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

CREDITS (TOP TO BOTTOM): R. KOENIG/SCIENCE; R. KOENIG/SCIENCE

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 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.

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.

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 concessions 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 hazards 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.

CREDITS (TOP TO BOTTOM): DAVID LIGGETT; GEORGE STEINMETZ/CORBIS

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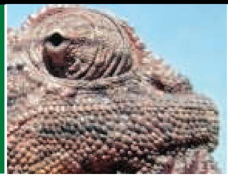

LETTERS

edited by Jennifer Sills

An Editor's Checklist

THE LETTER FROM M. RAFF *ET AL*. ("PAINFUL PUBLISHING," 4 JULY, P. 36) RAISES A CRUCIAL issue about peer review. A young investigator who is challenged to undertake more experiments in order to get a paper published is not usually in a position to argue. To make sure additional work is justified, an editor asking for extra experiments should be able to answer the following questions: (i) Has the reviewer rigorously justified each suggested experiment? (ii) How much time and investment of resources such as animals and materials will likely be involved? (iii) Will the additional experiments strengthen a specific, identified weakness of the manuscript rather than move the work on to the next stage or to one side? (iv) Does the reviewer have any conflicts of interest in making these requests? For example, would the reviewer's current research program benefit from information generated by the additional experiments? By asking these questions, the editor can intervene on behalf of the researcher, ensuring the best final product for publication.

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High-Profile Journals Not Worth the Trouble

RAFF, JOHNSON, AND WALTER ("PAINFUL publishing," Letters, 4 July, p. 36) make some excellent points about how peer reviewers for journals should conduct themselves. There is a fine line between being too demanding by requiring a lot of extra work and making sure a paper with important results gets out to the scientific public in a timely way.

In my laboratory, there is no pressure to publish in journals like *Science*, *Nature*, or *Cell* because we simply do not send our manuscripts to them anymore, no matter how important or high-impact we think the work may be. We have found that there is an excellent group of other, first-line journals of cell biology for which we do not need to subject ourselves to the type of competition required for publication in these three journals.

When I have served on peer-review panels, I have fought against the common practice of relating grant awards to publication in high-profile journals such as *Science*, *Nature*, and *Cell*. It is the impact and importance of the work that matters (thereby requiring the peer reviewers to read the applicant's papers quite thoroughly), not where the work is published.

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Taking Responsibility for Scientific Discourse

RECENT EXPLORATION OF THE DARKER SIDE of the scientific literature (*1*) supports the idea that more than honest error plagues modern scientific discourse (*2*). Many solutions focus on improving administrative oversight (*3*). I believe that a greater burden of responsibility and potential for change falls on each of us. Here, I delineate some practices that might transform modern discourse.

Rapidly test competing hypotheses with unconventional search engines. In one example from my own experience, a Google search yielded an important paper as the first hit [(*4*), as cited in (*5*)]; this paper was much more challenging to find in a search of the same terms on PubMed. It is time-prohibitive to collect and read all cited papers, leading to a problematic compression of breadth. Multiple reviewers can ameliorate this problem, but the danger remains of creating an environment where responsibility is undesirably diffused.

Seek statistical consultation from an expert or, better, experts. Although statistical training is a core subject in graduate programs, too often the skills acquired are inadequate to deal with the actual complexity of the acquired data. Greater quantitative rigor extending to all facets of data-handling should be the common goal. Many journals now use an expert statistical reviewer; this should become the norm.

Describe your data analyses and results to a colleague who is not a coauthor. Such communication increases the likelihood of noticing an oversight in design, analysis, or logic. If such dialogue took place on a large scale, the implications for translational research could be substantial.

Fight to publish results that are clearly negative. The scientific literature and grant system are focused on positive results, but robust negative findings, if highlighted by journals, would prevent future labs from wasting time and money recreating these efforts.

Examine unspoken pressures. Too often, scientific acts are affected by influences other than those of "pure" science, such as conducting unblinded reviews, affirming popular literature conclusions despite contrary empirical evidence, meeting promotion requirements, sustaining unhealthy hierarchies in laboratories, fulfilling a priori grant data despite insufficient statistical power, and keeping one's constructed intellectual towers

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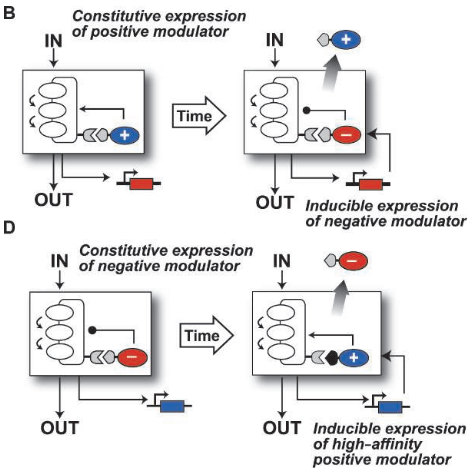
CORRECTIONS AND CLARIFICATIONS

News of the Week: "Senate inquiry on research conflicts shifts to grantees" by J. Kaiser (27 June, p. 1708). The article incorrectly suggested that NIH can fine institutions for violating conflict-of-interest policies. In addition, total consulting income since 2000 reported by the three Harvard researchers was $4.2 million, not $3.6 million.

Special Issue on Forests in Flux: News: "A second chance for rainforest biodiversity" by E. Stokstad (13 June, p. 1436) states that Daniel Ludwig hoped to grow *Eucalyptus* in the Amazon. In fact, he intended to plant an Asian tree, *Gmelina arborea*. After that failed, he switched to *Eucalyptus*. In addition, the field work was managed by Jos Barlow.

Special Issue on Forests in Flux: News: "Critical time for African rainforests" by R. Koenig (13 June, p. 1439). On page 1440, the credit should read CARPE, not CAPRPE.

Reports: "Using engineered scaffold interactions to reshape MAP kinase pathway signaling dynamics" by C. J. Bashor *et al*. (14 March, p. 1539). There were two errors in Fig. 4 in describing the precise components used to construct specific circuits. In Fig. 4B, the leucine zippers attached to both the negative and positive modulators should have both been colored gray, since both modulators were fused to identical zippers (rather than to zippers with different affinity). The label was also incorrect: The resulting negative modulator does not bind with high affinity. In Fig. 4D, the leucine zipper attached to the positive modulator should have been colored black, since this modulator was fused to a zipper with higher affinity than the zipper (colored gray) fused to the negative modulator. The zipper is now black, and "high-affinity" has been added to the label. The corrected figure panels are shown here. In the main text, in the second sentence in the penultimate paragraph on page 1541, the words "high affinity" should be deleted. The correct sentence should read "In this accelerator circuit, the positive modulator (Ste50-zipper) was constitutively expressed, but the negative modulator (Msg5-zipper) was inducibly expressed." In the first sentence on page 1542, the words "higher affinity" should be inserted such that the corrected sentence reads "We built a circuit with enhanced ultrasensitive switch behavior by constitutively expressing a negative modulator (Msg5-zipper) and inducibly expressing a positive modulator (Ste50-zipper, higher affinity) (Fig. 4D)." In the legend for Fig. 4 (page 1542), the third-to-last sentence should be corrected to read "Negative modulator is displaced by inducibly expressed positive modulator fused to a higher-affinity zipper (Kd = 6.1 versus 41 nM)." The corresponding errors are also corrected in fig. S3 and tables S1 and S2 of the supporting online material, which list the exact plasmids and constructs used for construction of each circuit.



TECHNICAL COMMENT ABSTRACTS

Comment on "Protein Sequences from Mastodon and *Tyrannosaurus rex* Revealed by Mass Spectrometry"

Pavel A. Pevzner, Sangtae Kim, Julio Ng

Asara *et al*. (Reports, 13 April 2007, p. 280) reported sequencing of *Tyrannosaurus rex* proteins and used them to establish the evolutionary relationships between birds and dinosaurs. We argue that the reported *T. rex* peptides may represent statistical artifacts and call for complete data release to enable experimental and computational verification of their findings.

Full text at www.sciencemag.org/cgi/content/full/321/5892/1040b

Response to Comment on "Protein Sequences from Mastodon and *Tyrannosaurus rex* Revealed by Mass Spectrometry"

John M. Asara, Mary H. Schweitzer, Lewis C. Cantley, John S. Cottrell

Endogenous peptide sequences extracted from a 68-million-year-old *Tyrannosaurus rex* fossil bone and obtained by mass spectrometry have been shown to be statistically significant based on protein database searches using two different search engines and similarity comparisons to authentic tandem mass spectrometry spectra. Specifically, we have validated the sequence GVVGLP$_{(OH)}$GQR.

Full text at www.sciencemag.org/cgi/content/full/321/5892/1040c

buffered from attack. Although these factors could be attributed to effectively playing the modern "game" of science, failure to consider their influence will guarantee their undesirable expression (*6*).

From an organizational level, refinement of guidelines for grant and paper review will be invaluable to improve both the process and products of science. However, I fear the solutions developed can only be as healthy and sustainable as an individual's resolve to infuse meaningful content. The responsibility for scientific progress has seemingly shifted from the individual to the literature as a whole, with this latter agent being a poor policeman and historian (*7*). Continued dilution of responsibility within scientific discourse and lack of personal engagement is at our collective peril. Each intentional discourse provides the opportunity for engagement. Thrown together at the collective target known as science, I have little doubt that these efforts will hit their mark.

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The Carrageenan Diet: Not Recommended

WE READ WITH GREAT INTEREST AND CONCERN recent reports of the spread of carrageenan-producing seaweeds in coral reefs in the Bay of Bengal, as well as in Butaritari, Kiribati, and other Pacific atolls ["Seaweed invader elicits angst in India," P. Bagla, News of the Week, 6 June, p. 1271, and (*1*)]. The bioinvasion of carrageenan-producing, coral-destroying algae in remote Pacific atolls and marine reserves in the Gulf of Mannar Marine National Park is unfortunately a metaphor for the invasiveness of carrageenan in the Western diet and in other commonly used products. Although carrageenan exposure has been associated with development of inflammation in experimental models for decades (*2*), its use in processed foods (including infant formula and nutritional supplements) and other manufactured products (including pharmaceuticals, cosmetics, and toothpaste) continues to increase. In view of uncertainty about the safety of consumption of carrageenan-containing products, the efforts to cultivate carrageenan-producing seaweeds seem ill-advised.

At its 68th meeting in June 2007, the Joint Expert Committee on Food Additives (formed by the Food and Agriculture Organization of the United Nations and the World Health Organization) advised against the continued use of carrageenan or processed Eucheuma seaweed (PES) in infant formulas (*3*). It also recommended a new dietary exposure evaluation of carrageenan intake, noting that previous estimates of carrageenan intake might be outdated. Also, the Scientific Committee on Food of the European Commission advised and the European Commission adopted the recommendation that the content of carrageenan of size less than 50,000 Da in food products should not exceed 5%, if feasible (*4*). In response to this, carrageenan manufacturers performed round-robin testing of food-grade carrageenan and PES samples and found >5% content over 50,000 Da, as well as marked variation in their determinations (*5*). We have published several reports about carrageenan-induced effects on human colonic epithelial cells in tissue culture and in ex vivo human and mouse colonic tissues. We also published a review of the harmful effects of carrageenan in many animal experiments (*6*–*10*).

With these considerations in mind, we are concerned not only about the extraordinary overgrowth associated with the attempted cultivation of carrageenan near the Gulf of Mannar Marine National Park and in Pacific sites, but the thinking associated with the spread of the use of carrageenan in products for human consumption and the increased dependence on carrageenan farming in developing economies, as in Indonesia and the Philippines. The efforts at cultivation of carrageenan-producing seaweed have demonstrated how a natural product can produce harmful effects to the marine environment; similarly, harmful effects to humans may be attributable to carrageenan exposure.

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Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the previous 3 months or issues of general interest. They can be submitted through the Web (www.submit2science.org) or by regular mail (1200 New York Ave., NW, Washington, DC 20005, USA). Letters are not acknowledged upon receipt, nor are authors generally consulted before publication. Whether published in full or in part, letters are subject to editing for clarity and space.