

Conserving Southeast Asia's imperiled biodiversity: scientific, management, and policy challenges

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Abstract Southeast Asia was almost entirely covered by rainforest 8,000 years ago. Today, this region is experiencing the highest relative rates of deforestation and forest degradation in the humid tropics. Every year, millions of hectares of tropical forests are destroyed and degraded. Given the rapid rate of deforestation and the high concentration of endemic species in the region, Southeast Asia could lose 13–42% of local populations by the turn of the next century, at least 50% of which could represent global species extinction. In this Special Issue, we discuss the uniqueness of Southeast Asian biodiversity, drivers of forest destruction, threats to the region's unique ecosystems and taxa, and key conservation challenges to provide a broad-based review of the science, management and policy issues concerning biodiversity conservation. Overall, we highlight the need for an interdisciplinary and multi-pronged strategy requiring all major stakeholders to work together to achieve the ultimate goal of reconciling biodiversity conservation and human well-being in the region.

Keywords Conservation · Extinction · Deforestation · Climate change · Wildlife trade · Livelihoods

Southeast Asia—comprising Brunei, Myanmar, Cambodia, East Timor, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand and Vietnam—arguably harbors the most threatened and endemic species in the world (Sodhi et al. 2004, 2010a). Its biotas are threatened because of unprecedented habitat loss—annually millions of hectares of tropical forests are destroyed and degraded (Hansen et al. 2008). The threat to Southeast Asia's biodiversity is exacerbated by other drivers such as climate change, invasive species, pollution and overharvesting (Sodhi and Brook 2006). Given the rapid rate of deforestation

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and the high concentration of endemic species in the region, Southeast Asia could lose 13–42% of local populations by the turn of the next century, at least 50% of which could represent global species extinction (Brook et al. 2003). Southeast Asia is also facing widespread and imminent threats from industrial-scale agricultural expansion for crops, such as oil palm for food and biofuel (Koh and Wilcove 2007, 2008, 2009; Koh and Ghazoul 2008; Wilcove and Koh 2010). Conservation initiatives in the region continue to be impeded by socio-economic challenges, including poverty, corruption and human population growth (Sodhi and Brook 2006; Koh et al. 2009; Sodhi et al. 2008, 2010a). There is, therefore, an urgent need for a broad-scale analysis of both biological and socio-economic issues pertaining to conservation in the region.

Given these exigent circumstances, we present this Special Issue to highlight the plight of Southeast Asia's biodiversity and to offer some solutions. Specifically, we highlight a broad range of threats such as deforestation, biomass fires and climate change that confront biodiversity in the region. We also discuss the Southeast Asia's biogeographic uniqueness, and the dire need for more ecological research. Since tangible conservation can only be achieved with the support of local communities, we also highlight the importance of valuing natural capital (i.e. ecosystem services) in land-use decision making. This Special Issue is partly based on papers presented in a symposium held at the 2009 Annual Meeting of the Society for Conservation Biology in Beijing (China). Below we briefly introduce the papers presented in this Special Issue.

To achieve long term success in protecting the forests and biodiversity of Southeast Asia, we must first understand the historical biogeography of this region. Much of Southeast Asia experienced extensive fluctuations in sea levels and climate regimes over the past few million years. These environmental upheavals were largely responsible for Southeast Asia's biogeographic uniqueness. Woodruff (2010) argues that contemporary forests in the region are in fact its refugia, and not those of the Last Glacial Maximum. He explains how the biogeographic history of the region could affect responses of species to land-use and global climate change in the coming decades, which in turn could have immense implications for practicing conservation in the region. Furthermore, Woodruff argues that as land-use and climate change drive more people to become environmental refugees, human biogeography and movement will likely gain prominence in conservation planning.

Southeast Asia overlaps with four "biodiversity hotspots", which are geographic regions of the world that both contain high concentrations of endemic species (not found elsewhere) and are experiencing rapid deforestation and forest degradation (Myers et al. 2000). Southeast Asia is also a region where new fascinating species are still being discovered (e.g. lungless frog, *Barbourula kalimantanensis*, Bickford et al. 2008). The rapid rate at which forests are being converted to other land uses (e.g. agriculture) further suggests that many undiscovered species might have gone extinct or will go extinct in the future without being scientifically recorded. Giam et al. (2010) attempts a "first look" at the magnitude of Southeast Asia's undiscovered species. Based on species-area relationships, they estimate the number of undiscovered species across eight taxonomic groups—mosses, legumes, freshwater fish, amphibians, mosquitoes, hawkmoths, birds and mammals—and conclude that legumes have the greatest extent of undiscovered species, and therefore, deserve the greatest focus in future taxonomic and ecological research.

This will be a considerable challenge, owing to the rapid rate of deforestation and lack of conservation resources in Southeast Asia. Indeed, Webb et al. (2010) argue that traditional methods of collecting and describing species can no longer keep pace with the rate at which populations and species are going extinct. This problem is further exacerbated by the

lengthy and often excruciating process of describing and revising species' taxonomy. To overcome these challenges, Webb et al. (2010) propose that the abundant resource pool of biology students can be enthused and co-opted to perform taxonomic research; that biodiversity informatic tools can be more efficiently utilized to engage both specialists and parataxonomists; and that molecular methods and other emerging technologies can help facilitate taxonomic studies.

In addition to taxonomic research, Southeast Asia is urgently in need of studies that address the drivers of biodiversity loss, which can act both independently and in synergy (Brook et al. 2008). Land-use change is arguably the biggest challenge facing biodiversity in Southeast Asia. Wilcove and Koh (2010) argue that oil palm agriculture, in particular, is the region's greatest immediate threat. They provide an in-depth analysis of why oil palm continues to expand across the region despite the efforts of conservationists and non-governmental organizations. Based on their analysis, Wilcove and Koh (2010) propose a matrix of "pressure points" that can be applied to the oil palm industry to mitigate its impacts on biodiversity. These solutions include regulations, financial incentives and disincentives, and the promotion of alternative environmentally-friendly uses of forested land. Another form of large-scale land-use change in Southeast Asia is biomass fires. Taylor (2010) shows that fire has increasingly affected forests in Indonesia over the last few decades, leading to severe consequences for the native biodiversity. He further argues that global warming coupled with land-use changes could lead to more frequent fires, which in turn could result in positive feedbacks with climate change.

Poaching and illegal wildlife trade also remain formidable threats to Southeast Asian biodiversity. Nijman (2010) reports that during the period 1998–2007, more than 30 million wild-caught animals were smuggled out of Southeast Asian nations, of which butterflies were the most commonly traded taxonomic group. Most of this wildlife originated from Malaysia, Vietnam, Indonesia and China; and most of them were exported to the European Union and Japan. Thus, there remains much room for improvement in terms of regulation and enforcement to curb future increases in wildlife trade. For some species in Southeast Asia, time might be running out. Clements et al. (2010) show that populations of the Sumatran rhino (*Dicerorhinus sumatrensis*), the Asian elephant (*Elephas maximus*), and the Malayan tiger (*Panthera tigris jacksoni*) are experiencing precipitous declines. The authors argue that in addition to the traditional approaches of protecting forests and monitoring of animal populations, innovative approaches such as the creation of inter-agency anti-poaching units might be required to prevent further losses.

In addition to the threats discussed above, there are several other less understood environmental challenges. Todd et al. (2010) review the impacts of pollution on marine life in Southeast Asia. This is an important area of research given that over two-thirds of Southeast Asia's human population lives in coastal areas. Peh (2010) compiles empirical evidence on the effects of invasive species in Southeast Asia, and reports that the proliferation of alien species has resulted in severe impacts including displacement of native biota, modification of ecosystems, hybridization, environmental disturbance, and economic losses. Bickford et al. (2010) discuss the impacts of climate change on Southeast Asia's herpetofauna. They estimate that in less than 50 years, amphibians and reptiles in the region will have reached or exceeded most tipping-point in their abilities to adapt to rising temperatures, which will have severe and irreversible effects.

While it is important to understand the threats facing Southeast Asia's biodiversity, it is also crucial to develop science-based approaches for mitigating the detrimental impacts of these threats. Berry et al. (2010) investigate the potential of logged forests for biodiversity conservation, and found that in most of the studies they reviewed, more than 90% of

species recorded in primary forests were also present in logged forests. They conclude that allowing logged forests to regenerate into old-growth forests could be a viable conservation strategy. Kettle (2010) reviews the ecological and financial constraints to restoration of lowland dipterocarp forests in Southeast Asia, and highlights the gaps in our knowledge in this area of research. Laumonier et al. (2010) discuss the use of the eco-floristic sector framework for identifying new conservation area networks for ecosystem-based land use planning. They propose how such an approach could facilitate the protection of a wide range of ecosystem diversity in Sumatra, Indonesia. Linkie et al. (2010) also argue that the prioritization and targeting of conservation efforts and resources to appropriate localities is a key to ensuring conservation success. They produce a model of deforestation risk, and use it to predict where remaining forests in the Kerinci Seblat National Forest in Indonesia would be at highest risk of being cleared. Such approaches are useful decision making aids for deforestation mitigation and land-use planning.

No conservation strategy can be successful without the cooperation and involvement of local communities. Antons (2010) discusses the importance of traditional knowledge and the role of rural communities in safeguarding biodiversity. He also highlights some of the difficulties in implementing community-based models of environmental governance in Southeast Asia. Rist et al. (2010) assess the livelihood impacts of oil palm development in Southeast Asia, and make specific recommendations to mitigate the costs while enhancing the benefits of oil palm expansion to rural communities. Sodhi et al. (2010b) report strong evidence that local communities living near protected areas do value a wide range of environmental services provided by forests, including cultural, provisioning, and regulating services. These studies suggest that local stakeholders need to partake in conservation planning for conservation endeavors to be successful.

We hope that this issue will stimulate further interest and, more importantly, research on Southeast Asia's biodiversity. The recommendations presented (e.g. better wildlife laws and conservation incentives) should form the basis for broad-based, interdisciplinary and multi-pronged approaches to conserve the biodiversity of this region. Tangible conservation in Southeast Asia will require the involvement and support of the biologists, governmental and nongovernmental organizations, policy makers, social scientists, and above all, the civil society.

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