CENTRAL AFRICAN REGIONAL PROGRAM FOR THE ENVIRONMENT

CONGO BASIN Information SERIES

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Issue Brief #7

#7 — Seeing the Future Now Simulating Forest Changes in the Congo Basin

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Key Concepts

- Unless government officials in Central African nations are able to visualize and quantify how their decisions directly or indirectly alter land use and forest cover in the region over time, they will be limited in their ability to develop and implement policies that effectively address national economic and resource conservation concerns and priorities.
- Rule-based spatial simulation modeling can provide policy makers with a flexible tool to

explore the economic and conservation impacts of various policy options on land use and forest cover.

- Given current conditions, forest clearing over the next 50 years will result in a 41% reduction in present dense forest cover and extensive forest fragmentation.
- Simulated deforestation between 1990 and 2050 will release 9 Pg of carbon (one Petagram = one billion metric tons = 1 thousand billion kg) into the atmosphere. Though equivalent to only 1 year of current global carbon emissions, deforestation and forest fragmentation will likely result in a major loss of forest dependent plant and animal species.

History of Forest Change

The majority of the forest within the Congo Basin is of relatively recent origin. During the last glacial maximum, savanna was much more extensive and forests were restricted to a few refugia (c. 16,000 BC; Fig 1). As rainfall increased in the Basin, forest once again invaded the savannas and dominated the landscape (c. 6,000 BC).

The first farming people to enter the African equatorial rain forest (c. 3,000 BC) were Bantu migrating from the northern periphery to the east and south following rivers and settling primarily in the transition zone between forest and savanna (Fig. 2). Thousands of years of agriculture have left its mark on the landscape by modifying forest distribution, structure and species composition. Today, human transformation of the forest continues to occur primarily along rivers and road networks, and the forest remains the primary source of subsistence and income for Central African families.

Logging in the Congo Basin is highly selective, focusing on a few tree species. Timber extraction thus seldom results in deforestation, rather it causes forest fragmentation and degradation. Though deforestation to establish industrial scale plantations of coffee, oil palm and rubber increased substantially during the colonial period, forest clearing is still predominantly a result of individual families securing traditional tenure to agricultural land. With human populations expected to double over the next 25 years, family farms are likely to continue to be the most significant driver of forest cover change in Central Africa in the near future.

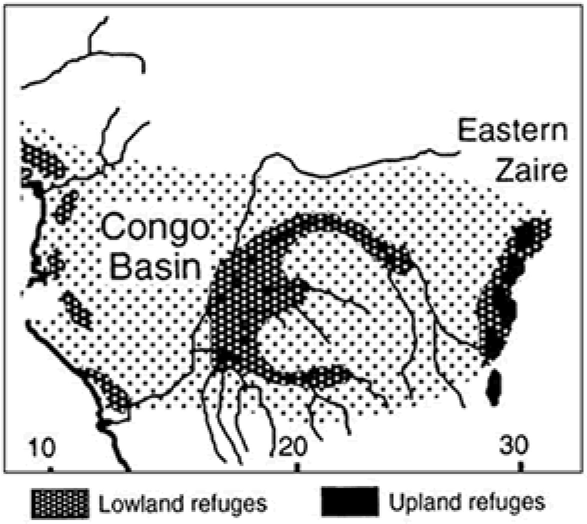

Figure 1: Rain forest refugia during the last glacier maximum (c. 18,000 BC) in contrast to approximately current forest distribution (1996). Source: Maley.

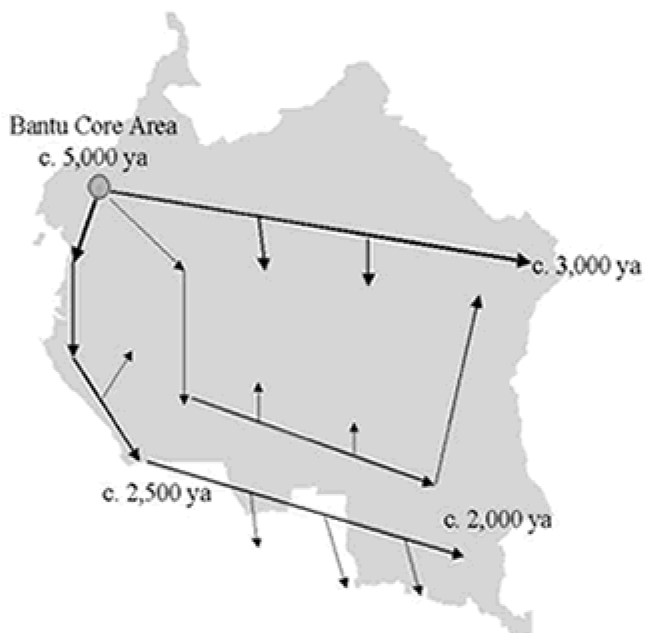

Figure 2: Migration of farming people along the northern periphery of the rain forest and coast in Central Africa (1995). Source: Newman.

Value of Predicting the Future

Though family farms are the primary direct cause of deforestation in the region, the pattern and extent over space and time are determined by a complex combination of factors that include population growth and movement, land-use and tenure policies, commodity prices and transportation costs, and the opportunity costs of labor and capital.

It is relatively simple to extrapolate the scale of future deforestation and the extent of future forest cover based on presents basin-wide estimates of the rate of change. However, knowing how much forest is likely to disappear tells us only so much about the ecological impacts of expected deforestation. Growing evidence from the Amazon suggests that the spatial patterning of deforestation is as important as the overall scale of forest clearing, because forest fragmentation results in tree biomass collapse at the edges of forest patches, and risks the loss of wide ranging animals species that require large intact blocks of forest. Predicting both the extent and spatial pattern of future deforestation is thus essential to understanding what will be gained and lost as a result of development policies.

Given how intertwined and interdependent are the drivers of household-level deforestation it is difficult for decision-makers to visualize, a priori the environmental consequences of their policies. To help policy makers better understand how the continuation of recent trends and present policies are likely to impact the forest over the next 50 years, and to help minimize the environmental impacts of development policies it is critical to develop realistic spatially explicit models of forest change.

Spatial and non-spatial regression models are able to combine historical changes in land-cover with geographic and socio-economic data to characterize the factors that determine deforestation. Model results can then be used to predict the future local and extent of forest cover conversion. Absence of data throughout most of Central Africa typically precludes the use of regression models as crystal balls, and mandates the use of deterministic, rule-based models built on expert knowledge.

Developing a Crystal Ball

The current model was developed using (1) a forest cover map of the region generated by the TREES project derived from 1km resolution satellite data, (2) population distribution and change information from the WRI Africa Data Sampler, (3) road network from the Digital Chart of the World, (4) protected areas from WCMC, and (5) logging concession information from WRI's Global Forest Watch program. Deforestation rates were obtained from UN/FAO and the NASA Landsat Pathfinder program. We assumed that the direct cause of deforestation was demand for agricultural lands that increased linearly by population growth. The probability of forest being converted to farms was related to population density, and proximity to roads and logging concessions. Though an optimistic assumption, protected areas were excluded from deforestation during the simulation. The relative weight of each factor driving deforestation was derived subjectively from the pattern of forest change data generated by the NASA Landsat Pathfinder project. Using this simplistic regional model, the extent and spatial distribution of deforestation was estimated between 1990 and 2050, with the annual rate of deforestation increasing from its present value of 0.5% to 1% by the year 2050.

Future Forests

The simulation predicts a general contraction of large intact contiguous forest blocks inwards from the forest boundaries to create three large fragments, one in the triangular intersection of Cameroon, Gabon and Congo, and the other two in the East and West of DRC (Figure. 3). The most extensive loss of forest cover can be expected in southern Congo, coastal Cameroon and Gabon, north of the Congo River within DRC, and southern DRC. Increasing penetration into the forest can be expected along the road network, especially within DRC.

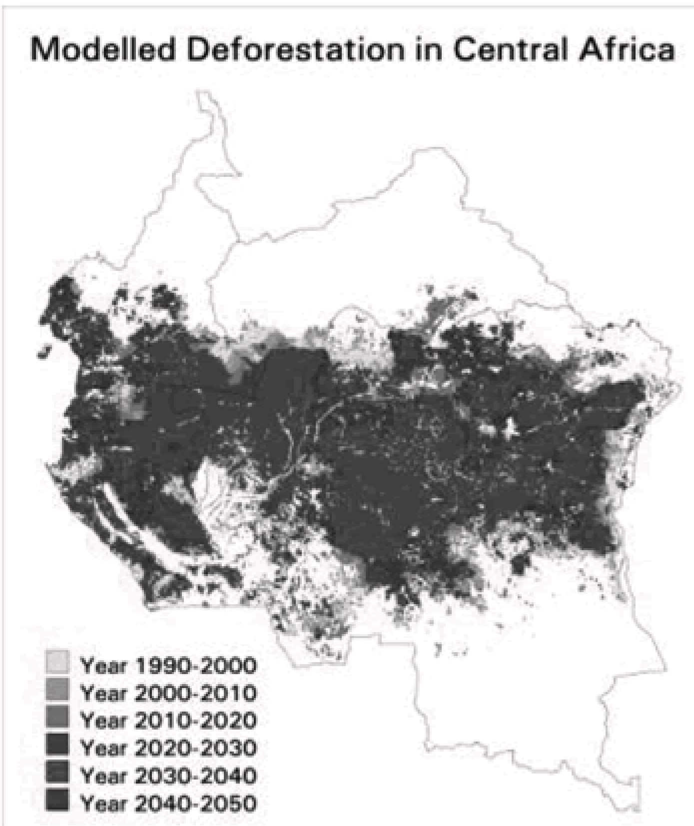

Figure 3: Simulated change in forest cover 1990–2050. Source: Quanfa Zhang.

In addition to regional scale fragmentation of the present contiguous forest blocks, land use over the next 50 years will generate a large number of small forest patches, isolated from the larger forest fragments. Increased fragmentation will make the forest more accessible by 2050. In the 1990s over 70% of the forest was at least 10 km away from non-forest land cover, whereas less than 50% will be ‘interior’ forest by 2050.

Deforestation over the next 50 years is expected to reduce the forest area by 41% across the region, with overall dense forest cover declining from 46% to 27%. Direct loss of carbon from simulated deforestation is estimated to be 9 Pg over the next 50 years (Table 1), with an additional 1 Pg of carbon released because of higher tree mortality along fragmented forest edges. This would account for half of the carbon stocks presently contained within Central Africa's dense forests. However, given that present global carbon emissions from biomass burning (i.e., vegetation fires, and fuel-wood and charcoal burning) are estimated to be 4.1 Pg/year, and emissions from fossil fuel burning are 6.1 Pg/year, total simulated emissions from Central Africa between 1990 and 2050 would contribute less than one year of current total global emissions. Assuming continuation of present population growth rates and land-use policies, deforestation in Central Africa over the next 50 years will contribute little to global warming relative to fossil fuel burning.

Conversion of 41% of the remaining dense forest in the region to agricultural land-uses and the extent of forest fragmentation will likely have a profound adverse effect on biodiversity conservation. Large bodied, wide-ranging animals will increasingly find their greatly diminished habitat insufficient to supply dietary needs throughout the year and will consequently encroach more frequently on human dominated landscapes. Increased human-wildlife conflicts will threaten the livelihoods and safety of forest dwelling families, and risks retaliatory slaughter of elephant, buffalo, pigs, and gorilla, that are often viewed simply as crop pests. Moreover, reduced size of forest fragments will increase the influence of forest edges resulting in sufficient changes in microclimates that many shade loving, moisture dependent species may decline in abundance or become locally extinct.

What Are the Policy Implications?

The results of the simulation only reflect status quo conditions and assume that land-use policies and effect of demographic pressure remain the same over the next 50 years. Sensitivity analyses indicate that logging, which dominates the landscape outside of protected areas and builds roads into previously isolated forest blocks, is the most important variable in determining the future of the moist forests in the Basin. Human population growth will have a relatively small effect on the current pattern of deforestation, because settlements are already well established across the Basin and future population growth will simply expand the size of these settlements and follow the existing road networks, especially if road improvements are made.

Forest sector policies that reduce the extensive logging in isolated forests, minimize construction of roads within concessions, and discourage establishment of permanent settlements within concessions would help reduce the role of logging in forest fragmentation.

Lastly, results of the simulation can be used by the conservation community to identify areas known to be of high biodiversity value that are likely to be converted to other land-uses by 2050, and conversely areas that will remain intact. This information would help to prioritize biodiversity conservation investments in the region.

Table 1: Changes of Forest Extent and Carbon Stocks (1990–2050)					
Country	**Land Area**	**Forest Extent 1990**	**(km²) % 2050**	**% of forest remaining**	**Loss of Carbon (Pg)**
Cameroon	465,400	173,780	109,500	63	0.7
CAR	622,980	60,370	26,700	44	0.34
Congo Rep.	341,500	239,160	165,200	69	1.27
Dem. Congo	2,267,600	1,141,470	646,600	57	5.37
Eq. Guinea	28,050	18,110	12,100	67	0.01
Gabon	257,670	206,770	127,000	61	1.35
Regional Total	3,983,200	1,839,660	1,087,100	59	9.04

For More Information

Technical Reports

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CARPE...What Is It?

Central African Regional Program for the Environment (CARPE)

Launched in 1995, the *Central African Regional Program for the Environment (CARPE)* engages African NGOs, research and educational organizations, private-sector consultants, and government agencies in evaluating threats to forest integrity in the Congo Basin and in identifying opportunities to sustainably manage the region's vast forests for the benefit of Africans and the world. CARPE's members are helping to provide African decision makers with the information they will need to make well-informed choices about forest use in the future. BSP has assumed the role of "air traffic controller" for CARPE's African partners. Participating countries include Burundi, Cameroon, Central African Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon, Republic of Congo, Rwanda, and São Tomé e Principe.

Web site:
http://carpe.umd.edu

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