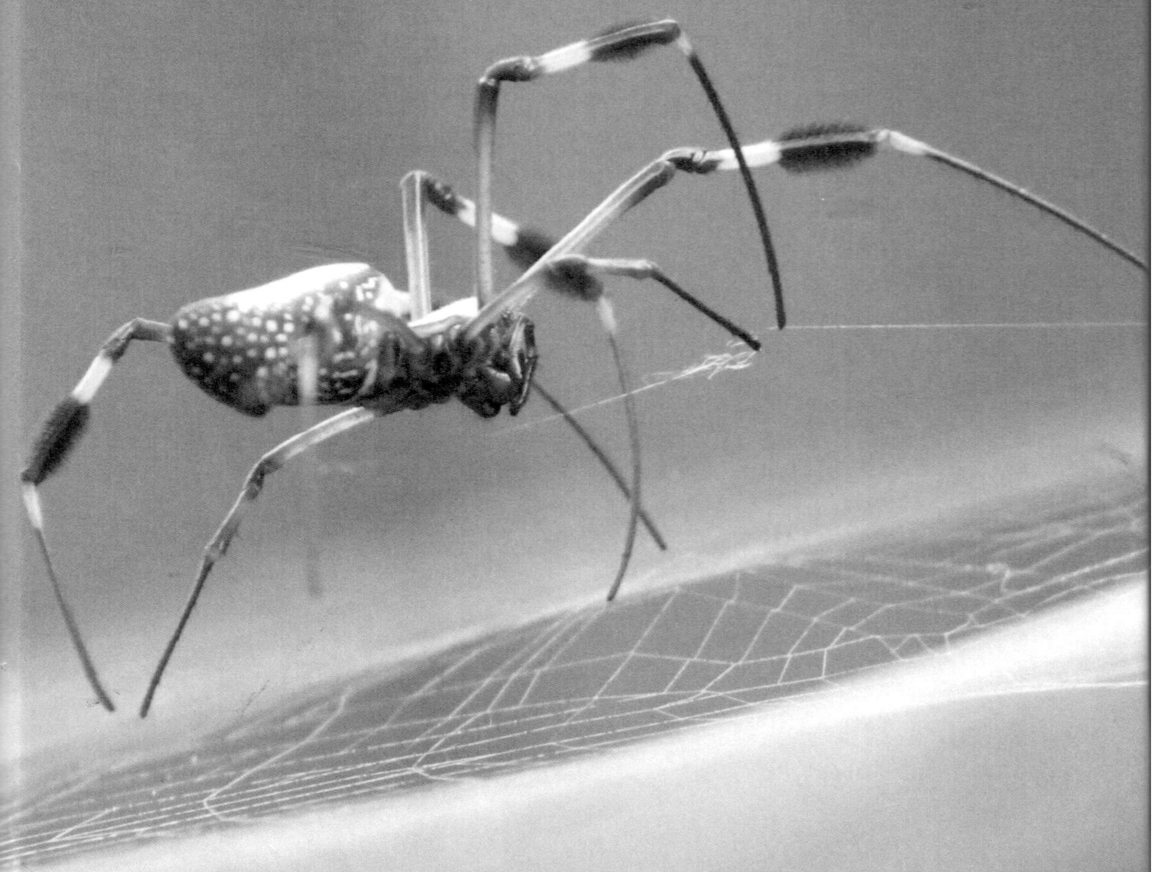
THE PARADIGM OF FORESTS

and the survival of the fittest



Editors

Sergio A. Molina-Murillo
Carlos Rojas

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Editors

Sergio A. Molina-Murillo
Associate Professor/Researcher
Department of Environmental Sciences
National University of Costa Rica (UNA);
Forest Resources Unit
University of Costa Rica (UCR)
Costa Rica

Carlos Rojas
Coordinator and Researcher/Professor
Forest Resources Unit/Dpt. of Agricultural Engineering
University of Costa Rica (UCR)
San Pedro de Montes de Oca
Costa Rica

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CHAPTER 7

Challenges of Forest Conservation

J. Edgardo Arévalo[1,2,*] and *Richard J. Ladle*[3]

ABSTRACT

Forest conservation is entering a critical and challenging period due to a shifting mosaic of threats, policies, and actors. In this chapter we: (i) provide a brief summary of the history of forest conservation; (ii) identify the main threats to the preservation and biological integrity of the World's forests; and (iii) outline the key strategies that have been developed to address these challenges. We specifically highlight the development of macroeconomic mechanisms for forest conservation, many of which are a consequence of the recent alignment of forest conservation with the international agenda of climate change. Such approaches include market-based mechanisms such as the certification of forest products, payments for ecosystem services, carbon credits, clean development mechanisms, and REDD (Reduced Emissions from Deforestation and Degradation). Another promising financial tool for forest conservation is debt for nature swaps, which have enormous potential in much of the developing world. We conclude by identifying the key challenges for the conservation of forests in the 21st century, the most important of which will be to halt the continuing loss of habitat from the biodiverse tropical forests of the developing world.

[1] Center for Sustainable Development Studies, The School for Field Studies, Apdo.Post. 150-4013, Atenas, Alajuela, Costa Rica.

[2] Escuela de Biología, Universidad de Costa Rica, San Pedro, Costa Rica, ZC-2090 E-mail: jose.arevalohernandez@ucr.ac.cr

[3] Institute of Biological and Health Sciences, Federal University of Alagoas, PraçaAfrânio, Jorge, s/n, Prado, Maceió, AL, Brazil. CEP: 57010-020. E-mail: richard.ladle@ouce.ox.ac.uk

* Corresponding author: earevalo@fieldstudies.org

Introduction

Forests are one of the most conspicuous ecosystems on the planet and have immense economic, cultural, and conservation importance. For example, they are home to numerous indigenous peoples, they protect watersheds, they store the largest stocks of carbon, they act as a source of invaluable food and firewood for the rural and low-income human populations, and they are home to vast amounts of biodiversity including some of the rarest species on the planet. Given the multiplicity of functions and roles, it is unsurprising that challenges of contemporary forest conservation are correspondingly numerous, complex, and dynamic.

In this chapter we: (i) provide a brief summary of the history of forest conservation; (ii) identify the main threats to the preservation and biological integrity of the World's forests; and (iii) outline the key strategies that have been developed to address these challenges.

History of Forest Conservation

Forests have always been at the forefront of nature conservation. One of the oldest protected areas in the world is the Main Ridge Reserve in Tobago, officially created on 13 April 1776 with the goal to protect the watershed that the colonial sugarcane plantations relied upon (Ramdial 1980). This is a remarkably early example of the use of protected areas for the creation of what is now known as ecosystem services (*sensu* Costanza et al. 1998) and illustrates that early conservationists already recognized many of the greatest challenges in forest conservation. Indeed, one of the main drivers of early conservation sentiment in the United States in the mid-19th century was the rapid demise of the once vast forests in the American great lakes region (Jepson and Ladle 2010). While widespread deforestation was invigorating a strong conservation sentiment in the US, elsewhere in the world efforts were directed to the rational and planned utilization of nature. The major proponents of these values, forerunners of the economic rationalism inherent in the ecosystem services concept, were the influential community of scientists supporting the vital forestry and agricultural sectors of the colonial endeavor—particularly Dutch scientists in Indonesia and British scientists in the Caribbean (Jepson and Whittaker 2002).

Another important historical element in the patchwork of values that infuse modern forest conservation is the idea that forests are intrinsic elements of the natural landscape with distinct cultural significance. This perspective was particularly developed by German foresters in the late 19th and early 20th centuries who became increasingly concerned that clear-felling policies were destroying magnificent specimen trees and despoiling areas of forests with special scientific and aesthetic value (Jepson and Whittaker 2002). Their response was to promote rational resource planning through the careful assessment and protection of culturally important attributes of nature. This, in turn, has led to the production of detailed forest and vegetation maps, the first versions of which were published in the first decades of the 20th century and which quickly became a standard tool for forest conservation and management.

By the early years of the 20th Century, it was almost universally accepted that the world's forests should be protected and managed, to maintain their valuable resources (mainly timber), sustain their important biophysical role in the water cycle, and because they are important elements of landscapes with unique cultural and aesthetic values. During the 20th century, these largely western-centered cultural values were considerably reinforced by the knowledge that vast stores of terrestrial biodiversity reside within tropical forests (mainly found in developing countries), and that these same forests were being destroyed at unprecedented rates leading to inflated levels of species extinctions. This knowledge soon became an essential element of modern conservation advocacy, propelled into the public sphere through high profile media campaigns by conservation NGOs and through popular science books. Possibly the most important example of the latter was the publication in 1979 of *The Sinking Ark: A new look at the problem of disappearing species* by the Oxford-based forester and conservation polemicist Norman Myers. It was in this book that Myers claimed (with very little scientific evidence) that as many as 40,000 species were going extinct every year due to tropical deforestation (Myers 1979).

The most recent chapter in the history of forest conservation has been the increasing realization that forests may have a pivotal role in mitigating the impacts of anthropogenic climate change. This has led to unprecedented levels of research and scientific cooperation to uncover the complex bi-directional interactions between the world's major forests and the regional climate. The recent alignment of forest conservation with the climate change agenda provides both potential opportunities and costs. With respect to the former, conservation of the world's forests has never had a higher profile, providing abundant opportunities for policy makers and practitioners to tap into diverse funding sources. The potential risks involved with such alignment are less obvious, but are nevertheless real. Foremost of these is the prioritizing of carbon benefits over biodiversity, potentially leading to further extinctions and the loss of biologically unique ecosystems. More generally, the explicit use of carbon benefits to target the protection of highly threatened ecosystems is yet to be fully developed.

Why Conserve Forests?

Forest conservation clearly has a long history and has been motivated by a wide variety of societal values. Initially, forests were protected to prevent indiscriminate exploitation of key natural resources such as timber or, less frequently, to maintain their role in the regional water cycle. Forests can also have important cultural significance and may be key constituents of the landscape, justifying the forest conservation because of their intrinsic qualities. More recently, the importance of forests as shrinking reservoirs for biodiversity and their potential role in mitigating climate change has made them a major target for contemporary conservation.

Global concerns about the alarming estimated rate of species loss in tropical forests was one of the key drivers of the landmark Convention on Biodiversity, signed at the Earth Summit in Rio de Janeiro in 1992. The Convention takes a clear utilitarian approach to conservation and developed a framework to ensure the protection of biodiversity. This approach has a clear focus on the sustainable use of natural resources and benefit-sharing from commercialization of genetic resources, and responds to the concerns of developing nations about the exploitation of genetic resources by western-based private institutions (Vale et al. 2008). There have been various knock-on effects of this perspective, perhaps the most critical of which is side-lining of older conservation values based on the intrinsic and cultural values of biodiversity (Ladle et al. 2011).

The last 30 years have also seen an increasing focus on the welfare and rights of indigenous forest communities and, to a lesser extent, of other communities and social groups that have historically exploited forest resources. Once again, of particular importance in tropical regions is that indigenous groups are becoming increasingly crucial actors in forest conservation policy and management. Most recently, the complex interactions between forests and global and regional climates (Bonan 2008) and the potentially devastating effects of climate change on forest structure (Nepstad et al. 2008) and biodiversity (Thomas et al. 2004) have reinvigorated debates about the most effective strategies for forest conservation.

In summary, conservation is moving towards a new era where the global focus is shifting from biodiversity towards the protection and management of ecosystem services such as the ability of forests to influence regional climatic conditions or their role as carbon sources or sinks. This policy shift is taking place during a uniquely dynamic period for many forests, driven by wide-scale changes in ecological assemblages and structure, weakening the resilience of these ecosystems to further environmental changes and, in the worst scenarios, pushing them towards ecological tipping points. One consequence of this shifting mosaic of threats, policies, and actors is that the conservation, management, and governance of forests has never been so complicated, or so challenging.

Deforestation: The Ongoing Threat

Despite historical and current efforts to preserve forests around the world, the challenges of effectively achieving forest protection goals are still numerous and complex. Although forest loss can also be attributed to natural disasters (e.g., fires), most of the enormous devastation of the Earth's forests over the last two centuries can be attributed to human activities. Since the rise of human civilizations, forests have been cleared to make room for growing crops, raising livestock, or to provide materials for building. Forest conversion to agricultural land began some nine to seven thousand years ago and has accelerated ever since but especially so during the last century. The continually increasing rate of forest loss is a consequence of both human population exponential growth and continually improving technology for forest conversion into other land uses. This process was responsible for the progressive depletion of the forests of the Middle East, the Mediterranean, Europe and, finally, the New World. Recent research indicates that about half of the original forest that once covered the terrestrial surface of Earth has been removed and that the war of attrition against forests continues at an unabated pace (Laurance 2010).

Forests can be either totally or partially removed to make room for other types of land use. While a clear-cut forest removal leaves little room for interpretation about the extent of loss, the degree of degradation caused by partially cleared areas (e.g., selective logging) varies greatly. One definition of forest degradation is the reduction of the capacity of a forest to provide goods and services (Lund 2009), stressing the utilitarian values of forests. However, other definitions incorporate parameters that include other values such as biological diversity, species composition, forest structure and function, soil composition, and carbon stocks (Simula 2009). Regardless of the degree of alteration of the species assemblage and biophysical structure of the original forest—from clearance to selective logging—human induced changes in forests are a leading cause of terrestrial biodiversity loss around the world (Whitmore and Sayer 1992; Brook et al. 2003; Riddle et al. 2011).

After enormous amounts of deforestation over the last three centuries or so, only about 39 million km² of forest remain at the 10 percent tree cover threshold (Schmitt et al. 2009). Despite the popular view that forest ecosystems are still disappearing, the extent of this loss and its associated consequences are still hotly debated (Laurance 2007). Such debates are partly driven by the difficulties of making accurate estimates of forest cover and degradation over large spatial scales. Indeed, accurate estimates of forest loss are difficult to obtain for a number of reasons: first, insufficient resources may limit many developing countries to produce reliable information about the status of their forests. Second, countries use different classification and assessment methods to survey forest cover and loss making comparisons and global statistics are difficult to obtain. The FAO (2010) reported an underestimation of 30,000 km² of forest loss between 1990 and 2000 after revising the figures using more precise information from cooperating countries. Moreover, differences in the parameters used to define "forest" can lead to significant discrepancies of forest loss estimates.

The calculation of net forest loss in different regions has also been problematic. Net forest loss is the balance between how much forest is lost (through deforestation) and how much forest is gained (through natural regeneration and reforestation) in a given period of time. Recent analyses have shown that while temperate forests in Europe and Asia have gained forest cover, other forests, such as tropical forests in South America and Africa, have experienced a comparatively large net loss (Fig. 1). The good

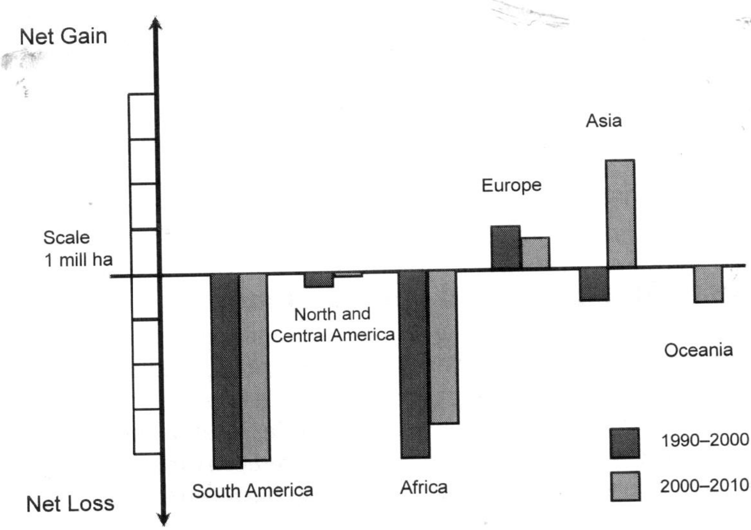

Fig. 1. Net forest loss and net forest gain in different regions of the world. Tropical forests of South America and Africa are greatly affected by deforestation whereas Europe and Asia are gaining forest through afforestation, defined as the conversion from other land uses into forests (based on FAO 2010).

news is that deforestation worldwide has dropped from 83,000 km^2 a year in the 1990s to 52,000 km^2 a year (an area roughly the size of Costa Rica) in the past decade.[1] However, such a coarse scale for global comparisons undoubtedly masks smaller scale variations of disproportionately high rates of forest destruction in areas such as Southeast Asia, Mesoamerica, and the Andes (Sodhi et al. 2004).

Tropical forests have been at the center of attention in terms of global conservation over the last 40 years. Such a focus is understandable, given that these forests maintain exceptionally high levels of biodiversity and, since recent decades, are being destroyed at a rapid rate. According to the Millennium Ecosystem Assessment report, about 9 million km^2 of tropical forests remain along the equator between the tropics of Cancer and Capricorn (N23.4° and S23.4°) (Duraiappah et al. 2005). Despite this convenient latitudinal delimitation, further complications arise when researchers try to reach a consistent and precise definition of "tropical forest". This is because there are numerous intermediate forms, along structural and biological continua, between sub-tropical and other woodland systems. Even when using the same forest definitions and similar methods, other studies assessing deforestation rates have yielded very different results. This suggests that factors such as variations in recording forest loss due to fires or different percentages of surveyed land can influence the final results of such surveys (see Lewis 2006).

Finer resolutions and precise estimates of net forest loss may help some tropical countries to tackle the conservation issue and to develop more effective strategies to prevent future biodiversity loss. Most importantly, the identification of areas in which at least 70% of their original vegetation has been lost is instrumental for the designation of high priority areas for biodiversity conservation. For example, this threshold is one component of the influential hotspots of the global conservation prioritization system (Myers et al. 2000).

Drivers of Forest Loss and Degradation

The factors driving forest loss are complex, interacting and operating across a variety of geographic and socio-political scales (Ladle et al. 2010). They include both ultimate factors such as subsidies, legislation, and international demand for forest and agricultural products, and proximate factors such as logging and the expansion of the agricultural frontier (Fig. 2).

[1] www.iucn.org/about/work/programmes/forest/iyf/facts_and_figure

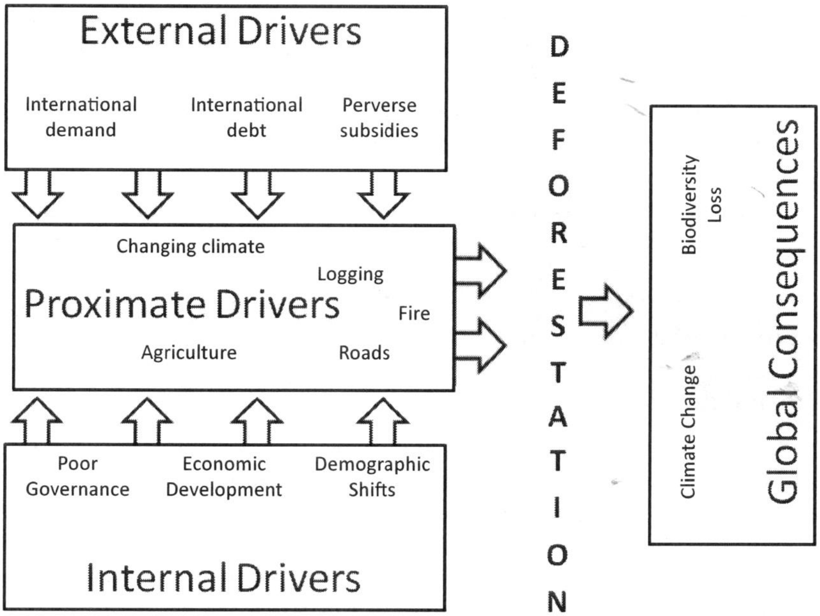

Fig. 2. Schematic representation of some of the major drivers of deforestation and their global consequences (based on Ladle et al. 2011).

Ultimate Factors

Temporal and spatial patterns of forest loss have historically varied greatly from region to region and more recently, from country to country. For example, human expansion in temperate regions such as the Mediterranean, Europe, and North America is thought to be one of the main reasons for large historical losses of different types of temperate forests (Kaplan et al. 2009). The underlying rationale is that population growth over a long period of time is associated to an ever increasing demand for food that, inevitably, leads to clearing of forests for agriculture. Another example, though at a much smaller scale, is the apparent relationship between increasing land clearing and population growth of the Mayan civilization in Northern Central America. The increasing population in the Copan area (650–900 AD) correlated with consumption of wood for fuel and construction as well as with land area for cultivation resulting in an increase in deforestation (Abrams and Rue 1988). Interestingly, recent research suggests that deforestation may have caused alterations in the regional climate contributing to frequent and severe droughts, which played a role in the eventual demise of the Mayan civilization (Oglesby et al. 2010).

Current estimates suggest that human population density is, or will become, a serious issue for some of the world's most biodiverse areas, including the remaining tropical lowland forests. Cincotta et al. (2000) estimated that in 1995 more than 1.1 billion people were living within the 25 biodiversity hotspots (Myers et al. 2000). Moreover, population growth rate within hotspots was estimated to be substantially higher than the global average, and even above that of developing countries. There is also good evidence that these increased human populations will have significant negative effects on biodiversity. For example, a study by McKee et al. (2003) found that human population density was strongly correlated with the number of threatened mammal and bird species across 114 continental nations, especially in those with large areas of tropical forests with high biological diversity.

Although the size of the human population may correlate with forest loss in many developing countries, population size per se is not the only ultimate factor driving environmental problems. Political organization, per capita income, insecure ownership, political turmoil, military unrest, international prices of goods and energy sources, and external debts are some of the interacting factors that can influence the rates of forest loss (Deacon 1994).

The distribution of human populations is also an important factor determining the degree of anthropogenic pressure on forests. Demographic shifts into forested regions are often heavily influenced by political policies, with a knock on effect for deforestation. For example, during the 1960s and 1970s many governments of developing countries implemented smallholder colonization policies under the U.S. program Alliance for Progress. These policies incentivized the colonization of pristine forested land by facilitating access through road infrastructure thereby preventing a costly agrarian distribution of the already owned land (Rudel et al. 2009). However, this process decreased in the 1990s when many governments began to preferentially incentivize highly capitalized enterprises to establish large cattle ranches and cultivate vast extensions of soybean and oil palm (Rudel et al. 2009).

Even if conservation policy is progressive and strictly implemented, the long-term success of forest conservation measures ultimately depends on public support. However, tapping into this support requires that the conservation message be carefully aligned with the target audience, whose expectations and values may differ between regions, countries, and to an extent, social groups. This is clearly illustrated in a recent study of media representations of Amazonian deforestation in the Brazilian and British print media (Ladle et al. 2010). In the U.K., the media highlighted the role of globalization in creating a demand for Brazilian agricultural products as the main proximate causes of Amazonian forest clearance. In contrast, the Brazilian news media generally showed far less interest in the external drivers of Amazonian deforestation and was much more tightly focused on internal drivers such as economic development and the effectiveness of national or local environmental policies.

It is unclear whether this pattern of representation is repeated in other developing and developed nations. Nevertheless, there has certainly been a strong tendency for western conservation organizations and conservationists to garner public support by highlighting the global significance of tropical deforestation for species extinctions or, more recently for ecosystem services. Indeed, NGOs such as Conservation International (CI) have been adept at utilizing a wide array of marketing strategies to get across their message about deforestation, extinction, and climate change. Perhaps surprisingly, this includes linking rainforest deforestation with American celebrity culture: in 2008 CI convinced the hirsute and globally famous actor Harrison Ford to have a patch of his chest hairs waxed (= ripped off) on camera. During this ordeal, he turns to the camera and declared that "every acre lost there [the rainforest of some developing world country], hurts here [in the developed world]!" (Jepson and Ladle 2010). However, it is unlikely that such celebrity-based media strategies would have the same impact on public opinion in the developed world, where conservation interventions need to be seen to balance biodiversity gains with economic and social progress.

In summary, the ultimate factors driving forest loss are complex and interacting, and include population growth, changing demographics, perverse incentives, and arguably, the need for economic growth driven by capitalist, free-market philosophies—although countries with different political ideologies have fared little better in protecting their forests. Reversing broader societal trends related to consumerism or eating behavior is clearly beyond the capabilities or remit of conservation. Nevertheless, the prospects for the long-term success and sustainability of forest conservation initiatives can potentially be improved by the careful alignment of the conservation message with societal values.

Proximate Factors

The immediate (proximate) causes of forest clearance are usually associated with the expansion of the agricultural frontier, logging, road building, and fires. These factors are typically interrelated, with road building allowing access to new areas of forest that are quickly exploited for valuable timber and cleared for small-holdings (Cropper et al. 1999; Perz et al. 2008). The influx of people into previously isolated areas is frequently associated with increased fire damage, either intentionally to clear forest for pasture/crops, or an unintentional consequence of human presence. Moreover, the knock-on effects of roads may be exacerbated by the construction of 'unofficial' roads that spring up near newly paved government-funded roads (Perz et al. 2008).

The effects of logging are often more difficult to assess since it is often selective and frequently illegal, making it difficult to monitor and to evaluate the environmental consequences. However, recent advances in remote sensing technology have started to reveal the enormous damage caused by loggers in some of the World's most valuable tropical forests. For example, a recent high-resolution remote sensing study in the top five timber-producing states of the Brazilian Amazon indicated that logged areas ranged from 12,075 to 19,823 km^2 per year (±14%) between 1999 and 2002, equivalent to 60 to 123% of previously reported deforestation area (Asner et al. 2005). Moreover, up to 1200 km^2 per year of logging were observed within protected areas, illustrating the enormous challenges of governing such activities in remote areas (Asner et al. 2005). Another study based on surveys of wood mills estimated that logging crews severely damage 10,000 to 15,000 km^2 per year of forests not included in deforestation mapping programmes (Nepstad et al. 1999).

Roads also have a major deforestation impact in terms of clearing new areas for agricultural expansion (Soares et al. 2004). In Brazilian Amazonia, the increase in deforestation since the 1960s was mainly caused by national policies supporting road building, tax and credit incentives to large corporations and ranches, and colonization projects for the rural poor. Smallholders in the Amazon have been estimated to clear between 2 to 3 ha per year per family in the first few years of settlement, but the rate is slowing down as crops (mainly rice, beans, maize, and cassava) are replaced by pasture (Fujisaka et al. 1996). Unfortunately, reducing deforestation by the rural poor has no easy solutions. Some models have suggested that policies seeking to intensify small-hold farming can somewhat reduce the rate of deforestation, although this result is dependent on both the distribution of land and the willingness of farmers to move to new areas (Rock 1996).

Roads also pose direct and indirect threats to wildlife populations as they may affect animal dispersal or cause mortality through vehicle-animal collisions (reviews in Forman and Alexander 1998; Forman et al. 2003; Coffin 2007). In this context, the expansion of roads and the associated increase in traffic volume would further exacerbate forest degradation though species loss. Recent research inside a protected area in Costa Rica strongly suggests the negative consequences of roads on biodiversity. A 4 km section of Carara National Park, located in the central pacific area of the country (Fig. 3), is delimited by a main highway and has experienced increasing traffic volume from 394.7 vehicles per hour in 2008 to 521.6 in

Fig. 3. View of Carara National Park delimited by the Coastal Highway (route 34), Central Pacific Conservation Area, Costa Rica (Photo credits: Roberto Ramos).

2012. This short stretch of road has reduced the diversity and density of birds in the surrounding forest (Arévalo and Knewhard 2011) and causes high mortality rates on thousands of vertebrates every year (J.E. Arévalo, unpublished data). Thus, although the actual forest area lost to roads might seem minimal, the various negative effects of roads contribute greatly to forest degradation (Forman et al. 2003).

Fire is often the main method to clear forest, both intentionally and unintentionally. Moreover, it is predicted that fires in tropical forests will increase as more damaged, less fire-resistant forests cover the landscape due to fragmentation, selective logging, and agricultural encroachment (Cochrane 2003). Indeed, some researchers argue that fire poses the greatest risk to tropical forest due to its interactions with other processes (Nepstad et al. 2001). For example, fires reduce precipitation by releasing smoke into the atmosphere. This, in turn, causes more fires. Likewise, fires kill trees, thereby increasing the susceptibility of forests to recurrent burning by opening gaps in the canopy and increasing material on the forest floor that can act as fuel (Nepstad et al. 2001).

Fires may also be related to climate change if a region experiences decreases in precipitation. Excess of atmospheric CO_2 (Lewis 2006) and nitrogen deposition from fires (Chen et al. 2010) can also affect forests by promoting plant growth (fertilization effect increasing NPP) or, in extreme cases, by causing dramatic shifts in ecology by tipping ecosystems over ecological 'tipping points' (e.g., Malhi et al. 2008). Conversely, forests themselves can have a substantial influence on regional and global climates because they account for ~40 percent of global NPP storing large amount of carbon (Cleveland et al. 2013). Thus, their removal could significantly alter climate regimes for remaining forests. Such effects may extend beyond the bounds of the biome, leading to strong synergies between deforestation in different regions. For example, Malhado et al. (2010) recently demonstrated that deforestation in the cerrado in central Brazil may be sufficient to significantly change the climate over some areas of the Amazon rainforest, in some cases crossing ecological thresholds of the biome putting the forests at risk of transformation into deciduous forest or even savannah vegetation. Forests also store a considerable amount of carbon, which is released during deforestation thereby contributing to global warming (Pan et al. 2011).

Current Approaches for Forest Conservation

The international conservation community has reacted to continuing tropical deforestation in a wide range of ways; most notably by establishing the Convention on Biological Diversity (CBD) in 1992. The CBD acknowledged that biodiversity is essential for human existence, but focusing strongly on the utilitarian value of biodiversity as a key to effective conservation. In other words, biodiversity must pay for itself, but only if the benefits arising from its use are fairly and equitably distributed (Gaston and Spicer 2009). The CBD obliges sovereign nations to develop national legislation, outlining strategies, plans and programmes that respond to the changing circumstances of biodiversity conservation in particular nations. Moreover, the CBD set ambitious global targets for biodiversity conservation. With respect to deforestation, the CBD has a target (reconfirmed in 2008), to effectively conserve at least 10% of each of the world's forest types.

The CBD may have set the framework within which nations develop their conservation strategies, but the cornerstone of global conservation action is undoubtedly protected areas (PAs) (Jepson et al. 2011). Globally, approximately 13.5 percent of all forests are under some form of protection, although this varies considerably across latitudes or continents (from 5.5% in the Palearctic to 13.4 percent in Australasia) and forest types (from 3.2% of temperate freshwater swamp forest to 28 percent of temperate broadleaf evergreen forest) (Schmitt et al. 2009). Nevertheless, this figure should not be taken at face value since many protected areas lack rigorous control leading to degradation of buffer zones, and frequently to logging within strictly protected areas (Curran et al. 2004). Moreover, tropical forests (especially those in South America and Southeast Asia) are becoming increasingly isolated, as the surrounding, unprotected forest is lost to agriculture, urban development, and fire (DeFries et al. 2005). More recently the role of PAs in maintaining regional climate dynamics has come under scrutiny. For example, a recent analysis by Walker et al. (2009) indicates that even if all the areas outside of PAs in the Amazon are deforested, this will not drive drier areas over their ecological tipping points. However, this may not be the case in other major forested areas that have considerably less protection than the Amazon, where approximately 54 percent of all forests are protected (Soares-Filho et al. 2010).

Restoration of Degraded Areas

Given that a large extent of the Earth's surface is already under some form of protection (see above), the scope for extensive increases in forest PAs may be limited. This firmly places the emphasis on reforestation and restoration of degraded areas as a way to maintain or even increase global forest cover, reunite ecologically isolated forest fragments, and meet diverse conservation objectives. Traditionally, forest restoration has relied on natural succession processes following agricultural or other land use abandonment; this accounts for the majority of forest regrowth in parts of Eastern Europe where population declines have led to wide-scale abandonment of cultivable lands (Baumann et al. 2012). It is also a potentially successful strategy for tropical forests, given enough time, protection from fire, and a viable seed-bank (Aide et al. 2000; Arroyo-Mora 2005). However, in the 1990s the focus of research and practice shifted towards ways to accelerate recovery, rapidly restore biodiversity, and increase productivity (Parrotta et al. 1997). One strategy is to use plantations to facilitate forest succession through modification of biophysical conditions in the regeneration area (Baumann et al. 2012)—this is often the only viable strategy when lands have been completely deforested with an accompanying change in soil chemistry and structure (Griscom and Ashton 2011).

One of the greatest challenges for forest regeneration is the sourcing of a wide diversity of native species—especially difficult in tropical ecosystems where tree diversity can be staggeringly high. Nevertheless, when appropriate seedlings are available the results of regeneration projects have been very promising. For example, in southwest Costa Rica, the restoration of 145 ha of abandoned pasture was stimulated by planting mixed stands of native hardwoods (Leopold et al. 2001). Planting native species to enrich degraded forest (enrichment planting) can also be an appropriate strategy, especially for low-diversity stands of early successional pioneer trees. Indeed, it has been estimated that planting deep-forest trees in pioneer stands may significantly reduce the impacts of fragmentation by attracting seed dispersers (Martinez-Garza and Howe 2003; Zahawi et al. 2013).

Market-based Mechanisms for Forest Conservation

Protection and restoration may still be the main strategies for forest conservation, but these are being increasingly complemented by so-called market-based mechanisms. The best known and arguably the most effective of these is the certification of forest products. Certification is achieved by creating a set of rules, categories, and criteria that provide consumers with a guarantee about the sustainability and traceability of a given forest product. The most well-known certification scheme is the one generated by the Forest Studies Council (FSC) for timber, which has had enormous success in persuading consumers to commercially boycott timber from non-sustainable sources. The underlying logic is that if the demand for non-certified timber is reduced, then the economic incentives for logging (legal and illegal) are also reduced.

Certification schemes can be effective, but it can be complicated and difficult to introduce and implement especially if the forest acts as a source for diverse products. When a faster response is required, it can be easier to negotiate directly with producers to modify their business practices. A recent example of this is the strategy that was adopted by conservationists to reduce the impact of palm oil plantations, which had expanded rapidly and were threatening some of the last remaining lowland forests in Sumatra (Fitzherbert et al. 2008). In 2001/2002, the international conservation organisation WWF initiated the Round Table on Sustainable Palm Oil (RSPO), involving big plantation companies and manufacturers of palm oil products.[2] The companies voluntarily agreed to practices that will reduce the impacts of palm oil plantations. However, the key to RSPO's success was a special scheme developed by the FSC known as High Conservation Value Forest (HCVF), which identifies forests within a plantation's forestry concession that are vital for conservation and should be protected.

The RSPO is an example of how market-based approaches are using corporate social responsibility as a tool for forest conservation. However, voluntary agreements are limited by the extent to which companies are willing to buy in to a given conservation scheme. This does not mean that conservation is powerless against non-compliant companies. One strategy is to pressure them by influencing companies further down the supply chain. A good example (described in detail in Jepson and Ladle 2010) is the Indonesian-owned company APRIL, which operates a huge pulp mill in

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2 www.rspo.org

Sumatra, which used timber from acacia plantations (in land converted from rainforest) and timber from more questionable sources. In 1997, Friends-of-the Earth (FoE) Groups in Finland and the UK discovered that APRIL owed large sums of money to eight leading financial institutions. These institutions were more sensitive to pressure coming from FoE than from ineffective regulations and quickly took remedial action to avoid becoming the target of a high profile conservation campaign. Shortly afterwards, WWF persuaded APRIL to adopt the HCVF scheme and tighten-up timber procurement and set aside a 100,000 ha forest block.

Perhaps the most ambitious market-based mechanism for forest conservation is the concept of paying for ecosystem/environmental services (PES) defined as "voluntary transactions where a well-defined environmental service is being bought by a buyer, if and only if the provider secures the provision of such service" (Wunder 2005). Forests provide various types of environmental services, but watershed protection and carbon storage have the highest profiles. Three broad types of PES are emerging: voluntary contractual agreements, public payment schemes, and the most ambitious of all, trading in environmental services.

Voluntary contractual arrangements are typically focused on relatively small geographic scales. An example of this is the arrangement between Inversiones La Manguera S.A. (a private company) and the Monterverde Conservation League (a non-profit organization described in detail in Bougherara et al. 2009). The company runs a 6 MW run-of-river power plant (*La Esperanza*) in northern Costa Rica and most of the watershed (3,000 ha) is located within the Children's Eternal Rainforest Reserve, owned by the NGO. Under a private agreement signed in October 1998 (Appendix 1 in Janzen 1999), *La Esperanza* pays the Monteverde Conservation League for environmental services (watershed protection) provided by their reserve. Although watershed protection is the key service for the efficient operation of the hydroelectric power plant, the conservation of the forest also contributes to mitigate climate change and to conserve biodiversity.

Public payment schemes are government led initiatives that require companies to pay a fee for ecosystems services, and then identifying areas on which to spend the generated income. One of the best examples is China's Forest Ecological Benefit Compensation Scheme, which involves levying an ecological tax on water and tourism businesses operating in scenic areas and then using this money to finance forest protection and restoration (Li et al. 2006).

The final mechanism, trading in environmental services, is both the most ambitious and the most problematic. Basically, a government or international organization sets a limit on the amount of ecological services that can be used. In the case of carbon trading, this limit is on how much carbon a company can emit. The government then issues quotas that can be traded. From the perspective of forest conservation, carbon trading is the focus of current action. The key concept in carbon trading is off-setting; because CO_2 has no geographic boundaries, companies and individuals who can't reduce their emissions can off-set them by buying into a new initiative that captures carbon or stops it from being released (Bumpus and Liverman 2008). This creates a market for 'credits' for tonnes of carbon emitted or sequestered (captured). The great hope is that it will create a financial incentive to avoid forests from being cut down, planting new ones, or restoring degraded ones.

There are two markets for carbon credits: the compliance market and the voluntary market. The cost of credits in the voluntary market is cheaper because they are not subject to the rigorous UN validation of credits traded under a flagship inter-government scheme called the Clean Development Mechanism (Streck 2004). A lot of effort is currently being expanded on efforts to bring forest conservation into the compliance market. The main mechanism for this is called REDD or Reduced Emissions from Deforestation and Degradation. Forest loss and damage contributes around 20 percent of all greenhouse gas emissions and REDD would enable countries to receive payments if they can reduce deforestation. Moreover, protecting or restoring forests based on their ability to store carbon will also protect biodiversity and potentially promote considerable synergies between these benefits (Phelps et al. 2012).

Despite significant progress towards becoming a universal and effective mechanism, REDD faces many challenges, such as: (i) how to know whether or not a forest would remain if the scheme was not enacted; (ii) how to set national and regional 'base-lines' of existing forest cover and deforestation rates against which carbon emission/sequestration rates can be measured (Olander et al. 2008); (iii) the possibility that, if a forest patch is protected, loggers or plantation companies might simply cut down another patch such that there is no net carbon gain—known as leakage (Dargusch et al. 2010); (iv) how to provide assurance that the forest is in the state it is claimed to be and remains in the claimed state; (v) how to quickly generate robust data on how much carbon different types of forest release when they are cut down, and how much carbon is sequestered by different types of forest growing under different conditions (Gibbs et al. 2007); (vi) how to ensure financial parity with destructive land-uses such as oil palm plantations (Butler et al. 2009); and (vii) how to factor in all of the socioeconomic costs of REDD, such as demographic shifts and declining tax revenues (Ghazoul et al. 2010).

The latest iteration of REDD, known as REDD+, takes into account the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks. The ultimate success of REDD and REDD+ are difficult to predict. There seems to be a wide consensus among private and public actors that deforestation and climate must be addressed simultaneously (Pistorius 2012). Nevertheless, there is still an absence of reliable funding mechanisms. In addition, the complex reality of forest governance in developing countries is beginning to cause problems to the on-the-ground implementation. In conclusion, REDD and other mechanisms of trading environmental services offer the greatest hope for transforming the nature of global forest conservation, but there are still significant challenges to be overcome before the potential benefits for climate change, biodiversity, and sustainable development are realized.

Debt Swaps for Forest Conservation

First proposed by conservationist T. Lovejoy in 1984, the debt-for-nature swap has been frequently used as a financial tool to allow developing countries to achieve specific conservation goals (Cassimon et al. 2011). Through this mechanism, a developing country can both reduce its foreign debt and receive liquid funds to be invested in conservation projects. This mechanism was conceived by conservationists to reduce deforestation in developing countries that were heavily indebted and that also had low probabilities to comply with the payments to the foreign creditors (Sheikh 2010). In order for a debt-for-nature swap transaction to take place, an investor or donor needs to purchase the debt from the international creditor that agrees to sell a given amount for less than the face value and then redeem it in the debtor country at a face value of the local currency (Sheikh 2010). For example, Madagascar obtained an equivalent of US$1.7 million (in Malagasy francs) after Conservation International negotiated the face value of US$3.2 million debt for a purchase price of US$1.5 (Greiner and Lankester 2007).

This kind of debt swap is more likely to materialize in democratic countries and in tropical areas with a relatively high density of threatened species (Deacon and Murphy 1997). Such swaps may be of great benefit for conservation efforts in biodiversity priority areas. For example, debt-for-nature swaps generated $80 million to help the process of establishment of the conservation system in Costa Rica (Boza 1993; Greiner and Lankester 2007). Nevertheless, the scale and dimension of this financial instrument may not contribute significantly to the financial and conservation status of other countries (see Greiner and Lankester 2007; Cassimon et al. 2011). Shortcomings of the debt-for-nature swaps and political inconveniences of the involved parties have contributed to a decrease in the use of this financial instrument. However, the need for new alternatives to meet the international agenda towards schemes to reduce emissions from deforestation has led to the re-emergence of the debt-for-nature swaps (Cassimon et al. 2011). The scheme has been expanded to many other tropical countries through the Tropical Forest Conservation Act and it is estimated that some $218.4 million in local currency will be generated in the next 12–26 years (Sheikh 2010). Thus, the direct and indirect benefits, derived from the debt-for-nature swaps for the reduction of deforestation is highly dependent on the fair design of transactions, taking into consideration the context and idiosyncrasy of individual countries.

The value of debt-for-nature swaps to conservation organizations is arguably much greater than their actual financial value. For example, they attract positive media attention and show the participating organizations (often conservation NGOs) to be both entrepreneurial and economically sophisticated. Moreover, debt-for-nature swaps involve a powerful network that includes commercial banks and finance ministers, institutions and individuals who have previously been only peripherally involved in conservation. Finally, those conservation organizations involved in debt-for-nature swaps often play a major role in determining how funds are dispersed and what kind of conservation approaches are adopted (Jepson and Ladle 2010), helping to embed the conservation philosophies and perspectives into developing regions of the world.

Conclusions

Forest conservation is reaching a crucial period. Our planet is facing unprecedented environmental change and at the same time, the priorities of the global conservation movement are changing from the establishment of new protected areas to market based mechanisms and sustainable exploitation of forest resources. In this context, we highlight five main challenges for global forest conservation for the coming decade:

1. Slowing and eventually halting deforestation in hyperdiverse tropical forests of South America, Asia, and Africa,
2. Restoring ecological connectivity of fragmented forests in order to reduce species extinctions caused by small population size and to provide dispersal routes for species who's current range of distribution is becoming inhabitable due to climate change,
3. Developing effective, cost effective, and rapid to implement protocols for reforesting cleared areas, restoring structure, key ecological processes, and biodiversity,
4. Improving and expanding Payment for Ecosystem Services schemes, including REDD, whereby they become a key mechanism for conserving forests outside of protected areas,

5. Improving the governance, management, and enforcement of protected areas, preventing encroachment and exploitation of the most valuable forests that are already under some level of protection.

Meeting these challenges will require considerable investment and unprecedented cooperation between nation states, international organizations, the private sector, NGOs, and civil society. Whether these challenges are met forest conservation is likely to remain at the forefront of the global conservation agenda over the following decades. During the following century, we may easily witness a new pulse of mass extinctions driven by the destruction and fragmentation of the World's remaining tropical forests. Nevertheless, we consider that there is reasonable ground for optimism due to the rapid development of market-based mechanisms, and more broadly, because of the recent alignment of forest conservation with the global threat of climate change.

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