Raptor Rescue:

Mapping Venezuela's Harpy Eagle Habitat

As the human population penetrates deeper into South American rain forests, the ecosystems that support native species frequently suffer. Such is the case with Harpy eagle habitat in Venezuela. But, by mapping the eagle's territory with GPS, using GIS to create buffer zones around nests, and informing the native population and policymakers about the eagle's plight, the Harpy Eagle Conservation Program hopes to protect the raptor's habitat and stabilize its declining population.

Peter E. Kung

Biological Consulting & Surveying

Eduardo Alvarez-Cordero

The Peregrine Fund

Peter E. Kung, a field biologist who has a private consulting firm in Logan, Utah, is an expert in biological applications of GPS. Kung facilitated the equipment and software loans to conduct the Harpy eagle habitat mapping and integrate the data into a geographic information system.

Eduardo Alvarez-Cordero, a Venezuelan who has been studying Harpy eagles for more than a decade, recently received his Ph.D. in wildlife ecology and conservation from the University of Florida in Gainesville. He has been director of the Peregrine Fund's Harpy Eagle Conservation Program since 1991.

Field Manager Rafael Alvarez cautiously descends from an eagle's nest. This fledgling will be banded, outfitted with a transmitter, and released within the hour.

Deep in the South American jungle, an enormous raptor hidden in the forest canopy's thick foliage stalks its prey. With its gaze locked firmly on a three-toed sloth, the predator launches from its perch with incredible speed. Moments later, its victim still struggling in the tremendous grip, the hunter returns to the treetops where a ravenous nestling awaits the feast.

Distinguished by its massive feet with four-inch talons, these skilled hunters select huge emergent trees in which to build their nests above the rain-forest canopy. The largest eagles in the world, Harpy eagles (*Harpia harpyja*) can reach lengths of four feet from their double crest to the tip of their tail, with a wingspan often exceeding seven feet. Preying predominantly on arboreal or tree-dwelling mammals — mostly sloths and monkeys — these huge birds range through the neotropical rain-forest ecosystems of Central and South America, from southern Mexico to northern Argentina. Harpies have been known to survive more than 40

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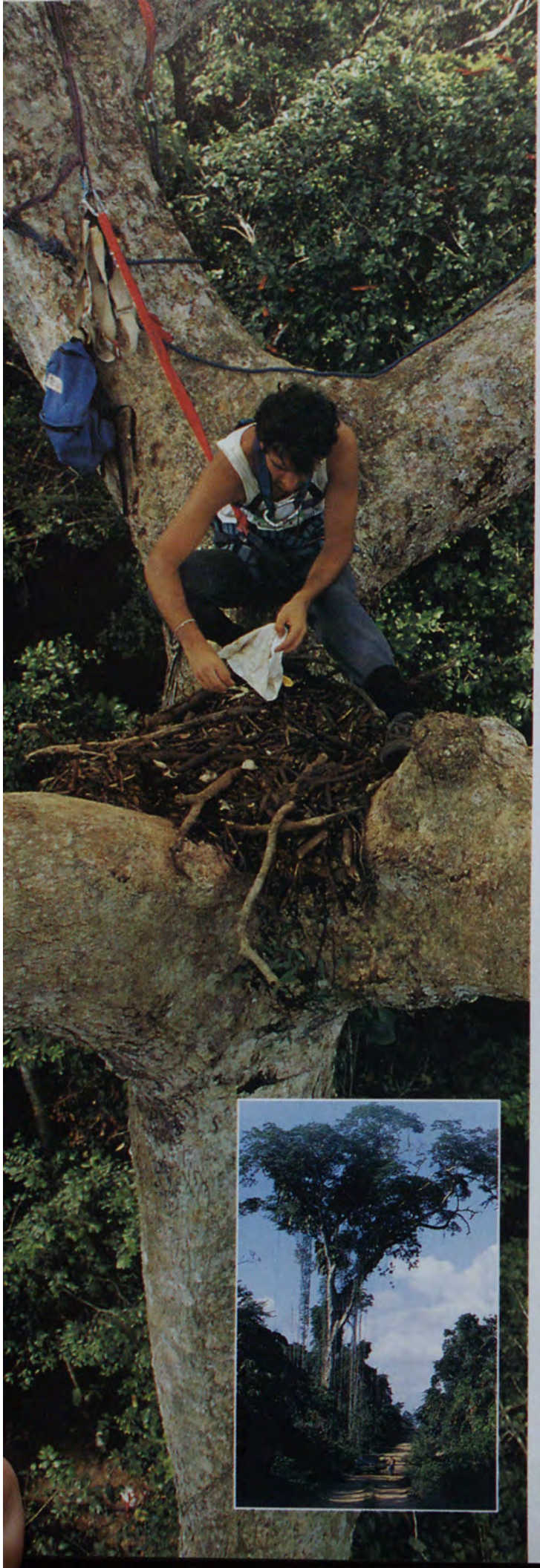

years in captivity, and females (as a rule the larger gender among most birds of prey) weigh as much as 18 pounds.

Because these huge raptors rarely, if ever, soar above the deep rain forest where they live, visitors seldom encounter the elusive birds. During the past decade, however, human activities within the eagle's habitat have risen sharply. Human settlements encroaching on the forest, logging and mining operations, and poaching have decimated the Harpy population. Recognized as the National Bird of Panama, the eagle is included in various lists of endangered or threatened species and has gained protected status in many countries throughout its range.

ECOSYSTEMS IN BALANCE

Emerging evidence suggests that large predators, such as raptors and wildcats, could play critical roles in maintaining biological diversity in complex forest ecosystems. Their loss could likely affect native flora and fauna. Maintaining these predators, however, requires multidisciplinary approaches that include educating local residents, cooperating with government leaders and field professionals, training students, and preserving the ecosystems in which the species lives.

To meet these requirements, the Peregrine Fund — a nonprofit international organization in Boise, Idaho, that is dedicated to conserving birds of prey and their environments — launched its Harpy Eagle Conservation Program (HECP) in 1991. HECP uses cutting-edge technologies, including GPS, to document threats to the Harpy's habitat in hopes of sparking action to curb the birds' population decline.

More than 100 feet above the forest floor, a field biologist (photo left) gathers samples of sloth and monkey bones scattered about a nest.

The survey crew's vehicle is dwarfed by one of the massive trees in which the eagles often nest (inset photo, left).

HECP TASKS AND TOOLS

Our HECP team members include Director Eduardo Alvarez-Cordero, a native Venezuelan now living in Florida; Peter Kung, a field biologist from Logan, Utah; HECP Field Manager Rafael Alvarez; and local associate Gustavo Martinez, an information systems expert.

HECP's first task was to locate Harpy eagles and study their nesting biology in Latin America. By gathering and sharing basic environmental knowledge about this bird and its habitat, we could encourage government and private agencies to redirect unrestricted development, identify sustainable land uses, and support local initiatives to preserve habitats hosting these large eagles and other key species. We hoped that, through these efforts, we could protect and stabilize local Harpy populations to prevent the species' extinction.

First, though, we needed to answer some tough questions about this little-known bird. For example, how long is their nesting cycle and where do the young eagles go after leaving their parents' territory? Not only must we consider the adult's requirements for breeding, we must also ensure juvenile dispersal for reproduction to be successful. In addition, we needed to determine the layout and compare the distribution of nests and breeding pairs among different rain-forest settings in Central and South America. This information would help us to analyze the birds' habitat needs.

Knowledge of Harpy eagle biology and ecology would indicate whether location, size, and quality of existing and planned habitat reserves would be sufficient to sustain viable populations. Unfortunately, because the Harpy is one of

the least-studied birds of prey in Latin America, this information would not be easy to come by.

Only a handful of nests had been located in Guyana by cinematographer-naturalist Neil Rettig, one of the world experts about this species. Because the raptor moves stealthily inside the forest canopy — a multilayer portion of its ecosystem where most of a rain forest's vertebrate fauna is found — this species is very hard to locate and monitor. In addition, the habitat is extremely remote, served mostly by rivers, jungle trails, and logging roads.

To meet the challenges posed by this harsh study environment, and because many of the answers we were seeking have some geographic or spatial element, we engaged a host of new technologies. These included using remote tracking tools — such as conventional radio telemetry and satellite transmitters — to monitor adult pairs and to map the dispersal of young eagles from their parents' nests.

Satellite Tracking. In 1992, we began capturing eagles at active nest sites and banding them for identification. We also outfitted them with transmitters so we could monitor the eagles' movements. Within a few years, HECP biologists, in cooperation with David Ellis (United States Department of Interior, National Biological Service), had outfitted nearly 20 Harpies with satellite telemetry tags provided by the National Aeronautics and Space Administration (NASA). (See sidebar on page 27 entitled "An Eyrie Encounter.")

These backpack transmitters emit a signal that is detected by U.S. National Oceanographic and Atmospheric Administration (NOAA) weather satellites as they orbit the earth. After HECP tags and releases the bird, the transmitter sends data to the satellites, which the French Argos Service downloads and sends to NASA on a daily basis.

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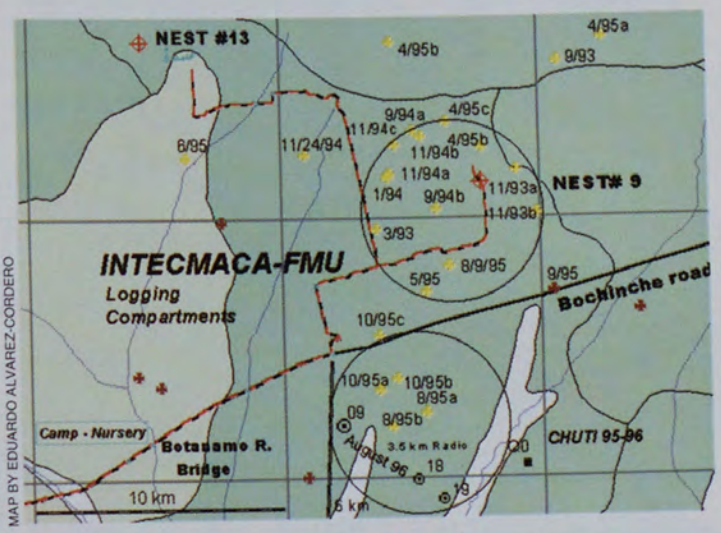

MAP BY EDUARDO ALVAREZ-CORDERO

NASA then sends the bird's location information to HECP using electronic mail. We use these data to update our geographic information system (GIS) and produce maps for field biologists and forest managers.

GPS and GIS. We used GPS to map the locations of Harpy Eagle nests. By gathering georeferenced data about the birds and their habitat and storing them in GIS, we could follow trends in the Harpy's habitat conditions and monitor the ranging and hunting habits of specific birds.

Using GIS, we could also help those managing the forests to create buffer zones around nesting pairs. If implemented in time, these buffer zones would prevent human activities from encroaching on the birds' territory.

We also used GPS to map the network of roads and trails that provide access to the nesting sites. Because the area is so remote, many of the roads were not on any maps.

PIONEERING USE

HECP first used GPS in Venezuela in December 1991 and expanded its use into Panama in March 1992. These trial runs helped the team to explore the technology's ability to map in a forest environment and to become familiar with general GPS operations.

While in Panama, director Alvarez-Cordero visited a Harpy eagle nest reported by a ranger in Darien National Park. Using a five-channel, L1, C/A-code GPS

Alvarez cautiously lowers a snared Harpy from its nest for banding (top photo).

HECP faced many challenges in the Venezuelan jungle (photo, above left). Here, Peter Kung tries to capture usable satellite signals from the rain-forest floor.

The map above reflects the movements of *Chuti*, a juvenile eagle tagged in 1993. Each yellow symbol reflects the bird's location and date as indicated by the satellite transmissions. For the first 20 months, Chuti remained within his parents' territory. Following the bird's movements helped HECP learn more about Harpy eagles' nest-dispersal patterns.

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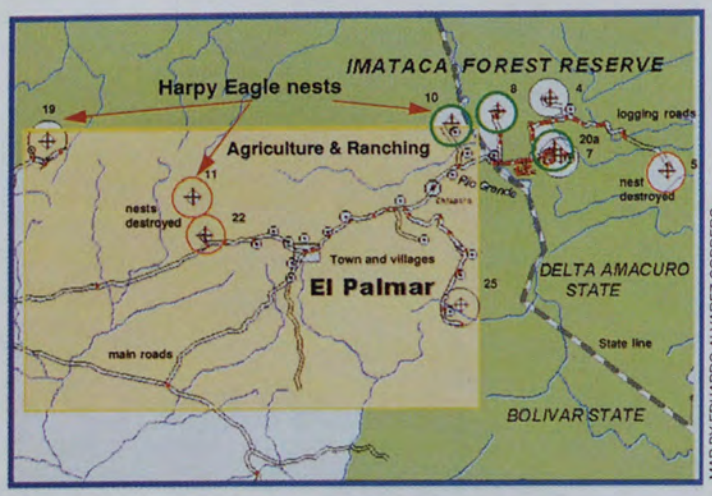

MAP BY EDUARDO ALVAREZ-CORDERO

Alvarez-Cordero (left) and Alvarez (right) attach a satellite transmitter to a young Harpy eagle.

The above map reflects the most dense concentration of Harpy nests that the team found during its survey. Because they are so close to human settlements (agricultural land), these nests will be carefully monitored.

receiver, he logged the nest site coordinates. In January 1993, when he returned to the park with a Venezuelan filming project, he used those coordinates to navigate back to the nest on a different trail. The system worked perfectly, alerting him as he approached the target.

Alvarez-Cordero further tested GPS navigation during a series of cross-country hikes to other nests and was able to reach targeted locations even when navigating through uncharted territory. These experiences gave the team confidence in this new tool, which would become the basis of its data collection efforts.

Team members continued to locate and georeference nests in the dense South American jungles, gaining further experience and confidence in GPS's ability to help them navigate the rough terrain.

We were then ready to put GPS to the test in Venezuela. This phase of our research required us to map a 250 × 300–kilometer area where more than 30 nest sites had been identified.

VENEZUELAN VENUE

In January 1995, taking advantage of the dry season, HECP team members traveled to Venezuela to conduct the first field mapping session of confirmed nesting sites.

We chose to start in the lowland tropical rain forest of eastern Venezuela's Sierra Imataca Forest Reserve because the birds are particularly threatened in this area, where much of the forest has been converted to pasture and agricultural land.

In the 1980s, timber companies also began conducting selective logging in large tracts (more than 150,000 hectares each) of public land designated as forest management units (FMUs). The Venezuelan government designates these FMUs as logging concessions to be harvested by private companies. This started a significant process of fragmentation in much of the remaining forest. Many confirmed Harpy sightings and most of the nests we are monitoring are inside these FMUs. We proceeded into the area intent on mapping the nest locations, identifiable features in the habitat immediately surrounding them, and access roads and rivers within the unit.

We began with an aerial reconnaissance of the area to be mapped. In addition to arranging for us to use a laptop computer, team member Martinez had procured a full day of complimentary helicopter time from CVG-Ferrominera Orinoco (FMO, a Venezuelan government company that mines iron ore).

Although FMO officials had committed the helicopter, the pilot demanded at the last minute that we deliver additional fuel before we took off the next morning. Alvarez-Cordero borrowed a pickup from collaborators at the nearby Guri dam. He then rushed to purchase the empty barrels needed to carry the specified 250 gallons of fuel. By sundown we had obtained the fuel and were on our way to a logging camp near the nests sites at the Imataca Forest Reserve, almost 200 kilometers east.

BIRDS-EYE VIEW

Our first objective while we had access to the helicopter, was to make an overflight of the Imataca Range. Since 1992, we had been monitoring several nests from the ground. Using waypoints that Alvarez-Cordero had previously collected, we attempted to locate some of these nests from the air and inspect their surrounding habitat. Captain Morillo, the chopper pilot, entered the waypoints and off we flew toward the frontier with neighboring Guyana. Because the Bell Ranger chopper could accommodate only four passengers and the pilot, part of the team traveled overland and met us in the forest later.

As the aircraft's built-in navigational GPS unit indicated that we were approaching the first waypoint, Alvarez-Cordero recognized a nearby village by its water tower. He instructed the pilot to circle a logging camp beyond the Rio Grande bridge. There, we found our other teammates and the precious spare fuel on the ground. Then we headed for the next waypoint and our first nest.

As the GPS receiver signaled completion of the first navigational "leg," we sighted the nest known as *Baquiro* in a tree emerging above the forest canopy. The pilot circled closer, and a large bird flew out, perching on a nearby branch. We hovered closer to confirm the identity of this young Harpy eagle, still in white plumage. It was *Taya,* a bird that team members had tagged as a nestling 10 months earlier. The

backpack satellite transmitter and the eagle's blue leg band were clearly visible.

Guided by GPS, we had flown straight to the site, conserving precious time and fuel. Already, this trip had proven aerial monitoring to be a successful method.

The chopper pilot's flying talents also greatly helped our efforts. He could hover almost motionless over nests while we double checked their locations with our GPS units. He also saved all the waypoints to the onboard GPS unit's memory, promising to revisit and check the nests for us if he found himself working nearby in the future.

When the pilot landed to refuel, team members took turns flying to other nearby nest sites. In all, we visually checked and recorded the status of five nests in a small fraction of the time that it would have taken using ground-based alternatives. In addition, using both the built-in and handheld GPS units, we were able to accurately georeference the Harpy nest locations from the air and compare these coordinates with those obtained on the ground.

MURPHY'S LAW

The HECP team spent the next few days checking, rechecking, and preparing all the necessary field and office gear for the upcoming ground-based data collection effort. Previous experience told us to expect the worst. Sure enough, once we were in country, initial attempts to integrate various computer software (in some cases, beta versions) and hardware revealed signs of incompatibility.

The team had loaded one 486 laptop computer with base station software and coupled it with a 12-channel, L1, C/A-code GPS receiver and a remote compact dome antenna to act as a community base station. The lack of an upgraded software security key, however, prevented its use. We still had functioning GPS gear, so the challenge was to use each component to its fullest capacity and compatibility to collect as much data as possible while in the field. We could conduct our differential corrections later.

We improvised by using our 12-channel receiver with a data collector (that had only 640 kilobytes of memory) as our local base station. We used an eight-channel, L1, C/A-code receiver as a rover and a six-channel, L1, C/A-code handheld receiver served as both a quick waypoint navigating tool and a second rover.

DAM DETAILS

Plans called for establishing our GPS base station at the hydroelectric dam in Guri, approximately 150 kilometers west of the first intended survey area. Before turning his attention to Harpies, Alvarez-Cordero had lived at Guri and worked as the resident ecologist for EDELCA, the Venezuelan government's hydroelectric company; thus, he was familiar with the area and the organization.

We elected to locate the base station at the Ecologia office near the dam because of its security, essentially unlimited satellite horizon, and access to an international phone line in case we required additional assistance.

Orlando Borrome, a professional surveyor stationed at the dam, directed us to a nearby high-order control point on which we could locate our base station. By using the 12-channel and eight-channel receivers, we established a new base reference point at the Ecologia office. This would enable us to postprocess and differentially correct files while we were still in the country.

Fortunately, Borrome was also willing to run the base station while we were in the forest. Not only a top-notch surveyor, but also very computer literate, Borrome was a breeze to train. Kung quickly walked him

An Eyrie Encounter

Since 1992, the Harpy Eagle Conservation Program (HECP) has outfitted more than 20 Harpies with satellite and radio transmitters, enabling the team to monitor and map the bird's movements for years. Using the satellite data helps the team to better understand the eagle's habits and needs.

But, before HECP can obtain the valuable information provided by satellite tracking, someone must outfit a giant Harpy eagle with a backpack transmitter. This poses quite a challenge, considering the eagle often builds its nest 150 feet above the ground and its talons are the size of a grizzly bear's claws.

As it turns out, Rafael Alvarez, a native of Venezuela, was the man for the job. Hired as HECP's field manager for his knowledge of the area and

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ability to help locate the birds and negotiate with local citizens, Alvarez's climbing skills were an added bonus. HECP also trained the young man to use GPS, making him an invaluable team member.

During one HECP expedition this spring, Alvarez used a modified crossbow to shoot a climbing line over the branch supporting a Harpy nest. After removing the slack and securing his safety lines, he scrambled into a climbing harness and ascended. Once he reached the nest, he dropped a line to another intrepid team member who wished to make the climb.

As he climbed, Alvarez passed through the various layers of the rainforest canopy. As he reached the nest, which was built above the canopy, Alvarez emerged into the sunlight. The nest measured more than six-feet wide and two-feet thick. These structures can last for five years or more. Because the eagles mate for life and can live 40 years, this will be only one of the homes a pair occupies throughout their lifetime.

As he entered the nest, Alvarez encountered a chick about 10 weeks old and already as large as a full-grown domestic rooster. Although the parents were not in the nest, they watched from a short distance and occasionally issued shrill warnings.

Alvarez made a quick mental inventory of the littered remains of sloths and monkeys — the bird's primary prey. He immediately began his first task of examining the chick. Using one hand to distract it, he grabbed the chick's legs and immobilized its already impressive talons by wrapping them in an Ace bandage.

After a cursory examination to check the chick's general health, Alvarez used a set of nylon cords baited with chicken to set a snare.

With the snare in place, he descended. The team waited. Hours passed while they watched and listened for an adult to return. Finally, the male appeared. The team members sat perfectly still as the great bird slowly moved closer to the snare. Suddenly, Alvarez signaled a teammate to spring the trap.

Next, the team carefully lowered the bird from the tree. As it neared the ground, Alvarez cautiously secured its massive legs and wrapped its razor-sharp talons. Team members weighed and measured the bird before mounting the transmitter. The bird weighed more than 10 pounds (females can weigh as much as 18) and was in excellent physical condition.

The team then attached the three-ounce backpack transmitter and outfitted the bird with a leg band for identification. Powered by a solar battery, the satellite transmitter could last as long as five years. They also attached a radio transmitter that would provide a local signal, enabling biologists to locate the bird for future visits.

Less than one hour after snaring the bird, Alvarez released the bonds around the eagle's talons and placed the bird on the ground. As Alvarez walked away, the eagle cautiously looked around and then suddenly took off. With a few flaps of its enormous wings, the bird was gone.

For years, the team will monitor this magnificent male as he and his mate fly and hunt in the South American rain forests. HECP hopes the knowledge gained by watching the bird's movements will help these beautiful creatures to continue to thrive in their native environment.

The above map reflects Harpy eagle nest distribution in the eastern lowlands of Venezuela's Guyana region. To create the map, HECP obtained the GIS base map data from CVG-TECMIN, a private company. The team then added the road network (shown in red) during the 1995 survey. The black cross hairs represent Harpy nests visited during the same expedition. Rivers, which were already in the GIS, are shown in blue. Guri — one of the largest human-made lakes in the world, about 120 kilometers long and 60 kilometers wide — is shown on the left side of the map.

through the start-up and shutdown procedures for the base station and showed him how to archive collected files while we were on the road with the rover units. For the next week, he flawlessly tended the station at Guri, allowing the team to work exclusively in the field.

With the base station in place and staffed, we were ready to head for the forest to map and evaluate the impact of development on surrounding Harpy eagle habitat.

FOREST FOOTPATHS

During our first mapping trip we set out to reach as many of the known nests as possible in the few weeks allowed. We wanted to map readily identifiable features along the way and note habitat conditions as we approached each nest site.

During the weeks of preparation for the expedition, we had created a user-defined data dictionary of the most commonly encountered features such as stream crossings, human-made clearings, and road junctions. Our goal was to use GPS to georeference feature data so we could later export them into a GIS.

We began our groundwork in a portion of the Imataca Forest Reserve east of the town of *El Palmar* and accessed by the Rio Grande Bridge. Since 1992, we had been monitoring nests in this area shared by two FMUs.

With the rover's antenna mounted on the jeep's roof, we collected location data points every five seconds while traveling along the logging company's main access road. Following an access trail that had been used when this concession was logged in 1989–91, we headed for an area known as *La Planada*. The trail was very narrow and already covered with dense regrowth that gave it a green tunnel effect, but we soon came to a baseball diamond–sized opening in the forest. This was one of the hundreds of log yards (or *patios)* cleared, according to current government regulations, to sort out and prepare the harvested logs for inspection before trucking them to the sawmills.

Along the main road, we passed numerous branching trails. We also saw many ponds and lagoons that were the result of forest operations blocking the dense rain-forest drainage network. Loggers routinely lay piles of hollow logs over creeks to provide temporary access for their vehicles. As the upstream side of the forest becomes waterlogged and dies, the water impoundments evolve into a clearing with only a few standing snags. Thus, in many parts of the neotropics, the loggers and other road builders are fulfilling a new ecological role akin to that of the pond-builder beaver (*Castoridae*) in northern latitude forests. Using the eight-channel GPS receiver, we quickly tagged the location of these "beaver ponds," with plans for future studies of their effects on the local biodiversity.

We parked the vehicle in the clearing and set out on foot toward a nest that we had been monitoring since 1992. After leaving the boundary of the logged compartment, the forest was practically intact along the narrow trails. We could hear an ever-changing concert of bird song. We even bumped into the dream-come-true event for a bird watcher visiting the neotropics — a swarm of army ants and their cohort of ant-following birds that take advantage of the creatures flushed out by the thousands of advancing soldiers.

The narrow path to La Planada presented many challenges, such as fallen logs, creek crossings, and particular difficulty in trying to capture a usable satellite signal under a thick, multilayered tree canopy. Our eight-channel receiver was unable to acquire the minimum of four satellites needed to log three-dimensional data within the set of default GPS parameters. Consequently, we had to adjust several data collection settings — such as the signal-to-noise ratio and allowable position dilution of precision (PDOP) — until we could achieve the right balance of accuracy versus acquisition. Some data were better than no data, especially in areas that we might not be able to easily revisit.