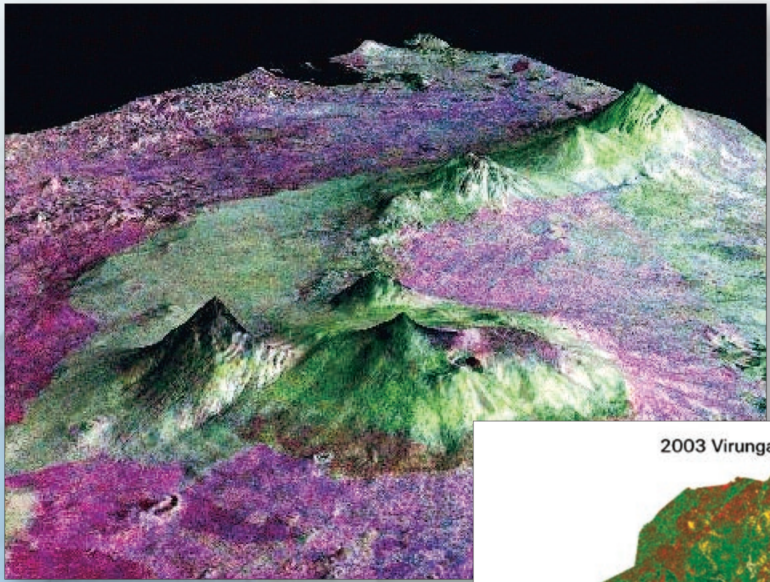
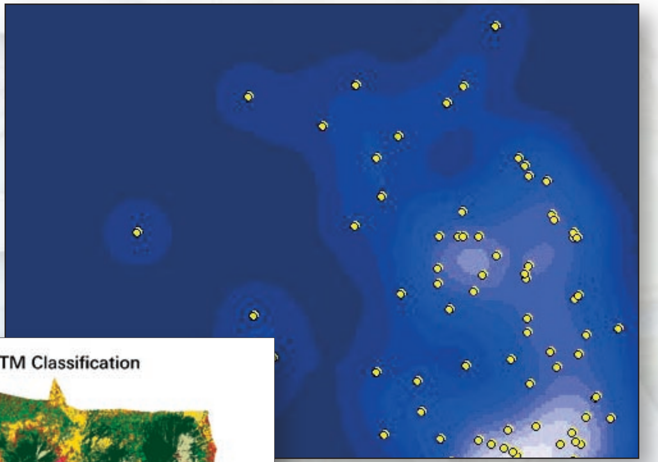
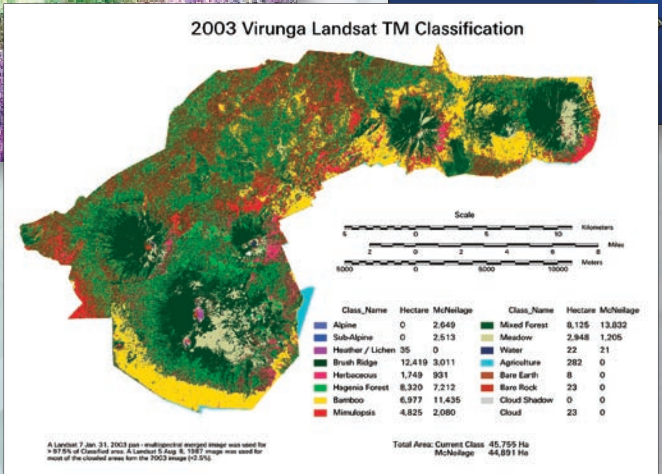
GIS Best Practices

GIS for Wildlife Conservation







December 2007

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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.

GIS for Wildlife Conservation

Habitat loss, global climate change, and human disruptions, such as pollution and deforestation, are threats to wildlife biodiversity and can cause fragmentation and extinction. GIS technology is an effective tool for managing, analyzing, and visualizing wildlife data in order to target areas where conservation practices are needed.

Habitat geospatial analysis is an important key to understanding the health of a species in the wild. Monitoring change in wildlife habitats is feasible with ESRI's suite of ArcGIS software, a tool for managing, analyzing, and depicting statistical and geographic data. GIS helps to monitor and visualize

- Population and distribution
- Habitat use and preferences
- Progress of conservation activities
- Historical and present regional biodiversity

Understanding threatened species is important in preventing their extinction and revitalizing their populations. ESRI's ArcIMS software makes sharing pertinent wildlife data on the Web easy and accessible and spreads the conservation movement across the globe.

Launching Spacecraft From a Wildlife Refuge

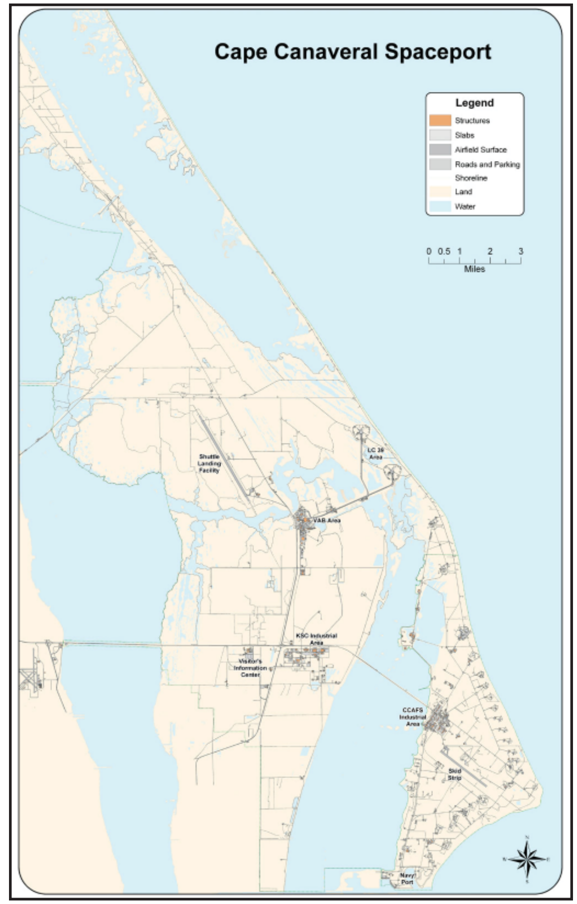
Florida's Cape Canaveral Spaceport GIS

For more than 40 years, the U.S. National Aeronautics and Space Administration (NASA) and the Air Force have shared Florida's Cape Canaveral, accomplishing the strange and awe-inspiring achievement of launching spacecraft from a wildlife refuge. Recently, managing such complexity has become decidedly simpler. Pooling their resources and data, NASA's John F. Kennedy Space Center and the 45th Space Wing's Cape Canaveral Air Force Station implemented a shared GIS.

A pair of breeding ospreys nest on a pole in the KSC Press Site parking lot with the NASA logo on the Vehicle Assembly Building in the background.

Known collectively as Cape Canaveral Spaceport, the launch pads, research buildings, educational facilities, and administrative offices on and around Cape Canaveral have sprawled to encompass many thousands of acres. Bill Sample, president of Spaceport's operations and maintenance provider, Space Gateway Support (SGS), says, "You essentially have a tremendous block of protected land on which NASA launches the space shuttle and the Air Force launches expendable, nonmanned launch vehicles."

As the Joint Base Operations Support Contract (JBOSC) contractor, SGS is responsible for Spaceport facilities management, public works, engineering services, infrastructure/ base support services, protective services, logistics, information technology, administrative services, medical services, and environmental services—essentially the management of a very specialized, technologically sophisticated city. The SGS contract is unique in Spaceport history, combining NASA and Air Force operations and maintenance into one contract for the first time, improving services, streamlining business practices, and keeping costs down.



A map depicting both Kennedy Space Center and Cape Canaveral Air Force Station. The Cape Canaveral Spaceport GIS is responsible for mapping both installations.

Implementation of a shared Cape Canaveral Spaceport GIS (CCSGIS) has brought these efforts one step further. "The system represents the partnering of two distinct federal agencies," says Sample. "It is the blending of their assets to more effectively achieve a common goal, while respecting NASA's scientific mission and the 45th Space Wing's national defense mission."

Aimed at capturing, recording, displaying, and analyzing geographic information within the Spaceport community, CCSGIS is available only inside existing firewalls. Based on ESRI software's compatibility with other GIS systems and databases, SGS built CCSGIS on an ArcView, ArcInfo, ArcSDE, and ArcIMS foundation. Taken as a whole, the enterprise system supports a framework of Web sites and specialized applications for functions ranging from environmental management to security calls to office allocation. "In 1998," says Sample, "we were challenged to develop a GIS within five years. And that's basically all the information we had to start the project. Within those years, we were able to build the system from the ground up."

Implementing CCSGIS

A project management approach was used to develop the system, relying on a multidisciplinary team of GIS and information technology professionals, real property accountants, and community planners. Using an Oracle database tied to ArcGIS through ArcSDE, SGS created a GIS repository for the whole Cape Canaveral Spaceport, consolidating data from disparate sources and formats. "Most of the data was stored in hard copy and in CAD drawings," says Bill Stoeckel, Real Property Information Systems supervisor, SGS. "It was not in an intelligent environment—there was no other information associated with it. Implementing CCSGIS was a big step forward for our customers."

A bobcat walks along high wires in the Merritt Island National Wildlife Refuge.

Data collection and processing proved to be a challenge. Aerial photography was used for feature extraction and as a backdrop for Web, ArcView, and ArcInfo applications. Aside from the photo feature extraction, pulling and consolidating other data for the Spaceport's facilities, pipelines, electrical systems, roads, and natural resources were the project's greatest hurdles. "Data was gathered on-site from existing sources or through actual field survey," says Stoeckel. "When the package was put together, the Real Property Accounting Office alone consolidated

13 different databases. We've seen data on the back of convenience store napkins and a lot of other things that just lacked substance."

As the data was cleaned and assembled, SGS staff began to use CCSGIS as a launching pad for applications and specialized projects. With a vast range of services and responsibilities, the contractor's most unique challenges were tied tightly to the land itself.

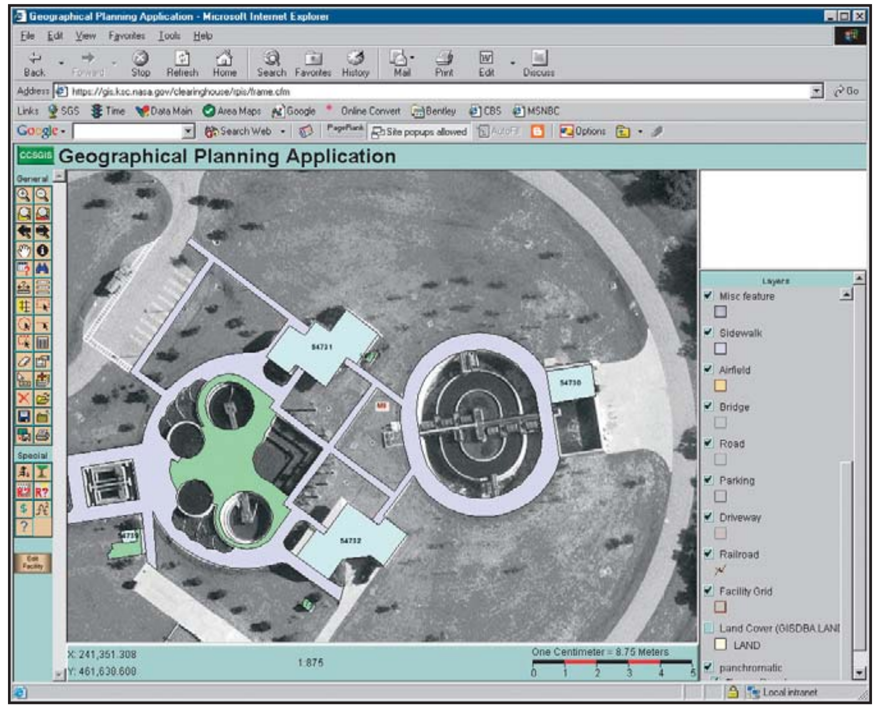
Preserving Natural Resources—148,000 Acres of Protected Land

A relatively small area of the Cape Canaveral Spaceport is dedicated to launch operations. Of the approximately 157,000 acres that comprise the Spaceport, more than 90 percent (148,000 acres) are reserved for conservation and recreation. The Merritt Island National Wildlife Refuge and Cape Canaveral National Seashore dominate the area, with protected segments of the Banana and Indian Rivers fringing the Spaceport's outer borders.

Consisting primarily of brackish estuaries and marshes, the protected land encompasses seven distinct habitat types and is an important wintering area for migratory birds. All told, there are more than 1,000 plant and animal species identified on the Spaceport, 89 of which are listed as threatened, endangered, or of special concern by state or federal agencies. Manatees, sea turtles, peregrine falcons, wood storks, and alligators are among the cape's residents. Sharing launch facilities and infrastructure with such natural resources is a difficult balancing act. CCSGIS forms a basis for successful preservation. Says Sample, "We have an awful lot of wildlife and other species that are resident and protected here. Using GIS, we have been able to link physical location and attributes with environmental data."

To support Spaceport's infrastructure, SGS responsibilities include the management of wastewater and industrial wastewater treatment facilities, hazardous wastes, air pollution sources, landfills, regulated tank systems, and asbestos in addition to the construction of new facilities and rehabilitation of existing facilities. Therefore, every year SGS collects and analyzes more than 3,000 environmental samples as part of its compliance with more than 200 environmental permits.

CSGIS not only facilitates these processes with easily managed and accurate data but also improves decision making by providing detailed analysis and modeling capabilities. Since its creation, the system has been used to plot utility corridor alignments, plan new facilities, locate monitoring wells and regulated pollutant sources, and identify areas of critical habitat. ArcView and ArcInfo functionality has been used to identify gopher tortoise burrows and quickly assess potential impacts on this protected species from various utility corridor alignments. Additionally, when linked by ArcSDE to Oracle operational databases, locations of regulated fuel tanks and storm water management systems have facilitated fast analysis of new or pending regulatory requirements, as well as cost estimates to upgrade or modify existing systems.



The Geographical Planning Application is one of two base applications available to Cape Canaveral Spaceport GIS users for viewing GIS data on the Web.

Supporting Human Resources—2,000 Employees and 25,000 Customers

With the population and facilities of a small city, the Spaceport's operation and maintenance concerns extend beyond environmental management. As CCSGIS became firmly established, allowing employees throughout Cape Canaveral's support base to leverage GIS capabilities was a high priority. To this end, SGS built outward from the core functionality of CCSGIS, implementing a Web-based Spaceport Map Viewer available to all employees.

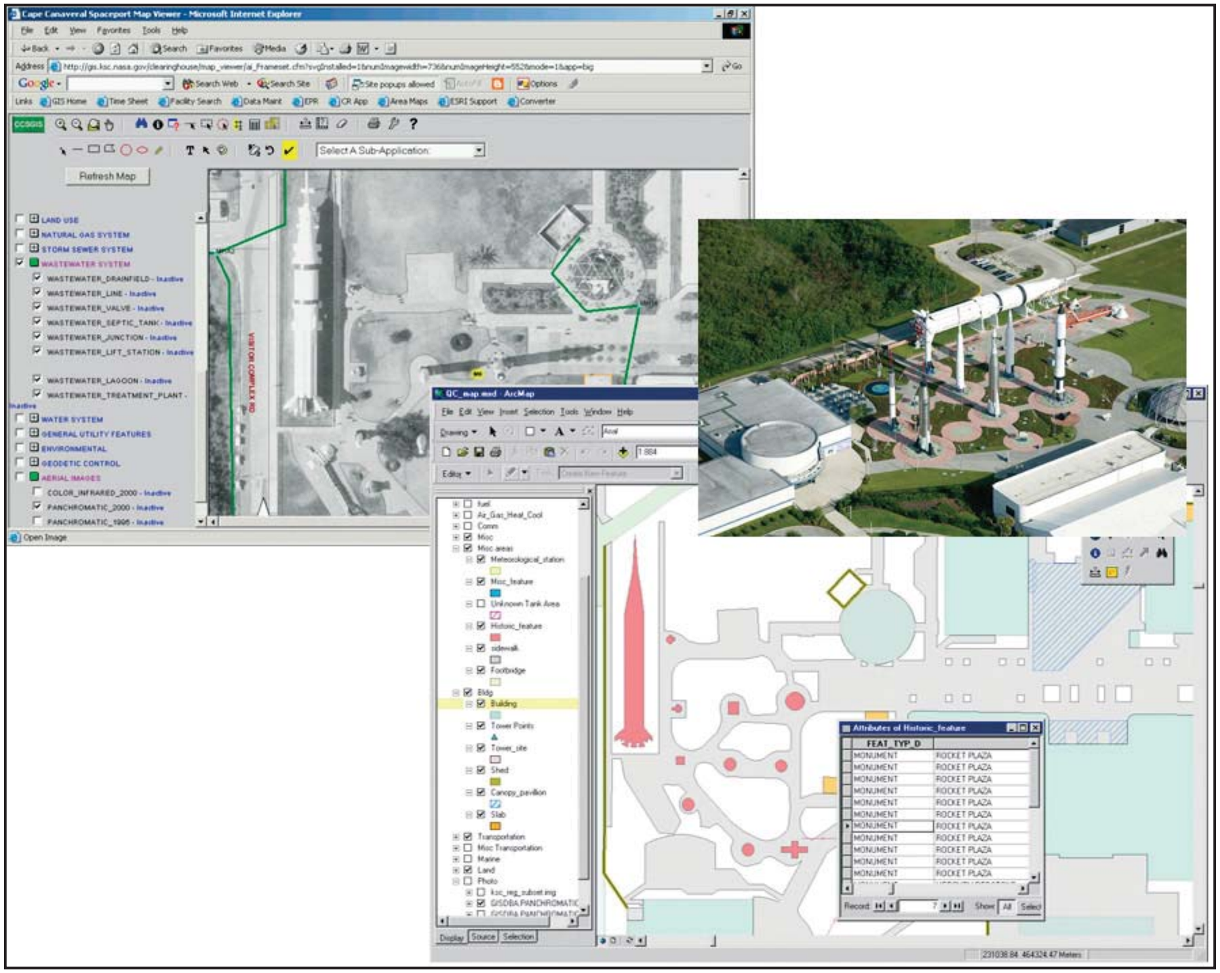
In addition to displaying planimetric, facility, and utility information, the Spaceport Map Viewer allows users to draw basic shapes and add text to maps. To achieve this functionality, ESRI's

ColdFusion (CF) Connector allows CF tags to display dynamic content from ArcSDE. All spatial data is contained within an Oracle database, and Adobe's Scalable Vector Graphics (SVG) viewer provides drawing and display capabilities. Image generation is triggered via a call to ArcSDE from the CF Connector and associated CF custom tags, with XML and XSL Transformations used to translate ArcXML to SVG–XML. A Java component lends quality control to the system, verifying that SVG-drawn shapes submitted to ArcSDE are valid polygons.

An American alligator in the Merritt Island National Wildlife Refuge at Kennedy Space Center (KSC). Nearly 5,000 alligators can be found in canals, ponds, and waterways throughout the Center and the surrounding Merritt Island National Wildlife Refuge.

The rich functionality of the Spaceport Map Viewer provided a jumping-off point for a number of specialized subapplications. Designed to meet the unique requirements of everyday users, these tools support functions from master planning to excavation permit mapping to security incident tracking.

"With more than 2,000 people who work under the support contract and a base population of about 25,000," says Sample, "you can imagine we have a fair share of security incidents requiring our response." To manage and track these incidents effectively and reliably, SGS built a password-protected Spaceport Map Viewer subapplication to depict incident locations and facilitate geospatial analysis. Its simple-to-use interface allows Spaceport staff to investigate and display information related to security incidents such as traffic accidents, theft, and complaints.



Views of the Rocket Plaza at the Kennedy Space Center from ArcGIS and Spaceport Map Viewer.

Once the capabilities of the Spaceport Map Viewer became apparent, Spaceport employees began to make requests for specialized subapplications to meet their needs. "One of our community planning customers needed a tool to determine how many people populated groups of buildings and the current replacement values of the buildings," says Stoeckel. In response, SGS created a subapplication that buffers a selected area, executes a program that pulls up facility replacement values from one database while extracting building populations from another, and produces a tidy summary report.

All together, 10 specialized Spaceport Map Viewer subapplications have been built and implemented, giving Spaceport employees access to the wide range of CCSGIS data and capabilities in a user-friendly format. However, the Spaceport Map Viewer base application and its progeny are supplemented by additional stand-alone CCSGIS applications addressing concerns such as geographic planning and 911 emergency response. "As a spin-off of the enterprise system, a secure stand-alone 911 application, Map-911, has been developed with a twofold purpose," says Stoeckel. "In addition to providing 911 operators with helpful information, such as nearby utilities or fire stations, the application can be deployed during contingency situations when the main system might not be available due to network or power outages."

The strength and spectrum of services and capabilities provided under the CCSGIS umbrella continue to grow. Implementation of ArcFM (from ESRI Business Partner Telvent Miner & Miner) is nearing completion for the Cape Canaveral Air Force Station. Data collection is complete, and the ArcFM model has been created and populated. Additionally, water models for both NASA and Air Force Spaceport components are well underway. Recent additions of ArcGIS 3D Analyst and ArcGIS Spatial Analyst to the SGS software base will provide this modeling with another boost in power and flexibility.

Future goals for more specialized functionality include a confined space hazard alert tool and vehicle tracking system. "We run roughly 6,000 work orders a month," says Sample. "That's everything from hanging a new light fixture to repairing carpet to tearing down a wall. It's important to know how we distribute our crews and where they are working. We are in the process of gathering requirements for tracking our vehicles with onboard GPS transmitters. This tool would benefit SGS teams beyond our maintenance group, enabling emergency and security commanders to view near real-time locations of their vehicles."

A trace of a specific electrical feeder through the Vehicle Assembly Building area.

By taking advantage of advanced software, CCSGIS continues to improve services and streamline processes, providing an accurate and usable single platform of facility information. Five years into the first joint operations and maintenance contract between Cape Canaveral's Air Force and NASA inhabitants, SGS' efforts are a vivid illustration of the power of data sharing and the potential of a robust enterprise GIS. "At the moment we have a 95 percent performance rating," says Sample. "That's a high report card—the experiment is working and our customers are very pleased."

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

GIS Applications for Gorilla Behavior and Habitat Analyses

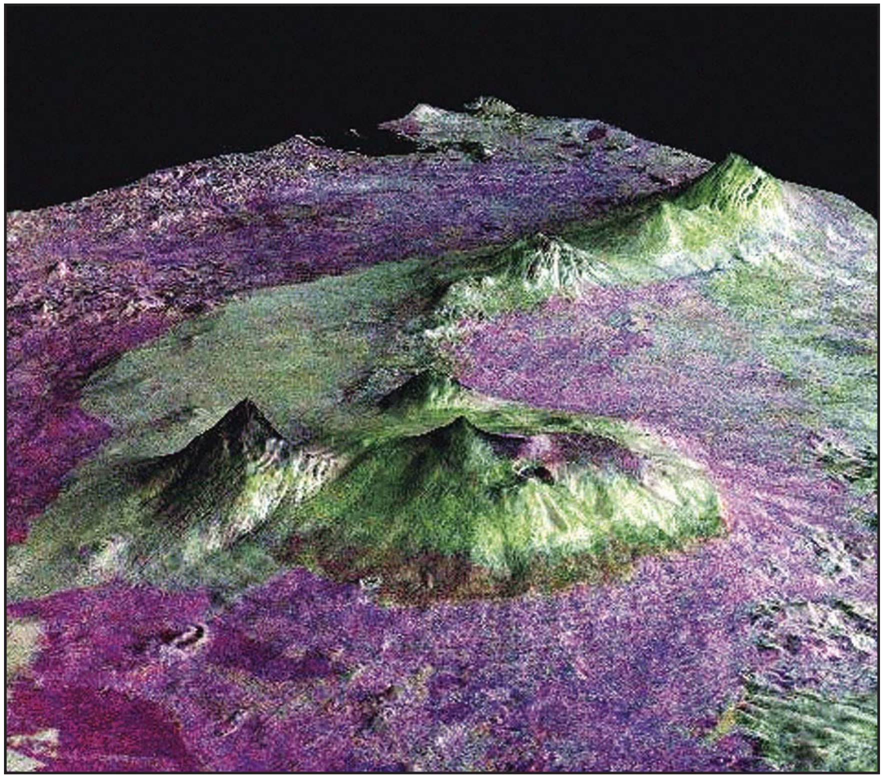
By H. Dieter Steklis, Ph.D., Scott Madry, Ph.D., Netzin Gerald Steklis, and Nick Faust

As the sun sets over the Virunga volcanoes of central East Africa, the volcanoes' steep slopes and moisture-laden vegetation seem about as far away from modern technology as you can be on this earth. But scientists with The Dian Fossey Gorilla Fund International (DFGFI) are harnessing the power of advanced spatial technologies and GIS to help study the Virunga gorilla habitat and gorilla behavior and, ultimately, to preserve this endangered remnant population of mountain gorillas (*Gorilla beringei beringei*).

A Sabinyo gorilla.

For the past decade, DFGFI scientists and collaborators have been studying the Virunga habitat and behavioral ecology of the mountain gorilla using images taken from space, GPS units to record gorilla movement and human activity, and historic maps. This data is then combined in a GIS to display and analyze the data for research and conservation purposes. The work of DFGFI is a pioneering application of these tools for primatology, and it has great potential for other conservation work throughout Africa and the rest of the world.

Collaboration began with a small United States Agency for International Development (USAID) grant to DFGFI for the creation of a digitized map of the Virunga volcanoes area. At first, this seemed to be a simple enough task, but it began a decade-long collaboration that has been a most interesting and challenging project for all involved.



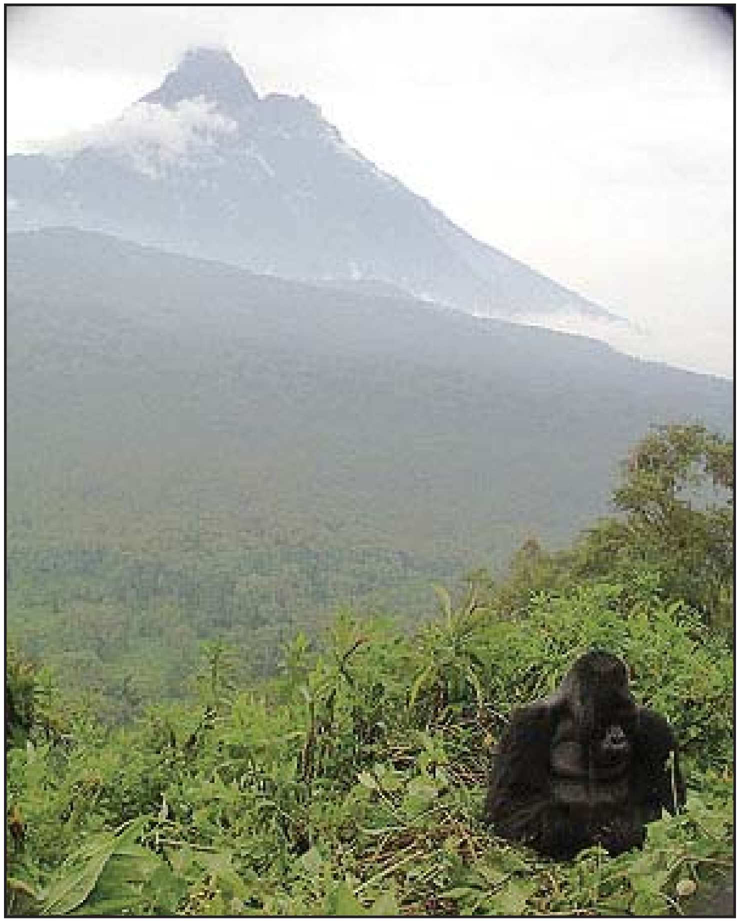
The Virunga volcanoes image from NASA radar data over the digital elevation model created from Belgian colonial maps.

Several problems quickly emerged as the researchers began a search for existing maps of the three countries (Rwanda, Uganda, and the Democratic Republic of the Congo [DRC]) that comprise the Virunga area. No maps of Zaire (now the Democratic Republic of the Congo) were available, as there was a civil war underway in the region and possession of topographic maps or aerial photographs was politically sensitive. Unfortunately, the Zaire area accounts for more than half of the gorilla habitat. The best maps of Rwanda and Uganda were made in the 1950s and 1960s during the colonial era. In addition, it was clear that the Rwandan maps (produced by the Belgians and French) and Ugandan maps (produced by the British) were the products of their respective traditions; different mapping projections and coordinate systems were used, and the maps did not seem to match up at all when put together. Creating a unified regional map was clearly going to be more difficult than it first appeared.

DFGFI contacted the Belgian Royal Museum for Central Africa in Tervuren to see if there were any historic maps that could be used to fill in the missing Zaire (DRC) areas. In response, researchers received a complete set of 1938 1:100,000- and 1:50,000-scale maps of the region that had been produced by the Belgian Colonial Service. These maps covered the entire Virunga volcano range and surrounding area, so at least researchers had a start. These maps also served an important purpose by showing the region before modern development and population encroachment. These old maps came to serve as the researchers' "basemap," which is still, amazingly enough, the most recent comprehensive map of the entire area with significant detail.

GIS Applications

DFGFI's first objective was to produce a three-dimensional digitized basemap that would serve as an important foundation for a variety of more sophisticated analyses concerning the relationships between the characteristics of the gorillas' environment and their behavior. ESRI's ArcView software (and later ArcGIS) became the perfect tool for DFGFI's objectives, because it would allow researchers to merge data from many different sources, scales, and dates and recombine them in a powerful display and analytical environment.

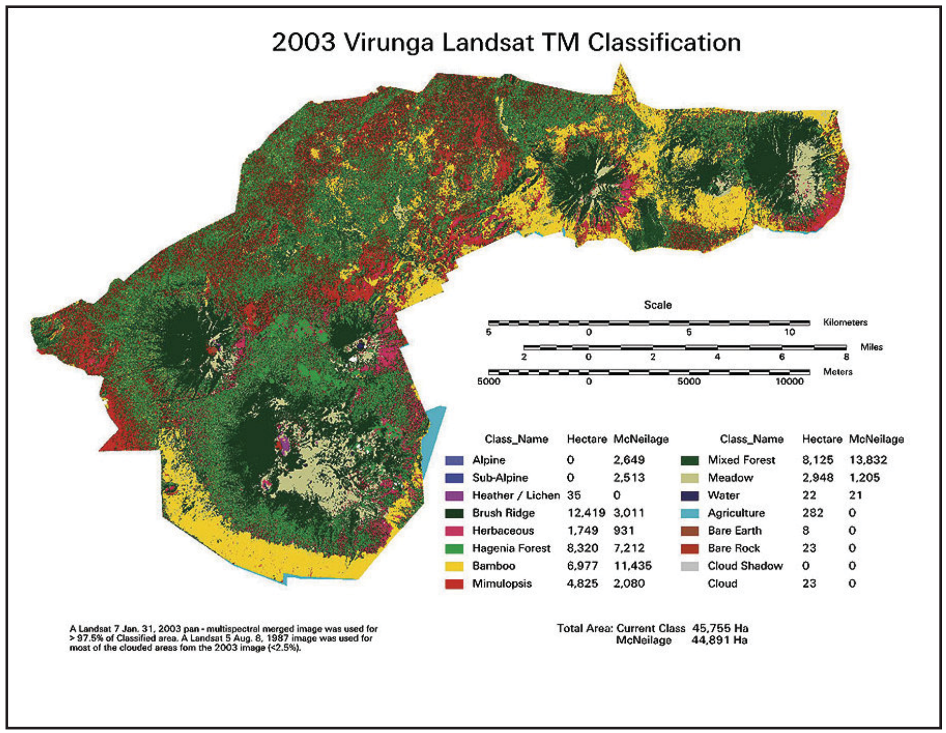


An endangered mountain gorilla resting in its Virunga volcanoes habitat.

DFGFI set about to digitize the various features from existing maps and to combine them in a GIS. Each contour from the 1938 Belgian maps was manually digitized to create a digital elevation model (DEM). This allowed the team to visualize the Virunga volcano region in three dimensions. They also extracted the main roads, political and park boundaries, hydrology, and other map features that were available, which would be used in future analyses of human impact on the habitat.

Habitat Classification and Monitoring

In order to generate accurate land-use and vegetation data for the Virunga region and to track habitat changes over time, DFGFI turned to satellites. Alas, another difficulty emerged—*Gorillas in the Mist* is more than the title of a book by Dian Fossey. Virtually all the satellite images were cloud covered. Many were clear *except* over the Virunga area due to the effect that the high mountains have on the microclimate. As a result, researchers searched for sources of satellite radar data, as these systems send their own burst of energy down to the earth and record the reflected energy, irrespective of cloud cover. The National Aeronautics and Space Administration was flying a research radar system on the space shuttle in 1994, so DFGFI arranged for the Virunga area to be imaged during the shuttle flight. This produced the first cloud-free remotely sensed view of the entire region and served to create an initial vegetation map. Not until January 2003 did DFGFI finally acquire a nearly cloud-free Landsat satellite image, and researchers used it to create a more accurate vegetation map of the region.



Vegetation classification of the Virunga volcanoes mountain gorilla habitat using the latest available Landsat data.

High-resolution (1 m) space radar imagery, such as provided by IKONOS, is particularly powerful for revealing the nature and extent of human impacts on the fragile gorilla habitat. In mid-2004, for example, within two months, approximately 6,000 farmers denuded approximately 15 square kilometers of prime gorilla habitat within the national park boundary. An international effort of government bodies and conservation organizations brought the destruction to a halt; although the farmers are gone now, the land still lies bare with the rows of cultivation clearly visible on the radar imagery. This type of imagery will prove important to the continued monitoring of the recovery of this habitat.

Patterns of Gorilla Habitat Use

With GPS receivers, DFGFI field staff members were trained to use GPS to log daily the gorilla group movements (i.e., nesting locations), from which group ranging patterns were established. Equally important, the DFGFI antipoaching patrols also recorded evidence of poaching activity. The GPS units were also used to map park boundaries and other major features in the area. Using small GPS units, this work is ongoing and provides researchers with the ability to include field observations directly into the GIS.

This GPS data gives DFGFI information on gorilla movements and poaching activity for recent years. However, to understand patterns over time that may be related to habitat changes or human activity (poaching), DFGFI needed to look back over decades. This means relying on DFGFI's store of archival maps, photographs, field notes, and other relevant data acquired in the field by numerous researchers, including Dian Fossey. For example, researchers digitized Fossey's hand-drawn maps of daily gorilla group locations, which allowed them to compare the current gorilla ranging patterns with those of 20 years ago. Their historic database is one of the longest sets of primate observations in the world and is ideal for revealing long-term patterns of habitat use.

Conclusion

The DFGFI goal is to understand the changing patterns of gorilla behavior and the gorillas' relationship to their environment and to quantify and understand the impacts of poaching and encroachment. There are many basic scientific questions that are still unknown, and the results of DFGFI's efforts should improve gorilla conservation practice. GIS allows researchers to combine all of the data that DFGFI has acquired (historic maps, aerial photographs, field observations, GPS locations, satellite images, and more) so they can begin to explore the data and ultimately test hypotheses in ways that were not possible only a decade ago. Another significant benefit of DFGFI's GIS database lies in the cumulative nature of DFGFI's field research. As field patrols continue and new research is conducted, the data is entered into the system, which constantly enlarges DFGFI's database and thereby enables researchers to compare data over time. Researchers can test hypotheses and track patterns in ways that are not possible using traditional field notes and hand-drawn maps.

A Sabyinyo gorilla.

An important part of DFGFI's mission is building scientific capacity in the region. Therefore, an aspect of its work is technology transfer to the countries comprising the Virunga region. For example, with a grant from the Georgia Research Alliance, DFGFI—in partnership with Clark Atlanta University, Georgia Tech, and the National University of Rwanda—established a GIS center in Rwanda that now serves as a successful, self-sustaining regional GIS research and training facility for a variety of applications in Rwanda and its neighboring countries. Such capacity building helps ensure local involvement in and commitment to long-term conservation.

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

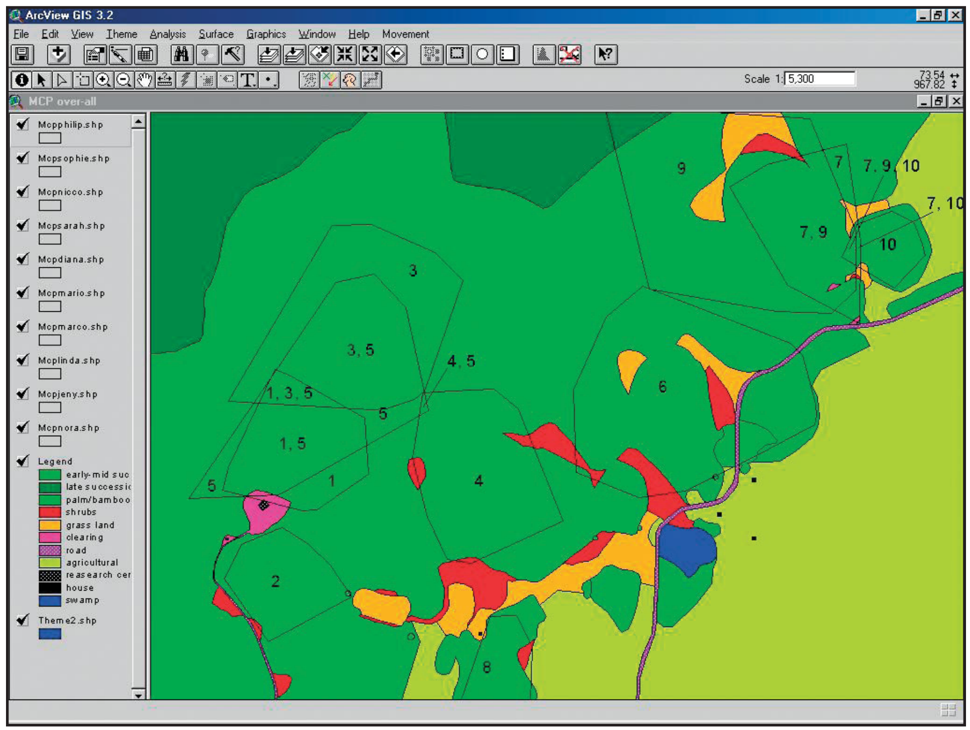
Philippine Tarsiers Conservation Program Streamlined With GIS

One of the World's Smallest Primates

The amazing Philippine tarsier is known for its big, round eyes; bat-like ears; and ability to turn its head almost 360 degrees. This nocturnal and highly cryptic prosimian is related to the aye-ayes of Madagascar and bush babies in Africa. The only other tarsier species currently known are found in Malaysia and Indonesia. These animals move about silently in the forests by clinging to and leaping on vertical branches of trees and saplings.

Philippine Tarsier Tarsius syrichta *(photo courtesy of PTFI).*

Tarsiers once widely roamed the tropical rain forest of the southeastern central islands of the Philippines. The Philippine tarsier has previously been reported as rare and decreasing and listed as endangered by the World Conservation Union (IUCN) in 1990. It has been described as threatened due to heavy deforestation, extensive hunting for the pet trade, and increasing agriculture in its natural habitat. The IUCN/Species Survival Commission Primate Specialist Group gave the species a Conservation Priority Rating 4, defining the species as highly vulnerable with the remaining population threatened by habitat destruction and hunting. It is currently listed by the IUCN as Data Deficient. To fill in the gap of knowledge on its ecology and behavior, a team comprising Filipino researchers affiliated with the University of Adelaide, South Australia, started conducting field data collection in the Philippine island province of Bohol where a radiotelemetry project incorporating GIS concluded in 2001. Their goal was to provide information that can be used as a sound basis for planning and implementation of management and conservation programs.



Minimum convex polygon home ranges of Philippine tarsiers.

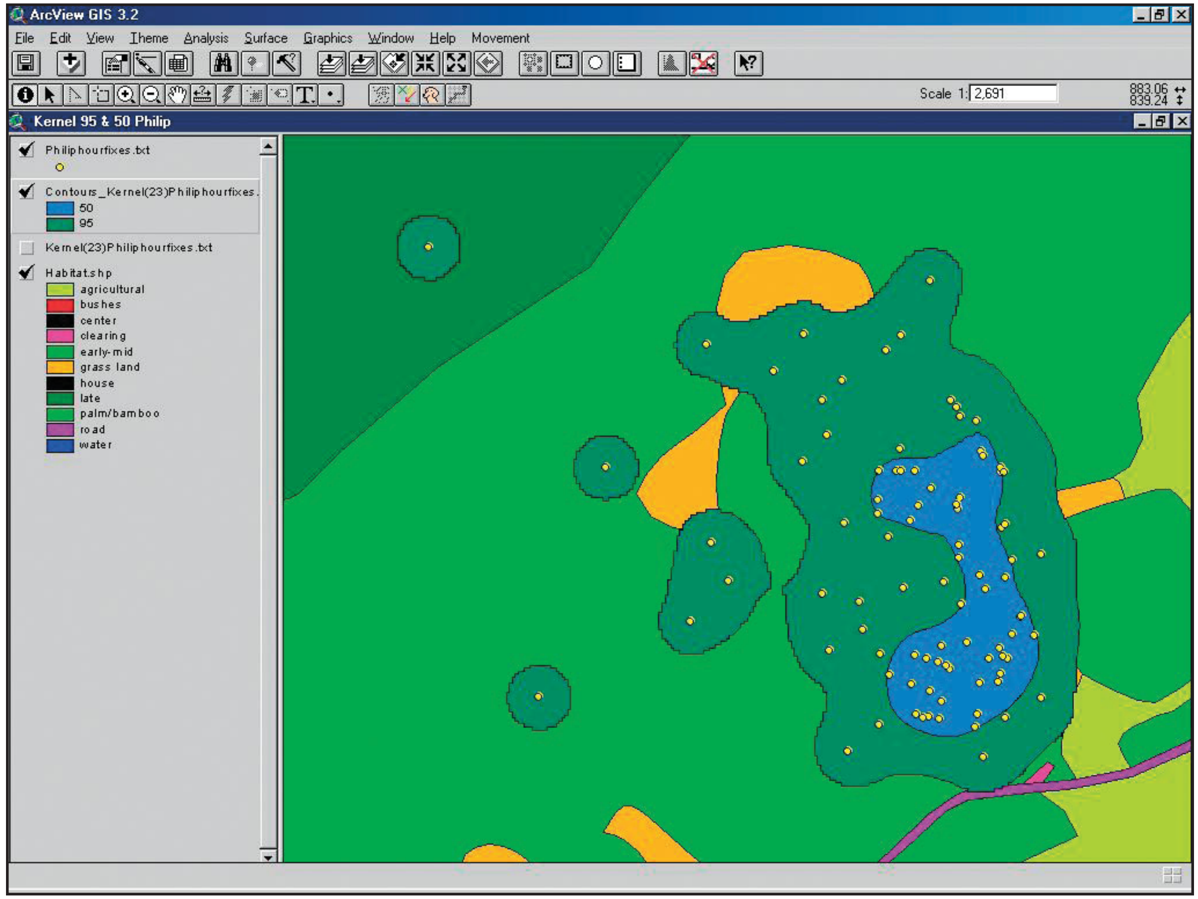
The tarsier is found in the limestone rolling hills of Bohol among other islands in the Greater Mindanao faunal region. The area is generally mountainous with rough terrain broken by deep gullies, ridges, and abrupt slopes. It averages 1,307 mm of rain per year.

Tarsiers are known to be solitary animals. Prior to this study, most of the observations on the animal's behavior were taken in a captive setting. Because these animals do not thrive in strict confinement, attempts to breed them in captivity produced dismal results. The decision to study them in the wild was, therefore, timely and appropriate. Field experts trapped a total of 11 individuals including four adult males, six adult females, and one subadult male. Radiocollar transmitters were attached to each tarsier's neck.

The study area was traversed by foot and mapped according to vegetation type, physical characteristics, and land use patterns. This was important in determining the habitat use and preference of the animal. The team then entered the habitat map into ArcView 3.x, which was converted to both vector and raster data models. One to three animals were tracked at night using a flashlight with a low-powered battery to help visually locate the animals. However, most of the time, the locations of the animals were determined by remote triangulation.

ArcView was used because of its extension programs that allow easier manipulation of data. It was also highly recommended by the information technology officer of the Applied and Molecular Ecology Department, University of Adelaide, South Australia. The ArcView 3.x extension, Animal Movement Analyst (developed by the United States Geological Survey to study animal migration and movement patterns), was used to calculate and map out male and female home ranges, degree of home range overlap, and extent of habitat use. Animal Movement Analyst, in conjunction with the ArcView Spatial Analyst extension, worked in multiple projection systems, used selected records (enabling complex queries or selections), and integrated with many types of spatial data.

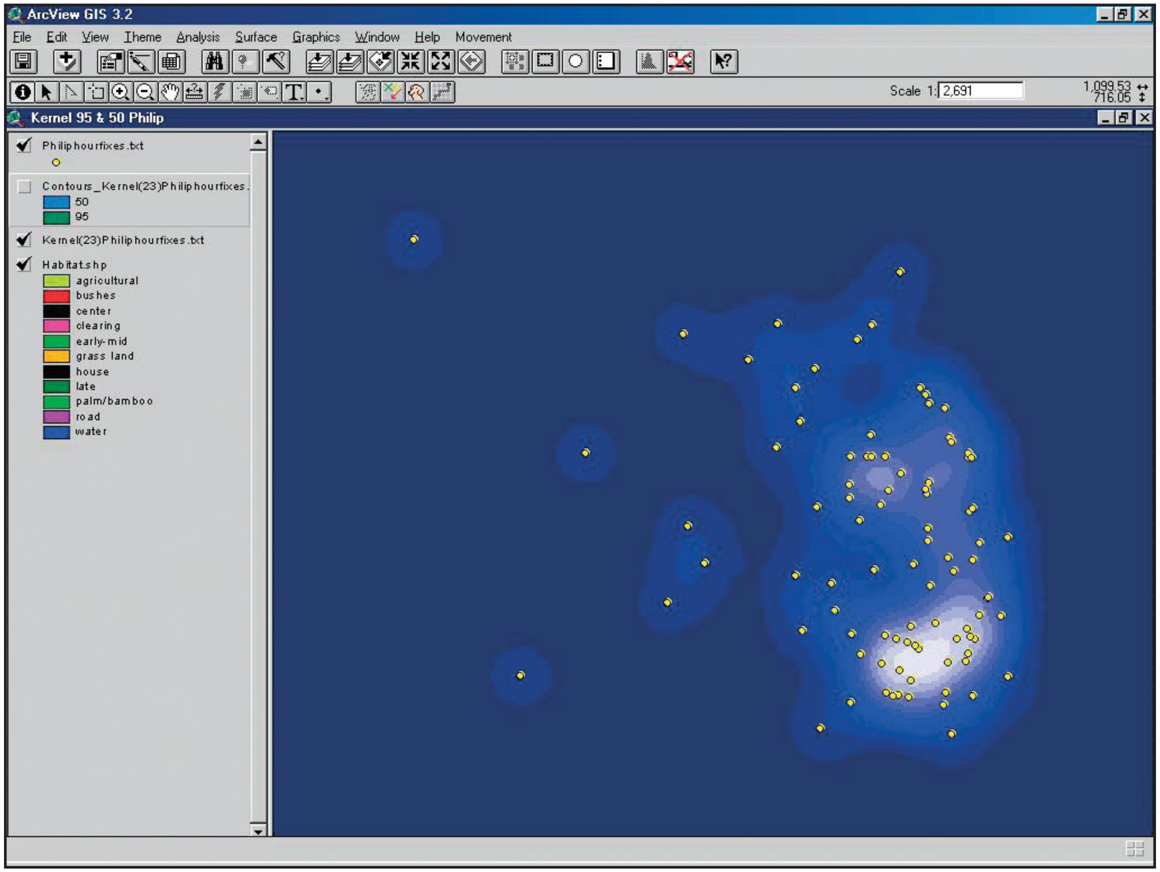
Size and shape of home ranges of radiocollared tarsiers were determined using the Minimum Convex Probability polygons and Kernel (i.e., grid cell) Home Range estimates. The Animal Movement Analyst extension also allowed nearest neighbor analyses to determine pair bonds and the extent of range overlap between individuals of the same and opposite genders. Movement and activity patterns, as well as nightly distances traveled, were traced and calculated using Create Polyline from the Pointfile Option of the extension. The zigzag pattern of tarsier movement was a classic representation of solitary animal movement. Males average almost 2 km per night in their nocturnal travel, but females cover only half that distance. This data was determined by continuous tracking that involved acquiring locational fixes every 15 minutes within a six- or 12-hour shift.



Ninety-five and 50 percent kernel probability polygon on habitat map in raster format.

Map overlay analyses were performed to determine the extent of use of a particular habitat type by radiocollared individuals. Determining the extent of habitat use by the tarsiers required the use of the raster data set, and the observed values accounted for the total pixel counts per habitat of all the radiocollared tarsiers.

The radiotracking, including creation of reference points and cutting down of trails and footpaths in the rain forest, lasted 10 months. It yielded interesting results regarding the tarsiers' behavior and ecology. Tarsiers tend to avoid their capture sites. Although males and females are never seen together, their ranges overlap significantly (males often have more than one or two mates in their lifetimes). Rainfall greatly limits the tarsiers' movement. Pregnancy, as well as carrying infants during the preweaning period, restricts the movement of females. Tarsiers stay roughly one meter above the ground most of the time, but they will climb up to the canopy as high as four to five meters.



Ninety-five and 50 percent kernel probability polygon of a radiocollared male tarsier.

After a flurry of activities at the onset of dusk and a bout of feeding, they sit still. Tarsiers were observed to savor crickets, which requires them to forage near the ground. This makes them easy targets of feral cats, the number one predator in the area. Tree snakes are also believed to be predators. In addition, tarsiers' preference for crickets makes them stay near the periphery of the forest. Although they are nocturnal, a male was tracked and found to be active after 7 a.m., but he was moving so fast that he appeared to be in a hurry to get back to his sleep tree. One male was even seen hopping like a kangaroo as he crossed a narrow grassy strip between adjoining forest patches.

Philippine tarsiers were observed to avoid agricultural areas, unlike their counterparts in Sulawesi and Borneo. This behavior can be attributed to the fact that the agricultural land within the study area in Bohol covers only rice fields and coconut plantations and does not provide any suitable substrates for the tarsiers.

(Reprinted from the Winter 2003/2004 issue of *ArcNews* magazine)

The Orangutans of Borneo Are Aided With GIS

Dr. Biruté Mary Galdikas—Working in the Jungles of Borneo for More Than 33 Years

There are so many words that can describe Borneo, including verdant, vast, and vibrant. It is the world's third largest island with an extremely diverse flora and fauna that include more than 380 species of birds, 222 species of mammals, more than 2,000 species of orchids, and more than 3,000 species of trees. Borneo is one of 17,000 islands that comprise the country of Indonesia, and it's one of two places on the planet where orangutans live.

Unfortunately, as in the case with many other tropical paradises, Borneo's forests are rapidly disappearing and the orangutans with it. More than 80 percent of Borneo's forests have already been logged. Over the last 20 years, the amount of wood exports from Indonesian Borneo has surpassed all tropical wood exports from tropical Latin America and Africa combined. Borneo also lost at least 39 percent of its orangutan habitat from 1992-2002. If the rate of destruction continues at its current clip, the rain forests and its orangutan residents could vanish by 2015.

Dr. Biruté Mary Galdikas has worked in the jungles of Borneo for more than 33 years. She is one of three women that Dr. Louis Leakey recruited to work on the great apes; this is an illustrious group that also includes Dr. Jane Goodall and the late Dr. Dian Fossey. With the increasing effects of illegal activities and the fires of 1997-1998, Dr. Galdikas and her team at Orangutan Foundation International (OFI) have had to redouble their efforts to save the site where she has done her life work: Tanjung Puting National Park (TPNP). TPNP covers roughly 4,000 square kilometers and is one of the largest protected areas of tropical heath and peat swamp forest in Southeast Asia. It also contains the largest population of orangutans in a protected area, approximately 6,000.

Dr. Biruté Mary Galdikas
(Photo courtesy of Linda Leigh).

Working in conjunction with World Education Inc., OFI received funding from the United States Agency for International Development (USAID) in October 2003 for a program that aims to apply an integrated conservation and development approach to the protection of TPNP and its resident orangutans. The project's objectives are fourfold:

- Increase and improve community and park patrolling in TPNP.
- Improve stakeholder decision making and planning processes related to conservation and development in and around TPNP.
- Increase farmer food security and income generation through sustainable agricultural methods.
- Strengthen the capacities of local organizations and leaders to facilitate community, livelihood, and natural resource development.

ArcView software plays a significant role in this project and is now being used to support stakeholder decision making while improving biological analyses and monitoring. Going forward, GIS will support the integration of land use planning with local economic and conservation needs and assist in the effort to develop a more thorough understanding of the orangutan population of TPNP. GIS activities are already providing the first comprehensive, large-scale mapping and analysis of orangutan habitats in TPNP. Critical areas for conservation and management are being identified, and GIS data under development now will support long-term management of the park's valuable resources.

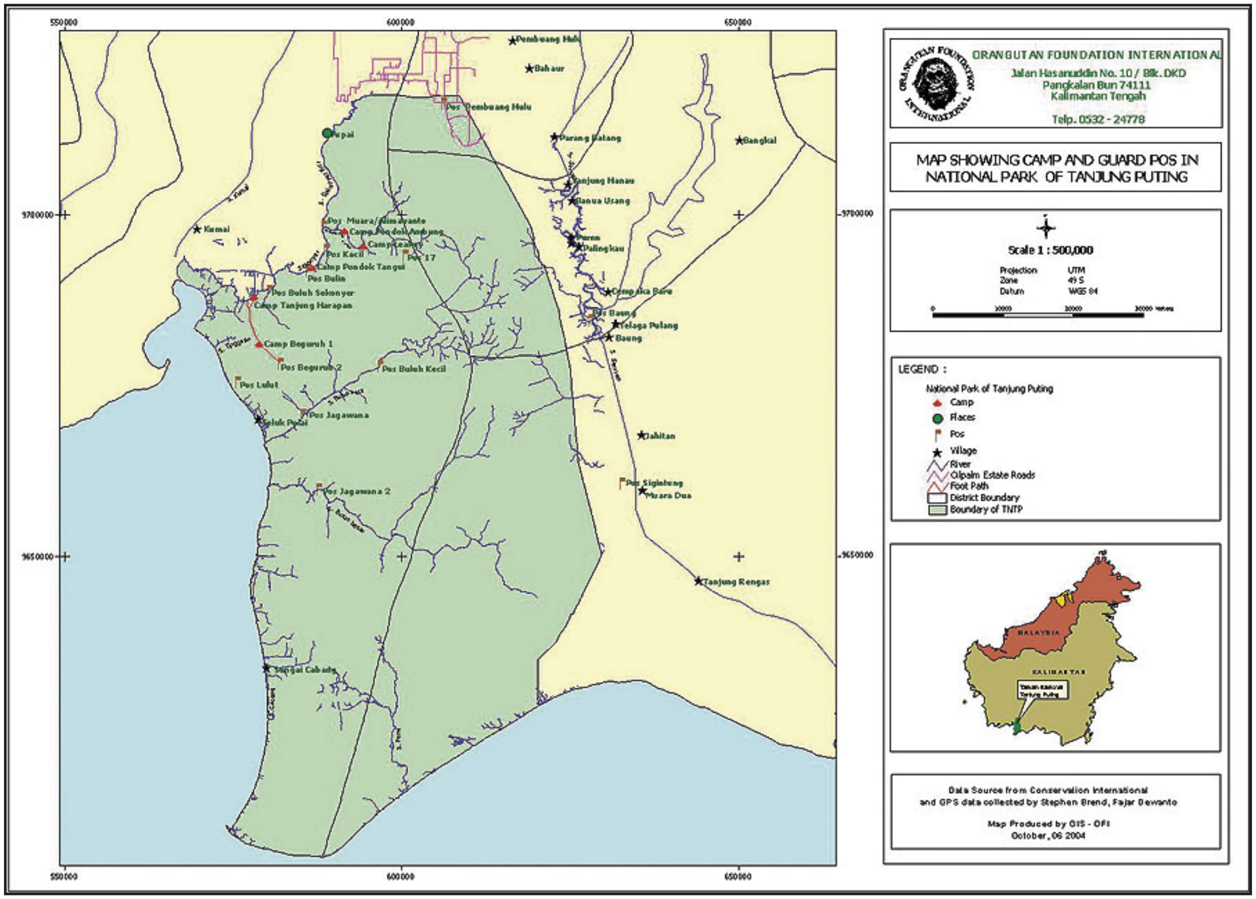
In October 2003, OFI began a comprehensive GIS program as part of its USAID work. Data layers of physical and political features were created from existing GPS, GIS, and hard-copy data from a variety of sources. Satellite imagery was used to generate a land cover map of the area, which will provide the key element of orangutan habitat mapping and conservation planning.

Land cover at TPNP is dominated by peat swamp and upland heath forest types in a mosaic of secondary forest and ruderal vegetation. For the initial land cover map, the focus was on delineating broad vegetation and land cover classes. Given the size of the study area and the level of detail needed, the GIS team determined that Landsat imagery satisfied the spatial and spectral resolution required to conduct land cover classification. Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) scenes cover approximately 31,000 square kilometers in Borneo, and all of TPNP was included in one image. Landsat sensors TM and ETM+ provided 30-meter spatial resolution and seven spectral bands, which enabled the differentiation of 40 image classes. The GIS team recoded them into 14 major habitat types using ERDAS IMAGINE classification tools.

The primary challenge in using optical remotely sensed imagery to detect land cover in tropical regions, such as Borneo, is prevalent cloud cover that obscures ground conditions. Therefore, it was necessary to examine a number of Landsat scenes using a Web GIS application, the United States Geological Survey Global Visualization Viewer (glovis.usgs.gov), to preview the imagery and discern whether cloud-free images could be obtained. The GIS team obtained the most recent image, an ETM+ scene from April 2003, from the Tropical Rainforest Information Center at Michigan State University. 1999 and 2001 Landsat TM scenes were obtained through nonprofit partners. The GIS team determined the 2001 and 2003 scenes to be the most useful. It used ERDAS IMAGINE to composite the 2001 and 2003 images and classify land cover using unsupervised classification.

In November 2004, OFI began recruiting volunteers to assist with satellite imagery ground-truthing fieldwork, which was conducted for one month in June 2004. The results of this fieldwork were used to identify ground conditions for all land cover classes in diverse settings throughout the park. The volunteers recorded data for vegetation type, canopy height, canopy closure, water level, and disturbance. This data was then used to conduct a supervised classification and refine the land cover map.

The volunteers also collected detailed data in agricultural areas, including large-scale rice plantations in the western part of TPNP and an extensive palm oil plantation along the northern border of the park. They visited logging canals still operating in the eastern part of the park so these critical areas could be mapped and more effectively monitored.

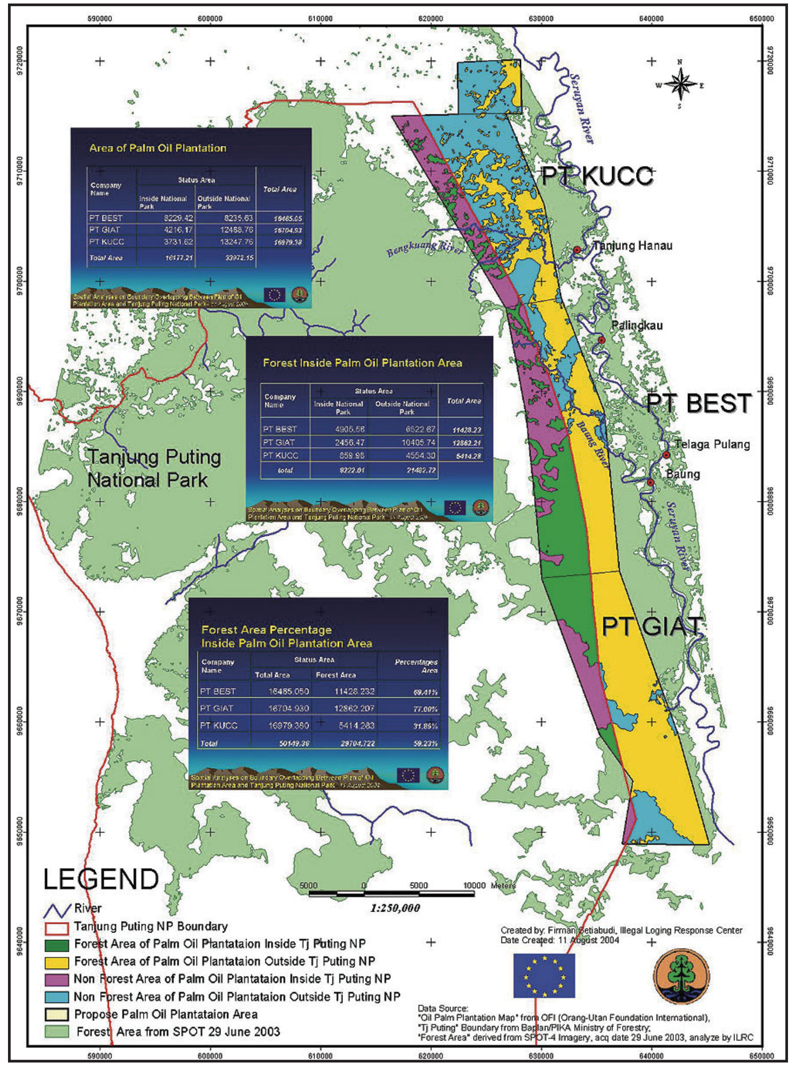


Camp and guard positions in the park.

The volunteers, all with prior experience using GIS and GPS technologies, convened in Ma 2004 for two days of intensive training and again in June at Camp Leakey for another day of training. Each field team used a GPS unit to map land cover point and line features that were later compared to the spectral signature of the satellite imagery. Tropical field conditions were rough; everyone slogged through knee- to waist-deep swamps daily.

Once the data was collected from the field, it was merged into thematic files using Trimble PathFinder software, edited by each field team in ArcView software, and uploaded to the data server as shapefiles. Vector data needed by the program was acquired from the Global Forest Watch Web site (www.globalforestwatch.org). The other major source of data was Conservation International (www.conservation.org). The GIS team displayed, queried, edited, and analyzed all the vector data initially using ArcView software in the OFI team headquarters in San Diego, California, and then in the OFI office in Borneo.

During the data analysis process, the GIS team discovered the survey line of a proposed palm oil plantation that encroached three miles into the existing park boundary. Based on the GIS analysis, OFI investigated and discovered that the plantation owner had scheduled forest clearing to begin July 1, 2004. OFI staff immediately contacted the Indonesian Ministry of Forestry to protest this illegal encroachment into the park. There was also an outcry from the local community that didn't want to see the neighboring lush forest turned into rows of palm oil trees, which would destroy their rice fields, river water quality, and fishing.



Tanjung Puting National Park covers roughly 4,000 square kilometers and is one of the largest protected areas of tropical heath and peat swamp forest in Southeast Asia. The GIS team discovered the survey line of a proposed palm oil plantation that encroached three miles into the existing park boundary.

The Indonesian Ministry of Forestry required the plantation owners to stop their plans to bulldoze the forest inside the park boundary. Unfortunately, the boundary controversy has not been permanently settled, since the Indonesian Ministry of Forestry has now designated the long-established park boundary as "temporary." The ArcView GIS Intersect geoprocessing tool was used to calculate the areas and quality of habitat remaining inside the area proposed for palm oil conversion. Using this information, OFI is now working with its partners, including the Illegal Logging Response Centre, to secure permanent status for the current park boundary.

GIS will continue to play an important role in assessing habitat conditions in TPNP. As part of ongoing data collection, OFI is currently mapping the villages inside the park. These village maps will be used to help resolve border issues and prioritize management for the park. To support growing GIS activities, GIS training was conducted for the OFI local staff in November 2004 in Borneo. With the recent availability of ArcInfo 9 licenses, more advanced data editing, image registration, and GIS analysis capabilities will be used to calculate the areas and quality of orangutan habitat remaining inside the park. GIS will also provide a spatial context for regional analysis of habitat conservation, helping planners and decision makers protect the park and identify surrounding areas in need of conservation. This work will help preserve TPNP as prime orangutan habitat for many years to come.

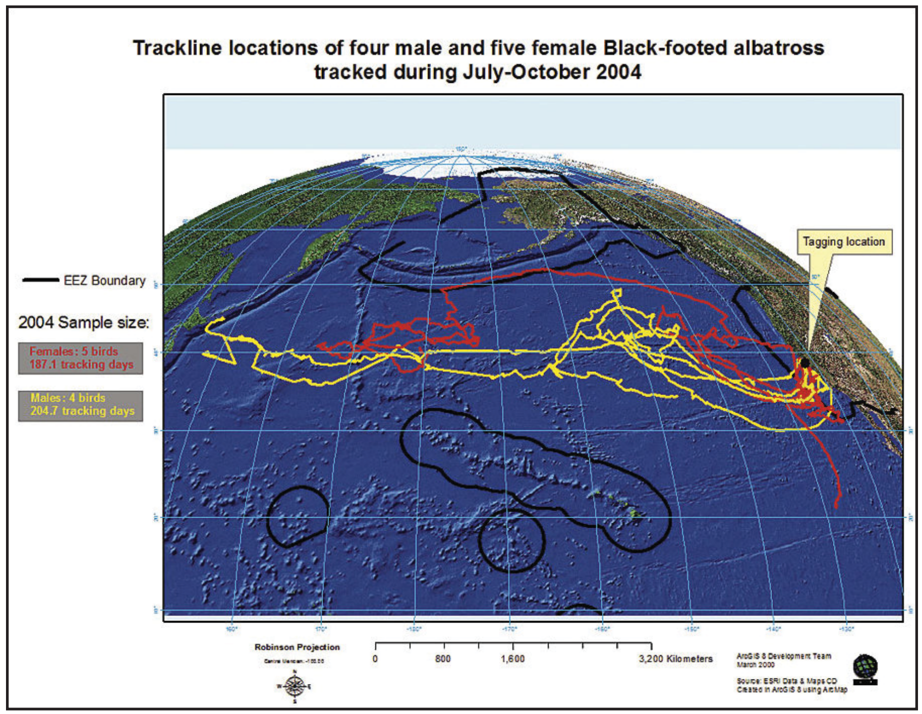
(Reprinted from the Spring 2005 issue of *ArcNews* magazine)

Turning the Tide for Troubled Albatross

For centuries, the world's largest seabird, the albatross, has been woven into the fabric of maritime lore. Its giant wings enable the albatross to stay aloft on nearly imperceptible winds, thus making it the harbinger of good sailing to mariners. Unfortunately, seamen have not returned the goodwill in kind. Each year, thousands of albatross die at the end of fishing hooks. Since the long-term monitoring studies at breeding colonies began in the 1960s and 1970s, some albatross species have decreased by 90 percent, with annual declines of up to 7 percent. The global conservation status of albatross continues to worsen, with two species listed as "critically endangered," seven considered "endangered," and ten regarded as "vulnerable," according to the International Union for the Conservation of Nature. Of the three North Pacific albatross species, the black-footed and the Laysan were recently upgraded to "endangered" and "vulnerable," respectively. The third species, the short-tailed albatross, was down-listed to "vulnerable."

Michele Hester (Oikonos) and David Hyrenbach (Duke University) banding a black-footed albatross.

Because of the worsening status of North Pacific albatross populations, the National Fish and Wildlife Foundation provided funding for a study on the postbreeding movements of the black-footed albatross. This species is facing a projected population decline of 60 percent over the next three generations (56 years) and remains susceptible to bycatch in domestic and foreign longline fisheries across the North Pacific Ocean. Longlines are single-stranded fishing lines, up to 40 miles in length, equipped with hundreds—and sometimes thousands—of baited hooks. The birds are attracted to the bait, get hooked, then are dragged under the water and drowned. Since 2002, pelagic long-lining on the U.S. Pacific coast has been banned in areas designated as the Exclusive Economic Zone (EEZ), which extends 200 miles offshore. But albatross remain threatened because they travel well beyond the safe zone into unregulated waters. Demersal long-lining still occurs off the Pacific coast of the United States and in the Aleutian and Bering Sea continental slope.



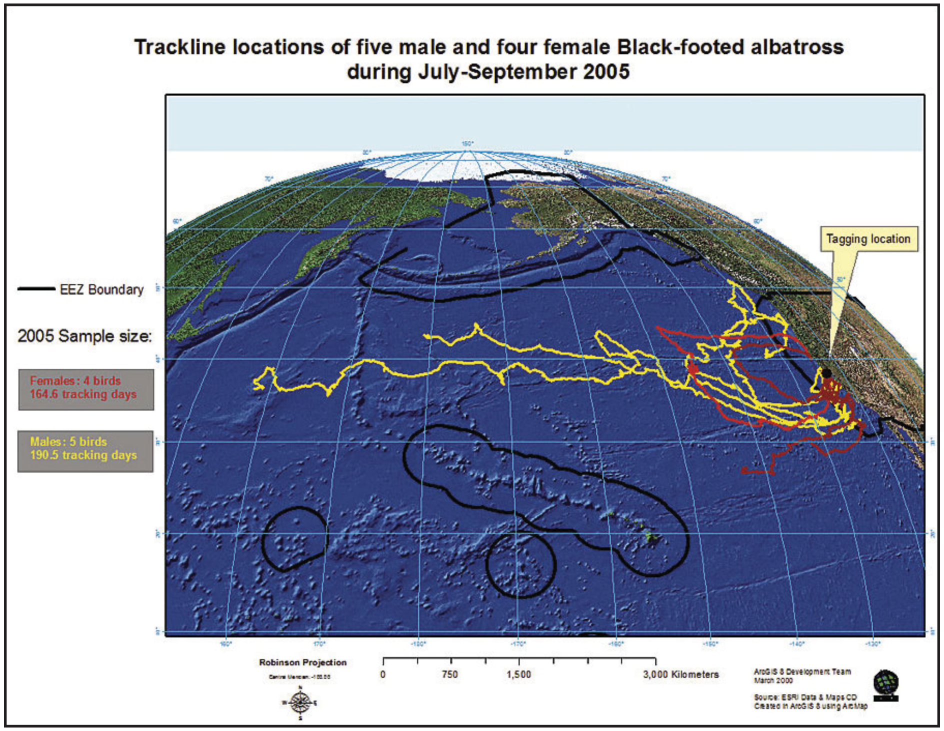
Tracks of four male (yellow) and five female (red) black-footed albatross followed for a total of 392.5 tracking days during the summer and fall of 2004. Black lines indicate the extent of the U.S. Exclusive Economic Zone.

This threat of loss to albatross populations has made these birds a priority for conservation action. Scientists are using GIS to gather information about albatross movements to identify those fisheries and nations with conservation responsibilities for these far-ranging seabirds. This information will improve the bird's chances for survival by focusing international management actions toward important foraging areas and potential fishery threats. GIS may be the harbinger of good fortune for troubled albatross populations.

Tracking Movements

Although large population declines have been projected, very little is known about the movements and threats faced by individual albatross at sea, especially during their postbreeding dispersal. Oikonos Ecosystem Knowledge is a nonprofit organization that is applying its GIS program to investigate how albatross habitats and longline fisheries are distributed spatially and temporally. ESRI provided Oikonos with a grant for GIS software, which is enabling the organization to map large-scale regions of the North Pacific Ocean and overlay point and polyline data with EEZ and U.S. National Marine Sanctuary polygon shapefiles to calculate the amount of time spent by bird species in specified regions. Oikonos and collaborators (Duke University, the Claremont Colleges, and the U.S. Geological Survey—Moss Landing Marine Laboratories) submitted findings to the National Fish and Wildlife Foundation as part of the foundation's albatross study.

During 2004–2005, the project team of scientists used Kiwisat Argos-linked transmitters to track the postbreeding movements of 18 black-footed albatross tagged in California's Cordell Bank National Marine Sanctuary. Albatross are known for flying long distances, and the study confirmed these incredible journeys. The duration of the birds' tracking sessions ranged from 22 days to an amazing 57 days. One bird traveled as far as Hokkaido, Japan, a linear distance of more than 7,300 kilometers from the tagging site. Overall, four out of nine males traveled west of the international dateline (180º W) yet only one of the nine tracked females ventured into the western North Pacific. This preliminary data suggests that male and female birds segregate at sea. This is an exciting possibility with important conservation implications.



Tracks of five male (yellow) and four female (red) black-footed albatross followed for a total of 355.1 tracking days during the summer and fall of 2005.

Evaluating Distributions

Oikonos used ArcGIS Desktop (ArcInfo) to evaluate spatial distributions of albatross telemetry locations throughout the North Pacific and performed a spatial analysis of mapped points, polylines, and polygon shapefiles. It evaluated differences in distribution between male and female albatross by comparing the extent of their foraging ranges, though this comparison showed no significant gender-based differences in the maximum distances traveled. Using the satellite-tagged birds and remotely sensed information from satellites, scientists are currently investigating and quantifying bird movements in association with sea surface temperature, chlorophyll concentration, and wind speed and direction. GIS analysis is also being used to identify those nations with responsibility for the conservation of this far-ranging species throughout the bird's life cycle. Using GIS, scientists are assessing the albatross distributions relative to management zones and protected regions. Findings to date showed that postbreeding black-footed albatross do not remain within the Cordell Bank National Marine Sanctuary or the U.S. EEZ waters but range widely across high seas areas harvested by pelagic longline fisheries.

Currently, based on the known breeding colonies, Japan and the United States have jurisdiction over the black-footed albatross. During the postbreeding season, however, the birds tracked during this study ranged within territorial waters of Canada, Japan, Mexico, and Russia. These impressive movement patterns represent a great challenge for albatross conservation, since fisheries management in the high seas is hampered by the lack of standardized bycatch data collection and enforcement mechanisms across fishing fleets. By overlapping albatross satellite telemetry tracks with boundaries of jurisdictional waters and fishing effort data, ArcGIS graphically highlights those fisheries and countries with responsibilities for albatross conservation.

Black-footed albatross ready for release by biologist Sue Abbott.

Results from this study have been provided to the black-footed albatross status assessment, currently under way by the U.S. Fish and Wildlife Service, and will be made available to BirdLife International's global procellariiform tracking database. This multinational database has been used to identify important seabird foraging grounds and migration corridors in the southern ocean and will provide a conceptual foundation for future important bird area delineation in the North Pacific.

Conservation of far-ranging albatross species requires accurate knowledge of their movement and distribution at sea. This study is the first of its kind to track the incredible postbreeding movement and habitats of the black-footed albatross across the North Pacific. Increasingly, the integration of satellite tracking, remote sensing, and GIS mapping is empowering resource managers to tackle large-scale conservation questions.

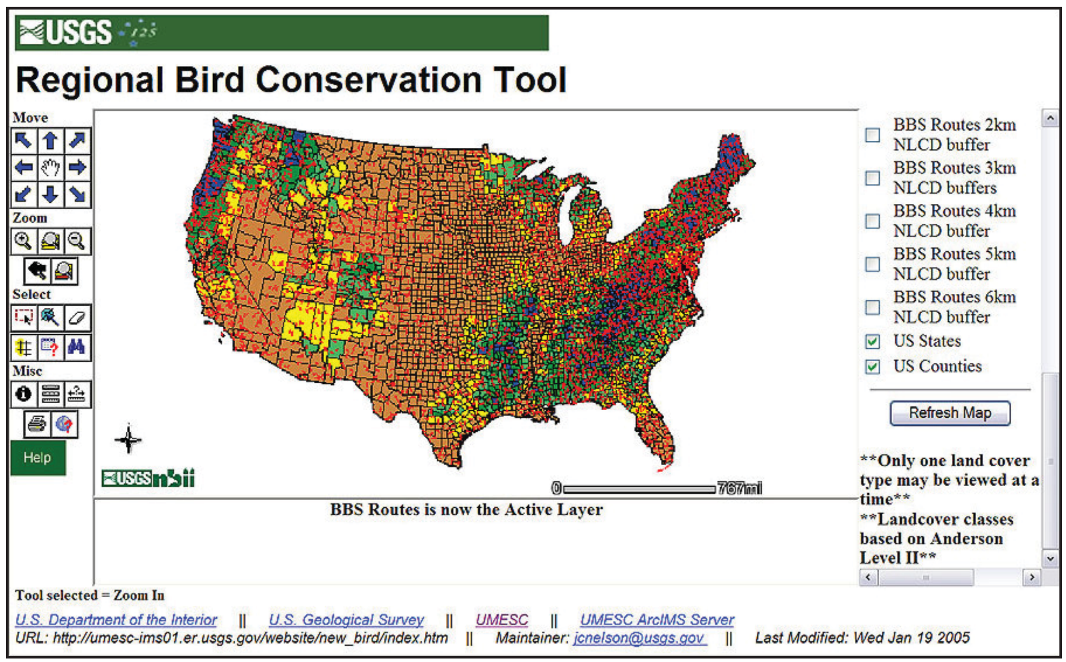
(Reprinted from the Spring 2006 issue of *ArcNews* magazine)

Regional Bird Conservation Internet Mapping Tool Takes Flight with GIS

USGS Bird and Land-Cover Data

By John C. Nelson, Timothy J. Fox, Melinda G. Knutson, John R. Sauer, and Wayne E. Thogmartin, USGS

Imagine having 30 years of bird data selected from anywhere in the continental United States analyzed in seconds by experts in bird biology, and you do not need an expense account or advanced degree in GIS technology or statistics! Is this a biologist's dream, or is it real? How many bird enthusiasts planning their next vacation know they can generate their own bird species checklist for their vacation destination from this same dataset?



Land cover composition is an important aspect of bird conservation. The Regional Bird Conservation Tool has summarized the National Land Cover Data set to provide this aspect to the user.

The dream became reality when the United States Geological Survey (USGS) developed an Internet mapping site to give natural resource managers and the general public access to an extensive federal breeding bird dataset. The USGS Breeding Bird Survey (BBS) has archived observations of birds sighted by volunteers along roadsides since 1968. BBS uses standard protocols to collect, archive, and analyze the data. USGS has long made the raw data and some summary analyses available on the Internet. The new Internet site, termed the Regional Bird Conservation Tool (RBCT), allows users to select specific routes graphically on a map and quickly obtain both habitat and bird information for that location. Also, the user can graphically select a route and link to existing bird population trend estimates, along with state and regional summaries, in a single work session. The USGS National Biological Information Infrastructure, Bird Conservation Node (birdcon.nbii.gov) is the Internet gateway to both the raw BBS data and RBCT.

Query Results Ranked Count RESULTS: >
Records: **131**

AOU	AOU_ABBREVIATION	COMMON_NAME	RANKED_ABUNDANCE	TOTAL_COUNT
5110	COGR	Common Grackle	1.0	6122.0
4980	RWBL	Red-winged Blackbird	0.953773276706959	5839.0
6882	HOSP	House Sparrow	0.746978111728193	4573.0
4930	EUST	European Starling	0.58265272786671	3567.0
3160	MODO	Mourning Dove	0.431885004900359	2644.0
3131	RODO	Rock Dove	0.406076445606011	2486.0
6130	BARS	Barn Swallow	0.406076445606011	2486.0
5011	WEME	Western Meadowlark	0.373244037896112	2285.0
4880	AMCR	American Crow	0.329467494282914	2017.0
7610	AMRO	American Robin	0.327670695851029	2006.0
5400	VESP	Vesper Sparrow	0.293531525645214	1797.0
4740	HOLA	Horned Lark	0.237830774256779	1456.0
1720	CAGO	Canada Goose	0.223783077425678	1370.0
4950	BHCO	Brown-headed Cowbird	0.216432538386148	1325.0
7210	HOWR	House Wren	0.157301535445933	963.0
1320	MALL	Mallard	0.152727866710225	935.0

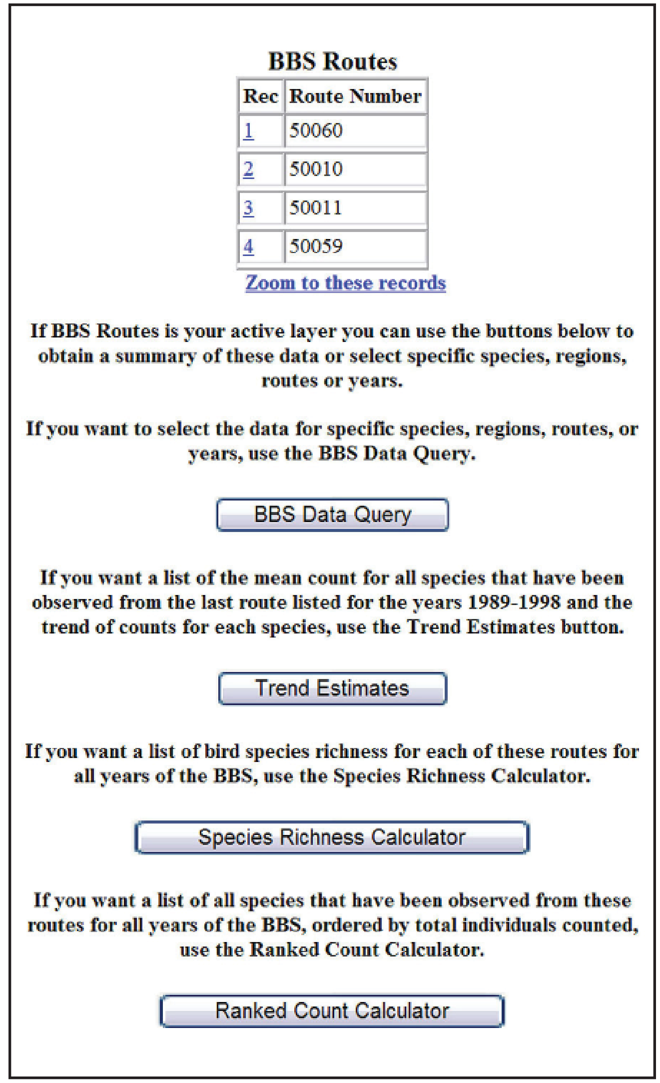
Both conservationists and novice bird watchers will find the Ranked Count calculation useful. Not only can the list be used for its value as a ranked bird count list, it can also be used as a birder's checklist.

Several factors led BBS to use ArcIMS for distributing breeding bird data. In many instances, the users have neither been trained in GIS nor do they have adequate software or hardware. Additionally, BBS wanted the tool to be dynamic. Using ArcIMS as the delivery mechanism, BBS is able to update databases and spatial coverages without the need to export the datasets to users and partners. Reaching a large audience was important, and using ArcIMS made this possible.

RBCT allows the user to visualize land uses and summarize bird counts collected by BBS for areas such as federal and tribal lands, counties, states, and other geographic divisions. Users can select a specific location and calculate the number of bird species observed on BBS routes adjacent to that location. For example, users can obtain information on the amount of forest within a county and find the number of golden-winged warblers (Vermivora chrysoptera) counted by BBS within or near that county over the last 30 years. This information is important to biologists seeking to conserve birds and their habitats.

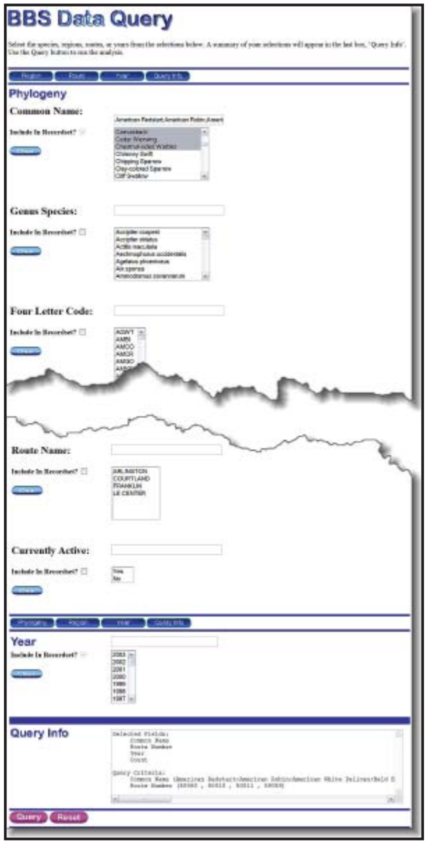
At the heart of RBCT is a ColdFusion connection from ArcIMS to the raw tabular BBS data (www.pwrc.usgs.gov/bbs). Using BBS routes selected in ArcIMS, a ColdFusion-driven Web page allows users to query the extensive BBS dataset. RBCT also allows users to perform additional calculations. A comprehensive list of all species ever identified by BBS on the selected routes, ranked by count, can be generated. Not only is the list useful for resource managers, but amateur bird-watchers can also use this list as a birding checklist. A species-richness formula was also added to the site, which allows users to get the cumulative number of all bird species identified on the selected routes. Species richness is a useful measurement for conservationists because it is a simple means for describing biodiversity. Bird populations change over time, and one of the big benefits of a long-term dataset, such as BBS, is that population trends can be calculated with some confidence. Population trends are highly valued measurements for conservation biologists because persistent population declines portend a species headed for trouble. RBCT also allows the user to select a single BBS route and see the population trend estimates, along with a graph for each species. State and regional summaries of population trend estimates are also available.

Resource managers are often interested in the habitat along BBS routes and how that habitat is used by birds. Biologists can use this data to better understand bird distributions and to estimate bird populations. A large federal dataset of land cover is available—the USGS National Land-Cover Dataset. Land-cover composition summaries of 1-10 km buffers of the BBS routes, U.S. counties, and federal and tribal lands for the continental United States were all completed using an ArcView Avenue script written by USGS. This summary information is available to users of RBCT.



Various queries and calculations are available to the user of the Regional Bird Conservation Tool.

RBCT makes available spatially explicit summaries of two large U.S. federal spatial datasets (birds and land cover) to anyone interested in exploring them. Conservationists, bird-watchers, and natural resource managers (and, of course, the birds) are expected to reap the benefits.



The Cold Fusion Query page ties the graphical selection of Breeding Bird Survey (BBS) routes to the extensive BBS database provided by Patuxent Wildlife Research Center. Our query page allows the user to select from 13 categories to refine the query.

(Reprinted from the Summer 2005 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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