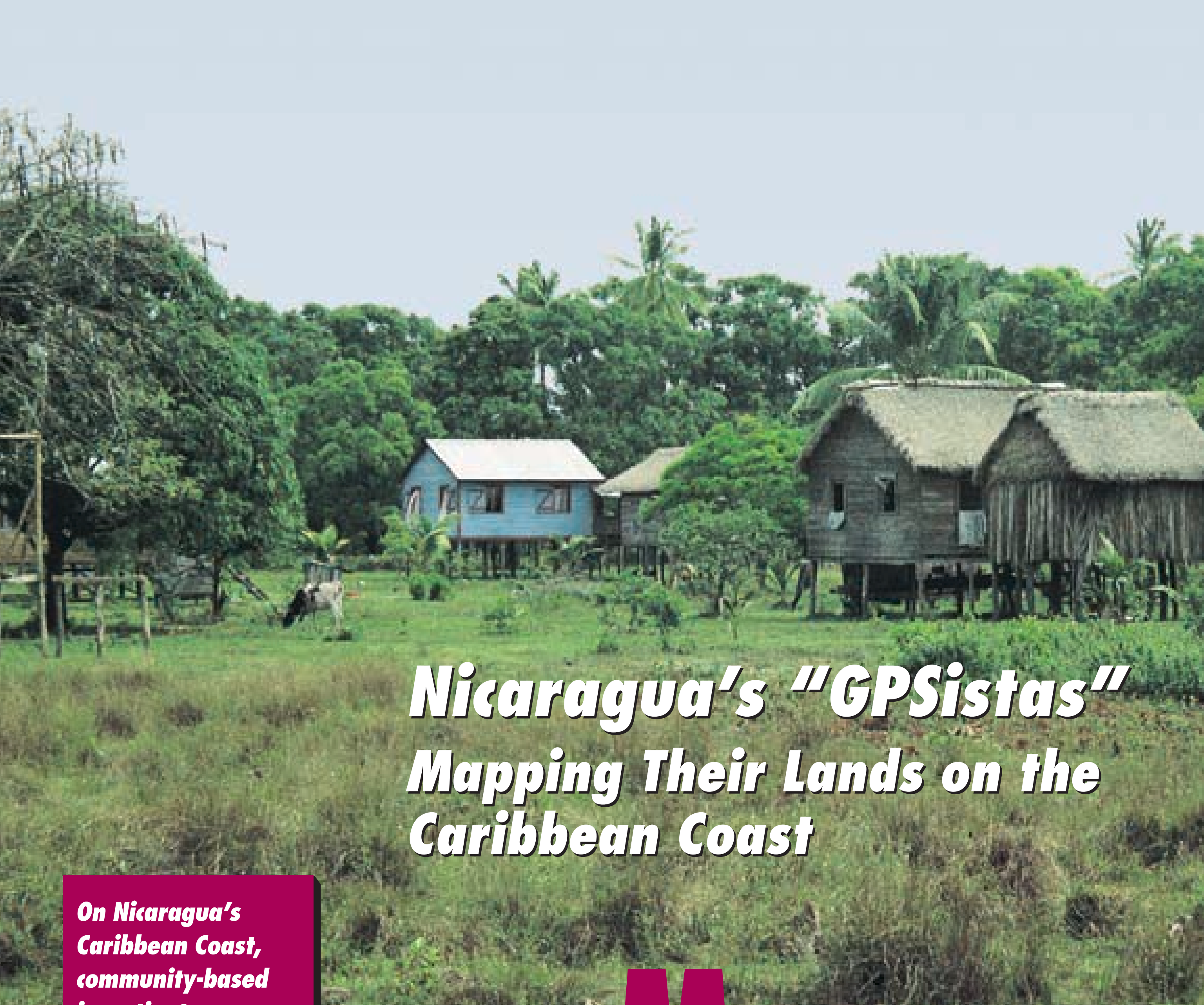

Nicaragua's "GPSistas"

Mapping Their Lands on the Caribbean Coast

On Nicaragua's Caribbean Coast, community-based investigators, many calling themselves "GPSistas," used low-cost GPS receivers and geographic information systems to produce those communities' first-ever maps. These documents may help resolve complex territorial disputes in a region long characterized by conflict.

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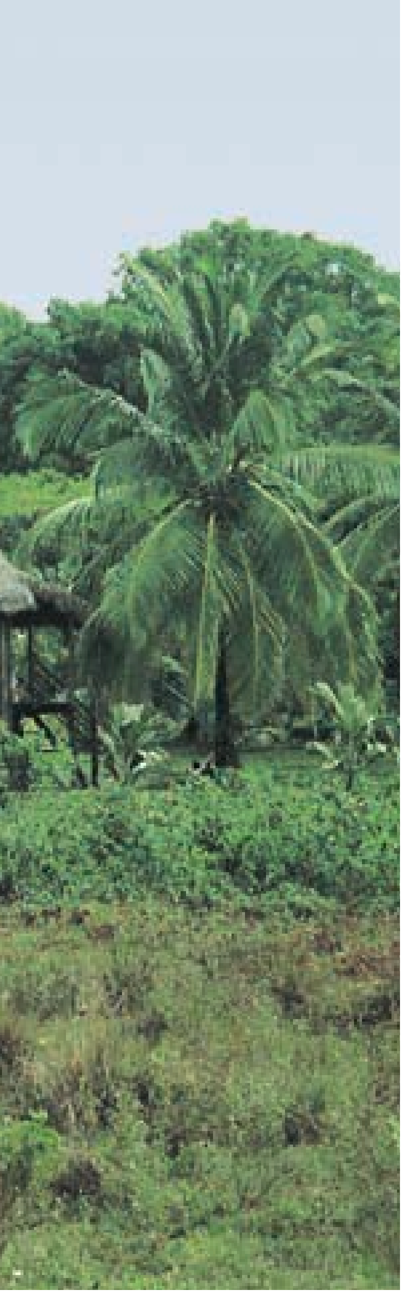
Many of the indigenous people of Nicaragua's Caribbean Coast remember 1979 as the year that isolation turned into conflict.

Then, as now, access to these communities was made difficult by a lack of roads, variable mountainous terrain, obstructive jungles, and an annual rainfall of five meters. Religious, racial, and ethnic differences also separated these coastal peoples from other Nicaraguans and the Nicaraguan government that had long allowed the Caribbean coastal communities to experience cycles of relative prosperity, followed by benign neglect. These cycles rose and fell, depending on outside interest in coastal assets. In the 1960s and 1970s, as pine-tree resources were depleted and mineral deposits became more difficult to extract, a period of disinterest fell over the region.

In 1979, though, the Sandinistas seized control of the government. Not long after, the Contras and other anti-Sandinista forces engaged them in a 10-year war that relocated thousands of coastal residents and killed hundreds. The isolation had been broken, but at a steep price.

Since the fall of the Sandinista government in 1990, international and Nicaraguan entities have increasingly sought to capitalize on the coast's valuable



assets, which include forest and fishery products, mineral deposits, and seafood. For the people who live on the coast — the Miskitu, Creole, Rama, Mayangna (Sumu), Garifuna, and Mestizos (see the “The Peoples of the Caribbean Coast” sidebar) — control of these resources and of the territories that contain them is crucial.

To resolve this issue, a natural first step is expressing the land tenure wishes of the coastal communities. By articulating their own concepts of use, ownership, control, and historic rights to land, irrespective of private land titles, the indigenous groups will be better able to protect, as well as profit from, their properties and assets.

The Peoples of the Caribbean Coast

Ethnic identity is complex, dynamic, and difficult to determine or describe anywhere, but especially so on Nicaragua’s Caribbean Coast, given the country’s past few decades of military and political conflict. Most authoritative sources, however, have identified six major groups living in that area: the Miskitu, Creole, Mayangna (Sumu), Rama, Garifuna, and Mestizo. These people account for a total population of perhaps 350,000.

Many of them have congregated in the multiethnic northern and southern coastal towns of Puerto Cabezas and Bluefields, respectively. These towns are the capitals of the northern and southern Atlantic autonomous regions.

Though they may share the same geographic area, the six ethnic groups are very distinct, with different languages, backgrounds, and livelihoods:

- The region’s 110,000 or so Miskitu Indians are mostly Moravian Protestants, who speak the Miskitu language. The majority of Miskitu live in villages and towns in the northern autonomous region and practice hunting, fishing, forest product extraction, mining, and subsistence agriculture.
- The 35,000 Creoles are of African descent and speak a Creolized English. They often work in commercial establishments and service jobs in Bluefields or farm and fish in the surrounding coastal area.
- The 5,000 Mayangna, or Sumu, people speak their own language. They live in small groups between the mountains and the coast and support themselves with subsistence agriculture and hunting along the river networks.
- The 1,500 Rama residents also speak an indigenous language. Rama communities dot the coast and islands within the Bluefield Lagoon, where members fish and farm.
- The 2,000 or so Garifuna are of African/Amerindian descent and speak an Amerindian language. Many live in small villages north of Bluefields in the Pearl Lagoon area, where they practice fishing and subsistence agriculture.
- Mestizos, Spanish-speaking Nicaraguans from the Pacific shore and highland Nicaragua, are moving into the Caribbean coastal areas in increasing numbers, for an approximate total of 200,000. They work in commerce, forest product extraction, mining, and transportation.

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The success of the project's participatory approach hinged on low-technology techniques, easy-to-use equipment, and interactive workshops. Here, prospective community investigators use GPS receivers in a field trial to record a point, the Benk mojón (Spanish for "landmark") near the town of Krukira.

A close-up view of the Benk mojón (bottom) shows details of its base.

This could have been a contentious process, subjecting the communities to even more conflict. During the past two years, however, the Central American and Caribbean Research Council (CACRC) — an organization led by Nicaraguan and University of Texas anthropologists and geographers — has collaborated with the Center for Investigation and Documentation of the Atlantic Coast (CIDCA), a Nicaraguan research institute, to help solve this problem peacefully.

Their approach stands on its head the notion that the best precision is always the highest precision obtainable — in this application, stand-alone GPS provides the perfect accuracy, expense, and technology level. Because of this, in 1996 CACRC was able to buy inexpensive, low-precision GPS receivers, train residents in the council's mapping methodology, and encourage the indigenous societies to map their own boundaries.

Low accuracy is preferred, because in this situation, in which boundary lines may be indeterminate or contested, an imprecise line may encourage negotiation. Thus, these initial expressions of community land claims represent only the first stage in what will certainly be a long, participatory process — in essence, an active, ongoing dialogue among indigenous groups.

In the years to come, residents will continue to incrementally redefine the areas that separate their neighboring societies. With luck and determination, the CACRC project should result in equitable and peaceful demarcation of lands that have value at almost every level of meaning.

PROJECT GENESIS

The World Bank initiated the project in 1996, by funding it through the Nicaraguan Institute of Agrarian Reform (Instituto Nicaraguense de Reforma Agraria, or INRA). INRA, in turn, contracted with CACRC.

Soon after, CACRC began defining the project goals, designing the participatory research approach, and selecting the project staff.

Because of my background as a GPS and geographic information system (GIS) consultant with an active research interest in the region, CACRC hired me as the project geographer/cartographer in November 1996. I prepared and tested a GPS measurement and GIS mapping methodology in December and January.

HIGHS OF LOW PRECISION

For any project, creating a methodology is an evolutionary process. All the preparation in the world is fine, but once the selected approach meets the practical nature of fieldwork, then modifications and permutations begin to take place. The Nicaraguan mapping project was no exception, as the methodology we finally arrived at was the result of prior planning and the ingenuity and dedication of the Caribbean Coast people who participated in the process.

Blurring the Lines. Traditional surveying practices yield varying levels of precision and accuracy. At the high end is the first-order survey, with a relative accuracy of one part in 100,000 (1 meter in 100 kilometers). Our work was based on the extreme opposite — the reconnaissance, or preliminary survey, whose goal is often to merely sketch out an idea of a parcel of land. This kind of accuracy was perfect for our potentially controversial work.

Real-World Technology. Early on, we rejected the possibility of using existing maps, aerial photographs, or satellite imagery, because they do not clearly depict the points important to community members, for example, certain trees.

Stand-alone GPS was ideal. In addition to aiding future negotiations, low accuracy, unlike high accuracy, does not assume the existence of precise points, lines, and areas. It also requires fewer measurement points along a boundary line.

Last but not least, lower accuracy usually brings with it lower technology and cost. This advantage enabled us to buy 15 rugged, 12-channel, L1, C/A-code handheld units for $200 each. With so many receivers and their relatively simple operation, we were able to train many investigators at once and map the land more quickly.

SIMPLY MAPPING

Our GPS measurement scheme placed little emphasis on technology, befitting the coast's difficult climate and unreliable supply lines. Batteries are

Crisp blue skies, lush green foliage, and clear ocean waters — the beauty of Nicaragua's Caribbean Coast is evident in this image of the Sahna Awala Housing River mojón, east of Krukira. Investigators mapped landmarks and boundaries at the site, using their handheld GPS receivers to record positions.

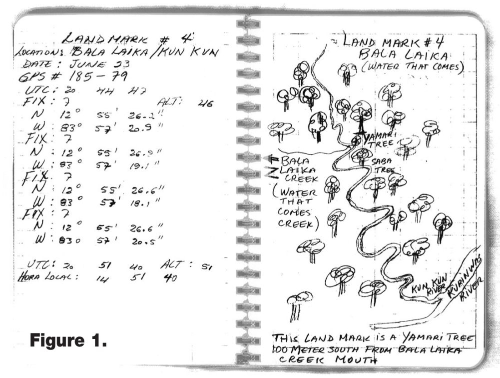


Figure 1. The investigators noted all important information in waterproof, paper field notebooks. These hand-printed, hand-sketched documents are examples of cartography's seamless melding of art and science.

difficult to obtain, and electric power, for charging computer batteries, is intermittent or often unavailable. Furthermore, as one of the wettest places in the hemisphere, the coast is often shrouded in clouds that prevent efficient solar power use. Such an environment demands the simplest possible plan.

Hold Back the Rain. To combat the everpresent moisture, our GPS receivers needed to be, above all, water-resistant. We relied on waterproof paper notebooks, instead of notebook computers, to record data. It was not just rain that dictated the use of paper notebooks in preference to computer disks. These yellow notebooks have become, by design, permanent and accessible records of the measurement process. They have remained in Nicaragua, easily read and understood by anyone with comments or questions about the process.

Each investigator carried a waterproof box containing a GPS receiver, a field notebook, a set of spare batteries, a compass, and several mechanical pencils. For trips to distant points, two boxes proved necessary to ensure the availability of at least one receiver, in case of loss or damage.

For Good Measure. Mappers measured significant turning points on boundaries. In most cases, these consisted of actual point features, natural or human-made, that held meaning for the communities. These ranged from concrete markers and sections of rail, to natural "monuments" such as coconut palm trees.

GPS measurements in places lacking a direct line of site to the satellites, though, produced poor position fixes. Mappers therefore used the magnetic compass to measure direction from an unobstructed point to the actual boundary point, estimating distance by pacing. They sometimes measured boundary points on small islands from boats, using compass bearings and distance estimates, which allowed the GIS to extrapolate the monument's position from the GPS measurements.

Essential Data. What did the mappers record? The left page of the notebook included four independent GPS position measurements in degrees, minutes, and seconds of the World Geodetic System of 1984 (WGS 84) latitude and longitude. By also noting elevations, we were able to check the data's legitimacy and ensure a minimum of four satellite signals. These four position readings also allowed us to perform some degree of averaging and error checking as well as double-check the handwritten digits.

Other recorded data included the GPS receiver number, fix quality, date, UTC (Universal Coordinated Time) time tag, position name, and names of community members and investigators.

The right-hand page contained a sketch of the point and its surroundings, showing its relationship to other points. It also revealed and measurement's order with respect to a point along the boundary polygon (see Figure 1).

THEORY INTO PRACTICE

We held the initial training workshops and sessions in Nicaragua in March and April 1997. CIDCA provided office space, meeting rooms, transportation, and local arrangements, all of which were essential to the project.

CACRC hired a cadre of 15 field investigators, entirely from the coast, and trained them in workshops in Puerto Cabezas, in the north, and in Haulover, in the south. We instructed them in the nuances of GPS theory and the basics of our measurement methodology. Putting the two concepts together in field exercises using the boundary points of a participating community demonstrated the intuitive

Puerto Cabezas (top) is one of the largest cities on Nicaragua's Caribbean Coast and correspondingly played an important role in the mapping project. The project leaders held workshops in Puerto Cabezas, and the investigators mapped many communities near the town.

Bluefields (bottom) is another major city. Whereas Puerto Cabezas is situated in the north, Bluefields lies far south. These two towns are the regional capitals of the northern and southern Atlantic autonomous regions.

nature of GPS technology and the importance people place on territory.

In the first field tests, workshop attendees clearly understood that GPS provides a means of transferring geographic knowledge and territorial desires to paper maps. For them, it was very easy to make the connection between the constellation of GPS satellites, geodetic coordinates in an abstract system, and the traditional boundaries of their communal lands.

In addition to training the investigators, the workshops brought societies together. We opened the classes to everyone, encouraging the participants to interact. CACRC consultants, investigators, and community members all contributed to the discussions about societies, boundaries, and conflicts.

From these fruitful exchanges came many different ideas about the meaning of boundaries. For some, monuments marked boundary turning points, and for others the boundary was unmarked but commonly understood. In these cases, the groups selected new turning points that would encompass the accepted sense of community limits.

THE FIRST PASS

Shortly after the first two-week training sessions, the investigators and CACRC consultants ventured into the field to make preliminary boundary measurements. Initial efforts focused on producing notebooks for those communities hardest to reach in the rainy season, which begins in early summer and lasts until mid-fall.

Using CACRC-supplied vehicles and small boats, principal investigators traveled to communities, received approval for the work from group leaders, selected community investigators, discussed boundary and land use issues, and set out to measure GPS points along the boundaries.

The last task was not always easy to perform. By their nature, most points were between communities and often in areas where travel was difficult. Several points took days of travel to reach. Investigators experienced difficulty obtaining fuel for trucks and boats; a couple of mappers lost notebooks, base maps, and other materials during a river crossing; and, most alarmingly, some participants were injured. Two people were hurt on separate occasions at sea in CACRC pangas (small boats) in the south, and other mappers reported injuries in the north.

Measuring the Monuments. During their fieldwork, the investigators found that communities hold varying concepts about land tenure. In the communities outside of Puerto Cabezas, few titles exist for home sites. Instead, residents often construct houses on communal lands. In the town of Bluefields, conversely, they build most of their homes on private property and have some form of land title. Many other coastal communities hold title to small portions of land that were granted at various times in the past. In most instances, these titles represent a small fraction of the lands claimed in our mapping process.

In both the north and south, communities often have ideas about land rights that transcend the concept of state or private property. Most societies can easily identify distinct points or landmarks (*mojónes*, in Spanish) that represent turning points in land boundaries. Although the line between monuments frequently was vague or difficult to describe, the monuments themselves were often well known, serving as common points for adjoining communities.

Coming Together. In the first few months, we assumed that each village would measure its own boundaries, resulting in 127 separate maps. As the work progressed, our initial beliefs slowly evolved into a new concept of community.

Many settlements joined together, forming blocks of contiguous regions. The block concept is not unprecedented — for example, the "Ten Communities" (Diez Communidades) in the Puerto Cabezas area banded together decades ago to increase political strength.

The new unions asked us to map "bloques" rather than individual groups to help dispel internal boundary disputes and to prevent the formation of "national land," which is unclaimed territory that the state can appropriate. The neighboring communities of Klingna and Suket Pin, for example, elected to be mapped as "Bloque Klingna."

In the end, the 127 communities melded into 30 blocks. In many cases, groups agreed on names for these blocks that represent completely new associations.

Figure 2

This map displays several places mentioned in the article, such as Diez Communidades and Puerto Cabezas. As can be seen, the investigators covered much ground during their months of fieldwork.

Figure 2. The investigators used various icons to identify many important land-use categories. In this particular legend, categories are defined in both Spanish (top) and Miskitu (bottom).

Name Recognition. As one would expect in a place with many languages — including Miskitu, Rama, Sumu, Garifuna, English Creole, and Spanish — place names were very much a point of contention. (In fact, while we were preparing this article, officials changed the name of Puerto Cabezas to Bilwi, the indigenous term long preferred by the Miskitu. Because most of our references to that town concern work performed before the name change, we will continue calling it by its old name in this article.)

For one monument along the Diez Communidades boundary, for instance, the name was variously "Sana Awala," "Barra Sanawala," "Sahnawala Bar," and "Kukuta Housing River," before the communities agreed on the name of "Sahna Awala Housing River." The final maps identify most monuments with a single name agreed to by community members active in the mapping process.

Ethnographic Symbols. Mappers spent part of their time gathering ethnographic data about the communities. The information emphasized past and present land use to provide evidence of historic and current land claims. As the mapping progressed, we devised a set of land use categories and symbols for the final maps.

These categories included mineral resources, forest products, fishing, permanent and annual agriculture, hunting, livestock grazing, places of historical and cultural importance, sacred and religious places, ecological reserves, social and recreational areas, and locations of transportation or communication infrastructure (see Figure 2).

The Power of Maps

Mapping and surveying can have profound effects on the relationships between people and their lands. The points, lines, and areas on maps can suggest a finality and a legitimacy to land tenure issues that may, in fact, be in considerable flux and contention. The symbols and text can imply, in the selection of shapes and language, the importance of one culture over another.

To bring this concept home, imagine a map of your own town, with familiar places given new names in a foreign language, with strange symbols for churches and hospitals, and with lines enclosing areas you think of as being separate from each other and vice versa. Then consider that colonial powers have done this for centuries.

Surveying often results in new maps; but even if the measurements are never charted, the physical process of surveying can change perceptions of place. "Staking a claim" can suggest rightful ownership, and "running a line" (that is, surveying a single transect) through wild and unexplored territory can imply that the area is controllable and accessible. So potent is this act of measuring that to comfort investors, depictions of surveyors and their equipment illustrated nineteenth-century promotional literature about railroad and canal projects.

Many books explore the connections between values and power, politics and control, and maps and surveying. These include Dennis Woods's *The Power of Maps* (The Guilford Press, 1992), Mark Monmonier's *Drawing the Line: Tales of Cartocontroversy* (Henry Holt, 1995), and David Buisseret's *Monarchs, Ministers, and Maps: The Emergence of Cartography as a Tool of Government in Early Modern Europe* (University of Chicago Press, 1992).

J. Brian Harley, coeditor of the ongoing multivolume *History of Cartography* (University of Chicago Press, 1987 for the first volume), wrote this about the links among values, power, maps,

Checking Twice. A vital part of the mapping was validating the methodology. Unlike traditional surveying techniques in which relationships exist between traverse length and expected accuracy, GPS offers no internal estimates of error.

To test our GPS-based mapping, we compared independent measurements made by different observers at different times. In general, we found that independent checks of GPS measurements verified the specified 100 meters of unaided GPS accuracy.

We substantiated other aspects of our methodology. Recording the receiver number, for example, enabled us to correct measurements from an improperly configured receiver. An error in setup procedures left one receiver in the degrees, minutes, and decimal minutes mode. When we saw recorded numbers exceeding 59 seconds, we knew that a unit had been incorrectly set. By tracing the recorded receiver number, we isolated that unit's measurements. Then, by identifying the dates and times, we determined the time period for which we would later have to convert the measurements from fractional minutes to seconds.

NOTES BECOME MAPS

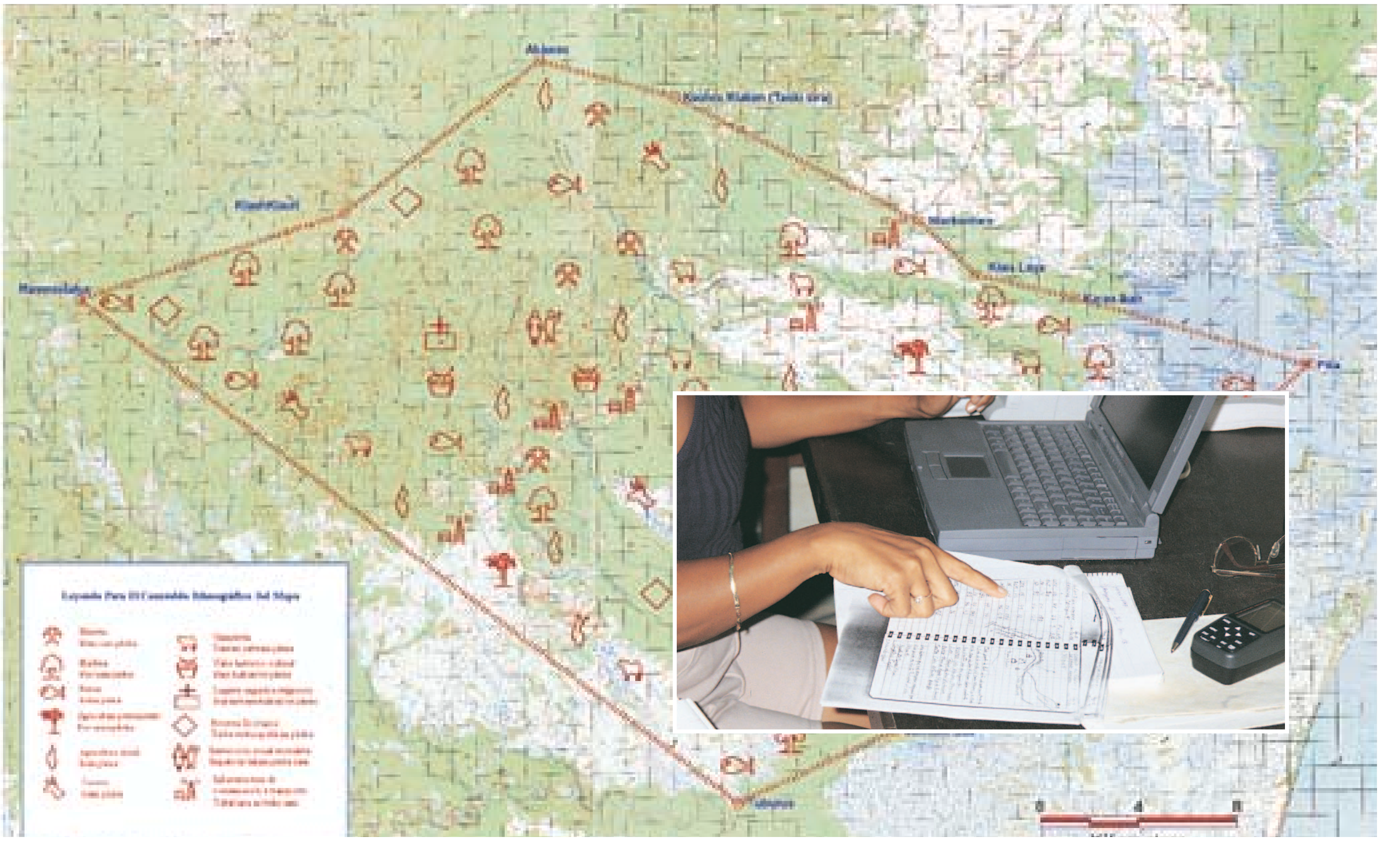
The yellow waterproof notebooks held a wealth of information that we converted into digital formats to create maps. In keeping with our simple approach, we developed an easy map-generating process: Input the notebook data into a spread-

and surveying in his well-known paper, "Maps, Knowledge, and Power," in *The Iconography of Landscape: Essays on the Symbolic Representation, Design, and Use of Past Environment,* edited by Denis Cosgrove and Stephen Daniels (Cambridge University Press, 1988):

> As much as guns and warships, maps have been the weapons of imperialism. Insofar as maps were used in colonial promotion, and lands claimed on paper before they were effectively occupied, maps anticipated empire. Surveyors marched alongside soldiers, initially mapping for reconnaissance, then for general information, and eventually as tools of pacification, civilization, and exploitation in the defined colonies. But there is more to this than the drawing of boundaries for the practical political or military containment of subject populations. Maps were used to legitimize the reality of conquest and empire. They helped create myths which would assist in the maintenance of the territorial *status quo.* As communicators of an imperial message, they have been used as an aggressive complement to the rhetoric of speeches, newspapers, and written texts, or to the histories and popular songs extolling the virtues of empire.

In the past, mapping and surveying processes were more accessible to those with economic power. This, however, is changing. The availability of low-cost GPS and geographic information systems (GIS) has allowed increasing balance in technological access. More and more projects around the world (including several in Nicaragua, in addition to the CACRC project described in this article) have resulted in participatory mapping of indigenous land claims, resource management plans, and conservation studies.

Thanks to GIS, maps are becoming available to everyone, and they are now just as likely to be used as tools of persuasion and self-expression as imperial weapons. GPS, likewise, has made surveying less a means of exploitation and more a way of allowing local participation in land tenure issues.



Creating a preliminary map begins with the simple act of entering data from a field notebook (above right).

Then, investigators import scanned background maps, overlay boundaries and land-use categories, receive community input, and print out maps, such as this one of the Bloque Klingna (top).

The project goal is to enable community members, such as Betty Rigby (above), to perform all the steps needed to create such maps.

sheet program running on a laptop computer, import the spreadsheet to a GIS, label the features and points, draw in boundaries, import scanned background maps, and print out a preliminary draft.

Filling in the Spreadsheet. To enter data into the spreadsheet, we first photocopied the notebooks and then entered position names, degrees, and minutes and seconds of latitude and longitude for each point. For points determined using a compass and offset points, we entered the bearings and ranges using the spreadsheet to calculate the final values in decimal degrees of longitude and latitude.

GIS Data Layering. After importing the data to our GIS, we referenced point tables to the WGS 84 geodetic datum used in the GPS measurements. A large map point symbol suggested the measurement imprecision.

We then created a region layer, "snapped" to the GPS measurement points, making boundaries that connected the points in the order that correctly bounded the region. Because the lines between points were even more in dispute than the points themselves, we selected a 100-meter-wide series of short dashes perpendicular to the boundary to indicate the size of the possible measurement error.

The Preliminary Maps. To create the first set of maps, we overlaid the GPS points and community boundary lines onto scanned 1:250,000-scale topographic maps registered to the North American Datum of 1927 (NAD 27). Though made in the 1940s and revised in the 1950s, these maps were useful for labeling the drafts with land use symbols, correcting point placement errors, and naming points. We sent these draft maps to the communities for land use demarcation.

The Revised Versions. Based on community input, we created the final maps by overlaying the GPS points, community boundaries, and land use symbols on a set of scanned 1:50,000-scale topographic maps from the 1980s. We scanned more than 100 maps at 300 pixels per inch and stored them on CD-ROMS. To use them in the GIS, we resampled them at a lower resolution, rotated them when necessary, and cropped them to exclude borders and legends. Tabular files along with resampled maps formed registration files for direct import to the GIS.

The GIS converted the GPS points and region boundaries lines from WGS 84 to NAD 27 during the overlay process, shifting the WGS 84 GPS longitudes about 13 meters west and the latitudes about 110 meters south on an NAD 27 map of Nicaragua. The GIS engine then computed areas representing communities, area overlap, and land and sea distribution in those groups claiming Caribbean waters and cays.

FIRST EXPRESSIONS

March 25, 1998, was a momentous day for us. That was when we finished the community map set. Those 90 map sheets represent the work of many people in more than 100 communities. Traveling by foot, horse, car, truck, and small boat, these dedicated individuals measured hundreds of points. In several instances, investigators and community members walked for hours in chest-high water, along empty stretches of narrow beach, or in the pouring rain to measure a single point with GPS.

Although the fortitude shown during the fieldwork was heartening, for me the most exciting moment of this entire project occurred earlier this year, when Betty Rigby, an investigator in Puerto Cabezas, made a full-color community map from the field notebook she had helped fill with GPS measurements. She parsed the notebook, filled in the spreadsheet template, imported the points to the GIS, labeled them, made the Klingna community boundary, imported the scanned background maps, and printed the draft for community review.

From beginning to end, she performed all the tasks needed to create a product that will serve as a basis for discussion during the coming years. The importance of placing technology in the hands of the people — that is, distributing tools to the many, rather than the few — cannot be overstated. As "The Power of Maps" sidebar illustrates, such a capability has only recently become available.

It is still too early to predict how the border negotiations among communities, community blocks, and the state will go. Those of us involved in this project hope that everyone will see these maps not as absolute land claims, but as a first step — an expression of community wishes, subject to modification in the placement and arrangement of points, lines, and areas and in the affiliations between communities.

Using GPS, GIS, and participatory approaches, this Nicaraguan mapping project may evolve into a new process — one in which the new "GPSistas," (pronounced *g-p-sistas*) as many of the project investigators now call themselves, will continue employing GPS and GIS to refine the boundaries through the next few years. As communities begin to express their views and compromise with one another, the maps will evolve, reflecting the changing wishes of those who live on Nicaragua's Caribbean Coast. ■

MANUFACTURERS

The CACRC consultants and community investigators used 15 handheld Explorer receivers from **Eagle Electronics** (Tulsa, Oklahoma), MapInfo GIS software from **MapInfo** (Troy, New York), and the Excel spreadsheet program from **Microsoft** (Redmond, Washington). They printed the maps on a Stylus Color 1520 printer from **Epson America** (Torrance, California).