Special Section: *New Insights into the Tropical Biodiversity Crisis*

Introduction

For conservation biologists, the contemporary loss of tropical biodiversity is among the greatest of all concerns. Regarded as the biologically richest ecosystems on the planet, old-growth tropical forests are disappearing at an alarming pace—roughly 30–60 football fields per minute (approximately 8–15 million ha/year) in recent decades (Achard et al. 2002; FAO 2007; Grainger 2008). During the past half-century, numerous tropical nations, including many in West Africa, Southeast Asia, South Asia, Central America, and Oceania, among others, have suffered striking declines in forest cover (FAO 2007). Even the world's greatest tropical forests, such as the Amazon and Congo Basin, are being rapidly altered (Laurance et al. 2001; Soares-Filho et al. 2006; Laporte et al. 2007).

Largely as a result of such alarming forest disruption, some argue that contemporary rates of species extinction are likely to be orders of magnitude higher than natural baseline levels (Pimm et al. 1995; Brooks et al. 1999; Pimm & Raven 2000; Brook et al. 2003). Others suggest that, if forest loss continues apace, we could witness catastrophic species losses this century. For example, on the basis of their assumption that just 5–10% of old-growth tropical forests will survive by 2050, Dirzo and Raven (2003) suggest that 50–75% of all tropical species—a shocking figure—could be committed to eventual extinction. Although other projections are less dire, the idea of a "tropical extinction crisis" is now well entrenched in the lexicon of conservation science (e.g., Wilson & Peter 1988; Laurance 1999; Sodhi et al. 2007).

Nevertheless, as highlighted by the papers in this special section, the on-the-ground realities are more complex and more nuanced than simple projections can convey. In fact, prevailing views about the magnitude of tropical species extinctions have recently been challenged (Wright & Muller-Landau 2006*a*, 2006*b*), generating a heated debate about the fate of tropical biodiversity (e.g., Brook et al. 2006; Barlow et al. 2007; Laurance 2007; Fearnside 2008; Bradshaw et al. 2009). In addition, the drivers of tropical deforestation have shifted in recent years (Rudel 2005), with potentially important implications for conservation strategies (Butler & Laurance 2008). Finally, potentially serious new threats to tropical biodiversity, such as climatic change, overhunting, and emerging pathogens, are growing in importance (Laurance & Peres 2006). By exploring such issues in detail, we hope to provide here a fuller and more accurate perspective on the causes of biodiversity loss in the tropics.

Background to a Controversy

Much of what is highlighted in this special section has arisen during an ongoing dispute about the fate of tropical biodiversity. This debate has taken place in scientific journals and several events, including a symposium in Morelia, Mexico (June 2007), a workshop and symposium in Panama (August 2008), and a public debate in Washington, D.C. (January 2009), the latter of which received widespread media coverage.

The debate was instigated by a controversial analysis by Wright and Muller-Landau (2006*a*) that challenged the view that ongoing losses of tropical forest cover and species will be alarmingly high, at least over the next several decades. At the outset, these authors demonstrated a strong relationship between rural population size and forest cover and between total population size (rural plus urban) and forest cover in tropical nations (Fig. 1). In short, they showed that more people means less forest. They argue that slowing population growth rates and strong urbanization trends in many developing countries (Fig. 2) will promote rural depopulation and thus reduce pressures on forests and allow forest regeneration in some areas. Extrapolating into the future on the basis of UN population projections, they argued that less forest cover will be lost than some have suggested—although they readily concede that much old-growth forest will be converted to secondary, logged, and fragmented habitats.

In addition to challenging the idea that tropical forest cover will rapidly disappear, Wright and Muller-Landau (2006*a*) explicitly assumed that old-growth, secondary, and otherwise modified forests all have similar value for biodiversity conservation. Many conservation analyses implicitly assume that tropical secondary forests have near-zero value for biodiversity conservation (e.g., Stotz et al. 1996; Myers et al. 2000), and Wright and Muller-Landau (2006*a*) sought to draw attention to this key issue. They also assert that many tropical regions have passed through "extinction filters" as a result of past environmental insults (cf. Balmford 1996), including severe Pleistocene forest contractions in Africa and past waves of deforestation by indigenous people. In sum, they argue that future losses of natural forest cover are unlikely

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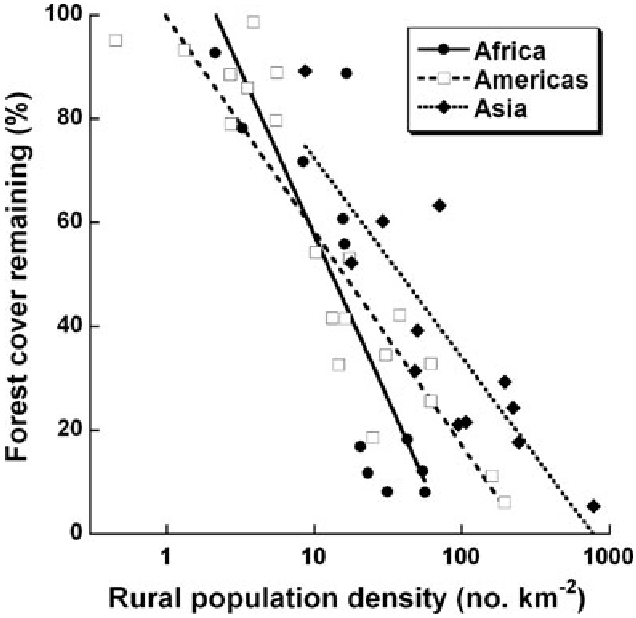

Figure 1. Relationship between rural population density and remaining forest cover in 45 tropical nations (adapted from Wright & Muller-Landau 2006a). In addition to old-growth forest, "forest cover" includes logged, fragmented, and secondary forests as well as native and exotic tree plantations.

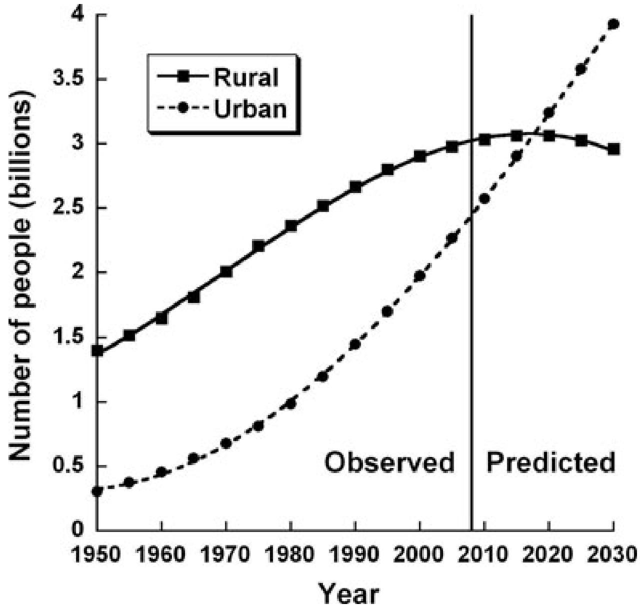

Figure 2. Observed and projected changes in rural and urban populations for developing nations on the basis of the median scenario of the U.N. Population Division (U.N. 2004).

to be as severe as feared and that tropical biota are likely to be more resilient to the widespread replacement of old-growth forests by secondary forests and other human-altered habitats than many believe.

As can be imagined, Wright and Muller-Landau's (2006a) analysis has not gone unchallenged (Laurance 2007; Bradshaw et al. 2009). At least two dozen papers have recently appeared (and more will appear soon) that revolve around this debate. Key points of contention include (1) the extent to which old-growth species can persist in degraded or secondary habitats; (2) the effects of changing human-population densities on forest cover; (3) the growing effects of economic globalization, industrial drivers, and agribusiness on forests; (4) the potentially serious effects of emerging threats—such as climatic change, overharvesting, exotic pathogens and invaders, and environmental synergisms—on tropical biodiversity; and (5) the fact that habitat loss can cause severe declines of geographic, demographic, and genetic variation even where it does not lead to the complete extinction of a species.

Overview of Contributions

As highlighted by the seven articles in this special section, this debate is yielding important insights into the prevailing threats to tropical biodiversity. To set the stage, Greg Asner and colleagues provide an invaluable, cutting-edge assessment of recent changes in primary, secondary, and selectively logged forests across the world's tropical regions. They find that recent deforestation has been partially offset by natural secondary forest succession, but that vast areas are actively being logged or have been consigned to logging concessions. Thomas Rudel and colleagues then provide a major meta-analysis of the drivers of forest loss. Small farmers and population growth are the main drivers of forest loss in Central America, Africa, and South Asia, and small farmers remain an important driver in Amazonia and Southeast Asia. Recently, however, agribusiness and international markets have become important drivers of forest loss in Amazonia and Southeast Asia. As discussed by Rudel et al., this change creates both perils and opportunities for forest conservation and suggests that the fundamental relationship between population size and tropical forest cover described by Wright and Muller-Landau (Fig. 1) could progressively weaken in some regions. This is important, if true, because it suggests that even nations with relatively sparse populations could still lose much of their forest.

In the third paper, Robin Chazdon and colleagues critically evaluate the degree to which tropical forest species can persist in regenerating forests. They conclude that some secondary forests, particularly those that are older (>20 years) and near old-growth forest that are a source of plant propagules and animal seed dispersers, can support surprisingly high biodiversity. Other secondary forests, however, are far poorer in old-growth and forest-interior species, which are likely to be the most imperiled by large-scale habitat disruption. Fortunately, Asner et al. show that tropical secondary forests are often in hilly terrain close to old-growth forests.

In the fourth paper, S. Joseph Wright and colleagues argue that global warming is likely to pose a far greater threat to tropical species than is commonly realized. Tropical species are likely to be particularly sensitive to global warming because they are adapted to limited geographic and seasonal variation in temperature, and, prior to the onset of global warming, already lived at or near the highest temperatures on Earth. As the Earth warms further, many biota, such as those in large areas of the Amazon and Congo basins and on isolated tropical mountains, will be thousands of kilometers from potential cool refuges.

In the following article, William Laurance and Diana Useche highlight the potentially key role of environmental synergisms as drivers of tropical species loss. As examples, they describe five potentially critical synergisms in the tropics and then use data on threatened and vulnerable mammal, bird, and amphibian species from the IUCN Red Data Book to assess the potential impacts of various synergisms on declining species.

The penultimate paper, by Nigel Stork and colleagues, provides a broad overview of factors that influence species vulnerability. They evaluated the ecological and life-history traits of species that increased their susceptibility to extinction over geological time scales and the traits that predispose animal and plants to specific threats, such as deforestation, fire, climate change, pathogens, and hunting. Like Laurance and Useche, they too consider environmental synergisms to be a potentially critical driver of species declines, and they ultimately decry the relative paucity of data on species distributions and the factors that predispose them to extinction.

In the final contribution, Thomas Brooks and colleagues review a wide variety of conservation actions in the tropics and critically evaluate their efficacy. Such actions include landscape-scale initiatives such as the establishment of nature reserves and efforts to promote sustainable timber harvests; environmental education and training; and efforts focused on protecting individual species, such as captive breeding and other intensive interventions. For birds, the best-studied taxon, they conclude that such actions have prevented around one-fifth of the extinctions that would otherwise have occurred in the past century. Thus, conservation efforts are having a positive effect, but few would conclude that these benefits are adequate.

It is important to emphasize that the authors of these seven papers—not to mention the two guest editors—often had sharply differing views on the gravity of the tropical extinction crisis, as well as widely varying fields of expertise. The resulting manuscripts have been honed by disagreement and compromise, but in the end we are confident that they provide a fuller and richer perspective on the contemporary threats to tropical biodiversity.

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