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Conservation research in Brazilian Amazonia and its contribution to biodiversity maintenance and sustainable use of tropical forests/ Recherche sur la conservation en Amazonie, et sa contribution à la biodiversité

Conservation research has an important role in biodiversity maintenance and in sustainable use options for Amazonia. However, research interacts with decision makers and civil society as development choices are made, and the decision process is often not primarily guided by priorities identified through research. Opportunism, for example in creating protected areas, often precipitates conservation action. Nevertheless, the existence of research plays an essential role in providing justification for protection when opportunities arise. In some cases, the existence of research can lead to study areas gaining protected status. Research can rank the 'scientific' priority of areas for biodiversity protection. It can also help quantify conservation benefits for environmental services other than biodiversity, such as water cycling and carbon storage. These environmental services are important as a potentially sustainable and environmentally beneficial basis for supporting the rural population in Amazonia, in contrast to the current economy that is almost entirely based on destroying the forest. The pace of destruction is rapid despite a decline totaling 79% in Brazil's annual deforestation rate since 2004. Deforestation is far from being under control, and forest degradation is even farther from this ideal. The decline in the rate of forest loss from 2004 to 2008 is virtually all explained by temporary declines in commodity prices, while much of the decline since 2008 is dependent on measures that could be reversed at the stroke of a pen. A powerful "ruralist" political group representing agribusiness and large landholders is pressing to do just that. The Brazilian government also has massive plans for roads, dams and other infrastructure that imply greater deforestation. Conservation research has a key place in helping to quantify the environmental, social and economic costs of forest destruction before it is too late to avert the worst of these impacts. Research also is important in identifying ways that tropical forests are maintained or lost as a result of decisions such as creating protected areas of different types, building infrastructure projects, and implementing various policy interventions to discourage deforestation and encourage sustainable alternatives.

KEYWORDS: AMAZONIA, PROTECTED AREAS, DEFORESTATION, ENVIRONMENTAL SERVICES, ECOSYSTEM SERVICES, TROPICAL FOREST, RAINFOREST

1/ INTRODUCTION: CONSERVATION VERSUS DESTRUCTION IN AMAZONIA

The history of conservation research in Brazilian Amazonia contains many lessons for other tropical areas, both in offering some examples of successful examples that could be applied elsewhere and mistakes to be avoided. The Amazon Basin covers 7,003,067 km^2, of which 67.9% is in Brazil, 9.8% in Bolivia, 8.8% in Peru, 1.6% in Ecuador and 6.4% in Colombia; in addition, a "greater Amazon" region with similar environmental conditions encompasses parts of Venezuela, Guyana, Surinam and French Guiana (Mardas et al., 2013).

In Brazil a 5 × 10^6 km^2 administrative area denominated "Legal Amazonia" has been established since 1953, covering all or part of nine states (Figure 1). Various fiscal incentives, development programs and environmental regulations apply to this area. About three-fourths of Legal Amazonia was "originally" covered by Amazonian forest (i.e., at the time Europeans arrived in Brazil in 1500). The remaining one-fourth is mainly *cerrado* – the central Brazilian savanna. Until 2004 Brazil's conservation actions in Amazonia invariably applied to Legal Amazonia, but many of the actions since then have applied instead to the "Amazonia Biome." The Brazilian Institute for Geography and Statistics (IBGE) officially divides the country into six biomes: Amazonia, *Cerrado*, Atlantic forest, *Caatinga* (northeastern Brazilian semi-arid scrublands), *Pampas* (southern Brazilian grasslands) and *Pantanal* (Paraná River wetlands) (Brazil, IBGE, 2012). The Amazonia Biome, covers 4.196.943 km^2 (Brazil, IBGE, 2004). In addition to forest, in 4% of the area the original vegetation was one of several non-forest vegetation types, mainly Amazonian savannas. The largest savanna area is the "lavrado" in Roraima in the northernmost portion of the country (Barbosa et al., 2007).

Satellite monitoring of deforestation first covered all of the forest in Brazil's Legal Amazonia region in 1978, and has been annual (with the only exception of 1994) since 1988. The monitoring since 1988 has been with LANDSAT-TM imagery with 30-m resolution (although this is degraded to 60-m resolution in the data released free on INPE's website: http://www.dpi.inpe.br/prodesdigital). In 2014 the Program for Monitoring of Deforestation in Amazonia (PRODES) is being extended to cover the *cerrado*, including both the *cerrado* inside Legal Amazonian and the remainder of the *Cerrado* biome. At some future date coverage will be extended to the remaining four Brazilian biomes. The PRODES program and the release and interpretation of its data have been subject to a variety of problems and political pressures in the past (Fearnside, 1997a), but in recent years the program has been much more transparent. Brazil is far ahead of other tropical countries in satellite monitoring capability, and this is fundamental to efforts to understand and control deforestation in Amazonia.

The pace of destruction of Amazonian forest is rapid (5843 km^2/year in 2013) despite a decline totaling 79% in Brazil's annual deforestation rate since 2004. Deforestation is far from being under control, and forest degradation is even farther from this ideal. The decline in the rate of forest loss from 2004 to 2008 is virtually all explained by temporary declines in commodity prices (Assunção et al., 2012), while much of the decline since 2008 is dependent on measures that could be reversed at the stroke of a pen. As will be explained later, a powerful "ruralist" political group representing agribusiness and large landholders is pressing to do just that. The Brazilian government also has massive plans for roads, dams and other infrastructure that imply greater deforestation (Fearnside, 2014a,b).

2/ OPPORTUNISM VERSUS SCIENTIFIC PRIORITIZATION

Protection of biodiversity requires an interaction between research communities of various types, the decision-makers who are responsible for creating and maintaining reserves, and the groups or indi-

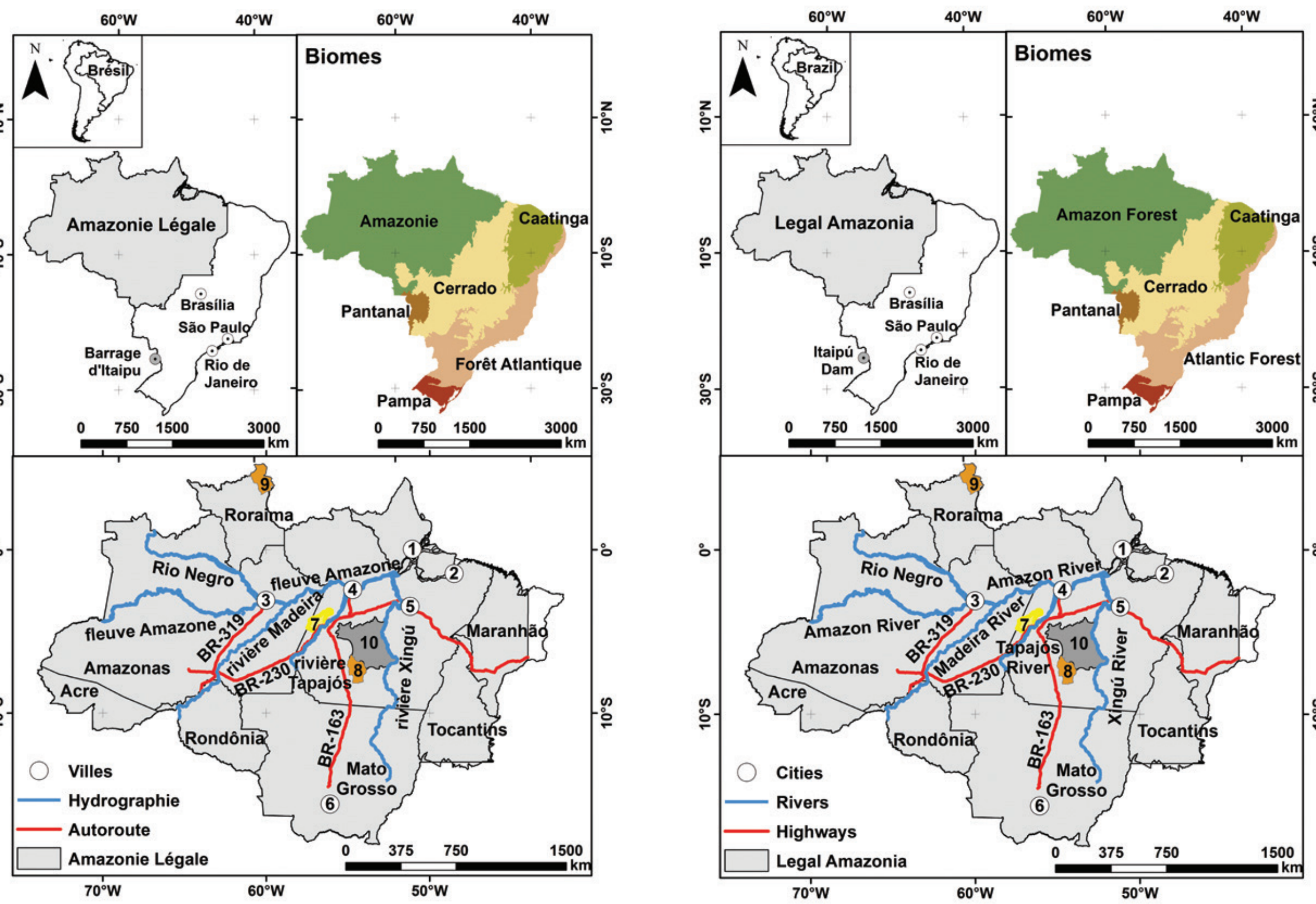

Fig.1 - Amazonia with locations mentioned in the text

viduals in civil society whose demands and pressure are, to a greater or lesser extent, reflected in government actions. In some cases private enterprises can represent an additional influence, but the influence of business groups is often negative, influencing governments to block the creation of reserves (as reflected in current legislative proposals by "ruralists" in Brazil's National Congress). Government decisions, both at the national and sub-national levels, are usually the key to creating reserves. Despite the urgency of creating protected areas before the opportunity is lost in practice, creating new protected areas has been practically paralyzed since 2008, both at the federal and at the state level.

The role of research is important, but repeating the many calls for decision makers to "listen to researchers" does not reflect the nature of the interaction between these groups. Research is needed to identify biodiversity values in areas that might be converted to reserves, as well as estimation of other environmental services (such as carbon storage and water cycling) and the degree of threat affecting each area. A line of research in "scientific" prioritization of potential reserves has been underway for years.

In 1979 the head of Brazil's national parks department, then a part of the Brazilian Institute for Forest Development (IBDF), adopted a systematic approach to prioritization based on identifying vegetation types that lacked protection (Padua & Quintão, 1982). This indicated unprotected vegetation types in Legal Amazonia, but when it was realized that about two-thirds of the cost of protecting these areas would be just in the state of Mato Grosso, where deforestation was well advanced and obtaining land for reserves would be very expensive, the decision was simply to not create reserves in Mato Grosso and to use the available resources for reserves elsewhere in Legal Amazonia.

In 1990 Conservation International organized a workshop in Manaus ("Workshop 90") to systematize expert opinion and available data on the priorities for creating protected areas in Brazilian Amazonia (Rylands, 1990). A gap analysis used the newly available tools of geographical information systems (GIS) to estimate the protected and unprotected area of each vegetation type in each state in Legal Amazonia based on Brazil's 1:5,000,000 vegetation map (Fearnside & Ferraz, 1995). The exercise produced a series of candidate areas for protection that would achieve the goal of protecting some of each vegetation type in each of the nine Amazonian states. The candidate areas chosen attempted to minimize the number of areas by choosing sites where more than one unprotected vegetation type occur in close proximity, and to avoid known impediments and conflicts. An additional consideration was suggested by Peres and Terborgh (1995) in a proposal that would organize priorities by river basin and give emphasis to candidate protected areas that are most defensible from the point of view of physical access. The size of reserves is also important, and many biodiversity considerations demand large continuous areas (Peres, 2005).

In 1995 the US Agency for International Development (USAID) contracted World Wildlife Fund US (WWF-US) to produce a conservation priority ranking for Latin America and the Caribbean, which was published by the World Bank (Dinerstein et al., 1995). In addition to the number of species (species richness) or other indices of species diversity within a given habitat (alpha diversity), the ranking takes into account beta diversity, or the turnover of species along ecological gradients. Beta diversity varies considerably across Amazonia, being highest near the Andes and decreasing across the basin towards the east (ter Steege et al., 2003, 2006). A number of non-diversity criteria were also applied to give priority to threated areas and to ecosystems that are unique or need protection to achieve regional representation. The result was that most Amazonian forests had their priorities reduced in deference to threatened ecosystems elsewhere (Fearnside, 1997b, 2013a).

In 1999 a gathering was convened in Macapá that brought together 220 researchers, environmentalists and other professionals to suggest priorities for protected areas (ISA et al., 1999; Capobianco et al., 2001). Maps of priorities were prepared for different taxonomic groups. The lack of knowledge regarding large geographical areas for some groups resulted in little-studied areas being assigned priority as a precautionary measure. The problem of very uneven collection density for sampling biodiversity, for example as reflected by botanical specimens, is a persistent artefact in mapping biodiversity, with locations near major research centers such as Manaus and Belém inevitably being identified as highly diverse, and poorly collected areas elsewhere as less diverse (Nelson et al., 1990). Priority to poorly known areas represents an attempt to counter this bias. The number of areas identified was very great compared to financial resources and political will for reserve creation: 265 "extreme-priority" areas and 105 "very high-priority" areas were

identified. The "Macapá priorities" became the basis for Brazil's National Program for Biological Diversity (PRONABIO) (Albernaz & de Souza, 2007; Brazil, MMA, 2002).
In 2000, Norman Myers and coworkers proposed "hotspots" as a basis for establishing global conservation priorities (Myers et al., 2000). As with the Dinerstein et al. (1995) classification, extra priority was given to ecosystems on the basis of threat. Brazil's *cerrado* and Atlantic forest were classified as hotspots, but Amazonia was not.

A GIS analysis of vegetation in the Amazonia Biome by Leandro Ferreira (Ferreira, 2001; Ferreira et al., 2001, 2008) has been instrumental in providing justification for creating protected areas, especially those under integral protection. This was a key argument leading to creation of the Tumucumaque National Park in 2002 in the state of Pará on Brazil's border with Surname; at 38,874 km^2 it is now Brazil's largest. Conservation prioritization algorithms developed in Australia by Robert Pressey (e.g., Pressey et al., 1996) have been applied to the *várzea* (floodplain) in Brazil's state of Pará by Albernaz et al. (2007).

A presidential announcement in 1998 led to creation of the Protected Areas of Amazonia Project (ARPA), which was initially known as PROAPAM (Program to Expand Areas of Environmental Protection) (Fearnside, 2003). The program set a goal of providing integral protection for 10% of each ecosystem, this percentage including "core areas" delimited in management plans for conservation units in the sustainable use category. The presidential announcement of a 10% goal was a response to a call for this goal by Worldwide Fund for Nature (WWF-International) and the World Bank as part of the "forests for life" campaign. The program was important in stimulating reserve creation, and the percentage goals have been largely met in Amazonia. The protected areas in the ARPA program have been important in reducing forest loss (Soares-Filho & Dietzsch, 2008; Soares-Filho et al., 2010).

In addition to large-scale efforts at mapping and prioritization, the existence of on-the-ground studies on biodiversity and ecological processes in specific locations can sometimes lead to the study sites gaining protected status. An example is the Biological Dynamics of Forest Fragments Project (BDFFP) area north of Manaus where this large-scale project undertaken by the Smithsonian Institution and Brazil's National Institute for Research in Amazonia (INPA) has been working since 1979 (Bierregaard et al., 2001; Laurance & Bierregaard, 1997; Laurance & Peres, 2006). A much smaller example where research presence contributed is INPA's Ouro Preto do Oeste Ecological Reserve in a heavily deforested area in the state of Rondônia (Fearnside, 1984).

Research is important in identifying gaps in biodiversity protection and the relative values of one area versus another. However, the actual decision to create a protected area is often the result of opportunism rather than being directed at a particular priority area identified by research. An example of the importance of research in providing the justification to turn an opportunity into a reserve in reality is provided by the six reserves (not counting an "environmental protection areas," or "APAs" with negligible protection even on paper) created in the "Terra do Meio." The Terra do Meio is an area in central Pará the size of Switzerland that has largely been outside of the control of the Brazilian government (e.g., Escada et al., 2005; Taravella, 2008). The opportunity arose in 2005 as a result of the assassination of sister Dorothy Stang, who was a Catholic missionary and defender of the poor and of the environment in the area of Anapú, Pará, on the Transamazon Highway. She was murdered by a gunman hired by local ranchers (later convicted). The momentary peak in public concern for the environment in Amazonia in the succeeding weeks opened an opportunity to create reserves in the Terra do Meio area. A study had already been prepared by the Instituto Socioambiental (ISA) proposing a "mosaic" of protected areas in the Terra do Meio (ISA, 2003), but the proposal had been lying dormant because it was considered politically unviable. Having the technical justification in hand at the critical moment made it possible to create the reserves. The existence of the studies makes it possible to "run with the ball when you have it." The protected areas appear to have had some effect in averting deforestation and discouraging "*grilagem*," or the illegal appropriation of land by large ranchers and speculators (da Silva e Silva, 2013).

3/ WEAKNESS OF PARKS AND RESERVES

Most people assume that once a protected area is created it will be there forever. Unfortunately, this is not necessarily the case, and the government can totally or partially extinguish reserves with relative ease. Perhaps the best-known case in Brazil is the extinction of the Sete Quedas National Park to make way for the Itaipú hydroelectric project in 1982, among other examples (e.g., Fearnside & Ferreira, 1984). Most recently, in 2012, parts were cut from Amazonia National Park and from five other protected areas to remove impediments to planned dams in the Tapajós Basin in Pará. These protected areas were reduced by a temporary presidential decree (MP 558 of 6 January 2012), which was later enacted into law (No. 12.678/2012) in July 2012. The protected areas were reduced before the dams had had their viability studies completed, let alone the Environmental Impact Assessment, licensing and approval. Removing portions of the reserves without studies and consultations violated both Brazil's constitution and its environmental legislation (Araújo et al., 2012).

Indigenous areas are essential to maintaining biodiversity, and defending their integrity is therefore a central question. The relatively great success of indigenous areas in repelling deforestation is not so much due to the active defense by the indigenous people, although their presence is an important feature and is more effective than park guards employed by the government. What prevents indigenous areas from being invaded is mainly the assumption by potential invaders that those who attempt to invade the areas will not be successful in obtaining a land title. Were this perception to change to one of expected impunity, as is the case for much of the public land in Amazonia, the result would be disastrous for the indigenous peoples and for biodiversity. Unfortunately, some events have occurred that could contribute to just such a shift in perceptions. One is the case of the Baú indigenous land in Pará. Invaders from the nearby BR-163 (Santarém-Cuiabá) Highway took over part of the reserve and, instead of being summarily removed without compensation, as is theoretically the policy of the government, they were instead rewarded by having the invaded area removed from the reserve and their land claims legalized (see Fearnside, 2007). A key question at present is the case of the Raposa/Serra do Sol indigenous land in Roraima. A part of the area had been occupied by large-scale rice farmers who, after a long judicial battle, were finally removed in 2013 after a video of violence against Indians by thugs hired by the farmers became a national scandal. "Ruralists" in Brazil's major soy-producing areas support the rice farmers who have been expelled from the reserve (e.g., Mazui, 2013), and their efforts to recapture the area by means of increased ruralist political influence continue.

4/ RECUPERATION OF DEGRADED AREAS VERSUS PROTECTING FOREST

Calls for doing more to recuperate degraded areas are commonplace in discussions of Amazonia and of the impacts of deforestation. Although heads always nod in agreement when this touchstone is mentioned, more careful consideration of this option is needed in the case of Amazonia. Most of Brazil's Amazon forest is still standing (although a significant part of what is left has been subject to some form of recent disturbance). The area of forest cleared by 2013 totaled 765,354 km^2 (Brazil, INPE, 2014), or 19.8% of the 3.87 millon km^2 originally forested in Brazil's 5 million km^2 Legal Amazonia region. Avoiding the destruction of as much as possible of the remaining forest must be the first priority, and the opportunities to do this by creating protected areas are highly time dependent, with the difficulty of creating these areas increasing rapidly as human occupation advances. The financial cost of recuperating a hectare of degraded land is much higher than the cost of avoiding the deforestation of a hectare of native forest, and the benefit in terms of biodiversity, water and carbon is much less. Since the funds available for environmental actions are always limited and insufficient, money spent on recuperating degraded lands implies less for avoiding deforestation. The great advantage of recuperating degraded areas as an option is that everyone is in favor of it, whereas avoiding deforestation can run counter to powerful economic interests. Creation of protected areas represents the most long-lasting and effective means of avoiding deforestation, and must be the priority. Recuperation of degraded lands can become a priority under other circumstances, such as the case of Brazil's Atlantic forest, where only small fragments of the original forest remain. However, that day has not yet arrived for Amazonia, and it is essential to maintain the focus on protecting the remaining forest.

The distribution, connectivity and degree of disturbance of forest fragments is important in highly deforested areas such as northern Mato Grosso, and various interventions can help to minimize biodiversity loss (Peres et al., 2010). The strips of riparian forest along stream banks, traditionally protected by Brazil's Forest Code, are particularly important in providing migration corridors that interconnect forest fragments. Since there was little enforcement of these provisions of the Forest Code for many years, these riparian forests have been largely eliminated in agricultural landscapes, particularly those in the Atlantic forest biome where deforestation is much more advanced than in Amazonia. Recuperation of these connections is part of a strategy for maintaining wildlife populations, especially large predators such as jaguars (*Panthera onca*), and remarkable success has been achieved in an ongoing program the western part of the state of São Paulo (e.g., Cullen Junior et al., 2005). In *cerrado* areas of Mato Grosso, where habitat loss is also more advanced than in Amazonian forest, the breaking of these riparian migration corridors is one of the major threats to maintaining viable populations of jaguars (Zeilhofer et al., 2014).

5/ "INTEGRAL PROTECTION" VERSUS "SUSTAINABLE USE"

Brazil's system of protected areas has evolved significantly over the past three decades. Protected areas were classified into those for "direct" and "indirect" use, the latter category, including parks and reserves without a resident population living inside them. In 2000 the National System of Conservation Units (SNUC) was enacted (law no. 9985/2000), but the "regulamentation" process to establish the system in practice lasted until 2002. The SNUC changed the classification of conservation units to "sustainable use" and "integral protection" areas. The "sustainable use" category includes national forests (FLONAs) for timber management, extractive reserves (RESEX) for traditional rubber tappers, Brazilnut gatherers and other groups harvesting non-timber forest products (NTFPs), and sustainable development reserves (RDS), a category of state reserve that includes local populations of fishermen and small riverside farmers (*riberinhos*). A controversial aspect is the inclusion of "environmental protection areas" (APAs), a category that allows many damaging activities and can even include urban areas. This category allows large areas on the map to be colored green without much of any real protection.

Integral protection areas include national parks (PARNAs), ecological stations, and biological reserves. The different categories of protected areas have differing levels of success in impeding deforestation, with federal areas performing better than state government areas and integral protection areas performing better than sustainable use areas (Vitel et al., 2009; see also: Ferreira et al., 2005). Note that effectiveness in impeding deforestation is not the same as effectiveness in impeding forest degradation, as by logging and fire. Indigenous areas, for example, generally have high effectiveness in repelling deforestation but their effectiveness against degradation is much less. Forest degradation has rapidly become a major destroyer of environmental services in Amazonia (Asner et al., 2005; Foley et al., 2007; Merry et al., 2009; Nepstad et al., 2001).

The creation of new conservation units has shifted markedly from the integral protection to the sustainable use category. The political facility of creating sustainable use areas is much greater because creating integral protection areas generally requires resettlement of a resident population. Resettlement has historically been marred by social injustice and broken promises regarding compensation and programs for supporting the displaced population (e.g., Fearnside, 1999a), although the protected areas programs intend to do better (e.g., World Bank. 2002). In the sustainable use category, those in reserves often gain greater security against expulsion by more powerful actors and against loss of natural resources to outsiders such as logging firms and commercial fishing boats. Various other forms of benefits, such as the *Bolsa Floresta* (Forest Stipend) program in the state of Amazonas, also make it more attractive to be living inside a sustainable use area (Viana et al., 2013). This generates political support for creating more of these areas.

Creating protected areas rapidly becomes unviable as human occupation advances into the forest. The relative ease of creating sustainable use areas makes this the most logical path to achieving some of the needed protection ahead of the advancing frontier. Brazil's massive plans for infrastructure such as highways and dams can be expected to increase migration to many potential areas for creating reserves, rendering plans unachievable.

The future of indigenous areas is critical to biodiversity maintenance in Amazonia. Indigenous areas are not "conservation units" included in the SNUC, but they are a form of "protected area." Indigenous areas are under the jurisdiction of the Ministry of Justice, whereas federal conservation units are either under the Chico Mendes Institute for Biodiversity (ICMBio) or, in the case of national forests, under the Brazilian Forest Service (SFB), both of which are part of the Ministry of the Environment. State-level conservation units are under the corresponding state government agencies.

Indigenous areas have a better record than conservation units in inhibiting deforestation, and in many parts of the arc of deforestation the only significant areas of natural forest remaining are on indigenous land (Nepstad et al., 2006; Schwartzman et al., 2000a,b). However, indigenous areas are not immune to deforestation, and indigenous peoples cannot be assumed to continue performing their valuable role in maintaining environmental services to be pocketed for free by the rest of society (Fearnside, 2005).

6/ PROSPECTS FOR SUSTAINABLE USE

The prospects for sustainable use are not particularly good due to a series of limiting factors that restrain the dominant land uses in deforested areas in the region today (Fearnside, 1988, 1997c). The focus of the search for sustainable use options is therefore on uses that maintain the forest cover. One of the major efforts is promotion of non-timber forest products, such as tapping natural rubber (*Hevea brasiliensis*) and copaiba oil (*Copaifera* spp.), collecting Brazilnuts (*Bertholletia excelsa*) and andiroba seeds (*Carapa guianensis*), and harvesting fibers such as piaçava (*Leopoldinia piassaba*) (Clay & Clement, 1993; Murrieta & Rueda, 1995). These products can, indeed, be harvested on a sustainable basis without harming the major environmental services of the forest. The challenges are in the social and institutional spheres to keep these systems functioning without economic activity shifting in non-sustainable directions.

Non-timber forest products as a basis for sustaining the local population is fundamental to the creation and maintenance of "extractive reserves" (Fearnside, 1989a). These reserves were proposed by the National Council of Rubbertappers (CNS) in 1985, and the first such reserve was created in the state of Acre in February 1988. Chico Mendes, the rubbertapper leader and advocate for environmental and social causes, was assassinated in December of that year. His death stirred outrage in Brazil and elsewhere, creating the opportunity for rapid expansion of extractive reserves in Brazilian Amazonia. In the years since, the economic viability of rubber tapping has become weaker. Producing natural rubber is much cheaper in Asia, where the absence of the South American leaf blight (*Microcyclus ulei*) allows efficient production in plantations. Although most of the natural rubber used in the Brazil is imported from Asia, since 1997 Brazil has maintained artificial price supports for rubber from domestic sources, 20% of the total amount of the subsidy being reserved for rubber from natural forest, and the remainder being for plantations (Brazil, MMA, 2014). However, the subsidy has progressively declined. This, combined with the tendency of the resident populations to have ever-expanding expectations for their material standard of living, has led to increasing frequency of non-sustainable choices, especially clearing areas for cattle pasture (e.g., Fernandes, 2008). Selling of timber, officially under "sustainable" community management plans, has also begun in extractive reserves that were initially intended to be limited to non-timber forest products. Despite these deviations from the low-impact occupation originally proposed, extractive reserves provide much better protection than what prevails in the surrounding landscape outside of the reserves.

"Sustainable" forest management is being promoted on a large scale as an alternative to deforestation and as the source for tropical timber for Brazil and for export markets. Unfortunately, the term "sustainable" that is universally emphasized in the naming and description of these plans is very rarely matched with a real probability of the production system continuing over the long term. A fundamental problem is the inherent contradiction between the rate at which managed Amazonian trees can grow and the rate at which money can be made by investment in other activities, including investment in timber exploitation elsewhere in the region (Fearnside, 1989b). The rate at which trees grow (roughly 2% per year) is limited by biology, and has no connection with the discount rate (on the order of 10% per year in real terms) used in financial decision making. The return on alternative investments ultimately determines the financial "rationality" of destroying a potentially renewable natural resource like a tropical forest (Clark, 1973, 1976).

"Sustainable" forest management is being promoted in various forms. One is by contracts that are granted to companies on the basis of competitive bidding in national forests (FLONAs), with management plans specifying a 30-year rotation being required by the Brazilian Forest Service (SFB) of the federal government. The equivalent state forests (FLOTAs) have similar requirements from the analogous state agencies. Large firms can also obtain permits to log in private land where a management plan is approved by the state government environmental agency, also requiring a 30-year cycle (see Eve et al., 2000). The theory is that the area to be managed will be divided into 30 plots, and selective harvesting will be carried out in one plot each year, such that at the end of the cycle the first plot will have recovered to an equilibrium state and can be harvested again. The continual flow of income will pay for managing the entire area, and will supposedly assure an indefinite continuation of the system. Unfortunately, the temptation is inherent to harvest the large trees as quickly as possible, whether legally or not. These trees have taken centuries to grow at no expense to the logging company, and the first cycle of logging will therefore be more profitable than subsequent cycles where the volume of wood that is harvested corresponds to what has grown while the manager invests in maintaining the system (Fearnside, 2003).

Brazil's regulations have been relaxed to allow the area under management to be harvested more rapidly than would be the case in following the theoretically sustainable sequence of 30 annual plots. An example is provided by an 12,000-ha management area in the state of Acre, where the company was allowed to divide the area into only six plots. After the fifth plot had been harvested, the area was sold for a small-farmer settlement scheme (with the proviso that the logging company could still harvest the sixth plot). Theoretically, the management plan foresees the area simply sitting idle for 24 years before another harvest cycle is begun. However, the chance of this scenario actually taking place, whether under the original ownership or not, is virtually zero (Fearnside, 2013b). The same applies to "Small-Scale Sustainable Forest Management Plans" (PMFSPE), which represents the predominant system in the state of Amazonas. These management plans are approved by the state government for 100-ha areas, but they allow the entire area to be harvested in the first year. Likewise, the probability that the property owner will sit with no income for the next 29 years while waiting for another cycle to begin is virtually zero.

Ecotourism has often been mentioned as an alternative to deforestation, and has even been used to justify major development projects with enormous environmental impacts, such as the BR-319 (Manaus-Porto Velho) Highway (Fearnside & Graça, 2009). Tourism can, indeed, provide economic support for some. However, the scale of this option is minimal compared to the size of Amazonia. In a small country that is easily accessible to foreign tourists, such as Costa Rica, tourism can be a significant factor at a regional or national scale, but the demand for this form of tourism is not expandable to provide a similar input in Amazonia. The scale is different: just the state of Rondônia is five times the size of Costa Rica.

Environmental services represents a potential source of financial flows on a scale that could be transformational in Amazonia (Fearnside, 1997d, 2008). This refers to the functions of ecosystems in maintaining such values as biodiversity and climate stability. One such service is the role of Amazon forest in water cycling, which provides water vapor that generates rainfall not only Amazonia but also in Brazil's heavily populated central-south region as well as in neighboring countries (Fearnside, 2004; Marengo, 2006). Another is the avoidance of global warming by maintaining carbon stocked in the forest and in the soil, rather than allowing it to be released as greenhouse gases (Fearnside, 1997e, 2000; Nogueira et al., 2008). Despite the promise of substantial value and advances in negotiations of various types, capturing the value of environmental services is still largely a potential factor for the future rather than a serious competitor with options such as cattle ranching, logging and soybeans. Research has an essential role to play in speeding a transition to an economy founded on maintaining the forest rather than on destroying it. Better quantification of the environmental services provided by the forest is one such area. This involves quantifying the impacts of forest loss, since the other side of the coin is the gain from not deforesting. Another research need is better understanding of how to reduce deforestation, including the measures needed and their financial and other costs. Information on alternative uses of the forest is also a part of the need for research: subsidizing the various products that can be sustainably harvested from the forest has a potential role as a means of maintaining traditional forest populations, such as rubbertappers, who serve as guardians of the forests that produce environmental services worth much more than the physical products that may be harvested. The social destruction that results from paying people to do nothing means that simple cash payments cannot be the choice for achieving the two essential goals of maintaining the human population in the forest and maintaining the forest with its environmental services.

7/ BRAZIL'S FOREST CODE AND THE SHIFT OF POLITICAL POWER

Brazil's efforts to protect forests and biodiversity are constrained by a shift in the country's economic base and political power. This became clear with the gutting of Brazil's "Forest Code," which is a set of regulations enacted in 1965 (Law No. 4.771/1965) restricting deforestation and other activities affecting the country's forests. On 24 May 2011, a bill was approved in the House of Deputies (lower house) of the National Congress, and the process of Senate approval, amendments and final Presidential approval lasted until October 2012 (Law No. 12.651/2012). The "reform" of the Forest Code removed protection of hilltops and steep hillsides greatly reduced the width of the area to be protected along water courses by redefining the water level from which the measurements are made, and reduced the area in each property to be protected by "incorporating" the "area of permanent protection" (APP) into the "legal reserve" (RL) that each property must maintain (e.g., Metzger et al. 2010). Most importantly, the reform created an expectation of impunity in the future by effectively forgiving the majority of past violations of the Forest Code (Fearnside, 2010). Input from the scientific community was completely ignored, including a joint report by the Brazilian Society for the Progress of Science (SBPC) and the Brazilian Academy of Sciences (ABC) (Silva et al., 2011).

The vote in the House of Deputies was in a ratio of seven to one against the environment. This is hard to explain by normal political logic, given that representation in the House of Deputies is proportional to population and 85% of Brazil's population lives in cities, meaning that the vast majority of the electorate has no direct financial stake in being allowed to clear stream banks and steep hillsides. On the contrary, their interest is on the other side: during the debate on the Forest Code over 200 people were killed in landslides in towns in the coastal mountains in Rio de Janeiro state, and massive flooding along rivers in Northeastern Brazil displaced many thousands. Public opinion polls a few days after the 2011 vote indicated 85% of the public opposing the "reform" of the Forest Code (Barrionuevo, 2012).

The explanation for the remarkable lack of connection between the vote in the House of Deputies and the interests and opinions of the electorate lies in a shift in the economic power centers of the country. The manufacturing sector has declined markedly, with Brazilian manufacturing being replaced by Chinese imports both in domestic markets and in the foreign markets to which Brazil traditionally exported (Bittencourt et al., 2012, p. 106; Cintra, 2013). Economic power and political influence has shifted from urban labor unions and industrialists to the "ruralists" – the voting and lobbying block representing large landholders and agribusiness. Soy exports (now predominantly to China) put the production centers in Mato Grosso and other states as the source of political influence (Fearnside et al., 2013). This shift affects many issues in Brazil in addition to the environment, but its effect on the environment is fundamental.

In addition to the Forest Code, the ruralists have pushed for restrictions that will require congressional approval for creating protected areas, including indigenous areas (PEC 215/2000). This would effectively block any future creation of protected areas, since the history of the Forest Code shows the control of ruralist influence in the congress. The amendment is rapidly progressing towards final approval (Brazil, Câmara dos Deputados, 2014). The ruralists are also moving to repeal the Central Bank resolution (BACEN no. 3.545/2008) that links public bank financing to a clean environmental record with the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA). This would remove an anti-deforestation measure that has real teeth, in contrast to fines that can be appealed essentially indefinitely and are often never paid. This 2008 Central Bank resolution is believed to be the major factor in the continued decline in Brazil's deforestation rates after 2008, when commodity prices began to recover. General pressure to weaken the environmental licensing and enforcement systems is a constant threat. The *de facto* closing off of any possibility to strengthen environmental controls is crippling. Any proposed legislation to strengthen controls would instead be amended to have the opposite effect (Fearnside & Laurance, 2012).

8/ SOURCES OF FUNDS FOR ENVIRONMENTAL SERVICES

It is easy to achieve agreement on the fact that environmental services are important and should somehow be rewarded. How to do this is not an area of such easy agreement. Progress has been made in international negotiations in both the United Nations Framework Convention on Climate Change (UNFCCC), better known as the "Climate Convention," and in the Convention on Biological Diversity (CBD), better known as the "Biodiversity Convention." However, this has not yet resulted in significant monetary flows. Negotiations under the Biodiversity Convention focus on establishing intellectual property rights such as the traditional knowledge that forest peoples have of medicinal plants. Unfortunately, the development and testing of pharmacological products from this knowledge requires decades, and is not a likely source of financial flows with the scale and timing needed to give this environmental service a substantial role in maintaining Amazonian forests (Fearnside, 1999b). Averting climate change, however, is much more advanced in international negotiations and has the greatest likelihood of generating monetary flows with the scale and timing that are needed (Fearnside, 2013c).

How to pay for the services that tropical forests provide in avoiding global warming is a matter of great controversy. REDD, or "reducing emissions from deforestation and degradation," is seen by some as the savior of tropical forests and others as an immoral evil that would price nature in a trick to allow rich countries to continue on a path to climate disaster. These controversies stem from long list of political and other considerations, many of which have little or nothing to do with climate issues (Fearnside, 2001, 2012a,b). A voluntary market for forest carbon already exists, but this has much more limited potential than does the as-yet nonexistent market under the Climate Convention, assuming that the countries of the world become more serious about containing global warming and agree to the needed very large reductions in greenhouse gas emissions.

An important question is whether the funds would be derived from a market or from contributions to a fund. A fund would reward forest carbon at the minimum price possible, namely the opportunity cost of not deforesting – that is, the value of a low-productivity cattle pasture in the case of Brazilian Amazonia. In contrast, a market would put forest carbon in direct competition with other mitigation options, such as measures to increase energy efficiency and reduce fossil fuel consumption in the developed countries. The ways for developed countries to reduce emissions “at home” are generally more expensive per ton of carbon kept out of the atmosphere than is reducing tropical deforestation. This means that the price per ton of carbon sold in a market that includes this competition will be reasonably high, that is, high enough to capture both all of the potential emission reduction from reducing tropical deforestation and also motivate reduced domestic emissions in developed countries -- assuming that the countries agree to the large reductions in emissions that are needed. Achieving agreement on reductions at this level is exactly the key issue in the climate negotiations. Confining tropical forest mitigation to a fund effectively surrenders to the assumption that no such deep emissions cuts will be agreed, even before the diplomatic battle on this issue has begun in earnest.

Unfortunately, there is a strong tendency to tokenism from Europe, allowing payment for tropical forests but only on a small scale that is not part of the main effort to combat climate change (Fearnside, 2012a). This stems from fact that reducing emissions from actions “at home,” such as installing wind and solar power and manufacturing more efficient cars, all results in greater employment and income at home, whereas sending the money to tropical countries to reduce deforestation does nothing for the economies of Europe. This means that arguments will be raised to spend mitigation funds at home, with only token amounts going to tropical countries, even though the climatic benefit achieved with the same expenditure is much less. Countries can simply refuse to agree to the needed level of emissions reductions in order to keep their commitments within the limits they view as acceptable for their national budgets under the assumption of the more-expensive domestic mitigation options.

There are also technical issues in making mitigation through reducing emissions from tropical deforestation and degradation, and research is an essential part of addressing these. One is the reliability of baseline scenarios to represent how much emission would occur in the absence of a mitigation activity. This is an area in which exaggerating the baseline emission is easy, but substantial progress has been made in Amazonian cases of modeling baselines that avoid these biases (Yanai et al., 2012; Vitel et al., 2013). Important as these technical issues are, it is the institutional issue of what to do with the money obtained from environmental services that is the least developed part of proposals in this area (Fearnside, 2008). Unfortunately, the present REDD proposal is for the government to receive the money, thus reducing the chances that much of these funds will, in fact, find their way to the intended beneficiaries who inhabit and defend the standing forest.

9/ CONCLUSIONS

Research on biodiversity can help provide justification for specific conservation actions such as reserve creation, but often the decision to act depends on opportunism rather than on conservation priorities established by research.

Research on environmental services other than biodiversity maintenance, such as carbon and water, is important in providing the foundation for more general support for conservation based on the value of these services.

Research to better understand the processes of deforestation and forest degradation is essential to efforts to bring these processes under control.

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