BIOTROPICA 38(4): 443–445 2006 10.1111/j.1744-7429.2006.00177.x

COMMENTARY

The Uncertain Future of Tropical Forest Species[1]

S. Joseph Wright[2]

Smithsonian Tropical Research Institute, Apartado 0843-03092, Balboa, Ancón, Panamá, República de Panamá

and

Helene C. Muller-Landau

Department of Ecology, Evolution and Behavior, University of Minnesota, St. Paul, Minnesota, U.S.A.

Key words: biodiversity loss; deforestation rates; population projections; secondary forests; species extinction.

IT IS WIDELY ANTICIPATED THAT HABITAT LOSS will cause a mass extinction of tropical forest species. To evaluate this possibility, Wright & Muller-Landau (2006, henceforth WML) project future net tropical forest loss from United Nations projections of human population growth and present day relationships between human population density and the percentage of original forest cover remaining for 45 countries that support 89.6 percent of extant, humid tropical forest. Absolute rates of deforestation (area/yr) are predicted to decline in this analysis, and urbanization is predicted to accelerate the decline to the extent that rural populations control forest cover change. These projections suggest that large areas of tropical forest cover will remain in 2030 and beyond, and thus that habitat loss will threaten extinction for a smaller proportion of tropical forest species than previously predicted. Brook *et al.* (2006, henceforth BBKS) object. BBKS repeat caveats presented by WML and raise additional objections. Here, we show why we believe most of these new objections are unfounded.

HUMAN POPULATION DENSITY AND NET FOREST LOSS

BBKS believe present day age structures skewed toward youth create a human population growth momentum that compromises the analysis of WML. This argument is irrelevant, because the United Nations population projections used by WML incorporate present day age structure. Even with this momentum, tropical populations stop growing. Moreover, the present day skewed age structures mean that the number of young people stops growing sooner than the population as a whole. Thus, if BBKS are correct that the young population causes most deforestation, then net forest loss is likely to decrease even faster and sooner than projected by WML based on total population growth.

BBKS argue that the relationship between rural population density and forest cover is likely to change in the future, because urban populations also place demands on forests, and because the correlation between urban and rural population sizes is projected to decline. These uncertainties are one reason WML repeated their analyses for both total (urban plus rural) and rural population densities. The net loss of forest cover is surprisingly small even when projected from total population growth (Fig. 6 in WML). In an increasingly global economy, however, forest cover may be decoupled even from total country-level population density and respond instead to global markets, as BBKS and WML both note. Global food needs are unlikely to result in a large expansion of the worldwide area in agriculture, given increasing agricultural yields, especially in the tropics (Green *et al.* 2005), although increasing meat consumption in developing countries could substantially increase the per capita impact on forest cover (Green *et al.* 2005). However, increased trade liberalization could lead to shifts in agricultural production from temperate to tropical countries, increasing pressure on tropical forests. Energy demand represents a potentially larger danger to tropical forests if biofuels are developed on large scales: the production of sugarcane for ethanol, oil palm for palm oil, and plantation trees for wood could easily replace *all* natural forests (Pacala & Socolow 2004). Thus, agricultural trade liberalization and large-scale increases in biofuel production could both lead to increased demand for tropical land, and change land-use dynamics in such a way that country-level population densities, rural or urban, cease to predict forest cover.

BBKS introduce a "business as usual" scenario that predicts forest loss not much greater than that projected by WML, and thus reinforces the case for an optimistic view while understating the difference between traditional projections of forest loss and the projections of WML. BBKS assume "the annual percentage rate of forest loss (l) remains constant" to project Southeast Asian forest loss for 2000–2030. Absolute deforestation rates decline under this assumption. The 30-yr decline equals $F \times l \times [1 - (1 - l)^{29}]$, where F is the area forested in 2000, $F \times l$ is the area deforested in 2000–2001, and $F \times l \times (1 - l)^{29}$ is the area deforested in

[1] Received 11 April 2006; revision accepted 12 April 2006.
[2] Corresponding author; e-mail: wrightj@si.edu

2029–2030. This "business as usual" scenario and the total population growth projection of WML, respectively, predict similar 30-yr decreases of 33 and 48 percent in absolute deforestation rates and similar percentages of 26.5 and 35 percent of the original forest cover remaining in 2030 for Southeast Asia. These predictions contrast with the Millennium Ecosystem Assessment (2005, henceforth MEA). The MEA documents the loss of about 3 percent of the potential area of tropical and subtropical moist broadleaf forest in 40 yr from 1950 to 1990 and predicts the additional loss of nearly 20 percent in 60 yr from 1990 to 2050 (Fig. 4.4 in MEA). Thus, the MEA predicts a huge increase in absolute deforestation rates. In a similar vein, Dirzo & Raven (2003) conclude "It is therefore doubtful that more than 10 percent of the tropical forests will be protected, and probably more realistic to think of 5 percent surviving the next 50 years." These and many similar predictions, which differ radically from the "business as usual" scenario of BBKS, stimulated the analysis by WML.

EXTINCTION AND FOREST AREA LOSS

Species-area relationships are used to predict the number of species of habitat specialists that will become extinct when the global area of a habitat is reduced (Pimm & Askins 1995). The concept of an extinction debt applies when habitat area has been reduced, but the resulting extinctions have yet to occur because of short-term persistence of ultimately unviably small populations. No one knows how long it will take to settle the present day extinction debt. But, we do know that all extant tropical forest species survived past reductions in tropical forest cover associated with glacial cycles and the activities of prehistoric humans. Thus, WML reasoned that the length of time and the area affected during past changes in forest cover provide insights into the length of time it will take to settle the present day extinction debt induced by the reduction in the area of primary tropical forests. This window of time presents an opportunity for natural secondary succession to reestablish forest habitats and reduce modern extinctions.

BBKS respond that species "previously driven to small population sizes are already committed to extinction . . .because they are too small to be viable in the long term." We reiterate that all extant species survived much longer periods of habitat contraction in the past, and that this suggests that the resulting small populations are in fact viable. We argue that the small population paradigm is relevant only to species undergoing the most severe and historically unprecedented habitat contractions, such as Brazilian Atlantic forest endemics (Brooks *et al.* 2002). BBKS further dispute the relevance of historical forest contraction to current extinction risks, because present day forest contraction and expansion is more rapid, and because habitat fragmentation and environmental alteration are more severe. We believe that the rate of forest loss is irrelevant, because forest area is contracting, and thus habitat specialists need not disperse to the forests that will survive (they are already there). The higher rate of forest expansion through secondary regrowth can only be a plus: faster expansion should reduce the time species must endure small population size and enhance their survival probability. We agree that present day environmental conditions pose many challenges that might increase extinction rates above those predicted based on remaining habitat area alone. Nonetheless, we believe the large number, long duration, and severity of past changes in the tropical forest area, which all extant species survived, provide an important perspective on the capacity of tropical species to endure habitat reductions.

EXTINCTION, DEGRADATION, AND SECONDARY FORESTS

A crucial difference between BBKS and WML concerns the conservation value of degraded and secondary forests. The optimistic arguments of WML are based on counting the increasing area of secondary tropical forests as current or future habitat for tropical species—habitat that could rescue species unlikely to persist in the long term in the small remaining areas of old-growth forest alone. BBKS believe tropical secondary forests are depauperate, are dominated by generalist species, and can act as reproductive sinks that diminish the viability of remnant populations in nearby primary habitats.

Secondary and degraded tropical forests are crucially important to conservation because of the vast areas of land involved. There are approximately 11,000,000 km^2 of tropical forest today, of which 5,000,000 km^2 are degraded or secondary forests (International Tropical Timber Organization 2002, Wright 2005). Conservationists have only recently begun to evaluate these forests (Cannon *et al.* 1998, Lawton *et al.* 1998). Logged and unlogged forests support similar plant species diversity, and even tree species targeted by decades of selective logging maintain large populations, although not of timber-quality individuals (Cannon *et al.* 1998, ter Steege *et al.* 2002). Secondary forests quickly restore conditions favorable for functionally important arthropods and often support as many animal species as do nearby primary forests after just 40 yr of natural regrowth (Lawton *et al.* 1998, Dunn 2004, Quintero & Roslin 2005). Species composition often differs between primary and secondary forests, however, and the extent of such differences varies widely among higher taxa (Lawton *et al.* 1998, Chazdon 2003, Dunn 2004, Lugo & Helmer 2004). A landscape perspective also indicates that small forest fragments can enhance biodiversity in largely agricultural settings (Ricketts *et al.* 2001, Horner-Devine *et al.* 2003). There are many promising indications that secondary and degraded tropical forests might rescue threatened species even though the conservation value of these new tropical forests and landscapes has only just begun to be explored.

Finally, whatever their value in the short term, most secondary and degraded forests have the potential to attain a structure and species composition similar to primary forests in the long term, provided that they are sufficiently connected to sources of primary forest species and protected from further disturbance (Lamb *et al.* 2005). Current and future conservation efforts are crucial to determining the degree to which this potential will be realized, and thus to the long-term contribution that 5,000,000 km^2 of secondary and degraded tropical forests will make to the conservation of biodiversity.

CONCLUSIONS

The uncertain future of tropical forest species suggests that the widespread belief in an inevitable mass extinction might be premature. This conclusion is reinforced by recent evidence for the effectiveness of tropical protected areas. The IUCN lists 3026 protected areas that include 1,542,000 km^2 of tropical forests (S. J. Wright, C. Portillo, and A. Sanchez-Azofeifa, pers. obs.). Recent satellite image analyses indicate that these protected areas reduce deforestation and fire frequency (DeFries *et al.* 2005, Nepstad *et al.* 2006). The world's poorer countries have made a vast commitment of their scarce resources to conservation, and this commitment is already having a positive effect. As tropical agricultural experiments on marginal lands fail and are abandoned, these protected old growth forests will continue to serve as a source of colonists for secondary forest succession. Management to enhance the recovery of secondary forests will further enhance their biodiversity value (Lamb *et al.* 2005). In sum, we believe that the area covered by tropical forest will never fall to the exceedingly low levels that are often predicted, and that extinction will threaten a smaller proportion of tropical forest species than previously predicted.

Answers to two key questions raised by WML and by BBKS are urgently needed to validate this optimism. First, what proportion of tropical species is completely dependent on pristine, old growth forests? These are the species most vulnerable to extinction caused by habitat loss, and it will be an immense job to identify them (Lawton *et al.* 1998). Second, how will global atmospheric and climatic changes affect old growth and secondary tropical forests? Ongoing changes to temperature, rainfall, nutrient deposition, and atmospheric CO_2 concentrations and transmissivity to solar energy could yet undo tropical forests (Lewis *et al.* 2004, Wright 2005). Among a nearly infinite number of possible recommendations, we repeat here just one recommendation made by WML. Assist countries with large areas of extant forest, large projected human population growth rates, and limited protected area networks to establish and maintain new protected areas now. The Democratic Republic of the Congo is a prime example. Forest still covered 65 percent of its potential distribution in 2000, the human population is projected to increase by 312 percent by 2050, and just seven IUCN-listed reserves include forest today (another 15 reserves include savannah or shrubland). The window of opportunity to establish protected areas will soon close in the Democratic Republic of the Congo and similar countries.

LITERATURE CITED

Brook, B. W., C. J. A. Bradshaw, L. P. Koh, and N. S. Sodhi. 2006. Momentum drives the crash: Mass extinction in the tropics. Biotropica 38: 302–305.

Brooks, T. M., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, A. B. Rylands, W. R. Konstant, P. Flick, J. Pilgrim, S. Oldfield, G. Magin, and C. Hilton-Taylor. 2002. Habitat loss and extinction in the hotspots of biodiversity. Conserv. Biol. 16: 909–923.

Cannon, C. H., D. R. Peart, and M. Leighton. 1998. Tree species diversity in commercially logged Bornean rainforest. Science 281: 1366–1368.

Chazdon, R. L. 2003. Tropical forest recovery: Legacies of human impact and natural disturbances. Perspect. Plant Ecol. Evol. Syst. 6: 51–71.

DeFries, R., A. Hansen, A. C. Newton, and M. C. Hansen. 2005. Increasing isolation of protected areas in tropical forests over the past twenty years. Ecol. Appl. 15: 19–26.

Dirzo, R., and P. H. Raven. 2003. Global state of biodiversity and loss. Annu. Rev. Environ. Resour. 28: 137–167.

Dunn, R. R. 2004. Recovery of faunal communities during tropical forest regeneration. Conserv. Biol. 18: 302–309.

Green, R. E., S. J. Cornell, J. P. W. Scharlemann, and A. Balmford. 2005. Farming and the fate of wild nature. Science 307: 550–555.

Horner-Devine, C., G. C. Daily, P. R. Ehrlich, and C. L. Boggs. 2003. Countryside biogeography of tropical butterflies. Conserv. Biol. 17: 168–177.

International Tropical Timber Organization. 2002. ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. ITTO Policy Development Series No. 13.

Lamb, D., P. D. Erskine, and J. A. Parrotta. 2005. Restoration of degraded tropical forest landscapes. Science 310: 1628–1632.

Lawton, J. H., D. E. Bignell, B. Bolton, G. F. Bloemers, P. Eggleton, P. M. Hammond, M. Hodda, R. D. Holt, T. B. Larsenk, N. A. Mawdsley, N. E. Stork, D. S. Srivastava, and A. D. Watt. 1998. Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. Nature 391: 72–76.

Lewis, S. L., Y. Malhi, and O. L. Phillips. 2004. Fingerprinting the impacts of global change on tropical forests. Philos. Trans. R. Soc. Lond. B Biol. Sci. 359: 437–462.

Lugo, A. E., and E. Helmer. 2004. Emerging forests on abandoned land: Puerto Rico's new forests. For. Ecol. Manage. 190: 145–161.

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: Biodiversity synthesis. World Resources Institute, Washington, DC.

Nepstad, D., S. Schwartzman, B. Bamberger, M. Santilli, D. Ray, P. Schlesinger, P. Lefebvre, A. Alencar, E. Prinz, G. Fiske, and A. Rolla. 2006. Inhibition of Amazon deforestation and fire by parks and indigenous lands. Conserv. Biol. 20: 65–73.

Pacala, S., and R. Socolow. 2004. Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. Science 305: 968–972.

Pimm, S. L., and R. A. Askins. 1995. Forest losses predict bird extinctions in eastern North America. Proc. Natl. Acad. Sci. U.S.A. 92: 9343–9347.

Quintero, I., and T. Roslin. 2005. Rapid recovery of dung beetle communities following habitat fragmentation in central Amazonia. Ecology 86: 3303–3311.

Ricketts, T. H., G. C. Daily, P. R. Ehrlich, and J. P. Fay. 2001. Countryside biogeography of moths in native and human dominated habitats. Conserv. Biol. 15: 378–388.

ter Steege, H., I. Welch, and R. Zagt. 2002. Long-term effect of timber harvesting in the Bartica Triangle, Central Guyana. For. Ecol. Manage. 170: 127–144.

Wright, S. J. 2005. Tropical forests in a changing environment. Trends Ecol. Evol. 20: 553–560.

———, and H. C. Muller-Landau. 2006. The future of tropical forest species. Biotropica 38: 287–301.