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Essays on Geography and GIS

Volume 4

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Through the Macroscope: Geography's View of the World

By Jerome E. Dobson, Professor of Geography, University of Kansas

We have in our hands a new scientific instrument as powerful as any that have come before it, including the microscope and telescope. Collectively, GIS, GPS, satellite remote sensing, and popular geographics constitute a *macroscope* that allows scientists, practitioners, and the public alike to view the earth as never before.

Today, this geographically enabled macroscope (which was first proposed by Joël de Rosnay in 1975) allows humans to visualize earth processes extending over vast regions or even the whole globe while still maintaining the finest measurable detail. We who use it can capture and analyze far more complete representations of places and features than ever before. We can "see" earth features, such as gravity and magnetism, that are invisible to the naked eye and yet as real and commanding as the mountains and valleys we've seen all along. Most important, we can marshal this diverse information into working models of earth processes large and small.

The microscope allowed humans to see smaller particles and organisms and led to scientific revolutions in biology, medicine, and nuclear physics. The telescope allowed humans to see farther away with greater detail and led to revolutions in astronomy and geodesy.

Will the macroscope similarly lead to scientific revolutions of its own? Will it change the way science itself is conducted, as those earlier instruments did? Has this scientific revolution already begun? Yes, but it has done so slowly and mostly unrecognized by pundits and the public alike.

In 2008, the *Proceedings of the National Academy of Sciences* announced that cattle and deer can sense magnetism. Biologists in Germany and the Czech Republic discovered this amazing and previously unsuspected phenomenon not by sensing brainwaves or measuring body chemistry but by "analysis of satellite images, field observations, and measuring 'deer beds' in snow."

In the 1990s, a geophysicist solved a mystery that had perplexed hydrologists for decades—a significant portion of the global transport of water had never been explained. Perusing satellite imagery, he suddenly realized that the answer lay in vast currents of water vapor drifting through the atmosphere. He calculated their mass and followed their flows and found the H_2O that had been missing from the global water cycle equation.

Thus, in two diverse realms of science, the geographically enabled macroscope actively bolstered the analytic powers of specialized disciplines. Where will this lead?

Geography in the Crucible of Science

Is geography a science? Yes, most definitely, because science would be diminished too much without it.

In classical times, geography was viewed as a fundamental science and humanity on par, at least, with the specialized disciplines of today. During the Middle Ages in Europe, however, notions of real-world geography devolved into fantasies, and no term for geography was in common usage even in the highest realms of government and academe. The discipline thrived again from the mid-15th to mid-20th centuries based on an evolving chain of influences from exploration to westward expansion to geopolitics. Since 1948, however, geography has undergone a second academic purge, primarily in the United States, and the word itself has lost ground to a host of popular aliases, *geospatial* not least among them.

Finally, we practitioners have an instrument that potentially enables us to reinstate geography in science as it was practiced in classical times and in the Renaissance. What will science, enhanced by the macroscope, look like a generation or more from now?

First, we, its stewards, must decide what to do with this new instrument and what role we will play in the science that follows. Will geographers and GIScientists drive the revolution or merely go along for the ride? In the case of animal magnetism, for instance, why didn't we, who worked intensely with such imagery for decades, notice this odd phenomenon long before the biologists did? In the case of global water circulation, why didn't we, who used the imagery routinely and knew its spectral characteristics so well, make that discovery ourselves? Instead, we spent enormous efforts trying to get rid of the haze that was blocking our view of the ground but was, for the geophysicist, the key to a scientific breakthrough of historic proportions.

Bluntly, how did we get scooped on major discoveries so easily resolved with our own data? Why was science held back until biologists and geophysicists discovered those insights themselves? Surely, we must rethink our own functions, motivations, and pursuits if we want to be the ones making discoveries, grabbing headlines, and gaining financial and administrative support for our work.

How Will Geography Itself Fare?

By any measure, geography has been remarkably productive in the past half-century, and yet department after department has been closed. In 2007, I wrote in *ArcNews* that only two geography departments remained in the top 20 private universities in the United States. Four years later, no viable ones are left. The University of Southern California abolished its geography department in favor of a geospatial technology program, and Johns Hopkins University's Department of Geography and Environmental Engineering slipped to only two geographers in a faculty of 18.

To anyone who values education, it should be self-evident that such widespread blindness toward any discipline inevitably must have a damaging impact on science itself. Accordingly, I offer two propositions:

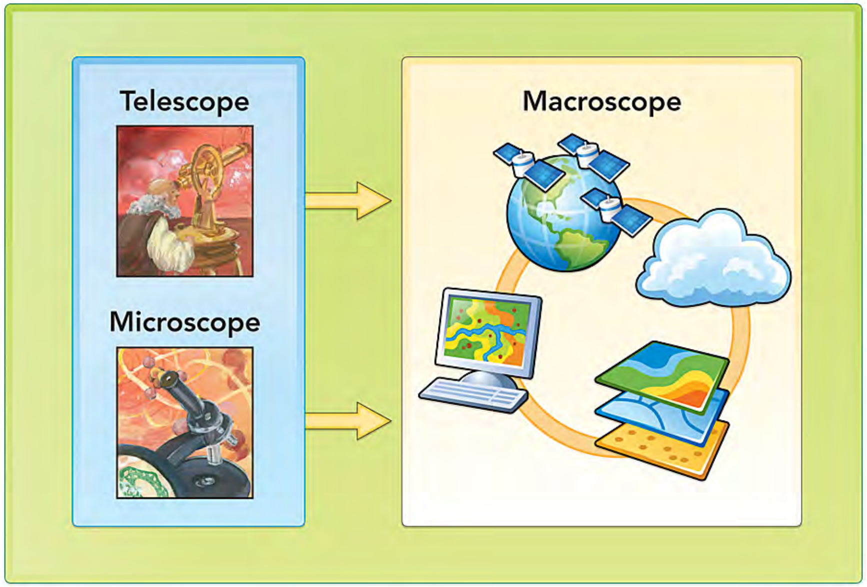
- **Proposition 1—**Science itself is rife with errors and omissions due to lack of geographic input in formulation and testing of theory.
- **Proposition 2—**Any well-trained geographer or GIScientist who focuses on any popular tenet of conventional theory, emphasizes the missing spatial components, and works conscientiously *can make groundbreaking discoveries in one year of elapsed time*. In common English, I am suggesting that earth science as a whole is so flawed by lack of spatial thinking that there will be "easy picking" and lots of "low-hanging fruit." Discoveries will come easily, but acceptance may take decades, since that depends on the culture of science far more than factual evidence.

To illustrate, let's focus on continental drift, as suggested by de Rosnay in *The Macroscope*: "Around the concept of continental drift it is possible to teach the complementary aspects of geography, geology, biology, and ecology. . . ." Then I will focus on another of my favorite topics, the origins of human culture.

Continental Drift and Plate Tectonics

There is no better case than plate tectonics to demonstrate the abiding value of spatial evidence and, simultaneously, society's habitual rejection of it. Starting with the European discovery of the Americas, it took about half a century to produce a decent map of their coasts and only another half-century for Abraham Ortelius to notice the fit between South America and Africa and propose they must once have been joined. In the third edition of his popular text *Thesaurus Geographicus* (1596), he proposed the theory of continental drift in no uncertain terms. Yet there is no known instance of anyone citing his remarkable insight over the next four centuries. Others did reach the same conclusion—Lilienthal (1756), DeBrahm (1771), Snider-Pellegrini (1858)—always based on the fit of coasts, but all were ignored or dismissed until Alfred Wegener in 1912. Soon, he too was rejected and ridiculed for his unconventional theory until ocean floor spreading was discovered and accepted as proof in the early 1960s.

For thousands of years, the interplay of our community—geographers, cartographers, geodesists, and surveyors—with the rest of science was central to the advancement of fundamental



The Macroscope

The macroscope was first proposed by Joël de Rosnay in 1975. His foresighted book, *The Macroscope*, brilliantly proclaims the need and lays the intellectual foundation for such a technological advancement. Writing so early in the history of GIS, however, he does not seem to be aware that work had already begun on his marvelous instrument. He mentions geography, but only as one of many disciplines that one learns in school and that can be illuminated by posing great questions about how the world works. He says, for instance, "Around the concept of continental drift it is possible to teach the complementary aspects of geography, geology, biology, and ecology. . . ."

theories, including plate tectonics. Sometimes we led science theory, as when Bouguer found that mountains are lighter than other crust (1737–1740) and the Great Trigonometrical Survey of India confirmed his findings (early 1850s), and together they laid the foundations for current understandings of plate tectonics. Sometimes we proved the grand theories of others, as when de Maupertuis (1736) and La Condamine (1736–1743) proved that the earth bulges at its middle, thus confirming Isaac Newton's theory that centrifugal force opposes gravity in planetary motions.

Still, we somehow never managed to claim a place among the authoritative disciplines in that realm of science, even though much of it is called paleogeography. One major factor is the scientific community's overwhelming preference for *process logic over spatial logic*. Spatial logic accepts morphology, spatial distribution, and spatial association as primary evidence of earth processes that must be tested through process-oriented research. Conversely, process logic accepts contemporary knowledge about individual earth processes; synthesizes general theory; and proposes all sorts of tests, though rarely are the tests overtly spatial.

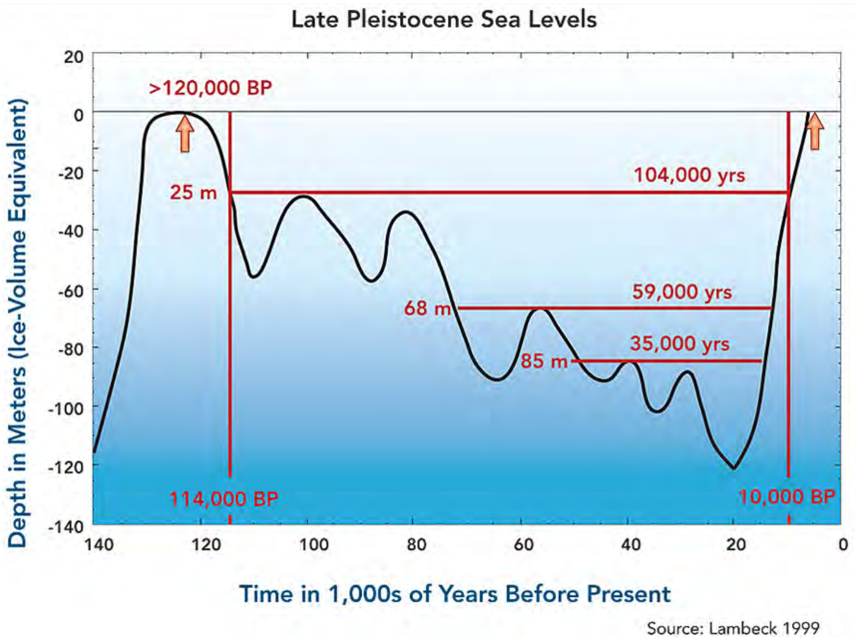
Today, the macroscope has much to offer, opportunities abound, and dramatic new insights are likely. Geographers, cartographers, and GIScientists are ideally suited, for instance, to verify previously discovered continental fits and search for new ones. Likewise, our community is the one most capable of developing a spatial statistic to measure the probability of fit among coastlines.

In GIS per se, it's up to us to develop the functionality to move land masses independent of earth coordinates. When available, this new capability should be used to follow all paths connecting known or suspected continental fits. The ultimate challenge, of course, will be to disassemble all land masses into their geologic formations; run spatial statistics, such as principal components analysis, to determine their affinities to one another based on age, lithology, paleontology, polarity, and elevation/bathymetry; and then reassemble the whole earth based on evidence rather than theory.

The rewards may be invaluable for understanding deep earth processes, estimating seismic risks, reconstructing the paleogeography of plant and animal life, predicting the distributions of oil and other essential minerals, and scores of revelations yet to come.

Origins of Human Culture

Take a look at the graph of global sea level rise below, annotated to show how long each zone was exposed. Has anyone ever told you that for 104,000 years, the world ocean remained at least 25 meters lower than it is today? That for 59,000 years, it was at least 68 meters lower, and for 35,000 years, it was at least 85 meters lower? That geographic information has to be the single most important clue to how and where humans developed into the sentient beings of today. Yet scientists routinely call the old coast a "land bridge," as if it were only good for getting from one place exposed today to another place exposed today (e.g., Siberia to Alaska, Asia to Japan, Australia to Tasmania).



Global sea level rise and the number of years each zone was exposed.

Make no mistake. That was a vast coastal plain, and people surely lived there.

The rise and fall of sea level during the ice ages—due to water tied up in ice sheets and then released during interglacial periods—is like a vast millennial tide, and its total area is equivalent to the continent of North America in size. It is flat, coastal, and mostly tropical and would have been the best place to live during the ice ages. Yet we collectively have never mapped it or agreed on a name for it.

Here again, the opportunities for geographic revelations are boundless. Our community is the one best suited to map the land that was inundated. We can trace the old coasts at various stages and times over the past 120,000 years and predict likely settlement sites and trade routes. We can document authoritative and unproven claims of ancient structures on land and underwater, entering them into a proper GIS with precise coordinates, attributes, and confidence levels. Ultimately, we can build a 3D geovisualization so the land now below sea level can be studied like the land above.

The rewards will be invaluable for understanding the human and biophysical processes operating during the ice ages. Consider, for instance, that sediments deposited from the ice sheets of 20,000 years ago do not lie in the deltas of today but rather in the old deltas, 400 feet down. The greatest scientific revolution, however, may lie in better understanding of human evolution itself, since several glaciation cycles coincide with the time period, 120,000 years, in which modern humans are known to have existed.

"Aha!" Revolution Under Way. Mind Your Step.

I've had a few "aha" moments enabled by the macroscope.

First, once, while conducting fieldwork in the Adirondack Mountains of New York State at the center of the acid rain debate, I found myself in a forest so dense and disturbed that I could shoulder forward at no more than one-half mile per hour. I could see merely a few feet ahead, but I had with me a map of land-cover types previously classified in the laboratory—a bit of the macroscope, one might say. Checking the map, I realized the unusual forest before me went on for miles in every direction. More important, it displayed a discernible pattern that revealed dramatic new insights into the lake acidification process that so concerned the nation at the time.

Second, while working in Liberia in 1981, my attention was drawn to the geographic distribution of mineral deposits in West Africa, which I later compared to those of South America. That line of reasoning, enhanced by the macroscope, soon led to numerous continental fits that had never been noted before. Now, as always since 1596, the question is: Do continental fits imply adjacency? In terms of pure geometry, South America fits beautifully when turned 90 degrees clockwise from its traditional fit with Africa, and Australia exquisitely matches eastern North America. Both fits have considerable geologic evidence in their favor as well. But does that mean each pair actually did lie side by side at some time in its geologic past? The centuries-old lopsided debate lumbers on.

The macroscope enables, and even entices, its users to view old questions in new ways. In terms of pure geometry, for instance, South America may fit Africa better when rotated 90 degrees clockwise than it does in the fit that has been observed for four centuries.

Third, years later, reading a science magazine, I ran across a forthright statement that sea level had risen 400 feet over the past 20,000 years. I immediately saw it as the key to a mystery that had puzzled me since boyhood. That aha moment prompted a series of geographic questions: What is missing from the archaeological record? Were coastal populations identical to inland populations? Might there have been some factor, cultural or physical, that caused systematic differences between coastal and interior people? My brother Jeff Dobson, also a geographer, pointed out that iodine is primarily a coastal resource. Noting that Neanderthals lived primarily in places that are iodine deficient today, I spent several years investigating iodine in human evolution.

My purpose here is not to discuss the insights themselves, and certainly not to prove that I was right, but rather to share some lessons learned from the overall experience.

These three experiences in diverse realms of science support, first and foremost, both of the propositions stated above. Clearly, there is much left to discover, and our community is in an ideal position to advance the macroscope and support or lead the coming revolution in science theory.

Furthermore, there is much personal satisfaction awaiting those who take up the gauntlet and wield the macroscope to advance science theory. After each of the aha moments listed above, I came down from the mountain—literally in one case and figuratively in the others—so elated that adrenaline fueled my research for several years to come.

But the road will not be easy. Revolutions always stir passions. Prepare yourself for praise from those who appreciate spatial logic but rejection, even humiliation at times, from those who don't.

Fervor is essential. Wegener's own father-in-law, the renowned climatologist Wladimir Köppen, advised him not to publish his revolutionary theory for fear of the damage it would do to his reputation and career. How different the history of earth science might have been if Wegener had shown less fervor . . . or Ortelius had shown more.

Ultimately, it will be essential to upgrade the scientific method. Our community must insist on testing all earth science hypotheses for space as well as time, entity, and process. We must insist that all other disciplines live up to our standards, which are far more demanding in terms of space.

It will be essential to allow investigators to ask "stupid" questions arising from spatial evidence without penalty, as long as they truly ask and do not proclaim unproven truths. Otherwise, science will throttle its best and brightest minds—those most suited to the new way of thinking—and hold back the advancement of science theory.

A concrete step in this direction will be to recognize a new grade of hypotheses so encompassing that testing requires simultaneously or subsequently rethinking many related hypotheses and even widely accepted theories. Perhaps they should be called *hypertheses* (meaning "above or beyond") rather than *hypotheses*. At present, there is no middle ground between an individual hypothesis proposed for testing and an encompassing theory widely accepted by many scholars in any given field. Hence, conventional wisdom based on popular theory often trumps the facts at hand without prompting much reconsideration of existing theory. Alternatively, hypertheses could be tested first for their central claim and then, if found solid, would force rigorous testing of related hypotheses and theories.

The macroscope is here today, and science is already changing in response to it. We are entering a new scientific era that may be every bit as exciting and enlightening as the revolutions prompted earlier by the microscope and telescope. Surely our professional lives will be richer, and science itself will gain, if we, who know the marvelous instrument best, insist on using it ourselves to tackle the greatest mysteries of our time. Surely we must insist on reviving the classical model in which geography is viewed as a fundamental discipline.

Again, I urge, bring back geography! To science . . . education . . . business . . . and government! The benefits to science and society will be incalculable.

About the Author

Jerome Dobson is president of the American Geographical Society and a professor of geography at the University of Kansas. He is a Jefferson Science Fellow, a fellow of the American Association for the Advancement of Science, and chair of fellows of the University Consortium for Geographic Information Science. He formerly served as senior scientist in the Office of the Geographer and Global Issues, United States Department of State, and as a member of the distinguished research and development staff, Oak Ridge National Laboratory. For further reading, see the author's previous *ArcNews* article "Bring Back Geography!" (Spring 2007). Also see:

Dobson, Jerome E., Richard M. Rush, and Robert W. Peplies. 1990. "Forest Blowdown and Lake Acidification," *Annals of the Association of American Geographers* 80(3): 343–361.

Dobson, J. E. 1992. "Spatial Logic in Paleogeography and the Explanation of Continental Drift," *Annals of the Association of American Geographers* 82(2): 187–206.

Dobson, J. E. 1996. "A Paleogeographic Link Between Australia and Eastern North America: A New England Connection?" *Journal of Biogeography* 23: 609–617.

Dobson, J. E. 1998. "The Iodine Factor in Health and Evolution," *Geographical Review* 88(1): 1–28.

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See also "The STEP Model" and "Popular Geographics."

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A Role for Old-Fashioned Geographia in Education

A column by Daniel C. Edelson, Vice President for Education, National Geographic Society

The word *geography* comes from the Greek *geographia*, which means "writing or describing the world." I frequently hear people say that the word *geography* is outdated because modern geography is about much more than just describing the world.

I tend to be sympathetic to that view because I believe that the power of modern geography is in its approaches to solving problems and answering questions. However, I think that describing the world is an essential component of geography, and it should have a central part in geography education.

I have been thinking about this a lot lately because I have been thinking about the challenges of teaching young people about human impacts on the environment. I have become convinced that the biggest challenge in teaching about the environment is students' lack of familiarity with their environment. How do you teach children about changes to the environment if they do not know what the environment is currently like?

But how, you might ask, is it possible to not be familiar with one's environment? In the modern world, there are two ways in which children are unfamiliar with their environment.

First, the environment they live in is increasingly circumscribed. Middle-class youth in our society live largely in enclosed, interior spaces. When they need to travel through external spaces, they tend to do so in enclosed vehicles that are piloted by an adult. Today's typical K–12 students go to school in a car or bus that picks them up very close to their homes and delivers them to the front door of their schools. They typically spend their afternoons in their school or another building, which they are transported to, again, in a bus or a car, until they return home by the same modes of transportation.

Second, they have little opportunity or motivation to notice their environments. They are isolated from the external environment by various forms of cocoon, and they are not responsible for navigating by themselves, protecting themselves, or caring for any aspect of the environment.

I do not want to romanticize the past, but I do want to point out that only two generations ago, most Americans still depended directly on their environment for their livelihood and were not isolated from the external world by fully climate-controlled, protective buildings and vehicles. I also cannot ignore the fact that most people on earth still live that way.

Middle-class American children no longer have much need to be aware of their environment. They are isolated and protected from it, particularly during the part of the day set aside for education.

The result is that we have created an excellent environment for young people to learn math, language arts, and abstract science and social studies, but we have created a terrible environment for young people to learn about their world. I worry about my own middle school daughter, who is studying earth science right now in a classroom that seals her off from any direct interaction with the natural processes that she is studying.

Worrying about how to teach children about a world from which they are so isolated eventually led me back to the original concept of *geographia*. Before students can understand the world, they need to observe it. To observe it, they need to experience it, of course, but they also need to notice it. It's not just about looking; it's about seeing. And teachers have known forever that the best way to get students to be good observers is to engage them in documentation and description.

Young people learning to notice patterns in nature.

At National Geographic, we have begun exploring ways to turn students into old-fashioned geographers—in other words, describers of their world. One of the strategies we have been using is engaging students in what different people call *citizen science*, *public participation in research*, and *volunteered geographic information* initiatives. In these projects, participants collect and share geographic information with each other and, in some cases, conduct investigations or solve problems with the information. At National Geographic, we've adopted our own term for these projects. We call them *community geography* projects, and with support from the National Science Foundation and Esri, we're developing a web-based GIS and social networking platform to support community geography initiatives.

I like to use Project BudBurst as an example of how these projects foster noticing. Project BudBurst is an educational outreach initiative of the National Ecological Observatory Network that focuses on phenology (seasonal changes) in plants. The concept behind BudBurst is very simple. You pick a specific tree or shrub and monitor it throughout the year, recording your observations in a database that is shared among thousands of people monitoring other trees and shrubs throughout the United States. You note when flower and leaf buds appear and open. You also note when they fade, turn color, and fall off.

It's safe to say that virtually every student in every classroom in America knows that plants have seasonal cycles. But how many of them know the specific cycle of any specific types of plants? And how many know how these cycles change from place to place and year to year? And how many know what the natural variability of those cycles is in a specific location or a specific year?

It is only when people are familiar with these kinds of patterns and cycles that they can begin to understand what it might mean for human activities to change the environment.

So, ironically, the key to achieving the understanding and problem solving that we associate with modern geography is to start with the observation, documentation, and description that are characteristics of traditional geography.

Information about National Geographic Education's Community Geography initiative is available at natgeoed.org/community-geography.

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Zen and the Art of GIS Communication

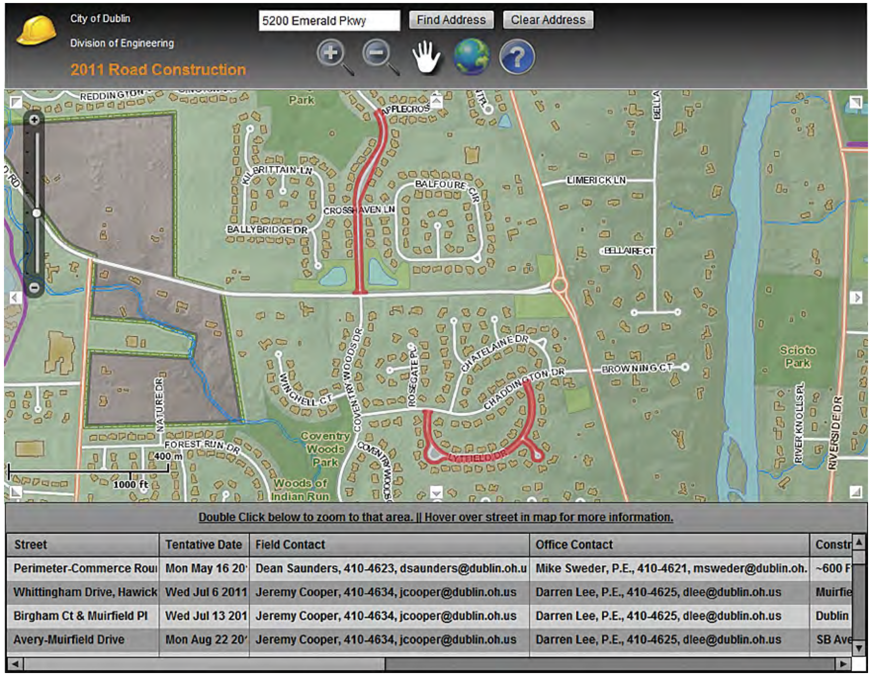
By Brandon B. Brown, GIS Administrator, City of Dublin, Ohio

I work in a basement. I bet many of you probably do, as well, or at least don't have windows. How do you figure out if it is raining outside at lunchtime? I go to isitraining.in/Columbus (enter your own city—it's awesome), and it gives me a simple answer in giant letters: Yes or No. Congratulations, you just "did" GIS. But notice that when you go to the site, there is no map or GIS logo, and it is not a rich Internet application full of flashy things. Even if it does some amazing spatial analysis and data gathering, to the consumer, it simply answers the question.

While this example is of something that is lighthearted and fun, albeit extremely practical, the take-home lesson for our profession is that we can have even more impact effecting change and influencing the world if we hone our skills as spatial communicators.

As the world's population is becoming more geographically literate (knowingly or unknowingly), expectations of us as spatial knowledge providers have risen. To meet these demands and facilitate spatial thinking, we must not only be able to deliver accurate, timely data but also provide it in a way that is easily found, consumed, and understood on any device.

We have been responding to these challenges by growing our skills in GIS tradecraft, data storage, and web technologies, all making great, new solutions possible. While providing these solutions, we need to remember to find balance in system design,



For annual street maintenance, there is a very simple way for residents to gauge the impact of projects on their neighborhoods.

application design, data uses, and cartography. For if the solution is not inviting, fast, and easy to use, our customers may simply move on.

The following are selected Zen-based sayings, with our interpretation of them as strategies that we follow toward GIS communication enlightenment in our work at the City of Dublin.

> *In all things, success depends on previous preparation, and without such previous preparation there is sure to be failure.*

As we set out to develop new web applications, we quickly found that we had not scheduled enough time to focus on building our base. There were so many questions, each with many answers. How many servers should we have? How many services? Should services be cached or dynamic? What about security? How do we best ensure good performance? We were thoroughly confused.

To move forward, we had to find a balance between learning and doing while overcoming our fear of making a wrong choice. Using this balance and newfound courage, we focused on planning and building not only a technical infrastructure but also a cartographic infrastructure. To guide service creation, we considered how we wanted to visually present and group our data to create consistency among our applications, maximize server resources, and minimize service management. These activities have allowed us to spend more time focusing on what we are trying to communicate with our final products.

> *Water which is too pure has no fish.*

When we began developing services and applications, we were excited to have web applications that finally utilized our live data. This was the highly detailed, accurate, and up-to-date data we had been trained to collect and maintain, and of course, we wanted our customers to see it.

We found a problem, though. For most of our applications, the level of detail maintained in the main data store was simply not necessary, and using it was having a negative impact on application performance. The lower performance drove away customers. We were left with a clean pond with no fish.

To speed things up and bring users back, we had to let go of the idea that the "pure" data was the best data. We do this by utilizing a presentation-tier data store. The data residing here has been cleansed of unnecessary fields and indexed, and it's had its geometries generalized. For example, there is no requirement

Is this address in the City of Dublin?

5200 | Find Address | *(enter an address number and/or street name - no street suffix please)*

In Dublin?	Jurisdiction	Address	City	State	Zipcode
IN	DUBLIN	5200 ARYSHIRE DR	DUBLIN	OH	43017
OUT	COLUMBUS	5200 AUTUMN FERN DR	DUBLIN	OH	43016
OUT	COLUMBUS	5200 BANDON CT	DUBLIN	OH	43016
IN	DUBLIN	5200 BETONYWOOD PL	DUBLIN	OH	43016
OUT	WASHINGTON TWP	5200 BRAND RD	DUBLIN	OH	43017
OUT	COLUMBUS	5200 CRITERION WAY	DUBLIN	OH	43016

An example of a tool designed to quickly answer a question.

to serve our street centerline as intersection-to-intersection segments, so we simply merge them by street name and functional class, creating a much more responsive feature class.

Eliminate what does not matter to make more room for what does.

There is great development and sharing going on in the GIS community, especially when it comes to widgets for web applications. We quickly ran into the trap of adding cool new tools to applications for no other reason than that they were cool new tools. We found that this quickly confused and alienated our customers. We now follow a strict rule that if a tool is not required for an application, it does not exist in that application.

Simplicity can also pay great dividends when applied to basemap creation. Removing decision points from the customer, such as when to turn on/off certain layers, eases the user experience. We manage layers and symbology for over 15 layers utilizing scale levels, leaving the customers' focus on more important aspects of the application.

The application level is the most visible area where we try to enforce simplicity. We do have a business case for having a traditional web GIS application. When creating it, it was done so with this strategy in mind, and even though it is full of data and tools, we try to minimize the clutter. More effective are what we call "maplications"—our version of focused applications.

No snowflake ever falls in the wrong place.

To effectively communicate, we must act as the gentle wind acts on a snowflake and guide our customers to the place they need to be. Rather than directing customers to the GIS home page, we try to incorporate our maplications into the appropriate city web page. We see the maplication as just another supporting piece, like an image or chart, to an existing story. Our goal is to have appropriate applications appear contextually during any customer experience with the city's web presence. For example, if they are visiting the main website, they may find more intricate data and tools than if they are visiting our mobile site. If they are on the road construction page, they will find the road construction maplication rather than a list of street names and dates.

See with your eyes, hear with your ears. Nothing is hidden.

While we try to guide our customers to the appropriate application and then guide their experience by making some decisions for them, sometimes it backfires. For this reason, we have placed a higher value on budgeting time to spend with customers during the design process and after release. We watch, we ask questions, and we encourage criticism.

During these sessions, we try to remove ourselves from our GIS role and think even more like the customer. A helpful question we ask ourselves is, "Would my mother understand this?" We also try to get input from customers that do not know much about GIS.

No flower ever sees the seed.

We try to create applications that help people become spatial thinkers and better decision makers. If we do our job correctly, they will be greeted by an application that is inviting, informing, and easy to use. They may never know they are using GIS.

This is hard for us as GIS professionals; for years, we have been trying to explain what we do and all the great benefits of our robust systems. Now, we are trying to train ourselves that we will probably be most impactful if we can remove jargon and buttons and if we can just roll with it if people call a map a picture or an intricate GIS web application a map. Of course, if they ask, feel free to blast them with a stream of acronyms and technical jargon that would make the GIS forefathers blush.

Conclusion

Our customers' demands are simple—they want to be able to find without looking, understand without learning, and do it all fast. We can satisfy these demands by building our base, releasing some of our long-held notions about data and techniques, create reusable resources, show only what is needed, tell a story, and listen to feedback. Good luck, and GIS be with you. Now, it's time for lunch—I wonder if it's raining.

About the Author

Brandon Brown is the GIS administrator for the City of Dublin, Ohio, where he has worked for the past eight years. Previous experience includes three years as an analyst/programmer at the Auditor's office of Lucas County, Ohio, and a short but wonderful time at Livingston County.

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Ecosystem Services—Learning to Leverage Natural Capital

By Frederick Steiner, Dean, School of Architecture, The University of Texas at Austin

The *ecosystem services* concept helps us understand and describe the benefits that the environment provides to humans, benefits that we have traditionally viewed as free and would have to supply for ourselves if our surroundings ceased to furnish them. The environment provides direct services, including air, minerals, food, water, and energy. It furnishes regulating services, such as the purification of water, carbon sequestration, climate mitigation, waste decomposition and detoxification, crop pollination, and pest and disease control. The environment supplies support services, including nutrient dispersal and cycling, as well as seed dissemination. The environment also yields cultural benefits, such as intellectual and spiritual inspiration, recreation, ecotourism, and scientific discovery.

The United Nations 2005 Millennium Ecosystem Assessment stressed the value of ecosystem services. For instance, the authors of the assessment noted the following:

> *The assessment focuses on the linkages between ecosystems and human well-being and, in particular, on "ecosystem services." An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. . . . Ecosystem services are the benefits people obtain from ecosystems. . . . The human species, while buffered against environmental changes by culture and technology, is fundamentally dependent on the flow of ecosystem services.*

The Galápagos Islands provide an example of ecosystem services at work. After Europeans discovered the archipelago in 1535, these hardscrabble, barren volcanic islands suffered centuries of abuse by buccaneers, whalers, settlers, and scientists before the Ecuadorian government created a national park in 1959. Some 97 percent of the Galápagos Islands (1,714,000 acres [693,700 hectares]) is in the national park. In 1986, the waters surrounding the islands received protection through the creation of the Galápagos Marine Reserve.

As a result, global science and the Ecuadorian economy have benefited. The Galápagos Islands continue to generate new biologic and geologic knowledge. Meanwhile, the archipelago has become a popular destination for ecotourism and recreation. These activities create jobs and revenue for Ecuador.

New York City's watershed protection efforts provide another example of ecosystem services. The watershed covers approximately 2,000 square miles (5,180 km²). Nineteen reservoirs supply 1.2 billion gallons (4.5 billion liters) of drinking water daily to nine million New Yorkers. In the 1990s, faced with the prospect of spending $8 billion on a new water filtration plant that would cost $300 million annually to operate, the city instead decided to invest $1.2 billion over 10 years to restore and protect its watersheds. These funds were used to purchase land and invest in environmentally sound economic development in the watershed.

In addition to benefiting New York City residents and reducing costs to urban taxpayers, the people who live in the watershed gained value from the ecosystem services approach. Everyone has good, clean water. Farmland has been preserved, habitat created, and recreational opportunities expanded.

Landscape architects, community and regional planners, conservationists, architects, engineers, and policy makers can employ the ecosystem services concept at many scales—from the megaregion to the site. GIS and GeoDesign technologies can contribute to these cross-scale applications because of their capacities to capture, manage, analyze, and display geographic information, as well as assist in the processes of planning and design.

The Rise of the Megas

Several researchers, led by the Regional Plan Association (www.america2050.org), have noted the blurring of large metropolitan areas into a new geographic scale, called a megaregion, with interlocking economic, ecological, and transportation systems. Eleven megaregions have been identified in the United States, including the Northeast, which spans several states, and the Texas Triangle, which is contained within a single state.

Megaregions	
Arizona Sun Corridor	Northeast
Cascadia	Northern California
Florida	Piedmont Atlantic
Front Range	Southern California
Great Lakes	Texas Triangle
Gulf Coast	

The Regional Plan Association and others estimate that over 70 percent of the nation's population and jobs are located in these megaregions. These megaregions are likely to gain even more population and economic growth in the future: one estimate is that they will account for 50 percent of the US population growth and 66 percent of our economic growth over the next 40–45 years (www.angeloueconomics.com/megaregions.html). Megaregions provide an example of "agglomeration economics," which Harvard economist Edward Glaeser defines as "the benefits that come from clustering cities."

This growth provides opportunities and challenges for environmental design and planning. One opportunity is to view environmental processes at the scales at which they occur: watersheds, rivers, mountain ranges, aquifers, and weather patterns. A challenge is that the detrimental effects associated with rapid growth are threatening environmental quality. Large-landscape protection can help mitigate negative environmental impacts.

Northeast Megaregion

In response, the Regional Plan Association has joined others to produce the *Northeast Landscapes Initiatives Atlas* (www.rpa.org/northeastlandscapes). The goal is to protect watersheds, wildlife habitat, and other landscape-scale processes in the 13-state Northeast megaregion. The Regional Plan Association-led team is using GIS to understand spatial interrelationships. The team has produced an inventory of public and private landscape conservation initiatives in the Northeast megaregion.

The GIS-based atlas will contain three types of data: landscape initiatives, conservation context, and development context. Robert Pirani of the Regional Plan Association notes that the delivery and valuation for ecosystem services are key values added for landscape planning:

> *Many ecosystem services are delivered through landscape-scale processes: source water protection, riverine and coastal flood management, sustaining fish and wildlife populations, and the agglomeration needed for viable agricultural and forestry economies.*
>
> *Monetizing these services depends on creating a market. Landscape conservation initiatives are the right scale for enabling viable markets. As institutions, land trusts and conservancies potentially can be the institutions that bridge upstream and downstream sellers and buyers.*

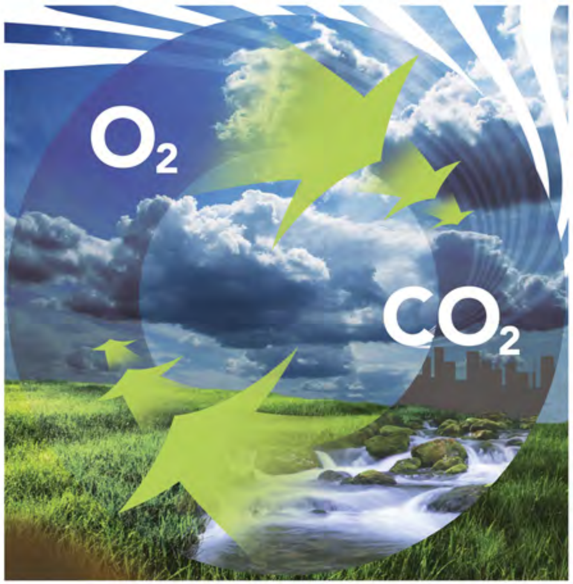
The Texas Triangle Megaregion

The Texas Triangle megaregion is formed with Houston and San Antonio at the base and Dallas and Fort Worth at the apex. By 2050, some 35 million people, or 70 percent of the population of Texas, will live in the triangle's four metropolitan areas: Dallas-Fort Worth, Houston, San Antonio, and Austin. The Edwards Aquifer supplies water to metropolitan San Antonio and Austin, as well as to many farmers and ranchers. In fact, this immense, prolific aquifer is the sole source of water for San Antonio. As a result, the protection of the aquifer is essential for the future of the Texas Triangle.

The Edwards Aquifer roughly underlies what is known as Texas Hill Country. In addition to being a rich source of water, the landscape contains important wildlife habitats and a significant cultural history. The landscape is also quite scenic and valuable for recreation. As a result, the ecosystem services provided by the Hill Country are many. In response to growth pressures in the Hill Country and over the aquifer, the cities of San Antonio and Austin, as well as several counties, have purchased conservation easements to protect the assets of the Hill Country.

The nonprofit Hill Country Conservancy contributes much to these government efforts. In addition to purchasing easements, this land trust is also engaged in the GIS mapping of the landscape assets of the Hill Country. The conservancy employs GIS at several scales—from individual parcels with conservation easements to the entire Hill Country region. While the Hill Country Conservancy has not quantified the ecosystem services provided by the land it protects, it certainly contributes to enhancing conservation values that benefit the whole region. These conservation values are the basis on which the Internal Revenue Service may grant tax credits for easement donations. Some benefits/services that have been documented include scenic views, aquifer recharge, high-quality storm runoff, habitat, and prime farmland. Beyond the explicitly documented benefits, the land trust is preserving grasslands that have the potential to sequester carbon and riparian areas that help prevent flooding and erosion.

Sustaining Sites



The ecosystem services concept is also being employed at the site level. The Sustainable Sites Initiative, known as SITES, is a joint effort by the American Society of Landscape Architects; Lady Bird Johnson Wildflower Center of The University of Texas at Austin; and the US Botanic Garden (www.sustainablesites.org). A goal of SITES is to produce the outdoor equivalent to the US Green Building Council's successful Leadership in Energy and Environmental Design (LEED) program. The SITES team has both learned from LEED and relied on ecosystem services. The team identified specific ecosystem services that designers can strive to protect or regenerate at the site scale, which include

- **Global climate regulation—**Maintaining balance of atmospheric gases at historic levels, creating breathable air, and sequestering greenhouse gases

- **Local climate regulation—**Regulating local temperature, precipitation, and humidity through shading, evapotranspiration, and windbreaks
- **Air and water cleansing—**Removing and reducing pollutants in air and water
- **Water supply and regulation—**Storing and providing water within watersheds and aquifers
- **Erosion and sediment control—**Retaining soil within an ecosystem, preventing damage from erosion and siltation
- **Hazard mitigation—**Reducing vulnerability to damage from flooding, storm surge, wildfire, and drought
- **Pollination—**Providing pollinator species for reproduction of crops or other plants
- **Habitat functions—**Providing refuge and reproduction habitat to plants and animals, thereby contributing to conservation of biological and genetic diversity and evolutionary processes
- **Waste decomposition and treatment—**Breaking down waste and cycling nutrients
- **Human health and well-being benefits—**Enhancing physical, mental, and social well-being as a result of interaction with nature
- **Food and renewable nonfood products—**Producing food, fuel, energy, medicine, or other products for human use
- **Cultural benefits—**Enhancing cultural, educational, aesthetic, and spiritual experiences as a result of interaction with nature

Rating System

As a result of four years of research, the SITES team released guidelines and performance benchmarks in 2009. This rating system includes 15 prerequisites and 51 credits that cover all stages of development—from site selection to landscape maintenance. The rating system is currently being tested through over 150 pilot projects representing a diverse cross section of project types, sites, and geographic locations. The pilot projects include a range of types and sizes. The project types include parks and open spaces, educational and institutional, commercial, residential, streetscapes and transportation, gardens and arboretums, government complexes, mixed use, and industrial. The project sizes range from less than 1 acre (.4 hectares) to over 500 acres (202.3 hectares). Existing land uses include grayfield, greenfield, and brownfield sites.

Pilot Projects

Thirty-four states and the District of Columbia, Canada, Iceland, and Spain are represented in the pilot projects. Two examples of these pilot projects are Tempe Transportation Center in Arizona and Burnham Centennial-Midewin National Tallgrass Prairie in Illinois. The Tempe Transportation Center project team includes A Dye Design; City of Tempe; Michael Baker, Jr., Consulting Engineers; and Otak+Architekton. This transit plaza replaces a 2.7-acre (1.1-hectare) parking lot, linking the new METRO light rail to local/regional bus routes, bike facilities, and Arizona State University. The mixed-use LEED building provides transit-oriented retail/restaurant facilities at the plaza, where storm water and gray water collection for irrigating native plants and vegetated bus shelters sustainably integrate public spaces with pedestrian circulation at a busy urban multimodal hub.

Burnham Centennial-Midewin National Tallgrass Prairie is located in Wilmington, Illinois. Its design team includes the Conservation Design Forum, dbHMS, and Wheeler Kearns Architects. Two separate but integrated open-air visitor and education areas are proposed for construction in this area, which was once part of the Joliet Army Ammunition Plant. Design elements include outdoor classrooms, picnic areas, overlook stations, trails, and interpretive signage about the natural and cultural history of the site. All aspects of the project are intended to demonstrate green design principles, including capturing and cleaning runoff before release into the restored prairie.

The pilot project stage will be completed in June 2012. Lessons learned from the pilot projects will be incorporated into the formal release of the SITES rating system to the marketplace in 2013.

From the pilot projects, it is already clear that GIS plays an important role in designing sustainable landscapes, which could be expanded through GeoDesign. In addition to the mapping ability of GIS, it is also useful for calculations and data submittals. For example, a site assessment is required as a prerequisite, which can be submitted in GIS.

Advancing Ecosystem Services

National and local organizations and agencies increasingly use ecosystem services to advance their missions. For instance, the Trust for Public Land notes that the environmental and social benefits of parks and open space (such as improved recreation and health, as well as cleaner water and air) also engender economic benefits (such as increased tax revenue and an advantageous ability to attract businesses) (www.tpl.org). The Trust for Public Land has pursued this mission through its GIS-based Greenprinting tool. Greenprinting enables local officials and conservationists to identify and rank environmentally significant and fragile areas. Central Texas is one place where Greenprinting has been employed. The Edwards Aquifer and other environmental assets have been mapped with the Greenprinting tool.

In Philadelphia, University of Pennsylvania's student-faculty clinical design consulting practice, Penn Praxis, used economic arguments as the basis for its 2010 plan to add 500 acres (202.3 hectares) to the city's park system. In *Green 2015: An*

Action Plan for the First 500 Acres, the Penn Praxis team notes that converting vacant lots into community gardens can raise local property taxes and reduce the need for police and fire services. Furthermore, the team observes that replacing impervious asphalt surfaces with rain-absorbing green areas has already saved the city $35 million since 2006. In addition, the Penn Praxis team reports that the city's existing open space has generated over $400 million in health-related cost savings.

The Gund Institute for Ecological Economics at the University of Vermont has joined others to create a web-based tool for advancing ecosystem services globally called Artificial Intelligence for Ecosystem Services, or ARIES (www.uvm.edu/giee). ARIES researchers map benefits, beneficiaries, and service flows to help users visualize, value, and manage ecosystems. This technology assists users in making rapid ecosystem service assessment and valuation. It is open-source software that is free to all nonprofit users. ARIES integrates information from an extensive database, from global- to local-scale GIS, combined with ecosystem service models. ARIES is helping open new possibilities for the use of ecosystem services in environmental design and planning.

The ecosystem services concept can add value to large-landscape planning endeavors, such as the Regional Plan Association's *Northeast Landscapes Initiative Atlas* and the Hill Country Conservancy's efforts to protect the Edwards Aquifer. The concept has already proved to advance more sustainable landscape design through SITES. Ecosystem services help us protect the benefits nature provides for our health and well-being, as well as our very existence.

About the Author

Frederick Steiner is the dean of the School of Architecture and Henry M. Rockwell Chair in Architecture, The University of Texas at Austin. Steiner is the current president of the Hill Country Conservancy (a land trust) and past chair and current secretary of Envision Central Texas (a nongovernmental regional planning organization). As a Fulbright-Hays scholar in 1980, he conducted research on ecological planning at the Wageningen University, the Netherlands. In 1998, he was a Rome Prize Fellow at the American Academy in Rome. He received his PhD and MA degrees in city and regional planning from the University of Pennsylvania. Steiner's books include *Design for a Vulnerable Planet* (2011) and *The Essential Ian McHarg: Writings on Design and Nature* (2006). His next book, *Urban Ecological Design* (with Danilo Palazzo), will be available in January 2012.

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Looking Forward: Five Thoughts on the Future of GIS

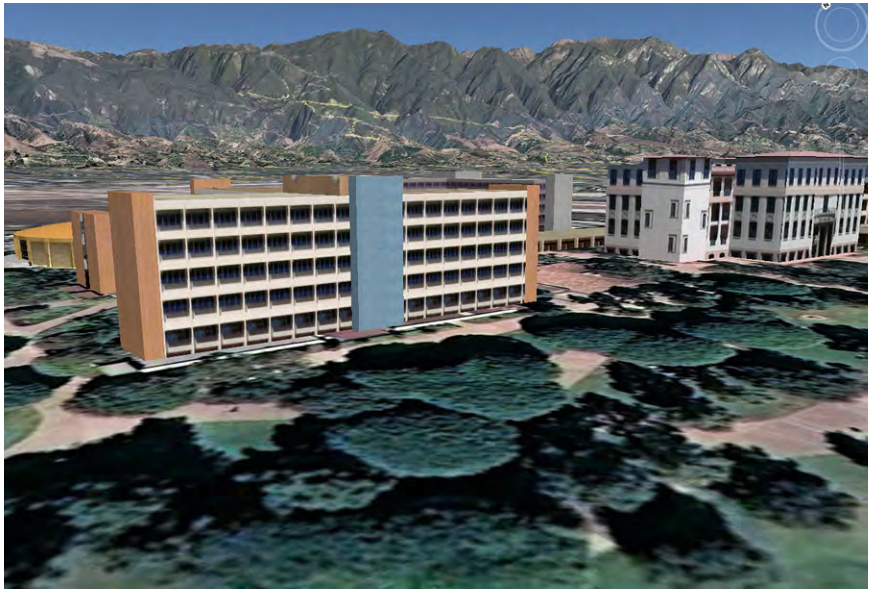
By Michael F. Goodchild

Any attempt to forecast the future is dangerous, and attempts to prophesy about GIS are especially fraught, so what follows should be taken with a large grain of salt. But it is good to think about where we—the GIS community—might be headed, and perhaps this short contribution will stimulate other members of the community to ponder and discuss the possibilities.

The 13 Percent Technology

The GIS domain has always been the outdoors, where GPS signals are strong and reliable, two spatial dimensions are generally adequate, and spatial resolutions are rarely better than a meter. Not surprisingly, the earliest applications of GIS were in forestry, resource management, and land-use planning. But the average American only spends 13 percent of the time outdoors. GIS-based services help us find restaurants and hotels, but they offer almost no support for navigating in the complex indoor spaces of shopping centers, hospitals, mines, or airports.

Two major problems currently stand in the way of moving GIS indoors. Several years ago, I was involved in a study sponsored by Defense Advanced Research Projects Agency (DARPA) to examine the potential of a fully three-dimensional GIS. There are



A visualization of part of the University of California, Santa Barbara, campus shows 3D representations of buildings superimposed on a more traditional 2D GIS representation of the ground surface. (Image courtesy of Keith Clarke)

several billion buildings on the planet, and we estimated that a database representing all of them, surface and interior (CityGML Level of Detail 3 and above), would occupy 3 petabytes (3,000 terabytes or 3,000,000 gigabytes), a not-unmanageable volume given today's technology. But the effort to assemble such a database using then-available technology would require an expenditure equivalent to 10 percent of the U.S. gross domestic product (GDP) for 10 years—in other words, it would need to employ 10 percent of the U.S. workforce for that period. And that figure would not include updates. We need techniques for the rapid, cheap, and accurate capture of 3D geometries and attributes.

Furthermore, we need effective methods for determining indoor position. Several technologies are under development: Wi-Fi, using known positions of transmitters; radio-frequency identification (RFID), using networks of fixed detectors; ultrasound or laser imaging matched to 3D geometry; and many more. At this point, we don't know which of these—if any—will eventually succeed. However, we do know that the market for solutions to the problem of moving GIS indoors—and integrating the indoors and outdoors—holds enormous potential.

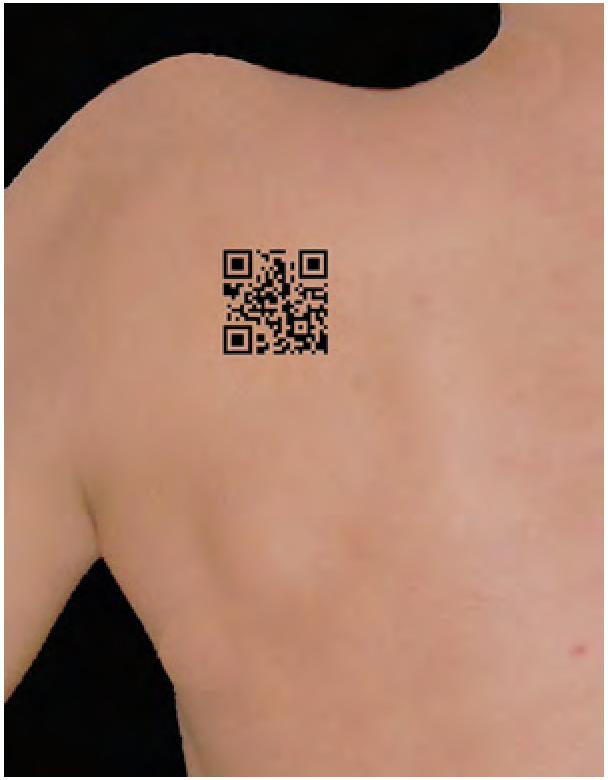
Knowing Where Everything Is

I can now express the location of my house in half a dozen ways, ranging from the National Grid reference 11SKU3614611561 to "Mike Goodchild's House," and expect Web services to make sense of all of them. Anything from the formal coordinates of GIS to the informal, everyday language of humans (street addresses, named points of interest, place-names) is now readily understood. This level of interoperability between different ways of specifying location is, in my view, one of the great geospatial achievements of the past decade. With GPS, RFID, and up-to-date databases, we can now imagine a time when it will be possible to know where everything is at all times. This is already true over surprisingly large domains: every vehicle in some major fleets, every farm animal in some countries, every commercial flight, every mobile phone, and every credit or debit card when it is swiped.

While there are obvious benefits in each of these cases, the possibility of knowing where every person is at all times is far more problematic. While a mobile phone user only has to turn the phone off, face-recognition software, coupled with the dense networks of video cameras now installed in many major cities, make it possible to track individuals without their knowledge and offer no way to opt out that is not itself grounds for suspicion. Yet consider the possibilities during emergencies: if every inhabitant of the Wenchuan area of China had been tracked prior to the May 2008 earthquake, it would have been much easier to search for possible victims.

An Internet of Things

Knowing where everything is, and where it has been, creates a host of interesting possibilities that is currently being explored by the Tales of Things project in the United Kingdom. All that is required is a Quick Response (QR) code (one of those random-looking square patterns of black and white that now appears on packages, airline boarding passes, and mail) attached to the object. When this pattern is scanned by a smartphone with the appropriate app, an online database of the object's history is accessed, and the object's current location is captured along with any other useful information. The result is a readily accessible geographic history of the object. Of course, QR technology is already widely used, but the smartphone enables many new and interesting applications. Imagine the possibilities of a QR tattoo.



A QR code tattooed on a human back is readable by a smartphone app. (Image courtesy of Karen Doehner)

Real-Time GIS

Maps take time to make, and to justify the cost of making them, it is important that they be valid for as long as possible. Traditionally, this has meant that maps are made up only of the more permanent features of the earth's surface: roads, rivers, mountains, and streets. Over the past two decades, however, the widespread availability of GPS and mapping software has changed the balance in this equation, making it possible to create maps of virtually anything for almost nothing. Neogeography is one result: the possibility of making personal maps, showing personal views that may be of interest only to the maker and for just a brief time. A GPS navigation system, fed by sensors, might show the state of congestion of the road system in real time; an air-traffic controller might see a real-time map of airplane traffic; an emergency manager might view the real-time situation of disaster response; and a public health researcher might monitor the real-time state of a disease outbreak.

All these possibilities and more are shifting GIS from the relatively leisurely process of analyzing static data to a far more dynamic process of real-time monitoring and decision making. In the future, GIS will involve much more real-time situation monitoring and assessment and will need new kinds of tools that treat information as continually changing. Decisions will have to be made on the basis of information available at the time and deal with uncertainties about the future in rational ways.

Multiple Views of the World

In the early 1990s, GIS came in for plenty of criticism from social scientists for its implied assumption that all aspects of the world could be measured and represented scientifically—that geographic truth was absolute rather than personal and relative. Too often GIS presented a single point of view, often that of government, rather than the multiple points of view of individuals and groups. Recently there have been several international incidents involving Google's maps and its portrayal of disputed boundaries and place-names, as reported in an article in *Maclean's*, a Canadian weekly current-affairs magazine. In the Himalayas, for example, the view presented by google.com is now sharply different from those presented to Indian users via google.in or to Chinese users via google.cn. In both countries, the law requires that maps displayed by local servers reflect official national policy. Thus, google.in shows Kashmir as part of India, whereas google.com shows it as disputed between India and Pakistan.

Maps reflect the agendas and beliefs of their makers, a point that sits uncomfortably with the prevailing scientific approach of GIS. In principle, the name given to a place is not absolute but is an attribute of the individual or group giving the name. To the English, the body of water separating England from France is the English Channel, whereas to the French it is La Manche. Will multiple views be manageable, or will GIS descend into a chaos of conflicting perspectives?

Multiple Futures for GIS

I hope these brief comments have stimulated an interest in discussing these five topics further. Are they equally important, and are there other ways in which the GIS of the future will be different from that of today? One fact is inescapable: the world of GIS has always been full of surprises, and there is every reason to believe the future will be just as exciting.

Michael F. Goodchild welcomes feedback on this topic. Contact him at good@geog.ucsb.edu.

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The Future Looks Bright for Spatial Thinkers

By Jack Dangermond

Many industries have suffered during the current economic downturn. So why is it that during this same period, demand for geospatial technology professionals has grown significantly?

I think that this trend is due to the growing understanding of the value of spatial information and analysis. There are many reasons to implement GIS, but the benefits that we see driving organizations in lean times are cost savings resulting from greater efficiency. And as we come out of this economic downturn, the efficiencies realized from GIS will become a standard way of doing business, so the need for geospatial professionals will increase even more.

Government has long been at the forefront of this movement, and there will be opportunities here for people with geospatial knowledge, most notably in the area of homeland security and in anything to do with increased transparency and accountability. But we're now seeing a huge shift in momentum in the commercial arena. Many of the future career opportunities for geospatial professionals will be in the private sector, as businesses increasingly realize the benefits that government has understood for some time.

The current high unemployment rate is sending a lot of experienced workers "back to school" to learn new skills more relevant for the 21st-century workplace. This is one factor driving the growth of focused geospatial programs at universities and community colleges, both at the degree level and the certificate level. These programs are doing a great service by training

As the reach of spatial information expands, new opportunities are created for spatial thinkers in many areas.

the geospatial workforce of tomorrow. They are also providing many opportunities for seasoned geospatial professionals to take on new roles themselves—passing on their vast knowledge by instructing and teaching the next generation of geospatial professionals.

But the career opportunities here are not just for the people who sit in front of keyboards and "do GIS." It's much bigger than that. I think that the real growth opportunity is in the area of spatial thinking. As people in all types of positions become more familiar with the value of geography, they begin to ask more intelligent questions about the world, and they begin to make more informed decisions. The coming opportunities for spatial thinkers will be even greater than those we are seeing for geospatial technology professionals.

(This blog post originally appeared in *Esri Insider* on October 3, 2011.)

Scaling Up Classroom Maps

A column by Daniel C. Edelson, Vice President for Education, National Geographic Society

Usually, when you talk about the scale of a map, you're talking about the ratio of distances on the map to distances in the real world. These days, however, when educators working with National Geographic maps talk about scale, they may be talking about how big the map is. For example, a teacher may have her students working on a map at the "scale" of a tabletop, a large wall, or even a basketball court.

So what's going on with all these big maps? Well, we've learned that kids find large maps to be magnetic. And not just young kids. Teens and adults find large maps irresistible as well.

Imagine walking into your school gym and finding half of the floor covered in a glorious, full-color, National Geographic map of Asia. If your school is one of those that has signed up for a visit from one of National Geographic's Giant Traveling Maps, you could.

Most people find they can't just look at these maps. They *must* walk on them. They count how many steps it takes to get from Beijing to Moscow. They lie down to see if they can reach from the southern tip of India to the northern tip. They find the maps amusing, just like the oversized cereal boxes at Costco.

Two Middlebury, Vermont, third graders explore the Atlantic coast of South America (photo: Dan Beaupré).

Students at Alta Vista Elementary School in Los Altos, California, take a well-earned break after traveling from Florida to Alaska on the Giant Traveling Map of North America (photo: Scott Schilling).

Frankly, people find the scale of these maps fascinating. And educational. Unlike regular-sized maps, you can see lots of detail and a large portion of the earth's surface at the same time. Similarly, you don't shift your eyes or turn the page if you want to look at a different location. You move your whole body, like you do in the real world. These maps allow people to interact with a map kinesthetically, experiencing scale and direction as physical sensation.

Now imagine taking 136 sheets of 8.5" x 11" paper and putting them together to form a mosaic map of the world that is 17 sheets wide and 8 sheets tall. If you download one of the free NatGeo MapMaker Kits, you could. These "megamaps" are only 10 feet wide and 7 feet tall, but they still take several strides to

Students use markers to illustrate data on National Geographic Education's NatGeo MapMaker Kits (photo: Mark Thiessen, NGS).

walk across. And, since they are made of regular printer paper, you can draw or paste things on them. You can even cut them up.

These "scaled-up" maps have great educational potential. They break down the usual barriers between people and maps. They draw people in, and they encourage them to interact.

Both the Giant Traveling Maps and the MapMaker Kits are packaged with a variety of hands-on (literally) activities. When a Giant Traveling Map arrives at your school, it comes with a trunk full of materials that transform it into a giant game board, including giant dice, traffic cones, plastic building blocks, and beanbags. The MapMaker Kits are designed as basemaps for students to draw, glue, or overlay information on.

In fact, some of the most engaging activities for these oversized maps are essentially low-tech versions of geospatial analyses. Have you ever represented a buffer with a hula hoop? Measured a linear distance in units of arm spans? In a classroom down the street, students may be symbolizing data by pasting construction paper circles of differing sizes and colors on a map. Or they may be creating contour maps with yarn and delineating watershed boundaries with a crayon.

Some of the best educational ideas are just slight twists on conventional practice. What we've discovered is that blowing up maps to unusual sizes is one of those ideas.

Students record data about tourist impact on different countries in Europe using National Geographic Education's NatGeo MapMaker Kits (photo: Mark Thiessen, NGS).

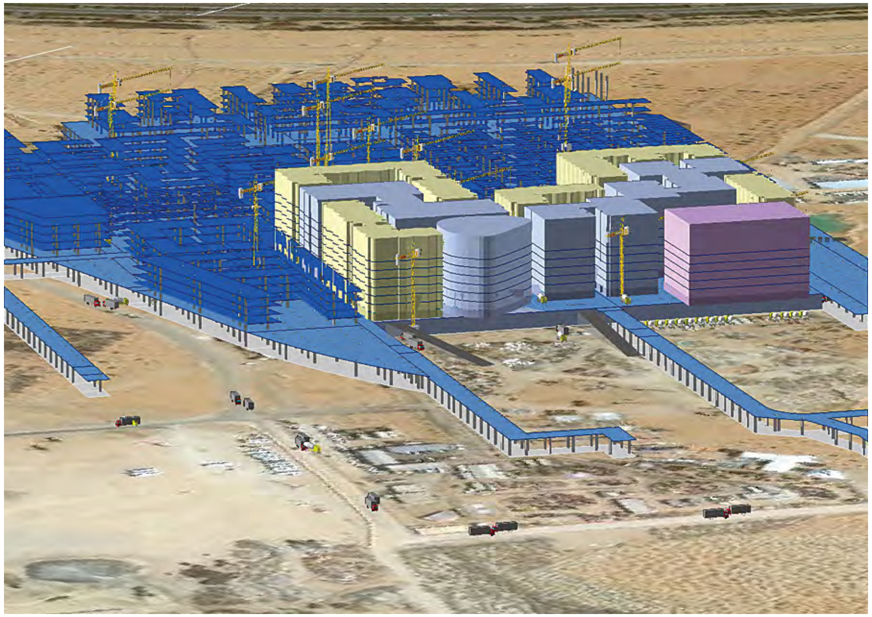
For more information about the Giant Traveling Maps, visit www.nationalgeographic.com/giantmaps. For more information on the NatGeo MapMaker Kits, visit www.natgeoed.org/mapping. Follow Daniel Edelson on Twitter @NatGeoEdelson.

(This article originally appeared in the Spring 2011 issue of *ArcNews*.)

Managing Our Man-Made Ecosystems

By Jack Dangermond

In modern society, buildings are where we spend the vast majority of our waking and sleeping hours. Our facilities are man-made ecosystems—vast assemblages of interdependent living and non-living components. Facilities have become the primary habitat for the human species.



Staff at the City of Masdar use GIS to model building information throughout the life cycle of the project.

As technology advances at a record pace, our man-made ecosystems are becoming ever more complex and sophisticated. These intricate collections of materials, infrastructure, machinery, and people, with countless spatial and temporal relationships and dependencies, require progressively more sophisticated tools to help us design and manage them.

The recognition of facilities as habitat for modern man is leading to a revolution in facilities management. GIS technology is designed specifically for the management and analysis of spatial relationships, and offers many benefits to the facilities management community. It only seems logical to manage, model, and design our new man-made ecosystem with the same tried and true tools used to manage, model, and design traditional ecosystems. And this is already happening.

GIS has long been used to help measure the impact of a facility on a natural ecosystem, but today it is increasingly being used to plan, manage, and operate the man-made ecosystem that is the facility. Facilities managers are finding that these powerful GIS tools, used successfully for many years in fields such as environmental analysis and landscape planning, also support a broad range of applications inside and outside of buildings and facilities—applications such as operations planning, emergency management, ADA compliance, safety/security planning, space utilization and optimization, and more. In fact, GIS can be used throughout the life cycle of a facility—from siting, design, and construction through ongoing use, maintenance, and adaptation, and ultimately through closing, repurposing, and reclamation.

In the last several years there has been much interest in the integration of building information models (BIM) with GIS. These highly detailed 3D representations of buildings can be imported into GIS, integrated with your existing GIS database, synthesized with legacy 2D CAD data, and used for visualization and analysis at the building or facility scale.

There is an emerging understanding that GIS can be extended into the built environment of individual buildings and campuses. Integrating BIM data into GIS data models provides the ability to leverage this information using the tools and applications of geoprocessing and visualization. In ArcGIS 10, we extended the data model and 3D tools to accommodate BIMs and other 3D building abstractions, and we have seen government organizations such as the National Institutes of Health as well as a number of universities and health care organizations integrating their BIM and 3D building models with GIS to better analyze and manage their facilities.

In Abu Dhabi, Masdar City uses a combination of BIM and GIS to plan and design buildings and infrastructure. And at NASA Langley Research Center's New Town project in Virginia, building designers are working with GIS and facility managers to develop BIM and GIS interoperability. Organizations with large and small building portfolios, public or private, are capitalizing on this ability with applications to support facility planning, operations and maintenance, space utilization and move management, emergency planning, energy and sustainability management, and much more. Esri is actively evolving its platform for not only these applications but also other 3D applications in the GeoDesign space.

BIM and GIS integration is not just about the building or the facility; it's about the relationship between natural and man-made ecosystems. Our challenge is to design our man-made ecosystems to achieve the maximum benefit to society while minimizing short- and long-term impacts on the natural environment. As an integrative platform for management and analysis of all things spatial, I believe that GIS can meet this challenge.

(This blog post originally appeared in *Esri Insider* on November 10, 2011.)

GIS and Geography: Interactions with the Humanities

By Doug Richardson, Executive Director, Association of American Geographers

The AAG will be continuing a decade-long arc of sustained activity around the theme of "Geography and the Humanities" with a special set of sessions on these interactions during its upcoming Annual Meeting in Seattle, Washington. We invite all interested GIS specialists, geographers, artists, writers, and humanities scholars to attend and participate in these sessions, to be held April 12–16, 2011.

As noted previously in this column ("Geography, GIS, and the Humanities," *ArcNews*, Summer 2006, Vol. 28, No. 2, p. 39), there has been a remarkable resurgence of intellectual interplay between geography, GIS, and the humanities in both academic and public circles. Metaphors and concepts of geography and GIS now permeate literature, philosophy, the arts, and other humanities. Terminology and concepts, such as space, place, landscape, mapping, and geography, are increasingly pervasive as conceptual frameworks and core metaphors in recent publications in the humanities.

The diffusion of ideas between geography and the humanities is significant for the insights and connections it has spawned. Scholars and writers outside the field of geography have developed new understandings from interrogating a sense of place or by examining the changing landscapes of globalization and complex new international realities in traditionally geographic terms. The core traditions of geography, combined with recent geographic technologies, such as GIS, have opened new lines of intellectual inquiry in the humanities and changed research methodologies in numerous fields. And, of course, the mutually beneficial interactions between the discipline of geography and such humanities fields as the philosophy of science, cultural and ethnic studies, and various literatures in postmodernist thought have also had far-reaching implications for GIScience and geographic research and education.

For many years, the AAG has focused on developing ideas, methods, and partnerships through which we might further explore, showcase, and foster the emerging interactions between geography, GIS, and the humanities. These efforts resulted in a seminal Symposium on Geography and the Humanities, sponsored jointly by the AAG, the American Council of Learned Societies, and the University of Virginia, in 2007. This symposium explored how geography informs the humanities and vice versa, took stock of the new and evolving connections between geography and the humanities, and identified promising new research paths along which such interaction can proliferate and be strengthened in the future.

These geography and humanities interactions are now the subject of two new books, emanating in part from the AAG Symposium and supported by grants from the National Endowment for the Humanities and the Virginia Foundation for the Humanities. The first of these complementary explorations, *Envisioning Landscapes, Making Worlds: Geography and the Humanities*, focuses a lens on the deep traditions of the humanities within the discipline of geography, with contributions from many of the most prominent authors in the humanities traditions of geography. The second book, *Geohumanities: Art, History, Text at the Edge of Place*, reaches outward to explore the new, rapidly evolving experimental and experiential engagements by humanities disciplines themselves as they seek to understand and incorporate geographic methods and concepts of space and place into their own work, which encompasses the rapidly expanding use of GIS throughout the humanities and the burgeoning field of historical GIS. Both of these new books, published by Routledge this spring, will be the subject of featured discussions during the AAG Annual Meeting's special Geography and the Humanities sessions in Seattle, together with the books' editors and authors.

Another highlight of the Geography and the Humanities track at the Seattle meeting for me will be a keynote presentation by the exquisite writer and longtime friend of geography, Barry Lopez, who won the National Book Award for his book *Arctic Dreams* and recently authored *Home Ground: Language for an American Landscape*. I am delighted to note as well that he has been selected as the AAG's 2011 Honorary Geographer, a fitting award in light of this year's special focus on geography and the humanities. Lopez's keynote talk will be presented on Friday, April 15, 2011.

The AAG welcomes and encourages broad participation by the Esri GIS community in these Geography and the Humanities sessions. An online program detailing these, as well as many other sessions of interest to GIS users (including three full days of special sessions on space-time integration in GIS and GIScience), is available at www.aag.org/annualmeetings. I look forward to seeing you in Seattle, a beautiful and most apt setting for these sessions on geography and the humanities.

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The Challenge of Defining Geo-Literacy

A column by Daniel C. Edelson, Vice President for Education, National Geographic Society

For quite some time, I've been struggling with the challenge of how to explain to the general public what geo-literacy is and why it is important. Over more than a year, with a lot of help from others, I've developed a definition that captures the essence of geo-literacy and resonates with both academic and applied geographers.

As I've written in this space before, geo-literacy is preparation for making geographic and far-reaching decisions. Geographic decisions are decisions about location or transportation; far-reaching decisions are decisions that have remote consequences. Geo-literacy requires three abilities:

- The ability to reason about human systems, environmental systems, and human-environment interactions
- The ability to reason about geography
- The ability to reason through decisions systematically

If you are an *ArcNews* reader, then the odds are good that these three bullets mean something pretty specific to you and that your interpretation of these bullets is pretty close to mine.

My challenge is that these bullets do not mean much to most Americans. Not only do most Americans lack these abilities, I believe that most of them have never even heard anyone talk about them. Phrases like *reasoning about systems*, *geographic reasoning*, and *systematic decision making* do not convey much meaning to people who have never been taught those skills. Worse, they do not have the power of name recognition the way algebra and calculus do.

The challenge here is how to convey a message about the importance of knowing something to people who don't know it themselves and to do it without (a) making them feel bad for something that is not their fault or (b) putting them off with a tone of superiority.

I am writing this column because I don't know how to solve this challenge, and I am looking for help. I am pretty sure, however, that the path to the solution lies through compelling examples. I argue that the reason modern societies need to provide their citizens with geo-education is the big cost that people pay individually and collectively for geo-illiteracy. My hunch is that the right examples of these costs will convince people.

I have collected a few examples, but I am hoping that, through the power of social networking, the readers of this column will help me build a compelling library of examples. Please give me feedback on my examples and share yours with me on Twitter (@NatGeoEdelson) or Facebook (www.facebook.com/geoliteracy).

Here are a few examples drawn from modern American life, some of them from my own experiences:

A geo-literate individual should be able to take constraints and considerations into account to optimize choices about locations. This is a case of geographic reasoning. For example, when people are not able to identify and weigh their commuting options successfully, they pay costs in the forms of wasted money, lost time, and frustration that only grow over time. When owners of small retail businesses or decision makers in large retail businesses make poor decisions about location, they pay for their failures in geographic reasoning in lost business, which translates directly into lower revenues for the company and reduced economic opportunity for the workforce.

The cost of a store or restaurant closing because of a poorly chosen location goes far beyond the business owner. It is an economic loss for the community. We currently consider the frequent failure of retail establishments to just be a part of life. However, a substantial percentage of these failures is a direct result of poor geographic reasoning that could be prevented, leading to substantial economic benefits.

Another important kind of geographic reasoning is not about where to do something but about whether to do something in a particular location. For example, in the last decade, citizens of America and many other nations have faced decisions about whether they should send troops to fight wars in foreign lands, such as Iraq and Afghanistan. A geo-literate individual should be able to analyze information about locations to form an independent assessment of the appropriateness of a proposed action in those locations.

I would have more confidence in the democratic decision-making process about military deployments in America if more Americans were able to interpret thematic maps showing topography, ethnic and religious populations, and distribution of natural resources. I believe there are many valid arguments on both sides for whether the United States should have gone to war in Iraq and Afghanistan, some of which may outweigh geographic considerations. However, I worry about the role of the public in making decisions like these in a society where many are not able to reason systematically about geographic factors.

Even though there is no way to determine, even in retrospect, whether we have made the right decision about military deployments, we can still assess the costs associated with those decisions. In the case of these large-scale military deployments, the costs are measured in billions of dollars, thousands of lost lives, and hundreds of thousands of lives permanently changed.

A geo-literate individual should be able to anticipate remote impacts of local decisions. This is a case of reasoning about systems. For example, in the Chesapeake Bay watershed where I live, state governments advise residents to only wash their cars at car washes because the runoff affects water quality in the bay. If most people who receive this advice do not understand the impact of detergent and other runoff from roads on aquatic ecosystems—which most don't—and do not understand where the water that leaves the bottom of their driveway goes—which most also don't—then the odds that they will follow that advice are very low.

The same goes for farmers and fertilizer, though farmers in the Chesapeake watershed are subject to laws restricting runoff, not just advisories. If farmers do not understand the effects of fertilizer runoff and they know that their state government cannot afford to enforce runoff laws, they are unlikely to expend much effort to obey them.

The result of uninformed decision making about runoff is an enormous environmental and financial cost resulting from millions of individual decisions with far-reaching consequences. The fisheries in the Chesapeake Bay, the Gulf of Mexico, the San Francisco Bay, Puget Sound, and many others, are all threatened by runoff. The livelihoods of hundreds of thousands of individuals who depend directly or indirectly on fishing in those locations are threatened.

Those are three examples of how the widespread lack of geo-literacy can add up to huge societal costs. What do you think? Are these compelling? Do you have others you can share with me? Let me know.

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Let's Exchange Competition for Cooperation

By Claudia Paskauskas, GIS Manager, East Central Florida Regional Planning Council

I would like to invite you on a trip back to our childhood. Let's think of the time that we were around two or three years old. Do you remember how the playground rules were back at that time? Lots of children playing with lots of toys. It was so hard to share our toys with somebody else. But then, all of a sudden, a little kid would come from nowhere wanting to play with our toys and keep offering his for us to play with until we finally decided to give it a try. It was always a hard decision to make—sharing our toys and playing with somebody else's—but it was always enjoyable and rewarding doing so because then we had a friend to play with, and things from that point on became way more fun than when we played alone!

Photo credit: Gina Marchica

Fast-forwarding and getting back to our current time, when we think of GIS collaboration, things are not much different from the playground rules. We have our data, our applications, our techniques, our models, our layers, and our services—our toys. And it's so hard to share them with others for reasons that vary on a case-by-case basis. Sometimes we have unique techniques and we don't want to share that with the competition. Other times, we just don't want to go through the entire documentation process that can take time to be completed. Yet other times, we just forget to scope time in our projects to share the final product with the GIS community via the clearinghouses and other resources, not to mention what it takes to collaborate in terms of stretching our comfort zone, exposing our work to peer evaluation, and many other reasons that we could write an entire new article about. But then your coworker encourages you to attend a local GIS user group meeting, and you listen to that presentation that gives you hints about how to improve your own project. Another situation could be how great it feels networking with other GIS professionals during a conference or during a GIS professional organization after-hours event just because you could help someone else answer a question that had been puzzling them. The point I am trying to make here is that it takes a leadership attitude to enable and accomplish collaboration.

One of the most basic leadership principles emphasizes the importance of individuals taking single steps to create big impacts. A leader doesn't need to be someone that's in a decision-making position or have formal authority. A leader is someone who can socially influence others to accomplish a common goal. Leaders come in various shapes and flavors. Leaders are simply messengers of new ways of thinking or transitioning processes or are simply supportive of new ideas and concept development. Leaders often are mentors. Leaders are passionate about what they do. Leaders engage. Leaders share, guide, and facilitate accomplishments. Leaders always strive and shine in what they do. Usually when you teach, you end up learning and knowing way more than that audience you are trying to educate. And that is just one of the beauties of having a leadership attitude.

Some people freeze when the word *leadership* is said aloud. Others think that being a leader is too much trouble, and they are already busy enough at work to get one more thing added to their plates. A common mind-set when the subject is leading can be easily illustrated in the following question: Why would my county, city, or even self want to collaborate and promote common professional growth in local GIS user group meetings, write articles, or mentor someone when I alone can deliver the highest-quality GIS projects on a daily basis?

One might also wonder why a GIS professional would want to do more than their own daily work. Why would a GIS professional want to contribute time, knowledge, and expertise to GIS professional organizations, local GIS groups, and data clearinghouses, aiding other peers and/or organizations and enabling them to grow stronger?

The problem embedded when someone thinks of these questions is more fundamental than it seems. The reality is that some professionals think they can survive forever by just flying solo. That notion clouds their ability to see the benefits of working and growing together.

By simply not being on the same page, this thinking may have effectively caused several significant duplications of effort and service. Loss of time. Loss of money. Loss of momentum to grow strong together as a knowledgeable GIS community. Loss of the opportunity to make a difference and be part of the solution. That's what happens when we don't have the mind-set of collaborating and sharing.

If all sides of our GIS community collectively discuss the common wants, needs, standards, and guidelines, duplication of efforts will not be an issue. Then, through collaboration, we can support the GIS community during these difficult economic times where budget constraints can unfortunately hinder success. History shows why collaborating is better than competing. When team players, being competitors or not, get together to help communities recover from unforeseen events like natural disasters, everybody wins. The community gets back to its normal life faster, jobs are created, knowledge is shared, and professionals get their skill sets sharpened. It's a win-win situation. No competition. Just collaboration!

The overwhelming support and participation of many GIS professionals, counties, cities, and organizations indicate that the GIS community would like to continue to work together. Pulling and tugging in different directions does not seem to make sense when we have collaboratively achieved better results shortcutting in project development by simply utilizing data that has been shared. Other successful proof that working together as a solid regional GIS community is worth it is reflected in the relationships built during several GIS functions, such as user groups, GIS Day celebrations, workshops, conferences, and specialized training.

For our GIS community to succeed, we must work together on projects and educational opportunities that make sense. Let us not be mistaken—competition is out there, and it is healthy. However, our spirit of competition needs to be a productive one that only makes us work harder and be that much stronger.

Working as a solid community means that everyone involved gets a little dirty, because we'll have to work at it. It's going to be work, but it's work worth doing. But the greater goal—not personal gain—has to be at the heart of what's driving us.

Ultimately, building a strong regional GIS community isn't something that can be accomplished by a handful of people. If something is to get done, it will be by individuals that simply have a passion for some segment of the work that's to be done.

Maybe that passion is in improving education and mentoring someone, developing grassroots efforts by being a mentor in local schools or maybe supporting the planning and execution of user groups, regional events, and newsletter publications. It could also be by volunteering with GIS professional organizations or even simply sharing data or supporting the development of new, needed data guidelines.

Regardless of the specific area of interest, the important factor is to simply become involved and help be a solution to some of our GIS community's issues and needs. One action at a time. Being a leader or just following one. Sharing your toys.

The sooner we all realize that cities; counties; organizations; companies; and, most importantly, professionals cannot survive without each other's collaboration, participation, and understanding, the better off we will all be.

I encourage you to share your toys. Going solo is good, but by traveling the journey together, we can accomplish much more.

About the Author

Claudia Paskauskas, PMP, MCSD, GISP, is the GIS manager for the East Central Florida Regional Planning Council (ECFRPC). She brings more than 18 years of IT professional experience, including GIS, working for private and government sectors. She is the vice president of the Florida URISA Chapter (FLURISA), chair of the URISA Leadership Academy, and the 2011 GIS-Pro URISA conference program chair.

For more information, or if you are looking to get involved in the GIS community or learn how to start your own collaborative GIS program, contact me (e-mail: Claudia@ecfrpc.org, tel.: 407-262-7772). There are plenty of opportunities out there where you could start making a difference.

Acknowledgments

Photo credit: Gina Marchica (e-mail: gmarchica@ecfrpc.org). Credits for the passion to carry on my mission of inspiring GIS peers to give their best and make a difference: the ECFRPC GIS team and CFGIS community, FLURISA, and URISA members.

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A National GIS Infrastructure for Health Research

By Doug Richardson, Executive Director, Association of American Geographers

The AAG has been working closely with the US National Institutes of Health (NIH) on the integration of geography and GIS in medical and health research for nearly a decade. Two years ago, we began building on the foundation of these research collaborations and multiple NIH relationships with a far-reaching new initiative for GIScience, health, and geography, called the AAG Initiative for an NIH-Wide GIS Infrastructure. This ongoing initiative, including a recent AAG-NIH joint workshop to explore and further develop such a complex and large-scale undertaking, is described in more detail below.

The AAG Initiative

The rationale for this AAG initiative is the unmet need for spatial and spatiotemporal data and analyses, as well as for geographic context, across nearly all NIH's 30 individual institutes. This need is pressing for research undertaken at NIH ranging from gene-environment interaction in biomedical research to the tracking of disease outbreaks and the assessment of health service delivery.

While some progress has been made in recent years in developing geographic information systems, geocoding services, mapping, and associated standards, problems nevertheless abound in the lack of interoperability among proprietary systems, longitudinal variation in data collection, difficulties of sharing inadequately documented data, issues of confidentiality of location-specific data, and lack of understanding of the basic concepts of geographic/environmental context and of spatial and spatiotemporal data and analysis. Although these problems and their solutions vary somewhat by institute across NIH, they also share a great deal in common, and therefore very substantial scale economies can be achieved by addressing them collectively.

Some individual NIH institutes have made independent and fragmented investments in spatial data and tools. The inefficiencies of this approach suggest that a common GIS infrastructure offers significant advantages. The AAG Initiative for an NIH-Wide GIS Infrastructure has been exploring the potential for such a collective solution, in consultation with many individual institutes and the NIH leadership. We are addressing opportunities and obstacles to establishing such an ambitious infrastructure, strategies for optimizing the long-term research value of an NIH-wide GIS infrastructure, common standards and protocols, a catalog of available data resources, training programs and examples of best practices, collective negotiation of software and data licenses, and tools specifically adapted to the needs of health research. The overall vision of the initiative is to enhance the ability of NIH researchers to make use of this rapidly growing and increasingly important area of research infrastructure while taking advantage of economies of scale.

The AAG initiative is led by a steering committee appointed by the AAG Council, consisting of five leaders in the health-research applications of spatial and spatiotemporal technologies: Michael Goodchild, Doug Richardson, Mei-Po Kwan, Jonathan Mayer, and Sara McLafferty. It receives input from a larger advisory group that includes geographers and health researchers from across the disciplines represented at NIH. The first phase of the initiative has focused on creating a broad road map for the development of a GIS infrastructure for health research, assessing and documenting the demand for such an infrastructure throughout the institutes and among NIH leadership, and developing a sustainable funding model.

The AAG-NIH Workshop

After discussions with NIH officials in multiple institutes, the AAG recently received funding support from NIH to hold a high-level workshop in February 2011 to further develop the conceptual framework and GIScience research needed for implementation of an NIH-wide GIS infrastructure, together with senior scientists and administrative leaders from all across NIH. This workshop, cosponsored by the AAG and NIH's National Cancer Institute and National Institute on Drug Abuse, was highly successful and represents what many attendees have characterized as a seminal event.

Presentations included an overview of current GIS activities at NIH institutes, perspectives from the GIScience research community, extramural researchers' views on GIS needs at NIH, and discussions of system architecture options for an NIH-wide geospatial infrastructure. Bill Davenhall of Esri also participated in the workshop and provided excellent background on a number of health-related GIS activities. Breakout groups in the workshop focused on identifying common needs, key challenges, and implementation alternatives. Recommendations, priorities, and next steps in this process were discussed and are the subject of a recent report prepared by the AAG and NIH (www.aag.org/health_geographies).

There was consensus among the participants in the workshop that developing a broader and deeper GIS infrastructure throughout NIH for medical research is needed. The discussion highlighted numerous benefits of geography and GIScience to NIH's health research programs. Examples of the benefits of a large-scale GIS infrastructure to health and biomedical researchers include generation of research hypotheses through discovering geographic patterns and by analyzing data in ways that would not otherwise be possible, increased ability to understand gene-environment interactions and their role in disease occurrence, ability to advance mobile health systems by incorporating real-time GPS/GIS technologies, and the potential to integrate and link other major health databases with such an infrastructure.

Workshop participants also discussed the substantial challenges to the implementation of such an ambitious project. These challenges include dealing with locational privacy and confidentiality issues; developing and disseminating GIS and analytic modeling tools specific to the needs of health and biomedical researchers; and incorporating training and education in GIS, geospatial tools, and spatial thinking for health and biomedical researchers. Participants also recognized the importance of having a forward-looking strategy in developing an NIH-wide GIS infrastructure, being mindful of new and emerging technologies, including, for example, the geospatial web, social media, new information from electronic medical records, real-time health monitoring, and developments in sensor and location-aware technologies.

The next steps for pursuing the concept of a large-scale, NIH-wide geospatial infrastructure to support health research will include wide dissemination of the AAG-NIH Workshop Report to both the geography and health and biomedical research communities, preparing a more detailed inventory of the portfolio of intramural and extramural GIS projects supported by NIH, and developing NIH requests for proposals and focused workshop proposals that address specific research needs related to such a complex infrastructure. Potential research would need, for example, to address spatiotemporal analysis in health research, where issues of scale, privacy, large datasets, and computational capacity are just some of the areas that need to be investigated;

defining a distributed computing architecture (including cloud computing) for an NIH-wide GIS; developing a common language, or ontology, shared by biomedical researchers and geographers to foster collaboration; and addressing other needs and challenges described above. The workshop concluded with an executive briefing for senior leadership from many institutes in the NIH.

If successful, I believe this AAG initiative will open new doors for geographic research and discovery at NIH in collaboration with biomedical scientists at most institutes within NIH and in related public health fields, as well. For geographers, GIScientists, and medical researchers alike, it also holds real promise for making a meaningful difference in the health and lives of people around the world.

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The Intersection of GIS and Gaming

By Matt Artz

Video games have moved beyond the stereotype of simple entertainment and are now a serious technological and cultural force to be reckoned with. Millions of people spend many hours each week immersed in the rich virtual environments of today's sophisticated games. And the multibillion dollar market for games has moved beyond teen males, with adults and women now more engaged than ever.

Most games today have a spatial component, and these virtual worlds are becoming more complex and sophisticated. There is no doubt that video games have a high potential for effective education, with individuals often learning valuable skills and gaining experience from within a simulated environment. But beyond education, where else do GIS and gaming intersect?

As the virtual worlds in video games become increasingly difficult to design and manage, it's easy to see the benefits of using proven geospatial tools to manage, model, and design this virtual geography. And making virtual worlds more realistic is key to leveraging them for geospatial research and analysis. In fact, some game designers and even players are already exporting rich spatial datasets from GIS to create new realistic levels or worlds within video games. But can we do more? How can the geospatial community leverage the talent and infrastructure of the gaming community? Can we use these virtual worlds as testing or prototype environments to help improve conditions in the real world?

Online, cooperative citizen science platforms such as PlanetHunters.org and eBird are becoming increasingly popular and successful. The next logical step would be to leverage existing online environments—specifically, online **gaming** environments—as platforms for research, analysis, and design. By testing alternative designs in the virtual world of a video game, people simply "playing games" could actually be playing a valuable role in designing future buildings, roads, cities, and parks. If this was done to be both representative of the real world and entertaining at the level expected in a video game, participants could make potentially important societal contributions while still having fun playing their games.

Leveraging online gaming environments as a resource could add a whole new dimension to geospatial research and analysis. But merging elements of "work" and "play" is a delicate balance and needs to be done without disrupting the gaming experience.

Because once you remove the entertainment from a game, it's just work.

(This blog post originally appeared in *Esri Insider* on October 7, 2011.)

Understanding Our World

"Understanding precedes action."

—Richard Saul Wurman

At the dawn of humankind, people made crude sketches of geography on cave walls and rocks. These early maps documented and communicated important geographic knowledge our ancestors needed to survive: What is the best way to get from here to there? Where is the water at this time of year? Where is the best place to hunt animals? Our ancestors faced critical choices that determined their survival or demise, and they used information stored in map form to help them make better decisions.

Early man used cave walls and rocks to communicate and share geographic knowledge.

Fast-forward to the 1960s. The world had become significantly more complex than it was for our early ancestors, and computers had arrived on the scene to help us solve increasingly complex problems. The 1960s were the dawn of environmental awareness, and it seemed a natural fit to apply this powerful new computer technology to the serious environmental and geographic problems we were facing. And so the geographic information system (GIS) was born.

Today, GIS has evolved into a crucial tool for science-based problem solving and decision making. People who use GIS examine geographic knowledge in ways that would be extremely time-consuming and expensive when done manually. The map metaphor remains the dominant medium for sharing our collective geographic intelligence, and development of a GIS-based global dashboard will lead to a revolution in how we understand our world and plan for the future.

Geographic Knowledge Leads to Geographic Intelligence

Geographic knowledge is information describing the natural and human environment on earth. For our ancestors, geographic knowledge was crucial for survival. For our own survival, geographic knowledge plays an equally fundamental role. The biggest differences between then and now are that our problems are much more complex, and the sheer volume of data—of geographic knowledge—at our disposal is daunting. And whereas passing down geographic knowledge in the past was limited to a few cave paintings or rock drawings, GIS technology now enables a collective geographic intelligence that knows no spatial or temporal bounds.

Today we have more geographic data available than ever before. Satellite imagery is commonplace. Scientists are producing mountains of modeled data. And an ever-increasing stream of data from social media, crowdsourcing, and the sensor web are threatening to overwhelm us. Gathering all this information—this geographic knowledge—and synthesizing it into something actionable is the domain of GIS. More data does not necessarily equate with more understanding, but GIS is already helping us make sense of it, turning this avalanche of raw data into actionable information.

Human-Made Ecosystems

Our traditional understanding of ecosystems as natural landscapes is changing. Anthropogenic factors are now the dominant contributor to changing ecosystems. Human beings have not only reshaped the physical aspects of the planet by literally moving mountains but also profoundly reshaped its ecology.

And it's not just landscape-scale geographies that can be considered human-made ecosystems. In modern society, buildings are where we spend the vast majority of our waking and sleeping hours. Our facilities are themselves man-made ecosystems—vast assemblages of interdependent living and nonliving components. Facilities have become the primary habitat for the human species, and this is changing the way we think about collecting, storing, and using information describing our environment.

A key aspect of our social evolution is to recognize the effects we have already had on ecosystems, as well as to predict what future impacts will result from our actions. Once we achieve this level of understanding, we can direct our actions in a more responsible manner. This type of long-term thinking and planning is one of the things that make humans human.

Recognition of the overwhelming dominance of man-made ecosystems also makes us cognizant of the tremendous responsibility we have—the responsibility to understand, manage, and steward these ecosystems.

> *"Only when people know will they care.*
> *Only when they care will they act.*
> *Only when they act can the world change."*
>
> *—Dr. Jane Goodall*

Designing Geography

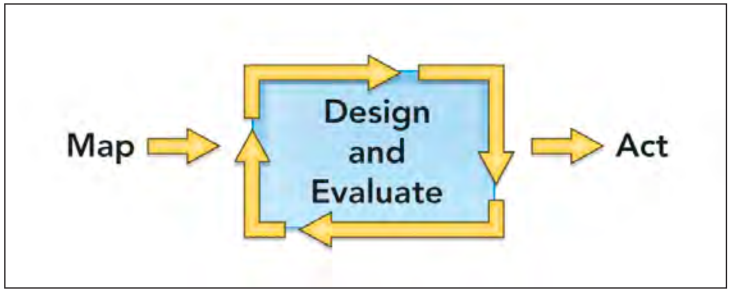
We humans are no longer simply passive observers of geography; for better or worse, we are now actively *changing* geography. Some of this change may be intentional and planned, but much of it is unintentional—"accidental geography." As we grow more knowledgeable, become better stewards, and obtain a greater understanding of our world and how humankind affects it, we need to move away from this "accidental geography" and toward what Carl Steinitz calls "changing geography by design." As GIS professionals, we can accomplish this through the integration of design into the GIS workflow.

The GIS workflow starts with a decision that needs to be made. We first gather background information about the geography of that decision and organize it on a digital map. We then use the map to evaluate the decision. Once we fully understand the geographic consequences of the decision, we can act.

When an idea is proposed with geographic consequences—a housing development, a shopping center, a road, a wildlife preserve, a farm—it first goes through a design process. After it is initially designed, a project is vetted against geography using this approach.

A typical project will go through many iterations of design and evaluation. As the constraints of geography on the project—and the impacts of the project on geography—are revealed, the design is continually refined. Because design and evaluation have traditionally been separate disciplines, this phase of a project can be time-consuming, inefficient, and tedious.

What if we could reduce the time and tedium of these iterations by integrating design directly into the GIS workflow?



This integration—what we refer to as GeoDesign—is a promising alternative to traditional processes. It allows designers and evaluators to work closely together to significantly lessen the time it takes to produce and evaluate design iterations.

Bringing *science* into the design process without compromising the *art* of design will require new tools and enhanced workflows. Most of all, it will require a new way of thinking about design. And it will allow us to more easily move from designing *around* geography to actively designing *with* geography.

We must manage our actions in ways that maximize benefits to society while minimizing both short- and long-term impacts on the natural environment. GeoDesign leverages a deep geographic understanding of our world to help us make more logical, scientific, sustainable, and future-friendly decisions. GeoDesign is our best hope for designing a better world.

Toward a Global Dashboard

An important tool for understanding our dynamic planet is a global dashboard. This tool would operate as a framework for taking many different pieces of past, present, and future data from a variety of sources, merging them together, and displaying them in an easy-to-read-and-interpret format that indicates where action needs to be taken. That such a dashboard would use the map metaphor seems obvious; our long history with map representations means that people intuitively understand maps.

GIS helps provide this framework by allowing users to inventory and display large, complex spatial datasets. When people see all this geographic knowledge on a map, and they see environmental problems or economic issues in the context of their neighborhood, their street, or their house, this leads to a new level of understanding. They get it right away. The ability to take all this data and put it in context on a dynamic, personalized map is very powerful.

GIS can also be used to analyze the potential interplay between various factors, getting us closer to a true understanding of how our dynamic planet may change in the coming decades and centuries.

A better world is the common goal all of us—geographers, planners, scientists, and others—have been striving for. Although we've made a lot of progress in building the technological infrastructure to help us accomplish this monumental task, we're still not quite there yet.

I'm a firm believer that we have the intelligence and the technology—the ability—to change the world. We can make it better. We must make it better. But we first need a firm and complete understanding of our world before we act to design our future.

(This article originally appeared in the Summer 2011 issue of *ArcNews*.)

From Maps to GeoDesign

Conserving Great Ape Landscapes in Africa

By Lilian Pintea, Africa Programs, The Jane Goodall Institute

The Jane Goodall Institute (JGI) has been very interested in the evolution of the new field of GeoDesign, which offers the vision and the infrastructure to bring people, disciplines, data, and technology together to not only better describe landscapes but also develop more successful conservation strategies and actions.

Jane Goodall with Freud (courtesy The Jane Goodall Institute).

One practical application of GeoDesign has been the successful use of geospatial and conservation sciences to inform decisions in the Greater Gombe Ecosystem in Tanzania. JGI greatly improved village land use in this very sociopolitically difficult and historic setting. We were successful not only because of the technology we employed but also because the JGI staff understood human values and decision-making processes that influence landscape change in that particular region. We learned that helping develop the region (e.g., through working together to provide clean water sources, among many projects) opened the door to communities and motivated them to "buy in" to our efforts, creating a window of opportunity to apply conservation science to threatened ecological systems. Some of these programs are discussed in detail below.

At the core of JGI's applied conservation science program is using geography as a common framework to support our projects in Africa by connecting people, their values and activities, and conservation data and developing a shared understanding and vision of landscapes and how they should be changed. This in turn enables us to implement, monitor, and measure the success of those changes for both human and chimpanzee livelihoods.

We Need to Make More Enlightened Decisions

Time is running out for many endangered species, including our closest living relatives, chimpanzees. Chimpanzee and human populations are part of the same life support system, embedded in ecological systems that are intimately linked and dependent upon ecosystem services to survive. Unsustainable uses of natural resources by humans result in loss of those ecosystem services, with negative consequences for both chimpanzee and human livelihoods. The fundamental problem is that, despite advances in science and technology, we have not yet developed the methodologies to apply these to conservation and make more enlightened decisions about how to achieve a better balance between environmental and economic results.

Fifty years ago, on July 14, 1960, Jane Goodall stepped for the first time onto the shores of Lake Tanganyika and, through her groundbreaking discoveries about chimpanzees in what is now Gombe National Park in Tanzania, opened a new window to the natural world and to ourselves. This unique long-term research continues today with daily chimpanzee data collected by the JGI Gombe Stream Research Center and digitized, stored, and analyzed at the Jane Goodall Center at Duke University.

GIS and Imagery for Clearer Understanding

GIS has been used to georeference and digitize hundreds of thousands of chimpanzee behavior locations and analyze ranging and feeding patterns and relations with habitat characteristics as detected by remote-sensing and field surveys. The use of geospatial data for chimpanzee research was straightforward. Spatial tools and variables derived from GIS and remote sensing were directly used as part of research collaborations to test hypotheses. For example, a vegetation map derived from 4-meter IKONOS imagery helped demonstrate that chimpanzee hunts on colobus monkeys are more likely to occur and succeed in woodland and semideciduous forest than in evergreen forest, emphasizing the importance of visibility and prey mobility. JGI also worked with the Tanzania National Parks to improve the management of the park by using geospatial technology to visualize habitat change, map the park boundary, and support the development of the Gombe National Park Management Plan.

In addition to continuing Jane Goodall's pioneering research, JGI has been accumulating decades of experience and practical knowledge outside protected areas on how to successfully engage local communities and decision makers in the sustainable use of their natural resources. While the technology to map land cover inside and outside Gombe National Park was mostly the same, the way geospatial information was used to inform decisions was very different.

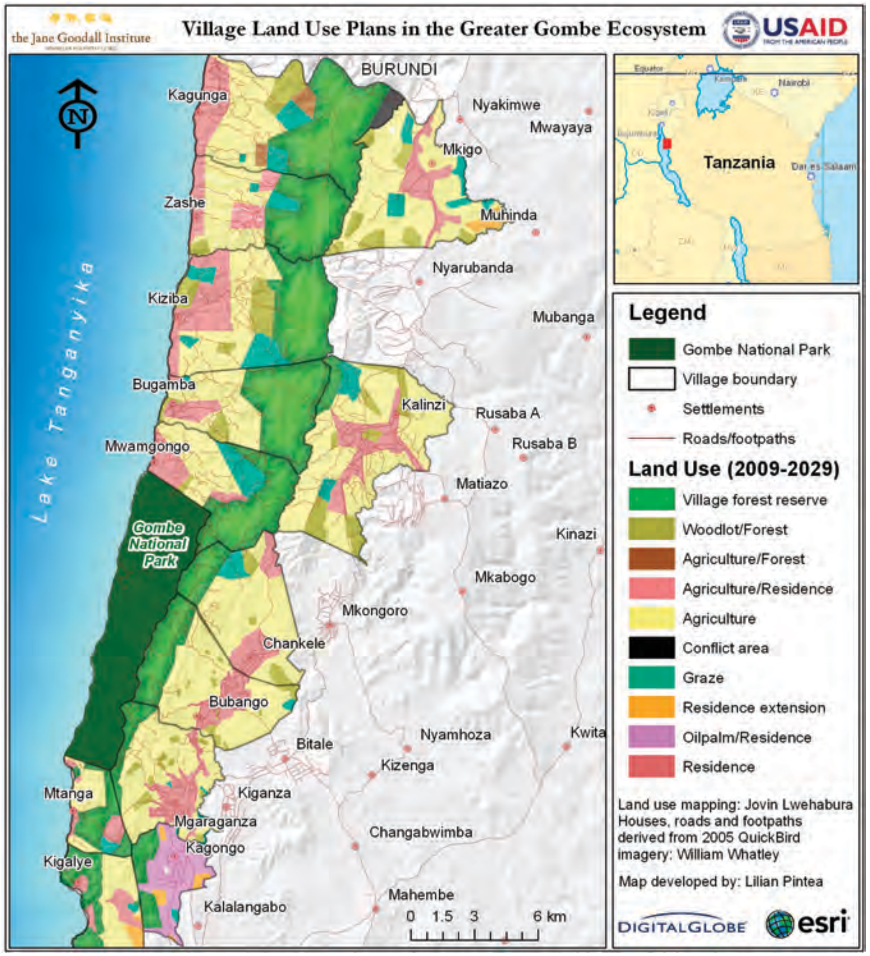
The use of geospatial information to inform decisions outside the park has been more complex. Gombe National Park was created in 1968. The park inherited a history of conflict with the local communities that started in 1943 when the colonial government established for the first time Gombe Stream Game Reserve. In 1994, JGI began working with the local communities outside Gombe through the Lake Tanganyika Catchment Reforestation and Education (TACARE, pronounced "take care") project to seek ways of arresting the rapid degradation of natural resources. TACARE project staff quickly learned that community buy-in was essential for success. Therefore, the TACARE project added agriculture, health, social infrastructure, community development, and clean water components to the range of interventions it employed. These interventions initially focused mostly on areas close to village centers.

However, forest change detection using Landsat imagery from 1972 and 1999 showed that most chimpanzee habitats outside the park had been in areas away from the village centers and almost 80 percent of it converted to farmland and oil palm plantations. Remote-sensing and GIS analysis led to a landscape approach by focusing conservation efforts geographically on areas away from village centers and on forest patches with the most benefits to chimpanzees. In 2005, adopting the recommendations obtained through analysis of satellite imagery and with funds from the US Agency for International Development (USAID) and other donors, JGI and its partners embarked on a five-year Greater Gombe Ecosystem (GGE) project.

A Conservation Action Plan approach was developed to identify and prioritize conservation strategies. Village land-use planning was identified as one of the top strategies. GIS was used to overlay deforestation layers, historic distribution of chimpanzees and habitats, slope, footpaths, roads, streams, watersheds, density of human structures, and 60-centimeter QuickBird imagery to prioritize a conservation area that, if protected, would substantially increase the viability of chimpanzees inside and outside the park and stabilize the watersheds to support human livelihoods.

Participatory village land-use plans were prepared by the communities according to Tanzanian laws and with full involvement of government and community stakeholders. JGI facilitated the process and provided technical support, including maps and geospatial tools to record and manage spatial data. The planning process followed seven steps and required villagers to settle any existing land disagreements and agree on village boundaries and how land resources located within the villages should be used to meet specific human livelihood needs and environmental objectives.

At the end of the project in 2009, 13 villages within GGE completed their participatory village land-use plans, which became ratified by the Tanzanian government. Local communities voluntarily assigned 9,690 hectares, or 26 percent, of their village lands as Village Forest Reserves. These reserves are interconnected across village boundaries to minimize fragmentation and cover 68 percent of the priority conservation area identified by the GGE Conservation Action Plan.



Participatory village land-use plans were prepared by the communities according to Tanzanian laws (courtesy The Jane Goodall Institute).

With renewed financial support from USAID, JGI and partners are now engaged in facilitating community-based organizations, developing bylaws and building local capacity to implement these village land-use plans and restore and manage newly established Village Forest Reserves. The plan is to use DigitalGlobe imagery continuously to provide detailed information on village land-cover change, such as increases in forest cover in Kigalye Village Forest Reserve, and monitor both new threats and conservation successes.

About the Author

Dr. Lilian Pintea brings more than 15 years of experience in applying remote sensing and GIS to the job of protecting chimpanzees and their vanishing habitats in Africa. As vice president of conservation science at JGI, Pintea directs the scientific department at the institute and conducts applied conservation research in Tanzania, Uganda, the Democratic Republic of the Congo, and the Republic of the Congo.

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(This article originally appeared in the Summer 2011 issue of *ArcNews*.)

Making Sense of Our Sensored Planet

By Matt Artz

Geography—the scientific foundation of GIS—has for many years been concerned with exploring and describing our world. Historically, explorers led grand expeditions to the farthest reaches of the globe. This golden age of exploration contributed greatly to our understanding of how our world works.

This was followed by the space age—an era where we left the planet and turned our cameras and sensors to look back on our home, giving us an entirely new perspective. Bound to the surface of earth for millennia, humankind was getting its first opportunity to look at our planetary system as a whole—from a few hundred miles up in space.

Exploration 2.0

While data remotely sensed from satellites continues to play an important role in monitoring and understanding our planet, "earth observation" has more recently taken on a whole new dimension thanks to deployment of an increasingly complex and pervasive network of earthbound sensors. These sensors are practically everywhere you look—and in places you could never imagine. From stream gauges to seismographs, from weather stations to air quality monitors, from ocean buoys to even our cell phones, countless sensors are measuring and collecting important data about our planet at a rate that seemed impossible just a short time ago.

We're collecting more information about the geography of planet Earth today than ever before. New data sources, along with the sheer volume of data being collected, are spawning a new

Live Stream Data Displayed via USGS Real-Time KML File.

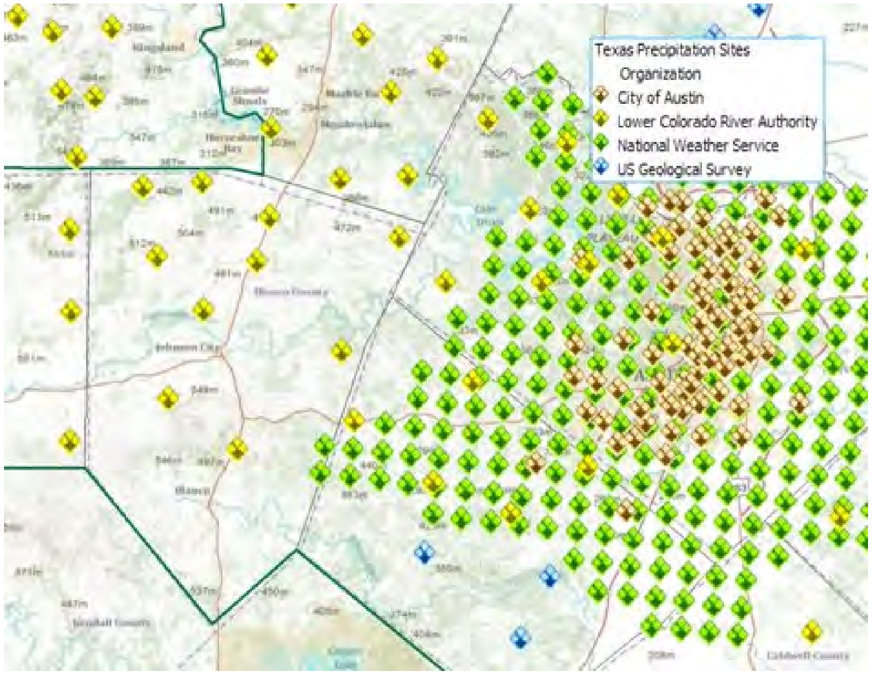
The rise of crowdsourcing applications means that every citizen becomes a sensor, empowering everyone to participate and contribute.

age of exploration. But the new explorers are navigating a vast, uncharted sea of data. What do we do with all of this sensed data? How can we make sense of the sensor web?

A Global Dashboard

Modern science and advanced technology have resulted in unprecedented access to global environmental information through the placement of countless sensors across the planet—and the linking together of this information through the Internet. The sensor web has inundated us with data that needs to be stored, managed, analyzed, and used to inform better decisions about our many social and environmental challenges. Integrating and synthesizing all of this disparate sensor data into a single, comprehensive view—a global dashboard—is our next great opportunity for exploring our world.

A global dashboard is a decision support tool that helps monitor current conditions, identify change, and drive informed action. It enables exploration at scales from local to global. It allows people to visualize large, complex spatial datasets in the context of their neighborhood, their street, and their house. The ability to explore a world of data from a personal perspective is a very powerful idea.



GIS enables real-time integration of sensors from multiple sources, using maps as a means to help us understand our world.

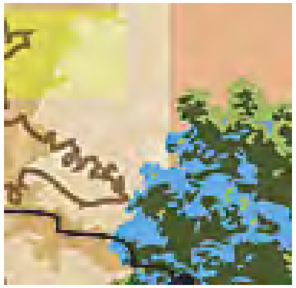
The New Explorers

We live in a world full of sensors. Thanks to the rich information flow they provide, and the availability of new mapping tools to display and analyze this information in context, now everyone can be an explorer. This has far-reaching benefits to both society and the environment, ushering in a new era of understanding and leading us toward more informed, equitable, and sustainable action.

(This blog post originally appeared in *Esri Insider* on November 2, 2011.)

Hand in Hand—Spatial Information for Latin America

By Santiago Borrero, Secretary General, Pan American Institute of Geography and History



In order to better implement spatial information in developing countries, training and institutional development must go hand in hand.

A good number of national development plans in Latin America prioritize education based on new technologies and state that digital illiteracy must be eradicated, as it constitutes an obstacle to access to the opportunities offered in today's globalized world. However, very little, if ever, is said about the fundamental need for spatial information, and thus the subject should be incorporated into national development plans and broad interdisciplinary processes. GIS is a key tool to critically understand geographic problems and put geographic thought into practice, especially now that citizens enjoy the benefits of instant geography through map services, dynamic photo files, and 360-degree street maps, for example.

The Pan American Institute of Geography and History (PAIGH) is the oldest organization in the Organization of American States (OAS) and the one in charge of providing it with the spatiotemporal component necessary to promote the comprehensive development of the region. Among other activities, PAIGH fosters the development of spatial data infrastructure in the Americas and to that end carries out workshops and regional projects every year.

Development Is Relative and Highly Subjective

When using the term *development*, we are referring to a relative, extremely subjective and often contradictory concept in which what some regard as progress is often viewed by others, from an equally subjective perspective, as a setback. Take, for example, the United Nations Development Programme's annual report on global development. The 2007 report, prior to the 2008 financial crisis, asserted that the global economy was growing at a steady pace and that, in spite of increased inequality, the human development gap was in sharp decline. More recently, the 2010 report stated the world was on an inexorable path to compliance with the Millennium Development Goals, as evidenced by graphs and statistics that critics might disagree with. Personally, I feel it has been quite a feat for the United Nations to make its members agree upon an effective, well-intentioned global strategy.[1]

Now let's look at our region with the same magnifying glass. In 2010, a significant number of countries held bicentennial celebrations with great fanfare. One thing was made patently clear to me during the commemorations: Although the nations of the American continent are indeed young, and the economic and social progress achieved by countries such as the United States and Canada is impressive, for the great majority of our countries, the twenty-first century holds a geopolitical vision quite unlike that of the days of independence in the early nineteenth century. Nowadays, the challenges of the Pan-American movement are very different and focus on the war on poverty, climate change, the scale of natural disasters and their mitigation, management and organization of land and natural resources, development of global markets and their local impact, and the social and economic significance of knowledge. Today, the objectives of the PAIGH 2010–2020 Pan American Agenda include

- To consolidate PAIGH as a *regional Pan-American forum* to advance geographic information and assist with the comprehensive development of its member states
- To encourage the *development of spatial databases* so they can be used in decision-making processes, to make early-warning systems more efficient, and to improve disaster response times
- To identify actions that will contribute to *regional integration* in specific fields, such as *climate change*, *territorial organization*, and *natural disasters*
- To assist with development of *high-quality geographic information* infrastructure essential to analysis processes

To successfully deal with these challenges, information technologies, such as earth observation systems, GIS, and spatial data infrastructure, play an increasingly relevant role. Although they are revolutionary in and of themselves, from the development perspective, the same relativity I mentioned with regard to global growth could apply here as well. Take, for example, the principle of sharing and accessing spatial data through the Global Earth Observation System of Systems (GEOSS). In the short term, application of technologies may be limited, such as when the international community tries to react, in the midst of serious coordination and logistical difficulties, to natural disasters in impoverished countries, as was the case of Haiti in early 2010.

Two Sides of the Coin

The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) agency, a key instrument in the process of expansion that has provided incremental results acknowledged by the specialized community, highlights how reality is often quite different from what even the keenest supporters had envisioned. Here are excerpts from the UN-SPIDER report on Haiti's 2010 disaster.[2] On one hand, the report says

> *When the devastating earthquake of magnitude 7 struck Haiti on 12 January 2010, the UN-SPIDER SpaceAid framework was immediately activated and UN-SPIDER experts became involved in supporting the early response efforts less than 30 minutes after the earthquake hit . . . Without delay, UN-SPIDER experts began to coordinate through their well established network with providers of space-based information, including public and private satellite operators, informed them of the most pressing needs and requested tasking of their satellites . . . Precious hours were saved because of these efforts. Eventually, post-disaster imagery was made available within less than 24 hours after the event . . . In a second step, UN-SPIDER coordinated with several value adding providers to ensure that the available imagery could be used immediately to produce required services as for example maps to display accessible roads and suitable areas to set up relief facilities . . .*

But the report also states

> *Unfortunately, due to the disrupted infrastructure in Haiti, the huge amount of compiled data could not be downloaded by the partners on the ground via internet. Interrupted networks and low bandwidth pose a serious bottle neck, and this was also the case in Haiti.*[2]

Certainly, responsibility in the case of developing countries lies not only in the international community. National authorities responsible for spatial information must enhance their capacity to offer assistance during disasters. In Haiti's case, the National Center for Geospatial Information collapsed, and its director, an enterprising woman who was doing a fine job, died together with a group of colleagues. In the case of the 2010 earthquake in Chile, the Military Geographic Institute provided significant help in response and recovery efforts. Moreover, upon realizing that available information was insufficient, the national government recently allocated resources to take national cartography to 1:25,000 scale.

In the case of spatial data infrastructure in the Americas,[3] the region is progressing at its own pace, and headway has been made thanks to a set of national efforts at all levels, together with contributions from the private sector and regional projects. Nonetheless, availability of high-quality data at the supranational level is still wanting. One critical problem is the lack of effective implementation of the international standards promoted by the International Organization for Standardization (ISO), not to mention those of Open Geospatial Consortium, Inc. Several programs and initiatives are making relevant contributions, such as the joint Andean Development Corporation/PAIGH program, known as GeoSUR, and the Geocentric Reference System for the Americas that successfully espouse the continental unification of the geodesic system.[3]

PAIGH Highlights

Founded in 1928 and headquartered in Mexico, PAIGH assists member states with geographic and historical analyses of their territories from a continental perspective.

It is a decentralized intergovernmental agency with 21 member states, each of which has its own national section.

Four technical commissions are responsible for the scientific program: cartography (1941), geography (1946), history (1946), and geophysics (1969).

The Institute is currently implementing a strategic plan entitled The PAIGH 2010–2020 Pan American Agenda, aimed at furthering regional integration through multidisciplinary actions and prioritizing natural disasters and territorial organization in a climate change scenario.

The Future of the Region's Geographic Institutes

Institutions responsible for national cartography in Latin America and the Caribbean are at a critical juncture and face the challenge of transforming their functions, skills, and human and technological resources.

Geographic institutes are no longer the sole producers of spatial information. Various public, private, local, and international institutions are equally, or better, equipped to produce fundamental spatial data and applications and make them accessible. ArcGIS Online, Google Maps, OpenStreetMap, and Bing have more and superior maps than many countries have through their institutions. The matter of who should pay for geographic information continues to be an issue. Geographic institution budgets are usually insufficient, bearing in mind the expense of the activities required to have complete spatial databases that encourage development. Guardianship, quality, integrity, and pertinence of fundamental data, as well as the tasks of coordination, certification, and verification of productive processes, access mechanisms, and data availability, are basic duties that should be assumed by geographic institutions.

Here are some key areas on which to focus to consolidate production, access, and application of the region's fundamental databases:[4]

- Geodesic networks (control stations, altitude and geoidal models)
- Base geographies (rectified prints, elevation models, hydrography)
- Spatial management (territorial units, geographic names, rural and urban land management)
- Infrastructure (transportation, communications, utilities)
- Soil and environment (soil coverage, geology)

To consolidate the Institute's position as the foremost Pan-American regional forum on geographic information in the region, PAIGH endorses the modernization of the geographic institutes that are responsible for national cartography in its member states, the development of spatial data infrastructures, and ISO international standards certification.

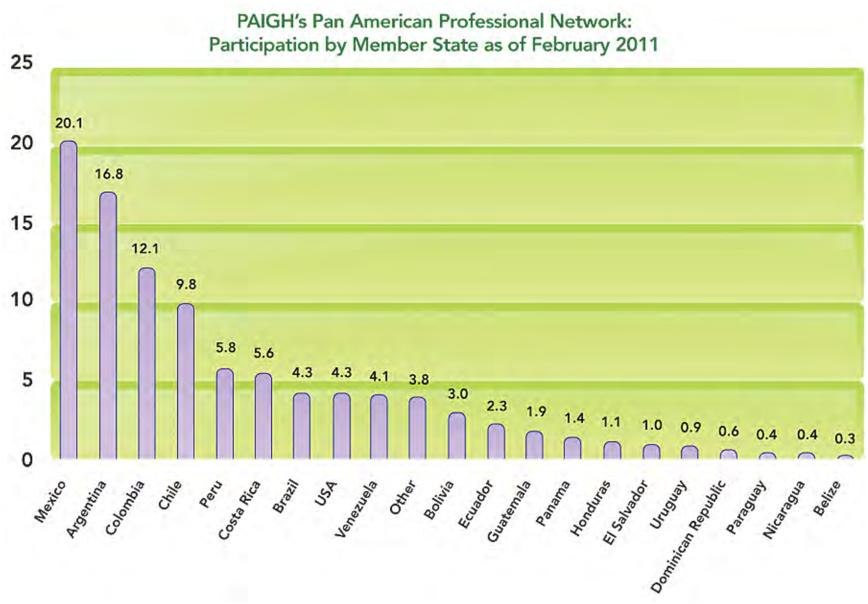
Three Types of Cartographic Institutions

There are basically three types of cartographic institutions in the region: (i) military, as is the case of Chile, the Dominican Republic, Ecuador, Paraguay, Peru, and Uruguay; (ii) civilian, including some in transition, as is the case of Brazil, Colombia, Mexico, and Venezuela; and (iii) what we could call the Central American model, in which cartographic production is a function of the priority given to cadastre information within the framework of land management, as in Costa Rica, El Salvador, Honduras, Jamaica, Nicaragua, and Panama.

It would be fitting for the region to ask itself what purpose and mandate national geographic institutes should have in the twenty-first century and what the long-term plans to obtain basic strategic information in order to operate effectively are. Many variables will determine the results, and surely some are part of the decision-making process of each country, but it is clear that capacity building is at the heart of the strategy. In essence, it is a matter of education.

Training and Institutional Development Must Go Hand in Hand

PAIGH's experience compels us to reflect on the effectiveness of strategies that focus on institutional capacity building and human resource training in agencies responsible for national spatial databases. To better implement spatial information in developing countries, training and institutional development must go hand in hand. In Latin America and the Caribbean, improved results will not be attained in the short and medium term if, in addition to public- and private-sector training programs, there is no improvement in institutional management capacity. In other words, without the comprehensive strategic modernization of institutes responsible for national cartography and geography, institutional capacity building will continue to be marginal.



PAIGH's experience invites reflection on the effectiveness observed in current capacity-building strategies, focusing more on training of human resources than on institutional and organizational development.

Technology procurement should unvaryingly be managed rationally and in such a way as to make purchases more effective. As I stated in 2003, "Technology itself does not ensure proper implementation and successful use of spatial data. Information technologies, spatial data infrastructures, and improvements in connectivity do not necessarily translate into increased access to geographic information, nor do they narrow the digital divide."[5] Technological developments render formal training for data measurement and processing unnecessary. Increasingly, anybody can click a button to produce survey information and process the data in an automated system. Developments have put GIS within the reach of almost anyone. Formal training will focus on data interpretation and management. Although computers have still not replaced the benefits of personal interaction and key learning processes that are not automated, virtual academies are quickly gaining ground.[6]

Needed: Better Quality Spatial Data

If I had to point to one crucial aspect of training processes, I would say it is the need for better quality spatial data. It is not unusual to find digitized, nonstandardized, obsolete data generated by means of uncontrolled methods with significant margins of error, among other drawbacks. Perhaps we should begin with a clear definition of the term *better quality*, which would seem a simple matter but is neither evident nor accurate and, above all, is subject to a wide variety of interpretations.

To summarize, let us return to the regional vision and the meaning of the recent bicentennial celebrations. The economy is improving, and after a lost decade, many studies refer to the rise of Latin America and, on a hopeful note, to the fact that over the past 10 years, the region has experienced sustained annual growth of close to 6 percent. Nonetheless, the economies of the region have competitiveness issues or, to a great degree, are operating outside the formal economy; inequities persist. In this context, regardless of the progress achieved, I believe accessing spatial information, incorporating pertinent technologies, and designing applications to contribute to solve multiple economic and social problems, such as those related to climate change, territorial organization, and natural disasters, are essential to regional development and integration and fields in which our community has much to do.

A Note from the Author

In autumn 2010, I was asked to speak at the Latin American GIS in Education Conference held in Mexico City. There, I shared my thoughts on the connection between development, education, and spatial information technologies in Latin America and the Caribbean based on my years of experience in the field of information and development and as secretary general of PAIGH, and the above paper is the essence of my presentation, which is my personal assessment and does not necessarily reflect the views of PAIGH.

About the Author

Santiago Borrero received his master's degree from the Massachusetts Institute of Technology and has nearly three decades of experience in information and development. Previous appointments include the chair of the Global Spatial Data Infrastructure Association and the Permanent Committee on SDI for the Americas, as well as the general director of the Agustin Codazzi Geographic Institute in Colombia (1994–2002). In Colombia, he has also been general manager of Bogotá's Water Supply Company and the National Fund for Development Projects.

For more information, contact PAIGH secretary general Santiago Borrero (e-mail: sborrero@ipgh.org).

Footnotes

1. www.undp.org/publications/index.shtml.
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(This article originally appeared in the Summer 2011 issue of *ArcNews*.)

Delivering GIS in a Period of Unsustainable Growth

By Corey Halford, Information Technology Team Leader, Data Services, City of Airdrie

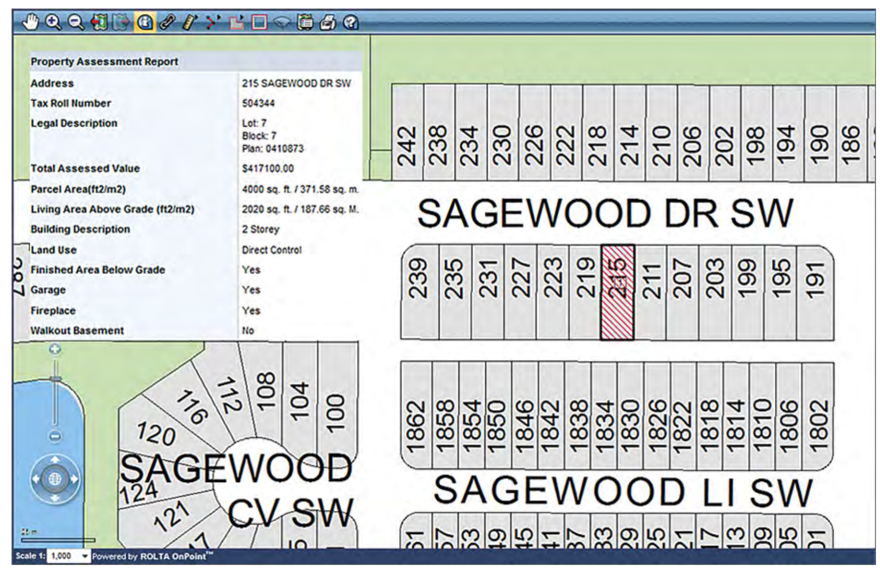
Airdrie, Alberta, Canada, is a small city located just north of Calgary. The city covers an area of 33.1 km^2 (12.8 square miles), is home to 43,155 residents, and employs 374 full-time staff. On staff are two GIS specialists and one GIS technician who provide the core support for the city's corporate GIS system.

History of Growth

The past 10 years have been dynamic and exciting for the City of Airdrie, as it has experienced high rates of growth through periods of both economic boom and collapse. For example, the lowest rate of population growth experienced over the past decade has been 4.54 percent (2010), while the highest rate has been 11.65 percent (2009), and the findings from the 2011 municipal census determined the city's population growth to be 8.37 percent year over year. To further illustrate the growth being experienced, the total population increase in Airdrie since 2001 is 22,747—a 111 percent increase. Similarly, the dwelling counts have increased by 10,768—a 156 percent increase since 2001. In contrast to these statistics, many growth planning professionals consider a population growth rate of approximately 2 percent to be a sustainable growth rate.

Dealing with the Challenges of Unsustainable Growth

The current period of unsustainable growth in Airdrie began in 1997. Around that time, GIS became an acronym that city staff started to come across frequently, and by 2001, the city finally decided to invest in this new technology. This decision was made as it became increasingly obvious that GIS could enable the city



Example of public web mapping search for assessment values.

to make more accurate business decisions and assist in dealing with the population and development growth that was being experienced.

The implementation phase of GIS at the city was initiated in 2001 and completed in 2003. Since 2002, the city has been using Esri technologies to support its GIS and is currently a subscriber to the Esri Small Municipal and County Government Enterprise License. At that time, however, GIS faced its first major operational concern—who would own it? There were many departments interested in GIS at the city, but finally, after much debate, corporate leadership determined that GIS would be a tool that could support the entire organization and therefore decided that GIS would sit in the information technology (IT) department. This wasn't a decision supported by everyone in the organization, but in light of the dependency of GIS on IT and its related infrastructure, this is, in actuality, the best place for it.

Following the implementation of GIS at the City of Airdrie, departments were able to justify new GIS-related positions based on Airdrie's increasing growth issues; however, this posed two major challenges to the GIS team. The first was that many of the individuals hired were ill equipped to offer the GIS support needed by their department, as they had only taken a GIS course or two and didn't fully understand the principles of GIS. The second was that some individuals began working alone in departmental silos without seeking support from the actual GIS team. Furthermore, these individuals began offering support to other departments, which resulted in significant confusion and conflicts with staff. To address this challenge, the GIS team, in collaboration with the rest of the organization, defined roles and responsibilities that all parties were able to agree on in an effort to properly support the city's GIS needs.

In recognition of the obstacles being faced by departments pursuing GIS initiatives, the GIS team developed a new method of customer engagement to be proactively involved, assigning a department to each GIS team member for which they would become the direct GIS support. Originally initiated as a pilot project with the parks department, this new approach started with four dedicated, on-site hours from a GIS specialist. At first, no one was sure how these visits would go, but after only a few weeks, it became apparent that the project could be considered a success, and it was soon rolled out to the rest of the organization. This model was so effective because it allowed the GIS specialist to witness the everyday operations of the parks department and find ways to use GIS as a tool to make those operations more efficient. Another benefit of this process is that it allows adaptability and customization per department. For example, while the parks department works well with four hours per week, the planning department prefers one, whereas public works requires even less time than that, and so on.

The implementation of the service model described above has also created a more organized and efficient environment for the GIS team. By having dedicated departments to support, there is less ambiguity over who is going to do what and when, which makes for a smoother response to requests. In addition, as demands for GIS resources increase and GIS staff reach their capacity, it is easier to justify the need for more staff and/or consulting dollars, as there is more tangible proof of the work being done. Lastly, all this has increased the team's customer satisfaction and engagement to a level better than experienced prior to the implementation of this service model.

Managing GIS during a time of growth has been very challenging. One would assume that, during a period of high population increase, obtaining funding would be easy; however, this has certainly not been the case in Airdrie. Since 2001, all aspects of the GIS program have been scrutinized on an annual basis, and the ability to secure adequate funding has relied directly on how effective budget justifications communicate the organizational need for GIS services. These needs are now being better demonstrated in the form of outcomes and deliverables so corporate leaders can clearly understand what they are investing in. Therefore, it is essential for GIS to deliver on its outcomes in order to justify additional resources and maintain corporate support.

An effective GIS program is built on the foundation of knowledgeable and skilled professionals, but it is the dynamics around people management that make staffing complicated. Staffing consists of more than just hiring and firing, as it involves discipline, recognition, rewards, and a strong organizational culture. In regard to the hiring processes, there have been challenges in the recruitment of skilled individuals. This has been mostly attributable to the economic boom in Alberta from 2002 to 2007, which reduced the pool of skilled GIS professionals that was available. Coupled with this, the financial benefits of working in the private sector have often placed the city at a disadvantage when recruiting staff. Unfortunately, this problem persists, but one method in which the city has attempted to overcome this disadvantage has been its commitment to an open and honest culture that fosters personal growth, development, and professional creativity. For the GIS team, this has resulted in only one cycle of significant staff turnover in the past 10 years. Ultimately, if you can make work a fun place to be and demonstrate that each person has the power to make valuable changes, people will want to work for you; at the City of Airdrie, this is where most success can be attributed.

Overall, it may not matter whether you are supporting a GIS in a municipality that is experiencing increasing or decreasing growth and budget pressures, as many of the difficulties facing GIS operations are the same. There remains a continuous need to justify how GIS adds value to the organization. This is a burden that every GIS professional has, and it is the knowledge, skills, experience, and creativity that each of us possess as GIS professionals that will help us meet the challenges of today and the future.

Recognitions

In 2009, the City of Airdrie was the recipient of the URISA Exemplary Systems in Government (ESIG) Award in the Single Process category for its development of the Online Census. In 2010, Airdrie's *Tourist* map, created by GIS specialist Jessica Letizia, won first place in the Best Cartographic Design in the Single Map Product category at the Esri International User Conference.

About the Author

Corey Halford, BSc, is the information technology team leader of Data Services at the City of Airdrie, where he is responsible for the management of the city's GIS program. In 2009, Halford was the recipient of the URISA Exemplary Systems in Government Award. He now sits on the ESIG Award review committee, and he is a graduate of URISA Leadership Academy. Halford is also president of the Prairies Chapter (Alberta, Saskatchewan, and Manitoba) of the Municipal Information Systems Association and chair of the Calgary Regional Partnership's GIS technical committee.

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