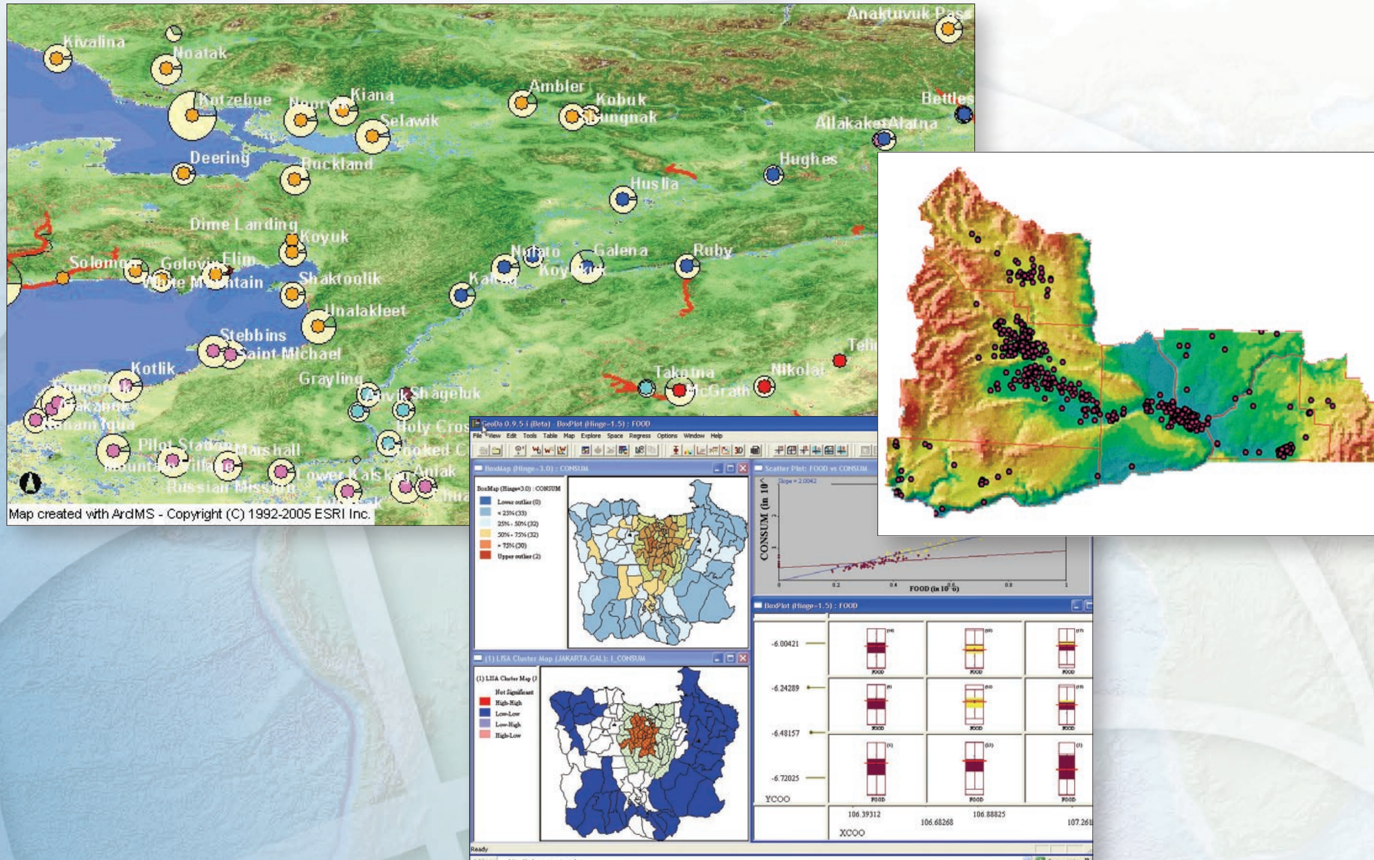
GIS Best Practices

Social Sciences



July 2009

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What Is GIS?

Making decisions based on geography is basic to human thinking. Where shall we go, what will it be like, and what shall we do when we get there are applied to the simple event of going to the store or to the major event of launching a bathysphere into the ocean's depths. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet. A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task. A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. For example, a social analyst might use the basemap of Eugene, Oregon, and select datasets from the U.S. Census Bureau to add data layers to a map that shows residents' education levels, ages, and employment status. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge from archaeology to zoology.

A good GIS program is able to process geographic data from a variety of sources and integrate it into a map project. Many countries have an abundance of geographic data for analysis, and governments often make GIS datasets publicly available. Map file databases often come included with GIS packages; others can be obtained from both commercial vendors and government agencies. Some data is gathered in the field by global positioning units that attach a location coordinate (latitude and longitude) to a feature such as a pump station.

GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as storm drains, gas lines, rare plants, or hospitals. Some GIS programs are designed to perform sophisticated calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

From routinely performing work-related tasks to scientifically exploring the complexities of our world, GIS gives people the geographic advantage to become more productive, more aware, and more responsive citizens of planet Earth.

Social Sciences: Interest in GIS Grows

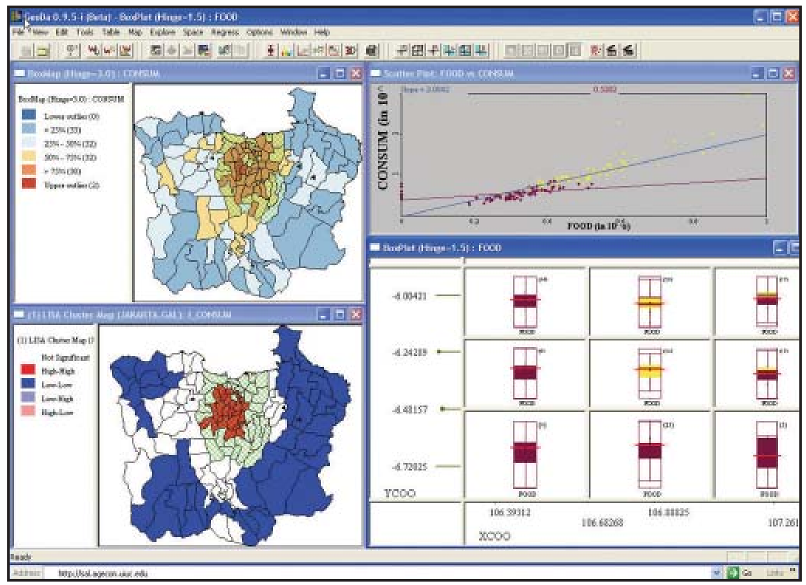
By Michael F. Goodchild, Center for Spatially Integrated Social Science, University of California, Santa Barbara

Space is what GIS is all about, and business knows the critical importance of the three Ls: location, location, location. But for many social scientists, location is just another attribute in a table and not a very important one at that. After all, the processes that lead to social deprivation, crime, or family dysfunction are more or less the same everywhere, and, in the minds of social scientists, many other variables, such as education, unemployment, or age, are far more interesting as explanatory factors of social phenomena than geographic location. Geographers have been almost alone among social scientists in their concern for space; to economists, sociologists, political scientists, demographers, and anthropologists, space has been a minor issue and one that these disciplines have often been happy to leave to geographers.

But that situation is changing, and many social scientists have begun to talk about a "spatial turn," a new interest in location, and a new "spatial social science" that crosses the traditional boundaries between disciplines. Interest is rising in GIS and in what GIS makes possible: mapping, spatial analysis, and spatial modeling. At the same time, new tools are becoming available that give GIS users access to some of the big ideas of social science.

Writing in *Scientific American,* economist Jeffrey Sachs and his colleagues Andrew Mellinger and John Gallup ask the basic question: "Why are some countries stupendously rich and others horrendously poor?" (Sachs, Jeffrey D., Andrew D. Mellinger, and John L. Gallup, "The Geography of Poverty and Wealth," *Scientific American,* March 2001). They go on to combine GIS analysis with the methods and equations of macroeconomics to show that location matters: where you were born globally has a lot to do with your chances in life. At a much more detailed spatial scale, geographer Danny Dorling and his colleagues have shown that location makes an increasing difference to your chances of early death in the United Kingdom (Yamey, G., "Study Shows Growing Inequalities in Health in Britain," *British Medical Journal,* 1999, Vol. 319, p. 1453).

One of the strongest arguments for looking at society through a spatial lens—through maps, GIS, and spatial analysis—is that it provides observations with context: processes can be examined in their geographic settings. A criminologist looking at community crime rates might otherwise miss the recent increase of policing in a neighboring community, which simply displaced the crime that had previously occurred there. This type of spillover process can be analyzed using a variety of methods that have evolved in the social sciences in the past decade or so under the general rubric of autoregressive models. Luc Anselin at the University of Illinois is a world leader in this area; working with the Center for Spatially Integrated Social Science (CSISS), he recently released GeoDa, a new suite of tools for this and other types of spatial analysis that is fully compatible with ESRI products (downloadable at www.csiss.org/clearinghouse/GeoDa, along with extensive documentation and tutorials).

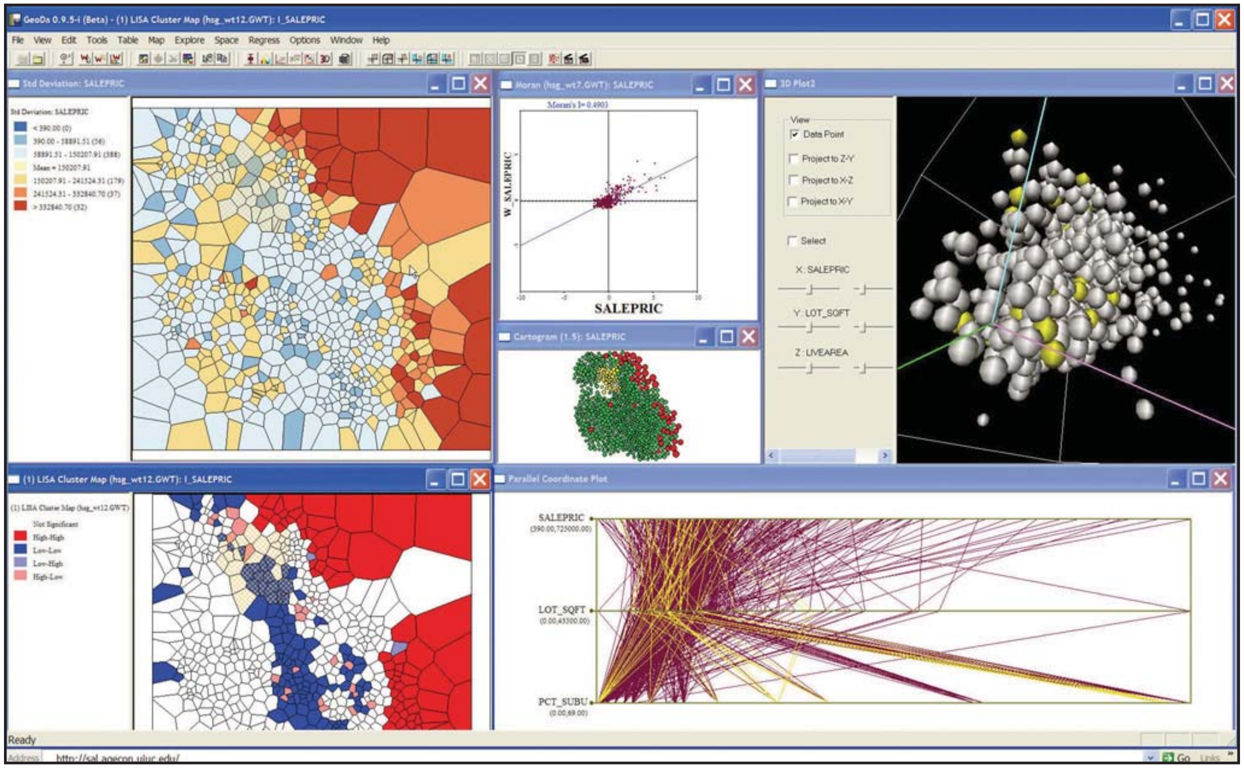


This shows a GeoDa analysis of Jakarta, Indonesia, neighborhood consumption patterns combining dynamically linked maps and graphs, including an outlier map, a cluster map (local spatial autocorrelation), a scatter plot, and a conditional box plot. (Image courtesy of Luc Anselin.)

Distance Decay

Spillover is subject to the much more general principle of distance decay, which dictates that human interaction declines steadily and often predictably with distance. Despite the power of the Internet to link people across space, physical distance is still a major determinant of human interaction. Predicting is never easy or perfectly reliable for any social process, but market analysts and others are well aware that predictions can often be reliable enough to be useful.

Spatial interaction models, for example, are widely used to predict retail shopping behavior, based on the principle that people balance distance with the attraction of shopping destinations in making choices.



This shows a GeoDa analysis of Seattle, Washington, house sales prices combining dynamically linked maps and graphs, including an outlier map, a cluster map (local spatial autocorrelation), a cartogram, parallel coordinate plot, Moran scatter plot (global spatial autocorrelation), and three-dimensional scatter plot. The points/locations highlighted in yellow are linked. (Image courtesy of Luc Anselin.)

Geographic profiling, an important spatial tool in fighting crime, makes use of the principle of distance decay applied to the behavior of the offender and the locations of a series of crimes that show the same modus operandi. To put it crudely, a criminal prefers to work at some distance from home, but not too far. Distance decay surfaces are generated centered on each crime and superimposed to create a three-dimensional surface that likely peaks in the criminal's home area. The method has achieved some convincing successes (for a good summary overview and references to software, see Keith Harries' "Mapping Crime: Principle and Practice," Washington, D.C.: Department of Justice, 1999, available online at www.ncjrs.org/html/nij/mapping).

Geographic profiling depends on getting the distance decay surfaces right, and as long as the method is applied to a single metropolitan area, there are good grounds for believing that this is possible (much of the development of the method occurred in the Vancouver, B.C., Canada, metropolitan area, led by researchers at Simon Fraser University). But there is no reason to suspect that the distance decay functions that work for Vancouver, with its low density and major highways, will also work for the comparatively cramped urban spaces of Amsterdam, the Netherlands, or Hong Kong. Despite decades of searching, social scientists are often frustrated by the evident lack of general, universal laws in social science—mathematical models that apply equally to human societies everywhere. But the combination of GIS and spatial thinking has produced a new and exciting option: the possibility that general principles might exist but that their expression in different areas might be substantially different. Many methods of so-called place-based analysis have been developed over the past two decades to exploit this potential. They rely on ready access to georeferenced data and on the kinds of computing power now available on the researcher's desktop.

Geographically Weighted Regression

One of the newest of these is Geographically Weighted Regression (GWR), developed by Stewart Fotheringham and his colleagues at the University of Newcastle Upon Tyne, United Kingdom. GWR looks for simple linear relationships between variables, just like ordinary regression, but allows the parameters of the relationship (the slope and intercept) to vary spatially. For example, one might be interested in the relationship between family income and expenditure or between age and voting behavior. In both cases a linear relationship is expected (higher income leads to more expenditure; older people are more likely to vote), but the details of the relationship are allowed to vary from one area to another. The result of the analysis is a series of maps that allows the user to assess how the characteristics of the relationship vary spatially—a radically different and useful spatial twist on an old nonspatial idea. A book is now available on GWR (Fotheringham, A. Stewart, Chris Brunsdon, and Martin Charlton, *Geographically Weighted Regression: The Analysis of Spatially Varying Relationships,* New York: Wiley, 2002 [Editor's note: The GWR tools described here were included in ArcGIS 9.3.]), and software is available from www.ncl.ac.uk/~ngeog/GWR.

The Center for Spatially Integrated Social Science was established at the University of California, Santa Barbara, in 1999 to help social scientists learn about GIS and spatial analysis and to provide them with tools and other kinds of infrastructure support. CSISS runs seven programs:

- Conducting summer workshops for social scientists to introduce them to basic and advanced concepts in spatial social science
- Conducting specialist meetings that bring together people, working on major social issues, to discuss the importance of spatial methods
- Disseminating examples of best practice (Spatially Integrated Social Science, Oxford University Press, December 2003)
- Developing new tools that implement methods of spatial social science (directed by Luc Anselin at the University of Illinois, Urbana-Champaign)
- Providing an extensive set of resources on the CSISS Web site (www.csiss.org) including bibliographies and engines that search the Web for relevant information and tools
- Enhancing the ability of social scientists to search for data and other information by geographic location
- Providing a collection of online materials (e.g., syllabi, lecture notes, tutorials) to help social scientists learn about GIS and spatial analysis

CSISS was founded on the principle that space can be an integrating theme across the social sciences. Economists study economic processes, demographers study population, and criminologists study crime; to a large extent each social science exists in isolation from the others, studying its own piece of the social pie. Every GIS professional is familiar with the notion that location can integrate disparate layers of information. CSISS extends this argument to disparate social processes, arguing that it is at specific places and times that economic, demographic, and other social processes interact and combine and that GIS and spatial analysis therefore provide the key to interaction.

These are very early days in spatial social science. Only a fraction of 1 percent of the literature published in the social sciences takes a spatial perspective, so the potential for growth is still enormous. Very few university programs in the social science disciplines currently include GIS or spatial analysis, although interest is definitely growing. The National Science Foundation (NSF) recently announced a program to support research in spatial social science, and NSF also supports CSISS. In the coming years CSISS anticipates a rapid growth of interest—with GIS facilitating greater interaction among the social sciences and more productive connections outside the "ivory tower."

(Reprinted from the Spring 2004 issue of *ArcNews* magazine)

Pinpointing the Languages of the World with GIS

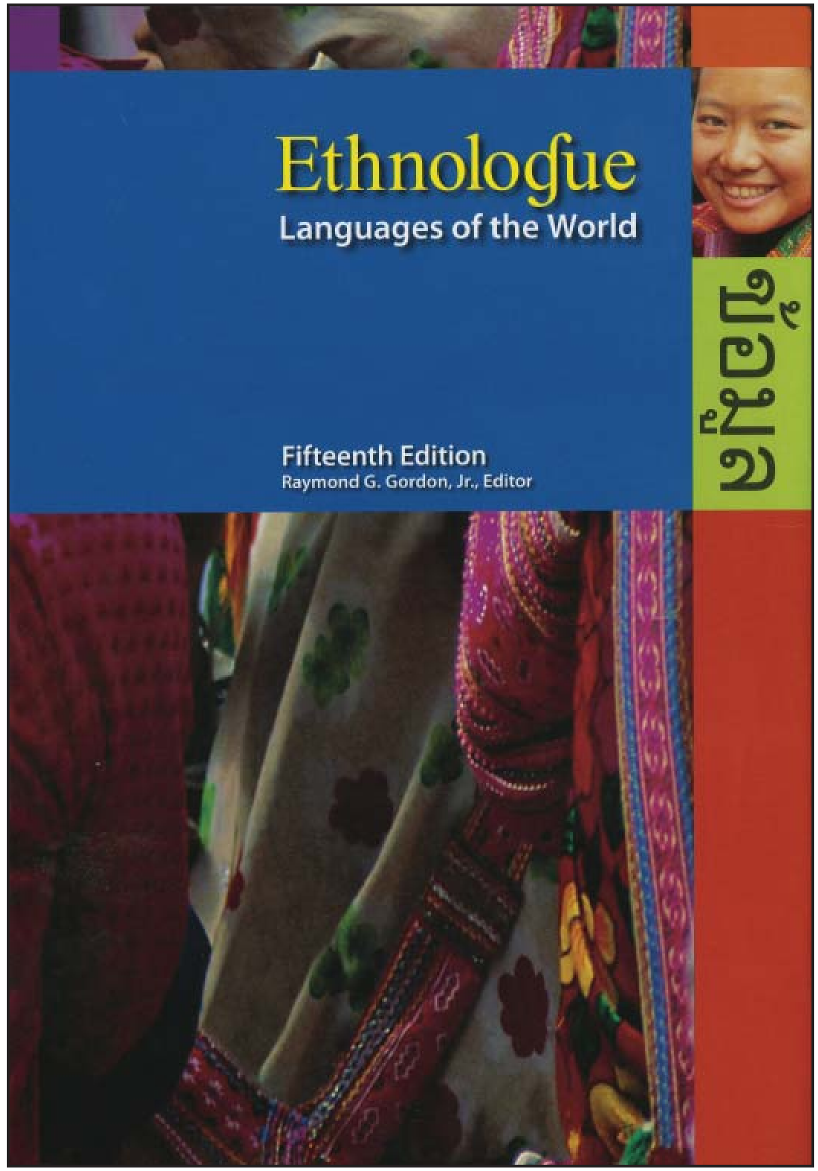
Service Organization Catalogs and Maps Linguistic Data

Relatively few of the nearly 7,000 existing languages have the global influence of, for example, English or Spanish. In fact, many languages are in danger of becoming extinct because so few people speak them. For various reasons, speakers of a particular language might stop using it, and sometimes the number of users declines until there are no speakers left and the language vanishes. This kind of loss of linguistic diversity can affect changes in societies and cultures. At the same time, as endangered languages fall out of use, new languages are discovered or reclassified.

People with language interests, who study the vicissitudes of languages as new ones are cataloged and others fade away, need information about the locations of the world's living languages. Linguists, translators, anthropologists, educators, government officials, aid workers, and investigators rely on up-to-date data about the currently known languages of the world.

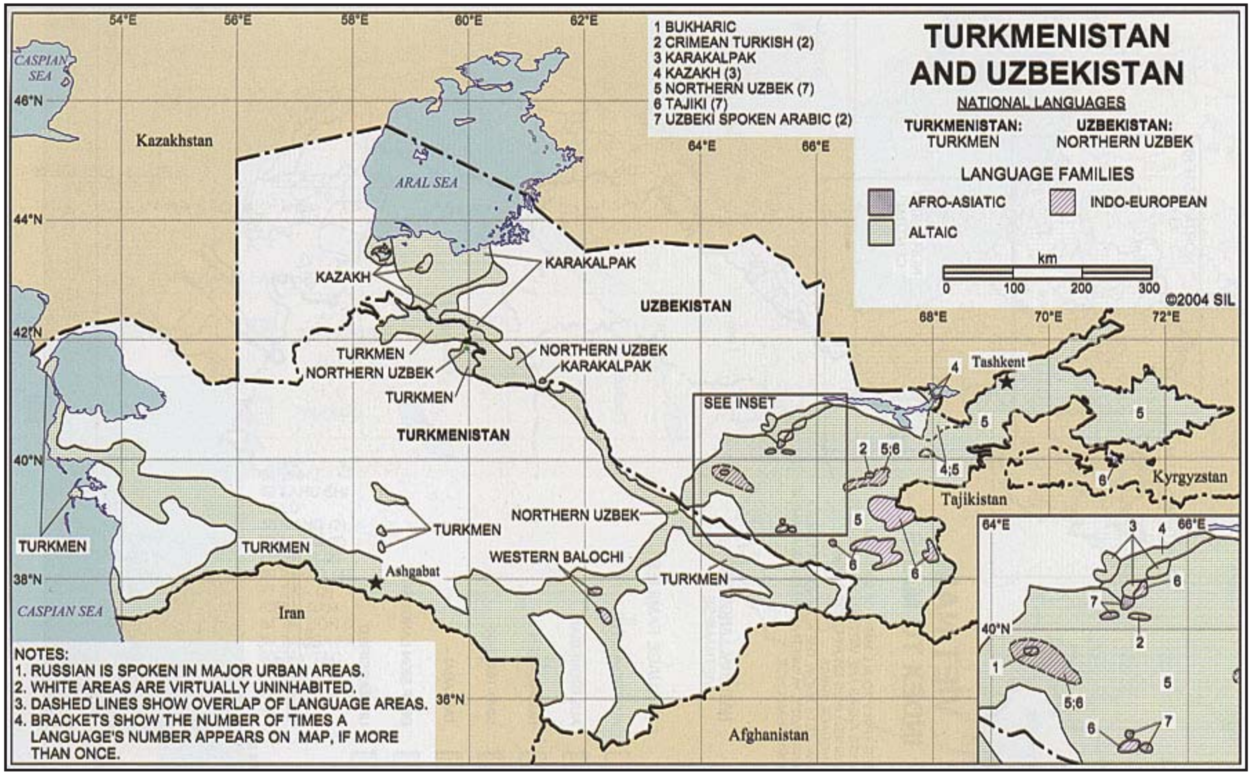
For more than 50 years, SIL International, a service organization that works with people who speak the world's lesser-known languages, has published *Ethnologue,* a comprehensive listing of the known living languages of the world. Richard S. Pittman founded *Ethnologue* because he wanted to share information on language development needs with his colleagues and other language researchers. The fourth edition of the book, published in 1953, included maps for the first time showing the locations of language homelands for a few countries. In 1992, the project began generating the maps using GIS, and since then increasing numbers of maps have been included with each edition so that now maps are published for most countries of the world. The recently-published Fifteenth Edition of the *Ethnologue* includes 214 pages of maps produced with GIS and appearing in color for the first time. The Fifteenth Edition also introduces a new set of language codes adopted by the International Organization for Standardization.

The *Ethnologue* database has been an ongoing research project. Every four years, a new edition of the book is published, and the continually updated database is available online at www.ethnologue.com, which includes maps and an extensive bibliography with citations for thousands of published works with additional information about the languages of the world.


Ethnologue
Languages of the World
Fifteenth Edition
Raymond G. Gordon, Jr., Editor

Language Mapping Project

The map products are the result of a collaborative effort between Global Mapping International (GMI), an ESRI Business Partner, and SIL International. The geographic database developed from this joint effort is called the Language Mapping Project. Initially, the two organizations worked together to digitize information from various sources. Currently, SIL International is responsible for maintaining and revising the language polygon data and other linguistic information, and GMI provides the GIS technical expertise and geographic data and shares the language data.



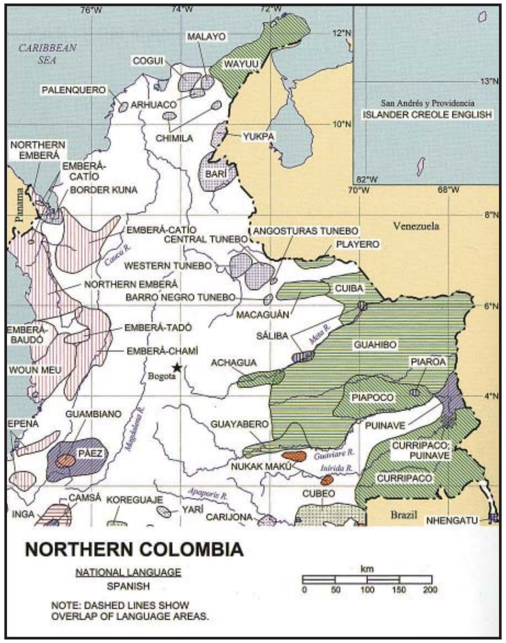
Ethnologue *maps of Turkmenistan and Uzbekistan.*

In addition to providing map output for *Ethnologue,* the Language Mapping Project also distributes language location data to other SIL publications and agencies that use the data for planning and publication.

Irene Tucker is SIL International's chief cartographer and is responsible for research and maintenance of the map database of the world's language groups, producing the maps for *Ethnologue* and other corporate requests and supporting language surveys. The boundaries of individual languages and language families are shown with polygons. Tucker says, "Since 2004, we have introduced the use of ArcGIS Desktop and are now working toward moving all our work across to ArcGIS 9.1. Most jobs can be done using ArcView, but we use ArcEditor for annotations because it is vital to maintain the link between the individual language polygons and their language names as they are supplied and revised in the *Ethnologue* database."

Tucker has a GIS staff of three full-time and four part-time people working on the database. Another dozen SIL International staff members use GIS software for maps in their specific regions of interest and contribute to the database maintenance. Other data is generated from first-hand knowledge of SIL International members who are working in the field on approximately 1,400 language projects around the world.

The hand-drawn maps that were first published in *Ethnologue* quickly became out of date, says Tucker. "The GIS allows us to maintain a database of polygons that can be linked or joined to the textual information published in *Ethnologue.* This information is also stored in database format, which enables us to quickly and easily produce maps that are both up to date and capable of showing any aspect of language development and linguistics that is required."



Ethnologue *map of northern Colombia.*

Broader Coverage

Bill Dickson, GMI, says that the worldwide GIS point, polygon, and *Ethnologue* attribute data from the Language Mapping Project is available to the GIS community as the World Language Mapping System (www.gmi.org/wlms).

Polygons delineate the linguistic homelands of approximately 8,800 language-in-country entries in *Ethnologue* with coastlines and international borders corresponding with ESRI's Digital Chart of the World (VMap Level 0). Also included are polygon overlays for mixed-language areas, point locations of all *Ethnologue* languages, and attribute data corresponding to *Ethnologue*. Data from this system appeared in a large map on display at the 2004 ESRI International User Conference.

(Reprinted from the Spring 2006 issue of *ArcNews* magazine)

Spatial Analysis Optimizes Malaria Prevention Measures

By Allen Hightower, Centers for Disease Control and Prevention

International organizations that provide aid to poor, sick, and vulnerable people in underdeveloped nations often struggle with a serious ethical question. In a world in which resources are insufficient to help everyone, will assistance given to one group negatively impact other groups?

This was the dilemma faced by public health researchers working in Africa during the late 1990s. A major program had been proposed to test the effectiveness of insecticide-treated bed nets in reducing the incidence of malaria, especially among children. Although the impetus for the program was developing strategies for efficient distribution of the limited bed net supplies, the chief concern of researchers was whether people who didn't receive nets would suffer because their neighbors did receive bed nets.

Epidemiologists hypothesized that malaria carrying mosquitoes, unable to feed on people protected by the nets, might swarm in greater numbers at nearby homes lacking nets. Ultimately, this question and several others were answered—with surprising results—through spatial analysis of bed net distribution patterns and malaria infection rates in Kenya. The area was mapped using GPS and GIS technology.

"We had to make sure that bed nets did not merely redistribute malaria cases throughout a community," said Bill Hawley, biologist with the Centers for Disease Control and Prevention (CDC) in Atlanta. "Without GPS mapping and GIS analysis, this project would have been impossible."

CDC teams mapped one village per day and collected location and attribute data for features relating to malaria and other health studies.

Dying of Malaria

Malaria kills between one and two million children under the age of five every year in Africa. Nearly all of the infectious bites come from three mosquito species that feed on blood between 11 p.m. and 3 a.m. In equatorial Africa, most houses have open doors and windows. People asleep in their beds are easy prey. However, this predictable feeding pattern also was advantageous in developing preventive measures because both the timing and setting of infectious bites were known.

Permethrin is an insecticide that is harmful to mosquitoes but safe for humans. Draping permethrin-treated nets around beds was a practical solution. But before the nets could be widely distributed, international aid organizations wanted evidence that bed nets were effective in reducing malarial infection, mortality, and morbidity and that neighboring areas without nets would not experience corresponding increases in these effects.

CDC believed this type of statistical and spatial analysis could only be conducted in the GIS environment and spearheaded the effort to track and map the results of a pilot bed net study in Kenya. Two adjacent sites near Lake Victoria, Asembo and Gem, were selected because both had high rates of malarial infection. Covering roughly 500 square kilometers, the study area included 125,000 people living in 200 villages. Each village is comprised of multihouse compounds occupied by extended families.

In 1998, CDC initiated the pilot study at an existing field station in the village of Kisian. Here, ArcView was used to build a GIS of the study areas of Asembo and Gem. The only usable maps available had been created in the late 1960s at 1:50,000 scale. This meant Asembo and Gem would have to be mapped on foot using GPS receivers. The accuracy of this field mapping was crucial to the project's success because the analysis of bed net distribution and human infection rates would be conducted at the individual house level.

"Prior to the study, the majority of the scientists, including myself, were rather skeptical about the use of GIS mapping," said Feiko ter Kuile, a project participant and clinical epidemiologist at the Liverpool School of Tropical Medicine in the United Kingdom. "I don't think any of us appreciated that the ability to map each household was going to be so beneficial years later in the analysis phase."

Mapping from Scratch

CDC and participating researchers trained mapping teams in the use of GPS receivers and handheld data collection devices. These teams were mostly composed of Kenyans with no background in GPS or mapping. CDC purchased four Trimble Pathfinder Pro XRS GPS receivers with Trimble TDC1 Dataloggers. *[TDC1s are handheld computers.]* Trimble Pathfinder Office software was loaded onto a PC at the Kisian station, and feature collection dictionaries and menus were created and uploaded to the TDC1s for field use.

When the project began, commercial GPS reception was still being degraded by Selective Availability to an accuracy of 100 meters. Because the houses to be mapped were relatively small and spaced just a meter or so apart, differential correction was required. CDC dedicated one Pro XRS to base station duty in Kisian. Unfortunately, no known survey markers were located nearby to provide a reliable control, so CDC researchers averaged one month's worth of nondifferential readings at the site and used the result at the base station location.

The teams mapped one village per day focusing on the collection of location and attribute data for features relating to malaria and other health studies. Key map features included houses, compounds, villages, roads, livestock pens, water sources, medical facilities, and the Lake Victoria shoreline. Villages and compounds were identified by numbers and houses by letters marked on the structures and recorded in the data collector. Mapping teams used pull-down menus on data collector screens to enter attributes of features such as the number and ages of each house's occupants and the codes used to identify occupants by their positions in the family.

House mapping was greatly accelerated by an Advantage GPS mapping laser from Laser Atlanta of Norcross, Georgia. The laser was linked by split serial cable to the GPS receiver and the data collector. This enabled a field crew member to stand in the middle of a compound and remotely record the location of each house by firing the laser. The laser calculated the offset distance from the crew to the house, which was then automatically corrected by the GPS to determine the precise coordinates of the structure.

After each day's mapping, the crews returned to Kisian and uploaded the location and attribute data from TDC1s into Pathfinder Office. Although the GPS equipment used was capable of real-time differential correction, this was not done because it would have required radio broadcasting of the correction signals from the base station. In Kenya, broadcast licenses are difficult for foreigners to obtain, and the field site was located 40 kilometers away over rocky terrain.

Instead, Pathfinder Office used the base station GPS data to perform differential postprocessing to correct the accuracy of the feature location measurements collected in the field. The attribute data was edited and cleaned up using Pathfinder Office software and added, along with feature points, to the GIS for Asembo and Gem.

Over the course of the project, CDC upgraded its equipment. In late 2003, it began using integrated Trimble GeoXT receivers. These units combine a rugged GPS receiver and data collector in one unit that eliminates complicated cable hookups and greatly simplifies fieldwork.

In late 2003, the team began using integrated Trimble GeoXT units, which simplified data collection.

Tracking Malaria

With the initial basemap and data collection completed, CDC began distributing bed nets to half the villages in the study area. Houses in villages with the nets were noted in the GIS. From that point, information gathering shifted primarily to the collection of health and related statistics. Crews kept careful records of those who became infected with malaria, those who became ill, and those who died. Field teams counted mosquito larvae found in stagnant water as well as live mosquitoes captured in traps placed throughout the project area. In all cases, the results were mapped in the GIS.

In addition to tracking illness, the crews continually updated existing data and gathered new data on the study area. As new houses were built or families moved to other villages, these occurrences were recorded. In later phases of the project, feature map updating became a much simpler process. Trimble TerraSync software allowed the researchers to download GIS map and attribute data from the office PC in Kisian to the GeoXT units. Crews took GIS data into the field, updated it there, and uploaded the updated files to the enterprise GIS at the end of the day.

Surprising Results

After several years, clear trends began emerging in the bed net study. Results were quantified by multivariate analysis of the relationships among villages with bed nets; villages without nets; mosquito density surveys; and instances of malarial infection, sickness, and death. In the early phases of the program, GIS data was downloaded to a statistics software package to help unravel these complex spatial relationships. However, after CDC upgraded to ArcGIS ArcView 8.3, this analysis could be performed and visualized using the ArcGIS Geostatistical Analyst extension.

"The results were surprising," said CDC's Hawley. "Bed nets not only reduced malarial infection within the villages where they were used, but they also benefited people in villages without nets." The study confirmed that bed nets generated significant results in all statistical categories in the villages that received them. Incidents of bites, sickness, and death all fell. In children less than two years old, mortality was reduced by 17 percent, clinical malaria attack rates were reduced 75 percent, and mosquito biting rates were reduced by more than 90 percent.

It may seem redundant to track all three of these seemingly related statistics (bites, sickness, and death), but this data was the key to gauging the nets' overall effectiveness. Some scientists feared that mosquito bites were occurring in such large numbers in the study area that simply reducing the total might have no impact on the overall spread of malaria. However, the study proved otherwise.

As several researchers observed, the real surprise was that infection, sickness, and mortality also dropped in areas where no nets were used. Spatial analysis revealed that houses within 300 meters of a bed net village enjoyed protective benefits. This halo effect diminished at a distance of 300 to 600 meters and beyond. "We would not have been able to detect this community effect without information on the exact location of each household," said ter Kuile.

Approximately 22 percent of households without bed nets benefited from this community effect. Traditional estimates of bed net effectiveness compare the health of people without bed nets to people with bed nets. Because people without nets were benefiting from their neighbors' nets, bed nets were more effective than researchers thought.

Clues to why the community effect occurs are emerging from analysis of mosquito densities recorded within the study area. "The nets profoundly reduced the population of mosquitoes in and around the villages that had them," said Hawley. "We believe that people sleeping under nets attract mosquitoes to the permethrin-coated net surface, which then kills, or at least sickens, the mosquitoes so they never have the chance to travel elsewhere to find a meal."

This project continues, but the focus has shifted to determine the ideal pattern of distribution for insecticide-treated bed nets so the limited supply can be used to benefit the greatest number of people. The most important result of this study was proof that the nets were effective. Millions of children in Africa and around the world are now sleeping more safely beneath bed nets donated by international aid organizations.

About the Author

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Note: Use of trade names and commercial sources is for identification only and does not imply endorsement by the U.S. Department of Health and Human Services.

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Preserving the World's Dying Languages with GIS

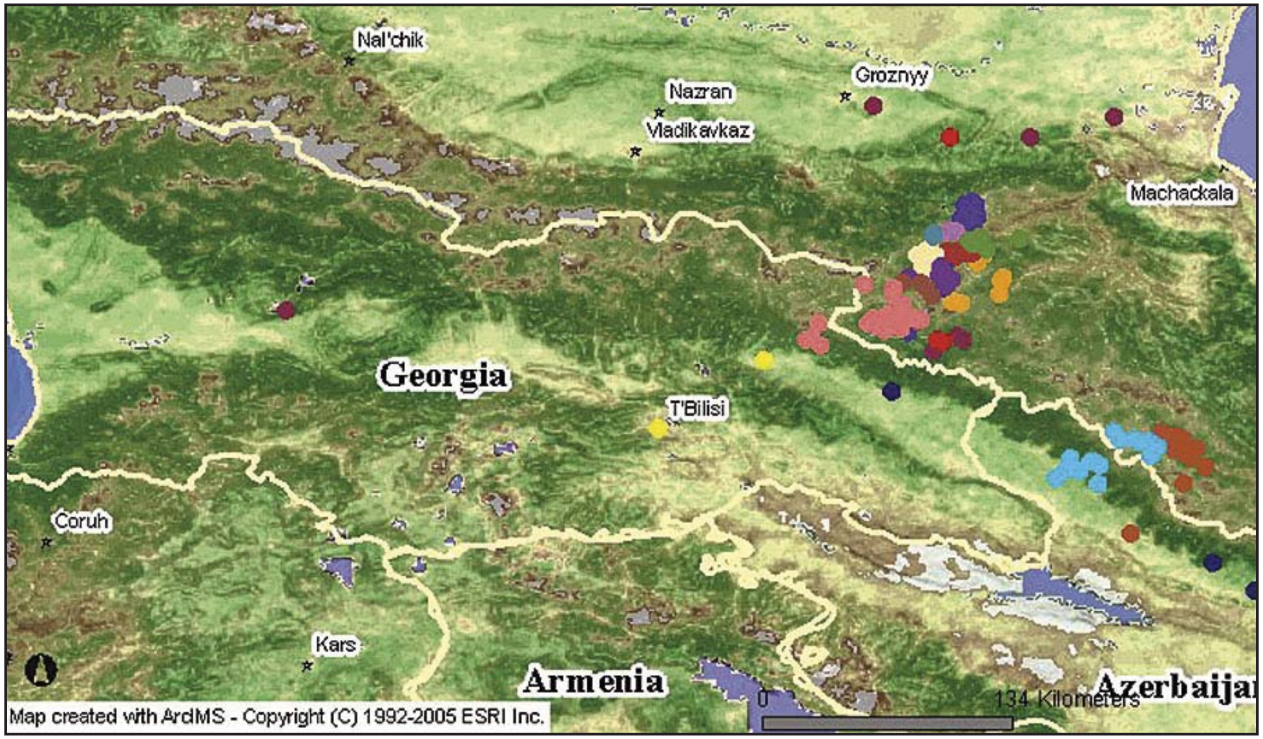
Language evolves out of a need to communicate the experiences, instruction, cultural development, and idiosyncrasies of the village. It is the vessel that retains the special character of the village and the thoughts and beliefs that foster its uniqueness. Language provides the village with identity, community, and context.

With languages such as Mandarin Chinese and English, taken together, currently being spoken by almost 1.5 billion people throughout the world, it is difficult to imagine them as linguistic communities within the village or tribal context. However, the tribal influences are there, if only by dialect and colloquialisms.

At last count, nearly 7,000 distinct languages are spoken in the world today. However, fewer than 100,000 people speak 90 percent of these known languages, and some of those that are more rare have significantly fewer native speakers. As a result, linguists estimate that more than half the languages currently spoken in the world will become extinct by the end of this century.

Because of its geographic location, wedged as it is in the mountainous region of southeastern Europe between the Black and Caspian Seas, the Caucasus is considered one of the most linguistically and culturally diverse places on earth. The Caucasus is home to about seven million people from 17 nations and autonomous regions that speak nearly 60 different languages. The region is sometimes known as "the Mountain of Languages," and in some cases, the smallest languages are spoken in single villages only.

The geographic and cultural isolation of the Caucasus engenders the development of self-sustaining pocket languages, limited to village or pan-village use. Economics plays a role in the use of village languages in this region. Those residing on the upper slopes of a mountain tend to learn the language of those below them but not vice versa. This is because those in the upper villages must sometimes travel to villages in lower areas for employment and trade, while those inhabitants of villages in the lower regions rarely move up the mountain for commerce or social interaction. It is a foregone conclusion that many of the languages currently spoken in the Caucasus will disappear within the next 100 years and, with them, the cultural context from which these languages sprung.



The smaller languages of the northeast Caucasian family.

Because of size constraints, the majority of the lesser languages spoken in the Caucasus are not represented in the existing map books of the region that highlight language use. The number of languages is too great, and the map scale and page size restrict the amount of printed information that can be included on the map and still remain intelligible to the reader.

In response, linguists in the Department of Linguistics at Stockholm University in Sweden are using ArcGIS Desktop (ArcInfo) for the development and maintenance of their Language Map Server applications. ArcIMS is used to distribute the information generated via the Web. The researchers' ultimate goal is to document the geographic range of the minor languages spoken throughout the world before they are lost forever.

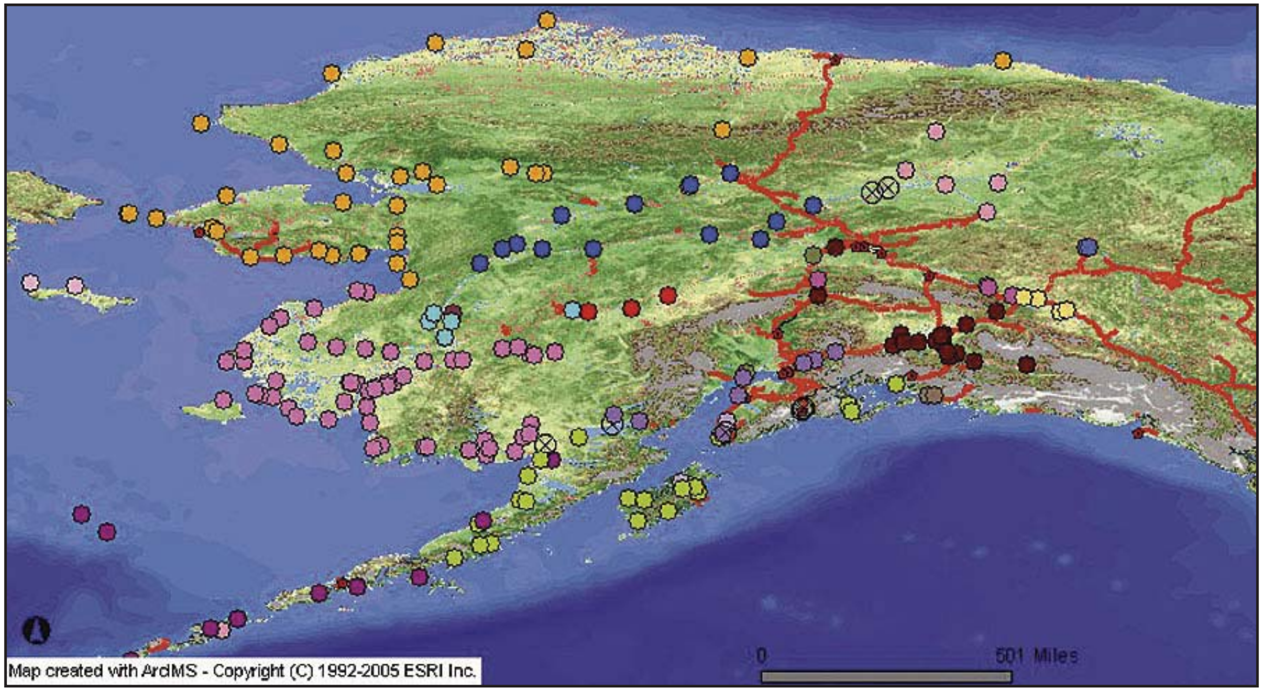
The first step is their prototype application documenting the smaller northeast Caucasian languages.

Comments Stockholm University linguist Dr. Ljuba Veselinova, "Our application depicts the location of the people speaking the various languages in this area as accurately as possible on the displayed maps. It also presents the genetic affiliation of the languages, information about dialects, and the current number of speakers through the use of pop-up tabular data stored in a relational database. This method allows us to accurately record areas where there is an overlap of different languages currently being spoken—that is, multilingual areas. The site can be used by anyone who needs to obtain genealogical, demographic, or geographic information about these languages. It will be of particular use to cultural anthropologists."

The university hopes to expand the database to include all the languages currently spoken in the Caucasus, which would allow comparative historical studies of the area, such as tracing the traditional migratory patterns of the people of the region through their languages. In addition, the application could hot link photos of the people of the region to the displayed maps and provide audio samples of their languages.

"The languages that we are targeting are documented in a variety of ways," continues Veselinova. "In some cases, all we have is the grammar. In others, audio files, as well as other language-related materials, are available. Once the general structure is developed, we will be able to include multimedia materials in the later stages of the project."

Professor Östen Dahl, Stockholm University linguist, is collecting data on native Alaskan languages for an additional geographic region of the Language Map Server project. His research not only includes genealogical and geographical information about the languages of the region but also census information regarding the proportions of native and nonnative populations in the areas depicted on the Alaskan map.



The Languages of Alaska—general overview.

Concludes Veselinova, "In the future, we plan to provide Language Map Server applications for other regions in the world where a great variety of lesser languages are spoken. Our ultimate goal is to create an interactive language atlas of the world, which would be useful not only to researchers but also for language instruction at all levels of education."

The Languages of Alaska—a closer look at Inupiaq, and Koyukon.

GIS in Linguistics, which is hosted by the Department of Linguistics at Stockholm University, is the official Web site for the Map Server Project (Web: ling-map.ling.su.se/website).

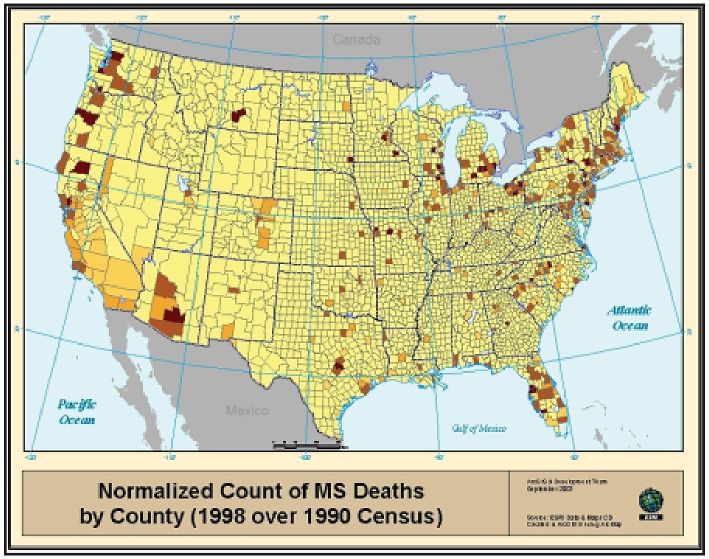
(Reprinted from the Spring 2006 issue of *ArcNews* magazine)

Spatial Patterns of Disease Inspire New Ideas on Possible Causes

By Susan Harp, ESRI writer

George de Mestral envisioned the design of the Velcro fastener in 1948 while picking burr-covered seedpods from his dog's fur after a mountain hike. As the story goes, the Swiss citizen stopped to observe the sticking qualities of Mother Nature's design and made the leap to a new, creative application. With the avalanche of information available to researchers today, the catalyst that helps produce this kind of "ah hah!" moment is extremely valuable. For Megan M. Blewett, a young 21st-century researcher, spatial geography played a role in both her "ah hah!" experience and her research.

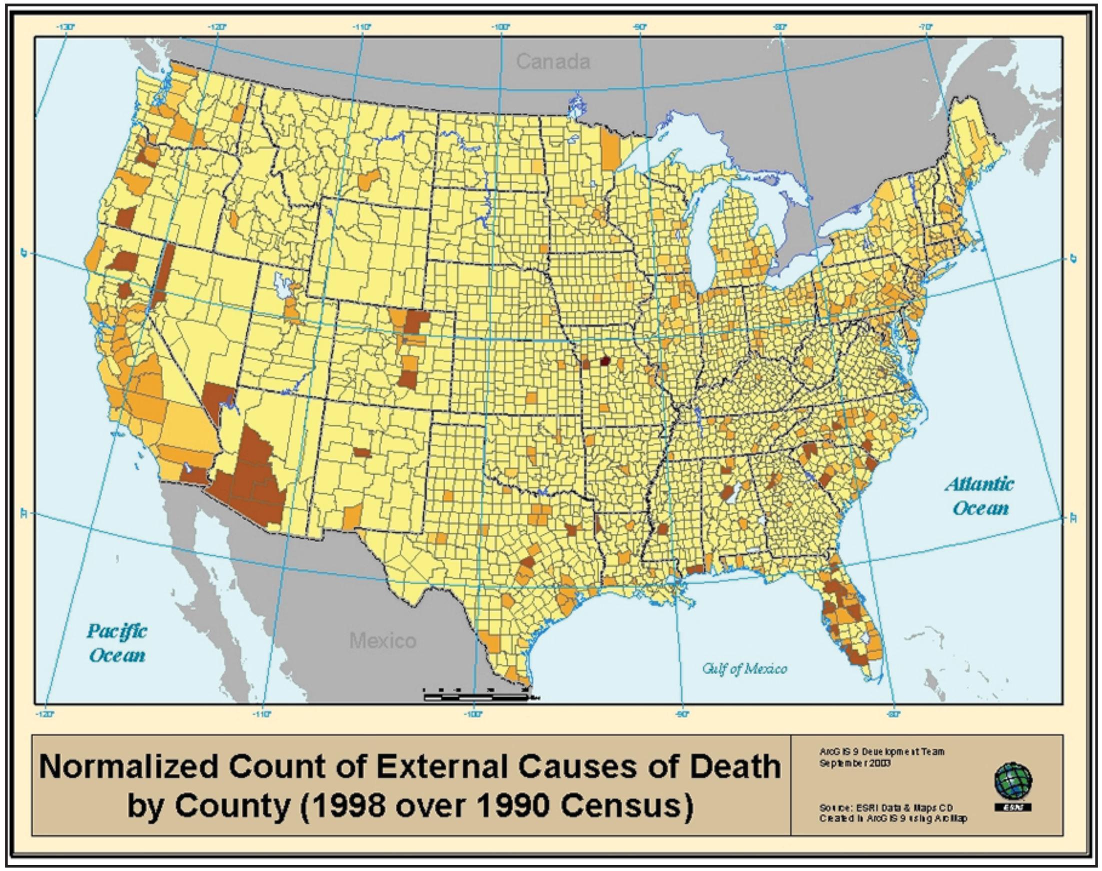
Blewett turns 18 this year, but five years ago, she was already reading a neuroscience textbook and asking questions about a mysterious disease—multiple sclerosis (MS)—that she found described in its pages.



Normalized count of multiple sclerosis deaths by county for 1998 shown over 1990 Census data.

"I started researching MS when I was 12 and have since fallen in love with discovering the insights spatial statistics can give," Blewett says.

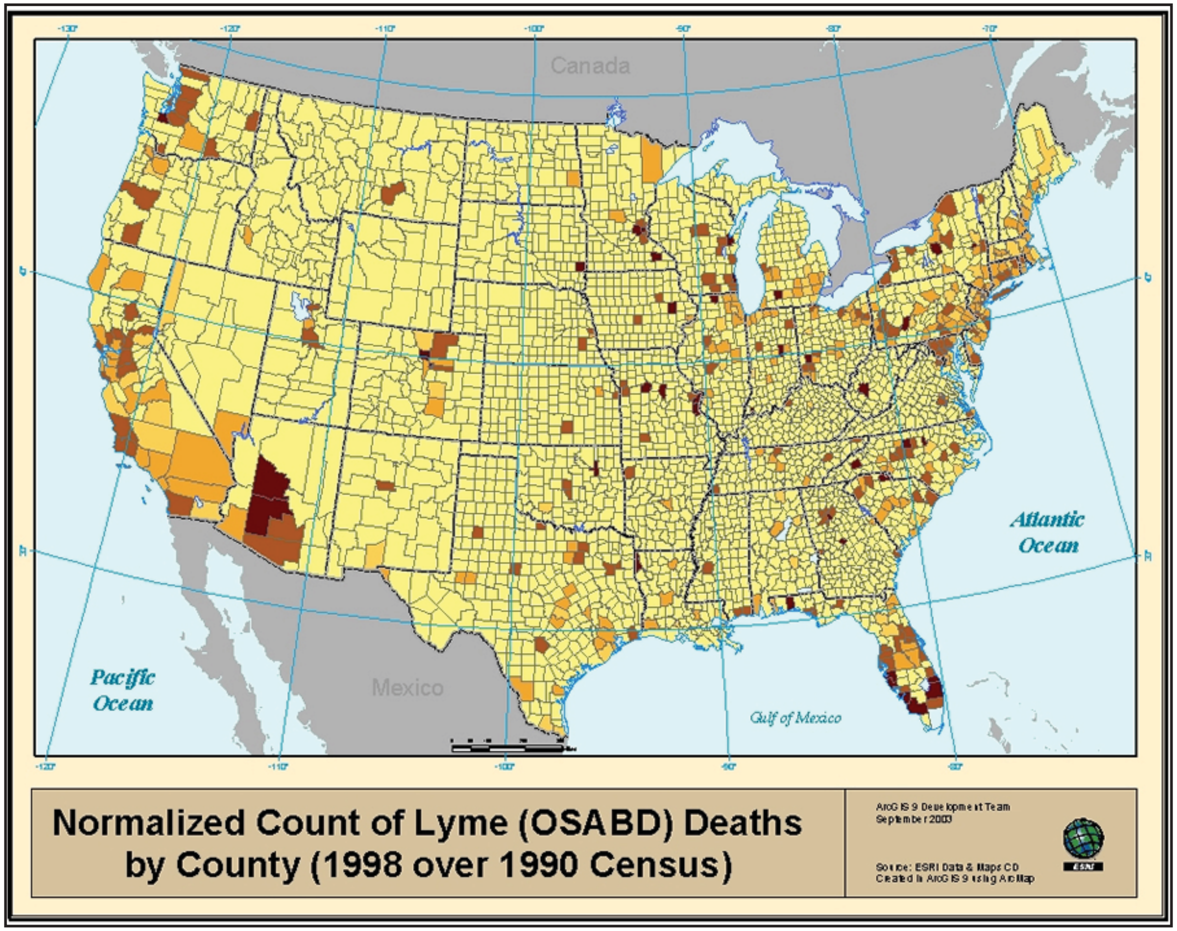
MS is a disease that affects the central nervous system. Its cause is unknown, but many researchers think environmental triggers might be a factor. This unsolved puzzle caught Blewett's attention. She started collecting data about MS cases in her home state of New Jersey, learning to map their distribution with GIS software and use spatial statistics tools to analyze that distribution. She also continued to read about the neurological and biochemical aspects of the disease.



Control data: Normalized count of external causes of death by county for 1998 shown over 1990 Census data.

However, the "ah hah!" moment came while looking at a map. Blewett explains that it occurred at a science fair while talking with one of the judges about her map of MS distribution in New Jersey.

"I just got lucky there," comments Blewett. "I was looking at a state map of MS distribution and saw that my county, Morris County, has a high incidence of MS. You could see individual towns and I knew the town next to me had a high incidence of Lyme disease." Lyme disease is a bacterial infection known to be spread by tick-borne spirochetes.



Normalized count of Lyme disease deaths by county for 1998 shown over 1990 Census data.

Blewett was already using ArcGIS Desktop to map MS distribution. When she started thinking about a possible Lyme disease correlation with MS, she added Lyme data to her map layers. "I saw all these correlations and results that I hadn't been able to see before and still don't think I would have been able to see if I had been using more conventional chemical research to look at individual proteins at work," Blewett adds. "Spatial statistics allowed me to see the bigger picture. Then I zoomed in to look at proteins at work in MS and related demyelinating diseases. I like to say my research path is analogous to reading the summary before reading the book."

The data collection process turned out to be one of the harder parts of the research. Data came from TheDataWeb and DataFerrett through the Census Bureau and the Centers for Disease Control and Prevention (CDC). Blewett contacted every mainland U.S. state epidemiologist asking for Lyme disease data and eventually received data from every one.

"To my knowledge, it is the largest standardized dataset of Lyme information in existence," says Blewett about the dataset, expressing a willingness to make the data available to other researchers. She subsequently ran correlation analyses using a Pearson's, Kendall's, or Spearman's coefficient, as deemed appropriate.

All variable values were converted to z-scores for use in a regression analysis. Finally, cartographic analyses compared MS, Lyme (from other specified arthropod-borne diseases data), and control from external cause of death data.

"The two disease distributions were pretty similar—they correlate and the control doesn't," explains Blewett. "Biochemically they are also very similar, so it has just taken off from there."

She hypothesizes that both diseases may share a common spirochetal basis and MS might develop from a secondary tick bite.

Megan M. Blewett.

Blewett consulted with ESRI spatial statistics expert Lauren Scott on using GIS in her research, and Scott comments, "While biologists and medical researchers investigate this hypothesis at the cellular level, Megan's work examines the spatial fingerprint of these two diseases at broad spatial scales, then tests hypotheses regarding their spatial correlation." "I wish to expand my research from a national to a global scale, while also testing my models in smaller geographic areas," Blewett continues. "A recent study suggests that MS is in fact 50 percent more common than previously predicted."

Blewett presented her work at the 2006 ESRI International User Conference and participated in the Academic Fair during the 2006 ESRI Health GIS Conference. This year, she was accepted into several top universities and awarded seventh place in the prestigious 66th Annual Intel Science Talent Search.

(Reprinted from the October 2007 issue of *ArcWatch*)

What Historians Want from GIS

By J. B. "Jack" Owens

An increasing number of historians, particularly those dealing with world history or the history of large geographic regions, are becoming interested in using geographic information systems for research and teaching. Historians are noticing GIS because they normally deal with processes in complex, dynamic, nonlinear systems and, therefore, demand a means to organize a large number of variables and identify those variables most likely implicated in the stability and transformation of such systems.

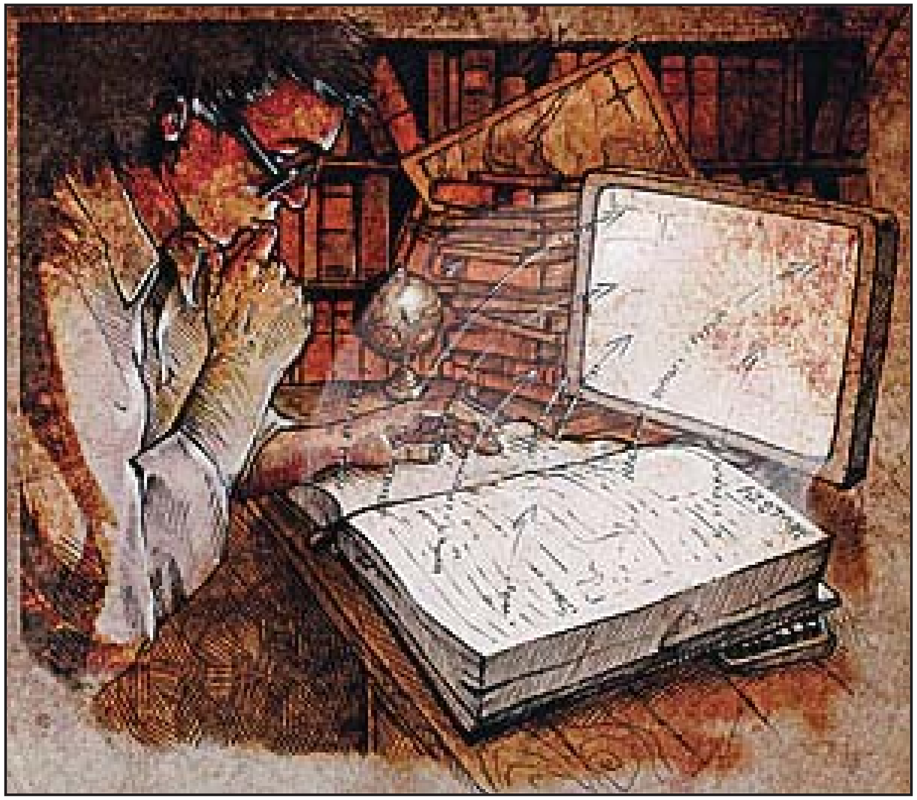


Illustration by Jay Merryweather, ESRI.

However, GIS remains largely unknown among the vast majority of professional historians, and a significant percentage of those who believe they know about the technology think it is something they can buy with their next car so that they will not become lost. Even those interested in some sort of *geographically integrated history,* a term I prefer to escape some of the limitations of the more familiar *GIS history,* would justifiably categorize the title of this article as pretentious.

GIS and History

I am often the only historian at geographic information science (GIScience) meetings, and my presence provokes the obvious question. A story will explain why a historian would become interested in GIS. At the beginning of my graduate studies, I read Fernand Braudel's *La Méditerranee et le monde méditerranéen a l'époque de Philippe II* because I was studying the western Mediterranean in the 16th century and plunged into this 1949 book with considerable enthusiasm despite its imposing length. As I read Braudel's attempt to integrate the slow changes in the Mediterranean's geographic form, climate, flora, and fauna with the faster alterations in human socioeconomic relations and the specific wars, political alterations, and other events of the 16th century, I struggled to understand how these different layers of the account, which were discussed in sections characterized by the variable speeds of temporal process, fit together. At the time, I tried tracing maps of human cultural features, such as cities and centers of economic activity, over topographic maps in an effort to integrate better the elements of Braudel's history. This work produced nothing more than a visual mess, which also failed to capture the considerable dynamism of Braudel's account. Moreover, I repeatedly felt frustrated that I could not easily examine particularly interesting segments of my visualizations at a larger scale.

Many years later, on a hot, sleepless night in Murcia, Spain, in 1983, I used my daughters' tracing paper and colored pencils to try this technique again. This time, I was investigating the development of a cohesive oligarchy in southeastern Castile and wanted to see, literally, how my different types of data went together. I was particularly interested in the evolution of social networks among individuals, families, and communities within a regional social and cultural environment. Alas, even for this more spatially restricted story, no useful result emerged from the tracings that captured the dynamism and complexity of the processes involved.

Fernand Braudel sought ways to shake historians into an awareness that they needed to focus on geography. The second edition of La Mediterranee (1966) featured a striking image designed by famed cartographer Jacques Bertin. Maps of the Mediterranean Sea often show how much of Europe is only a tiny slice of North Africa. To emphasize the importance of Africa to the Mediterranean, Bertin oriented the map toward the south, **showing Africa looming over the Mediterranean with a relatively small Europe on the other side of the sea,** *much as this satellite image conveys this geographic relationship. (Image courtesy of NASA.)*

Again, after the passage of many years, when I told this story during an online discussion of possible titles for Andre Gunder Frank's 1998 book *ReORIENT: Global Economy in the Asian*

Age, I learned from other participants, Martin Lewis and Kären Wigen, that a method existed to undertake the type of visualization I had earlier attempted. They recommended that I try GIS as an integration and visualization tool, and I participated in my first GIS workshops with great aesthetic and intellectual satisfaction.

It so happens that Frank's book, which focuses on the first global age, 1400–1800 CE, formed part of a body of work produced by Braudel, Immanuel Wallerstein, and others on historic "world systems," which were geospatially large, interconnected, dynamic entities of considerable complexity. Although Frank rejected existing linear, civilizationalist, and Eurocentric social science theories of historical development, as well as his own pioneering work in economics on dependency theory, he admitted that he did not know how to undertake the type of data organization and analysis that would be necessary to understand such complex systems. He, therefore, limited his book to a path-breaking discussion of the world economy, for which he received the inaugural Best Book prize of the World History Association in 1999. Since early 1995, Frank had been pushing me to figure out how such a comprehensive "holistic global analysis" (his phrase) could be done. It increasingly appeared to me that GIS, with its capacity for the aggregation of data on the basis of geographic location and spatial analysis, provided a tool for the work that Frank had wanted to do before he died in April 2005.

GIS and Disciplinary Crisis

It is difficult to convey to readers of a written text a complex, multidimensional history, even a linear one. Because such a high percentage of the human brain becomes engaged by visual tasks, visualization must be a component of any account of this type of historical system, and with its tie to cartographic forms of representation, GIS visualizations can play a particularly valuable role in increasing the understanding of geographically vast subjects like the histories of major world regions or of the world itself. For this reason, GIS offers great promise as a means to develop high-quality classroom materials for history teaching.

Therefore, beyond its integration, visualization, and analytical potential, I began to look on GIS as the central piece of a response to the serious and worsening crisis in which the discipline of history had been enmeshed throughout my teaching career. Through a failure to adapt, history surrendered its place in a curriculum designed by Renaissance educators to prepare students for *humanitas,* effective leadership. For 35 years, the discipline has suffered from a tight higher education job market, the relatively low position of history departments in the development plans of most colleges and universities, a lack of appreciation by university administrators for the discipline's traditional publication emphasis on the individually authored monograph, and the growing weakness and instability of history in K–12 curricula. Over the past decade or more, the disciplinary crisis has become dangerous because leaders of four-year and graduate institutions have confronted a rapidly changing U.S. higher education environment. Levels of federal and state support have fallen, and public and private institutions recognize limits on tuition increases to cover budget shortfalls. Higher education cannot easily reduce expenditures because students must be prepared to deal with constantly shifting, globalized environments whose developments are driven by rapid changes in communications and information management.

The discipline will either contribute to the painful readjustment of U.S. higher education that is currently under way, or history departments will decline further in terms of resources and internal administrative influence within their respective institutions. In the midst of some institutional crises, existing history departments may disappear as the remaining history courses will be housed within other units, such as education, which will undermine the discipline's contributions to critical, research-oriented thought. It does not take much imagination to envision education programs, without coherent history departments, organized to produce teachers of the sort of uncritical, "patriotic" K–12 history curriculum advocated in the 1990s by some opponents of the national standards for U.S. and world history. What solution does the use of GIS offer?

Collaboration and GIS

Leaders of the discipline of history have long resisted collaborative forms of research, and they have been slow to adopt contemporary communications and information management technologies. Working alone, historians frequently extract data from sources that are difficult and time-consuming to discover and use, and thus, their research usually has a relatively narrow geographic and temporal focus. As one result, synthetic studies of cultural, institutional, and economic evolution over long historical periods often badly distort reality because this type of work has frequently been left to scholars from other disciplines who are largely unfamiliar with the nature, limitations, and uncertainty of the poorly structured, fragmented, messy data used by historians in their individual research. The failure to transform research practices and graduate training has crippled the ability of historians to respond effectively to major problems in world history and increasingly marginalized the discipline at major research universities.

GIS offers historians who specialize in the histories of different places and chronological periods an effective vehicle for collaborative research among themselves and for involving researchers from other disciplines. At any point in its work, a research team can visualize its available data and decide what additional information is required. Such research will often produce and be based on digital, shared databases, archived in public, online repositories, which will constitute a body of knowledge capable of expansion and the correction of errors. The cumulative results will allow us to better address the complexity of history by melding diverse voices and stories and a wide variety of sources. This capacity for collaborative work will enable historians to join research teams able to submit more ambitious proposals to a greater variety of funding sources and will lead to jointly authored papers addressing a broader range of problems and readers. By escaping their self-imposed disciplinary isolation, historians will enhance an already dynamic discipline at the same time they will make themselves an important part of the solutions to institutional budget difficulties.

The Future of History at ISU

In response to these many factors, and to produce leaders for this exciting future for historical research and teaching, the History Department of Idaho State University (ISU) developed a new internship- and GIS-based master's degree program in geographically integrated history, known officially as the M.A. in Historical Resources Management (MHRM). This appears to be the first history program of its kind in the world (see the Fall 2005 *ArcNews* article on the program, "Idaho State University Creates Innovative Program in History and GIS"), and it is one of the fundamental building blocks of ISU's proposed interdisciplinary Ph.D. in social dynamics and human biocomplexity. These developments are supported by ISU's GIS Center. Because the university has never had a geography department, the center's director reports directly to the vice president for research, and its oversight committee has representatives from all interested academic units, including the History Department.

During the process of creating the master's degree program, we transformed our undergraduate history curriculum to give it a distinctly geospatial focus. For example, we may be the only history department to state as a core objective that students will understand cartographic design and maps as historic sources. With the kind assistance of Waldo Tobler, I introduced a course on this subject to history undergraduates in the fall of 2006.

Although the first students only began their master's studies in August 2007, the program has already permitted the department to submit major multiyear funding proposals to support our own research and the educations of the master's students and participating undergraduates. We have under consideration a proposal for an ambitious multidisciplinary, comparative study of the impact of public policy on rangeland health in 20th-century Idaho, Mongolia, and Spain, and we are in the preliminary proposal stage of a project to develop GIS-based support for the high school U.S. history standards and to train public school teachers for this type of teaching.

We are also part of a campus group that is preparing a funding proposal for a temporal GIS. The National Science Foundation (NSF) has provided $394,000 to support for three years my participation and that of my graduate research assistants in a large GIS-based, multinational, multidisciplinary, collaborative research project entitled Dynamic Complexity of Cooperation-Based Self-Organizing Commercial Networks in the First Global Age (DynCoopNet). I designed DynCoopNet to address a program of the European Science Foundation's (ESF) European Collaborative Research (EUROCORES) Scheme, The Evolution of Cooperation and Trading (TECT), which was devised by evolutionary biologists and economists. The DynCoopNet collaborative research community investigates the evolution of cooperation among merchants and between merchants and other groups, with particular attention to the commercial networks of importance to the global domains of Iberian monarchies, 1400–1800 CE. In addition to the NSF support, I also receive generous travel support from EUROCORES, and I was named to the Scientific Committee, which will guide the entire TECT program.

After years of administrative neglect and failure to provide the History Department with necessary resources in the face of greatly increased enrollments, our GIS activity has drawn significant attention from ISU's administration. As one direct consequence, my department received approval to hire Sarah Hinman for a new position. She is a recent Ph.D. (of Louisiana State University's Geography Department) who uses GIS to study historic public health problems of U.S. cities. She will provide us with significant support as we strengthen our research and teaching programs. To help us maintain our momentum, we have reason to hope that we will soon be permitted to hire a historian of modern Europe with a strong programming and GIS background and to receive support for the graduate GIS teaching laboratory and classroom we have designed.

Challenges for GIS

As exciting as these new triumphs and opportunities are, we nonetheless recognize that there is much more to do to adapt GIS to a discipline, such as history, for which time is significant. I prefer to describe what we advocate as geographically integrated history because we cannot be locked into the questions and analytical techniques dictated by the available GIS software. Yes, of course, there are applications and combinations of applications that will take us partway down the required paths of dynamic history. To make further progress, though, it is clear that historians must concentrate on developing, in collaboration with other disciplines, process models that capture the importance of geospatial relationships and variations.

Because of the importance of time to their discipline, historians especially require a spatial-temporal GIS built on the basis of mathematical models that will permit an evaluation of the fit between data and theory, compensate for gaps in the data or missing data types, and facilitate the analysis of the emergence of new forms in complex systems and of object/field dynamics, such as the diffusion of innovations. These models must be appropriate for dealing with complex, dynamic, nonlinear systems, which are probably a great deal more common than simple, linear ones, and with the geospatial aspects of these systems.

The existing forms of GIS visualization usually involve some sort of cartographic representation, and these lend themselves well to presenting research results, engaging the public in discussions, and teaching. A spatial-temporal GIS should also provide effective means of visualizing the dynamics of complex systems because the visualizations produced by the mathematical expressions used to model nonlinear dynamics, while often aesthetically pleasing, are too difficult to grasp for policy makers or other audiences whose mathematical skills do not extend to partial differential equations.

In economics, both these concerns, nonlinear dynamics and geographic space, have been marginalized in recent decades in preference for simpler, linear economic models, which offer the illusion of confident predictability without reference to geospatial variations. As a consequence, around 1990, leaders in the field were predicting the universal benefits of a globalized economy from which all the planet's inhabitants would enjoy increased well-being. Many of them have begun to recognize the error in their prediction. If they had used nonlinear, spatial models, they would have warned policy makers that pushing locally stable economies into a world one would likely produce local chaos, resulting in environmental degradation, famine, disease epidemics, wars, and other forms of terrible human suffering with planetary impacts. But at least a number of useful spatial models already exist in economics, and major figures continue to develop these, such as Swedish economist Tönu Puu of Umeå University's Centre for Regional Science.

Spatial, complex economic models, like this one of a choppy-growth pattern, can be projected cartographically. The bottom sheet shows alternating growth and decline areas projected to a regional map. Adapted from T. Puu, Mathematical Location and Land Use Theory *(2nd ed.; 2003: 276), with permission from the publisher Springer Verlag.*

GIS Research Opportunities

Because other social sciences, especially political science and sociology, have remained more faithful to the 19th-century linear theories around which they were developed, the number of available, useful models, which can be expressed in mathematical terms, is much more limited. However, there are researchers working to develop such models, such as Michael Sonis of the Geography Department of Bar-Ilan University in Israel. He is writing a book on the diffusion of innovations for which he models sociological theories to account for the diffusion of ideological innovations producing "aggressive intolerance." A great many exciting research possibilities are open to historians interested in the nonlinear dynamics of human ecology, social organization, and political institutions and the interpretive schemes of the cultural environment to create such models and to GIScientists interested in integrating such process models into GIS. Moreover, except to assert the supremacy of a European pattern of development as the model for understanding and "modernization," these 19th-century social science theories and their 20th-century descendants largely ignored geographic differences and spatial questions, which means that there is much that geographers can do to expand the horizons of the social sciences.

Because of humans' weak cognitive capacity to grasp spatial relationships, it is helpful to historians to make "snapshots" of their data at various intervals in the historic chronology, as we do now, but more must be done if GIS is to fulfill its promise for historical research and teaching. Historians require distinctly temporal forms of GIS and must collaborate with experts in GIScience and mathematical modeling. The DynCoopNet project of TECT is addressing these issues.

Getting What Historians Want

In his book *ReORIENT,* Frank argues that the history of no place can be adequately understood without integrating into the analysis environmental, economic, political-social, and cultural information about it or taking into account how that place has been connected to other places. All locations were parts of geospatially large systems, which, after the 15th century CE, constituted a single world system whose dynamics continuously shaped what happened in these places, while at the same time local developments influenced systemic processes.

In 2000, the authors of the Organization of American Historians' *LaPietra Report* (www.oah.org/activities/lapietra/final.html) emphasized that, for reasons similar to Frank's, you cannot make sense of U.S. history without taking into account the ways in which the country has been linked to other places in the world and the changes in the pattern of those interactions over time.

In fact, because for thousands of years most of the world's people have been connected throughout large geographic regions, the history of any place, including large countries, can only be understood by grasping how that history has been shaped by the way the place has been connected to other places. Since the 15th century and the development of some sort of truly global, dynamic, nonlinear system, the histories of the places within the system have been shaped by the nature of the system and the way they have been linked to it. The common practice of writing and teaching history on the basis of the political boundaries of modern countries is antithetical to such a connected history, and it will be necessary to conceptualize geographic regions on the basis of additional variables. Because the spatially large systems have undergone systemic transformations, which fundamentally alter human cultural perceptions and values, models for understanding process within one historic system, even ours, may not be easily adaptable to others.

Therefore, to create a GIS for data organization and visualization that is fully useful for historical research and teaching, many new models will be required, and this demand should stimulate research capable of profoundly changing a number of academic disciplines. In exploring the evolution of cooperation-based commercial networks in the first global age, which requires understanding the pattern or form of these networked interactions and the processes of a dynamic, nonlinear world system, the DynCoopNet project will create the spatial-temporal GIS to implant GIS as a significant component of historical research and teaching.

About the Author

J. B. "Jack" Owens is professor of history at Idaho State University. He is the cocreator of ISU's GIS-based master's program in geographically integrated history, the M.A. in Historical Resources Management. The U.S. National Science Foundation has funded his work on the DynCoopNet project for three years. Owens' understanding of complexity, nonlinear dynamics, and temporal GIS has been shaped by reading papers by the computer scientists, economists, geographers, and mathematicians of the DynCoopNet research team, including professors Puu and Sonis (identified above) and professors Monica Wachowicz and May Yuan, and he wishes to thank them for their patience in responding to his endless questions about their work.

(Reprinted from the Summer 2007 issue of *ArcNews* magazine)

Bringing Foster Care Management into the 21st Century with GIS

Groundbreaking Approach in Washington State

By Tiffany Potter, Scientific Technologies Corporation

Every year in the United States, approximately 800,000 children enter the foster care system. An outdated management system exacerbates this already difficult time in a child's life. A recent study conducted by the Urban Institute showed that more than 90 percent of states report difficulty identifying appropriate adoptive families, resulting in longer stays within the foster care system. The study also showed that 88 percent of states are currently working to improve their child welfare case management process.

The consequences of the nation's failure in this area, to both the children in the system and the nation as a whole, are evident in this year's study by Casey Family Programs. (Established by United Parcel Service founder Jim Casey, Casey Family Programs is a Seattle, Washington-based national operating foundation that has served children, youth, and families in the child welfare system since 1966.) The study focused on adults who had spent at least one year in foster care as children—far less than the national average of three years in the system. One-third of these adults currently live at or below the poverty level, and only one-fifth are employed and were determined to be mentally healthy. More than one-half exhibited signs of at least one mental disorder. A full 25 percent were diagnosed with post-traumatic stress disorder—more than six times the rate in the general population and higher than in war veterans.

Case reporting and placement data are often fragmented because of the archaic information management systems used by most social workers. Social workers must search multiple databases to obtain the information necessary to make the best possible placement decision. This time-consuming and inefficient process bogs down an already overloaded system and places additional stress on placement workers. As a result, qualified social workers are becoming increasingly difficult to retain. These shortcomings directly affect the children that the foster system is supposed to protect.

Washington Governor Christine Gregorian comments: "Each day, foster parents, social workers, police officers, and others strive to do one of the most complex and emotional jobs imaginable—

reclaiming young lives too often given up as lost and providing hope to those lives where so little hope seems to exist."

Last year the Washington Department of Social and Human Services (DSHS) settled a multimillion-dollar class action lawsuit filed on behalf of children in the state's foster care system. The suit was filed six years ago on behalf of Jessica Braam and approximately 3,500 other foster children who had been moved three or more times while in foster care. More than one-third of those children were placed in more than eight homes. The settlement agreement required DSHS to make major changes in its system of placing and caring for children in its custody.

Brainstorming an Innovative Approach

The idea for an innovative approach to this daunting problem arose when DSHS workers brainstormed with ESRI and Scientific Technologies Corporation (STC), an ESRI Business Partner, at the 2004 Washington State Health Conference. It was agreed that STC, a public health informatics company with nearly 20 years of experience, and ESRI would collaborate to create a viable solution.

As a result, DSHS authorized a Children's Administration-GIS Pilot Project. DSHS contracted with STC and ESRI to create a more robust case management system with integrated GIS. State officials are currently considering replacing the existing system based on the pilot project's success.

According to Pat Brown, program manager for DSHS, "We saw in the pilot application how data mapping would allow our field staff to visualize the relationships among referrals, biological homes, foster homes, schools, and health providers, to name a few, in ways that would dramatically improve the safety, permanency, and well-being of children in out-of-home care."

STC performed an in-depth needs assessment and interviewed social workers before developing the software. Because GIS was one of the focuses of the project, interviewers discovered which spatial issues were most relevant to placement decisions.

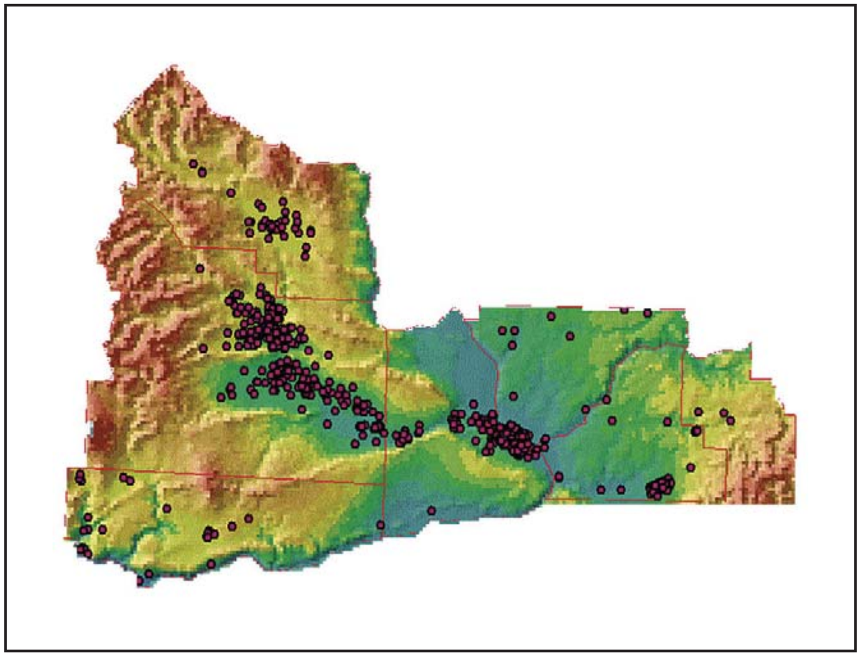
The first and most basic task was to integrate all of the aggregate data into one place, which was supported by an Oracle database. This allowed social workers access to all of the available information in a more expeditious manner and provided them with a Web-based interface supported by a central data repository.

Better Visual Tools

The real improvement, however, was in the area of visual tools. "GIS is the best tool I've seen for helping us protect vulnerable kids," says Kenneth Nichols, administrator, Division of Children and Family Services. "Using GIS, we can see where kids are and create wraparound care for them that is both reasonable and cost-effective."

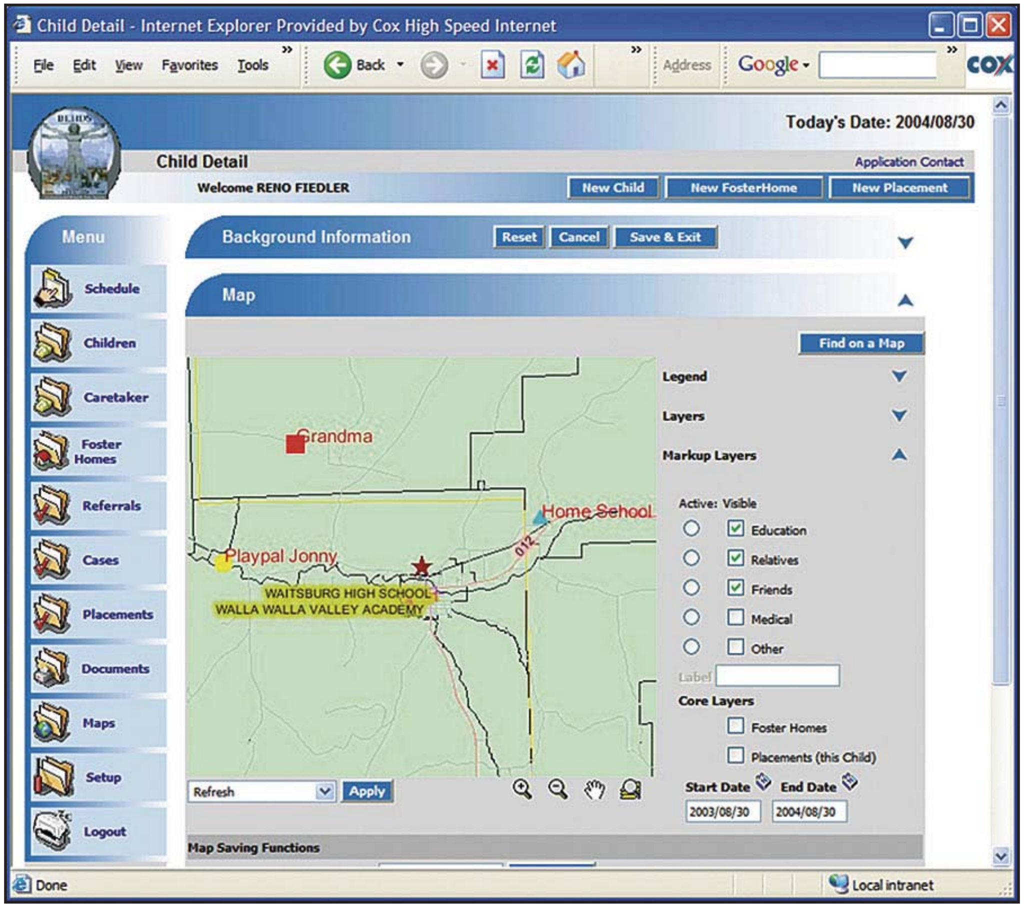
Data visualization is vital in giving social workers a complete understanding of the child's environment. ArcIMS provided the spatial representation of pertinent placement information. By overlaying data, workers were able to perform both overlay and proximity analysis. This gave social workers an effective tool to track children in the foster system as well as their geographic relationship to families, schools, community services, transportation, and other important resources.

According to Neal F. Cotner, a Region 2 Social Work supervisor, "This mapping system added a new dimension in social work practice by raising awareness of the children and their surroundings in a graphic, cohesive manner that could be viewed layer by layer as the social worker saw fit."



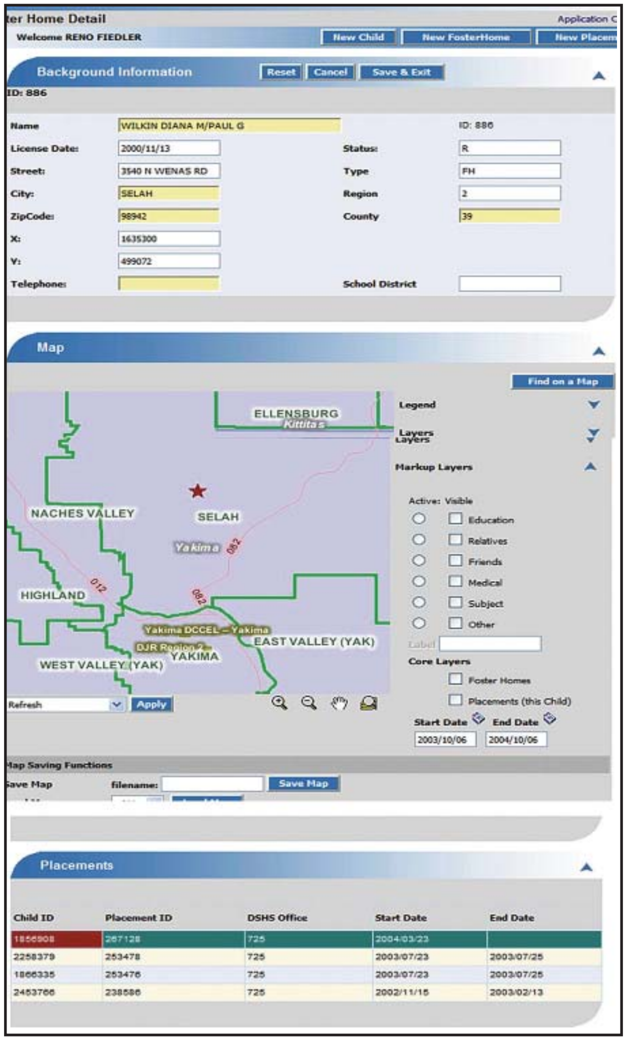
The distribution of foster homes in the seven counties comprising Region 2.

For this pilot project, STC completed the address geocoding for the children's administration data using ArcView and the ArcGIS StreetMap extension. Users are able to insert additional information by creating an "acetate" layer. These layers allow caseworkers to add relevant information about the child or location without address geocoding. Information, such as the location of relatives, schools, friends, medical care, and registered sex offenders, could be added or deleted as part of an acetate layer that could be seen or made invisible as the user desired. Spatial analysis also provides maps of available foster homes within a set distance of a child's school district, helping eliminate avoidable changes in environment.



Using the acetate capabilities, social workers can add their own layers to the map.

This project has proven the viability and necessity of an updated and vastly improved child care management system with integrated GIS. Washington's children will benefit from caseworkers' improved capacity to make informed, rapid placement decisions. Washington may lead the way for the rest of the nation in foster care management reform.



Each acetate layer is separate, allowing social workers to see as many or as few layers as they desire.

In response to the current situation, Mary Herrick, an Issaquah, Washington, resident who spent more than seven years in the foster care system, commented, "The Casey Foundation study validates what we have all known—the more homes youths are placed in, the more likely they will have mental health issues, lower educational outcomes, and ultimately less ability to earn above poverty-level wages. It is my hope that as a community we will rise up and take responsibility for our children and that future generations of foster children will have a better life because of our efforts."

(Reprinted from the Fall 2005 issue of *ArcNews* magazine)

Archaeology, Genealogy, and GIS Meet at Columbia Cemetery

Building a Unique, Informative Web Site in Boulder, Colorado

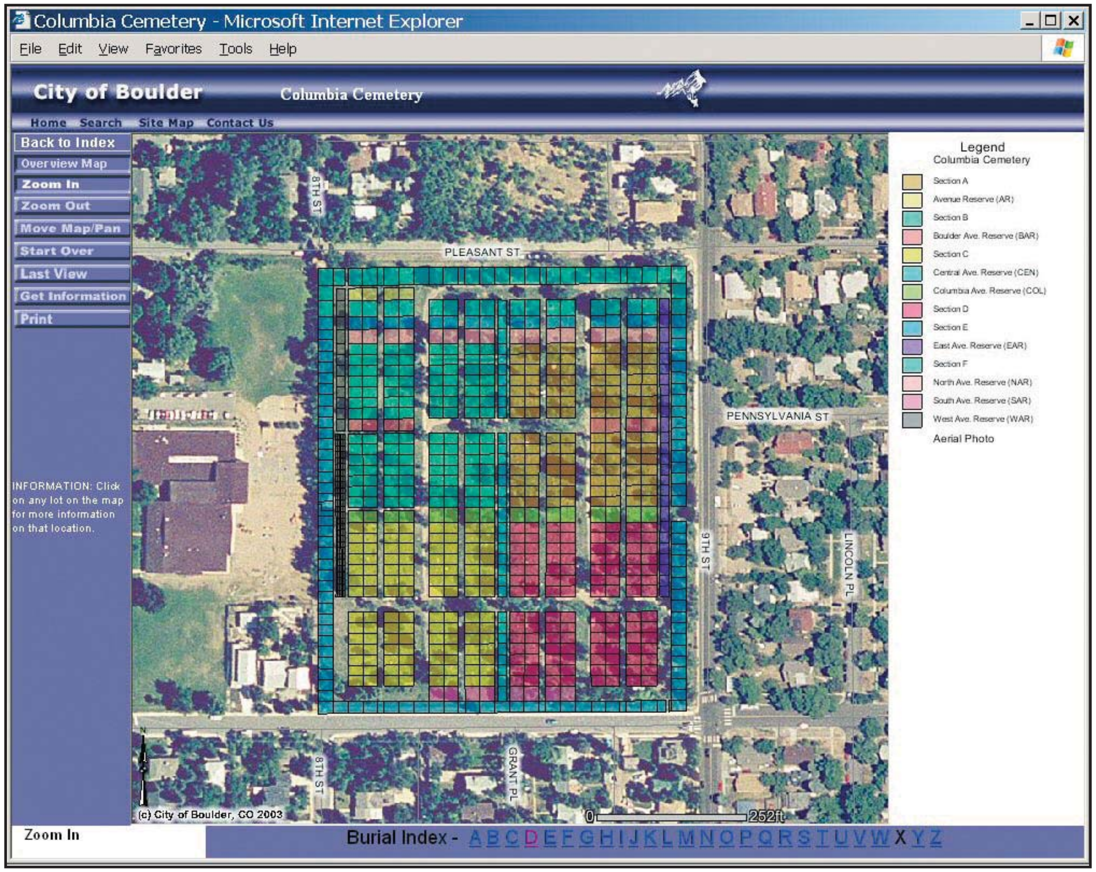
By Mary Reilly-McNellan and Kip White, City of Boulder, Colorado

Cemeteries are a wonderful source of information for anyone interested in digging up information about their past. Genealogists, especially, are known for their tenacity, and generally leave no stone unturned when it comes to researching their roots. But sometimes time and distance preclude travel that is often necessary to discover the clues that may lie buried in preserved cemeteries. Now, thanks to a new Web site developed for historic Columbia Cemetery at Ninth and Pleasant Streets in Boulder, Colorado, the dead can speak any time, anywhere over the Internet (www3.ci.boulder.co.us/ parks-recreation/COLUMBIA/ Columbia_main.htm).

Boulder, like many municipalities, offers GIS-enabled Web sites using ArcIMS to provide its citizens with the latest information on flood control, zoning, and historic preservation. In 2001, the Columbia Cemetery Preservation project manager approached the GIS team to ask if a Web site dedicated to preserving the history of the cemetery could be created. A great deal of information about the historic cemetery had been compiled, but it was located in many different places.

A marvelous opportunity existed, it seemed, to wed history and technology, but the solution had to be able to make maps, display photos, query databases, and allow for customization, all in a Web environment. Since Boulder has been a longtime user of ArcGIS Desktop (ArcView, ArcEditor, ArcInfo) and ArcSDE and knows the power of GIS to integrate information, ArcIMS seemed to be the logical choice to bring this disparate data into a unique and informative Web site.

Columbia Cemetery is a virtual "Who's Who" of early Boulder—a historic, cultural, and artistic resource containing the remains of many of the city's founders and pioneers. Initially established in 1870 on 10 acres of cattle-grazed pastureland, the cemetery today has 6,500 burials and 3,000 headstones. Like many other Victorian era cemeteries, Columbia contains grave markers of various types: monuments, crosses, obelisks, and tablets made of marble, granite, sandstone, limestone, and wood. The tombstones not only mark the graves of early pioneers who have helped make Boulder what it is today, but they are also narratives describing Colorado's social and economic structure, its religious tenets, and ethnic composition. The epitaphs, engravings, and decorations provide insight into earlier customs, religious beliefs, folklore, art, and medicine. Homemade Depression-era "folk markers" are juxtaposed with ornate and towering granite monuments belonging to bank presidents. Marble lambs and doves mark the graves of children felled by scarlet fever, diphtheria, and tuberculosis, and graves adorned with flowers, stuffed animals, and coins poignantly indicate recent visits to century-old burials.



The interactive map of Columbia Cemetery is an HTML viewer page created by ArcIMS. The user can zoom in and out of the map and get information about who is buried in a particular cemetery lot.

Columbia Cemetery is owned by the city of Boulder and managed by the Parks and Recreation Department. It is a city landmark and was placed on the National Register of Historic Places in 1997. Over the past decade, the Parks and Recreation Department and Historic Boulder, Inc., have been implementing a Columbia Cemetery Preservation Master Plan—thanks in large part to funding from the Colorado Historical Society's State Historical Fund. Each grave marker was digitally photographed, and more than 100 have received professional restoration work. Several hundred others have received help from a group of volunteers that comprises the Columbia Cemetery Conservation Corps.

Columbia Cemetery Web site.

Members of the Boulder Genealogical Society, in particular Mary McRoberts, have scoured historic burial ledgers, mortuary documents, obituaries, and court records to compile information about persons interred in Columbia Cemetery. McRoberts' information helped to make history come alive for volunteers as she shared the life story of each person whose stone underwent conservation work. The Boulder Genealogical Society published an eight-volume set entitled, *Columbia Cemetery, Boulder, Colorado, 1870 to the Present.* In addition, McRoberts prepared maps of each of the burial lots in Columbia Cemetery, indicating who had purchased the lots as well as precisely who is buried within the lot and where. An index of Columbia Cemetery burials is listed on the Boulder Genealogical Society's Web site (www.rootsweb.com/~bgs).

The Web site project actually began in 2002 when the Boulder Genealogical Society kindly gave the city permission for use of its Index of Burials and biographical information contained in the eight volumes. Oracle-based ArcSDE was used to store a cemetery map that was digitized and registered to the city's aerial photography basemap. Tables were created to hold each name, biographical sketch, cemetery lot, and grave marker photograph. By linking the biographical information table to a grave lot feature, Web site visitors are able to query and display biographical information with ArcIMS software's query server. Custom JavaScript was used to send XML requests to ArcIMS software's query server and then parse the responses to generate attractive Web pages presenting maps, scanned records, photographs of grave markers, lists of all people buried in a particular cemetery lot, and biographical information.

What does the future hold for Columbia Cemetery? Hopefully, grant monies will continue to provide funding for ongoing preservation of the burial ground, and grave markers will be carefully repaired or restored one by one. The Columbia Cemetery Conservation Corps has been working in the graveyard on Saturdays for five summers and shows no sign of stopping. New ordinances are in place to help protect the graveyard, and the community enjoys strolling the grounds, picnicking, and studying the fascinating old markers. Tours organized each year by the Parks and Recreation Department and Historic Boulder, Inc., are hugely successful. Educating the public about Columbia and old cemeteries in general is considered to be the best tool for fostering the appreciation and respect that will ultimately encourage people to help protect these cultural treasures. And with Columbia Cemetery information now available to Web users across the globe, perhaps additional information will come to light as the site is visited by persons who have knowledge of Columbia Cemetery "residents."

A view of Columbia Cemetery with the Boulder Flatirons Mountains in the background.

(Reprinted from the Spring 2004 issue of *ArcNews* magazine)

Ghana Project Leverages GIS-Based Title Registration and Microfinance to Alleviate Poverty

By Peter Rabley, International Land Systems, Inc.

Highlights

- The project was presented to the United Nations Commission on the Legal Empowerment of the Poor.
- System incorporates ArcGIS functionality to link title information with the digital parcel map.
- Title and parcel data for loan processing is batched and provided to the ministry.

This article is part one of a multipart series.

A pilot project under way in the African nation of Ghana seeks to demonstrate the vital role that formalization of landownership can play in helping the poor take a crucial first step away from poverty. Focused on one of the poorest areas in the capital city of Accra, the pilot is leveraging the latest geospatial technologies to create a land titling process and GIS-based land records system where neither existed in the past.

Impetus for the Ghana pilot comes from the Clinton Global Initiative (CGI), started by former U.S. president Bill Clinton to challenge some of the world's leading organizations and individuals to make commitments that positively impact global health, poverty, climate change, and education. Accepting the CGI challenge to work toward alleviating poverty was First American Corp., a major title insurance and real estate information provider based in Santa Ana, California.

With an extensive background in land titling, Craig DeRoy, then president of First American, embraced the economic theories described by Dr. Hernando de Soto in his acclaimed book The Mystery of Capital. The Peruvian economist is among the first to identify and describe the relationship between the formal recognition of property rights and the fight against poverty. DeRoy saw the CGI challenge as an opportunity to put de Soto's ideas into action.

With several partners, DeRoy presented the concept of a pilot project to the United Nations Commission on the Legal Empowerment of the Poor, which seeks to "make legal protection and economic opportunity not the privilege of the few but the right of all." The project received immediate feedback and encouragement from the commission's cochairpersons, Madeleine Albright and de Soto.

"Government recognition of landownership [through land titling] gives the poor an identity, which yields numerous benefits," says DeRoy. "The land title can ultimately be used as an asset to leverage permanent change in their economic and financial futures."

According to de Soto, poor people almost everywhere in the world have one thing in common—the only asset they have is the land they occupy. Unfortunately, very few of these people have ever received any type of legal recognition that the land is theirs, especially in situations where the ownership is informal or based on customary forms of tenure. Without a registered deed, title, or lease, the owner cannot leverage the land as collateral to take out a loan that might be used to start a business or improve the property.

From an economic perspective, this untitled land represents trapped capital that could be accessed to stimulate the local financial market with microfinance loans and mortgages. But gaining access to this hidden capital requires the landowners to have formal titles or deeds to their properties.

De Soto's research revealed that the benefits of formal landownership extend beyond the monetary value of loans and mortgages and provide another crucial stepping-stone out of the hopelessness of poverty. A land title gives a person an address, often for the first time, which dramatically improves that individual's sense of identity. As a result, the impoverished enjoy a greater feeling of security that their land won't be taken away and that they can improve the property. People with land titles are more likely to put their children in local schools and demand basic services from the government.

Despite these benefits, land titling and registration are out of reach for most of the poor. The process itself may be too daunting for governments to implement in poverty-stricken areas where no property mapping has ever occurred. And even in countries where titles and deeds do exist, the procedure may be too complicated, expensive, and time-consuming for low-income people to consider. As a result, the capital remains locked in the land, the local economy suffers, and the poor have no way out of their poverty.

Assembling the Team

First American and CGI clearly understood the benefits of land titling and in 2006 agreed on a commitment for the U.S. company to develop a template for cost-effective, in-country creation and maintenance of a land record system that ensures a means for establishing and holding the legal title to a property. To lead this project beyond the original commitment, DeRoy took early retirement and formed a new company called Corporate Initiatives Development Group (CIDG).

"In creating the land record template, the challenge was not in developing it, but in actually implementing it and making it practical," says DeRoy. "There had been much historic debate on the effects of formalizing landownership for the poor, but little had been done to bring these theories to market. I believed it could be done if the right individuals and companies could be engaged, leveraging years of experience and intelligence in land and technology issues to put together a process that could be made simple."

He sought to extend the CGI commitment to include an in-country pilot implementation. To make the pilot a reality, CIDG assembled a team consisting of International Land Systems, Inc. (ILS), Opportunity International, Trimble Navigation, and ESRI. Each provides a capability vital to the development of a practical land record system:

- ILS, an ESRI Business Partner in Silver Spring, Maryland, is implementing its commercial off-the-shelf GIS-based land recording and registration system, the key deliverable in the pilot.
- Opportunity International of San Diego, California, is a nonprofit microfinance lender already active in Africa.
- Trimble Navigation of Sunnyvale, California, is providing handheld mobile GPS devices that are being used to map the parcels in the field.
- ESRI is supplying core technology, in addition to managing the land surveying and mapping activities to create a parcel map, for the land registry database through Sambus Company Ltd., ESRI's international distributor in Ghana.

Selection of Opportunity International as a partner in the pilot highlights the important role that microfinance can play in the alleviation of poverty through formalized land titling. Historically, microfinance has focused on lending relatively small amounts of money—$50–$500—to individuals for use in starting in-home businesses. A sewing machine, for instance, can allow a woman to make and sell clothing in her neighborhood. Usually based on short-term paybacks, these loans are often made in trust groups so that peer pressure, not collateral, is the incentive for repayment. The result is a repayment rate of more than 95 percent on microfinance loans worldwide.

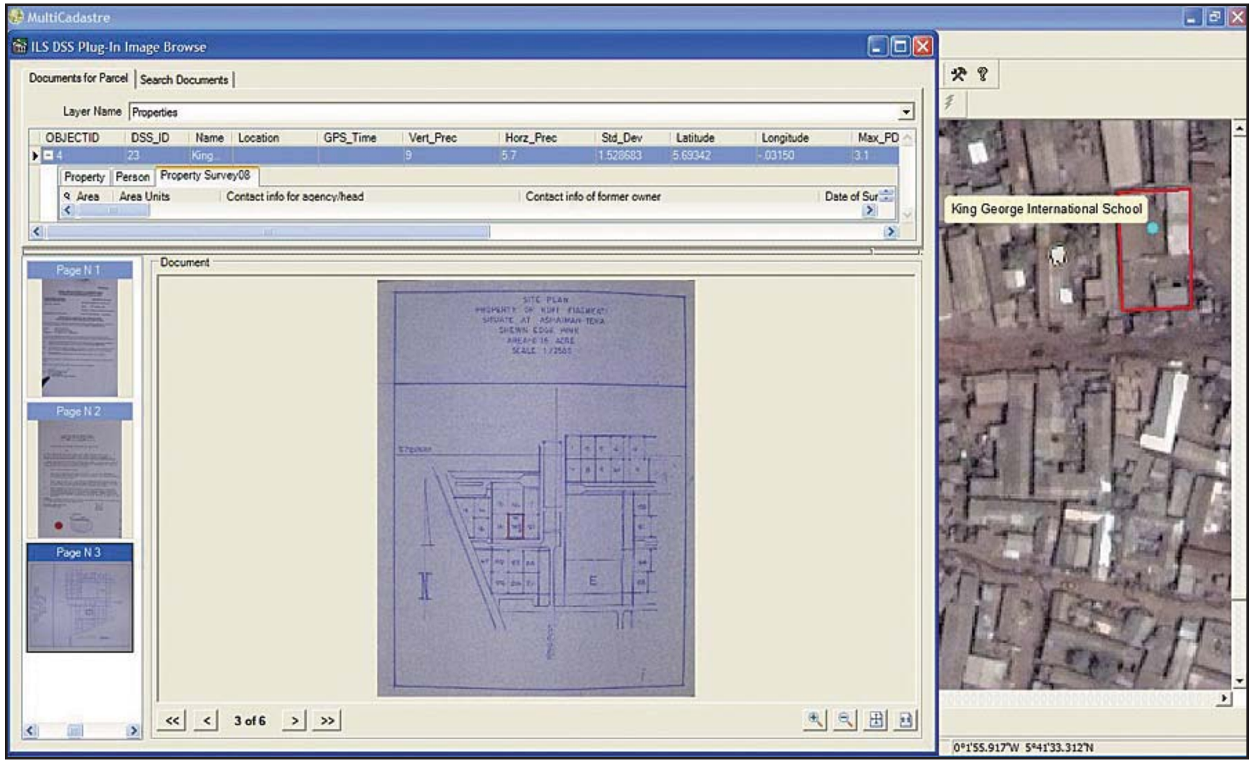
"Microfinance brings capital to these emerging markets in a very responsible way," explains DeRoy. "The creation of micro-entrepreneurs is a proven approach to the transformation of entire communities. In our project, we move microfinance one step further by placing Opportunity International, the microfinance lender, into the position of acting as a trusted broker for its clients seeking land registration. This use of the private sector serves to initiate, simplify, and accelerate a process that is often stymied by overwhelming governmental procedures and bureaucracy."

In recent years, microfinance lenders have been looking to expand their reach by loaning larger amounts of money for a variety of uses beyond entrepreneurial business, but this type of lending often requires an asset to be offered as collateral. More often than not, these lenders experience the other side of the situation described by de Soto. They want to loan money to the poor, but the only asset is untitled land, which can't be used to secure the transaction.

This oft-repeated scenario provided Opportunity International an incentive to facilitate land titling as a means of growing the potential market for its microfinance product offerings.

Targeting Ghana's Schools

In 2007, the participants chose a very poor area known as Ashaiman on the outskirts of Accra, Ghana, as the pilot location. Ashaiman is home to about 400,000 people in a 40-square-kilometer region where most of the structures can best be described as shacks and shanties. It was considered ideal for the pilot because Opportunity International is actively involved in microfinance there and had already been considering developing loan programs for the hundreds of private schools located in the area.

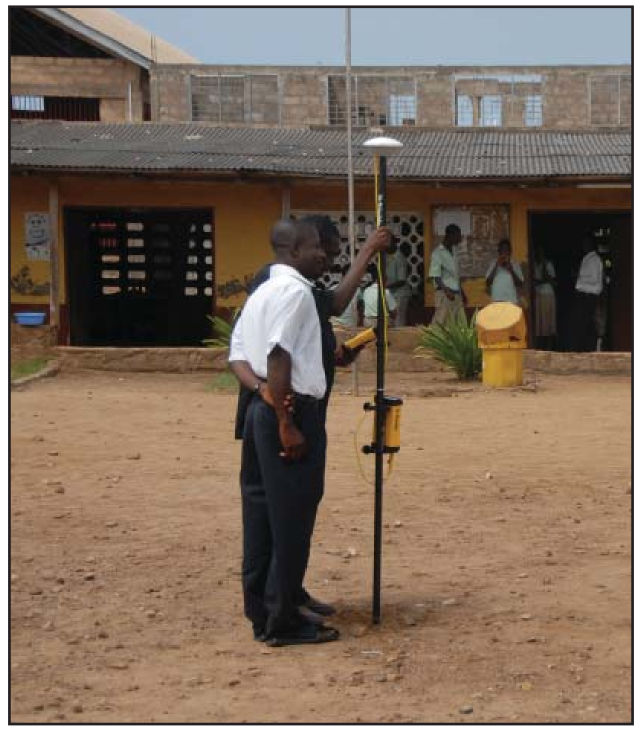


Using ILS MultiCadastre, all surveyed schools can be viewed. The ILS document scanning system plug-in allows for documents and images associated with each property to be examined as well.

Operation of private schools is a growing business in Ghana, and the owners are seeking funds to build additional facilities and accommodate more students. From a mapping perspective, the schools were appealing for the pilot because the boundaries of their land are usually well defined. The decision was made to target only private schools in the initial pilot, because they presented the best opportunity to demonstrate the mutually beneficial link that can be made between formalized land registration, microfinance, and poverty alleviation.

Although the Ashaiman pilot is being conducted in close cooperation with the Ghana Ministry of Lands, Forestry and Mines, the project is relying solely on private funds. In this case, the fees associated with land titling will be rolled into the cost of processing the loan, so there will be no up-front transaction expense for the school operator to register a title. Economies of scale in processing multiple titles are expected to reduce costs significantly as the land registry becomes operational.

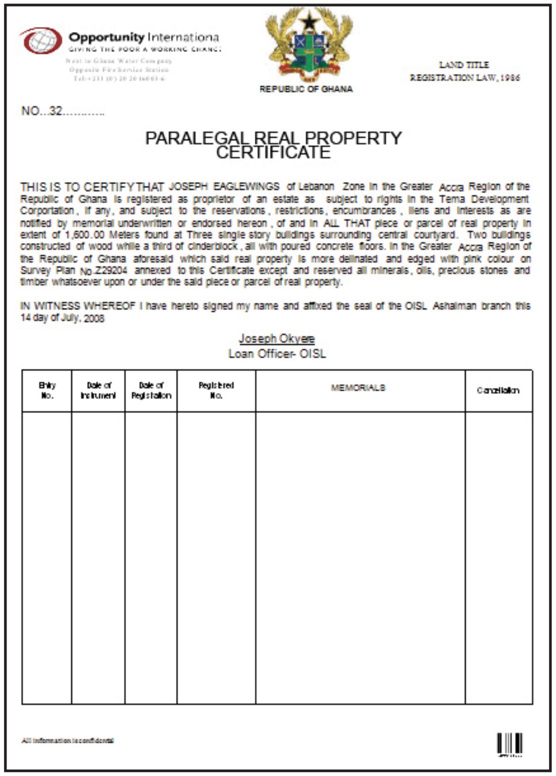
Implementation of the pilot began in March 2008, and land titling had been completed for more than half of the 51 private schools in the pilot zone by August. This adjudication process, which will be described in technical detail in subsequent issues of *ArcNews,* involves surveying the school property with GPS-based mobile GIS equipment, creating a legal description of the land, and collecting property ownership information from the school operators and neighbors via personal interviews conducted by members of the local team. Each school owner has sought to become part of the land registration pilot and actively participated in the required procedures as part of the loan processing.



Ghanaian surveyors perform a cadastral survey of the property boundaries as described by the occupant, as well as neighbors.

As the interviews and fieldwork are completed, ILS is uploading the data into its parcel-based MultiCadastre package, an off-the-shelf product that incorporates ArcGIS functionality to link the title information with the digital parcel map. This system is already managing the entire title registration process and workflow in a fully automated environment. For the pilot phase, this system will be maintained at the Sambus office and will generate paralegal land titles that will be provided to the participating schools for use in securing private loans.

The term *paralegal title i*s used to indicate that the titling process has been initiated for acceptance by the private sector to jump-start microfinance activities. This commitment from the private sector is designed to give the government of Ghana the confidence to use the paralegal titles as the starting points for official title processing in the public land registry.



Opportunity International
GIVING THE POOR A WORKING CHANCE

REPUBLIC OF GHANA

LAND TITLE
REGISTRATION LAW, 1986

NO...32..........

PARALEGAL REAL PROPERTY CERTIFICATE

THIS IS TO CERTIFY THAT JOSEPH EAGLEWINGS of Lebanon Zone in the Greater Accra Region of the Republic of Ghana is registered as proprietor of an estate as subject to rights in the Tema Development Corportation, if any, and subject to the reservations, restrictions, encumbrances, liens and interests as are notified by memorial underwritten or endorsed hereon, of and in ALL THAT piece or parcel of real property in extent of 1,600.00 Meters found at Three single story buildings surrounding central courtyard. Two buildings constructed of wood while a third of cinderblock, all with poured concrete floors. In the Greater Accra Region of the Republic of Ghana aforesaid which said real property is more delinated and edged with pink colour on Survey Plan No.Z29204 annexed to this Certificate except and reserved all minerals, oils, precious stones and timber whatsoever upon or under the said piece or parcel of real property.

IN WITNESS WHEREOF I have hereto signed my name and affixed the seal of the OISL Ashaiman branch this 14 day of July, 2008

Joseph Okyere
Loan Officer- OISL

Entry No.	Date of Instrument	Date of Registration	Registered No.	MEMORIALS	Cancellation

All information is confidential

The ILS DSS system allows for the creation of a paralegal title based on information gathered during the interview process.

While the overall aim of the Ghanaian project is to continue to rely on private-sector entities to perform the land surveying and title recording work in support of microfinance work, participants are simultaneously assisting the government in modernizing its land titling and cadastral capabilities with many of the same GIS-based systems being implemented in the pilot. All title and parcel data collected for loan processing is batched and provided to the Ministry of Lands for its own land registry, which the team believes will be among the world's most technologically advanced.

According to DeRoy, this project demonstrates the true effect of what is called the "leapfrog factor." Given the rapid pace of technology development, those who come to implement a system of land registration today and are not burdened with existing infrastructure or bureaucracy can gain the maximum benefit from streamlined and cost-effective new processes while leveraging proven solutions.

"It is terrific that microfinance has matured to the point of being accepted as a traditional banking solution for the emerging markets of the world," says DeRoy.

About the Author

Peter Rabley is president of International Land Systems, Inc., with more than 20 years of experience designing and implementing land information systems around the world.

(Reprinted from the Fall 2008 issue of *ArcNews* magazine)

Mapping Hunger with GIS

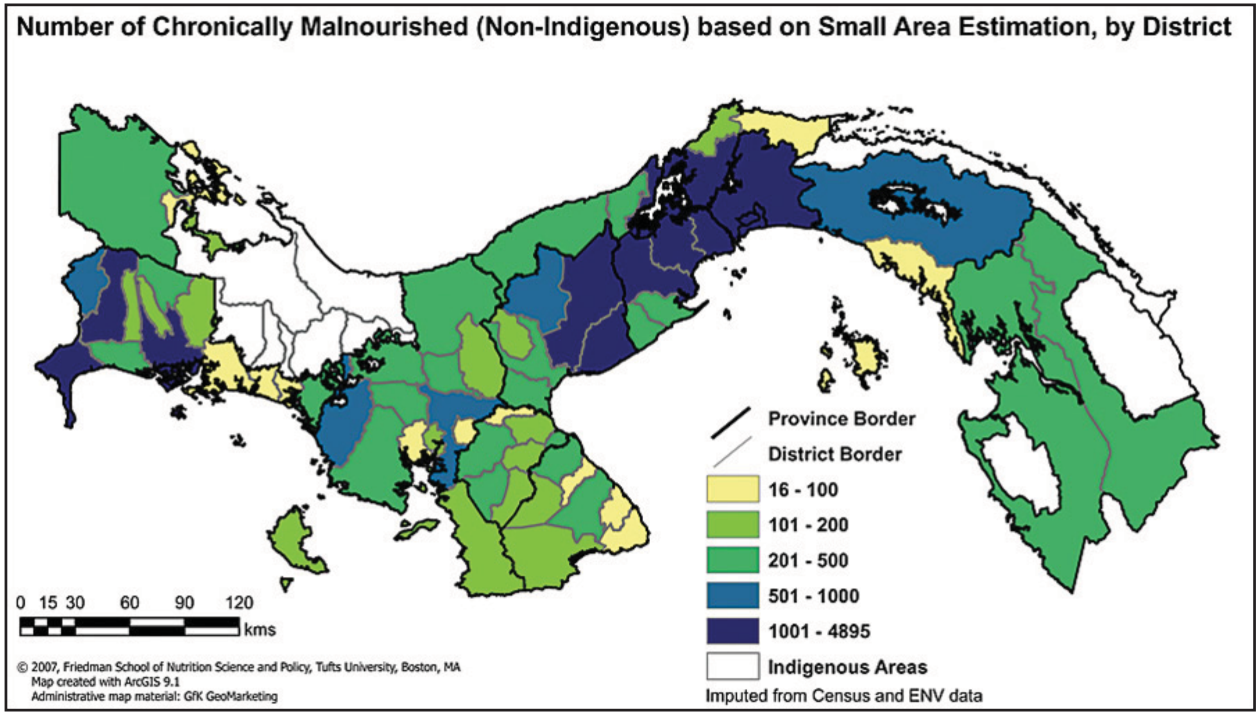
Analyzing Distribution of Malnourished Children in Panama, Ecuador, and the Dominican Republic

Highlights

- ArcGIS Spatial Analyst is key to mapping program.
- Malnutrition maps are used to target nutrition programs.
- Resultant maps illustrate the malnutrition mapping manual.

Reducing poverty and hunger is the first Millennium Development Goal of the United Nations. *Hunger,* defined in terms of nutritional status, is most commonly measured among children and contributes directly to morbidity, mortality, and poor cognitive development. A first step toward realizing the goal of reducing malnutrition in children is to identify places where the problem is the most severe.

The Gerald J. and Dorothy R. Friedman School of Nutrition Science and Policy at Tufts University in Boston, Massachusetts, is a leader in food policy research and the development of innovative solutions to reduce malnutrition worldwide. In conjunction with the United Nations World Food Programme and the governments of Panama, Ecuador, and the Dominican Republic, the Tufts Malnutrition Mapping Team (TMMT) has helped pioneer a method that estimates the prevalence and number of malnourished children for small geographic areas. This helps governments use scarce resources effectively by focusing on areas where the problem is more severe and by revealing underlying geographic factors that cause malnutrition in different settings (e.g., rural versus urban, mountains versus coast).



The hunger mapping team of Tufts University created maps of Panama using GIS so that areas with a high prevalence of malnourished children could be identified.

ArcGIS software was selected for this mapping exercise due to the functionality of its ArcGIS Spatial Analyst extension, which enabled TMMT to calculate the numerous geographic variables included in the analysis. ArcGIS provided a straightforward platform to map the results and thus provided a powerful tool for visualization of the nature and distribution of the nutrition problem in each country.

The task of locating malnourished children is more complicated than it may first appear. Consider the fact that children's nutritional status is indicated by their height, weight, and age and that collecting this information for every single child in a country would be nearly impossible due to the cost and time needed to measure and weigh. But, typically national surveys take a sample of the whole population, which is often representative for provinces but not for smaller geographic units.

Malnutrition maps for Panama, Ecuador, and the Dominican Republic were developed in ArcGIS using Small Area Estimation, a statistical procedure that combines data from a sample national population survey with a national census.

GfK GeoMarketing, an ESRI Geoinformatik GmbH Business Partner in Waghausel, Germany, supplied TMMT with geographic data that details administrative boundaries and major cities. TMMT used this information to calculate the distance from small communities to urban centers, a proxy measure of market access. As GfK GeoMarketing has an extensive library of global geographic data, it was a logical partner for TMMT to approach.

In addition to producing malnutrition estimates for Panama, Ecuador, and the Dominican Republic, TMMT has also created a malnutrition mapping manual. The goal of the manual, which is also the ultimate goal of the project, is to increase the technical capacity of developing countries and provide them with the tools and expertise to conduct their own malnutrition mapping exercises.

(Reprinted from the Fall 2008 issue of *ArcNews* magazine)

Since 1969, ESRI has been giving customers around the world the power to think and plan geographically. The market leader in geographic information system (GIS) solutions, ESRI software is used in more than 300,000 organizations worldwide including each of the 200 largest cities in the United States, most national governments, more than two-thirds of Fortune 500 companies, and more than 5,000 colleges and universities. ESRI applications, running on more than one million desktops and thousands of Web and enterprise servers, provide the backbone for the world's mapping and spatial analysis. ESRI is the only vendor that provides complete technical solutions for desktop, mobile, server, and Internet platforms. Visit us at www.esri.com.

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