Inhibition of Amazon Deforestation and Fire by Parks and Indigenous Lands

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Abstract: *Conservation scientists generally agree that many types of protected areas will be needed to protect tropical forests. But little is known of the comparative performance of inhabited and uninhabited reserves in slowing the most extreme form of forest disturbance: conversion to agriculture. We used satellite-based maps of land cover and fire occurrence in the Brazilian Amazon to compare the performance of large (>10,000 ha) uninhabited (parks) and inhabited (indigenous lands, extractive reserves, and national forests) reserves. Reserves significantly reduced both deforestation and fire. Deforestation was 1.7 (extractive reserves) to 20 (parks) times higher along the outside versus the inside of the reserve perimeters and fire occurrence was 4 (indigenous lands) to 9 (national forests) times higher. No strong difference in the inhibition of deforestation (*$p = 0.11$*) or fire (*$p = 0.34$*) was found between parks and indigenous lands. However, uninhabited reserves tended to be located away from areas of high deforestation and burning rates. In contrast, indigenous lands were often created in response to frontier expansion, and many prevented deforestation completely despite high rates of deforestation along their boundaries. The inhibitory effect of indigenous lands on deforestation was strong after centuries of contact with the national society and was not correlated with indigenous population density. Indigenous lands occupy one-fifth of the Brazilian Amazon—five times the area under protection in parks—and are currently the most important barrier to Amazon deforestation. As the protected-area network expands from 36% to 41% of the Brazilian Amazon over the coming years, the greatest challenge will be successful reserve implementation in high-risk areas of frontier expansion as indigenous lands are strengthened. This success will depend on a broad base of political support.*

Key Words: Brazil, protected areas, tropical forests

Inhibición de Deforestación e Incendios por Parques y Terrenos Indígenas en la Amazonia

Resumen: *Los científicos de la conservación generalmente están de acuerdo en que se requerirán muchos tipos de áreas protegidas para proteger a los bosques tropicales. Pero se conoce poco del funcionamiento comparativo de reservas habitadas y deshabitadas en la reducción de la forma más extrema de perturbación de bosques: conversión a agricultura. Utilizamos mapas, basados en satélites, de cobertura e incidencia de incendios en la Amazonía Brasileña para comparar el funcionamiento de reservas deshabitadas (parques) grandes (>10,000 ha) y habitadas (terrenos indígenas, reservas extractivas y bosques nacionales). Las reservas redujeron tanto la deforestación como los incendios significativamente. La deforestación fue 1.7 (reservas extractivas) a 20 (parques) veces mayor a lo largo del exterior* versus *el interior de los perímetros de las*

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reservas y la ocurrencia de incendios fue 4 (terrenos indígenas) a 9 (bosques nacionales) veces mayor. No encontramos diferencias significativas en la inhibición de la deforestación (p = 0.11) o incendios (p = 0.34) entre parques y terrenos indígenas. Sin embargo, las reservas deshabitadas tendieron a estar localizadas lejos de áreas con altas tasas de deforestación y ocurrencia de incendios. En contraste, los terrenos indígenas a menudo fueron creados en respuesta a la expansión de la frontera, y muchos previnieron la deforestación completamente a pesar de las altas tasas de deforestación a lo largo de sus límites. El efecto inhibidor de los terrenos indígenas sobre la deforestación fue notable después de siglos de contacto con la sociedad nacional y no se correlacionó con la densidad de la población indígena. Los terrenos indígenas ocupan una quinta parte de la Amazonía Brasileña—cinco veces el área bajo protección en parques—y actualmente son la barrera más importante para la deforestación de la Amazonía. A medida que la red de áreas protegidas se expanda de 36 a 41% de la Amazonía Brasileña en los próximos años, el mayor reto será la implementación exitosa de reservas en áreas con alto riesgo de expansión de la frontera agrícola al mismo tiempo que se refuercen los terrenos indígenas. Este éxito dependerá de una amplia base de soporte político.

Palabras Clave: áreas protegidas, Brasil, bosques tropicales

Introduction

There is growing agreement among conservation scientists that many types of protected areas, including those with resident human populations, are needed for an effective global strategy to preserve tropical forests. A recent synthesis concludes that protection of a substantial proportion of the world's remaining biodiversity is feasible in part because approximately 2 million km^2 of tropical forest are already protected for indigenous peoples and biodiversity (Pimm et al., 2001). Officially recognized indigenous lands of the Brazilian Amazon alone comprise half of this total. Most conservation literature and policy recommendations are still directed at uninhabited protected areas. However, these areas differ significantly from inhabited protected areas such as indigenous lands and extractive reserves in the processes by which they are created, in their long-term management needs, and, hence, in their role within conservation strategies. One rationale for this emphasis on uninhabited protected areas is that the conservation value of indigenous lands is lower than that of parks because indigenous people ultimately adopt the cultural values, technology, and patterns of resource exploitation of their nonindigenous neighbors, a trend that is exacerbated by population growth within indigenous lands (Terborgh 1999, 2000; Redford & Sanderson 2000; Terborgh & van Shaik 2002).

The refinement of biodiversity conservation strategies in the tropics is hampered by a dearth of comparisons of the performance of inhabited versus uninhabited protected areas in slowing the most extreme form of human disturbance: forest conversion to agriculture. Several researchers (e.g., Redford 1992; Peres 2000*a*, 2000*b*; Robinson & Bennett 2000) have examined the effects of rural people on wild game populations and others (Terborgh 1999; Sá & Ferreira 2000; Bruner et al. 2001; Terborgh & van Schaik 2002) have analyzed the performance of uninhabited parks in protecting biological diversity. Ferreira et al. (2005) recently analyzed deforestation rates within uninhabited reserves, indigenous lands, and unprotected lands for three Amazon states but did not conduct a rigorous comparison of deforestation inhibition by the two types of reserves. The assumption that the conservation value of uninhabited parks is higher than reserves with human residents remains untested.

We report on the results of a satellite-based comparison of the inhibitory effects of protected areas that prohibit human habitation (parks, biological reserves, ecological stations) and those that permit habitation (indigenous lands, extractive reserves, and national forests) on deforestation and fire within the Brazilian Amazon. Logging and hunting damage forests, but were omitted from this analysis because they are difficult to quantify (Nepstad et al. 1999).

Methods

The quantification of reserve performance in slowing deforestation is best measured against a baseline that describes the trajectory of deforestation in the absence of the reserve. This trajectory is influenced by the suitability of the land within the reserve for agriculture, logging, and other economic activities, by market trends for agricultural and forest products, by investments in transportation and energy infrastructure, and by agrarian reform. A reserve therefore inhibits deforestation only if it (1) slows the expansion of economic activities (i.e., protects natural resources that would otherwise be exploited), (2) prevents or mitigates the effects of investments in roads and other infrastructure that cause direct environmental damages and/or that indirectly foster natural resource exploitation, and (3) prevents agricultural settlements—either planned or spontaneous—motivated by agrarian reform pressures. (The third condition is not redundant of the first because agricultural settlements are often planned in places that are not suitable for agriculture.) Within this context, reserves that are far from the expanding agricultural and logging frontier and are not slated for infrastructural investments or agricultural settlement have a negligible short-term effect on deforestation, but may have a very important inhibitory effect as the frontier grows nearer.

To measure protected-area performance one must distinguish between local and regional effects. To what extent is the inhibition of deforestation within a reserve counterbalanced by an increase in deforestation elsewhere? In general, this "leakage" of the inhibitory effect of reserves should be greatest in young, expanding agricultural frontiers, where land tends to be cheap and abundant but diminishes over time as land suitable for agriculture becomes scarce. We did not address this aspect of reserve performance.

We provide an initial comparative assessment of reserve performance in the Brazilian Amazon by using deforestation and fire occurrence along the reserve perimeter as a proxy for the threat of imminent deforestation. We assume that reserves with rapid rates of forest conversion to agriculture and/or high incidence of fire along the outside of their perimeters are more likely to suffer forest clearcutting than reserves with low rates of forest conversion along their perimeters. Therefore, the ratio of deforestation and burning in buffer zones outside versus inside the reserve boundary provides a measure of reserve performance that normalizes the threat. When this ratio is greater than unity, the reserve has deflected forest conversion from the baseline trajectory. This approach overestimates the inhibition of deforestation in cases where the reserves were established close to existing roads or to the boundaries of existing colonization projects.

Interview-based analyses (e.g., Bruner et al. 2001) provide a qualitative indication of reserve performance, but are vulnerable to the biases of informants who have a vested interest in this performance. Park managers and conservation NGO personnel may have the best information about the status of reserves, but they also may have motives for overstating the success of the reserves. We therefore measured reserve performance with maps of land cover developed from satellite images (INPE 2004) that identify those areas deforested during the period 1997–2000 and maps of active fires derived from a geostationary weather satellite in 1998 (GOES-8, Menzel & Purdom 1994; E.M. Prins, W. P. Menzel, and J. M. Feltz. 1998. Characterizing spatial and temporal distributions of biomass burning using multi-spectral geostationary satellite data. Pages 94–97 in Proceedings of the Ninth Conference on Satellite Meteorology and Oceanography). Deforestation is indicated by satellite detection of forest replacement by cattle pastures and agricultural systems, and by detection of the fires that are used as part of the forest-clearing process and in the maintenance of cattle pastures (Nepstad et al. 2001). Of the four major types of land-use fire in the Amazon—including fire used to burn felled forest, fire used to improve forage quality in cattle pastures, accidental cattle pasture fire, and fires that burn standing forests—only the first three are registered as "hot pixels" by the thermal channels of satellites (Nepstad et al. 2001). Our analysis did not capture understory fires in standing forests.

Maps of reserves for the Brazilian Amazon were acquired from the *Instituto Socioambiental* (Capobianco et al. 2001; Fig. 1). We refer here to those federal land designations that prohibit resource exploitation by people (national parks, biological reserves, ecological research stations) as "parks." Indigenous lands, extractive reserves, and national forests permit human residents and subsistence agricultural activities, but partially restrict deforestation. Deforestation in extractive reserves, for example, is restricted to 10% of the forest area. Indigenous peoples have permanent use rights to their land, but regulations on resource use are ambiguous. In contrast, private landholders can clear up to 20% of the forests on their properties, although enforcement of this legislation is largely ineffective.

Our metric for reserve performance—the ratio of deforestation and fire occurrence rates along the outside versus inside of the reserve perimeter—is sensitive to coregistration errors between land cover maps of different years, and between land cover and park boundaries. We therefore excluded from the deforestation analysis those reserves that were small (<10,000 ha) and therefore had proportionally high image coregistration errors. We also inspected the superimposed land cover maps and reserve locations for each of the reserves and excluded from the analysis those for which coregistration errors could be detected visually. Reserves established after 1997, reserves established by state governments, images with clouds or missing data accounting for >20% of the inside or outside reserve buffer, reserves with <10% forest cover in 2000, and reserves for which satellite data were not available were also excluded from the analysis. Based on these selection criteria, we were able to quantify deforestation rates of 15 parks, 121 indigenous lands, 10 extractive reserves, and 18 national forests, representing 40%, 35%, 58%, and 39%, respectively, of the total area of each reserve type under federal jurisdiction.

Fire inhibition was quantified for reserves that were at least 50,000 ha and that had <20% classified as cerrado—Brazil's savanna woodland vegetation that burns naturally. The spatial distribution of fires was compiled for 1998, a severely dry year. This sample consisted of 11 parks, 87 indigenous lands, 4 extractive reserves, and 12 national forests, representing 35%, 51%, 74%, and 34% of the area of these federal reserves, respectively.

We measured deforestation inhibition by comparing average annual deforestation rates from 1997 to 2000 within 10-km-wide strips of land located along the inside and outside of the reserve perimeter. Deforestation rates were calculated as

$$r = (F_{1997}/F_{2000})^{1/t} - 1, \qquad (1)$$

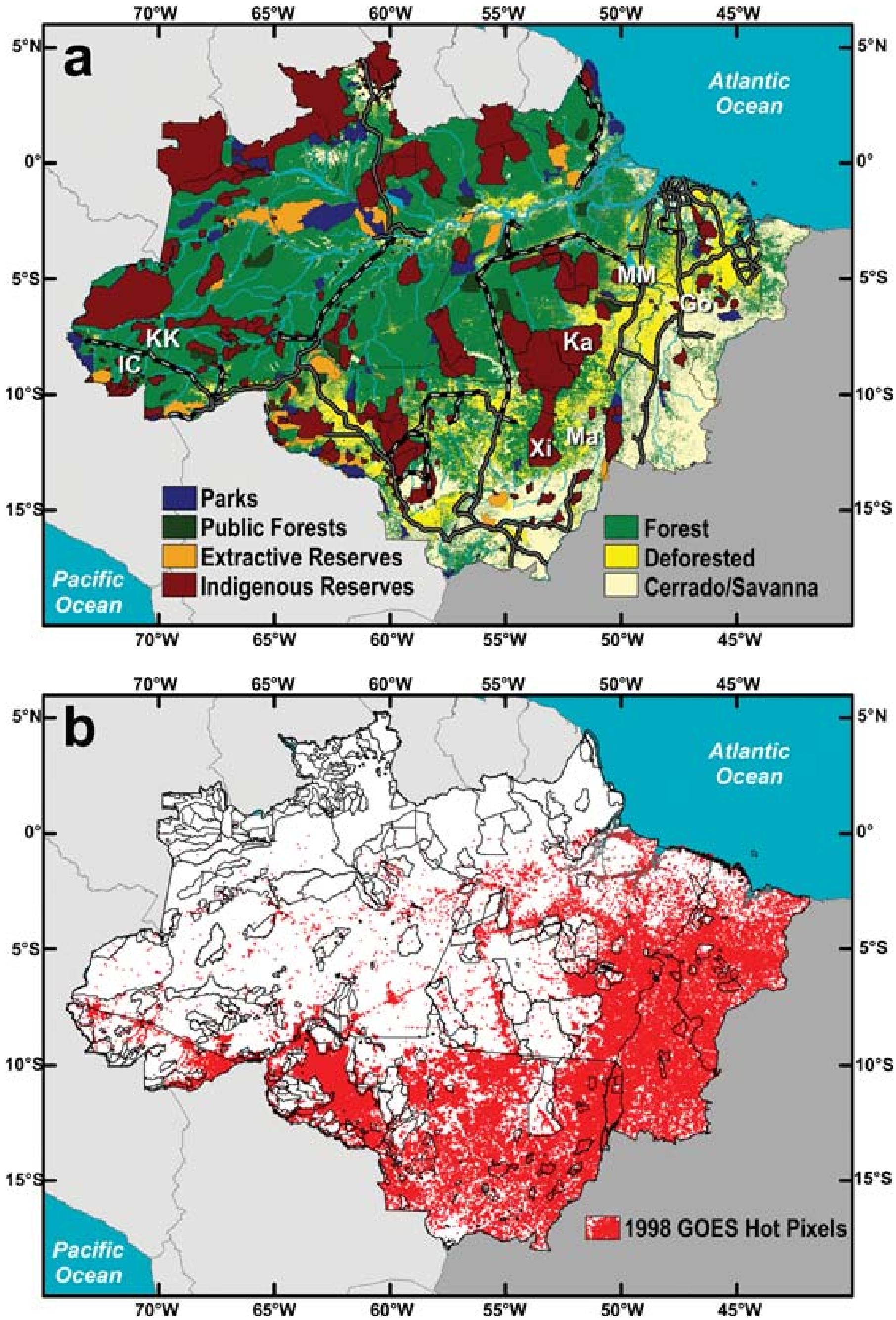

Figure 1. Reserves and human-caused disturbance in the Brazilian Amazon. (a) Reserves, highways (paved in gray, unpaved in dashed black and white lines), and deforestation (as of 2000) of the Brazilian Amazon (letters indicate indigenous lands referred to in the text: Go, Governador; IC, Igarapé do Caucho; Ka, Kayapó; KK, Katukina/Kaxinawá; MM, Mãe Maria; Ma, Maraiwatsede; and Xi, Xingú Indigenous Park. (b) Reserves (polygons) and active fires (hot pixels) registered by the GOES satellite for 1998.

where r is the annual deforestation rate (%), F_{1997} and F_{2000} are forest cover in 1997 and 2000, respectively, and t is time in years. The influence of reserves on fire occurrence was measured by comparing fire density (number of fires per square kilometer in 1998) within 20-km-wide strips along the inside and outside of the reserve perimeter. We used larger buffer areas for the fire data because of the coarser spatial resolution of these data—the GOES pixels are 4 km wide, whereas the Landsat thematic mapper pixels are 30 m wide. Spatial accuracy of GOES fire detection is within one pixel (Menzel & Purdom 1994). Only those hot pixels detected at mid-day and classified as having a high probability of being associated with fire were included in the analysis (GOES-8, Menzel & Purdom 1994; E.M. Prins, W. P. Menzel, and J. M. Feltz. 1998). For reserves <200,000 ha in size, fire density of the entire reserve was compared with that along the outside of the perimeter.

Nonparametric statistics were used to make comparisons among reserve types due to the highly skewed distribution of the deforestation rate data. First, we compared the inhibition of deforestation and fire by the reserves (outside buffer vs. inside buffer values) within each reserve type with Wilcoxon signed ranks test for dependent samples. We used Kruskal–Wallis one-way analysis of variance for independent samples to compare inhibition of deforestation and fire across reserve types. The dependent variable for this analysis was the ratio between inside and outside buffer values. We used the same procedure to test for differences between parks and inhabited reserves (for two samples the test reduces to the Mann–Whitney *U* test).

Finally, we used rank correlation analysis to test for a relationship between deforestation in indigenous lands as a function of time since first contact with nonindigenous groups and reserve population density. The ratio between the annual deforestation rates, inside and outside the reserve, determined between 1997 and 2000, provided the dependent variable for these analyses. All significance tests were carried out at the $\alpha = 0.05$ level in SyStat software (SPSS 2000).

Results

On average, deforestation from 1997 to 2000 was 1.7 (extractive reserves) to 20 (parks) times higher along the outside of the reserves than along the inside (Figs. 1a, 2a, & 3a). This inhibitory effect was significant for all reserve types except extractive reserves, for which the sample size was smallest, as follows: indigenous lands ($Z = 8.053$; $p < 0.000$), parks ($Z = 3.076$; $p = 0.002$), extractive reserves ($Z = 0.771$; $p = 0.441$), and national forests ($Z = 3.061$; $p = 0.002$). Eighty-five percent of indigenous lands (97 of 114, with 7 ties) had higher deforestation rates in the outer than inner buffer; this figure was 92% for parks (12 of 13, with 2 ties). Differences among the four reserve types were indicated (K–$W = 11.390$; $p = 0.010$), perhaps because of the large difference between parks and extractive reserves in the ratio of deforestation in the outer and inner buffers. Inhibition of deforestation was highest for the parks (20-fold), intermediate for the national forests (9.5-fold) and indigenous lands (8.2-fold), and lowest for extractive reserves (1.7-fold) (Fig. 2a; 3a).

A similar inhibitory effect was found for fire (Figs. 1b; 2b; 3b). The average density of fires was 3.7 to 9.4 times higher along the outside of the reserves than along the inside (Figs. 2b & 3b). This effect was highly significant for indigenous lands ($Z = 6.84$; $p < 0.000$), parks ($Z = 2.94$; $p = 0.002$), and national forests ($Z = 2.76$; $p = 0.003$). For fires we also detected a marginally significant effect for the small number of extractive reserves ($n = 4$) included in the sample ($Z = 1.604$; $p = 0.055$). Each of these reserve types exerted a similar degree of control over fire occurrence (K–$W = 3.253$; $p = 0.354$, Figs. 2b & 3b).

Indigenous lands strongly inhibited deforestation in the active agricultural frontier. Thirty-three of 38 indigenous lands with high annual deforestation rates (>1.5%/year) along the outside of their perimeters had inner deforestation rates of 0.75% or lower (Fig. 2a). When expressed on an area basis, 31% of indigenous lands, representing 39% of the total land area for this reserve type in our sample, were exposed to this level of outside pressure. Fewer parks have been established within the active agricultural frontiers of eastern and southern Amazonia (Fig. 1a), in part because of the historical tendency of park planners to avoid the conflicts and conservation threats

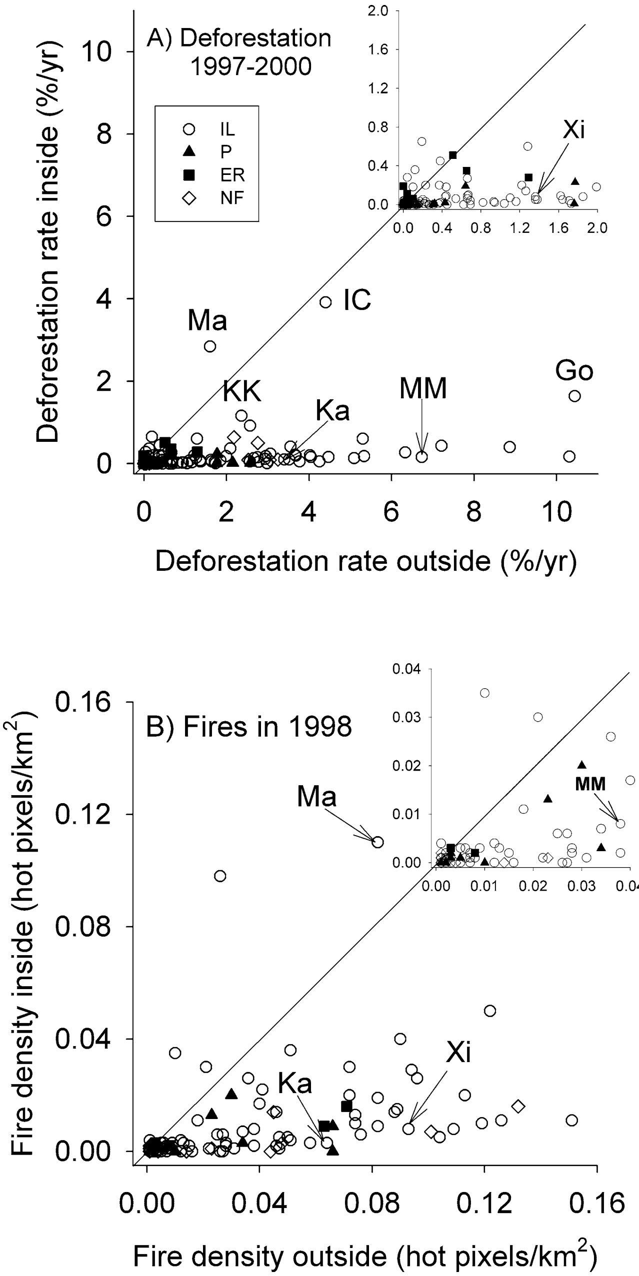

Figure 2. Inhibition of (a) deforestation and (b) fire by individual reserves (inside and outside is inside and outside reserves). Boundary effectiveness is illustrated relative to the 1:1 line, which represents the null effect. Reserve codes defined in Fig. 1 legend.

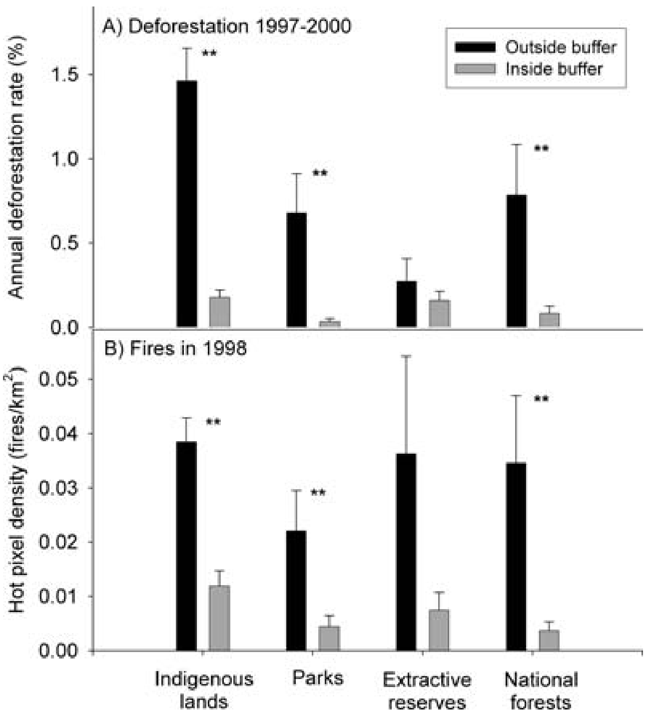

Figure 3. Reserve performance in slowing Amazon deforestation and fire. (a) Average annual deforestation rates (Eq. 1) from 1997 to 2000 within 10-km strips of land along the inside and outside of each reserve boundary of 121 indigenous lands, 15 parks, 10 extractive reserves, and 18 national forests. (b) Cumulative fire density for 1998 within 20-km strips of land along the inside and outside of each reserve boundary (87 indigenous lands, 11 parks, 4 extractive reserves, 12 national forests). Fire data were restricted to one fire/day/16-km^2 pixel.

associated with expanding frontier regions (Peres & Terborgh 1995). Only four of the 15 parks in our sample, representing 21% of the land area, were exposed to similar outside deforestation pressure (>1.5% deforestation per year in the outer buffer). The parks and indigenous lands included in this analysis appeared similar in their capacity to inhibit deforestation ($U = 259.5$; $p = 0.113$).

The proximity of indigenous lands to the active frontier is also reflected in the fire data (Figs. 1b, 2b, & 3b). The average density of fires was nearly two times greater along the outside of indigenous lands than it was along park perimeters (Fig. 3b). Through their location in lower risk regions of the Amazon, the park network has had a proportionally smaller effect on frontier expansion. Indigenous groups, in contrast, often live in the path of expanding frontiers, and fight to win legal recognition of their land rights while defending their forests from clearing by outsiders.

Discussion

The high variability of reserve performance can be traced to individual reserve histories. High rates of deforestation in indigenous lands were generally associated with exploitation or invasions from nonindigenous populations that had occurred prior to reserve demarcation. The indigenous lands with the highest interior deforestation in our sample (Igarape do Caucho, Acre State, Katukina/Kaxinawa, Acre State, Governador, Maranhão State and Maraiwatsede, Mato Grosso State) either border urban areas or are on roads already opened when the reserves were recognized, or both.

Mairawatsede, a somewhat special case, was to have been returned in 1992 to a group of Xavante who had been forcibly removed from the area by the military in 1966. When local politicians became aware of the plan, they fomented large-scale invasions by colonists. The area was recognized as indigenous land by the Justice Ministry in 1993, but the government never resettled the colonists. The Xavante have not returned and the colonists remain. At the same time, established indigenous lands are virtually the only places in active frontiers traversed by roads without deforestation (Mãe Maria, Pará State, Xingu Park, Mato Grosso State). The Mãe Maria reserve of the Gaviões is cut by the Pará-332 road, a power line, and borders the Carajás Iron Ore Railway, but strong Gaviões leadership has negotiated compensation for the works and exercises vigilance over reserve boundaries.

Indigenous lands that successfully inhibited deforestation within the active agricultural frontier were often inhabited by tribes who actively enforce legal restrictions on natural resource exploitation by outsiders. The Kayapó people have successfully defended their ancestral lands, expelling ranchers and settlers who invade their reserve (Zimmerman et al. 2001), maintaining deforestation rates at close to zero (Schwartzman et al. 2000; Zimmerman et al. 2001) (Figs. 1a & 2a). In recent years, various indigenous groups have taken intruders hostage to reinforce demands for reserve demarcation and government assistance in protecting boundaries.

It has been postulated that the tendency of indigenous people to protect their forests from deforestation is lost as these groups adopt the values of a market-based society, and as their population densities increase (Terborgh 2000; Redford & Sanderson 2000; Terborgh & van Shaik 2002). We tested this prediction by examining the response of deforestation inhibition by indigenous lands to population density within the reserve and the time since first contact with nonindigenous groups. The relationship between indigenous land population density and deforestation inhibition was highly variable ($r = 0.19$) and was significant at the 90% confidence level ($p < 0.06$; Fig. 4a). Although indigenous land performance in slowing deforestation also varied greatly with time since contact

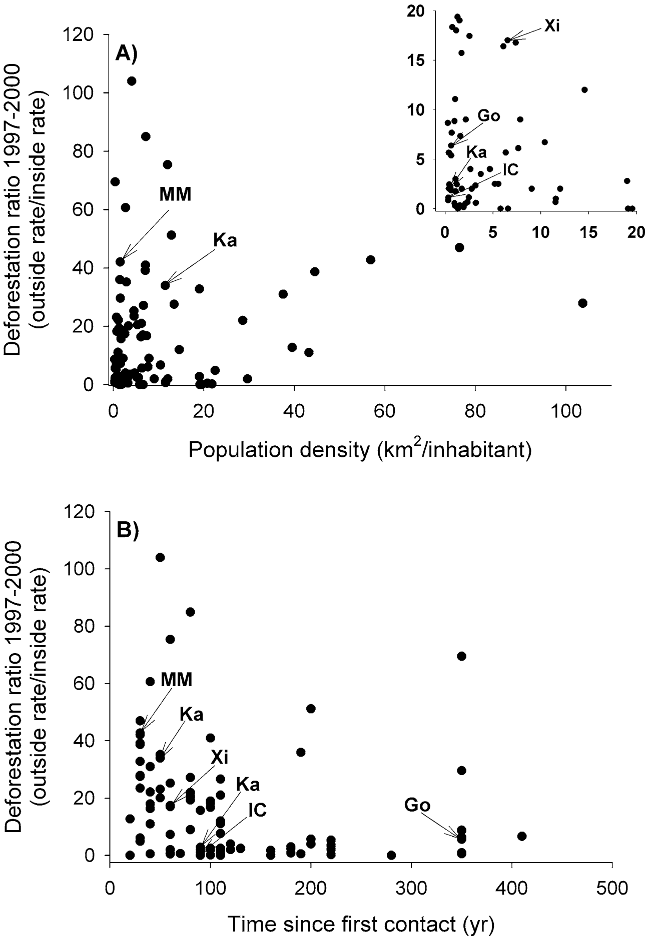

Figure 4. The relationship between deforestation inhibition by indigenous lands and (a) population density and (b) time since contact with white populations. The ratio between the deforestation rates inside and outside reserves determined between 1997 and 2000 provided the dependent variable for these analyses. Reserve codes defined in Fig. 1 legend.

($r = 0.40$; Fig. 4b), the lands continued to substantially inhibit deforestation in almost all cases up to 400 years after contact with the national society. A negative correlation was found over the 200-year gradient ($p < 0.05$), indicating a slight tendency for the inhibitory effect of indigenous lands on deforestation to decline following contact with nonindigenous people. Factors that we did not analyze may be more significant for this variation than time, such as whether or not reserves were invaded before their legal recognition. (A similar test for parks is not possible because most were created in the last 50 years.)

The high level of variability of both of these relationships (the dependence of deforestation inhibition on time since contact and population density) indicates that contact with the national society, population growth, and resource degradation are not inevitably linked. The ecological integrity of the indigenous lands will ultimately depend on cultural factors and on the economic alternatives that are available to indigenous peoples.

We did not measure reserve performance in protecting forests from impoverishment through logging and hunting. Many indigenous groups have opened their lands to mahogany extraction. Logging is also common in those parks that are located in the active frontier. The Panará people have actively expelled mahogany loggers from their area. The A'Ukre group of the Kayapó people has initiated a promising resource management system that may have prevented depletion of game species (Zimmerman et al. 2001). The 13-million-ha reserve of the Kayapó and the Upper Xingu peoples in south-central Pará and Mato Grosso is larger than any tropical forest park in the world and is the main barrier between the forest and business-as-usual frontier expansion in the heavily settled eastern Amazon (Fig. 1a, b). These indigenous groups have been strengthened through collaboration with conservation organizations (Zimmerman et al. 2001).

Indigenous lands occupy one-fifth of the closed-canopy forests of the Brazilian Amazon, which is twice the area targeted by the Brazilian government for preservation in parks (http://www.mma.gov.br/port/sbf/dap/parqbras.html), and five times the area currently designated as parks (Fig. 1). They also contain larger blocks of forest than parks, as represented in our sample (Fig. 5). In Amazonia, where 84% of the forest is still standing, protection of the regional forest-climate system is critical to the long-term protection of biodiversity, and this will demand forest cover over most of the region (Nobre et al. 1991; Silva Dias et al. 2002). Recent advances in the enforcement of

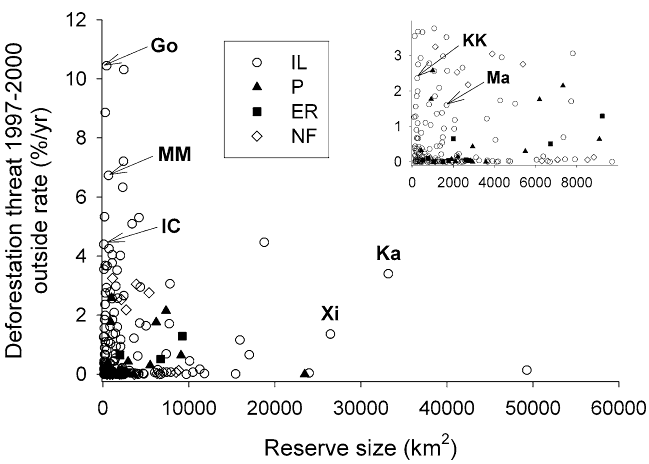

Figure 5. Reserve size versus deforestation rate in the 10-km-wide buffer (i.e., outside) along the outer perimeter of reserve boundaries. Indigenous lands are larger than other reserves and many have high rates of deforestation along their perimeters. Reserve codes defined in Fig. 1 legend.

environmental legislation in the Brazilian Amazon (Nepstad et al. 2002; Fearnside 2003; Soares et al. 2006) demonstrate the potential feasibility of maintaining forest over most of this region. Government regulation of deforestation, fire, and logging is essential to this strategy, as is an expanding network of forest reserves.

The establishment of parks in regions that are largely inaccessible to humans is an important component of a long-term strategy to defend nature in places like the Amazon, but such risk-avoiding reserves must be complemented by reserves within the active frontier. The Brazilian government's efforts to expand the network of parks in the Amazon will have the greatest conservation value if protected areas are successfully established in active frontier regions, where >20,000 km^2 of forest are currently being converted to agriculture each year. This will require strong political support for such initiatives (Brandon 2002; Dourojeanni 2002; van Shaik & Rao 2002) and improvements in government capacity to protect such reserves.

Recent experiences in the 7-million-ha Terra do Meio (Land in the Middle) region north of the Kayapo reserve complex (Fig. 1a) demonstrate that uninhabited parks can gain broad political support within active frontier regions of the Brazilian Amazon if they are advanced within the context of a regional conservation and development planning process that addresses the needs and aspiration of local indigenous groups, agroextractivist populations (e.g., rubber tappers), and colonist farmers. From November 2004 through February 2005, 7 million ha of new reserves were declared in the Brazilian Amazon, including 5 million ha created in the Terra do Meio mosaic. The creation of these reserves brought to fruition a 7-year series of conflicts and campaigns, initiated by a smallholder organization of the Transamazon highway, the Movimento pelo Desenvolvimento do Transamazonico e Xingu (MDTX–Movement for the Development of the Transamazon and Xingu), and supported by regional (Instituto Socioambiental, Instituto de Pesquisa Ambiental da Amazonia, Comissão Pastoral da Terra, Conselho Nacional dos Seringueiros) and international (Environmental Defense, Greenpeace) conservation and land-rights organizations. These new reserves may represent the biggest conservation achievement in the history of tropical conservation. The prospects for further conservation successes on this scale will improve to the extent that conservationists recognize existing and potential roles of diverse alliances of the Amazon's rural populations as protagonists of nature conservation (Diegues 1992).

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