Map Me a Reason
Purposeful Geospatial Work

Jonathan W. Lowe

This column covers the role of emerging technologies in the exchange of spatial information.

In the days when stock values kept rocketing skyward, there wasn't much discussion about the deeper meaning of our work. Plentiful contracts left no time for existential questions. Why ask why? You're getting rich! But today, increasingly, technical people are asking themselves how their work makes a difference.

It's hardly surprising. Jobs and money are tight and getting tighter. Periodic layoffs discourage the creative risks that made projects so exciting in the 1990s. Without the external reassurance of a secure job, swelling stock portfolio, or creative outlet, is it any wonder that people are seeking stability, sustenance, and self-expression within, and then yearning to apply their internal purpose to the appropriate career?

Some wonder whether the spatial industry still supports meaningful careers at all. For those in doubt, even one or two purposeful people who have aligned their work with their values would be great inspirations. Thankfully, in any economic conditions, our industry is rich in worthwhile projects and people of substance.

In a departure from my usual technically-oriented focus on emerging spatial technologies, this column covers the efforts of two such unassuming spatial professionals, Andy Jarvis and Drew Sayles, who believe in their work — as unpredictable, exotic, or low-budget as it may sometimes be. Both are making a difference.

Social entrepreneur Drew Sayles (top) started CompuLinks, Inc. to bring sustainable jobs to Bangladesh and GIS/CAD services to U.S. firms. Andy Jarvis (above) went into the Colombian jungle hoping to safeguard as many species as possible from extinction.

Gringo loco

In 1999, at the age of 22, Andy Jarvis flew 15 hours from Kings College, London, England, to the foothills of the Colombian Andes in South America, bringing only a scientist's curiosity and what he could fit into a duffel bag. Colombia is a politically volatile nation, infamous for regional drug lords and frequent kidnappings. Jarvis spoke no Spanish and had no idea where he would sleep that night or any night to follow. His final destination that first long day was a research position at the International Center for Tropical Agriculture (www.ciat.cgiar.org) in the city of Cali. When he arrived at CIAT's offices, his first question to the circle of new colleagues was, "Can anybody spare a couch tonight?" He hasn't looked back since.

The impetus behind Jarvis' madness is a silent but scientifically accepted ecological disaster called *the sixth extinction*. Paleontological debates still rage about why the dinosaurs went extinct 65 million years ago, but whatever the reason, the disappearance of the dinosaurs is just one of five periods of unusually high species extinction revealed by the geologic fossil record. In the sixth extinction, a relatively large number of today's species have already gone the way of the dinosaurs — disappearing forever.

An asteroid, greenhouse gases, volcanoes, or some combination of all three may have

Glossary

CARE: Cooperative for Assistance and Relief Everywhere, Inc.

CIAT: International Center for Tropical Agriculture

DEM: Digital elevation model

UNICEF: United Nations Children's Fund

USAID: United States Agency for International Development

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wiped out the dinosaurs, but today's species extinction is due largely to people. Ever-expanding human populations that demand increasingly large quantities of Earth's finite resources are outcompeting other populations. Among the threatened species are plants, animals, and insects that benefit human beings, either as food sources, medicines, or necessary pieces of the larger web of life. Jarvis has joined the ranks of scientists trying to reverse this process or, at the very least, safeguard as many species as possible against the tide of extinction.

Jarvis chose his current research location because, in his words, "Colombia is one of the richest countries in terms of species diversity per unit area, comprising an estimated 14–15 percent of the planet's flora and fauna in 0.77 percent of its surface." And these statistics on species density are likely to increase with time, as the majority of Colombian species are not yet documented. Colombia's diverse ecology is, unfortunately, suffering rapid deforestation from agricultural colonization and resource extraction, particularly of oil reserves. In the long term, global warming poses another catalyst to worldwide species extinction. Jarvis' ultimate goal is to conserve biodiversity in the face of these threats, starting with one of the world's most species-rich locations.

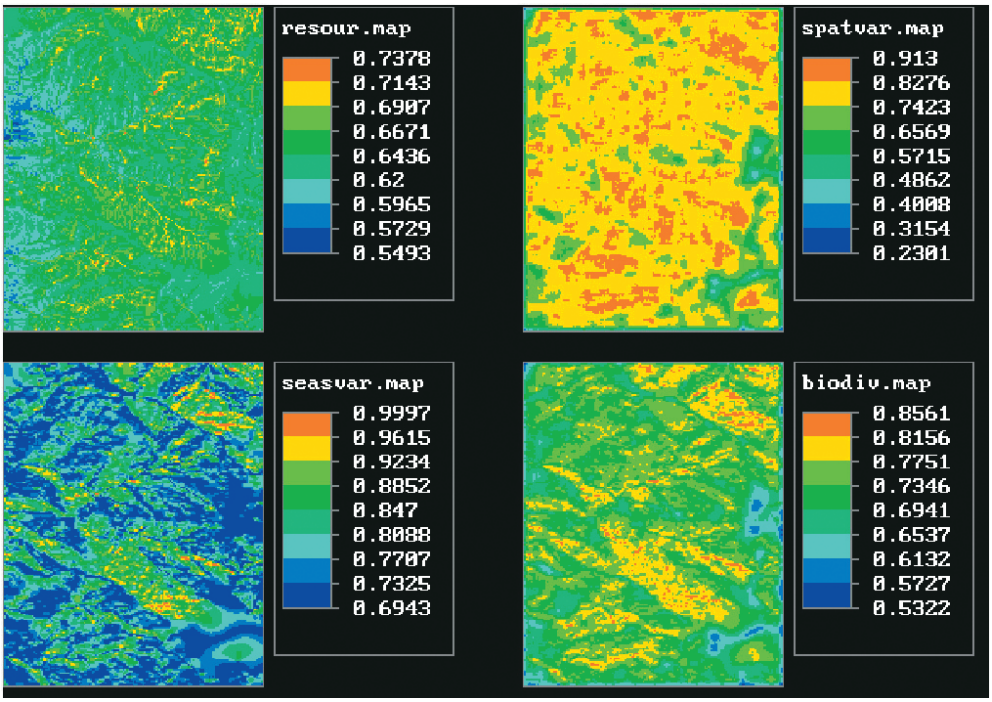

FIGURE 1 To predict areas of high biodiversity, Jarvis uses a GIS model that overlays four variables: resources (top-left), spatial heterogeneity (top-right), temporal variability (bottom-left) and the ecosystem disturbance (bottom-right).

Can't boil the ocean

To protect ecologically diverse sites, one must first know where to find them. Jarvis' focus is tropical montane cloud forest ecosystems, which dominate his study sites in the Northern Andes. It's unrealistic, however, to hope to save the entire cloud forest ecosystem of Colombia and Ecuador. Instead, Jarvis hopes to identify the most species-rich locations within this ecosystem as prime conservation candidates. His findings will empower policy makers to forge more effective land-use agreements, such as designations of protected parks.

Other researchers have established diversity profiles for isolated study areas, but their findings are not extrapolated over the larger geography of the region's cloud forest ecosystems. Realistically, there will never be enough researchers or time to document the species diversity across thousands of square meters of cloud forest. What Jarvis' small team needed was a way to anticipate which areas were most likely to have high diversity. That's where GIS modeling entered the picture.

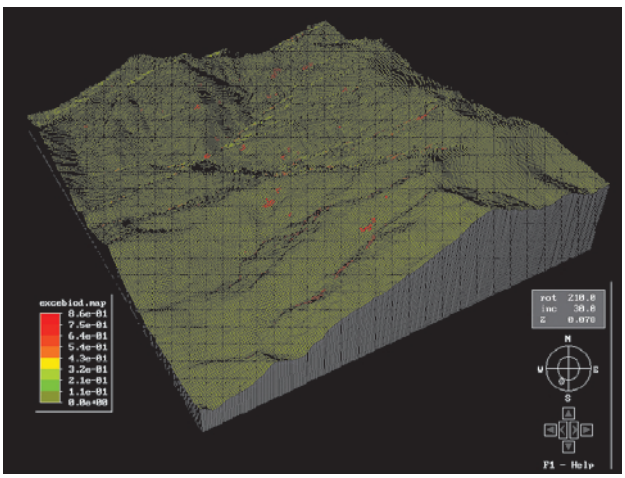

FIGURE 2 In this three-dimensional view, areas most likely to have high biodiversity are shown in red.

Using a GIS model to predict areas of highest diversity, Jarvis is leveraging the limited resources of his local research team over the largest possible geographic area. His "Potential for Biodiversity" model superimposes the field data about tree species diversity over more extensive and uniform topographic and climate data for Colombia and Ecuador. The approach hinges on the hypothesis that physical geography influences biological diversity. So far, the success of the model's predictive powers supports this idea.

The model overlays four variables — resources, spatial and temporal variation, and ecosystem disturbance — to identify the top 5 percent of diverse species-rich areas (see Figures 1 and 2). Jarvis divides his study areas into 25-square-meter grid cells which he ranks using DEM and climate data.

To derive resource availability, he equally weights precipitation, temper-

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A view of the canopy from the tropical forest floor in Colombia. Areas such as this are study sites for Jarvis.

ature, and solar radiation because all three influence the moisture and sunlight available to the trees. (Soil nutrients are homogenous enough across the study areas to be excluded from the model.)

Spatial variation also influences tree diversity. Environments that pack a variety of habitats into a small area, such as stands of forest near open riverbanks or cliffs, tend to have lower extinction rates than more homogeneous areas. Areas deep in the forest that are surrounded only by more forest tend to support less diversity than the margins between multiple ecosystems — a condition called *reduced competitive exclusion*. In the model, the diversity of values for resource availability in adjoining grid cells yields a spatial variability value for each individual cell.

Seasonal changes in rainfall and temperature also influence tree growth, so seasonal variation (derived from the climate data) is another component of the model. Areas with more climate change from season to season, are more likely to support a high diversity of tree species.

If a tree falls . . . Similar to heterogeneous environments, areas experiencing moderate disturbance statistically support higher species diversity than stable or highly disturbed areas. In the cloud forest, the most disruptive event is a falling tree, which often pulls down a dozen neighboring trees with it. The resulting clearing becomes a hotspot for diversity as many organisms compete for the newly available sunny real estate. On the assumption that moderately steep slopes will have a moderate number of fallen trees, the model incorporates a disturbance ranking derived from the DEM slope data.

The model's main benefit is its predictive abilities. Says Jarvis, "I go with the botanists and ethnobotanists and agronomists with my laptop tucked under my arm, and help define where we go to collect based on species distribution modeling and satellite imagery. As we collect something new, I update the model in the evening and use it to fine-tune our predictions."

Not only can the model serve as a predictor of overall forest biodiversity, it can also predict individual species locations. In Paraguay, for instance, the model has successfully guided numerous discoveries of wild chilli and wild peanuts, two important but rare agricultural plant species.

Furthermore, the model has consistently confirmed the researchers' suspicions about the existence of a mid-altitude biodiversity peak. Both the model and field investigation suggest that in an elevation range from 1000 to 3000 meters, tree diversity steadily increases to a maximum at 2000 meters, then drops off again at elevations above 2000 meters. In attempting to fine tune his physical geography model of tropical montane cloud forest ecosystems, Jarvis is simultaneously demystifying the biological behavior of their inhabitants.

Into the jungle. Jarvis is the sort of person who makes the best of whatever cards life deals him. If this sounds passive, don't be fooled. When the spatial analysis predicted high biodiversity in an area of the jungle safely accessible only with formal permission from a local drug czar, for instance, Jarvis simply requested an audience. Entering the compound unarmed and alone, he was treated to a private and completely unexpected full English tea with the drug lord himself. Following a polite conversation, mostly about the weather, Jarvis returned home with the assurance that his scientific forays would go undisturbed. This valuable character trait of flexible assertiveness was key in resolving many of Jarvis' adventures in the Colombian and Ecuadorian jungles (while also earning a Ph.D.). In the corporate jungle, would his character serve him equally well? I like to think so.

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First to third to first

Drew Sayles, who considers himself a social entrepreneur, also thinks his adventures in the Third World will serve him well. Having built an international spatial business, Sayles is bringing Third World skills and a strong work ethic home to the United States. He spent fifteen years in Asia, starting as a Peace Corps volunteer in Nepal and later as a civil engineer on CARE (www.care.org)-, UNICEF (www.unicef.org)-, and USAID (www.usaid.gov)-funded projects in Bangladesh. The goal of one such project was to improve rural roads in approximately 450 Bangladeshi towns and thereby reduce farm-to-market transportation costs. To optimize the use of funds, the project required an inventory of Bangladesh's rural roads which, at the time, did not exist in any format. In collaboration with the government of Bangladesh's Local Government Engineering Department, Sayles joined the ambitious effort of creating not just any inventory, but a GIS inventory of rural roads.

As is typical of any large project, people take on a variety of roles. In this case, many local, but also some

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expatriate personnel, developed database schemas, designed the data management system, and trained other staff in its use. But how (I wondered) did a country as technically primitive as Bangladesh equip 450 rural towns with the computer hardware and network connections to enable spatial data exchange to a central planning point? Silly question; there was only one GIS, centrally located. The 450 towns each took responsibility for their own local data capture in the form of hand-annotated paper maps of rural roads, checked for accuracy by local people — the true experts. The finished paper maps eventually made their way to the central office where trained staff digitized and loaded them into the GIS.

International handshake. Though he didn't know it at the time, Sayles was also training himself in the formation of an international business partnership. Before leaving Bangladesh in early 1996, he made a handshake agreement with a Bangladeshi consulting engineering firm which was eager to take on international projects. Once back in the United States, Sayles implemented a business plan with the dual objective of creating sustainable job opportunities for Third World technicians and also earning a living. As president of his company, Compu-Links, Inc. (www.compu-links.com), he now closely collaborates with a partner company in Bangladesh. Sayles drums up First World work for which the Bangladesh company charges Third World prices. Although the projects are often labor intensive — such as registering, digitizing, and attributing data — the quality of the Bangladeshi output is consistently high thanks to the workers' patience and pride in their work.

Sayles reports that "last year was very successful" for Compu-Links, but that he "underestimated the challenge" of achieving the success he now enjoys. In the first year of operation, most of the work was CAD-related. Over the past four years, the scope has widened to include GIS projects such as cadastral digitization and attribution, developing DEMs from topographic maps, snapping vector data to orthophotography, and gas or electrical infrastructure paper-to-vector data conversion. Although the personnel in Bangladesh had a variety of CAD capabilities and experience, Sayles discovered that, to get good projects, he had to expand his company's offerings to also include GIS-related software development. Gradually, Sayles established relationships with U.S. utilities, consulting firms, and municipalities willing to take the risk of working with a new company and its offshore facility.

Compared with this initial challenge of breaking into the U.S. GIS market, he finds the process of managing an office that is 13,000 miles away quite feasible — thanks to a variety of Internet technologies. In addition to reviewing e-mail and uploading and downloading files, Sayles spends hours each day discussing the status of projects and addressing technical specifications with the Bangladeshi firm through the use of Microsoft's (www.microsoft.com) Net Meeting, which supports audio and video conferencing and sharing applications on another conferee's desktop. One thing he can't change, however, is the 11-hour time difference!

In search of a spatial niche

Jarvis' work is itself aimed at improving life on Earth whereas Sayles' work, regardless of the content, provides sustainable job opportunities for Third World workers in need. Both men derive great satisfaction from their efforts despite, or maybe because of, unusual and exotic circumstances in the mix. Both have overcome initial uncertainty to establish themselves in their current jobs, relying on flexible yet determined attitudes toward change and people. To tell the truth, their enthusiasm and character, more so than their adventuresome tales of faraway lands, were the most stimulating aspects of interviewing Jarvis and Sayles. As unusual and exotic as their jobs may be, their attitudes are familiar to anyone who has worked in the geospatial industry, which remains rich in inspiring people in any kind of economy.

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Compu-Links' partner company in Bangladesh currently staffs two dozen trained GIS specialists.