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Conservation and development alliances with the Kayapó of south-eastern Amazonia, a tropical forest indigenous people

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Summary

Legally recognized Indian reserves of Brazilian Amazonia span over 100 million ha of largely intact forest and are potentially valuable for biodiversity conservation. An important example is provided by the Kayapó territories which span more than 13 million ha in Pará and Mato Grosso, Brazil, and protect a unique and vulnerable Amazonian forest type that is poorly represented in existing nature reserves. The Kayapó of southern Pará have stopped invasion of their lands by the most perverse threats to Amazonian forests, but they have become involved extensively in the sale of illegal logging concessions for the high-value timber species mahogany (*Swietenia macrophylla*). In 1992, the non-governmental organization Conservation International do Brasil (CI-Brasil) began a conservation and development project with the Kayapó community of A'Ukre with the objective of providing economic alternatives to logging and protecting a population of mahogany trees. This paper demonstrates the conservation benefits that can be achieved by supporting sustainable development of indigenous peoples in the Amazon. Specifically, we: (1) evaluate the ecological importance of the Kayapó reserves from a biodiversity conservation viewpoint, (2) evaluate the conservation success of the CI-Brasil project and test whether the implementation of the conservation alliance between A'Ukre and CI-Brasil satisfies common pool resource principles, and (3) propose a model for expanding the small-scale conservation results achieved by the CI-Brasil project to all Kayapó territories. Several mammals (*Tayassu pecari*, *Pteronura brasiliensis*, *Priodontes maximus*, *Panthera onca*) and at least one bird species (*Anodorhynchus hyacinthinus*) listed as endangered were regularly encountered within 15 km of A'Ukre. Taxa encountered at relatively high densities in the project area included large cracids, lowland tapir, and white-lipped peccary, indicating an ecosystem that is not severely impacted by hunting. Harvest offtakes of mahogany averaged 0.44 stems ha^{-1} within groves and 0.13 stems ha^{-1} at the landscape level. We estimate that 85% of the fruiting population of *Swietenia macrophylla* has been removed in harvested Kayapó territories in Pará. We found Kayapó social organization in A'Ukre to meet criteria of successful common pool resource institutions. The CI-Brasil project resulted in protection of an intact mahogany population in 8000 ha of forest maintained by the community for ecological research purposes and mahogany preservation. Our analysis attributes the success of the conservation alliance with A'Ukre to: (1) direct benefits accruing to all members of the community, (2) fulfilment of criteria for development of common pool resource institutions, and (3) long-term commitment of an external agency. We propose that by implementing these three elements elsewhere, the modest conservation result achieved at A'Ukre could be expanded to include the entire Kayapó nation and thereby contribute to conservation of more than 13 000 000 ha of forest and cerrado in the south-eastern Amazon.

Keywords: Amazon forest, indigenous community, biodiversity conservation, common pool resource institution, conservation and development project, Kayapó Indians, *Swietenia macrophylla*

Introduction

Legally-recognized Indian reserves of Amazonia span tens of millions of hectares of intact forest ecosystems, placing aboriginal issues at the forefront of biodiversity conservation in the neotropics. Indigenous territories account for 248 of all 459 officially designated conservation areas in the Amazonian region of nine South American countries, encompassing 52% of the area which receives some form of protection (Peres 1994). In the Brazilian Amazon, these protected areas comprise over 100 million ha in area, including 29 reserves each with an area larger than 1 million ha (WCMC 1992). These territories span a broader geographic representation than either nature or extractive reserves (Peres & Terborgh 1995). This makes indigenous territories of enormous poten-

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tial value for biodiversity conservation. Furthermore, human population densities in Amazonian Indian reserves are often low (<0.5 people/km^2) and as a result subsistence extraction of game animals, fish, and non-timber plant products by forest dwellers may be less likely to deplete resource populations.

In the Brazilian States of Pará and Mato Grosso, the Kayapó Indian nation has achieved, both in law and in practice, control over more than 13 million ha of primary forest and *cerrado* (savanna). Remarkably, the most perverse threats to Amazonian forests, including ranching, colonist settlement, and hydroelectric development (Foresta 1991; Fearnside 1993) have been kept outside of Kayapó lands, as demonstrated by the fact that although deforestation has advanced into southern and eastern Pará (Alves *et al.* 1998), it ends abruptly at the borders of two Kayapó lands, the Terras Indígenas Kayapó (hereafter, TIK) and Xicrin do Cateté (Fig. 1).

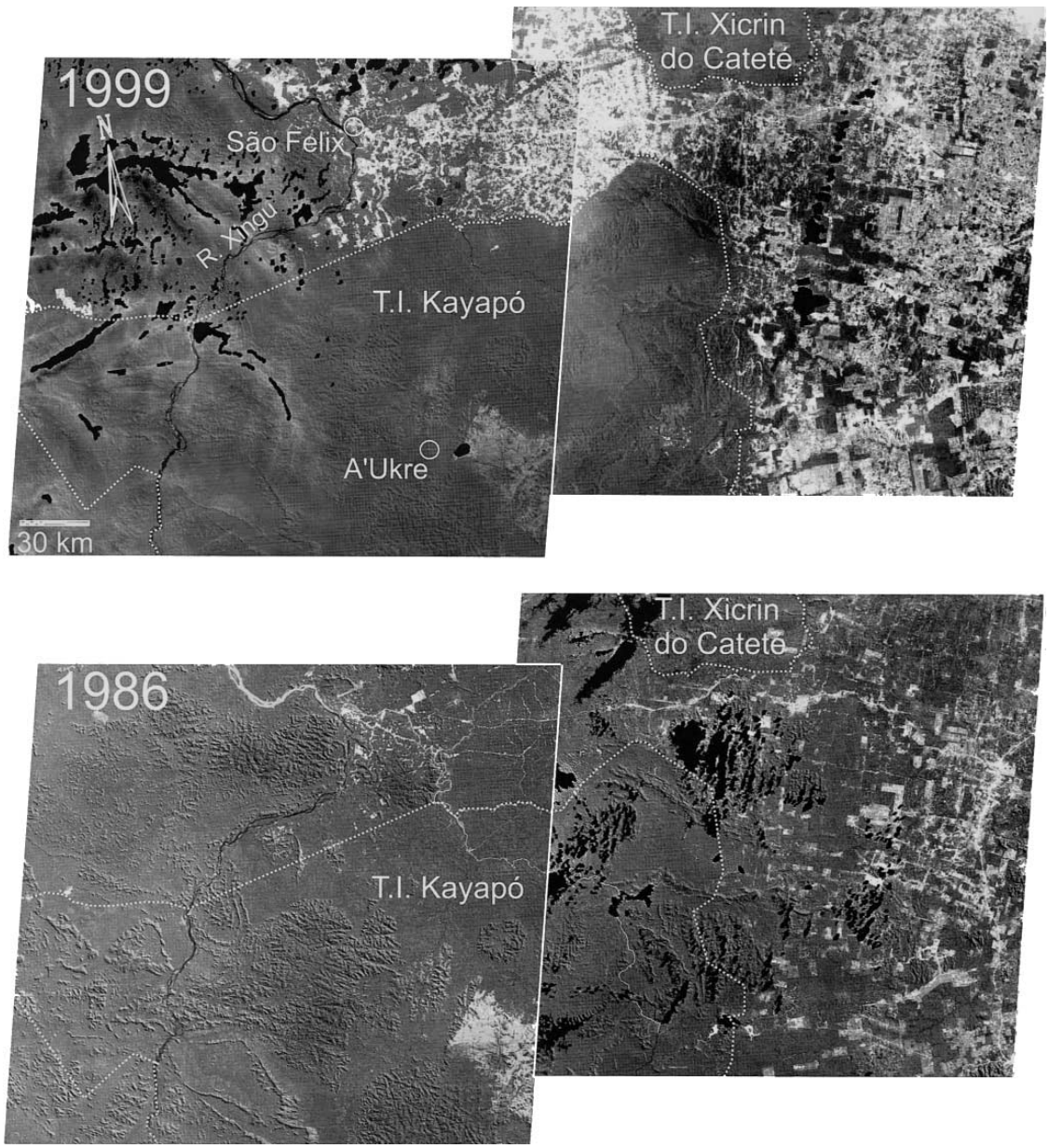

Figure 1 Composites of 1986 and 1999 Landsat satellite images showing that the boundaries of the Terra Indígena Xicrin do Cateté and Terra Indígena Kayapó have served as barriers to deforestation. The rapidly expanding deforestation between 1986 and 1999, especially east of Sâo Felix, remained outside of the Kayapó reserve territories. In the images, light grey geometrical areas are deforestation; dark grey areas are forest; and black areas are cloud cover. The light grey, irregularly-shaped area east of A'Ukre is a naturally occurring savanna (cerrado). The images were acquired by satellite on 15 July 1986, 24 July 1986, 12 August 1999 and 18 October 1999.

Yet, there is much evidence that, like western societies, indigenous South Americans are prone to liquidating their natural resources (Seeger 1982; Redford & Stearman 1993; Peres 1994; Watson 1996), casting doubt on the role of indigenous reserves as viable, long-term repositories of biodiversity. A prominent example of this process is provided by the Kayapó themselves, who during the past 15 years have made millions of dollars selling illegal gold-mining and mahogany-logging concessions (Verissimo *et al.* 1995; Watson 1996; Turner 1999). The highly selective logging of broadleaf mahogany (*Swietenia macrophylla*) is driven by the extraordinarily high value of mahogany on international markets, which makes it lucrative for loggers to harvest in remote Kayapó lands even when transportation and royalty costs are high.

Nevertheless, the Kayapó present an extraordinary opportunity for ecosystem conservation because in addition to the vast area of their combined reserve units, they militantly defend their territory and rights and remain a traditional culture adapted to forest/cerrado with no present interest or capacity to engage in large-scale agriculture. The challenge for environmentalists working to construct conservation alliances with indigenous peoples in Brazil is to seek a 'middle ground',whereby the desire of indigenous peoples for self-determination and control over their resources coincides with sustainable resource management and persistence of natural forest ecosystems (Conklin & Graham 1995). Specific challenges for conservation organizations working with Kayapó communities are to provide: (1) economic alternatives to logging and, possibly in a few cases, gold-mining, (2) information to make rational development decisions while contributing to empowerment of the Kayapó as protectors of natural habitats in the south-eastern Amazon, and (3) protection for broadleaf mahogany, which, under unrelenting harvest, has lost much of its reproductive population in Pará state. With these aims in mind, and recognizing the extraordinary territorial protection services provided by the Kayapó, Conservation International do Brasil (CI-Brasil) established a conservation and development project with the Kayapó community of A'Ukre in the TIK, Pará.

The objective of this paper is to demonstrate the conservation benefits that can be achieved by supporting sustainable development of indigenous peoples in the Amazon. Specifically, our goals are threefold. First, we evaluate the ecological importance of the Kayapó reserves from a biodiversity conservation viewpoint, focusing on survey records of rare and endangered taxa and on the potential damage incurred during mahogany logging. Second, we evaluate the conservation success of the CI-Brasil project and test whether the implementation of the conservation alliance between A'Ukre and CI-Brasil satisfies Ostrom's (1990) common pool resource (CPR) principles as revised by Morrow and Hull (1996). Thirdly, we propose a model for expanding the small-scale conservation results achieved by the CI-Brasil project to the 13 million ha of forest and cerrado controlled by the Kayapó in the south-eastern Amazon.

Historical Background

The Kayapó occupy an area spanning more than 13 million ha on both sides of the Xingú River in the Brazilian states of Pará and Mato Grosso (Fig. 2). The Kayapó, who call themselves Mebengokre, officially include the following peoples in Pará and Mato Grosso: Menkrangnotire, Kararaô, Xicrin do Bacaja, Xicrin do Cateté, Pu'Ro, Pituiaro, Metuktire, A'Ukre, Gorotire, Kikretum, Kokraimoro, and Kubenkran-ken (CEDI 1990). The following contiguous Kayapó reservations encompass a total of 10 905 175 ha and to the south abut with the Parque Indígena do Xingu (2 642 008 ha): Terra Indígena Capoto-Jarina (634 915 ha), Terra Indígena Menkragnoti (4 914 255 ha), Terra Indígena Baú (1 850 000 ha), Terra Indígena Kayapó (3 284 005 ha) and Terra Indígena Badjonkore (222 000 ha) (ISA [Brasilia], personal communication 1999). The Terra Indígenas Capoto-Jarina, Menkragnoti and Kayapó are legally ratified and demarcated whereas Terra Indígenas Baú and Badjonkore await legal rati-

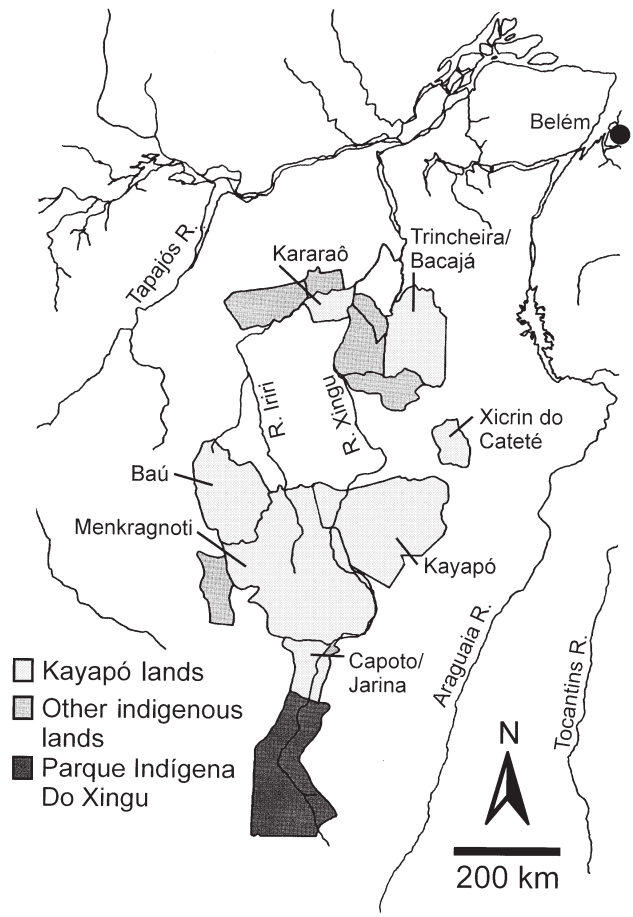

Figure 2 Map showing locations of the Kayapó lands (Terras Indígenas) in the Brazilian States of Pará and Mato Grosso. The Terra Indigena Badjonkore is not yet drawn on available maps but this Kayapó territory spans the area between the southern border of the TI Kayapó and eastern border of the TI Menkragnoti (ISA, personal communication 2000).

fication (ISA [Brasília], personal communication 1999). In addition, there are three non-contiguous, but demarcated and legally ratified, Kayapó reservations, namely: Terra Indígena Xikcrin do Cateté (439 151 ha), Terra Indígena Trincheira-Bacajá (1 650 939 ha) and Terra Indígena Kararaô (330 837 ha). Fifteen Kayapó villages are widely dispersed over this area and range in size from <100 to 1000 people; the total population in 1998 was about 5000 (T. Turner, unpublished data 1998). After more than a century of battles over Brazilian incursions into their territories, most of the extant Kayapó groups entered into peaceful relations with the national society in the mid-1950s.

Peace, however, has not stopped the pressure on their lands and communities that is being exerted by encroaching settlers, miners, loggers, ranchers, and governments. Unlike many other native Amazonians, however, the Kayapó were able to organize the resources and political will to resist these pressures. Drawing on social institutions, cultural traditions, and able leadership, they launched a resistance campaign that since its beginnings in the 1970s has won them official recognition on most of their traditional lands and gained them influence on the national and international scenes (Turner 1999). The Kayapó resistance combined armed struggle against illegal intruders with diplomatic negotiation and a series of demonstrations in Brazilian cities. These demonstrations contributed significantly to forcing: (1) the halting of a Brazilian government and World Bank-financed hydroelectric megaproject in the Xingú valley, (2) abandonment of governmental efforts to prosecute Kayapó leaders for protests against government development plans within Kayapó territory, (3) abandonment of a government plan for dumping radioactive waste in Indian-occupied areas of the Amazon forest, and (4) return to Kayapó ownership of tribal lands from mining companies (and the Brazilian government itself) that had been illegally expropriated or not recognized as belonging to the Kayapó (Turner 1999). In addition, they decisively influenced the redrafting of the 1988 Brazilian Constitution to protect the rights of all indigenous peoples within Brazil.

However, there are other sides to the Kayapó story. During the past fifteen years, many leaders entered into contracts with Brazilian mahogany loggers and gold miners. Although these contracts were ostensibly on behalf of their communities and did bring some communal benefits, some leaders abused the illegal deals to provide themselves with houses, cars, and airplanes in frontier towns adjacent to the Kayapó reserves. Gold-mining and logging in the vicinity of a few communities polluted rivers, introduced malaria and other diseases, and disturbed the forest. In 1994, after 10 years of these influences, the people of the two most affected communities, Gorotire and Caeteté, turned against these leaders and ended these activities on Kayapó land (Turner 1995). In these communities, villagers defied the younger leaders who had signed the contracts and brought in previously ineffective senior chiefs to give the stamp of traditional authority to community demands. These local movements precipitated a general meeting of the leaders of all Kayapó communities, which unanimously called for the expulsion of all miners and loggers from Kayapó land. With the cooperation of the Brazilian Federal Police, this was accomplished in all but one area of the TIK. Although mahogany logging was again widespread by the summer of 1996 under renewed contracts between loggers and Kayapó leaders, the events of 1994 demonstrated the control that the Kayapó exert over their lands. At present, gold mining and mahogany logging are greatly diminished in the TIK primarily because of resource depletion.

The Kayapó carried out this revolution against Brazilian loggers and miners through their own internal political processes and institutions, which continued to function along with the still-intact ceremonial and kinship systems as the framework of their communities that are socially and politically autonomous (Turner 1995). However, after three decades of interaction with Brazilian society, the Kayapó have become an inseparable part of the inter-ethnic economy of the region in which they live. They need to pay for medical treatment, education, transportation, and communication services that the Brazilian government is largely unable to provide. It is interesting to note that over the years, substantial profits from gold and mahogany have been invested in territorial protection. Territorial enforcement and monitoring costs included aerial patrols, purchases of communication radios and boats, demonstrations in Brasília and at Altamira, and strategic meetings of Kayapó leadership. Thus, despite corruption, significant resources were marshalled to support community activities. It is ironic that although mahogany has been a catalyst for initiating deforestation in much of the rest of eastern and southern Amazon (Fearnside 1997), the success of Kayapó territorial defence in part can be attributed to mahogany profits.

The village of A'Ukre in the TIK where the CI-Brasil project is based is a Kayapó community of approximately 200 people accessible by air from the south-eastern Pará frontier town of Redenção. River access is difficult and there are no permanent roads. This community was more or less isolated until 1989, when the leadership began selling mahogany logging concessions to illegal loggers from Redenção. A'Ukre controls an area of approximately 300 000 ha unofficially bounded by the territories of the neighbouring villages of Moikarako, Kubenkran-ken, and Gorotire. The extent to which these areas are controlled by different communities became an issue during the past decade when communities vied for ownership of mahogany trees. Boundaries were settled among the different community leaders and disputes sometimes involved taking the loggers hostage and seizing machinery that was perceived to be trespassing from neighbouring territories (B. Zimmerman, personal observation). In the early 1990s, warriors from A'Ukre killed trespassing loggers. This militant, action-oriented attitude, which effectively deterred appropriation of forest resources, is unprecedented in other tropical forest regions where invasions along logging roads by outsiders have usually proceeded unencumbered.

Methods

Study site

In 1992, the CI-Brasil project was initiated at the request of the leadership of the Kayapó Indian village of A'Ukre, Pará (S 7° 41' 15", W 51° 52' 25"). Ecological research is based at a biological research station, The Kayapó Centre for Ecological Studies (=Pinkaití), located 15 km upriver from A'Ukre in a 8000 ha forest reserve established by the community for research purposes.

This forest region of southern Pará has a highly seasonal rainfall of less than 1700 mm yr^{-1} and a strong dry season of as many as 100 rainless days yr^{-1}. The climate sustains a semi-deciduous forest. Approximately 15% of a 80 by 80 km area (640 000 ha) centred around A'Ukre is cerrado, distributed largely on a few upland plateaus (see Malcolm *et al.* 1999). The community of A'Ukre controls approximately 310 000 ha of this area. Rocky ridges throughout the area are 100–250 m in altitude. The cerrado has never been grazed by livestock and often burns during the dry season.

The forest controlled by A'Ukre was logged extensively for mahogany, principally along valley bottoms, during the dry seasons of 1989 through 1998 (with the exception of 1995). The road from A'Ukre to Redenção was recleared each of these years, becoming functional during the dry season (June–September or October) when logs were transported using heavy machinery. Between 1000 and 2000 mahogany trees >50 cm in diameter at breast height (dbh) were harvested each dry season (B. Zimmerman, unpublished data). The 50 cm diameter limit was the minimum saleable log size; however, because tree-fellers were paid by the number of mahogany trees felled and carried no measuring tapes, trees less than 50 cm diameter were often cut down (B. Zimmerman, personal observation). Logging intensities of mahogany reported elsewhere have averaged 3–5 m^3 ha^{-1} or approximately one tree ha^{-1} (Verissimo *et al.* 1995). Due principally to stock depletion, logging of mahogany in A'Ukre territory ceased in 1999.

Biological resources of the Kayapó indigenous territory

Large-bodied vertebrates are arguably the most sensitive renewable resources extracted from Amazonian forests (Robinson & Bennett 2000). Kayapó villagers of A'Ukre alone consumed a total of 743 mammals, 210 birds, and 364 tortoises over 324 days of study during 14 consecutive months between June 1995 and July 1996 (Nascimento 1999). Therefore, we quantified patterns of game abundance at the Pinkaití study area in order to evaluate the overall impact of the game harvest by the Kayapó villagers of A'Ukre.

A series of repeated line-transect censuses of forest mammal, bird, and tortoise populations were conducted by C. Peres on 4- to 5-km long transects on both banks of the Riozinho River at Pinkaití. The total census effort amounted to a cumulative walking distance of 248.5 km on five transects, conducted over four consecutive years (1994–1997). Population density estimates (individuals per km^{-2}) were calculated using the program DISTANCE (Version 3.5; Thomas *et al.* 1998) for all species that met the minimum number of independent sightings recommended (25-30) (Buckland *et al.* 1993). Because night surveys were not carried out, densities of nocturnal species such as pacas (*Agouti paca*) and armadillos (for example *Priodontes maximus*) were presumably underestimated. Density data for red (*Mazama americana*) and grey brocket deer (*M. gouazoubira*) were pooled because identifications to species level were rarely possible by the fleeting glimpse afforded upon an encounter. The same was done with both species of curassows (*Crax fasciolata* and *Mitu mitu*) and the two species of common guans (*Penelope pileata* and *P. superciliaris*). Further details of census methodology and data analysis are presented in Peres (1999, 2000*a*, *b*). In addition to this standardized survey effort, we also tabulate records of other notable taxa (especially rare and vulnerable species) reported by other researchers working in the area (C. Peres, H. Nascimento, A. Aleixo, B. Zimmerman & M. Rodrigues, unpublished data; Whitney 1995).

We estimated mahogany offtake rates both in mahogany groves and in the lowland forest as a whole. Groves (which formed the focus of logging operations) were defined operationally as concentrations of trees where trees were at most 300 m from one another. We mapped the stumps in five groves using a compass and hip chain and also measured the diameters of the stumps (without buttresses). To estimate the area of a grove, we measured the area of the minimum convex polygon encompassing the stumps (i.e. the polygon with all external angles greater than 180°). Landscape-level offtake rates were estimated in two ways: (1) by calculating minimum convex polygons that in addition to the stumps in the groves included isolated stumps in the vicinity of the groves and (2) by calculating the density of stems ⩾50 cm dbh in a 525 ha area in the 8000 ha Pinkaití ecological reserve that was censused exhaustively for mahogany ⩾5 cm dbh. We also used this 525-ha census to estimate the proportion of the total mahogany population in lowland areas that is removed by logging.

Common pool resource principles and conservation success

The objective of the CI-Brazil project is to direct a sustainable flow of benefits from the forest to the people of A'Ukre and hence provide an economic alternative to logging and contribute to the Kayapó's capacity for self-determination. The project followed a key principle shared by many conservation and development projects, namely: long-term conservation of biodiversity by generating benefits for local people. The project so far has focused its efforts on the ecological research station (Pinkaití) because: (1) as a protected and ecologically intact tropical wilderness, the TIK

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can be expected to attract researcher clients, (2) the intact nature of Kayapó culture and biological knowledge is an asset to researchers, (3) researchers can provide employment and training for Kayapó assistants, (4) station fees paid by researchers to the community provide tangible benefits to villagers, (5) the research station infrastructure can act as a base for elaborating other alternatives, such as ecotourism and research on non-timber forest products (such as Brazil nut), for example and (6) researchers can provide information on development options, understanding of the outside world, and validation of Kayapó culture that is not provided by other long-term contacts (principally loggers).

The criteria for successful common pool resource institutions as outlined by Ostrom (1990, 1992) and Morrow and Hull (1996) are:

(1) the resource and its users are clearly defined and the appropriators are able to sustain legal claims as owners of the resource or effectively defend the resource from outsiders;
(2) appropriation and provision rules are congruent with the resource and with the cultural norms and social and economic patterns of interaction of the appropriators. The pace and scale of the institution are congruent with traditional decision-making;
(3) most individuals affected by the operational rules can participate in modifying these rules;
(4) monitors, who actively audit common resource pool conditions and appropriator behaviour, are accountable to the appropriators or are the appropriators;
(5) appropriators have rapid access to low-cost, internally adaptive conflict-resolution mechanisms to resolve disputes among appropriators or between appropriators and project officials; and
(6) the rights and ability of appropriators to devise their own institutions are not challenged by any other authorities, internal or external, that have the ability to undermine the institutions.

Results

Biological resources of the Kayapó Indigenous Territory (TIK)

The TIK is of particular value in an Amazonian context because of the interdigitation of both closed-canopy Amazonian terra firme (non-flooded) forest and central Brazilian cerrado. Several vertebrate species of conservation note typically found in cerrado and adjacent transitional forests were recorded within the A'Ukre territory and in some cases occurred at relatively high densities (Table 1).

Several mammals (white-lipped peccary [*Tayassu pecari*], giant otter [*Pteronura brasiliensis*], giant armadillo [*Priodontes maximus*], jaguar [*Panthera onca*]) and at least one bird species (hyacinth macaw [*Anodorhynchus hyacinthinus*]) native to the south-eastern Amazon and listed as endangered (Collar *et al.* 1992; Fonseca *et al.* 1994) have been regularly encountered within 15 km of A'Ukre in the Pinkaití research area (Table 1). Vulnerable vertebrate species occurring east of the Xingú River, but entirely or largely unprotected outside the TIK, included the eastern Amazonian bearded saki monkey (*Chiropotes satanas utahicki*), red-handed howler monkey (*Alouatta belzebul* epiphenotype *discolor*), white-whiskered spider monkey (*Ateles marginatus*), neotropical otter (*Lutra longicaudis*), bush dog (*Speothos venaticus*), blue-winged macaw (*Ara maracana*), bare-faced curassow (*Crax fasciolata*), razor-billed curassow (*Mitu tuberosa*), red-throated piping guan (*Pipile cujubi*), umbrellabird (*Cephalopterus ornatus*), bare-necked fruitcrow (*Gymnoderus phoetidus*), wood stork (*Mycteria americana*), and chestnut-throated spinetail (*Synallaxis cherriei*) (Table 1).

The A'Ukre territory remained reasonably undisturbed as judged by population densities of some of the most vulnerable vertebrate species found in Amazonian forests. Several taxa encountered at relatively high densities in the Pinkaití area (including large cracids, lowland tapir, and white-lipped peccary; Table 2) indicate an ecosystem that is not severely impacted by hunting (Peres 2000*a*, *b*).

Harvest offtakes within mahogany groves ranged from 0.16 to 5.5 stems ha^{-1}, with an average of 0.44 stems ha^{-1} (119 stumps in 271 ha; Table 3). At the landscape level, offtakes were very low, ranging from 0.09 to 0.20 stems ha^{-1}, with an average of 0.13 stems stems ha^{-1} (170 stumps in 1292 ha including the 525-ha Pinkaití area with removal of stems $\geqslant$50 cm in dbh; Table 4).

A high percentage of *Swietenia macrophylla* over approximately 50 cm dbh has been harvested from more than 3 million ha of the TIK (B. Zimmerman, personal observation; Santilli 1999). Most of those trees that have survived the cut are located on ridges which are too steep for skidder or bulldozer travel. Although the crop of juveniles and subadults is abundant in some areas, the harvest has removed a considerable proportion of the population, especially the reproductive population. For example, of the 142 individuals $\geqslant$5 cm in dbh located in a 525 ha area close to the Pinkaití research station, removal of individuals $\geqslant$50 cm would result in removal of 39% of the total population (Fig. 3). Removal of individuals > 50 cm dbh at another study site in the region (Marajoara, 185 km from Pinkaití) would eliminate approximately 48% of the population (J. Grogan, personal communication 2000). If we consider just the reproductive population and use 40 cm dbh as the average size observed in natural forest at which mahogany trees begin producing mature fruits (J. Grogan, personal communication 2000), then the 50 cm diameter limit would result in removal of 85% of the fruiting population at Pinkaití. Even with a very conservative assumption of 30 cm dbh as fruiting maturity, a 50 cm cut would remove 78% of the reproducing population.

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Table 1 The conservation status according to IUCN (1996) and Brazil (1989; see Bernardes *et al*. 1990) of several species observed in the Terra Indígena Kayapó, Rio Xingu, Pará. EN = endangered, VU = vulnerable, LR nt = lower risk, near threatened, LR cd = lower risk, conservation dependent. The letters and numbers following the IUCN categories are codes for the reasons that the species is considered threatened following the Mace-Lande system adopted by the World Conservation Union (IUCN) Council in November 1994 (IUCN 1995). Sources: Bernardes *et al*. (1990), IUCN (1996), Fonseca *et al*. (1994), Rylands (1997), M.T. Rodrigues (personal communication 2000).

Species	*Common name*	*IUCN(1996)*	*Brazil (1989)*	*Threat*
Mammals				
Chiropotes satanas utahicki	Uta Hick's bearded saki	VU B1+2c	X	Restricted range, hunting
Alouatta belzebul (epiphenotype *discolor*)	Red-handed howler			Hunting, may be locally rare
Ateles marginatus	White-whiskered spider monkey	EN B1+2abcde	X	Restricted range, hunting
Pteronura brasiliensis	Giant river otter	VU A2cd	X	Hunting, habitat disturbance
Lontra longicaudis	Neotropical otter		X	Hunting, habitat disturbance
Speothos venaticus	Bush dog	VU C2a	X	Rare, habitat disturbance
Atelocynus microtis	Short-eared dog		X	Rare, hunted
Puma concolor	Puma		X	Rare, hunted
Leopardus pardalis	Ocelot		X	Rare, hunted
Leopardus wiedii	Margay		X	Rare, hunted
Leopardus tigrina	Forest cat		X	Rare, hunting
Panthera onca	Jaguar	LR nt	X	Rare, hunted
Tapirus terrestris	Brazilian tapir	LR nt		Hunting, habitat loss
Odocoileus virginianus	White-tailed deer		X	Hunting
Priodontes maximus	Giant armadillo	EN A1 cd	X	Hunting, naturally rare
Myrmecophaga tetradactyla	Giant anteater	VU A1 cd	X	Hunting, naturally rare
Birds				
Harpia harpyja	Harpy eagle	LR nt	X	Rare
Morphnus guianensis	Crested eagle	LR nt	X	Rare
Spizastur melanoleucus	Black-and-white hawk eagle	LR nt	X	Rare
Accipiter poliogaster	Grey-bellied goshawk	LR nt	X	Rare
Falco deiroleucus	Orange-breasted falcon	LR nt	X	Rare
Anodorhynchus hyacinthinus	Hyacinth macaw	VU A1cd+2cd	X	Hunting
Ara maracana	Blue-winged macaw	VU,A1 ac,C1+2a		Hunting
Penelope superciliaris	Rusty-margined guan			
Crax fasciolata	Bare-faced curassow		X	
Mitu tuberosa	Razor-billed curassow			
Pipile cujubi	Red-throated piping guan			
Cephalopterus ornatus	Umbrellabird			
Gymnoderus phoetidus	Bare-necked fruitcrow			
Mycteria americana	Wood stork			
Synallaxis cherriei	Chestnut-throated spinetail	LR nt		Very restricted range
Reptiles				
Podocnemis expansa	South American river turtle	LR cd		Hunted
Melanosuchus niger	Black caiman	EN A1cd	X	Hunting
Micrablepharus atticolus	Terrestrial lizard			Very restricted range
Tropidurus insulanus	Terrestrial lizard			Very restricted range
Mabuya sp. (*frenata* group)	Terrestrial lizard			Very restricted range
Apostolepis flavotorquata	Fossorial snake			Very restricted range
Crotalus durissus	Rattle-snake			Very restricted range

The Kayapó Conservation and Development Project as a common pool resource institution

The CI-Brasil Pinkaití research station project has resulted in: (1) a research station built by the Kayapó of A'Ukre and jointly managed by A'Ukre villagers and CI-Brasil; (2) a biological reserve of 8000 ha with a trail system for research and educational purposes; (3) preservation of an undisturbed population of mahogany trees in the 8000 ha research area; (4) ecological research on forest management (for example, seven Ph.D. dissertations and four M.Sc. theses completed or in progress); (5) research results that are

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Table 2 Average population density estimates for game vertebrate species within the Pinkaití study area of the Kayapó reserve based on 248.5 km of line transect (see text for details).

Taxon	*Mean adult body mass (kg)*	*Density (km^{-2})*
Game mammals		
Brown capuchin monkey *(Cebus apella)*	2.70	29.20
Bearded saki monkey *(Chiropotes satanas utahicki)*	2.40	16.50
Howler monkey *(Alouatta belzebul)*	6.50	8.03
Lowland tapir *(Tapirus terrestris)*	139.60	0.62
Collared peccary *(Pecari tajacu)*	16.20	8.48
White-lipped peccary *(Tayassu pecari)*	31.40	5.90
Brocket deer *(Mazama americana/ M. gouaz oubira)*	25.30	3.23
Agouti *(Dasyprocta agouti)*	2.90	43.34
Paca *(Agouti paca)*	6.80	4.50
South American coati *(Nasua nasua)*	3.10	5.68
Giant armadillo *(Priodontes maximus)*	31.50	1.60
Game birds		
Curassows *(Mitu tuberosa/ Crax fasciolata)*	2.70	9.00
Red-throated piping guan *(Pipile cujubi)*	1.20	2.77
Common guans *(Penelope pileata/ P. superciliaris)*	1.10	22.26
Dark-winged trumpeter *(Psophia viridis)*	1.10	33.06
Large tinamous *(Tinamus spp.)*	1.20	15.10
Small tinamous *(Crypturellus spp.)*	0.38	10.40
Game reptiles		
Tortoises *(Geochelone carbonaria/ G. denticulata)*	4.30	7.50

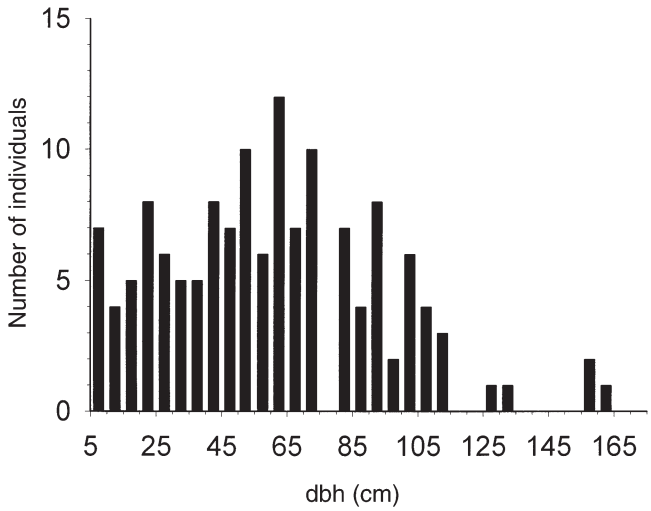

Figure 3 Number of mahogany (*Swietenia macrophylla*) individuals in 5 cm diameter at breast height (dbh) classes in a 525-ha area close to the Pinkaití research station in the Terra Indígena Kayapó, Pará, Brazil.

contributing to prospects for stainable forest management in the southeastern Amazon, including work completed or in progress on natural stands of mahogany, Brazil-nut trees, sustainable timber harvest intensities, biological indicators of sustainable logging, and sustainable harvest levels of game species; (6) in 2000, full time employment and training for five Kayapó research assistants and part-time positions for 10 others; and (7) in 1999 and 2000, US$7000 of medicines (entry fees), principally for malaria, paid to the community by researchers and visitors.

We found the Pinkaití project to satisfy design criteria of successful common pool resource institutions.

(1) The resource and the users of the resource are clearly

Table 3 Characteristics of logged mahogany (*Swietenia macrophylla*) groves in the Terra Indígena Kayapó. Stump diameters are without buttresses.

Grove	*Number of stumps*	*Mean (and range) of stump diameters (cm)*	*Area of minimum convex polygon (ha)*	*Stump density (stumps ha^{-1})*
Angrokudju-1	18	112 (56–233)	113.6	0.16
Angrokudju-2	14	109 (64–183)	6.5	2.16
Apetigniri	49	151 (66–364)	117.5	0.42
Djorodjo	15	173 (99–286)	2.7	5.5
Kenpore	12	163 (100–245)	17.5	0.69
Osmar	11	199 (103–395)	13.2	0.83

Table 4 Estimates of landscape-level logging intensity for mahogany *(Swietenia macrophylla)* in the Terra Indígena Kayapó.[1] Number of stems ⩾50 cm dbh in a 525-ha area censused exhaustively for mahogany.

Site	*Number of stumps*	*Area of minimum convex polygon (ha)*	*Stump density (stumps ha^{-1})*
Angro-kudju	35	376	0.09
Apeti-gniri	54	270	0.20
Kenpore	17	121	0.14
Pinkaití (50 cm dbh)[1]	64	525	0.12

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defined and the appropriators are able to sustain legal claims as owners of the resource, or, are able to effectively defend the resource from outsiders. The TIK in Pará is a legally ratified and demarcated reserve for Kayapó Indians who continue to successfully defend their lands from appropriation by outsiders (Fig. 1). Kayapó communities are politically and economically autonomous. The overall reservation territory is subdivided into areas agreed to, and controlled by, the different communities. As was observed during the years of mahogany logging, loggers contracted by neighbouring communities were prohibited from entering A'Ukre territory. There is the possibility that the Brazilian government will attempt to expropriate Kayapó territories (as it has done in the past), but the ability of the Kayapó to marshal negative press may serve as a deterrent.

(2) Appropriation and provision rules are congruent with the resource and with the cultural norms and social and economic patterns of interaction of the appropriators. The pace and scale of the institution are congruent with traditional decision-making. The research station project operates in accordance with Kayapó socioeconomic autonomy in that the project is a single-community institution. Administrative decisions by the Kayapó are based on traditional, consensual decision-making rather than western, hierarchical management, of which this egalitarian society has little understanding. It is anathema for one Kayapó to tell another Kayapó what to do.

The Pinkaití Research Station is in a biological reserve chosen by the community. Scientists who use the field station and research area execute their own projects and employ Kayapó field assistants and pay the community an entry fee. CI-Brazil provides infrastructure and administrative support that facilitates research at the site. The responsibility of the community is to: (i) maintain the pristine status of the research reserve, which includes a ban on hunting and logging, (ii) receive researchers arriving by plane at A'Ukre, and (iii) assist with transportation upriver to the field station. Expectations of the researchers by the community, and vice versa, are agreed upon in the traditional manner of consensus-seeking meetings with the senior men (warrior class). The important egalitarian principle of Kayapó society is satisfied by researcher contributions of medicine (or entry fee) to the community, which means that everyone benefits from the field station rather than just the few families with members employed by the station. The hunting opportunities forgone in the area do not incur significant costs to villagers at A'Ukre because their territory is large and human densities are low (approximately 0.07 people/km^2).

The Pinkaití project does not operate at a level above that of the kin groups in which the Kayapó are accustomed to working and the scale of the project is congruent with local conditions. The Kayapó of A'Ukre have been faced with a cash economy for only ten years. Social upheaval and transition precipitated by this new force revolves principally around resolution of the egalitarian nature of their traditional culture with the idea of wealth accumulation introduced by the loggers. Although the Kayapó have traditional chiefs, they lack experience with executive authority or management similar to that found in Western economic enterprises. Some socioeconomic adaptations have taken place, principally, for example, community members eventually demanded of their leaders that logging profits be spent to benefit everyone rather than just the chief and his family. Very few individuals are literate or speak Portuguese and project administration remains for now the responsibility of CI-Brazil.

(3) Most individuals affected by the operational rules can participate in modifying these rules. The project is not restricted by formal or legal rules of operation, and institutional structure is simple; project personnel and researchers meet with the community in traditional fora to agree upon operating strategies and rules.

(4) Monitors, who actively audit common resource pool conditions and appropriator behaviour, are accountable to the appropriators or are the appropriators. With the expectation of benefits, mahogany logging was monitored and loggers under contract with other villages were excluded from A'Ukre's territory. In 1998, the community stopped the attempted sale of mahogany logs in the research reserve by one of its members. Similarly, an influential individual's idea to open a goldmine within A'Ukre's territory was vetoed when the community understood that the research station project would be destroyed as a result. In general, the Kayapó patrol their borders and respond quickly to rancher or colonist threats across the entire Kayapó reserve. Hostage-taking is a favourite tactic. A'Ukre is located near the centre of the TIK and is buffered from the frontier by three other village territories.

(5) Appropriators have rapid access to low-cost, internally adaptive conflict-resolution mechanisms to resolve disputes among appropriators or between appropriators and project officials. Problems are resolved in the traditional Kayapó arena of community discussions which aim for consensus. Reasons why Kayapó-style dispute resolution functions for this project include the fact that the project is small scale and straightforward in nature, the village population is small, and external stakeholders are few, being only the long-term researchers, who are free to chose alternative field sites.

(6) The rights and ability of appropriators to devise their own institutions are not challenged by any other authorities, internal or external, that have the ability to undermine the institutions. The people of A'Ukre have controlled mahogany logging on their land, including the exclusion of trespassing loggers and prohibition of logging within the 8000 ha Pinkaití research reserve. The community has been able to protect the mahogany of the research reserve both from loggers and members of the community. Also, the project has been shaped according to the community's needs and demands. For example, researchers began paying an 'entry fee' in the form of medicine when it became clear that creating a few jobs, even with the possibility for growth in number of positions, was not satisfying the Kayapó social principle of egalitarianism.

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Discussion

Over the past three decades, the region spanning the southern and eastern flanks of Brazilian Amazonia has been threatened by high rates of agricultural encroachment and deforestation (Fearnside & Ferraz 1995; Fig. 1). Between 1991 and 1994, some 13 900 ha of forest were cleared from the municipal area of the town of Redenção alone (Alves *et al.* 1998). In the absence of adequate geographic representation of strictly protected conservation areas east of the Xingú River, the TIK serves an important function as a *de facto* protected area for the region's biological diversity. Only one officially-designated conservation area exists east of the entire Xingú-Tocantins/Araguaia interfluvium, namely the 103 000-ha Tapirapé Biological Reserve, which was decreed in 1989. However, this nature reserve does not include the same vegetation types as the TIK and in practice remains unprotected; as of 1991, this reserve employed no park guards or administrative staff (Rylands 1991). Indeed, almost all Amazonian nature reserves tend to be chronically understaffed and underfunded, exist only on paper, and in recent decades have been overrun by a number of severe threats to biological conservation (Peres & Terborgh 1995). The Tapirapé Biological Reserve is also unlikely to be large enough to retain viable populations of some of the disturbance-sensitive species found in TIK. In that respect, few research areas in the region other than TIK could be used for ecological studies of undisturbed populations of commercially important species. Indeed, no other large forest reserve in south-eastern Amazonia currently safeguards a full complement of disturbance-sensitive wildlife and the entire vegetation transition from open cerrado to close-canopy forests (Fearnside & Ferraz 1995).

Aside from mahogany, we found that populations of most species in the A'Ukre territory are unlikely to have been seriously impacted by recent human disturbances, particularly by hunting and logging. Large-bodied game species, which are preferred by local peoples throughout the Amazon (Bodmer 1995; Peres 1990, 2000*b*), were abundant within the hunting range of the Kayapó of A'Ukre. The high density of game species was also demonstrated by kill records from the village of A'Ukre during two years of study (Nascimento 1999; C. Peres & H. Nascimento, unpublished data). These include some of the highest recorded yields of tapir, white-lipped peccary, collared peccary, brown capuchin monkey, bearded saki monkeys, large cracids, and tortoises, populations of which tend to be severely depleted, if not driven to local extinction, in heavily-hunted Amazonian forests (Peres 1996, 1999, 2000*a*). Based on these observations, wildlife populations of the A'Ukre territory appear to be large enough to support subsistence lifestyles of members of this community at its present size.

Selective logging of mahogany has impacted the forest through creation of gaps due to tree falls and construction of roads and skid trails. Logging increases the natural density of gaps, which have been identified as a key correlate of plant regeneration (Brokaw 1985; Denslow 1987; Hartshorn 1989; Clark 1994) and trigger other ecological changes (Steege *et al.* 1996; Grieser-Johns 1997; Struhsaker 1997). However, indications are that except for the effects of logging on mahogany itself, this forest ecosystem is unlikely to have suffered severe or irreversible damage under the low intensity of selective logging. In Ugandan tropical forest, low intensity logging (approximately 1 tree ha^{-1}) resulted in few discernable ecological effects, and the regeneration dynamics of primary forest trees remained intact (Plumtre 1996; Chapman & Chapman 1997; Struhsaker 1997; Chapman *et al.* 2000). In the A'Ukre area, logging at its most intense occurred at lower intensities than this, and landscape-level estimates of offtake rates were nearly one-tenth of this (i.e. close to 0.1 stems ha^{-1}). Thus, the overall logging disturbance is very low, and it seems likely that it is within the range of disturbance from which this forest can recover naturally. Data on the effects of logging at various intensities on the regeneration capacity of Amazonian forests and tree populations are urgently needed.

For mahogany itself, however, regeneration may be seriously compromised. Our estimates of removal of mature individuals in the preferred lowland, stream-associated, habitat of this species (J. Grogan, personal communication 2000) were as high as 85%. Mahogany populations at Marajoara, a study site east of Pinkaití near Redençao, show size class frequency distributions similar to the Pinkaití sample, with approximately constant stem counts up to approximately 80 cm dbh, above which large individuals become progressively rarer (J. Grogan, personal communication 2000). Logging of individuals greater than 50 cm dbh at Marajoara would mean removal of approximately 80% of the mature, fruiting population. At least in the short term, harvest at such high rates can be expected to compromise population growth and re-colonization of harvested areas. Distribution of the remaining roughly one-half of the population > 5 cm dbh may be too sparse for effective regeneration (Guariguata & Pinard 1998).

In light of the uncontrolled, unsustainable exploitation of mahogany in Pará state, it is of conservation significance that the CI-Brazil project with A'Ukre resulted in protection of one of the last stands of mature mahogany (*Swietenia macrophylla*) in the region and possibly the only protected population of *S. macrophylla* anywhere. Direct benefits accruing to all community members proved decisive in motivating the community to maintain the Pinkaití biological reserve and research station project in a confrontation with a leading community member who wished to bring loggers and miners into the project area. In this case, the project was able to help the community with healthcare support, especially provision of medicines during a malaria epidemic when, for a period of three years, the government was unable to provide even basic healthcare service to this community. To date, we have only surveyed a fraction of the Pinkaití biological reserve (525 ha) and have so far located 64 mahogany trees >50 cm in dbh, but overflights by experienced mahogany spotters indicate over 200 individuals. The average wood

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volume furnished by a mahogany tree is $4\,m^3$ per tree (Verissimo *et al.* 1995) and in 1998 this wood was sold by loggers to sawmills in Redenção for an average of US\$250 m^{-3} (B. Zimmerman, unpublished data). Assuming 200 individuals, the trees in the biological reserve are worth an approximate value to the logger of US\$200 000. In 1998, the community sold mahogany to loggers for US\$ 50 m^{-3} (B. Zimmerman, unpublished data), and therefore could expect a return of about US\$40 000 for the Pinkaití mahogany. If this profit had been divided equally, each family head would have made about US\$2000. The usual Kayapó practice would have been to try to accommodate all sides, letting the project continue to operate while allowing the assertive leader to have his way and bring in the loggers and miners. However, once it was understood that the basis of the research station project, namely a pristine tract of forest, would be destroyed if logged, the community chose the long-term sustainable benefits and potential for growth of the Pinkaití research station project. In this egalitarian, consensus-seeking society, chiefs remain chiefs as long as they enjoy the support of the populace and act in everyone's perceived interest.

Although this conservation result is significant for mahogany conservation, its real significance may lie with the elucidation of design principals that can be used to extend this small-scale conservation success to impact all Kayapó lands. Our analysis attributes the success of the conservation alliance with A'Ukre to three factors, namely: (1) direct benefits accruing to all members of the community, (2) fulfilment of criteria for development of common pool resource institutions, and (3) long-term commitment of an external agency. Direct benefits provide the incentive for conservation in egalitarian societies like the Kayapó. The common pool resource institution allows for control of the resource by the society such that it is not overrun and destroyed by outsiders. Long-term involvement by an external agency ensures access to information and technical support in an unfamiliar post-contact world. We propose that by combining implementation of these three elements, the modest conservation result achieved at A'Ukre could be expanded to include the entire Kayapó nation and thereby potentially bring about conservation of more than 13 million ha of forests and cerrados in the south-eastern Amazon. The Kayapó situation is of particular value because the conditions for development of common pool resource institutions are largely met, especially regarding legal and physical control of resources. The requirement of direct benefits could be achieved by designing a set of conservation and development enterprises and social benefits that could be delivered to the various Kayapó villages situated throughout the enormous contiguous Kayapó lands, namely: Gorotire, Kuben-Kran-Ken, A'Ukre, Moikarako, Kikretum, Kokraimoro, Kubenkokre, Pukanu, Roykore, Metuktire, Piraracu, and Baú. Conservation and development enterprises might include a mixture of non-timber forest product sales including brazil-nuts, copaiba oil, jaborandi leaves, mahogany seeds, and artisanry, as markets for these products already exist. The Body Shop, UK, has already established successful trade ventures in brazil-nut oil with A'Ukre. Other possibilities are for ecotourism, sport fishing, research and education. Social benefits would comprise a package of healthcare and education services designed according to Kayapó priorities and delivered in an equivalent manner to communities that chose to enter conservation alliances and protect their forests from logging and deforestation. Long-term commitment by external agencies could be achieved by establishing an endowed fund to finance social benefits for Kayapó communities in perpetuity, in addition to the individual commitments by non-governmental organizations (NGOs) collaborating to manage conservation and development enterprises such as A'Ukre's research station. In these terms, communities choosing to sell logging or gold-mining concessions would not be involved in such conservation deals with external agencies. An important service that NGOs can perform is to provide data and information on development options and the relevance of conservation to people's lives, such as non-timber resources, speciality timber products, wildlife habitat, and option values (potential revenues from ecotourism, research, medicinal plants; Becker 1999). We saw that when the people of A'Ukre were fully informed of their choices, they chose sustainable development based on conservation over short-term gain based on predatory resource exploitation.

The recent macro-structural adjustments in the Brazilian economy have translated into severe funding cuts to Fundação Nacional do Índio (FUNAI), the government agency responsible for implementation of Indian areas in the Brazilian Amazon. Multilateral and Brazilian government disbursements scheduled for 1999 for FUNAI conservation programmes in Brazilian Amazonia have recently been reduced from R\$ 8.5 million (approximately US\$ 4.45 million in March 1999) to only R\$ 1.2 million (ISA 1999). Clearly, this reduction limits the ability of government conservation agencies to operate in Amazonia, and means that fewer government programmes, including reserve identification, demarcation, and aid, will actually be carried out. We expect the vacuum left by the absence of government action to further strengthen the significance of independent alliances between conservationists and indigenous Amazonians.

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