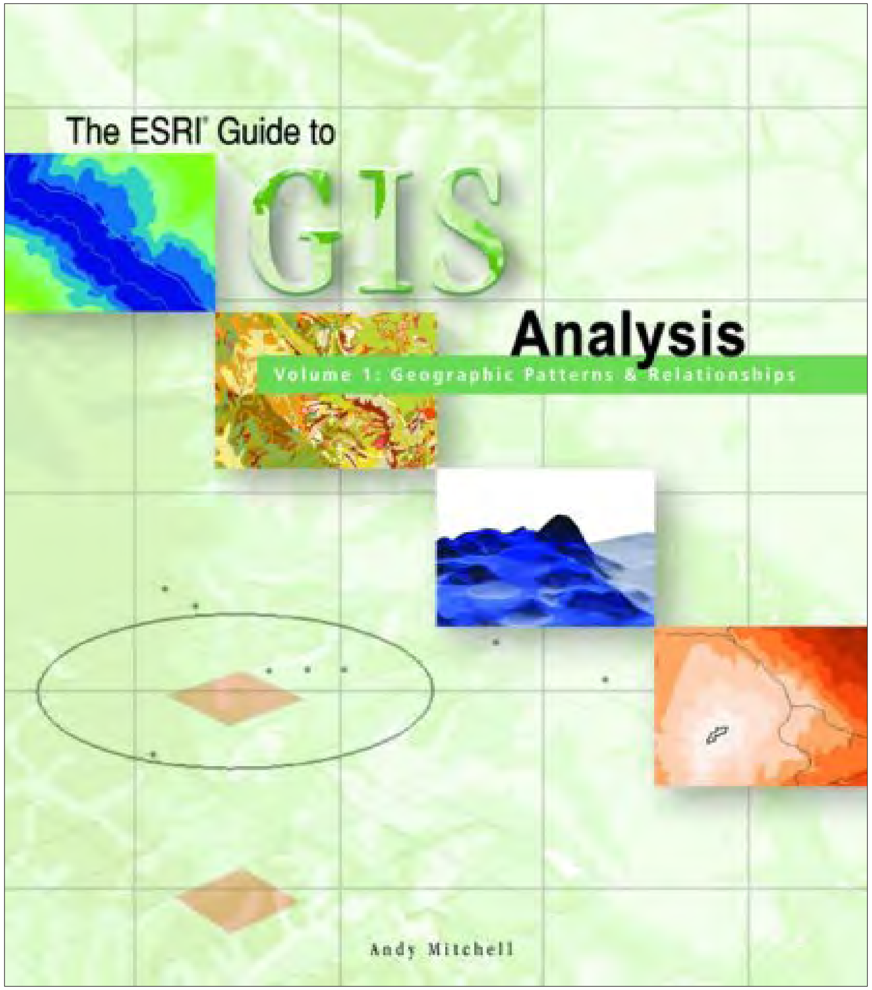
Daniel C. Edelson, National Geographic Society

I began the winding path that has become a career, as a researcher in artificial intelligence. I was drawn to artificial intelligence by one of its central tenets: you can understand how the human mind works by trying to reproduce its behaviors in the form of a computer program.

I was musing about that recently as I found myself using what GIS software does while trying to explain to someone what I mean by "geographic reasoning." As I've written before in this space, one of my biggest challenges as an advocate for improved geography education is explaining what geography is really about.

Since most people tend to associate geography with factual knowledge, I want to be able to broaden their understanding of geography by explaining geographic reasoning to them. However, I've struggled to find descriptions of geographic reasoning that are helpful when talking to people who haven't studied geography.

What I've found are two kinds of descriptions of geographic reasoning. One characterizes geographic reasoning using terms and examples that only other geographers can understand. The other is frustratingly circular: geographic reasoning is what geographers do to understand the world; geographic



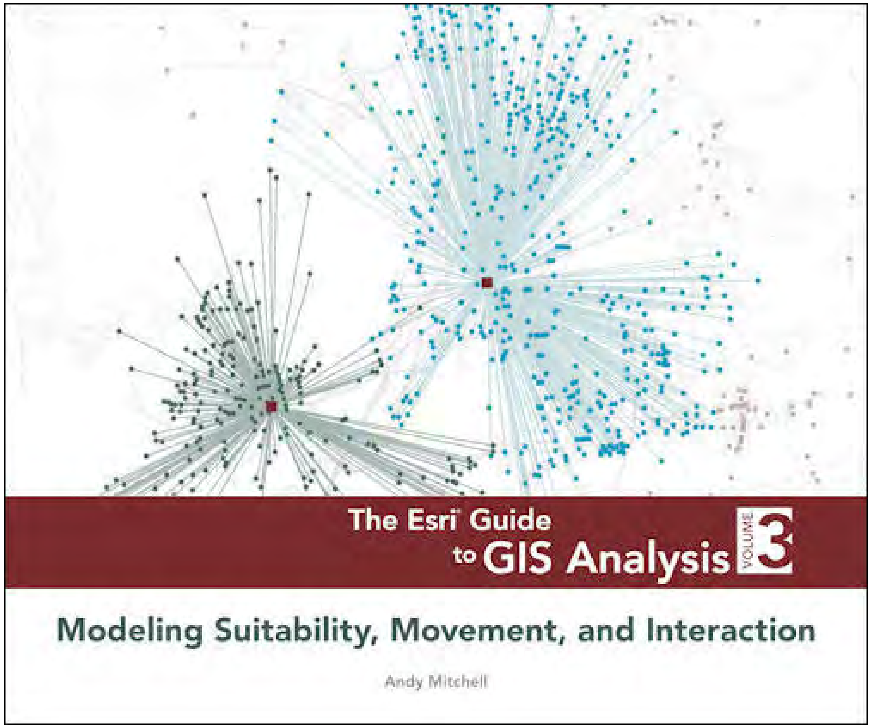
reasoning consists of asking geographic questions, gathering and analyzing geographic information, and constructing geographic explanations; geographic reasoning is the process of constructing explanations and predictions about place and location.

There is no shortage of examples of geographic reasoning. John Snow's discovery of the source of the 1854 cholera outbreak in London immediately comes to mind. However, it's hard to see what the underlying reasoning is in individual examples.

However, as I was leafing through Andy Mitchell's *Esri Guide to GIS Analysis* at the User Conference this summer, I had a flash of insight. The table of contents of that wonderful three-volume guide to GIS can be read as an overview of geographic reasoning. Consider the following:

- Measuring geographic distributions
- Identifying patterns
- Identifying clusters
- Analyzing geographic relationships

This list happens to be the main chapters in the second volume of Mitchell's series, but to me it reads like a clear list of the core components of geographic reasoning. I assume that Mitchell did not sit down to identify the conceptual categories of geographic reasoning. Presumably, he set out to create a well-organized overview of what you can do with sophisticated GIS software. However, the outcome here is the same as the one that many researchers in artificial intelligence seek.



Over the course of the last 50 years, GIS software developers set out to create a set of productivity-enhancing tools to support geographic reasoning. Over time, they increasingly externalized geographic reasoning in the software, so that when a modern instructor sets out to teach someone how to use GIS, what they are essentially doing is providing an overview of geographic reasoning.

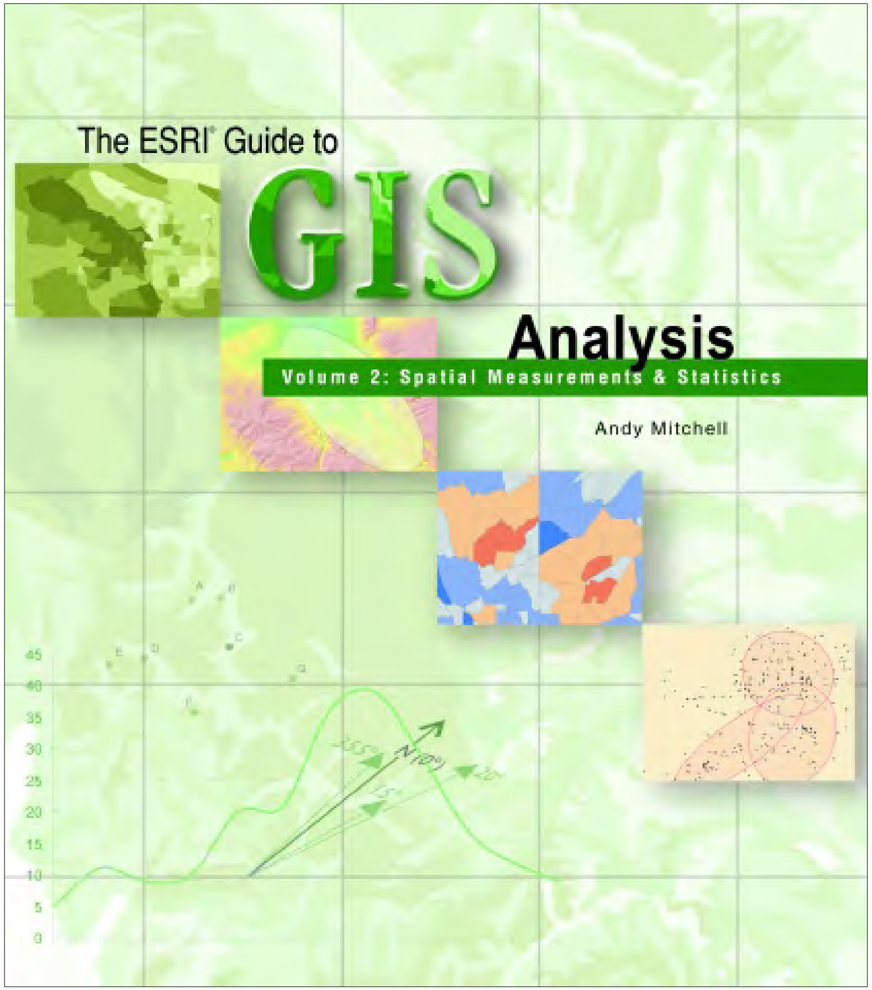
The hidden benefit of GIS, therefore, is that GIS software has come to embody geographic reasoning to the point where the best way to explain to someone what geographic reasoning consists of may be to demonstrate to them what you can do with GIS.

Want to introduce younger children to geographic reasoning? How about using the following as a progression?

1. Mapping where things are
2. Mapping the most and least
3. Mapping density
4. Finding what's inside
5. Finding what's nearby
6. Mapping change

Ready to teach advanced students about sophisticated forms of geographic reasoning? What about these?

1. Finding suitable locations
2. Rating suitable locations
3. Modeling paths



4. Modeling flow
5. Modeling interaction

It will come as no surprise that I lifted the first list from the table of contents of volume 1 and the second from volume 3 of Mitchell's series.

So the next time someone asks me what's valuable about geography education, I won't turn to John Snow and the 19th century. I will tell them about identifying patterns and clusters or modeling paths and flow.

Follow Daniel Edelson on Twitter: @NatGeoEdelson.

(This article originally appeared in the Spring 2013 issue of *ArcNews*.)

U-Spatial: A Consortium for the Spatial University

Francis Harvey, Len Kne, and Steven Manson, University of Minnesota

It is increasingly apparent to many within academia and beyond that spatial thinking, technologies, systems, and services matter. Building on a rich history of research, scholarship, and teaching related to spatial topics, the University of Minnesota (UMN) has embarked on a visionary endeavor called U-Spatial to develop a collaborative consortium that supports the spatial sciences and creative activities.

U-Spatial provides support for spatial research. It helps eliminate duplication and fragmentation of scientific resources and provides a framework of data, equipment, expertise, and resources that benefits all researchers working with spatial sciences and creative activities. The need for infrastructure support for the spatial sciences and creative activities has been apparent for some years, but the opportunity to build a broad-based infrastructure across traditional disciplinary and college boundaries has come much more recently.

Background

The spatial sciences compose a broad and fast-growing field that studies spatiotemporal aspects of people, places, and processes using information technologies that range from satellite imaging and GIS to computational technologies and social networks that rely on communication infrastructure. The US Department of Labor identifies spatial technology alongside nanotechnology and biotechnology as the three most important industries in the 21st century. Based on information from the Geospatial Information & Technology Association, the Department of Labor predicts widespread and diverse uses of geospatial technology, with the market growing at an annual rate of almost 35 percent (US Department of Labor, 2010).

For more than 50 years, the University of Minnesota has been a national and international leader in spatial scholarship and application development. Among many contributions, UMN helped create one of the first geographic information systems, the Land Management Information System, in the 1960s, as well as offered the first professional degree program in GIS in the United States. One of the key open software packages for displaying spatial information, MapServer, was developed at UMN. Along with a long history in cartography, geodesign, and geography, U-Spatial can build on a solid intellectual foundation in core disciplines ranging from computer science to remote sensing. The university has many internationally known spatial research centers, including the Center of Urban and Regional

Affairs (CURA), the Remote Sensing and Geospatial Analysis Laboratory (RSGAL), the Spatial Database and Spatial Data Mining Research Group, the Minnesota Population Center (MPC), the Geographic Information Sciences Laboratory, and the Polar Geospatial Center (PGC).

From 2006, momentum steadily increased to develop a geospatial infrastructure that both leveraged UMN's spatial resources and met the array of needs for spatial research on campus. By 2011, there was a network of more than 100 spatial researchers. A call for proposals from the university to develop infrastructure to support research and creative activities was a key catalyst that mobilized this network to take the next step in developing common resources for spatial research on campus. After preliminary discussions, a core group drafted a preproposal that was circulated in this network. The preproposal was successful, and based on comments and many rounds of discussions, the group developed an ultimately successful proposal to develop U-Spatial with a combination of matching funds from more than a dozen units and university contributions, together totaling $2.5 million over five years.

Year One

U-Spatial is off to a great start. It is meeting its mission and having a very broad and substantial impact. Because of the size of the project and its need to establish governance practices among the large number of participants, the U-Spatial team has taken a "soft start" approach that involves the gradual development of U-Spatial services while allowing a more rapid development of support for existing research.

The U-Spatial team is particularly interested in developing successful and sustainable models of spatial infrastructure that recognize and facilitate the many ways in which spatial science and thinking are essential to support the core missions of the university: research, learning, and service.

Research—Space and spatiality are increasingly central to many forms of research. GIS is being discovered by a wide array of disciplines as both an integrative approach and research topic in and of itself, be it use of 3D software to model the movement of dancers in space or geologists mapping oil deposits. Researchers are embracing digital environments, computational science, and e-science to the point where science is increasingly practiced via teamwork in traditional labs, international consortia, or citizen science in a way that is increasingly the central paradigm for generating new scientific discoveries. Spatial technologies are woven throughout these various facets of research.

Learning—Spatial science runs through the UMN curriculum and is important to furthering excellence in teaching and student learning. Spatial thinking is a core element of learning across the curriculum. Spatial technologies underpin emerging educational and work force needs. The National Research Council report *Learning to Think Spatially* emphasizes that spatial science and systems together are "an integrator and a facilitator for problem solving across the curriculum. With advances in computing technologies and the increasing availability of spatial data, spatial thinking will play a significant role in the information-based economy of the twenty-first century" (2006, 10).

Service—Spatial infrastructure is essential for the university to meet its long-standing mission of service to communities ranging from local to global in scope. Spatial systems are essential to community-based service learning projects and internships in ways ranging from learning to use GIS software to track home foreclosure to helping develop web mapping applications. The concept of service to the immediate university community is also seen in how enterprise GIS helps universities be effective managers of public resources required for operations, facilities, and planning.

Four Infrastructure Cores

Collectively, U-Spatial offers four infrastructure cores (thematic areas): (1) Central Core services include technical assistance, training, resource coordination, and development of the spatial science community; (2) Imaging Core infrastructure focuses on data and analysis of aerial and satellite imagery of the earth; (3) Data Core initiatives include development of data discovery and archiving tools, as well as shared computing infrastructure; and (4) Analysis Core efforts center on spatiotemporal modeling, geodesign, and mapping.

Central Core

The Central Core is in many ways the most visible component of U-Spatial and addresses overarching needs for helping organize and provide access to existing spatial resources on campus while also actively aiding spatial research via help desk support and training.

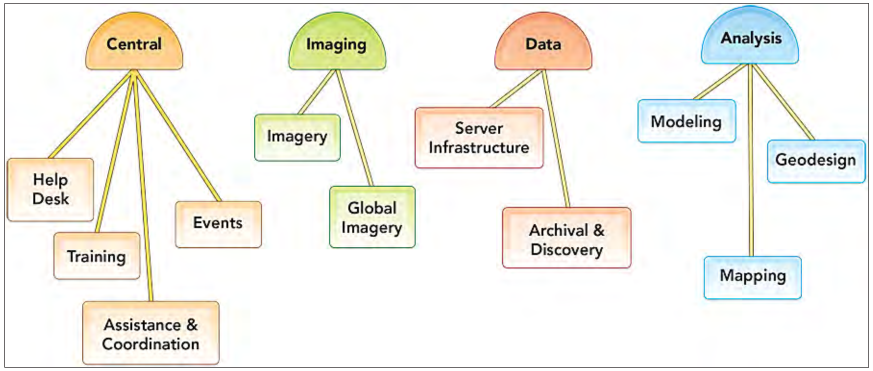
The most visible facet of the Central Core is the help desk. Since beginning operation in fall 2011, the help desk has assisted hundreds of researchers with questions ranging from locating data to creating interactive web maps. The goal of the help desk is to be the first point of contact when someone needs help with a GIS or spatial technology question. If help desk personnel cannot answer a question, they will find an expert in the U-Spatial network who can.

The Central Core regularly offers a popular GIS 101 workshop. This free, one-day workshop introduces participants to spatial analysis fundamentals, mapmaking, and working with common GIS applications. More than 500 people have attended the workshop, which often leads to contacts with the help desk or further consulting projects involving U-Spatial. Introduction to Web Mapping Using ArcGIS Online was recently added as a free three-hour workshop to introduce participants to how to create online maps using ArcGIS Online. Lidar 101 is another new workshop, offered this fall, that shows participants how to work with lidar data in ArcGIS for Desktop. Lidar data has been collected for the whole state of Minnesota and is currently being processed; having statewide lidar data has created interest among a wide variety of researchers.

To help sustain collaborative connections, U-Spatial supports bringing outstanding national and international researchers working on spatial issues to participate in colloquia hosted by departments/units. The primary criteria in making selections include the relevance of the speaker's spatial-related work to the university community and the capacity for presenting on topics that interest host departments, as well as the larger community. The aim of bringing in these speakers on the part of U-Spatial is to create a more persistent presence and framework for spatial science activities.

One of the first jobs that U-Spatial undertook was a census of spatial science researchers on campus. The U-Spatial team found that there are nearly a thousand people working with spatial information at the university. The sharing of information is crucial for people to expand their skills and knowledge, as well as foster research collaboration. In October, U-Spatial hosted the first U-Spatial Symposium, which brought together researchers from across UMN. The symposium featured a student poster competition and divided people into breakout sessions to discuss core interests for networking and provide guidance for the future of U-Spatial. In spring 2012, U-Spatial started a GIS user group for people to get together and share ideas. Having a regular meeting will allow people to learn who else is working with spatial data on campus and create a network of expertise. Anyone associated with the university is welcome to participate in the user group.

A final area where the Central Core has focused effort can best be described as raising awareness or marketing. The founding members of U-Spatial are well-practiced in their area of spatial research and for the most part are self-sufficient. But there are many colleagues at UMN who could make use of U-Spatial and resources described earlier. To make these contacts, the U-Spatial staff has been attending a variety of seminars and workshops, as well as countless meetings, to introduce U-Spatial. Growing U-Spatial participation is a first step toward making it sustainable beyond the five years of initial funding.



U-Spatial cores with activities.

Imaging Core

Remote imaging, or capturing digital images of the earth from airplanes and satellites, is critical to research domains ranging from deforestation measurement to urban growth analysis. Given the vast amount of data involved and the expertise and systems necessary for converting raw data into a format suitable for scientific analysis, researchers cannot currently take full advantage of these resources. U-Spatial helps support research at regional, state, national, and global scales and make remote imaging more accessible to UMN researchers. Currently, RSGAL provides assistance to researchers interested in using imagery and also provides raw and interpreted data products to all researchers. U-Spatial leverages existing imaging research to create detailed histories of Minnesota land and water resources. RSGAL manages data from multiple sensor platforms and offers expert help on image collection and analysis. PGC, the department of Computer Science and Engineering (CSE), and the Institute of the Environment (IonE) specialize in acquiring and analyzing global-scale imagery and attendant data. U-Spatial is building on these and several existing UMN research projects to develop some of the best available characterizations of global features, such as land cover, agriculture, and urbanization.

Data Core

A special issue of Science titled "Dealing with Data" (February 11, 2011) argues that it's important to deal with the growing "deluge" of huge and complex datasets in the face of critical shortcomings in data archiving and discovery. These needs are writ large for spatial science research on campus. U-Spatial is helping researchers archive their data, curate it, and make it discoverable and reusable by others at the university and beyond.

The University Libraries and MPC leverage their deep expertise in data management, archiving, and discovery services to improve data *reuse* and *citation* capabilities. *Reuse* refers to the ability to archive datasets, making them searchable and available over time for multiple uses and users, thereby minimizing duplication of research. *Citation* goes beyond basic metadata concepts to provide a robust identification framework for connecting data sources to scholarly publications. Data management services will facilitate and regulate open access to contributed datasets via a data portal and web communities that assist with spatial knowledge discovery. U-Spatial is in the process of exploring the use of data architectures that facilitate sharing with other university institutions.

The Data Core has developed a plan for collaborating with large data projects and is developing a prototype data management and access environment for geographic information. Access to spatial data is being addressed from two directions. One group is piloting a web-based system to make spatial data easy to discover and access; a second group is focusing on the long-term archiving and preservation of data. Out of this work will be procedures for creating data management plans for all research projects, a huge benefit to researchers on campus. Throughout this activity, U-Spatial is collaborating with researchers at a variety of institutions around the world to ensure its efforts contribute to the development of broader information infrastructure that is open and standards based.

The University Libraries and MPC are working with the office of information technologies, Enterprise GIS (EGIS), and others to develop a shared U-Spatial Data Core server infrastructure for the university. In addition to hosting specific projects as needed to support data activities, it will host virtual servers and a technology stack of Fedora Commons Repository archive software; the Lucene/Solr indexer platform; and spatial tools, such as MapServer, OpenGeoportal, ArcGIS for Server, and ArcGIS Online.

Analysis Core

Research on complex systems and complex issues, such as climate variability and rapid social change, requires advanced spatial analysis. While U-Spatial supports all spatial research on campus, its initial focus is leveraging current interdisciplinary research on human-environment systems to develop a solid foundation for the sustainable research infrastructure of the spatial university. The Analysis Core has been making important steps in developing the specifications for a geodesign environment that will support researchers in the Hubert H. Humphrey School of Public Affairs (HHH); College of Design (CDes); and College of Food, Agriculture and Natural Resource Sciences.

Both IonE and Computer Science and Engineering have been collaborating on developing modeling for networked data. CURA has hired a research assistant to support requests for scientific data from the community by creating a web mapping application of CURA's project work statewide to facilitate handling and enhancing access to external queries, as well as supporting the development of more connections to the Urban Research and Outreach-Engagement Center by offering workshops on how to use ArcGIS Online.

These activities all involve the three areas of modeling, geodesign, and mapping.

Modeling—IonE and CSE collaborate to develop modeling infrastructure, including a library of open source models and expertise for applying it to various domains. U-Spatial will also develop specific datasets that are currently in great demand, such as a spatially enabled public health database that is tied to census data or access to parcel data describing Minnesota and other places.

Geodesign—CDes, IonE, and HHH focus on geodesign—the application of technology to allow decision makers to collaboratively construct and evaluate landscape plans using spatiotemporal modeling and three-dimensional visualization. Geodesign nodes will host touch tables and multiple display facilities that will be synchronously interactive using ArcGIS 10.1 for Server services and web-based client interfaces.

Mapping—The University of Minnesota has several mapping initiatives under way. It is a beta tester and early adopter of ArcGIS Online subscriptions. This transformative service will help with curriculum, research, and administrative spatial analysis. Much of U-Spatial's testing of the service relates to how it can be implemented in a large and diverse organization. U-Spatial is working out issues with administration of ArcGIS Online that require the organization to look at how U-Spatial shares data and maps in a new way. CURA and EGIS build on successful GIS and web mapping programs that provide data and expertise to researchers working on scientific problems in Minnesota and elsewhere. The University Libraries have datasets for many regions of the world, consisting of thousands of data layers extending back to the 1800s, giving our researchers a competitive advantage in domains ranging from racial diversity to ecosystem services.

A Little Help from Friends

U-Spatial is only one piece of the future spatial university. Curriculum, outreach, and programs will have to evolve. U-Spatial is fortunate to have received significant support from the Office of Vice President for Research and the College of Liberal Arts in the stages that led to the successful U-Spatial collaborative proposal.

An important check for U-Spatial was a survey conducted in spring 2012. The staff contacted close to 300 people across the university with an invitation to complete a short survey to help refine the vision and prioritize the activities of U-Spatial. The responses gave broad and useful input for developing U-Spatial.

A Simple Concept with Many Impacts

U-Spatial is a simple concept for a large research university that provides the foundation for the development of the spatial university. When fully developed, U-Spatial will support the research, learning, and service missions of the university. The short-term goal is to ensure that U-Spatial provides an umbrella for science and creative activities and organizes researchers into an interconnected network of cores.

In addition to focusing on providing help and other services, for U-Spatial to be sustainable, it will also need to identify several layers of funding sources. At the large scale, it is actively participating with researchers throughout UMN to secure outside grants. At smaller scales, U-Spatial provides GIS and remote-sensing expertise to a growing number of research projects, helping them grow, and provide specialized training that is turning out to be an excellent value for those who take the courses. This diversified approach to funding and sustainability, along with providing good value to participants within U-Spatial, will help ensure that support for spatial research is pervasive at the University of Minnesota.

About the Authors

Francis Harvey is director of U-Spatial and associate professor of geography. He is one of the U-Spatial cofounders and contributed to previous projects as well. With input from across the University of Minnesota, he guides the implementation of U-Spatial on its path to becoming one of the world's premier centers for the spatial sciences. Len Kne is associate director of U-Spatial. Kne leads the day-to-day operations of the Central Core and looks forward to the day when everyone is thinking spatially. Steven Manson is an associate professor in the Department of Geography and directs the Human-Environment Geographic Information Science lab. He also cofounded U-Spatial and its antecedents, including the Geospatial Consortium, and is excited about continuing the development of spatial science and activities on campus.

(This article originally appeared in the Winter 2012/2013 issue of *ArcNews*.)

Getting a Job in Geography and GIS

"Crossing Borders"

Doug Richardson, Association of American Geographers

Employees with geographic and geospatial skills are in high demand to help solve real-world problems and enhance organizations' efficiency and effectiveness. The latest estimates from the US Bureau of Labor Statistics classify GIS and remote sensing (RS) as "new and emerging" fields, in part because of their importance to the "green" jobs sectors. Job openings for GIS and RS scientists, technicians, and technologists are projected to grow between three and nine percent between 2010 and 2020, while median salaries for these positions continue to rise. The job category of "geographer" is poised for even more dramatic growth, with job openings projected to increase nearly 30 percent by 2020.

A recent report by the Georgetown Center on Education and the Workforce revealed that geographers are highly dispersed across sectors and industries within the US work force. Therefore, a comprehensive search for geography-related jobs should span resources across the business, government, nonprofit, and educational sectors. The AAG's Jobs in Geography and GIS Center is an excellent starting point. This online jobs listing allows you to search for current job openings by sector (e.g., private, public, academic, nongovernmental organizations [NGOs], etc.), by state or international location, and by topical specialties.

Other leading industry resources for careers in geospatial technology and GIS include Esri, *Directions*, GISLounge.com, GISjobs.com, and the GIS Jobs Clearinghouse. Because the public sector continues to be a major employer of geographers, USAJobs.gov is a helpful place to go for federal government employment. Idealist.org is a central repository for volunteer and employment opportunities in the nonprofit and NGO sectors. Links to all these career resources can be found on the AAG careers website.

Research conducted for the AAG's National Science Foundation-funded EDGE program, which is geared to better preparing graduate students for nonacademic jobs in geography and GIS, indicates that employers today are particularly seeking employees who can apply broad, interdisciplinary perspectives and diverse expertise to the specific needs of their unique organizations and industries. More companies and industries are now using location-based data and spatial analysis to support business operations as wide-ranging as health care delivery, retail sales, environmental management, transportation planning, economic development, and more.

While the employment outlook for geography and GIS careers is relatively strong, competition for openings is high. In a tight job market, many students and professionals are considering strategies to boost their credentials and enhance their portfolio of skills. In addition to opening up new career paths, further education can also lead to increased earning potential. A directory of state-by-state listings of online courses, certificates, and degrees offered in geography and GIS is posted at www.aag.org/education. An important credential for GIS careers is professional certification. Information on becoming a certified GIS Professional (GISP) is available from the GIS Certification Institute, the leading GIS certification organization in the United States.

Volunteering and internships with potential employers also provide excellent work-based learning and professional development opportunities. Many employers recruit from their intern and volunteer pools, so these short-term experiences can often lead to longer-term or permanent employment. AAG has developed guidelines on how to get the most out of your internship and also lists internship and mentoring opportunities at its Jobs Center.

The Association of American Geographers offers a broad selection of resources to help current and aspiring geography and GIS professionals make the most of the many available employment opportunities. The Jobs & Careers area of the AAG website features a range of educational and informational materials to support career exploration, including profiles of geographers working in a variety of fields, salary data and employment trends for more than 90 geography and GIS-related subfields, tip sheets and resumé advice, and much more. Also available is the new book, *Practicing Geography*, which provides a wealth of information on geography and GIS careers in business, government, and non-profit organizations. To access this regularly updated information, visit www.aag.org/careers.

The AAG's Annual Meetings (April 9–13, 2013, in Los Angeles) also feature a robust offering of current job listings, careers panel discussions, drop-in career mentoring services, and professional guidance and networking opportunities for prospective employees at all career stages. Good luck with your next job search!

Doug Richardson

(with contributions by Joy Adams and Jean McKendry)

(This article originally appeared in the Spring 2013 issue of *ArcNews*.)

Urban Planning and the DNA of the City

Shannon McElvaney, Esri

A city looks and feels the way it does because of human intention. Early civilizations built their settlements next to waterways, designing them to accommodate this resource accessibility and their own survival. During the beginning of the industrial revolution, cities were planned with ever-evolving rules ensuring that city streets were wide enough to accommodate the full turn of a horse and carriage. In this way, the values of the people were encoded into the very **DNA of the city**.

A complex built environment can be reduced to three basic elements: links along which travel can occur, nodes representing the intersections where two paths cross and public spaces form, and buildings where most human activities take place. The functionalities of place are all defined by rules and procedures, which make up the core design vocabulary of a place. Procedural design techniques automatically generate urban designs through predefined rules which you can change as much as needed, providing room for limitless new design possibilities.

Procedural design of a new urban ecosystem starts with a street network. Street blocks are then subdivided into lots, resulting in a new urban form. By selecting all or some of the lots, you can then generate buildings with appropriate setbacks and architectural characteristics. Procedural design technology lets all buildings be made to vary from one another to achieve an urban aesthetic. At this point the city model can be re-designed quickly and iteratively by changing simple parameters.

Procedural design allows designers to write rules directly into the code of a rule set, essentially encoding anyone's values directly into how the city will look and feel. Any zoning code can be used to instantly model a city. Procedural design allows you to create complete city designs, not just a building at a time; entire neighborhoods with complete infrastructure and landscaping.

Procedural design opens the world to a new set of opportunities for urban planning and design. Today, a building must be designed as an integral part of the urban ecosystem to be considered sustainable. While design is not inherently dependent upon metrics during the realization process even a cursory look at today's architecture reveals the need for a standard method of accountability. Procedural design provides advanced analytical tools in response to the growing need for measurable, performance-based design.

By designing with defined performance indicators, procedural design enables the rapid launch of community design and implementation strategies enabling design at several scales simultaneously. Scenarios supporting the geodesign framework can then be easily evaluated and re-evaluated by comparing key performance indicators.

Procedural design creates a new relationship between people and their urban ecosystems. It's a technique which helps us to develop a better understanding of how we shape our cities and, in turn, how they shape us.

About Shannon McElvaney

Shannon McElvaney is the Community Development Manager at Esri and a geodesign evangelist working on developing tools, processes, and techniques that will enable people to design, build, and maintain livable, sustainable, healthy communities.

He has more than 20 years' experience applying geospatial technologies across a variety of industries. He writes a quarterly column and is on the Editorial Advisory Board at Informed Infrastructure. Most recently, he is the author of a new book, *Geodesign: Case Studies in Regional and Urban Planning*.

(This article originally appeared in the *Esri Insider* blog on 18 October 2013.)

Beginnings of Geodesign: A Personal Historical Perspective

Carl Steinitz, Harvard University

Geodesign is a method which tightly couples the creation of proposals for change with impact simulations informed by geographic contexts and systems thinking, and normally supported by digital technology.

—Michael Flaxman and Stephen Ervin, 2010

Geodesign is an invented word, and a very useful term to describe a collaborative activity that is not the exclusive territory of any design profession, geographic science or information technology. Each participant must know and be able to contribute something that the others cannot or do not . . . yet during the process, no one need lose his or her professional, scientific or personal identity.

—Adapted from C. Steinitz, 2012, A Framework for Geodesign, *Preface*

My first contact with computing occurred in early 1965 at a lunch at the Harvard-Massachusetts Institute of Technology (MIT) Joint Center for Urban Studies, where I was a graduate student fellow. By chance, I was seated next to Howard Fisher, who was visiting Harvard while considering a move from the Northwestern Technology Institute (now Northwestern University) to the Harvard Graduate School of Design. Fisher, an architect, had invented the Synagraphic Mapping System—SYMAP—in 1963. SYMAP was the first automated computer mapping system that included spatial-analytic capabilities applied to spatially distributed data. It was based on line-printer technology. Its principal technical innovations for graphics were to enable the typeface ball on the printer to be stopped and a series of overprinting commands to be invoked, which then created a gray scale (figure 1). SYMAP had not yet been applied to a substantive problem.

I immediately seized upon the relationship between the capabilities that Fisher described to me and the needs of my doctoral thesis on the perceptual geography of central Boston. With Fisher as my tutor, I gave SYMAP its first applied test. I was trying to explain why some parts of central Boston were included in Kevin Lynch's book *Image of the City* and some were not. I acquired data and mapped and analyzed it (figure 2), including via a graphic spreadsheet-type program, which I had to invent.

Partly because of this work, I obtained my first appointment at the Harvard University Graduate School of Design in 1965

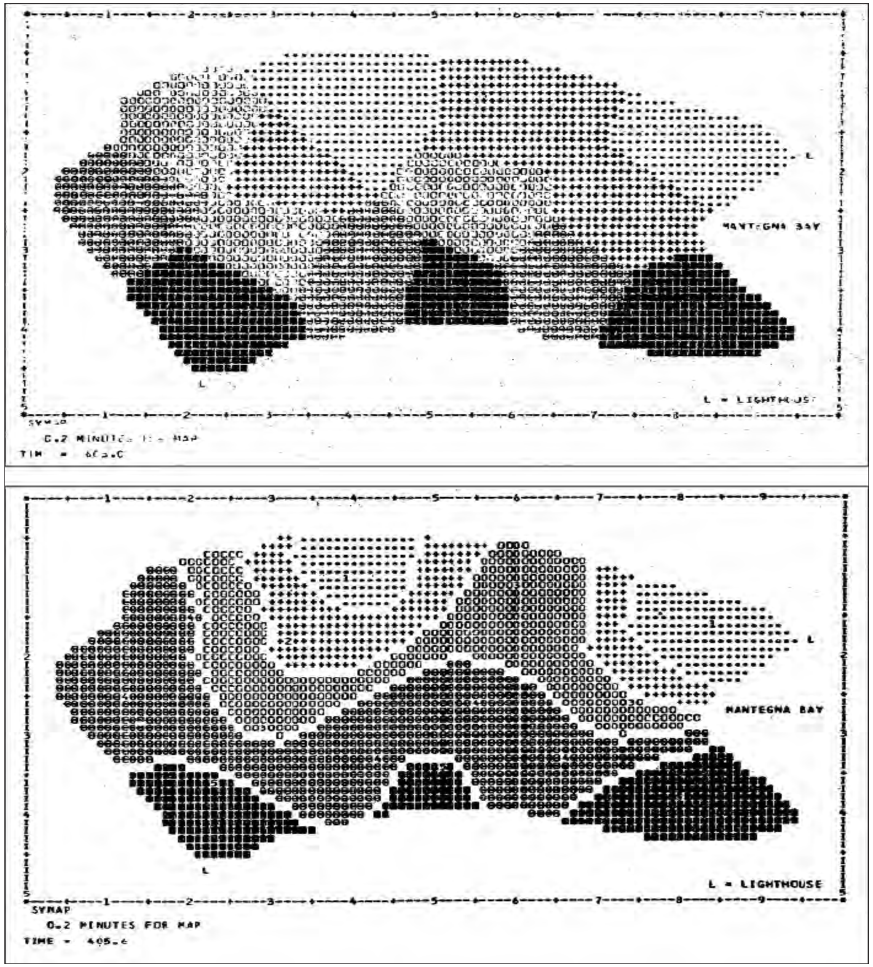


Figure 1. SYMAP Conformant map (top) and Contour map.

Figure 2. Data and analyses derived from photography and interviews to help explain why some parts of central Boston are memorable.

(Courtesy of C. Steinitz.)

as an assistant research professor and as an initial appointee to the then-new Laboratory for Computer Graphics. The Laboratory for Computer Graphics was established in 1965 with a grant of $294,000 from the Ford Foundation's Department of Public Affairs and various smaller contributions from and to the Graduate School of Design. Under Fisher's direction, the laboratory assembled a group of bright, energetic, and experiment-minded people, including urban planner Allan Schmidt, water engineer and economist Peter Rogers, and architect Allen Bernholtz.

The laboratory's research was basically of two types. The first was investigation into the analysis and computer-graphic representation of spatially and temporally distributed data and was built largely upon Fisher's SYMAP, which became in its time the world's most widely used computer mapping program. In a very short time, we developed several innovative methods of high-speed electronic digital computer mapping and new techniques for data analysis and graphic display. These made full and efficient use of the accuracy, speed, and cost of the computers of the time.

The second type was research in spatial analysis, mainly related to city and regional planning, landscape architecture, and architecture, with emphasis on the roles of computers in programming, design, evaluation, and simulation. For example, Frank Rens and his team were developing SYMVU, which was programmed to control the view angle and distance of plotted 3D data by enabling rotation of 3D volumes. This was a key step both for animation and for geographically focused global representations.

My assigned role in the lab was to represent landscape architecture and urban and regional planning. However, my personal experience at MIT in thinking about regional change as a designed process with Lynch and Lloyd Rodwin clearly led me to see (and perhaps foresee) computing as providing essential tools and methods for design (figure 3).

My first teaching assignment was in fall 1966 in a multidisciplinary collaborative studio, sponsored by the Conservation Foundation, that focused on future regional development and conservation of the Delmarva Peninsula (Delaware and parts of Maryland and Virginia). In this study, I and a small group of students chose not to use the then-common hand-drawn overlay methods being used by the rest of the class but rather to prepare computer programs in FORTRAN and use SYMAP to make and visualize a series of evaluation models for the future land uses under consideration. A design was made that was visually informed by the resultant maps (figures 4A and B).

To my knowledge, the Delmarva study was the first application of GIS-modeled evaluation to making a design for a large geographic region. It is worth noting that this earliest GIS work was accomplished using Hollerith cards and the line printer to make paper maps in black and white. My first regional-scale GIS

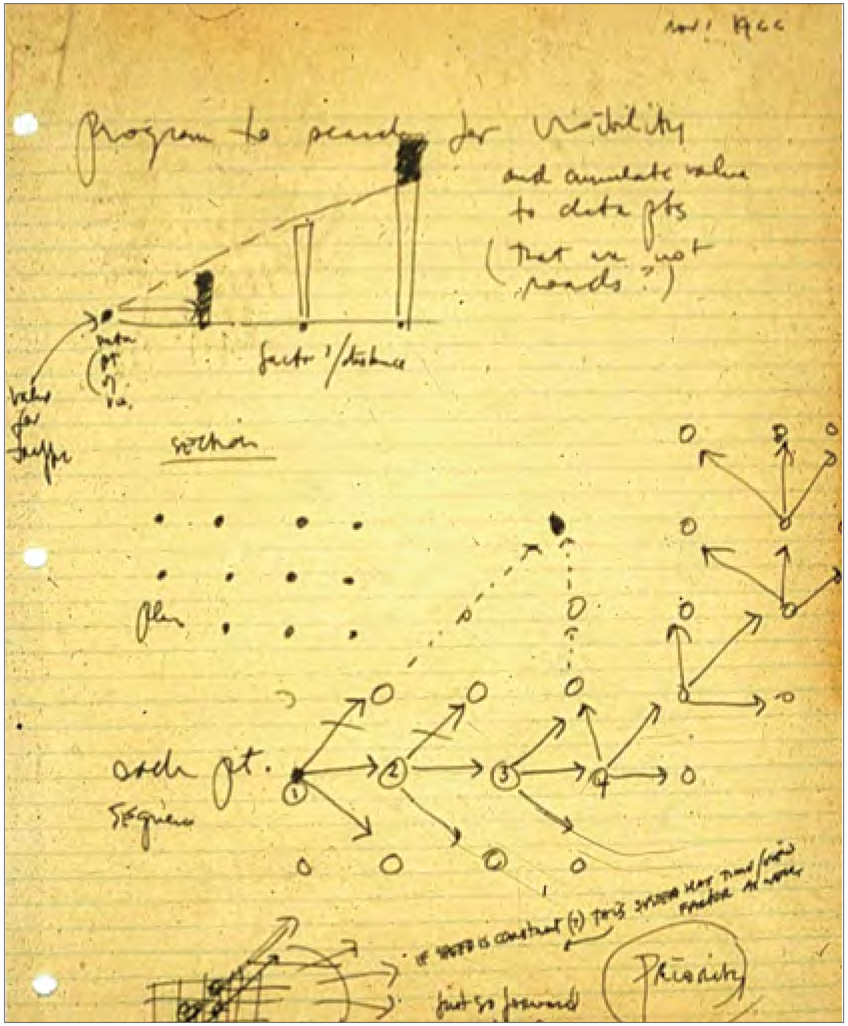


Figure 3. Ideas for analyzing networks, such as streets, and for assessing moving views in 3D, 1966.

(Courtesy of Carl Steinitz.)

map was based on hand-encoded data to a grid base measuring 2 miles by 2 miles. It cost $35 (in 1965 dollars) for computing time on a $2 million IBM machine, the only accessible computer at Harvard. A registered user was only allowed one computer use a day. How happy I was to produce my first basemap, finally, after 30 days of effort.

Yet even in this first study, some rather sophisticated analytic steps were undertaken. These included a gravity model; various terrain-related analyses; the effect of one map pattern on another; and overlain data maps combined via quantitatively weighted indexes, such as the relative attractiveness for vegetable or grain agriculture. I cannot overstate the importance of the initial academic decision of Charles Harris, then chairman of the Department of Landscape Architecture, to support me to introduce GIS-based computing in a design-oriented studio rather than in a specialized "technical/computer" course. This would prove crucial to the future development of GIS at Harvard as a set of methods for design.

In 1967, Rogers and I organized and taught an experimental multidisciplinary studio on the future of the southwestern sector of the Boston metropolitan region. The intent was to model the often-seen conflicts between the environmental vulnerability of the regional landscape and its attractiveness for development. We were also making a regional design for better managing the

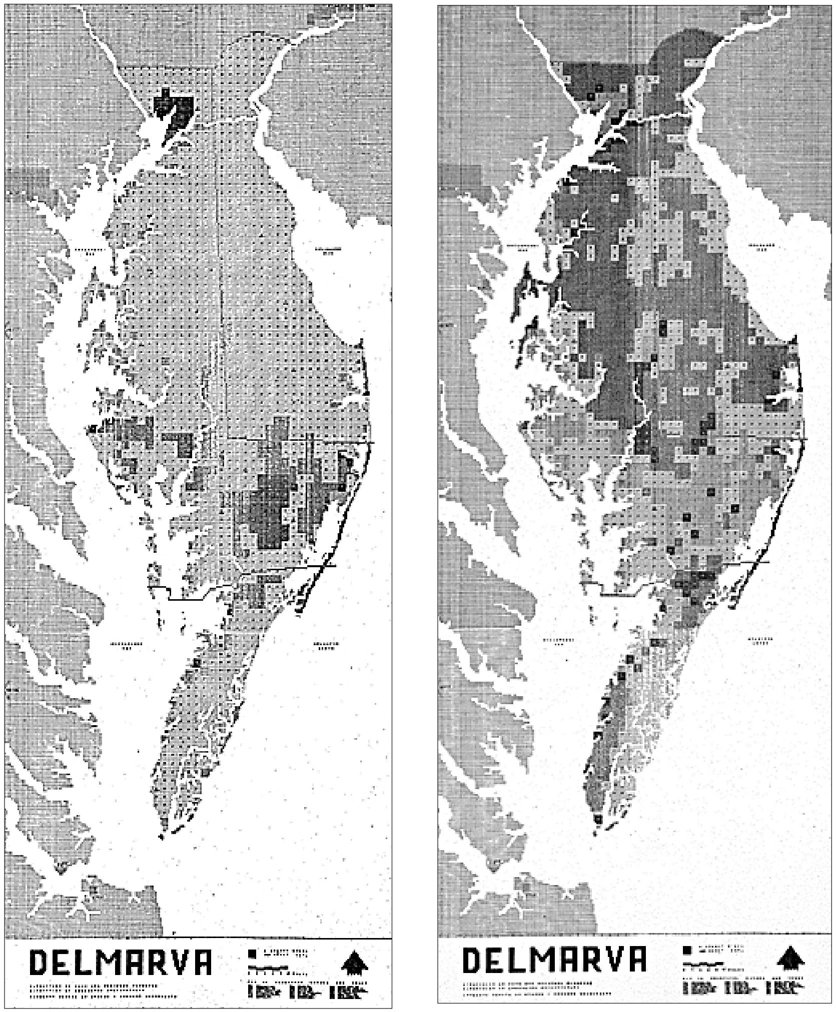


Figure 4A (left) and 4B. Data was combined using quantitatively weighted indexes to evaluate relative attractiveness for vegetable (left) and grain agriculture.

(Courtesy of C. Steinitz.)

region's sprawling urban expansion. My initial diagram for this study was made in early 1967 and is shown in figure 5. Note that it begins with an understanding of decision processes. It distinguishes between land-use demands and evaluations of their locational attractiveness and site resources and evaluations of their vulnerabilities. It assesses risk and impacts and proposes generating plans with the rules of a simulation model. It is organized in the same sequence now outlined in the second iteration of the framework in my 2012 book *A Framework for Geodesign* (although we didn't call our work that at that time).

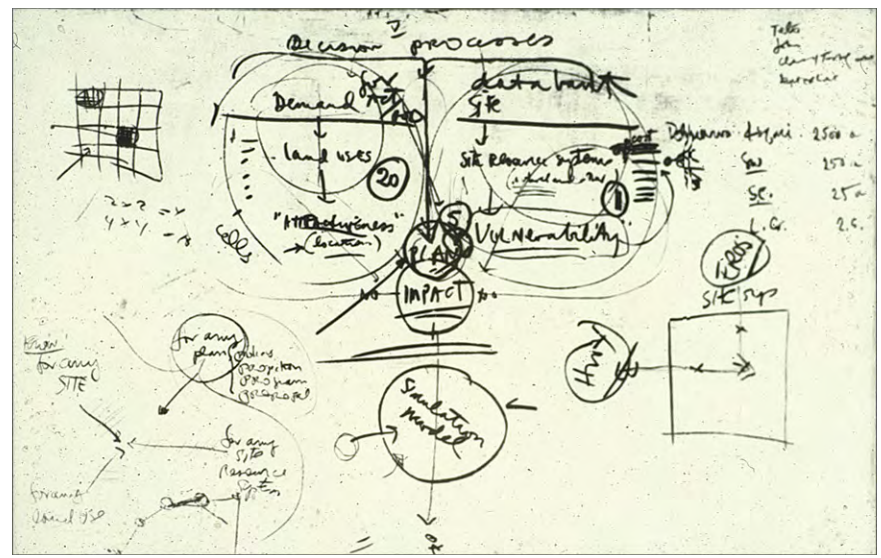


Figure 5. My earliest diagram for the information flow for a large-area design study, 1967.

(Courtesy of C. Steinitz.)

Figure 6. Peter Rogers (left) and Carl Steinitz at the Laboratory for Computer Graphics, Graduate School of Design, Harvard University, in 1967. Photographs of the process of working were taken only rarely, unfortunately.

The entire flow of information for the study was designed by Rogers and me before any "work" was begun (figure 6). The study area was a rapidly changing suburban area. There was no digital data, so the students organized a GIS from air photo interpretation based on a 1-kilometer grid. (Remember, this was 1967.) Our students were also involved in all phases of the detailed specification, implementation, and uses of the models.

Ten process-related models were organized and linked, sharing what was then state-of-the-art GIS and programming software. Change was based on a demographic model that forecast population growth in different social classes and was allocated in 5-year increments for a period of 25 years. These created demand for new locations to accommodate industry, three residential types, recreation and open space, and commercial/institutional centers. This new land-use pattern then required new transport services. Four purposely different types of impacts were selected for assessment: local politics, local finances, visual quality, and water pollution. If these were deemed unacceptable by the students representing the decision makers, several feedback paths would result in redesign toward an improved land-use pattern for that stage. If the impacts were satisfactory, the set of models would then be used to simulate the next 5-year stage.

The evaluation of attractiveness or vulnerability for each land use in the future was based on a regression model of the locational criteria for that land use in the present. Computer-made maps, such as the following evaluations of locational attractiveness for low-, medium-, and high-income housing, were made by SYMAP.

While we were certainly aware of computer-based allocation models at that time, we deliberately had our students conduct the change model (the phase that changed the geography of the region) by hand so that they would be as personally engaged as possible in the process. They made the allocations based on a smaller 250-meter grid, guided by the computer-generated evaluation maps.

These unit-areas of change were represented by color-coded cards for the land use to be allocated. The population model established the demand for each land-use type in a time stage, and then student teams, each representing different land uses, engaged in the physical and verbal process of competing for the most attractive locations, much in the way that an agent-based change model would function. They first simulated a future trend through the several time stages.

The students then assessed the consequences of the trend changes with the several impact models. These impacts were visualized by overlaying colored pins and notes on the causal changes. The students then interpreted the impacts and decided whether changes in the trend's land-use pattern of any stage were required. Lastly, they re-allocated the changes by design, producing results measured to be environmentally superior and meeting the criteria for development (figure 7). This Boston study was published in 1970 as *A Systems Analysis Model of Urbanization and Change: An Experiment in Interdisciplinary Education* (MIT Press).

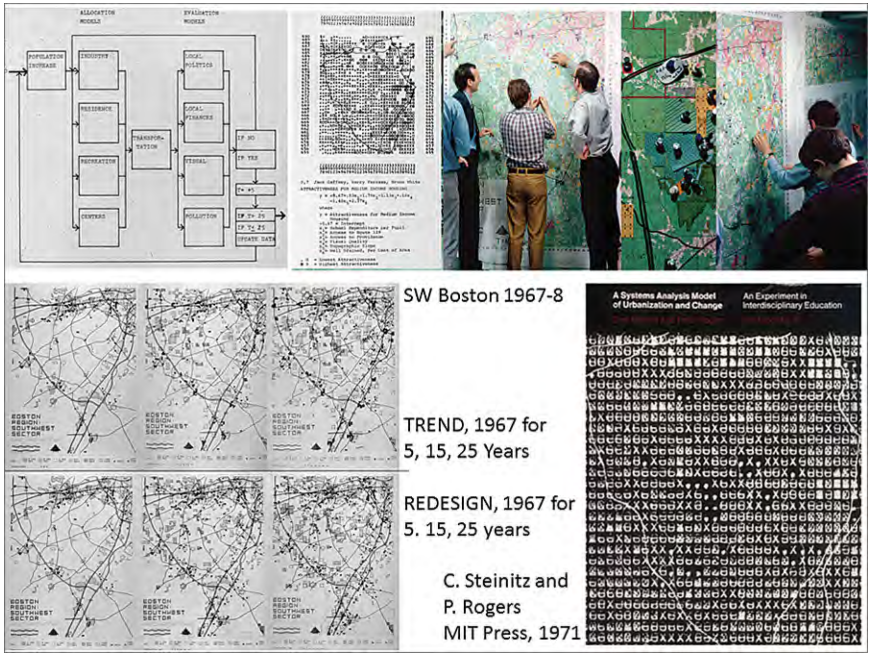
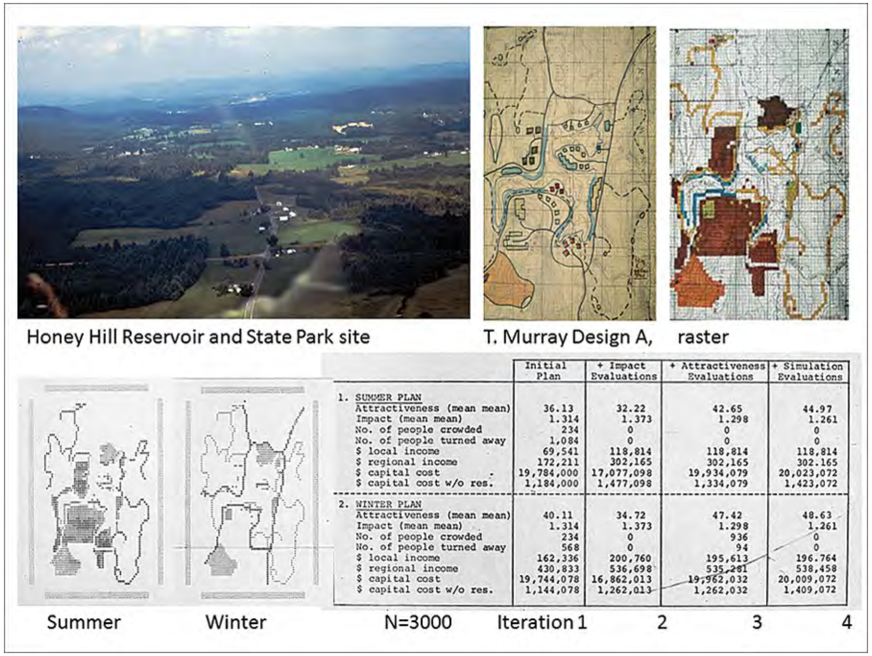


Figure 7. Upper: The structure of the study's 10 linked models, attractiveness for new middle-income housing, and allocating new development and conservation. Lower left: Trend growth (top three images) and improved growth (bottom three images). Lower right: Dust jacket of A Systems Analysis Model of Urbanization and Change, 1971.

Also in 1967, our research group, which included landscape architects Richard Toth, Tim Murray, and Douglas Way and engineer-economist Rogers, began a series of GIS-based studies that related various ways of making and comparing designs for large and environmentally vulnerable geographic areas with complicated programmatic needs. The Honey Hill study, named after its location in New Hampshire, was sponsored by the US



	Initial Plan	+ Impact Evaluations	+ Attractiveness Evaluations	+ Simulation Evaluations
1. SUMMER PLAN				
Attractiveness (mean mean)	36.13	32.22	42.65	44.97
Impact (mean mean)	1.314	1.373	1.298	1.261
No. of people crowded	234	0	0	0
No. of people turned away	1,084	0	0	0
$ local income	69,541	118,814	118,814	118,814
$ regional income	172,211	302,165	302,165	302.165
$ capital cost	19,784,000	17,077,098	19,934,079	20,023,072
$ capital cost w/o res.	1,184,000	1,477,098	1,334,079	1,423,072
2. WINTER PLAN				
Attractiveness (mean mean)	40.11	34.72	47.42	48.63
Impact (mean mean)	1.314	1.373	1.298	1.261
No. of people crowded	234	0	936	0
No. of people turned away	568	0	94	0
$ local income	162,336	200,760	195,613	196.764
$ regional income	430,833	536,698	535,281	538,458
$ capital cost	19,744,078	16,862,013	19,962,032	20,009,072
$ capital cost w/o res.	1,144,078	1,262,013	1,262,032	1,409,072

Figure 8. Top left: Aerial view of the site. Top right: Tim Murray's design. Bottom: Assessment of impacts of Murray's design.

Army Corps of Engineers. It involved a large proposed flood control reservoir and a new state park. GIS-based evaluation models were made of the attractiveness of this large area for recreation and other uses and of the vulnerability of the site's natural systems to harmful impacts. Each member of the research team then proposed a design for the new lake and park facilities, in summer and winter (figure 8). In addition, Rogers used a linear programming algorithm to produce a fiscally optimal plan.

These alternatives were all compared in yet another model, which simulated several levels of population demand and user movement to the area's facilities based on varied assumptions regarding number of persons and patterns of activity preference. Overcrowding and movement to second-choice locations or activities and capital and maintenance costs for the design alternatives were among the comparative impacts. Each design went through three iterations of assessment and redesign. The optimizing program performed best, and my design came in fourth.

This study provided important insights into the potential power of using GIS to link different model types and ways of designing to make better plans. This experience would shape our work for many years and, in my own case, to the present time. This research concept was the inspiration for a series of studies focusing on the Boston region in the late 1960s, as well as a major research program supported by the United States National Science Foundation in the early 1970s, which integrated GIS

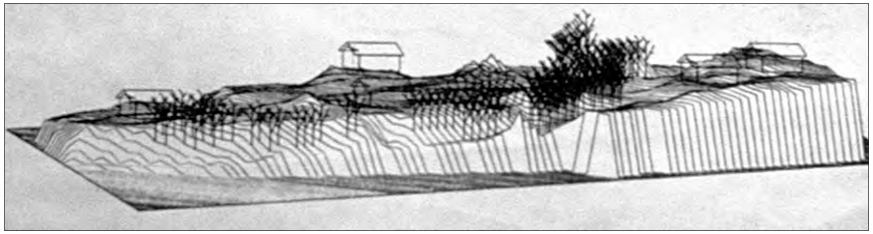


Figure 9. Buildings and trees on terrain.

(Courtesy of C. Steinitz.)

methods with sectoral models of the processes of urbanization and change.

Two additional early experiments may be of interest. In 1968, I designed a series of programs that automated the process of placing a series of prepackaged visual simulation forms for trees, houses, etc., on a raster terrain model and a land-cover map (figure 9). This program set then allowed one to specify the location and azimuth for a view or sequence (based on the work of Rens), and a pen plotter would painstakingly draw a series of perspectives in that GIS-generated landscape. The system was configured so that changes in the GIS terrain or land-cover map would automatically trigger changes in the landscape view. This technique was successful as an experiment but inefficient and uneconomical. It took several years before we efficiently linked GIS to automated allocation and animated visualization.

Also in 1968, and having made several experiments placing and visualizing a designed pattern of land uses on terrain, I had a series of discussions with architect Eric Teicholz about different ways in which rules could be established for the making of the designs themselves. We decided to make a series of experimental designs, which were rule based. There would be a street system and a pond, each with minimum setbacks; parking access within a minimum distance to every house; three housing types with prespecified locations for connections; and trees, which were allocated along roadways or near houses but could only be located on soil. The experiments varied the number of

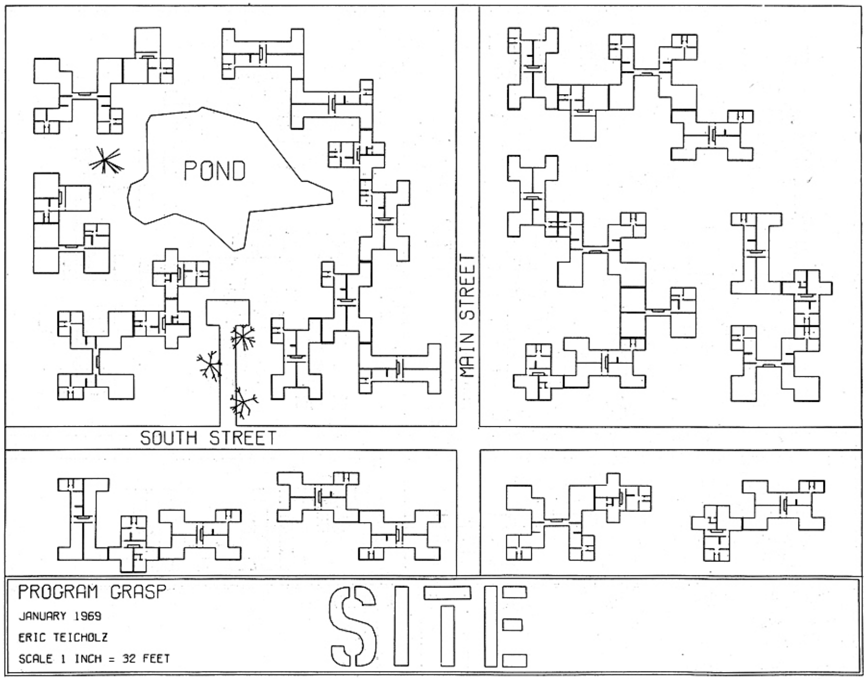


Figure 10. Our first experimental computer-generated, rule-based design.
(E. Teicholz with C. Steinitz.)

houses among the three types and the number and roles of trees. Figure 10 shows the first experimental rule-based design.

In retrospect, I would divide these earliest years of GIS and its applications into three stages. In the middle 1960s, we used computers and computer graphics to do things we already knew how to do using noncomputer technologies. We acquired data and encoded it and produced maps. The analytic capabilities of the time were primitive, typically limited to applied studies on landscape classifications, sieve maps, or overlay combinations, all of which could have been accomplished with hand-drawn methods. Spatial and statistical analyses were difficult; professional acceptance was low, and public cynicism was high regarding analyses and the resultant graphics produced by computers.

The second stage, in the later 1960s, emphasized substantially more sophisticated GIS analyses: the merging of mapping and statistical techniques, the introduction of more sophisticated spatial analysis methods, and the introduction of graphic displays more diverse than two-dimensional maps. A strong research effort in theoretical geography was organized and directed by William Warntz and related to the theory of surfaces, the macrogeography of social and economic phenomena and central place theory.

During the third stage in the early 1970s, the laboratory saw important interaction with other disciplines and professions, particularly the scientific and engineering professions. We had the self-criticism that recognized the need for more predictable analysis and for better models. The view throughout this third stage was that information could and should influence design decisions. A critical professional role would be to organize that information, have it available and adaptable to questions, and thus provide decision makers with information relevant to decisions at hand. The focus on *aiding* decisions rather than *making* decisions increased both public and professional interest and acceptance.

I ended my direct affiliation with the laboratory in this period. By then, we had developed, demonstrated, and occasionally linked and used computer software to fully support a variety of design processes. We had collaboratively applied these to significant studies of real, large, and complex places . . . the stuff of geodesign.

The laboratory continued to grow in size and influence under the further directorships of Warntz and Schmidt. The later 1970s to the mid-1980s may be characterized by the introduction of smaller and far less expensive computers, more user-friendly programs incorporating commands in common English or the ability to point a computer cursor, more easily acquired data, and a proliferation of analytic and graphics capabilities. These advances resulted in an increased potential for decentralized and networked computer use and in increased freedom from predefined analysis and planning approaches. However, the need—and responsibility—for selecting wisely from a much larger set of technical and methodological options also increased in this period. We saw in the universities and then in the professions the first computer-comfortable generation of students. Professional acceptance broadened, and computer use was no longer regarded as something special.

The Harvard Laboratory for Computer Graphics and Spatial Analysis ceased to exist—for many complex reasons—in 1981. By then, 165 people had served on the laboratory staff at one time or another. Much of the credit for the lab's diverse accomplishments should go to Fisher, who died in 1974 and who was a remarkable person of uncommon energy and foresight. The many individuals linked to the lab and their ideas, computer programs, demonstrations, publications, and especially students were significant contributors to the development of today's GIS and many of its applications, including geodesign.

About the Author

Carl Steinitz is the Alexander and Victoria Wiley Professor of Landscape Architecture and Planning, Emeritus, at the Graduate School of Design, Harvard University, and Honorary Visiting Professor, Centre for Advanced Spatial Analysis, University College London. In 1966, Steinitz received his PhD degree in city and regional planning, with a major in urban design, from MIT. He also holds a master of architecture degree from MIT and a bachelor of architecture degree from Cornell University. He is principal author of *Alternative Futures for Changing Landscapes* (Island Press, 2003) and author of *A Framework for Geodesign* (Esri Press, 2012).

(This article originally appeared in the Summer 2013 issue of *ArcNews*.)

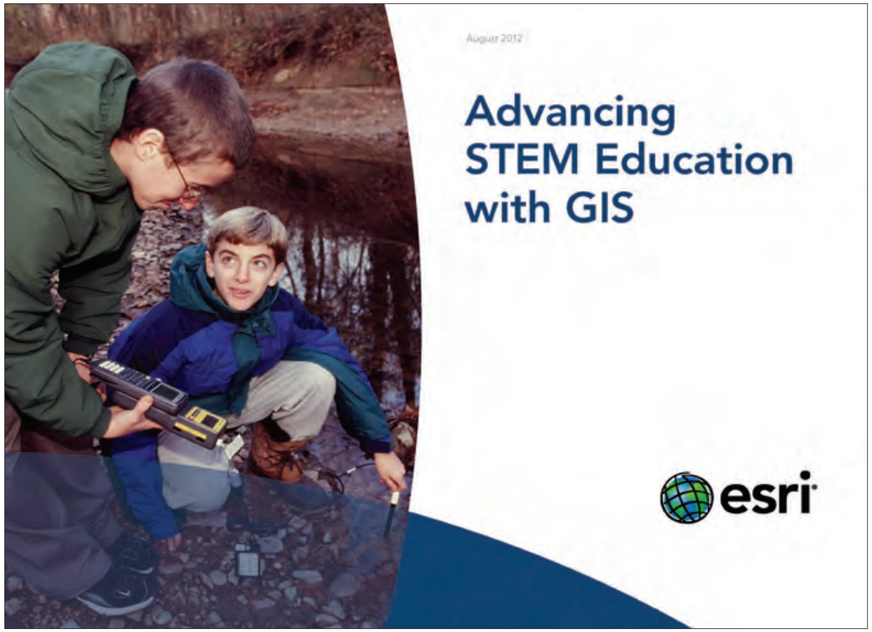
GIS Is STEM!

Jack Dangermond, Esri

Today's youth are tomorrow's decision makers, and an understanding of geography and the use of geospatial technology will be crucial to helping them make good decisions that affect global health and community life. Unfortunately, geography has always been sort of an "underdog" in our educational system; it's been misunderstood, generalized, and sometimes ignored. Even today, as we see increased focus on STEM in education, we frequently see geography completely disregarded as a component of STEM.

This is very unfortunate. STEM stands for science, technology, engineering, and mathematics. Geography touches heavily on all of these disciplines, and the application of geospatial technology helps us to better understand cross-disciplinary phenomena and solve important problems. GIS, GPS, and remote sensing can be used to simultaneously engage students in science, technology, engineering, and math.

To overlook geography as a critical component of STEM flies in the face of the goals of STEM—to improve education, the work force, and national competitiveness. We need to work together as a community and get geography back in to STEM. The geospatial community and larger geography community have responded in a number of ways. For example, National Geographic has organized a group called the Geo-Literacy Coalition, with the goal of raising awareness about the importance of a geo-literate population and the need to invest in geography education. More people in the GIS community need to support the efforts of the Geo-Literacy Coalition as well as other efforts to recognize the critical importance of geography in STEM.



About Jack Dangermond

Jack Dangermond founded Esri with a vision that computer-based mapping and analysis could make significant contributions in the areas of geographic planning and environmental science. The recipient of 10 honorary doctorate degrees, he has served on advisory committees for the National Aeronautics and Space Administration, the Environmental Protection Agency, the National Academy of Sciences, and the National Science Foundation.

Free e-book: Advancing STEM Education with GIS [PDF]

(This article originally appeared in the *Esri Insider* blog on 02 January 2013.)

Bridging the Gap between Scientists and Policy Makers: Whither Geospatial?

Dawn Wright, Esri

"We, the people, still believe that our obligations as Americans are not just to ourselves, but to all posterity. We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations. Some may still deny the overwhelming judgment of science, but none can avoid the devastating impact of raging fires, and crippling drought, and more powerful storms."

Thus spoke President Barack Obama in his 2nd inaugural address, to the delight of many, if not most in the scientific community. Indeed, there are many societal problems across the world that increasingly revolve around science. These include pollution and waste management, pandemics and biosecurity, access to clean air and clean drinking water, response to and recovery from natural disasters, choices among energy resources (oil and gas versus nuclear versus "alternative"), and the loss of open space in urban areas, as well as biodiversity in rural areas. And yet, there is a tension between the world of science, which is focused on discovery, and the world of policy making, which is focused on decisions.

In the US it does not help that less than 2% of Congress has a professional background in science [Otto, 2011]. Members of Congress are not as interested in science as they are in what science can do for society. They look to the scientific community to give them answers to help them make policy decisions. But the answers they seek are often simpler than the scientific community is able or willing to provide, given the complexity of Earth processes and the persisting gaps in our knowledge and ability to measure certain parameters. Policy makers live in a world that is extremely binary in comparison to scientists (e.g., casting a simple yes or no vote on a bill; a simple yes or no on a decision; standing for elections that are essentially driven by money and value-based issues that get citizens out to cast yes or no votes for or against them). Scientists are also used to communicating in a certain way, using their own specialized language and jargon that is often understood only among their peers. They may also be distrustful of how their results and interpretations may be used (or misused) outside of the traditional academic outlets of scientific journals and meetings. The academic world rewards scientists for participating in these activities, but not necessarily for reaching out to policy makers, the media, and the general public.

And yet, the ramifications of the aforementioned critical societal challenges have become too great. Inaction by our governments on these issues will have dire consequences, and many in the scientific community are realizing that scientists can no longer afford to stand on the sidelines and not speak out beyond the boundaries of academe. What is the "new normal" in terms of the frequency of severe storms [Shepherd and Knox, 2012] and how can we be more adequately prepared; how can we more quickly catalyze solutions for the protection and the good of our societies? Indeed, science is now part of an unavoidable and contentious public discussion on a host of issues, including climate change and public health. Perhaps the clearest example of late is the conviction of six Italian scientists and a government official on multiple charges of manslaughter for failing to adequately communicate the risk of the L'Aquila earthquake that claimed the lives of more than 300 people in April 2009 [Cicerone and Nurse, 2012]. They were sentenced to six years in prison and ordered to pay a fine equivalent to US$10 million in damages. Goldman [2012] discusses the many complexities of this case, including the important differences between communicating scientific uncertainty and communicating risk.

Indeed, the issue of scientific communication is paramount. Goldman [2012] goes on to state: "In times of crisis—hurricane, earthquake, tsunamis—scientists have a crucial role to play as trusted and sought-after sources of information. They should communicate their science, within their expertise . . .." I would argue further that both scientists and policy makers need each other now more than ever. The policy maker needs the knowledge of science communicated in a way in which they can take action to solve ever-pressing problems. In fact, scientists today can say not only that we have a problem, but also suggest what can be done about the problem. In turn, the scientist needs the policy maker to help extend his or her research into the realm of practical, useful outcomes that inform relevant, real-world societal issues. The policy maker may also be the one providing the lifeblood of funding that makes the science possible. However, two caveats are important to note:

1. Not every policy maker is going to be concerned with science and not every scientist is going to be concerned with policy; and
2. The role of science in policy should be that of informing policy, not making policy.

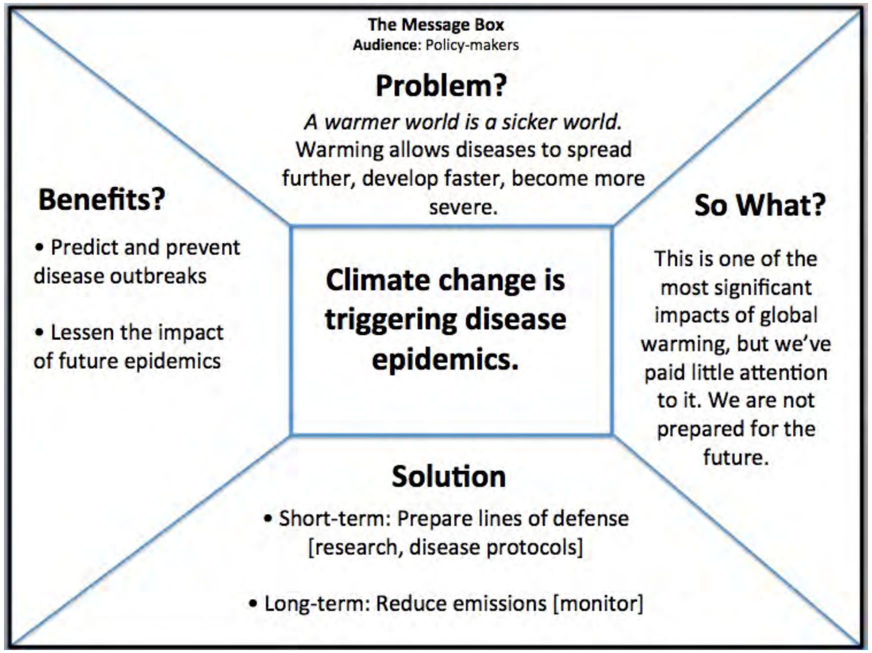
Resources for Scientists

The culture of science is changing to the point that there is growing agreement that scientists can and should seek to engage with policy makers, and many have already been called up by policy makers to do so [e.g., Baron 2011]. And increasingly, scientists as communicators are moving into positions of administrative leadership, where they not only continue to engage with society in various ways, but also work to change the culture of academic institutions from within. Many are devoted to developing strategic thinking and science communication outreach skills in their graduate students and young faculty, exposing them to issues not typically covered in the classroom or in research training.

What resources are available to scientists to help them become effective communicators to policy makers, especially in light of the already huge demands on their time?

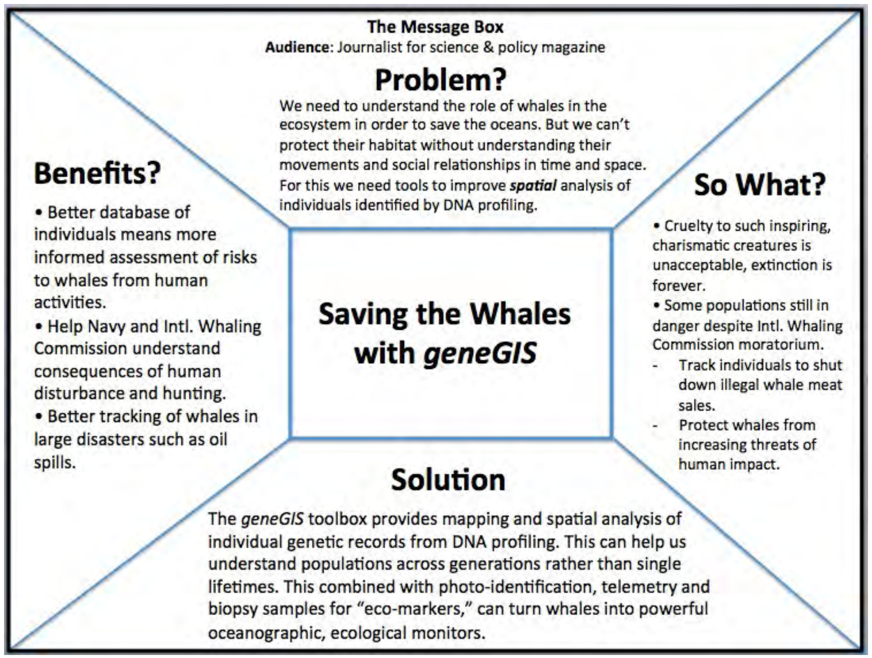
Special sessions on science communication and science informing policy are now being held regularly at prominent scientific meetings such as the annual meeting of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society, and the Fall Meeting of the American Geophysical Union (AGU), which hosts 20,000 attendees annually. To wit, the 2012 Fall AGU meeting featured workshops entitled *Climate Communication: Tools and Tips* and *Finding Your Voice: Effective Science Communication*. I am co-organizer of a session this week at the AAAS entitled *The Beauty and Benefits of Escaping the Ivory Tower*, that's part of a broader theme of exciting sessions on science communication. Along similar lines, scholars from the University of California, Santa Barbara will present a paper this spring at the American Association of Geographers Annual Meeting entitled, *What Can You Learn About Climate Change by Following the News? Themes and Frames in US News Reports, 1970s to Present*.

There are also several excellent programs available, including COMPASS, which supplies scientists with the communication tools needed to effectively bridge the worlds of science, policy, and journalism (and offered the aforementioned "Finding Your Voice…" workshop). One such tool is the "message box," which aids scientists in effectively distilling the importance of their research to policy makers in terms of what they really need to know, stated in a way that most matters to them. The message box below distills an entire scientific journal article [Patz et al., 2005] on the many effects of climate change on global human health for the benefit of policy makers, with the overarching and powerful message: "A warmer world is a sicker world."



Message box (after Patz et al. [2005]) aimed at policy makers and focused on climate science.

The message box below has a slightly different audience. It distills a 15-page GIScience research proposal funded by a federal agency into a salient message for a journalist interested in developing a feature article on the project.

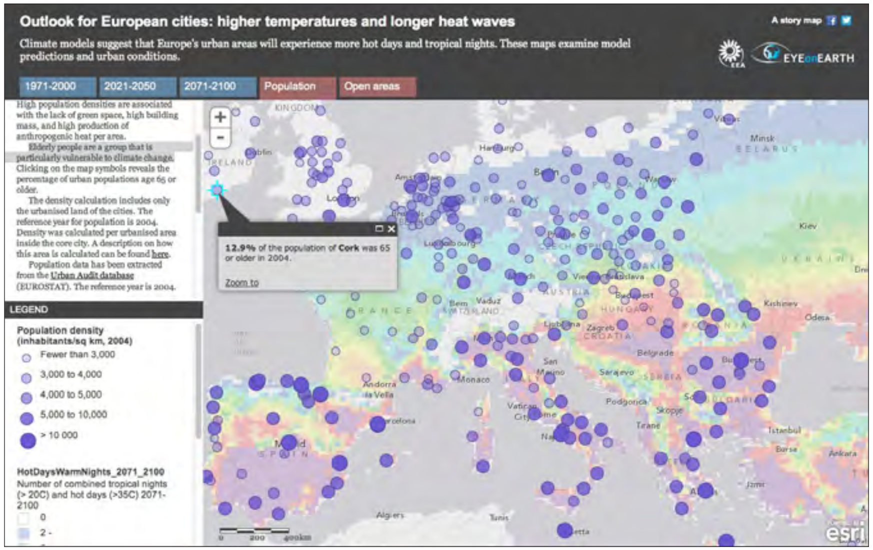


Message box aimed at a science journalist, and focused on GIS for marine mammal conservation.

Staffers of COMPASS are also regular trainers in the Leopold Leadership Program at Stanford University's Woods Institute for the Environment, which helps outstanding academic environmental researchers gain the tools and connections needed to translate their knowledge into action through engagement with media, government, NGOs, and business. Scientists chosen as fellows receive intensive experiential training and expert consultation in leadership and communication, including practice media interviews and meetings with policy makers in Washington, DC. After completion of the program, the new cohort joins other fellows in the Leopold Leadership Network, a community of academic scientists and former fellows who continue to communicate scientific information about environmental issues to policy makers and other non-scientists. Current fellows include members of the National Academy of Sciences, National Geographic Explorers-in-Residence, TED speakers, and top advisers to the nation via the National Academies of Science or Federal Advisory Committees.

Another effective tool is the Esri "Story Map" which combines the new medium of "intelligent web maps" with text, multimedia content, and intuitive user experiences to inform, educate, entertain, and inspire many audiences about a wide variety of environmental issues, including policy makers. The example below shows a Story Map developed in collaboration with the European Environment Agency (EEA) and the Eye on Earth Network that allows examination of climate model predictions suggesting that Europe's urban areas will experience more hot days and tropical nights in the period 2071-2100. Clearly this should be of interest to European policy makers. In fact, less than

24 hours after the EEA first posted an initial heat wave risk map on the Eye on Earth website, it received more than 100,000 views.



Story Map coupling climate model predictions of hot days and warm nights with population density throughout Europe. Given that elderly people are particularly vulnerable to climate change, clicking on a map symbol shows what percentage of the population was 65 or older in 2004.

Whither Geospatial?

What are the implications for scientific researchers in the geospatial realm? Scientists are normally concerned with how the Earth works. But the dominating force of humanity on the Earth begs the question of how the Earth should look, especially with regard to landscape architecture, urban planning, land-use planning and zoning, and ocean/coastal management. These involve decisions that must be made by policy makers and require the use of geospatial data and geographical analysis. And along these lines, geodesign will continue to make an impact in the sustainability world, leveraging geographic information and scientific modeling so that future designs for urban areas, watersheds, protected areas, and the like will more closely follow natural systems and result in less harmful impacts. How should geospatial scientists communicate this to policy makers? Given the challenges that our planet faces, I hope the geospatial community will also ponder and discuss whether communicating with policy makers is now an ethical issue, and if science communication should be made a formal part of geospatial curricula and professional GIS certification.

[*Small portions of this article appear in the January 2013 issue of* Geospatial World *magazine.*]

About Dawn Wright

Dawn Wright joined Esri as Chief Scientist in October 2011 and is responsible for formulating and advancing Esri's goals in the environmental, conservation, climate, and ocean sciences. She is also professor of geography and oceanography at Oregon State University and has participated in several initiatives around the world over the past 20 years to map, analyze, and preserve ocean terrains and ecosystems. Follow her on Twitter: @deepseadawn.

(This article originally appeared in the *Esri Insider* blog on 11 February 2013.)

Charting a Path for Precollege Geography Education in the United States

"Geo Learning"

Daniel C. Edelson, National Geographic Society

The problems of education can seem intractable, but four organizations have been working together to improve geography education in the United States for more than 30 years, and they continue to do so. These organizations—the Association of American Geographers (AAG), the National Council for Geographic Education (NCGE), the American Geographical Society (AGS), and the National Geographic Society—have recently recommitted themselves to this important work through the publication of several landmark documents.

The first of these is a major revision to *Geography for Life: National Geography Standards*. *Geography for Life* lays out learning goals for geography in three grade bands: K–4 (ages 5–10), 5–8 (ages 10–14), and 9–12 (ages 14–18). These goals represent a consensus among geographers and geography educators of what geographically informed individuals should know and be able to do with their knowledge.

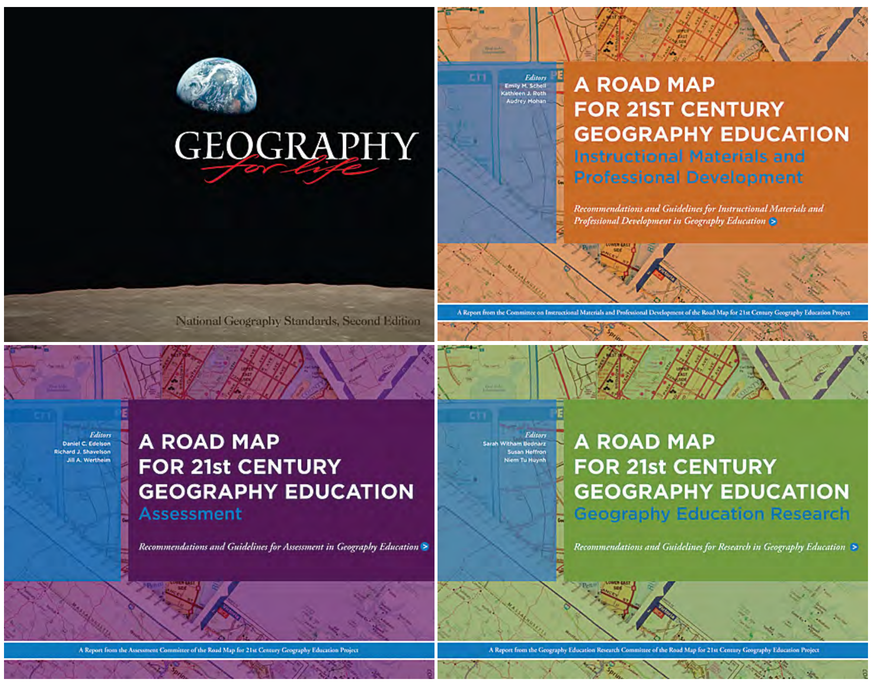
First published in 1994, *Geography for Life* has been thoroughly revised to bring it up-to-date with the state of geography and of research on education. For example, when the first edition of *Geography for Life* was published, GIS only merited a mention in an appendix. In the second edition, GIS figures very prominently in the section of standards called "The Earth in Spatial Terms."

While the federal government in the United States does not adopt or endorse educational standards, *Geography for Life* carries the weight of the four national geography organizations. The organizations created the standards to provide guidance to state and local educational agencies in the creation of their educational standards and curriculum programs.

Around the time that the second edition of *Geography for Life* was going into final edits, the four geography organizations, which collaborate on education initiatives under the auspices of the Geography Education National Implementation Project (GENIP), began discussing how to ramp up the speed and increase the reach of their collective efforts.

The result of these discussions was a proposal to the National Science Foundation to create a set of strategic plans for the improvement of geography education over a 5- to 10-year timeline. The organizations declared that it was time to create "a road map for geography education in the 21st century" and, with the support of the National Science Foundation, launched into an intensive 24-month research and planning project. The resultant road map, which lays out a path to the effective implementation of the learning objectives detailed in *Geography for Life*, was released this spring in the form of three topically focused reports.

The work of the Road Map Project was conducted by three committees composed of leading geographers, educators, and researchers in the science of learning who were selected by a leadership committee representing the four organizations. The committees were charged with creating recommendations for how to improve the effectiveness of geography education in three areas that the geography organizations identified as being important levers for change: instructional materials and professional development for teachers, assessment of student progress, and research on learning and teaching.



A road map, which lays out a path to the effective implementation of the learning objectives detailed in *Geography for Life*, was released in the form of three topically focused reports.

The committees conducted a review of current practices and current research in their assigned area and then formulated recommendations for how to improve geography education over the next decade through focused work in their area.

The Instructional Materials and Professional Development Committee considered the current state of the instructional materials for teaching geography and the preservice and in-service education that teachers who are responsible for geography education receive. Based on this analysis and a review of the literature, the committee formulated recommendations and guidelines for both instructional materials and professional development that will lead to improvements in instruction and in learning outcomes.

The Assessment Committee studied the current state of assessment in geography and reviewed its history. Based on the analysis of existing practices and a review of the literature on assessment as a support for improving educational outcomes, the committee formulated guidelines for developing assessment instruments and for conducting assessment that will lead to improvements in instruction and outcomes.

The Geography Education Research Committee reviewed the existing education and cognitive science research literature to identify gaps in our ability to answer significant questions about geography education based on research. Drawing on this analysis, the committee formulated recommendations for research questions and approaches that will build a knowledge base to guide improvement efforts for geography education in the future.

The result is a set of specific recommendations to improve geography education over the next decade that is grounded in the most comprehensive study of geography education that has been conducted in the United States. It is, in fact, a road map for achieving the goals laid out in *Geography for Life* that the four members of GENIP are committed to implementing over the course of the coming decade.

Achieving the goals of *Geography for Life* will require a greater public commitment to geography education and the allocation of more funding than we have seen before in the United States. By creating the road map, the geography education community has provided a strong justification for making that commitment and described how those resources can be used most effectively.

The next step in this process is to bring these landmark documents to the attention of policy makers, funders, and educators who are in a position to act on their recommendations. To assist with this effort, contact any of the GENIP organizations.

For more information, *Geography for Life* can be viewed online. The print edition can be purchased from the National Council for Geographic Education online store. The reports of The Road Map for 21st Century Geography Education Project and executive summaries are available at no charge.

Follow Daniel Edelson on Twitter @NatGeoEdelson.

(This article originally appeared in the Summer 2013 issue of *ArcNews*.)

Cause-Related Mapping

Allen Carroll, Esri

Many of us are familiar with the term "cause-related marketing." Sometimes the phrase is applied in a broad sense to any effort to increase public awareness of an important issue. A narrower definition is a campaign by a corporation to support a cause, either (cynically) to promote its own brand or (unselfishly) to lend its support to a worthy pursuit—depending on your point of view.

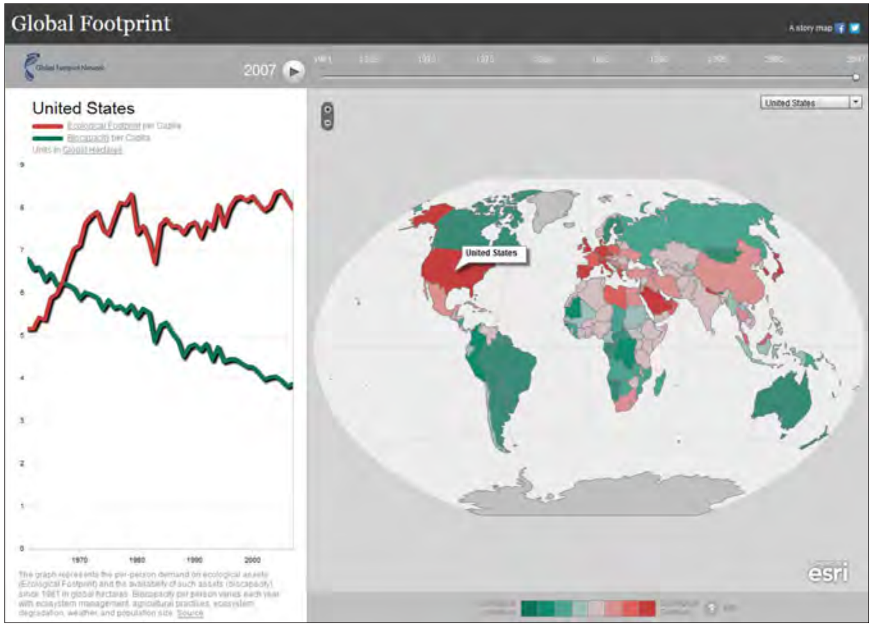
The Internet, the airwaves, and print media are rife with cause-related marketing. How many times, for instance, have you encountered ads by oil companies and automobile manufacturers touting their "green" practices? Cause-related *mapping*, on the other hand, is a far less common phenomenon.

What is cause-related mapping? It's my own term, so I'm happy to propose a definition: It's the use of maps, in combination with other rich media, to inform and engage the public in support of important causes.

There is vast, untapped potential in cause-related mapping. Consider three facts:

1. Every issue you can think of, from climate change to poverty reduction to job creation, has interesting and important geographic characteristics.
2. Maps reveal spatial patterns, facilitate understanding, and help us make sense of the world.
3. Most people like maps.

And yet how many times can you recall an organization using maps to show you why an issue is important and what you can do about it? Hardly ever, right?



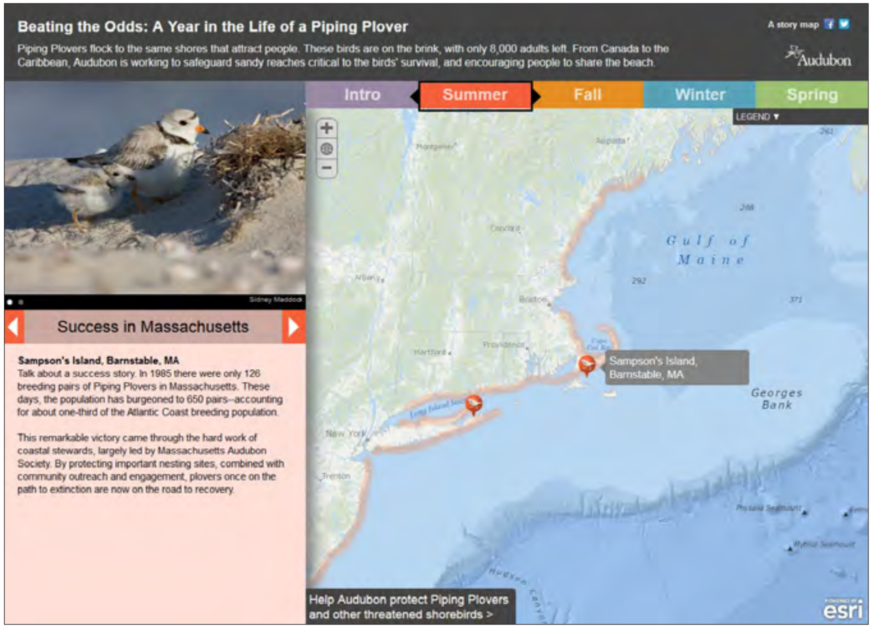
Story map on the ecological footprint of nations.

Now that maps are enabled via the Internet and distributed to our laptops, tablets, and smartphones, the potential for using them to catalyze awareness and action has become all the greater. Maps used to tell us stories in a singularly understated way. Now, supercharged by digital technology, distributed instantaneously across electronic networks, and enlivened by innovative user experiences, they've become much more active and versatile storytellers.

Our story maps team is beginning to explore this largely uncharted territory of cause-related mapping. One of our early projects highlighted the Global Footprint Network's insightful examination of the rates at which most nations are overspending their ecological capital:

Recently we teamed up with the National Audubon Society to depict the life cycle of the Piping Plover, a shorebird that nests, precariously, adjacent to Atlantic Coast beaches and is thus in constant conflict with *Homo sapiens recreationi*. The story reveals the many threats facing these beautiful little birds as they breed, migrate, and winter, and it shows how Audubon is working to protect it at every step of the way.

A few months ago we collaborated with IUCN, the big international conservation organization, to raise awareness of the increasing threat that human activities are bringing to the diverse array of life on earth. The conservation community depends on IUCN's "Red List" as the definitive catalog of thousands of rare



Piping Plover story map, a collaboration with Audubon.

and endangered species worldwide. Our story map profiles a selection of these species via a world map. A click on a map icon generates a species profile, including a close-up range map, photo, text description, and link to technical information.

These examples only hint at the potential of cause-related mapping. Thousands of humanitarian and conservation organizations administer countless projects in nearly every corner of the earth. Yet few people are aware of the vast scope of these operations. Wouldn't donors be inspired to see the distribution and breadth of these efforts? Wouldn't you, as a potential donor or volunteer, want to know more about the local, on-the-ground work of the groups that you support? Wouldn't more people be inspired to support conservation if they could track, in near real time, the movements of animals across threatened landscapes?

Maps can help turn abstract issues into tangible, understandable, *solvable* stories. Maps can inspire action. Let's use them not only to measure and observe the world, but to change it.

IUCN Red List story map.

About Allen Carroll

Allen Carroll is program manager, ArcGIS Online content, and heads the Story Maps team. He came to Esri in late 2010 after 27 years at the National Geographic Society, where he told stories with maps in *National Geographic* magazine, in three editions of its *Atlas of the World*, and in countless wall maps and websites.

(This article originally appeared in the *Esri Insider* blog on 17 October 2012.)

Geodesign Education Takes Flight

Kelleann Foster, Penn State University

Our world is experiencing a unique confluence of issues, innovations, and opportunities that is encouraging a hospitable academic atmosphere where geodesign can flourish as a platform for addressing the urgent environmental and community planning, conservation, and restoration needs of today and for the future.

The emerging field of geodesign can be characterized as the collaboration of science and design that takes into account the interconnectedness between humans and nature. Geodesign is a deceptively simple formula that brings together knowledge—in the form of both data and human expertise—and infuses it with design creativity for the purpose of revealing and evaluating alternative futures for a *place*. Geodesign is and will be an important agent for cultural change. Education is taking up the call to address how geographic and spatial information can be combined with design to address some of the most complex challenges facing the environment, including human habitats, and, indeed, the future of environmental care.

At the January 2013 Geodesign Summit hosted at Esri in Redlands, California, some core concepts were broached that can influence current and/or possible future curricula for geodesign educational programs or degrees. These key concepts indicate that geodesign has the following traits:

- Is collaborative in nature
- Is cross-disciplinary
- Is a design method that proposes creative change for a place
- Uses GIS and other technologies for modeling and evaluating impacts
- Engages with community stakeholders and assists them in evaluating design alternatives and making decisions

Geodesign education is taking flight, with several new programs and a few that will begin within the next year, and it is clear that these key concepts provide a foundation on which many of these programs have been or will be built. Additionally, many schools, mainly in landscape architecture or planning programs, offer geodesign classes, as well as classes not so named, that accomplish similar goals. Furthermore, it is highly likely that other programs are under development, and there are other signs of geodesign's emerging impact on academia, such as recent university job openings with *geodesign* in the position description. Nevertheless, the intent of this article is to provide an overview of some universities with new degrees, certificates, and options that are specifically working to address these core curricular ideas and to help encourage ongoing dialog, worldwide, about geodesign education.

Seven programs in the United States responded to a short survey, the results of which illustrate an interesting variety of ways that programs are emerging (see table on the right). These schools are Northern Arizona University, Penn State, Philadelphia University, the University of Arizona, the University of Georgia, the University of Southern California, and the University of Wisconsin (UW-Madison and UW-Stevens Point).

A Diversity of Reasons to Start Programs

To begin with, there are a diversity of reasons why these programs got their start:

Summary of Schools Offering Geodesign Programs

University Name	Northern Arizona University	Penn State	Philadelphia University	University of Arizona	University of Georgia	University of Southern California	University of Wisconsin (UW-Madison and UW-Stevens Point)
Weblink	nau.edu/SBS/GPR/Degrees-Programs/BS-Geographic-Science-Community-Planning	www.worldcampus.psu.edu/geodesign	www.philau.edu/msgeodesign	cala.arizona.edu/node/1033	www.ced.uga.edu	spatial.usc.edu/index.php/undergraduate-programs/geodesign/	www.la.wisc.edu www.uwsp.edu/geo/Pages/default.aspx
Delivery	On Campus	Online	On Campus	On Campus	On Campus	On Campus	Blended Online + on Campus
Type of Program	Undergraduate	Graduate	Graduate	Graduate	Undergraduate and Graduate	Undergraduate	Graduate
Program Title	BS in Geographic Science & Community Planning (optional emphases in Geospatial Sciences or Community Planning & Development)	Graduate Certificate in Geodesign Master of Professional Studies in Geodesign (in planning process)	MS in Geodesign	Master's of Science in Planning (optional Geodesign concentration)	Geodesign and Sustainable Practices Certificate within BLA, MLA, and Master of Environmental Planning (in planning process)	BS in Geodesign	Geodesign Capstone Certificate Program (in planning process)
Part or Full Time	Full Time (Part-time option)	Part-Time	Full or Part Time	Full Time	Full Time	Full Time	Full or Part Time
Program "home"	Department of Geography, Planning & Recreation, in the College of Social & Behavioral Sciences	Stuckeman School of Architecture and Landscape Architecture, in the College of Arts & Architecture, in collaboration with the Department of Geography	College of Architecture + the Built Environment	School of Landscape Architecture and Planning, in the College of Architecture, Planning, and Landscape Architecture	College of Environment and Design	The Spatial Sciences Institute, with the Dornsife College of Letters, Arts and Science, Price School of Public Policy, and School of Architecture	Department of Landscape Architecture, College of Agricultural and Life Sciences (Madison) and Department of Geography and Geology and GIS Center, College of Letters and Science (Stevens Point)
Length	4 Years	Certificate: 1 Year MPS: 2.5 Years	1 Year	Same as Base Degree	Same as Base Degree	4 Years	1 Year

- Two, both of which are undergraduate programs, were part of larger university-level curricular revisions that sought efficiency by combining programs or encouraging interdisciplinary initiatives. These schools saw geodesign as an effective way to advance those goals while crafting a future-oriented program that brings together different disciplinary strengths from across the university.
- Two of the graduate programs decided to pursue geodesign due to the emerging trend and need for professionals who are knowledgeable about how to better integrate science with design.

- Three of the programs trace their roots to ideas and inspiration gained through attending the early Geodesign Summits.
- One evolved in response to a recent university strategic plan that outlined graduate education growth objectives.
- One hosted a geospatial summit that brought together educators and researchers from across the school system, which resulted in the new geodesign program.

Commonalities in Geodesign Education

Though, as we shall see, the different schools have designed their programs to suit their own needs, the programs do have in common several important points. All the schools do the following:

- Emphasize the integrated nature of their curricula, several feeling that the mix of science and design courses is balanced
- Offer an interesting array of related courses that are either required or available as options to geodesign students
- Include studio-based experiences for their students
- Include GIS components early, as either an introductory course in the first year or second year of the program (One program lists GIS as a prerequisite to enter, and it offers an accelerated GIS summer program for students without a GIS background.)
- Reference GIS skills throughout the remainder of the curriculum, which speaks to the stated goal of integrating science and design

A Variety of Formats for Geodesign Education

Despite these areas of overlap, these schools are embarking on geodesign education from a variety of approaches as evidenced in the results of the survey:

- Four universities are offering only graduate-level programs; two, only undergraduate; and one university will address geodesign at both levels.
- Within the area of graduate education, there is diversity: two will offer master's degrees; there will be two stand-alone graduate certificates, and two of the programs will offer geodesign as a focus area or option for graduate students.
- All but two of the seven are resident programs.
- Two have online components; one is offered entirely online; and the other will have courses online, as well as some collaborative, face-to-face experiences.

Academic "Home"

While all schools make a point to emphasize the integrated nature of their curricula, it is not a surprise that a program's academic "home" provides insight regarding the curricular mix of GIS/science and design:

- Two of the programs rooted in landscape architecture schools slightly favor design.
- One housed in a department of geography, planning, and recreation slightly favors geospatial sciences, with only one course specifically focused on urban/community design. However, they feel that design is "scaffolded" throughout the curriculum, with a focus on design history in other classes, and students who take the Community Planning & Development emphasis will do a required conceptual design in a capstone course.
- Another promotes strengths in data inclusion and spatial modeling and therefore has a mix of approximately two-thirds science and one-third design.

Studio-Based Experiences

Studio courses are unique educational environments rooted in problems-based learning (PBL). In PBL courses, students are presented with a problem and then become active participants—the content is not provided, but rather the students, either individually or in teams, discover and work with content they determine to be necessary to solve the problem. In PBL, the teacher operates more as a facilitator and mentor. The problems are typically open ended, and students learn through a guided, collaborative experience. All the programs surveyed mention the inclusion of studio-based experiences for their students; furthermore, the following are true:

- One has collaborative studios every semester.
- One offers a geodesign concentration where design applications are a culminating experience after other competencies have been developed.
- One incorporates design in the first year, followed by three architecture/design classes.

Optional Classes That Complement Geodesign

As discussed above regarding the likelihood that geodesign programs will develop their own specialties and emphases, the schools surveyed listed an interesting array of related courses that are either required or available as options to geodesign students. These include landscape ecology, communications and professional skills, public policy and regulation, professional and cultural values and ethics, quantitative sociology, heritage conservation, public participation and dispute resolution, building information modeling/CityEngine and other 3D visualization tools, sustainable design methods, and global issues (biodiversity, climate change, etc.).

International Advances

Of course, this article cannot be all-inclusive nor list all schools with new or developing geodesign programs either in the United States or internationally. Outside the United States (e.g., in China, Germany, Japan, Portugal, the Netherlands, and Thailand), there are numerous programs that adhere to the definition of geodesign education but may not use the term *geodesign* in the name. Some of these programs are housed within departments of landscape architecture, geography, urban ecology, engineering, and civil engineering. It will be interesting to track the evolution of new programs and degrees worldwide.

About the Author

Kelleann Foster, RLA, ASLA, is associate professor of landscape architecture; lead faculty for Geodesign Programs; and interim director, Stuckeman School of Architecture and Landscape Architecture, Penn State University.

See also "Confluence of Trends and Issues Actuates a Path for Geodesign Education."

Related Podcast

The State of GIS in Education

David DiBiase, Esri director of education, talks about the integration of GIS in education, as well as new areas where geospatial technology is being applied. Listen to the podcast. [9:00 | 8 MB]

(This article originally appeared in the Fall 2013 issue of *ArcNews*.)

Confluence of Trends and Issues Actuates a Path for Geodesign Education

Kelleann Foster, Penn State University

The Cleveland Clinic

The Cleveland Clinic of Cleveland, Ohio, is recognized as a model for the future of health care. It has forged an innovative approach to patient diagnosis, which not only provides exciting results but also saves money. The approach required a cultural shift in how health care systems operate. "Health care has gone from a single sport to a team sport," says Dr. Delos M. Cosgrove, the CEO of the Cleveland Clinic. This is fueled by the belief that "collaboration has always, and will always, further discoveries in science and medicine."

While the Cleveland Clinic has disease-specific institutes that facilitate collaboration among physicians to address some of the most vexing medical problems, geodesign is providing a cultural shift in how geographic and spatial information can be used to address some of the most complex challenges facing the environment. In the case of geodesign, the future of environmental care is the collaboration of science and design.

Intellectual Jazz

The idea of marrying scientific and design thinking is really not new, but the possibilities and rewards are becoming more widely sought and valued. Over a decade ago in his book *Consilience*, E. O. Wilson urged us to consider that the most challenging issues facing humanity cannot "be solved without integrating knowledge from the natural sciences with that of social sciences and humanities." He clarifies that the humanities includes the creative arts.

More recently in a speech on arts and public policy, Yo-Yo Ma, who was a participant in Richard Saul Wurman's September 2012 WWW conference (see "Esri Hosts WWW Conference—Reinventing the Art of Conservation," *ArcNews* Winter 2012/2013), held on the Esri campus in Redlands, California, advocates adhering to the "edge effect." He says this is "where those of varied backgrounds come together in a zone of transition; a region of less structure, more diversity, and more possibility." This same notion of the edge effect, which is derived from the science of ecology, is what geodesign is all about—the synergy that is possible when science and design intersect. According to Albert Einstein, art and science have the same root: mystery. He also discusses the importance of curiosity, which is, of course, related to mystery. Focusing on commonalities will help scientists and designers forge a strong working relationship. Collaboration is a vital component of geodesign and will aid in the responsible transformation of places and provide movement toward more sustainable solutions for the land and communities.

Digital Literacy, or "Citizenville"

The world is becoming increasingly tied to and reliant on digital technology and easy access to information. In the five years from 2005 to 2010, the amount of global digital information (including documents, pictures, and Tweets) grew nine times to nearly two zettabytes (IDC Report). The trend shows no signs of slowing, and online content will continue to become easier to share, tag, and find. Important information and data are no longer solely the domain of select scientists or government officials. Regular Jane and Joe Citizen are becoming more digitally literate every day. California's lieutenant governor, Gavin Newsom, examines this trend and its potential for an even more widely connected society in his recent book, *Citizenville*. He discusses the exciting opportunities that have emerged due to the availability of big data being brought down to the consumer level. He envisions how digital technology has the capability to enable people to take a greater role in governing and increase civic participation. For example, the City of Philadelphia has an open data initiative where half of all datasets are from the city's GIS.

To be sure, more is not necessarily better—there are many questions about the quality and authenticity of information. But that does not change the fact that people now expect to have information at their fingertips (literally). All this information needs to be filtered and then accompanied by a process to determine its wise use. Therefore, the geodesign process, which ferrets out which data is most relevant to a particular challenge and then helps bring it alive for people, is going to become essential for design and planning. In the GIS world, data collection and availability had been a problem, but now, more and more authenticated data is being made available daily as a service. The geodesign methodology provides an approach that, along with combining data and design, enables increasingly digitally literate citizens to become engaged in this important dialog about their place.

The Age of Innovation and Rapid Adaptation

Many believe we have left the Information Age behind—the proficiency and benefits of technological advancements are now expected and are certain to continue. It is becoming clear that the world we reside in now has moved into a new era, one that requires adaptability, inventiveness, and big-picture capabilities. In his book *A Whole New Mind*, Daniel Pink discusses these ideas and asserts that embracing creativity will provide a competitive advantage in this new era. He posits that both "high-concept" and "high-touch" approaches will rule:

"High concept involves the capacity to detect patterns and opportunities, to create artistic and emotional beauty, to craft a satisfying narrative, and to combine seemingly unrelated ideas into something new. High touch involves the ability to empathize with others, to understand the subtleties of human interaction, to find joy in one's self and to elicit it in others, and to stretch beyond the quotidian in pursuit of purpose and meaning."

It is as if Pink knew about geodesign when he wrote this, as nearly all of it fits neatly into the definitions and aspirations of geodesign. Detecting patterns—the growing capabilities of GIS provide that. Combining those patterns with creativity to realize something new—that is the essence of geodesign. The part about a narrative relates directly to his high-touch discussion of empathizing with people. Here again, if the geodesign process is conducted well, a community's values should inform design alternatives that will resonate with the people and satisfy the purpose. The best way to engage the people of the place is through a narrative that has meaning—one which they can embrace and will want to implement.

Today's complex and fast-moving environment requires constant readjustment by responding quickly and creatively to changes as they arise. GIS tools and apps are becoming more efficient and effective to enable rapid evaluation of design alternatives and can better predict the potential consequences of future decisions. These technological advancements, coupled with high-touch and high-concept approaches, illustrate how geodesign truly is a methodology well-suited to this new age of innovation and rapid adaptation.

Geodesign Defined for Education

What distinguishes geodesign from processes that deploy more innovative approaches to GIS? For example, GIS is commonly used to aid in making better decisions about siting and location. Is this geodesign? Possibly, but it depends on whether design thinking was part of the decision-making process, if stakeholders were engaged, and how the results of the process are evaluated. The term geodesign is new enough, and evolving fast enough, that it is important to define it for this context: education.

The January 2013 Geodesign Summit, hosted at Esri in Redlands, included two sessions dedicated to geodesign education: a preconference workshop and a panel discussion during the summit. During these forums, educator and practitioner participants agreed that geodesign involves new tools and approaches related to technology and data. There was also agreement that geodesign is cross-disciplinary, that it can be a bridge between professions—scientists don't know design, and designers are often not fluent in science—and that curriculum methodologies should be spatially oriented. These discussions are helping to shape an overview of the components that may be included in curricula for educational programs or degrees focused on geodesign.

Interestingly, participants at the education sessions did not have consensus regarding whether all students getting a geodesign degree need to learn design. Neither did they determine whether all geodesign students should learn GIS. This is perhaps indicative that as new geodesign programs and degrees emerge, there may be distinction between differing philosophies regarding the design and GIS components of geodesign. Nevertheless, it would seem valuable that students taking geodesign curricula should, at a minimum, get solid exposure to design thinking and design methodologies. Equally important then would be that students in geodesign programs should, at a minimum, also get solid exposure to GIS principles and basic processes.

A presummit survey generated some thought-provoking topics that merit future consideration in developing curricula, for example:

- How can a geodesign program capitalize on the activist interests of students?
- If the engagement of people is important in the geodesign process, should skills in participatory design be introduced?
- Should geodesign curricula incorporate complex economic development issues?
- Can data and the continuum of analysis be overemphasized, precipitating "analysis paralysis"?

It is anticipated that the fall 2013 Geodesign Summits in Europe and China will provide opportunities to further these curricular discussions from an even wider perspective.

A Bridge Between Professions

Regarding the above-noted concept that geodesign is cross-disciplinary and that it can be a bridge between professions, the academy is a great place to foster that bridge and instill a collaborative approach among all disciplines needed to address a geodesign challenge. This quote, adapted from the preface of Dr. Carl Steinitz's book *A Framework for Geodesign*, says this well:

"Each participant must know and be able to contribute something that the others cannot or do not. . . . Yet during the process, *no one need lose his or her professional, scientific or personal identity*."

This may also stem from a related concept: people running a geodesign process can be considered "conductors," and conductors are not skilled at all instruments in the orchestra. Because of the complexity of the challenges geodesign addresses, no one person can have all the skills necessary to perform a geodesign process.

Clearly, at this early point in geodesign education's progression, it is important to realize that just as other fields have evolved to have unique variances in curricula based on faculty expertise, program location, and the like, so too it is likely that geodesign education will have variation by school, but one hopes that most programs will be rooted in a common core that includes the above points.

See also "Geodesign Education Takes Flight."

(This article originally appeared in the Fall 2013 issue of *ArcNews*.)

GIS: Transforming Our World

Jack Dangermond, Esri

Our world is facing serious challenges.

To everyone who attended the 2013 Esri International User Conference, I want to thank you for helping to make this year's conference such a great success. For those who could not attend, let me take a few minutes to give you an overview of the opening remarks from Monday morning. Also, if you would like to view the Monday Plenary Session, it is available at esri.com/uc.

The theme of this year's conference was "GIS: Transforming Our World." The word *transformation* can refer to two types of change: physical change, as well as change in how we perceive things. GIS is relevant to both.

The work of GIS professionals is creating many information products that are directly changing our physical world. Their work also changes how we see, understand, and interact with our world.

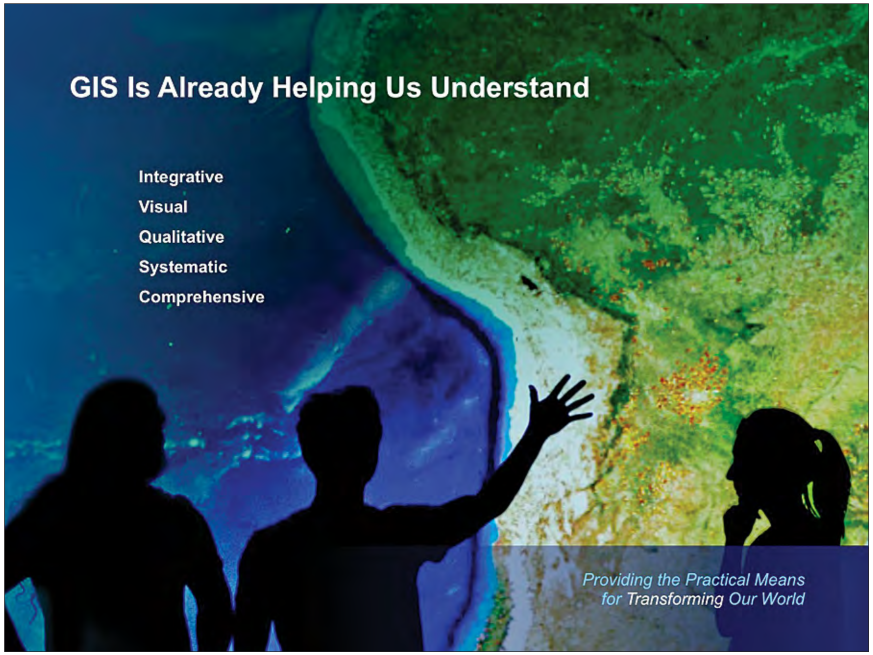
Today, our world is facing serious challenges on many fronts. It's becoming clear that we need to collectively work to create a better future. This means leveraging our very best design talent, as well as our best technology and science, to create a more sustainable future. GIS provides the platform for doing this.

The Power of GIS

GIS is already changing how we think and how we act. It is built on the science of geography and, as such, it provides an integrative and comprehensive framework that cuts across many disciplines and organizations. GIS also has the power of qualitative analytics blended with easy-to-comprehend geospatial visualization.

By integrating geographic science into everything we do, GIS is improving how we measure and analyze things, as well as how we predict the future. It is also providing better ways to plan, design, and make decisions. The success of the GIS community is creating tens of thousands of important systems around the world and providing evidence of the huge contributions our field is making.

For all these reasons, GIS is a promising technology for addressing issues at a larger scale—a global scale—in the world. To do this, we clearly need to also dramatically scale up its application and make it pervasive.



Scaling Up

By scaling up, I mean that we need to dramatically grow the application of GIS, leveraging the current community of users. We need to make it pervasive throughout organizations and across society.

Is this possible? My sense, as well as personal experience with other pervasive technologies such as the Internet and GPS, is that this scaling up is both possible and in some ways inevitable. GPS, for example, has been radically simplified, and this in turn has rapidly transformed human beings' sense of place. Together with consumer web mapping, we can now see both our whole planet and where we are at any time.

GIS will become pervasive in the same way, leveraging the connectivity of the web and cloud computing. The result will be better decisions that reflect better understanding and ultimately a more sustainable future.

GIS --> Web GIS

This next step in the evolution of GIS involves a new technology pattern—web GIS. With release 10.2 of ArcGIS is a complete web GIS, not just mapping. It integrates Esri's and other geospatial technology (i.e., using strong engineering and open standards). This platform takes advantage of the latest trends, including web and cloud technologies, big data, faster machines, and pervasive devices. Web GIS also directly models and integrates all the geospatial data types—remote sensing, GPS, the sensor web, 3D data, crowdsourcing data, real-time data, and pervasive web content.

The emerging platform is easy to use, more open, accessible, and collaborative. It uses focused apps for making maps, doing analytics, and accessing a rich, living library of shared maps and geographic data.

Web GIS Integrates Any Data

One of the key concepts of web GIS is how it organizes content. Web GIS models all types of information as web maps and web services. These web maps can represent typical geospatial data types—maps and imagery, as well as tabular data, such as geodatabases, spreadsheets, and enterprise databases. It also integrates social media and sensor networks with real-time information and the whole world of big data.

GIS is all about integration of data. Web GIS also provides new patterns for involving information sharing and collaboration, web maps and services, and visually and analytically combining geospatial data.

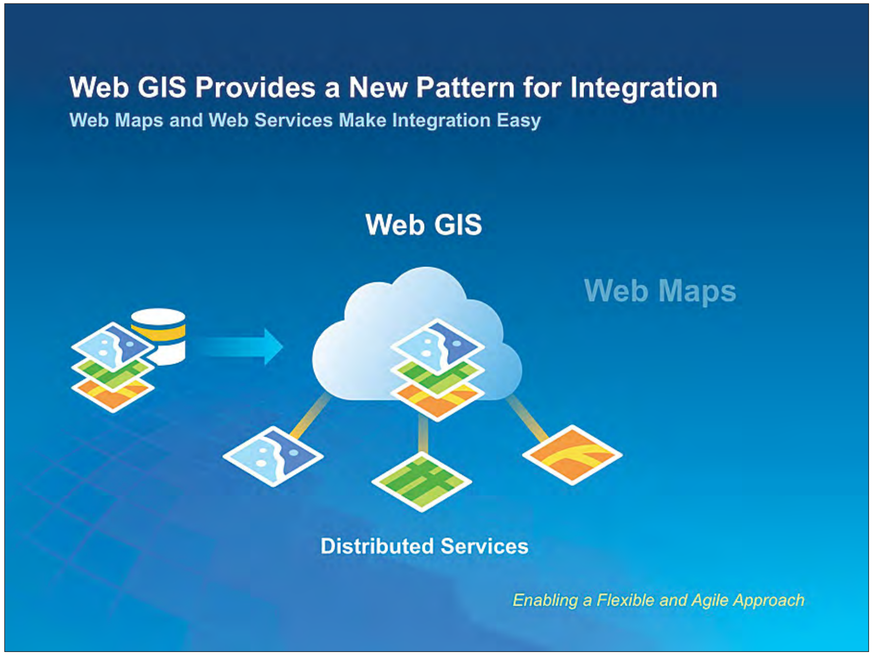
Another intriguing aspect of web GIS is that it can help break down the fundamental barriers that separate organizations. Whether the silos are professional or organizational, the ability of the web GIS environment to fluidly integrate different disciplines and activities gives us a new framework for collaboration.

Web GIS has one other interesting ingredient: it can help us easily organize our work. It provides content management capabilities for all your maps, apps, and models and also simplifies sharing these within a group or across departments and organizations.

Driving the Transformation

While web GIS is just starting, it is already proving to be an attractive platform that is helping us to scale up and leverage the work and knowledge of GIS professionals.

For GIS professionals, understanding this pattern and its underlying technology is important. Embracing these patterns will both leverage existing investments and drive geospatial adoption across organizations. Ultimately, this pattern promises to make huge contributions to our understanding of the world around us.



When you put all this together, you begin to realize that we have a huge opportunity to amplify the power of GIS. GIS professionals are essential to making this happen. In my mind, there has never been a more exciting time to be a GIS professional.

Thank you again for making the 2013 User Conference an amazing experience. As Esri continues to grow and evolve, you constantly remind us to stay focused on what is important: our mission of advancing GIS and supporting our users. Your efforts are having a large impact on our world. Thank you for letting us help you make a difference.

Related Video

GIS—Transforming Our World with Jack Dangermond

Jack Dangermond speaks about the theme of the 2013 Esri International User Conference: GIS—Transforming Our World.

(This article originally appeared in the Fall 2013 issue of *ArcNews*.)

GIS: Turning Geography into Geographic Understanding

Bern Szukalski, Esri

We're fortunate to be engaged as GIS professionals today. Never before has there been so much potential to transform the work we do and the organizations we serve *geospatially*.

What do we need for this transformation? We need authoritative data at a variety of scales—local, regional, and national. We need tools that can integrate data from many sources, and bring it together in meaningful ways. We need analytic capabilities that can help us glean every drop of valuable information that we can from these sources, and gain previously hidden insights. And we need ways to enable broader access to our work, foster collaboration among our peers and stakeholders, and facilitate public engagement when needed.

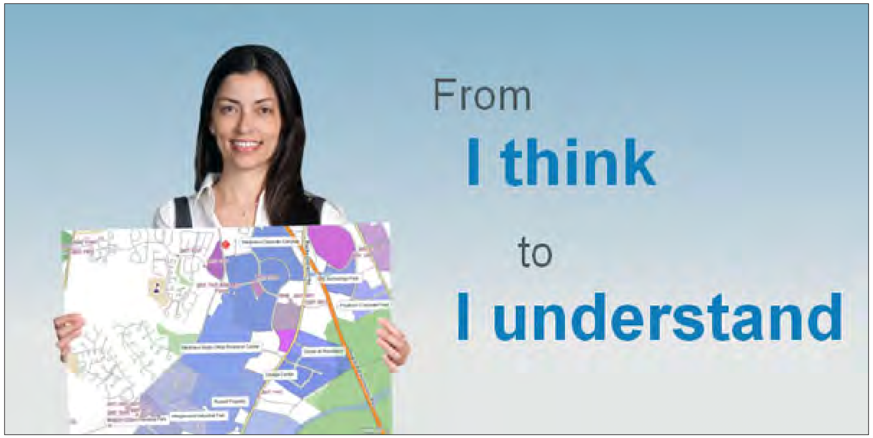
Today, we're lucky enough that we actually have all these things. And these capabilities are continuing to evolve rapidly.

Recently Bill Meehan, Esri's director of utility solutions, told me a story about a potential client that he had visited, one not currently using GIS. One of the corporate executives there told Bill about how they were embarking on a large project to meet customer needs and improve efficiency and infrastructure. It was a costly project that would last for years into the future.

Bill asked them a good, and perhaps obvious, question. Were they sure that this would achieve their intended goals? With what I would imagine was just a bit of hesitation they responded "We think so."

Going beyond "I think"

Geography is a science that we leverage in GIS. It's the context within which we work. While some degree of uncertainty is sometimes unavoidable, as geospatial professionals we need to do better than "I think" and achieve a deeper understanding. As GIS professionals we believe in, and strive for geographic



understanding. We want to turn "I think" into "I know" or "I understand."

So how do we accomplish this?

GIS—a platform for geographic understanding

Many years ago I worked with ARC/INFO, Esri's first software package. I sat at my desk in front of an ASCII terminal to type commands at the ARC: prompt, the only way to perform a task. It was software installed on a minicomputer in a back room that long ago vaporized from the Esri campus.

Today, I think of ArcGIS as much more than software. It's a platform. A platform we can use to turn simple geography and location into something more powerful and meaningful—geographic understanding. We use this platform to discover the *how* and the *why* from the *where*, and to share and communicate that knowledge with others.

What's a platform in this context? I struggle a bit to define that exactly, but I can identify its characteristics more easily.

- Platforms serve many communities; GIS serves utilities, health care, local government, conservation, public safety, education, business, and many others.
- Platforms can be used by many different people; professionals, knowledge workers, developers, and information consumers.
- Platforms include applications, data, services, and APIs.
- Platforms can be used by individuals, workgroups, organizations, and even entire governments.
- A platform provides a base upon which developers can build, leveraging core characteristics and components to create unique solutions.
- A platform supports a variety of ways to implement or experience it, in the cloud, on your desktop, via servers, and on mobile devices.

That's how I think of the ArcGIS platform—a complete ecosystem that incorporates the many facets mentioned above. We use it to turn geography into geographic understanding, and to share that understanding with others. What's our challenge after that? Our challenge as GIS professionals and organizations is to turn that understanding into action.

About Bern Szukalski

Bern Szukalski is an Esri technical evangelist and product manager, focusing on ways to broaden access to geographic information, and helping users succeed with the ArcGIS Platform.

(This article originally appeared in the *Esri Insider* blog on 14 February 2013.)

Transforming Essential GIS Skills

Bern Szukalski, Esri

Over the years GIS has grown to cover a very broad horizon. It's no longer the domain of specialized departments; instead it has become deeply woven into an organization's fabric and extends to a very public and connected audience. The fact that we think differently today than in the past about how we use—and perhaps more importantly how we *can* use—GIS reminds us that we need to continue to evolve our skills in new directions, whether we're seasoned GIS veterans, or simply trying to land that first job.

A recent e-mail from someone just beginning to take their first steps into the GIS job market had me thinking about this again. They asked me whether they should take a course in Python to improve their GIS job prospects. "Sure, that would definitely be a good idea," I said. But at the same time I realized that when I meet with GIS organizations, the things they seem to wrestle with are beyond the usually anticipated skills of data conversion and management, modelling, metadata, and Python prowess. Even cartography has to be considered in a different light in the web mapping world of mashups, slippy maps, and fast and furious app development.

In what areas do users feel challenged, or tell me they're seeking additional talent? The answers are easy when you consider how GIS has moved online towards transparency and self-service mapping, great browser apps, and into a device-centric world on your phone or tablet. Clearly this is a case where the technology of the day dictates the habits and expectations of consumers of geographic information, and also the corresponding requirements for today's GIS professional. Here's what I've come to understand are sought-after skills.

Design and User Experience

Even the best functionality or information can't be appreciated or effectively used behind a poorly designed website or app. The user experience (UX), as well as design of compelling apps and websites, is a key factor in reaching a target audience, and how that audience perceives the information presented. It doesn't matter whether it be a long-time resident in a city trying to find the office to pay a late bill, or a community activist looking to push the envelope by hacking with data the city's GIS has provided. What you deliver must be compelling and friendly. Lots of GIS organizations are challenged with a lack of design and UX talent.

Web Development

Great JavaScript, CSS, and HTML skills are sometimes harder to find in GIS organizations these days than experience with Python, C++, or ArcObjects. While GIS-centric skills are essential for a nuts and bolts GIS professional, if you want to push into new frontiers or land your first job, core competence in current web technologies is a must.

Responsive Design

Any app these days must work on a variety of form factors, from full-screen browser to tablets to smart phones. If you can build responsively designed apps that magically morph to fit all needs and form factors, you've got some valuable skills.

Mobile Platforms

Beyond ArcPad on your Trimble, Android and Apple devices rule the landscape, with Windows tablet devices close behind. If you want to reach a broad, public audience, skills in mobile and native app development are what GIS organizations are looking for. And, as an existing professional or new job seeker, skills in these areas will open doors for you.

Data Authoring, Cartography, Publishing

Remember when you published a GIS service with 20 layers and 50 sublayers? In the world of mashups this is more than a speed bump, it's a roadblock. Understanding the tradecraft involved in delivering building-block layers for authoring web maps begs for a different approach. And Web cartography sometimes requires different considerations and thinking than the cartographic design principles applied to that National Geographic-quality map you've hung on your wall.

Integration with Other Systems

A successful GIS does not live alone, but integrates with a variety of other systems in an organization. These can be business systems, enterprise tools, or real-time feeds. Experience in bridging these systems into GIS and integrating the work of other departments with skills in SharePoint, Cognos, or other enterprise software and systems are increasingly valuable.

Online Best Practices

As the ArcGIS platform moves to the cloud, there are lots of things to know about establishing and curating a successful GIS online. The new pattern of a cloud-based GIS means different ways to do things, and a new set of best practices. Many educational institutions are moving forward with specific courses and learning opportunities in these areas that can bring value to you and your resume.

Clearly, GIS and how we use and think about it has transformed. The age of ubiquitous geographic information and geo-enabled apps is upon us, and moving fast. With a few additional skills you can evolve your role in your organization, or land that first job and hit the ground running. GIS has transformed, and you should be sure you've transformed along with it.

About Bern Szukalski

Bern Szukalski is an Esri technical evangelist and product manager, focusing on ways to broaden access to geographic information, and helping users succeed with the ArcGIS Platform.

(This article originally appeared in the *Esri Insider* blog on 01 August 2013.)

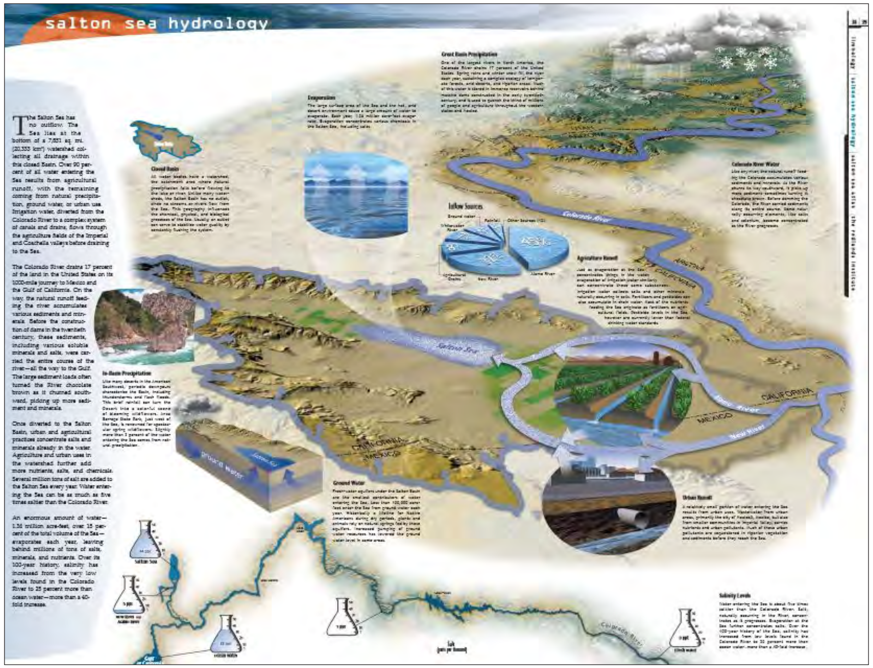
A Living Atlas of the World

Matt Artz, Esri

Atlases have long been used by people to help navigate and understand our world. A traditional atlas consists of a collection of static maps portraying various aspects of geography, bound together in book form and updated with new information at long intervals. The geography covered, in terms of both themes and extent, is set in stone for any given atlas, and the thematic information is typically created and authored by a select few authoritative sources.

These traditional atlases have served us well for many hundreds of years. But today, the world is changing rapidly, and it's difficult for traditional atlases to keep up with the pace of that change. To help us keep pace with our evolving planet, our concept of what exactly constitutes an atlas must also evolve.

At Esri, we strive to communicate the value of geospatial technology; that this technology matters, and that it can be used to make a difference. Technology is one of those things that is changing rapidly in our world today, and many individual pieces of advancing technology are clustering and converging together to create a new platform for understanding. We can leverage these advances to integrate geographic knowledge and apply it to solve the difficult problems the world is facing, and in doing so evolve our definition of an atlas to something that's more relevant to our needs today.



The pages of traditional atlases have served us well for many years, but a new approach is evolving.

A New Kind of Atlas

Geography is a science that helps us understand our world, and GIS is a technology that makes geography *come alive*, providing a framework for that understanding. GIS is the enabling technology for an idea that Esri president Jack Dangermond has called a "Living Atlas of the World." It's a new vision for the concept of an atlas: a global gathering place for integrating and applying dynamic knowledge about our planet and sharing it with everyone.

The Living Atlas of the World leverages recent advances in computing and communications technologies to build an atlas that anyone can contribute to, can cover any geographic extent, and is available to everyone. The thematic information available within this virtual atlas is dynamic; it's not stored in one centralized, static database—it's live, linked to and feeding in from multiple sources across the web and across the world in real time.

The geographic extent covered by the Living Atlas of the World can vary from your own backyard to the entire world. The online, interactive, multimedia nature of this new kind of atlas also makes it possible to integrate and display new types of information not possible in the traditional atlas paradigm. The geographic knowledge it contains knows no bounds, and includes more traditional themes such as geology, vegetation, and land use, as well as more dynamic, real-time information like weather, traffic, and sensor data. We're even working with our partners to get live satellite imagery coming in to the system just seconds after it has been captured. All of this and more makes the first Living Atlas of the World an exciting new mapping environment that gives everyone the ability to visualize the world around them in unprecedented depth and detail, and to do it all in real time.

Story maps can incorporate text, multimedia, and interactive functions to inform, educate, entertain, and inspire people about a wide variety of topics.

ArcGIS Online, Community Maps, and Story Maps

GIS technology is a strong enabler of the vision of a Living Atlas of the World, but GIS is only a part of the overall solution. New types and sources of geographic content, and new ways of sharing them, play a big role in the realization of this vision.

ArcGIS Online—the common platform that you can use to create interactive maps and apps and share them with the rest of your organization or the world—acts as the foundation of this new kind of atlas. Esri is also investing heavily in building basemaps and thematic layers that make ArcGIS Online instantly usable, and the content for this platform is growing very rapidly. We now provide multiple basemap options, and we recently added DigitalGlobe and GeoEye imagery for the entire world. Hundreds of thematic layers of information are now available.

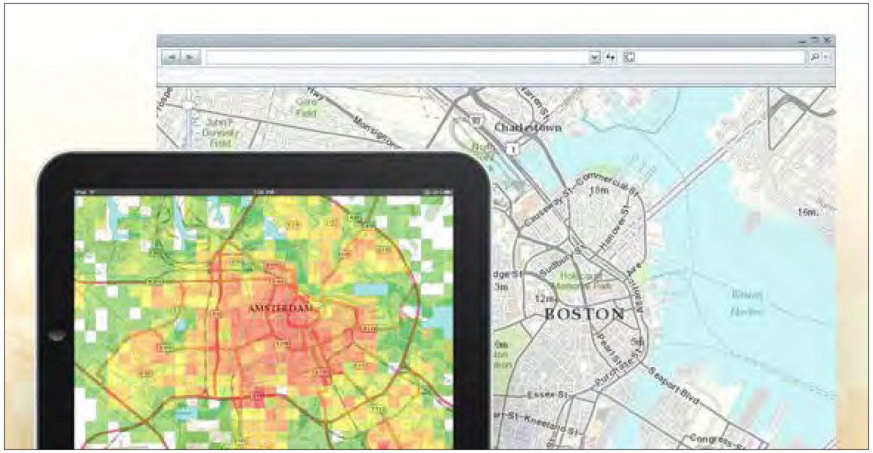
Another rich source of content for this new atlas is the Esri user community. We call this program Community Maps. It's a place where people can share their geographic information with the world, like they might share their photos on Flickr. Our vast user community is helping us build these maps, and they are also supplying hundreds of thousands of related content layers.

Another important element that separates atlases from simple maps is that most atlases tell stories. A new framework for organizing and sharing geospatial information in the form of stories, called story maps, is taking this idea to the next logical step. Story maps can take you from globe to street corner in seconds; they can dynamically show change over time; they can organize and present charts, graphs, photos, and video. With the sweep of a fingertip across a tablet, map users can compare one theme with another, ask questions of maps, add their own information to maps, and cast votes on maps. Almost anyone can put their own and shared data into a story map to communicate a specific message in a manner that is engaging and compelling.

All of this and more taken together constitutes a dynamic, comprehensive, and rapidly evolving ecosystem of geographic tools and data that enable the Living Atlas of the World.

A New Atlas for a New Planet

This concept of a Living Atlas is not only changing the way we



Esri's Community Maps Program lets you share your map data with the world.

look at the world, but it is also changing the way we interact with it. Everyone—from planners to designers, architects, scientists, politicians, businesses, non-profits, and even the general public—now has access to an increasingly diverse and deep collection of knowledge about the planet as well as to the tools to make sense of and use this information.

This new concept of a world atlas is open, shared, and universally accessible. While connecting people and leveraging their information in a kind of global synergy, it provides us with a completely new way to look at the science of our planet. And as we evolve the atlas from a platform primarily focused on mapping and visualization towards a platform supporting spatial analytics, it will provide everyone with the tools and data they need to become more actively engaged in designing and building the planet which will be our future home.

The Living Atlas of the World is your atlas. Contribute your geographic knowledge to this new ecosystem, and use the vast library of knowledge it contains to address the issues facing your neighborhood, your organization, and your world. Use it to make the world a better place.

More Information

- ArcGIS Online
- Community Maps Program
- Story Maps

About Matt Artz

Matt Artz joined Esri in 1989. In his current role as GIS and Science Manager, he helps communicate the value of GIS as a tool for scientific research and understanding. He writes extensively about geospatial technologies, manages the GIS and Science blog, and is the editor of GIS.com. Prior to joining Esri he worked as an Environmental Scientist at a large science and engineering consulting company, on such diverse projects as highway noise modeling, archaeological impact assessment, and chemical weapons disposal. His educational background includes an M.S. degree in Environmental Policy and Planning and a B.S. degree in Anthropology and Geography.

(This article originally appeared in the *Esri Insider* blog on 21 May 2013.)

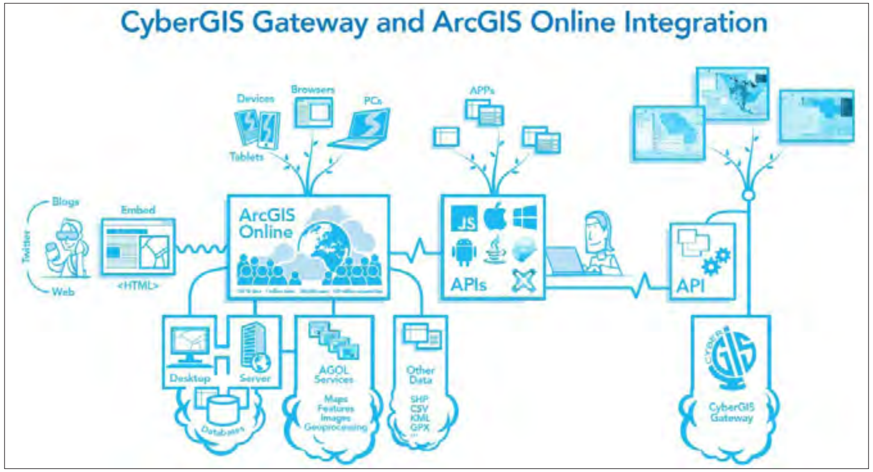
What Is CyberGIS?

Dawn Wright, Esri

In an earlier post, I had mentioned Esri's involvement in the large National Science Foundation-funded project known as **CyberGIS**, which aims to establish a fundamentally new software framework via a seamless integration of cyberinfrastructure, GIS, and spatial analysis/modeling capabilities. The project team is led by Professor Shaowen Wang at the University of Illinois, Urbana-Champaign and involves scientists from Arizona State, University of Washington, the San Diego Supercomputer Center, UCSB, the U.S. Geological Survey (USGS), and the Department of Energy's Oak Ridge National Laboratory (ORNL). A recent CyberGIS "All Hands Meeting" in Seattle allowed project partners, including Esri, to share progress to date, and to discuss and plan research activities and products for the next few years.

CyberGIS may be a new term to many, and may be evolving into a new field all its own.

At Esri, we understand *cyberGIS* to essentially mean GIS detached from the desktop and deployed on the web, with the associated issues of hardware, software, data storage, digital networks, people, training and education. This deployment may involve an individual, isolated server, a broader enterprise scenario including connection to a universe of mobile devices, or an even more pervasive deployment in the cloud. With the advent of cloud computing coupled with web mapping as a new platform for GIS, there is an opportunity to reinvent GIS applications, as well as to extend the discovery and availability of spatial data and geospatial analyses. Cloud computing provides the potential for access to and publication of dynamic data, as



A summary graphic of ArcGIS Online within the broader ArcGIS Platform, presented by Esri's Steve Kopp at CyberGIS AHM '13, highlighting the full breadth of "cyberGIS" capabilities to date, including various web service types, computing platforms served, API languages used, and the connection of ArcGIS Online to the high-performance, supercomputing environment of the CyberGIS Gateway.

well as the consumption of real-time information for analyses and modeling.

Although still to be proved conclusively in all possible use cases, the potential of clouds, with their rich collection of software modules, APIs, general- and special-purpose computation, and data storage, is extremely promising as an infrastructure for cyberGIS, and ultimately for e-science. We argue therefore, that in order to best achieve effective sharing and collaboration of data, users, and communities, one must also seek to understand the advantages and limitations of cloud computing in the context of spatial computation. In other words, cloud computing (and hence cloud GIS) needs to always be in the conversation when discussing CyberGIS.

Cloud GIS allows one to use GIS over the web without the cost and complexity of buying and managing the underlying hardware, software, and/or web server capabilities. In principle, it is always on, always available, and provides state-of-the-art functions that are supposed to be highly reliable and flexible enough to handle large volumes of Internet traffic. Further, there is the notion of an "intelligent web map," a medium by which to integrate multiple map services, data services, and analytical model services together, and to embed them in a browser or a web site, share them on a mobile device, or integrate them into social media. Such services support editing, pop-up windows, time-enabled slider functions, and the building of additional analytics and workflows so that changes made to the original data, to the analytic model dependent on the data, and to the properties of cartographic map layers, are immediately updated on the web map, in near real time.

Further, we posit that cyberGIS should provide for the user as a fundamental component an environment in which to perform and evaluate a wide array of spatial analyses in a "community playground" of datasets, maps, scripts, web-based geoprocessing services, and GIS analysis models. The "playground" may be in the context of an Intranet within organizations (e.g., private clouds, including virtual organizations), as well as the broader Internet (public clouds). With a low barrier to entry, a cloud-hosted environment for users to leverage as a platform for sharing, communication, and collaboration is achievable, and currently available in a variety of forms.

Using the example of the ArcGIS Platform (where ArcGIS Online is currently serving ***100 million requests per day, 150 Terabytes of data, 1 million items, and 500,000 users***), some of the latest developments include:

- **An explosion of content:** Content includes basemaps, web maps, imagery, demographics, and boundaries, much of which is exposed via pop-ups and infographics. The past year has also seen the integration of ArcGIS Online and the leveraging of the Esri topography, street, and imagery basemaps within the CyberGIS Gateway, allowing the reuse of content between the two sites. There are now ~300 user organizations registered in Esri's Community Maps 2.0 system underlying ArcGIS Online. These organizations have contributed tens of millions of features in over 20 layers. The freely accessible content within ArcGIS Online is continuously growing, evolving, and being updated, thus fueling a host of analytic services in the cloud, as well as geoenrichment services.

- **Geoenrichment:** Using the new capabilities in the ArcGIS API for JavaScript, developers can enrich ArcGIS Online data with interactive demographics, consumer spending, lifestyle, and similar contextual data (e.g., resource 1 and resource 2).
- **Social platforms:** Esri is broadening its support of community efforts to create social platforms for GIS and geographic education. As computing becomes more "consumerized," one of the interesting trends we see revolves around such social platforms. This is driving profound changes, even within commercial companies. For example, at Esri we are doing more and more with GitHub (http://esri.github.io) and using "social coding" practices for our own project management across our development teams. In addition, we are sharing many of our apps online as open source for developers from many user communities to leverage.
- **Ready-to-use services:** These are new Esri-hosted, cloud-hosted analytic services that perform functions on Esri-hosted, Esri-curated data. These services (e.g., create viewshed, profile, or watershed) assist users with large, complicated, difficult-to-build data such as elevation and hydrology, and can be used either on the web or directly from desktop ArcGIS.
- **ArcGIS Online analytics:** These are GIS analysis capabilities (e.g., aggregate points, find hot spots, create buffers, overlay layers, summarize within or nearby, create drive-time areas, extract or enrich data, find nearest, site suitability, raster analysis) already familiar to ArcGIS Desktop users but now already built into the web map to help non-GIS specialists quickly answer simple, straightforward analytical questions.

Indeed, in the broader scheme, exposing the power of spatial analysis to a larger audience (the non-GIS audience) may be the biggest long-term value of cyberGIS, and yet pose one of the most fundamental challenges: how best to make cyberGIS easier to use, easier for solving spatial problems, while still maintaining scientific rigor? We have more people now who are expert in GIS in its many forms (desktop, server, mobile, and cloud), so there is hope that some of that intellectual capacity could be devoted to making things easier, using the experiences of users to make things more interactive, more exploratory. We can ask questions about phenomena at finer and finer scales, all the while applying more computationally intensive algorithms not broached in the past.

As barriers to entry into cyberGIS environments continue to fall away, confidence in consuming and leveraging both public and private clouds for non-GIS audiences will be bolstered through the successes, ease of collaboration, and agility that on-demand cloud-hosted services can offer. This is ultimately one of the goals of cyberGIS: to integrate and synthesize data and information from multiple sources, thereby facilitating communication and collaboration, and breaking down barriers between institutions, disciplines, and cultures, fostering a better connection between cyberGIS and its many communities.

Thanks to Steve Kopp and Clint Brown who contributed to this post.

About Dawn Wright

Dawn Wright joined Esri as Chief Scientist in October 2011 and is responsible for formulating and advancing Esri's goals in the environmental, conservation, climate, and ocean sciences. She is also professor of geography and oceanography at Oregon State University and has participated in several initiatives around the world over the past 20 years to map, analyze, and preserve ocean terrains and ecosystems. Follow her on Twitter: @deepseadawn.

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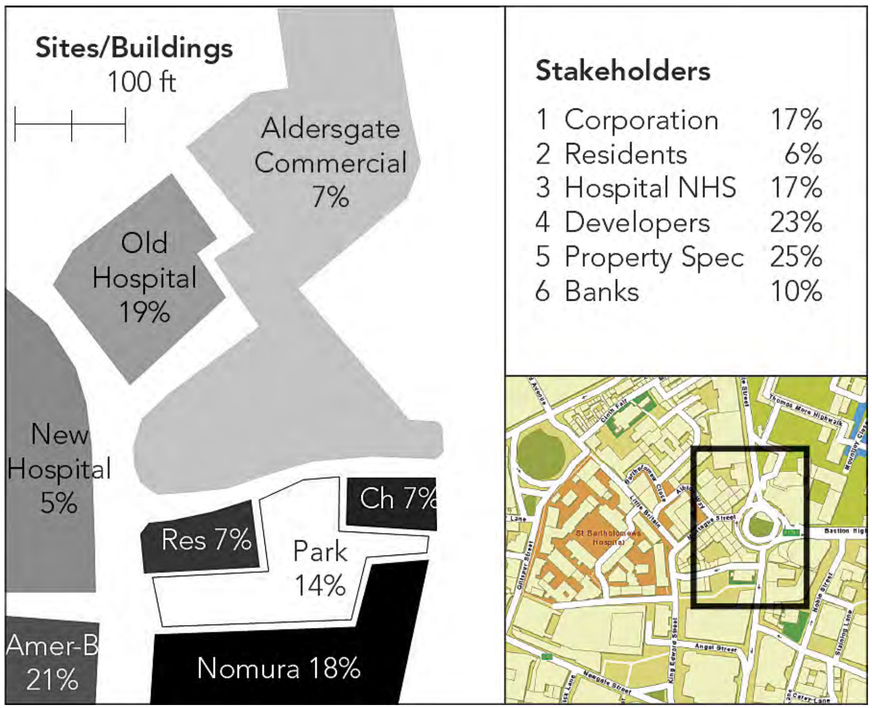
Agents, Models, and Geodesign

Michael Batty, University College London

Michael Batty explains how the process of geodesign might be compared to one in which conflicting views about a spatial design can be systematically resolved in moving to a solution by using a simple network model of conflict resolution. Such models assume two sets of agents—designers or stakeholders, as well as land parcels or locations—incorporated with attributes of suitability that the stakeholders use to reach a consensus over the best design. He illustrates the idea with a "toy" problem of the redevelopment potential of eight sites in central London that are influenced by six distinct stakeholders.

There are now many new methods for modeling cities that differ from the traditional approaches to simulating urban structure, land use, and transportation flows. As data has become richer and bigger and computers have become all-pervasive, with ever-increasing memories and ever-faster processing times, it has become possible to model the behaviors of individual objects that make up data aggregates, such as populations, that were the focus of simulation models a decade or more ago. Individuals that compose these populations can now be represented as distinct objects within computations, now usually being referred to as *agents*. Agents are essentially individual objects that have to be well-defined with strong identities and distinct from the environment in which they sit. These might be likened to the "atoms" that compose our cities, notwithstanding that what goes on inside the atom is hidden from our view. Although in cities agents are often considered to be human beings, it is quite possible to define them in terms of any distinct objects that compose a system. In particular, agents might be streets or buildings, components that make up the weather or vehicles on the highway, the bricks that a house is built from, or the pipes/wires that click together to keep our utilities functioning. Their definition is entirely dependent on the context, and in this sense, agent-based models or modeling (ABM) has emerged as a much more generic tool for simulation than most of the other approaches developed hitherto. Indeed, Esri has introduced a plug-in called Agent Analyst that enables users to build agent models that have a spatial component, which is the map in ArcGIS.

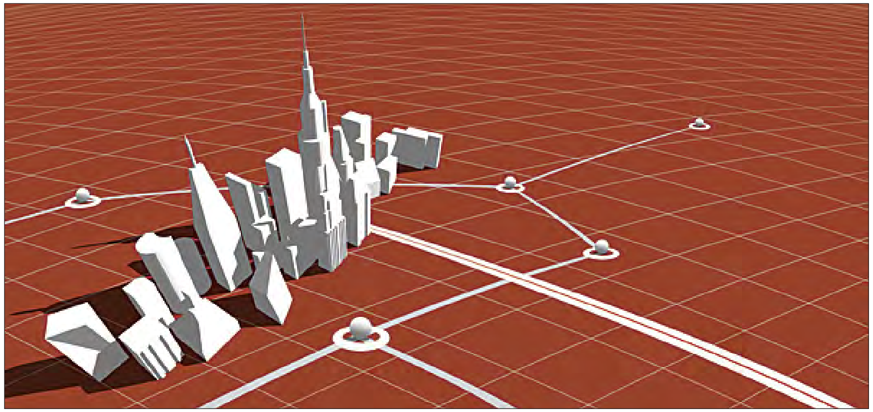
The easiest way to introduce ABM would be to illustrate a model of moving cars on a highway or pedestrians on a street. Agents in this case have mobility, and the focus of simulation would be the dynamics of how they behave and how they cluster and spread out. There are many models of this kind linked to spatial environments that are presented using GIS. But here we will change the focus and develop a model for illustrating how the agents who are actually involved in the design process itself communicate with one another in the effort to reach a collective decision. Our model will be about how designers design rather than how they use their knowledge of cities and their environments to generate decisions. We are thus transferring our focus to the design and decision process itself, and we will show how a model can be built that enables us to articulate the way those involved in design communicate and pool their ideas and opinions about what is the best design.



The Sites and the Stakeholders—The location of the area is shown in the inset at the bottom right, while the ultimate importance of each site for redevelopment and the power of the stakeholders in determining this are shown as the percentages in the figure.

In fact, the model of how geodesigners or the stakeholders who are involved in the design and decision process communicate with one another is rather simple to explain. Essentially, we assume there is a network of relations between stakeholders, which is a structure based on how close, in terms of ideas about the design problem, they are to one another and how likely they are to communicate. The network connects everyone to everyone else, some directly, but most indirectly. The process works as follows. At each time period, those agents who are connected to other agents send their opinions to those agents to whom they are directly connected across the network. When the agents receive the opinions of those to whom they are directly connected, they make a rational compromise: they change their own opinions to an average of those they receive. They then take these new averaged opinions and communicate these using the same network at the next time step. They then average the averages in the second round. If they keep doing this, the initial differences between the agents will be reduced, and eventually everyone will hold the same opinion. Consensus reigns in the form of a weighted average of all the differing opinions. If the problem is suitably framed, then this consensus can be seen as the design solution.

Of course, you might object that in any design problem, this kind of consensus could not be ensured. Links in the network might be absent, meaning that some agents never pass their opinions to others. If opinions are passed, the agents may not decide to consider them. There are many ways in which communication may fail or be blocked, distorted, or manipulated. But if a design is to result, then some sort of compromise of conflicting or differing views about the best design must occur. Moreover, this idea of a network could be the basis for the design of a process that would achieve consensus—that is, of designing a network that enables the right kinds of communication to take place from which the best solution is guaranteed. Now this, of course, is an ideal type. This model of agents who are geodesigners in the broadest sense of the word is what we might hope for, but it can be made operational, and it is a point of view that forces us to consider how geodesigners design and converge to an agreed solution.



To illustrate it, let me pose a hypothetical problem that we have studied in London's financial quarter, or the "square mile," where we have identified a typical problem of change and redevelopment of land use and building form that requires the agreement of several key stakeholders. This involves a cluster of buildings composed of residential, commercial, and hospital uses where we show and label the sites in question in the above illustration. This is a toy problem, but it could easily be scaled up to include many building parcels and land uses and many different stakeholders. As in any specific context, the model only comes into its own as a useful way of exploiting geodesign once we do scale up, and thus our toy model simply illustrates the method.

The area for our design is around the original location of the central post office adjacent to St. Paul's Cathedral and the new London Stock Exchange in central London. This is the notional center of the UK postcode districts. Here, Marconi sent the first public wireless signal in 1896, and John and Charles Wesley founded Methodism in 1738 in the street known as Little Britain. The area is composed of eight key sites: the Bank of America/ Merrill Lynch and Nomura Bank, which occupy two of the old post office buildings sold off to the private sector in the last 20 years; a residential block built recently; two buildings of St. Bartholomew's hospital, one of these just reconstructed and one ripe for redevelopment; a small Georgian church called St. Botolph's; a large commercial block recently developed;

and a pocket park of enormous charm. If you want to look at the problem more graphically, then see the PDF of my slides given when I presented a similar talk at the recent 2013 Geodesign Summit. We can now define six key interest groups—stakeholders—that all have some stake in whether or not these eight sites need to be redeveloped and/or change their use, which would involve some alteration to their building fabrics. The stakeholders are the hospital, in the form of the National Health Service; the residents; the banks; property speculators who continually dwell on high-value sites, such as those in this problem; developers anxious for lucrative redevelopment contracts; and the City Corporation (the municipality), which acts as the basic arbiter of all development in the city. Now each of these agents has a view about whether or not each of the eight buildings should be converted or redeveloped. If we then record these views as being in favor of change (1) or against it (0), then we can assemble a matrix or table where the rows are the stakeholder agents and the columns are the land parcels or sites, a second and different set of agents. We can show this level of interest as in Table 1, where each row is the interest (1) or disinterest (0) the relevant stakeholder has in the redevelopment potential of the building parcel.

Now, this matrix or table contains all the salient information about the design problem. This, in fact, is a set of maps. If you look at the table from the vantage point of each stakeholder—across each row—then each is a map of what the stakeholder thinks should be done in each parcel. One could easily imagine each row as constituting a set of grid squares from a 2D map splayed out as a vector rather than a grid or other 2D arrangement of sites. The second problem is defined when we look at each column, which is a set of what each stakeholder's interest is in any particular site.

Now, the problem as we posed it involves each stakeholder taking the map and pooling it with those to whom they are connected in a network. However, we have not yet been at all specific about what the network is, but one way of defining it is from the above matrix. If we pose the question, How related are each of the stakeholders to each other with respect to their maps? then we could relate each row/stakeholder to any other by simply counting the number of common links. We can

Stakeholders	Buildings	Aldersgate Office	St Botolph's Church	Nomura Bank	Residential	Postman's Park	Bank of America	Hospital New Build	Hospital Old Build
City Corporation		0	0	0	0	1	1	0	0
Residents		1	1	1	1	1	1	0	1
Hospital NHS		0	0	1	0	1	1	1	1
Developers		0	0	1	0	0	1	0	1
Property Spec		0	0	0	0	0	0	0	1
Banks		0	0	1	0	0	1	0	1

Table 1.

arrange this as an interaction matrix, and this can act as our communications network, with the strength of the links giving the importance of the communication for the pooling or averaging of maps. To give an idea of this interaction, the network between the stakeholders can be easily derived by counting in the way I have explained as shown in Table 2.

							Σ
City Corporation	3	1	3	3	3	1	14
Residents	1	1	1	1	1	0	5
Hospital NHS	3	1	3	3	3	1	14
Developers	3	1	3	5	4	2	18
Property Spec	3	1	3	4	7	2	20
Banks	1	0	1	2	2	2	8

Table 2.

The sums (Σ) of the interactions given at the end of each row must be divided into the entries to get the fractional network weights. Now for the action—for the way the agents interact in moving to a consensus. We can swap each map (row in the initial matrix) for all the other maps linked to each agent in the network mentioned above and then average these maps—the opinions of stakeholders to whom each agent is linked—using the strengths of the links as weights. So for the City Corporation, the new averaged map showing the corporation's new interest in the sites is formed by setting the weights proportionally to the strengths of the connections. So this would be 3/14, 1/14, 3/14, 3/14, 3/14, and 1/14, noting that these weights add to 1 to make the average of the maps of the stakeholders to which the corporation is linked. If we keep on averaging for all stakeholders in this manner, then eventually each map will converge to the same interest that each stakeholder shows in each site, and this would converge to the following values of interest, where we note that we have scaled these degrees of interest in each of the eight sites to add to 100: 7, 7, 18, 7, 14, 21, 5, and 19.

Now, this decision process gives us weights that each stakeholder can apply to produce an average map. But there is another process we might consider as the dual that involves us in averaging each site against each other site in terms of the weight associated with each stakeholder. We count the number of common stakeholders with respect to each pair of sites from the first matrix above, and this gives us another network—a dual network—which is generated as strengths of interaction between the sites. In this sense, the site might also be seen as an agent. If we average on sites with respect to the different views of stakeholders, eventually the same sort of convergence occurs, and we can then find the importance of each site as making up the consensus of the stakeholders. The values we get for each of the stakeholders from the averaging of sites when consensus is reached is as follows, noting again that the values are scaled to add to 100: 17, 6, 17, 23, 25, and 10.

What all this means is as follows: For the first problem—the so-called primal—we work out a probability that each site should be redeveloped for change of use, which is agreed by all stakeholders, and this occurs when they reach a consensus by successfully changing their degree of interest sequentially. For the dual problem, each stakeholder is given a degree of importance in the problem, which is due to the fact that there is convergence on the value of each site.

Now, I appreciate that this is a huge mouthful of ideas to absorb. I have not produced many graphics here to explain it blow by blow, but the map above shows the eight sites in question as land parcels and their relative importance and also tables of the stakeholders and their relative importance in determining the importance of the sites. What this shows is that the property speculators and developers have much more importance in influencing the outcomes of redevelopment than the residents or even the banks. In terms of the eight sites, the most important with respect to a change of use are, first, the banks that acquired the old post office sites and are now subject to financial problems—hence their current decision to lease out these buildings—and second, the old hospital site. The Georgian church is protected, and there is little enthusiasm to redevelop the newly developed hospital site, the existing Aldersgate offices, and the residential block, all of which have been renovated and/or rebuilt in the last 15 years. The park is intriguing, as there is more than a little interest in changing its use, for it appears the property and development interests are central in this. This is, however, unlikely to happen, as it is one of the most highly protected pieces of green space in the city, with more than a few historic associations.

What we have produced is a model of how we can articulate stakeholders and the sites they are interested in as two different sets of agents that interact within themselves as well as between. The model we have suggested is rather simple, but it does focus on what it might take to engender important changes in how these kinds of problems might be resolved. Of course, the problem can be formalized mathematically, and although the algebra is not difficult, it is needed so that one can work out weights and averages. The real power of this approach, however, is in dealing with big problems where it is not obvious how powerful interests might be or how important sites might be. If we have hundreds of stakeholders and hundreds of sites linked spatially, the sort of networks that might apply can be extremely tricky to explore. Moreover, in such problems, consensus is often difficult to achieve without ensuring that certain communication channels are put in place. This, then, is the process of geodesign. Our argument here is that it is important in advancing this science that links GIS and design to build models not only of the subject matter and focus of the design but of the design process itself: models not only of the product but also of the process.

Most of the software that is being developed for geodesign lies more in the geo component of GIS than in the design component. But the process we are suggesting as good geodesign practices is a kind of map algebra, and it could be implemented as a way of combining land coverages within software, such as ArcGIS using the ModelBuilder toolkit. If we think of stakeholder maps as different land coverages, then the process of combination is similar to many overlay map techniques central to land suitability analysis. I am not suggesting that we should use GIS in this way, although it would be easy to add this into such generic software. But I think that formal models of the geodesign process are useful as thought experiments about how one should go about design, and they clearly suggest ways in which stakeholders with very different interests might come to some sort of agreed answer.

Note: A version of this paper was presented at the 2013 Esri Geodesign Summit, held January 24–25, 2013. A PDF of the presentation is available at www.spatialcomplexity.info archives/1109.

About the Author

Michael Batty is Bartlett Professor at University College London and chair of the Centre for Advanced Spatial Analysis (CASA).

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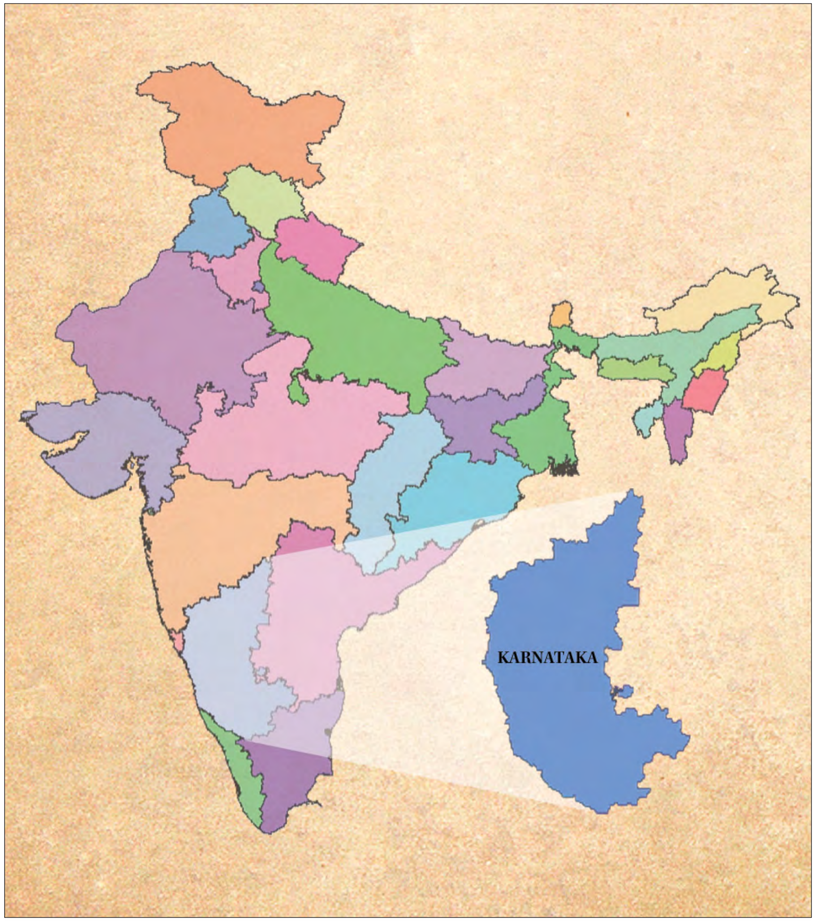
India: A Vision for National GIS

India has long been a leader in using modern spatial technologies and started its tryst with satellite images and GIS in the 1980s by having its own Indian Remote Sensing satellites and image-based mapping and creating GIS databases and applications. In the early 2000s, it took steps toward designing a National Spatial Data Infrastructure. With a large talent pool and many veterans providing the vision, leadership, and drive, now a national movement has taken shape in India's next-generation GIS program—National GIS. Moving away from looking at GIS as just a mapping or database tool or as scientific software, India recognized that the true power of GIS can be realized only when it reaches the hands of the governed—those who can demand efficiency of governance/development and transparency in democratic action.



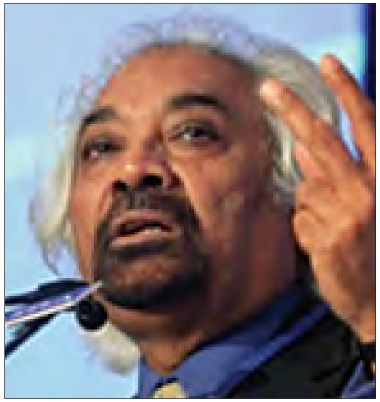
The state of Karnataka's GIS program is a successful model for National GIS.

India is a vast country, with a population of more than 1.2 billion people spread over 3.29 million square kilometers. The country is composed of more than 600,000 villages and 7,000 cities and features a varied geography with a rapidly changing and complex social and economic character. As a democracy, India is constantly dealing with ways and means to comprehend social and economic challenges and bring a good quality of life to all its citizenry—aiming to bridge the wide disparity in economic and social character. It is in this democratic character that India visualizes National GIS as important—to easily map, note changes to, and understand the complex interplay of social order and economic growth. India has visualized that GIS is not just essential but is now an urgent necessity—so as to empower its citizens and bring an inclusive economic growth and prosperity to its people. It hopes to reap demographic dividends, expedite development, and reduce disparity—thereby bringing more equity among its people.

To many, developing a national GIS would seem to be an insurmountable task. How would a single, comprehensive system ever be expected to serve the varied and separate needs of so widely contrasting elements? To others who know the challenges of GIS data availability in India, it would sound almost impossible to visualize a seamless national GIS that covers the whole nation. But a blueprint has been developed, and there is now a clear agenda that has been set for establishing and making operational National GIS—becoming one key element of a new innovative information foundation that will empower governance, enterprises, and citizens across the country.

The vision of National GIS for India has now been widely debated, discussed, and endorsed in a series of national-level meetings involving users, stakeholders, technical experts, policy makers, and the government. The National GIS vision document can be accessed at moes.gov.in/national_gis.pdf. The National GIS has now been incorporated into the Government of India Planning . . .

Sam Pitroda, Adviser to Prime Minister on IT and Innovations



Sam Pitroda

"India is at the cusp of another technological and development curve, and in its drive for inclusive growth, social equity, and development, a major requirement would be to reengineer many systems and processes. Information will be the fourth pillar of democracy, and GIS will be that important element of the fourth pillar—helping in the concept of unified information infrastructures. National GIS is envisaged not just to provide GIS data and GIS applications but serve as a platform for a host of e-services to every citizen—be they in urban or rural areas—and thereby leading India into inclusive growth and prosperity, expediting development, reducing disparity, and bringing rich demographic dividends."

—"A National GIS for India's Development," Keynote Address, Esri International User Conference, San Diego (July 8–12, 2013)

Related Video

A National GIS for India's Development with Sam Pitroda

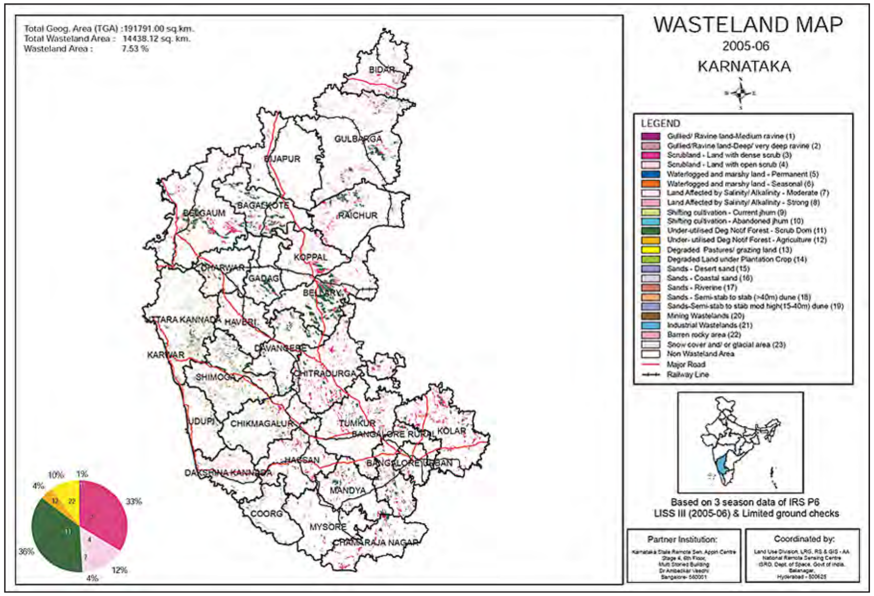
Sam Pitroda, adviser to India's Prime Minister for Public Information Infrastructure and Innovation, highlights India's efforts to solve its challenges with geospatial technology.

[Commission's *Twelfth Five Year Plan 2012–17*](#) as a new initiative for the future (Vol. I, page 248).

Reaching Full Potential

The vision report states that in spite of the wide usage of GIS as a technology, the potential of GIS has not yet been fully exploited for decision support by planners, stakeholders, decision makers, citizens, and others. Some of the initiatives have certainly been successful and have proved the potential of GIS for project work, but in many places, GIS has yet to achieve a full-service orientation and become a core component of the process of governance, planning, and nation building. Some key challenges that India faces in this regard include the following:

- How can the nation ensure that its decision-making/governance process is supported by a comprehensive, easy-to-use GIS decision support system that brings scientific, participatory, and quality dimensions into decision, planning, and development?
- How can the nation ensure that GIS-ready data is always easily available and maintained/updated by adding that critical capability differentiator over the images and maps that have already been invested in?
- How can India maintain a high level of national capability in this important technology area and leverage itself to be in the forefront of GIS technology in the international arena?



Wasteland map of the state of Karnataka based on three seasons of data, 2005–2006. Source: Director, Karnataka State Remote Sensing Centre (KSRSAC, Bangalore).

India has also recognized that there are some gaps in the widespread adoption of GIS in the country, and these need to be addressed as part of the process of building National GIS. GIS is technology-centric but needs to be decision-centric. This means that all types of decision makers—governments, enterprises, and citizens—should have the ability to easily make use of readily available GIS data and applications that can help solve their problems. GIS needs to become so easy to use and so deeply embedded in workflows and processes that it becomes integral to modern governance and nation building. In addition, there is as yet no widespread availability of GIS-ready data for the whole country, and no agency in India has overall responsibility for this activity. These shortcomings have been identified as critical and need to be addressed before GIS can become pervasive at both the state and national levels.

Key elements of India's National GIS vision include the following:

- A National GIS platform with GIS-centric computing and networking infrastructure
- Seamless, nationwide National GIS asset at 1:10,000 scale, as well as city-level data at larger scales
- Targeted National GIS applications to support government ministries and departments, private enterprises, and citizens and delivered through a National GIS portal; planned GIS dashboards for use by the Prime Minister's Office, Planning Commission, Cabinet Secretariat, and key dignitaries
- Focused GIS capacity-building initiatives
- Pragmatic geographic information (GI) policy positioning and best practices for National GIS

India has recognized that a strong organizational framework is essential for bringing focus and for institutionalizing National GIS and promoting geospatial technology use by government, enterprises, and citizens. To ensure success, it considers having an agency be made responsible for overseeing the vision of

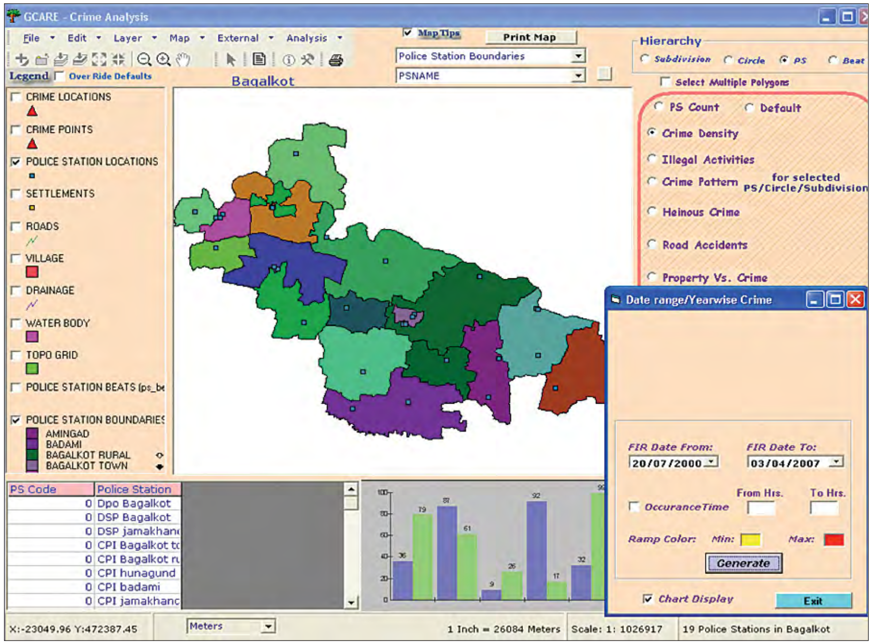
Dr. K. Kasturirangan, Member (Science), Planning Commission

"There are three important issues related to GIS. First, how can we ensure that our decision/governance system is supported by a comprehensive, easy-to-use GIS decision support system—whatever the decision maker wants must be supported by GIS? Second, how can any user be rid of the hassles of GIS data organization that he now faces—ensuring that GIS-ready data is readily available? Third, how can we have an institutional system in the country that is responsible for GIS and is accountable to meet the GIS needs of the country?"

—Key Address, National GIS Workshop, Delhi, India (September 14, 2011)

National GIS important. The Indian National GIS Organization (INGO) would have the primary mandate for the establishment, maintenance, and operation of National GIS. It would be responsible for guiding and shaping disparate components relating to infrastructure, technology, and services into a cohesive system.

In addition, a robust management structure has already been put in place to bring high-level focus and alignment across multiple ministries and all states and territories and to provide a flexible operational mechanism for implementation of National GIS. The Department of Science and Technology (DST) has



The Karnataka state police department has undertaken a pilot project for crime analytics and real-time monitoring. Source: Director, Karnataka State Remote Sensing Centre (KSRSAC, Bangalore).

been assigned the responsibility of implementing National GIS, and Dr. T. Ramasami, secretary, DST, is driving all the actions for the implementation. A National GIS Advisory Board has been established, with Dr. K. Kasturirangan as its chair, to provide overall policy direction and advice on implementation of the National GIS vision. A high-level National GIS executive committee has also been established to facilitate National GIS implementation, ensure INGO establishment, and help position across the entire country the concept of e-governance; e-governing is governing that takes advantage of the convergence of the newest geoinformation and communication technologies, such as improved spatial data management, GIS, GPS, remote sensing, satellite and mobile communications, and the web. A mission-mode implementation of National GIS is being taken up under DST, and soon, a mission director will be positioned to be responsible for implementing National GIS.

A National GI Policy

India also recognizes that a strong policy foundation is essential for National GIS and also for furthering a good GIS ecosystem in the country. An independent study on GI policy perspectives has been undertaken by the National Institute of Advanced Studies, Bangalore, for the Government of India. The study has brought out a comprehensive report that outlines the framework of India's GI policy document [PDF].

Presently, India has five policy tenets:

- **National Map Policy**, defining the scope, distribution, and access of Survey of India topographic maps
- **Civil Aviation Requirement**, detailing procedures for issuance of flight clearances for agencies undertaking aerial photography, geophysical surveys, cloud seeding, etc.
- **Remote Sensing Data Policy**, defining the process for distribution of satellite imagery

- **Delhi Geographical Spatial Data Infrastructure (Management, Control, Administration, Security, and Safety) Act**, defining the mandatory sharing, accessing, and utilization of Delhi geospatial data
- **National Data Sharing and Accessibility Policy**, declaring open access to data generated through public funding

The above existing policies have been analyzed, and the need for an overarching policy regime for GI has been emphasized. To bring rationality in policy analysis, seven basic segments were identified that describe a national capability in GI and that need to be factored into a GI policy: imaging capability, precise positioning capability, advanced surveying capability, mapping capability, GIS capability, GI knowledge capability, and GI policy capability. In addition, four major cross-cutting GI policy considerations were identified as key factors for policy definition: national security, social relevance, legal issues, and creation of industrial capacity. Based on these seven segments and four cross-cutting considerations, the policy analysis identified 62 critical parameters that are constantly assessed from a policy definition point of view. Based on these factors, the case has been built for a comprehensive, overarching, and visionary policy. The report has also drafted the text of the national GI policy that aims for an advanced and impacting national capability in GI that empowers citizens and governance and also for positioning India as a global leader in GI. Toward this aim, it identifies two important near-term goals:

Montek Singh Ahluwalia, Deputy Chairman, Planning Commission

"National GIS can serve multiple needs—government, enterprises, and citizens—and must power more open government and thereby leverage economic and social development and reach the gains of development to the most needy and at the right place. National GIS must also aim to bring accountability and responsibility of public activities where decision making can be centered around GIS—thus factoring location and time-domain map information."

—Inaugural Address, National GIS Workshop, Delhi, India (September 14, 2011)

- Establish National GIS in the next three to five years.
- Institute g-governance models in Indian society.

In India, individual states are the main delivery mechanisms of development and social programs, so it became clear very early in the visioning process for National GIS that success would be dependent on acceptance and buy-in at the state level. Various state GIS initiatives have brought good operational examples of statewide applications to the national forefront. Some very good statewide GIS examples that have been established are in states like Gujarat and Karnataka. Gujarat has developed comprehensive statewide GIS data and has operationalized GIS services to grassroots level in a unique way. Karnataka has multilayered statewide GIS data and a wide range of GIS applications. In other states like Andhra Pradesh, Maharashtra, Rajasthan, and Haryana, GIS usage has been good. Many other states also use GIS for specific projects. These state-level efforts, in addition to establishing the relevance of GIS for development in a wide spectrum of areas, provide significant insight into successful applications, which are closer to citizens' needs and direct governance. In addition to these government agencies, many private-sector agencies have also been successful in implementing GIS solutions and in providing GIS services.

Karnataka GIS

The state of Karnataka determined to define state GIS in the context of National GIS implementation and to address the model of *governance-enterprise-citizen*. The prototype that the state then developed resulted from close examination of governance issues and citizen empowerment (see www.karunadu.gov.in/ksac/documents/K-GISVisionDraftVerWshop_Jan18.pdf [PDF] and www.karunadu.gov.in/ksac/documents/KGisUserNeedsDraftWshop_Jan18.pdf. Once Karnataka had developed its strong state GIS model, it became a successful model for both state and national GIS implementation.

The state GIS would easily dovetail with and link to National GIS, and both could benefit from a common GIS data content (thereby reducing data duplication and redundancy) but service different applications (founded on a GIS services model). Such an approach is seen as essential to meet the needs of central and state governance and thereby its citizens.

Karnataka recognizes that GIS provides tangible benefits and that it is a key platform for the future of state governance. An institutionalized system that will ensure the availability and accessibility of GIS data and applications to different user groups and citizens is an important consideration in the vision of Karnataka's 21st century governance. With the vision for Karnataka GIS now defined, the result is a robust information

Dr. T. Ramasami, Secretary, Department of Science and Technology

"National GIS is a logical requirement—while e-Governance (e-Gov) is the current paradigm, the future is in embedding the GIS in governance and in establishing G (G signifying GIS-based)-Governance (G-Gov) as the next frontier. India is poised for developing GIS-based solutions as the next paradigm in governance. National GIS would also catalyze and transform the methods in which GIS is practiced in the country, the way maps/images as GIS-ready data get organized and the way customized GIS applications get created, managed, and deployed as unique GIS services. An institutional framework for National GIS is also a necessity, and evolving INGO [Indian National GIS Organization] must be a priority."

—Key Address, National GIS for G-Gov Workshop, Delhi, India (December 12, 2012) and decision support system that upholds the decision-making process for planning and implementing various state developmental programs and also for empowering citizens in the state, apart from contributing common content and linking to National GIS. Thus, the Karnataka GIS is well-aligned with the vision of National GIS, ensuring seamless interoperability and cooperation between the states and national-level government.

The Karnataka GIS visioning exercise, undertaken by the Karnataka Knowledge Commission's GIS Task Force, has resulted in focusing unique and innovative ways of implementing GIS. Apart from the vision definition, a comprehensive assessment of user needs, in terms of GIS data and applications for various state departments, citizens, and others, has been documented. A good matrix structure has been identified for implementation where multiple agency capability is integrated at the state level.

India's National GIS: A Model for the World

The Indian government's vision is to create a new paradigm for governance and development with emphasis on inclusive growth and development—especially to reduce disparity, expedite development, and bring demographic dividends that will be unique. The vision of National GIS is aligned to enable a scientific mapping of resources, disparities, and needs to meet the aspirations of beneficiaries and society, especially the most disadvantaged; support sustainable and spatial planning; assist quick and reliable monitoring of plan implementation and status of development; enable transparent systems for inclusivity of society; and support real-time mapping of feedback and redress systems.

S. V. Ranganath, Chief Secretary, Government of Karnataka

"The role of Karnataka GIS to the state's planning and development process is critical. Karnataka is committed to support a Karnataka GIS initiative to serve as an important tool to support governance and particularly to empower people of the state. Karnataka GIS is an innovative knowledge initiative and has far-reaching implications to the state."

—Inaugural Address, Karnataka GIS Workshop, Bangalore, India (January 23, 2013)

The process of establishing and implementing the state and national vision will also provide considerable opportunities for the private sector to contribute to and be part of this national endeavor. The national and state GIS will also boost education and research in GIS with specific school, university, and research programs focused on training the leaders of tomorrow in spatial thinking concepts and the core principles of GIS.

I.S.N. Prasad, Principal Secretary (IT&BT), Government of Karnataka

"Various Information Technology tools are being used for providing various citizen services and government programme outreach in Karnataka. Now, GIS will be yet another decision-support system that will bring benefit to the various departments of the state of Karnataka and citizens who seek the GIS data and services for their needs. The vision of Karnataka GIS has emerged after inclusive consultation and discussions amongst various department officials, industries, academia—thereby defining a statewide GIS ecosystem for growth and governance."

—Panel Discussion, Karnataka GIS Workshop, Bangalore, India (January 23, 2013)

In today's rapidly changing world, India recognizes that nations that possess a sound and progressive GIS vision will lead and chart ways not only within their own borders but also across the international arena. India is gearing up to implement National GIS and make it fully operational.

Dr. Shailesh Nayak, Chairman, National GIS Interim Core Group/ Secretary, MoES

"GIS is of great relevance for many government activities and enterprises and for citizen services. National GIS has the main aim of thrusting the use of GIS applications into governance/planning/ development activities. While India has made some progress in using GIS, a national system of a GIS is very important and timely for the nation to adopt. An organizational focus on GIS is important as an agile, rescoping organization—Indian National GIS Organization."

—Key Address, National GIS for G-Gov Workshop, Delhi, India (December 12, 2012)

Concluding Note from Jack Dangermond: *There is something for all GIS users to learn from this vision. It is sincerely hoped that what has been conceived as a national GIS platform to help bring growth, efficiency, transparency, equity, and inclusiveness to India will also serve as a useful model for other countries wishing to implement a national GIS.*

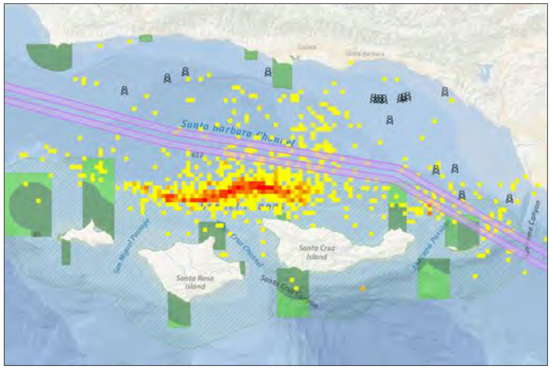
(Reprinted from the Fall 2013 issue of *ArcNews*.)

The Role of GIS in Sustainable Economies

Geoff Wade, Esri

The goal of sustainable planning, policies, and governance is to design processes that return our planet to a more balanced level of use. To do so we must realign our values and earth's ability to support them. The success of this effort is dependent upon a foundation of science, a means of collaboration, and the implementation of sustainable polices and administration. GIS is an essential tool for designing and implementing sustainable processes at a scale ranging from local to global.

People around the world continue to compile scientific data about resources, ecosystems, and human impact. GIS enables us to visualize and analyze these massive collections of data. Establishing a base for determining cause and effect, GIS tracks ecological change and provides chains of evidence of human impact. It tracks people's land use, methods of resource extraction, and peripheral activities, such as supporting road networks. GIS manages large databases, depicts and prioritizes problems, models scenarios of both positive and negative practices, and predicts environmental outcomes. It provides the quantified information and analytical capabilities required for making location-based decisions that increase economic efficiencies and reduce consumption and contamination.



GIS can be used to reroute shipping lanes away from ecologically sensitive areas such as whale migration grounds.

People's stakes in our environment vary. GIS gives us a lens to understand different objectives and create an environment for collaboration. Among these objectives are economic potentials, equality, environmental and social justice, environmental preservation, land use, and more. Understanding these concerns requires data and analysis. Many countries have set up spatial data infrastructures (SDI) that enable data exchange via standards and interoperability. Organizations have created GIS portals that enable fast access to geodata and map services. GIS platforms serve as frameworks for multidisciplinary collaboration in designing sustainable practice policies, implementation, and administration. These technologies promote dialogue by helping different organizations articulate their concerns within the scope of sustainable planning.

The environment is a global responsibility. Forests do not stop at a border; one ocean touches many coastlines; and climate change impacts every continent. The implementation of sustainable polices and administration must cross borders. The common language of geography expressed through the tools of GIS can bring people together, and thereby tip the balance toward a more sustainable planet.

About Geoff Wade

Geoff has more than 20 years of experience in the application of GIS technology to a broad array of Natural Resource disciplines and helps coordinate Esri's community outreach activities across the sector globally.

(This article originally appeared in the *Esri Insider* blog on 01 February 2013.)

A 250-Year Plan for the Planet

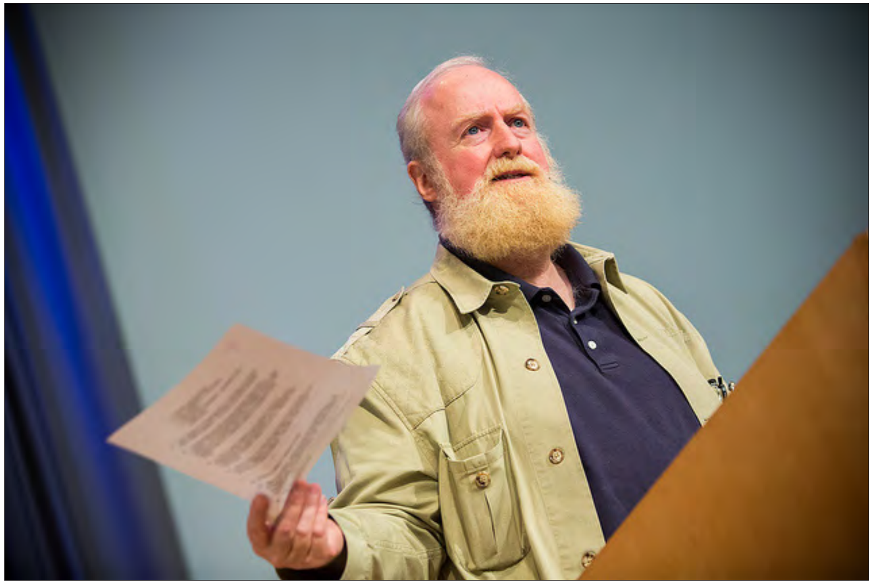
Shannon McElvaney, Esri

Four years ago, designer and technologist Bran Ferren issued a challenge during the first Geodesign Summit: Become better storytellers using geodesign.

Ferren, the chief creative officer of Applied Minds LLC, returned to Esri in January to keynote at the fourth Geodesign Summit and reiterate his first call to action and deliver another: Develop a 250-year plan for the planet enabled by geodesign to create a vision of the future.

"Geodesign combines geography and data with modeling, simulation, and visualization to tell stories and (show) the consequences of your actions," Ferren told more than 260 architects, urban and transportation planners, GIS and design professionals, educators, and others at the most well-attended Geodesign Summit to date. He sees great potential for geodesign to ultimately help find solutions to complex problems. "It is still in the shiny object stage but it will be *very* important," he said.

Geodesign technology will mature naturally much like other technologies such as GPS did. But meanwhile, says Ferren, in this era of short attention spans, people need to start thinking far, far into the future to create a problem-solving template that can be



Bran Ferren at the 2013 Geodesign Summit.

built upon over time. "If we are going to address these big global issues facing us—whether that's disease, education, freshwater, war, or global warming—you actually have to take a long view," Ferren said. "For this planet, we need—pick a number—a 250-year plan."

Ferren said questions need to be posed such as

- What is your current state of affairs or the topic you are worried about?
- What is your desired end state?
- How are you going to get there?"

"I argue that just having the discipline to sit down for a day and think about that will change your whole thought process," Ferren said. "It doesn't mean you are going to know exactly what the future is, but having a sense that in 250 years, you would like to address these things at least gives you an intellectual template and road map to test your ideas against."

This process will be collaborative, too, according to Ferren. "That's the power of geodesign," he said. "It's this network extension of shared intelligence where the insights of individuals can be shared among others, and that can be used as the foundation to build upon."

Ferren also said that geodesigners in the future will be entrusted with the same power over life and death that doctors have today, because the decisions they make will be critical to humans and other species. "The mistakes you make in planning and designing our cities may take 100 years until someone understands the consequences of those actions. The Hippocratic Oath for geodesign: First, do no harm," he said. "Understand what you are doing and the effect—if you know this is going to do long-term damage, it is not okay to do it. We aren't on this Earth very long. It's a mere blip. Try to leave it a little better than how we found it."

Geodesign Summit attendee Juan C. Perez, director of Transportation and Land Management for the Transportation and Land Management Agency for the County of Riverside, said Ferren's proposal of a 250-year plan was thought provoking. "While perhaps extreme at first blush, it really puts into perspective that the land-use decisions that we make have very long-term consequences."

- Watch Ferren's keynote at the fourth Geodesign Summit.

About Shannon McElvaney

Shannon McElvaney is the Community Development Manager at Esri and a geodesign evangelist working on developing tools, processes, and techniques that will enable people to design, build, and maintain livable, sustainable, healthy communities. He has more than 20 years' experience applying geospatial technologies across a variety of industries. He writes a quarterly column and is on the Editorial Advisory Board at Informed Infrastructure. Most recently, he is the author of a new book, *Geodesign: Case Studies in Regional and Urban Planning.*

(This article originally appeared in the *Esri Insider* blog on 08 February 2013.)

Creating the World of Tomorrow

Shannon McElvaney, Esri

Jennifer Sheldon is an ecologist, writer, and program manager specializing in terrestrial ecology and wild dog ecology. Her research emphasis includes development of spatial models of carnivore competitive interactions, as well as the demography of coyotes during gray wolf restoration in Yellowstone National Park. Her expertise includes working with multi-disciplinary and stakeholder teams on research efforts. She is the co-founder of Yellowstone Ecological Research Center, and was vice-president for 16 years. She is currently taking a sabbatical year in Victoria, British Columbia working on a book about ecological systems, the human dimension, and resilience. Jennifer spoke at the 2013 Geodesign Summit which Esri recently hosted in Redlands, California. This interview was conducted by Shannon McElvaney after the event, with impressions of the event and about the future of geodesign.

McElvaney: This was the fourth Geodesign Summit Esri has hosted, but the first you've attended. What did you think?

Sheldon: The gathered group was unusually varied and included academics, industry leaders, urban planners, students, geographers, educators, and analysts. Carl Steinitz provided the unifying theme with his elegant articulation of the theory of geodesign.

Concepts flew, turned on a dime, and looped back into applications. Talks were met with rowdy applause then contemplative silence. We ate lunch in the midst of a barrage of creative interchanges—young students talked a mile-a-minute with industry leaders, National Park Service landscape architects, and city planners, all exchanging ideas in a congenial atmosphere. Themes included water, resources, restoration, urban landscapes, and the human element. The mix of GIS platform advances with applications and theory was catalytic and provided serious brain-food for all attendees, moving everyone out of their comfort zones and into dynamic interactions during breaks and over meals.

Throughout, the theme of the Geodesign Summit was the open exchange of ideas. Dynamic presentations alternated with close-focus workshops. And threading through this free-wheeling and good-natured summit, the common language was empowered by advances in software, visualization technologies, and processing capabilities. Jack Dangermond's ready engagement provided a unifying good humor.

McElvaney: What at the Summit really made you think?

Sheldon: In today's highly technical and specialized world, solutions come from teams. Collegial, thoughtfully assembled groups of experts and non-experts working across disciplines can translate the complex technical requirements of today's design and planning challenges into reality-based solutions. We saw the best of this fusion and teaming begin to coalesce at the 2013 Geodesign Summit. It's the free interchange of thoughts and plans that gives the future its legs. The best of creative problem-solving happens with committed teams of creative, solutions-oriented people. The Geodesign Summit's setting and agenda provided a framework for success. Maps provide the common language.

McElvaney: This year, we intentionally brought in biologists to mix with urban and regional planning and design professionals to cross pollinate. Did it work?

Sheldon: Ecologists provide insight into the physical mechanisms underlying good design choices (examples: hydrological models let us know about impermeable surface and greenspace planning for cityscapes; Ground truthing provides feedback on CityEngine fly-throughs; Biodiversity assessments provide feedback on whether land set-asides are working effectively). In today's specialized world, talking with people from different disciplines is critical for solutions-oriented activities. Ecologists tend to be academic or management-oriented. It's good to build conversations with both of these approaches. From my perspective it was fruitful and productive. I learned a lot more about how urban planners approach their constraint space. More cross-discipline feedback from ecologists will be productive here.

One future activity might be to have a round table to focus more tightly on solutions (e.g., integration of an eco-constraints layer into urban planning efforts). Begin with a real-world problem presentation, then focus a panel discussion on expertise from different fields and how the solution can be parameterized (and supported by software). Be specific about the software architecture needed. For example, how do we address unmet needs in ecological constraint layers in the built environment?

The Yellowstone Ecological Research Center has pioneered work by examining whole landscapes for extended time frames, and by collaborating in multi-disciplinary teams.

(Photo by Hamilton Greenwood.)

McElvaney: What do you think is needed to bring about the geodesign tools we will need for holistic planning?

Sheldon: We need a three-way interface of

- Esri spatial visualization.
- Ecological data and models.
- Remote sensing data.

Integration of these three entities is the research and applications frontier for impacts assessments. The biggest unmet need in impacts assessments is a standardized set of utilities across these three domains. Typically each project comes up with its own unique and unstandardized solution for data integration. While we wait for the incentive system in real-world situations to be adjusted, we can still provide the utilities to make impacts more realistic and accountable. EAGLES was a first cut of articulating the unmet needs of practitioners in this three-way integration. Ecology is ready for the next generation.

McElvaney: What did you think of Bran Ferren's call for a "Bill of Rights for the planet"?

Sheldon: All world-changing movements begin with a timely, self-evident idea carried by people who are bold enough to move it forward.

What we are really mulling over is Where do human interests and ecosystem interests intersect? With Sandy, ocean issues, species declines, water quality, we intuitively understand that there isn't an "us (humans)" vs. "them (ecosystems)" frame any more. We are all supported within an integrated system of air, water, vegetation, ocean, and climate. This unified envelope can be mapped, measured, and supported through excellence in integrated design. Forecast models can yield a visualization of future outcomes for discussion and rational planning. One way to make it more tractable is to borrow from the legal disciplines and move toward the concept of "standing" for systems and their components.

Obama's Climate initiative provides a first lever. The link between human health and ecosystem health provides a second lever. The costs of continued impacts of current practices provide the third argument: food security (soils and agricultural productivity); energy issues; urban integrity; water issues all combine to make powerful economic arguments for eco-integrity.

Possible geodesign Hippocratic oath? Above all, do no harm.
(Photo courtesy of Jennifer Sheldon.)

As we move beyond simple arguments based on philosophy into a clear understanding of the linkages between ecosystem integrity and human well-being, a new evidence-based thought system will be essential. Spatial data represented clearly and accurately plays the keystone role.

McElvaney: One of the things that always comes up is the definition of geodesign, and we frequently go through a number of different definitions provided by various thought leaders. In simple terms, how would you explain the concept of geodesign?

Sheldon: The world of tomorrow is written in the (geo)designs of today.

Shannon McElvaney is the sustainable development industry manager at Esri and a geodesign evangelist working on developing geodesign tools, techniques, and processes that will enable people to design, build, and maintain livable, sustainable, healthy communities. He has more than 20 years of experience applying a broad range of geospatial technologies across a variety of industries.

(This article originally appeared in *Sensors & Systems* on 05 February 2013.)

Understanding our world.

Esri inspires and enables people to positively impact their future through a deeper, geographic understanding of the changing world around them.

Governments, industry leaders, academics, and nongovernmental organizations trust us to connect them with the analytic knowledge they need to make the critical decisions that shape the planet. For more than 40 years, Esri has cultivated collaborative relationships with partners who share our commitment to solving earth's most pressing challenges with geographic expertise and rational resolve. Today, we believe that geography is at the heart of a more resilient and sustainable future. Creating responsible products and solutions drives our passion for improving quality of life everywhere.

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