



NEWS

## Critical Time for African Rainforests

As threats to the Congo Basin's vast forests grow, scientists race to sharpen assessments and stem destruction

**KINSHASA, DEMOCRATIC REPUBLIC OF THE CONGO (DRC)**—From a workshop behind her house, botanist Terese Hart can glimpse log-filled barges churning down the Congo River toward a nearby sawmill. Such traffic had come to a virtual standstill during the nation's civil conflicts, but now, she says, the “lights are blazing at night” as massive logs from the forests of Bandundu and Équateur provinces are fed, around the clock, into the jaws of giant saws.

At nearly 2 million square kilometers, the Congo River Basin's dense tropical rainforest is second in size only to the Amazon's. In *Heart of Darkness*, novelist Joseph Conrad—who piloted a steamboat on the Congo a century ago—described this as “impenetrable” territory, where “the big trees were kings.”

Although deforestation is a severe problem in parts of the continent, central Africa's rainforests have so far avoided that fate. A recent analysis estimated that Africa accounted for less than 6% of the total loss of humid forest cover during the 1990s, whereas Brazil's loss represented nearly half of the total. The DRC's remoteness, political instability, bad roads, and unnavigable river rapids had helped save large tracts of its forests from exploitation. But forest degradation has been worsening in

other Congo Basin countries, and a combination of factors over the past few years—including a sharp population spike in the eastern DRC and the mounting Asian interest in African timber—have raised the ax over Conrad's “kings.”

The DRC contains more than 60% of the basin's remaining forests, and “the new scramble for central African resources, exerting massive pressures to open up frontier areas, has the potential to culminate in a ‘perfect storm,’” says William Laurance of the Smithsonian Tropical Research Institute (STRI) in Panama, who has studied the impact of logging on wildlife in several rainforests.



**Wood sale.** Local needs for lumber take a toll on Congo forests.

**Congo rapids.** Rough water near Kinshasa impedes the transport of logs.

At issue are “the loss of biodiversity, a massive waste of forest resources, the decline of rainforest people, and—in the long run—possible climate change,” warns University of Kinshasa botanist Constantin Lubini, whose garden is an oasis of flowering trees amid the dusty chaos of Kinshasa's *Debonhomme* quarter, where vendors sell charcoal along with bread and meat. In the region's fast-growing cities, the widespread use of charcoal and wood for cooking has taken a heavy toll on nearby forests.

Hart, Lubini, and other scientists—from big-picture geographers who scrutinize satellite images to on-site botanists who measure every sapling on 40-hectare rainforest plots—believe the next few years will be critical in determining the future of what is probably the least exploited yet most scantily studied of the world's humid forest regions. In conjunction with the 6-year-old Congo Basin Forest Partnership (CBFP)—an international association of government officials, nongovernmental organizations, and conservation experts—these researchers are now applying satellite maps, in-depth forest studies, and other tools

## Forests in Flux

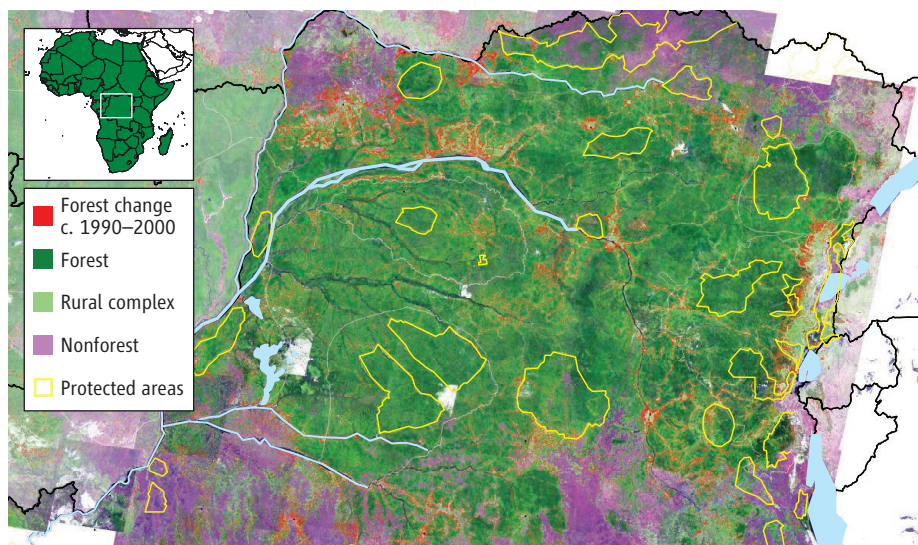
to help policymakers limit the sort of large-scale deforestation that is now decimating rainforests in the Amazon and Far East.

### Eyes in the sky

Earth-observation satellites have become the watchdogs for deforestation in remote areas, helping document regions in trouble. At the cluttered Kinshasa office of the OCEAN (Organisation Concertée des Ecologistes et Amis de la Nature) ecology group, director René Ngongo negotiates through the crowd—from shouting pygmies to low-key forest analysts—toward a map taped to the wall. “These red spots show what’s been destroyed,” he says, tapping the satellite-generated map of Congo Basin forest change, “but there is still more green forest, and we want to keep it that way.” The problem is that the map (above) shows the forests as of 2000, and the next update won’t be available until later this year.

For many technical reasons, remote sensing of Congo forests has lagged behind studies of the Amazon, which “is a much easier place to monitor,” says geographer Matthew C. Hansen of South Dakota State University’s Geographic Information Science Center of Excellence in Brookings. Persistent cloud cover prevents clear images of some Congo Basin areas, requiring far more images to be processed. Also, central Africa has no dish to receive data; thus, researchers get relatively few images from the Landsat satellites. And because of a glitch in Landsat 7, its images have been flawed since 2003. To make matters worse, it is far more difficult to detect the “selective” logging of just a few trees per hectare that is standard in the Congo than it is to identify clear-cut areas, typical in the Amazon. Forest change “is huge in the Amazon,” Hansen says, making it simpler to map deforestation.

To tackle those challenges, North American and European groups are bringing new analyses to bear on impoverished Congo data sets. In 2003, the U.S.-funded Central African Regional Program for the Environment commissioned Hansen and Christopher Justice of the University of Maryland, College Park, to produce a decadal deforestation map. It took Hansen, Justice, and their team 3 years to automate the calibration of the infrequent but higher resolution Landsat images with data from a lower resolution NASA instrument (MODIS) that measures tree cover. This map, released last year, shows that much of the forest loss during the 1990s occurred near densely populated areas in the eastern DRC, along principal rivers, and at the basin’s



**Deforestation hot spots.** Based on satellite images, this map shows that forest loss occurred mainly along the Congo River and near the Uganda and Rwanda borders (far right), areas of rapid population growth.

periphery. Even though the map is already 8 years out of date, Ngongo and other Congolese activists and officials regard it as a useful baseline for further research.

Meanwhile, a group led by Belgian forester Philippe Mayaux of the Joint Research Centre’s Institute for Environment and Sustainability in Ispra, Italy, used a less comprehensive “grid sampling” technique to parse Congo forest trends across the whole basin from the satellite data. In a paper in the 15 May issue of *Remote Sensing of Environment*, they concluded that the basin’s deforestation rate for the decade ending in 2000 was nearly 0.2% per year. In addition, the rate of forest degradation (thinning of forested areas) was 0.1%. The deforestation was low compared with the Amazon’s annual rate of about 0.5%, but it is still of concern because on-the-ground reports indicate that logging in the Congo region is escalating.

Some new data sets also show promise. Nadine Laporte, whose teams at the Woods Hole Research Center in Falmouth, Massachusetts, have been studying logging roads and biomass in the Congo Basin, says the Chinese-Brazilian CBERS satellites may offer cost-free data to African institutions. Microwave radar imagery from Japanese and Canadian satellites is now helping some scientists better assess forest trends in persistently cloud-covered coastal areas. And Laporte’s group is searching for ways to use data from NASA’s LIDAR laser-pulse sensor to calibrate optical imagery and improve estimates of forest biomass.

Perhaps more importantly, French and

British officials are separately considering plans to help build a receiving dish in central Africa to acquire and store up-to-date data from satellites as they fly over. Without such additional data, Hansen says, “you can only do accurate update maps for the entire basin every 3 to 5 years.” Looking forward to such data, the University of Maryland’s Paya de Marcken is now training central African scientists at a new remote-sensing lab at the University of Kinshasa to handle incoming images.

### On the ground

Although the Congo satellite maps are outdated, they drive home the vulnerability of the forests. At his office laptop in Kinshasa, Belgian geographer Benoit Mertens opens a satellite map, defines a forest area, and enlarges the pinpointed section to reveal that it is crisscrossed by what he calls “a wishbone pattern” of roads. They are a clear indication that the tract is being logged, says Mertens, who works for the World Resources Institute’s Global Forest Watch project. Laporte of Woods Hole says her group’s analysis of Landsat images for evidence of forest roads showed considerable logging road construction (about 460 kilometers per year) in the north-central DRC (*Science*, 8 June 2007, p. 1451). And, says Laporte, “you can make a pretty good assessment of the extent and intensity of logging from the road maps.”

What’s harder to assess is the relative impact of industrial versus “informal” (sometimes illegal) logging. Mertens coordinates a five-country project to monitor the basin’s timber industry. The DRC’s 156 logging con-

cessions control about 21 million hectares and take out about 500,000 cubic meters of timber a year. But Mertens and other experts say that chainsaw-wielding freelance loggers or farmers who practice “slash-and-burn” agriculture now account for more DRC forest degradation than industrial timber operations.

Informal logging takes place along many roads and in the forest fringes, with most of the timber used for local fuel or exported from the northeastern DRC to nearby Uganda, where population increases are driving up demand for wood. French forest scientist Robert Nasi of the Center for International Forestry Research in Bogor, Indonesia, estimates that Kinshasa alone (with a population of 8 million) consumes about 4.5 million cubic meters of wood equivalent per year for charcoal. “If you consider that all of the major cities are using fuel wood or charcoal, it dwarfs the selective logging harvest by more than an order of magnitude.”

But Susanne Breitkopf, who monitors Congo Basin forests for Greenpeace, contends that industrial logging “is now the main threat to the forest” in some major provinces, “not only because of the direct impact of logging on wildlife and ecosystems but also because it acts as a catalyst for further destruction, opening once-remote areas to increased levels of hunting, settlement, and agriculture.”

### Tracking forest fauna and flora

Remote-sensing data can provide important mapping information, but it takes researchers on the ground—in the midst of the forests—to shed light on exactly how the Congo Basin’s forests are changing and what their contribution to the global carbon cycle is. Numerous groups are now studying the impacts of civil wars, forest degradation, mining, and other factors on the region’s flora and fauna.

Some scientists have been tracking the fate of animals that live and breed in the DRC, from giraffelike okapi to great apes. Those species may be at greater risk than the trees around them. The sharp increase in forest hunting and the bush-meat trade, which was exacerbated by the civil conflicts and the incursion of logging roads into the deep forests, have emptied some landscapes. “Mammals are no longer seen along the roads in many forests,” observes ecologist Julien Punga-Kumanenge, who says that the DRC’s bush-meat trade—the world’s most extensive—has become so widespread that “even big snakes are sold in the markets.”

Logging itself can lead to wildlife haz-

ards as well. In a coastal study that directly links logging to endangered marine species, a team led by the Smithsonian’s Laurance reported this year that many sea turtles that are climbing onto Gabon beaches to nest “are being tangled, impeded, and killed” by thousands of lost logs that block the way to traditional nesting sites. “This is highly relevant because the region contains some of the most important nesting areas in the world for sea turtles, including the critically endangered leatherback turtle,” says Laurance.

Perhaps the longest running research survey in the DRC is the Ituri Forest project, part of STRI’s Center for Tropical Forest Science (CTFS) initiative. Since 1993, Congolese forest scientist Jean-Remy Makana and colleagues have been measuring and assessing all the trees and woody vines in a 40-hectare plot, part of the 21-site CTFS network that monitors more than 3 million tropical trees across the globe. The Ituri studies have found about 470 species of trees and shrubs, along with 240 species of liana (woody vines). “Most of the

diversity is not in the big-tree category but in the ‘treelet’ subcanopy category and in the lianas,” says botanist Hart.

Recent studies of biomass across the CTFS sites have indicated that the Congo Basin forest has among the highest carbon content per hectare of any rainforest, perhaps because of the density of its flora. If the Ituri site is typical, then preservation of the Congo Basin would do relatively more to prevent carbon release than preserving forests elsewhere, Makana says.

Such carbon accumulation could provide incentives to preserve the DRC’s forests if the government allowed local forest inhabitants, such as the region’s half-million pygmies, to engage in carbon trading. Local groups could lease forest tracts from the government and then sell “carbon units” valued according to the amount of deforestation circumvented. These earnings would serve as an alternative to logging income.

Even if the carbon scheme proves unfeasible, an ongoing effort to preserve vast tracts of the Congo Basin’s rainforests—focusing on a dozen large-scale “landscapes” with a total area larger than Texas—is showing potential. The Mayaux and Hansen studies both indicate that the “landscapes” selected by CBFP were less affected by deforestation and logging exploitation, at least through 2000. Scientists are now studying on-the-ground conservation in those landscapes. And activists such as Hart—who wants a new “landscape” designated in the central DRC—are calling for more stringent protection of biodiversity within them.

All of these efforts would be better off with more science behind them, says engineer Somnath Baidya Roy of the University of Illinois, Urbana-Champaign, who has developed a mathematical model to project how deforestation might influence climate in key central African parks and reserves. He and others are calling for more extensive land- and sky-based data and more intense research to improve methods of predicting the impacts of deforestation. Says Roy: “We need to do the same sort of work in the Congo Basin that has been done in the Amazon and elsewhere.”

—ROBERT KOENIG



**Logged in; burnt out.** Stray logs keep a sea turtle from its nesting site. Elsewhere, a woman makes charcoal from felled timber.