

Hunting in northern French Guiana and its impact on primate communities

Benoit de Thoisy, François Renoux and Catherine Julliot

Abstract The Guianas contain one of the largest single remaining tracts of undisturbed tropical rainforest in the world, but this forest and its fauna are facing increased threats. In the north of French Guiana both anthropogenic pressures and conflicts between settlements related to the use of natural resources are growing. Based on surveys in 17 forest sites we show that hunting pressure was the main factor determining current primate species richness, masking the effects of logging or forest type. Three of the larger species, the red howler monkey *Alouatta seniculus*, black spider monkey *Ateles paniscus* and tufted capuchin *Cebus apella*, were less abundant in hunted areas. In the areas around four settlements the harvested biomass of primates was low compared to other game species, but the harvests were close to or beyond the maximal sustainable thresholds for the red howler monkey and tufted capuchin. In French Guiana primates are either fully protected by law (the spider

monkey and white-faced saki *Pithecia pithecia*), or their hunting is restricted to subsistence use (howler monkey, tufted capuchin and wedge-capped capuchin *Cebus olivaceus*). Most hunted meat is, however, destined for sale. Current conservation policy in French Guiana is limited to legal protection for some species and areas, and laws are poorly enforced. Although large areas of forest and its wildlife are protected simply by their remoteness, there is an increasingly urgent need for the legal protection of all primate species, and the establishment of large protected areas and efficient forest management schemes to minimize the impacts of logging and hunting.

Keywords Bushmeat, French Guiana, habitats, hunting, neotropical primates, rainforest, sustainable harvest.

This paper contains supplementary material that can only be found online at <http://journals.cambridge.org>

Introduction

The Guianas (Guyana, Suriname, French Guiana and north-east Brazil) contain one of the largest single remaining tracts of undisturbed tropical rainforest in the world, and the region has been identified as a high priority for conservation because of its high level of endemism and biodiversity (Bush, 1996). Development and urbanization in the region have historically been restricted to the coastal zone and until recently the forest areas in the central and southern parts of the region have remained largely pristine, and therefore provide an opportunity for the strategic conservation of their biological diversity, natural resources, and human cultures. However, much of the region has only recently begun to focus on conservation policy, with new initiatives such as the Iwokrama Nature Reserve in Guyana, the Central Suriname Nature

Reserve, and the Tumucumaque National Park in Brazil. In French Guiana, however, where c. 90% of the territory is still covered by rainforest, no policy for biodiversity conservation has yet emerged. Current measures are limited to decrees protecting some species and areas, in what is effectively passive protection (Norconk *et al.*, 1996) in the absence of a protected areas network (Du Toit *et al.*, 2004) or any strategic use of renewable resources (Child, 1996). Despite having a low deforestation rate (Whitmore, 1997) direct threats are growing, mainly in the north, and include logging and widespread commercial hunting (Thoisy *et al.*, 2000; Thoisy & Vogel, 2002).

Primates are considered to be flagship and indicator species for the plight of tropical forests (Marsh & Mittermeier, 1987; Johns & Johns, 1995; Harcourt, 2000). Due to poor soil quality limiting plant productivity (Emmons, 1984), the Guianas have a relatively low primate diversity and abundance compared to the upper Amazon area. Although the eight species occurring in French Guiana have broad distributions and none are considered threatened (Rylands *et al.*, 1997), there are increasing interactions in the north between primates and the growing human population. The seven species widely distributed in French Guiana are the black spider

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monkey *Ateles paniscus* (mean adult weight 8.0 kg), the red howler monkey *Alouatta seniculus* (mean adult male and female weight 8.5 and 5.5 kg, respectively), the tufted and wedge-capped capuchins *Cebus apella* and *Cebus olivaceus* (mean adult weight 3.5 and 3.0 kg, respectively), the white-faced saki *Pithecia pithecia* (mean adult weight 1.8 kg), the squirrel monkey *Saimiri sciureus* (mean adult weight 0.7 kg), and the golden-handed tamarin *Saguinus midas* (mean adult weight 0.5 kg). The bearded saki *Chiropotes satanas* is confined to the south of French Guiana and is not considered here. The only detailed information available on these primates is research on behavioural ecology in the Nouragues Nature Reserve (Julliot & Sabatier, 1993; Zhang, 1995; Julliot, 1996, 1997; Simmen *et al.*, 2001). The work reported here focused on the north, and aimed to (1) assess habitat features, including anthropogenic disturbance, structuring primate communities, (2) describe current hunting practices and evaluate the sustainability or otherwise of harvests, (3) underline current shortcomings in government biodiversity preservation policies and discuss conservation needs for these primates.

Study area

French Guiana is a French administrative unit of 84,000 km² on the northern Atlantic coast of South America (Fig. 1). Human population density is low (168,000), but has increased rapidly over the last two decades (Barret, 2001). Most people live on the coastal plain, where communities include Amerindians from the Kaliña, Palikur and Arawak tribes, Europeans, Creoles (intermixed descendants from slaves), Bush Negroes, Brazilians, and Asians in refugee communities originating from Laos. These various communities have distinct ways of life, economies, production systems, and relationships with the forest and its fauna. These socio-economic and ethnic diversities have resulted in the emergence of conflicts over natural resources (Renoux, 2002).

Deforestation is limited to small patches for subsistence slash-and-burn agriculture (Renoux *et al.*, 2003) and around legal and illegal gold mining sites, which have increased in number over the last decade (Charlet & Boudou, 2002) and are now estimated to number 800–1,000 (A. Coppel, National Forest Agency, pers. comm.). Logging is currently restricted to a 70 km-wide belt in the north, over an area of 8,500 km², with a selective timber harvest of 3–10 m³ ha⁻¹ (Bruneaux & Demenois, 2003). Protected areas include five Nature Reserves, covering only 3% of the territory and restricted to the north (Fig. 1): Nouragues (100,000 ha; IUCN category I), Trinité (76,000 ha; category Ia), Kaw Roura (94,500 ha; category IV), Amana (14,800 ha, category IV), and Trésor (2,500 ha, category Ib). The establishment of a National

Park in the south, with a proposed area of 12,000–18,000 km², is at the planning stage. Hunting laws are restricted to a Ministerial Decree of 15 May 1986 in which the spider monkey and the two species of saki are fully protected. Other primates species can be hunted for subsistence purposes, but cannot be sold or purchased. There are no established hunting quotas or season.

Methods

Primate surveys were conducted in upland moist forest (13 sites), transition forest (two sites), marsh forest (one site) and submontane forest (one site) (Fig. 1, Table 1). The upland moist forest is the most common forest type in the Guianas, occurring on well-drained lateritic and oligotrophic soils over altitudes of 0–600 m, with high floristic diversity and endemism. Marsh forests are periodically flooded and have a relatively lower plant diversity, transition forests occur on the alluvial coastal plain, and submontane moist forests are located on lateritic crust at 500–600 m (Granville, 1988). The study sites face various degrees of human pressure, including hunting (categorized here as none, light, or heavy, determined on the basis of direct observations of footpaths, tracks, shotgun shells, and encounters with hunters), and logging (categorized here as none, recent (<5 years prior to the survey), or old (>10 years prior to the survey), on the basis of data provided by the National Forest Agency. Sites were surveyed with line transects (Peres, 1999) by walking slowly (1–1.3 km hr⁻¹) along a forest track; each site was surveyed using a single track of 4–5 km. This method has been used to assess species richness and abundance in both pristine and disturbed neotropical rainforests (Lopes & Ferrari, 2000; Peres, 2000; Thoisy, 2000; Wright *et al.*, 2000; Cullen *et al.*, 2001). Methods for estimating density require a minimum number of sightings (Peres, 1999) but as this was not obtained for most sites we used relative abundance, expressed as sighting rate, for between site comparisons (Carillo *et al.*, 2000; Lopes & Ferrari, 2000; Wright *et al.*, 2000). The relationships of species richness and relative abundances at each site with forest type, hunting and logging levels were examined by the Spearman rank test, using *XLStat* (Addinsoft, Paris, France).

Hunting was assessed in four settlements (Table 2) using interviews (Appendix) conducted over a period of 8–10 months, both during dry and wet seasons, by one of us (FR) and local key informants who lived in the villages and collected information related to hunting habits on a daily basis. A total of 206 hunters were included in the study. Data gathered included information on hunters (gender, age, economic status), hunting practices (number of hunting days, distances covered), species and number of animals harvested (including non-primate

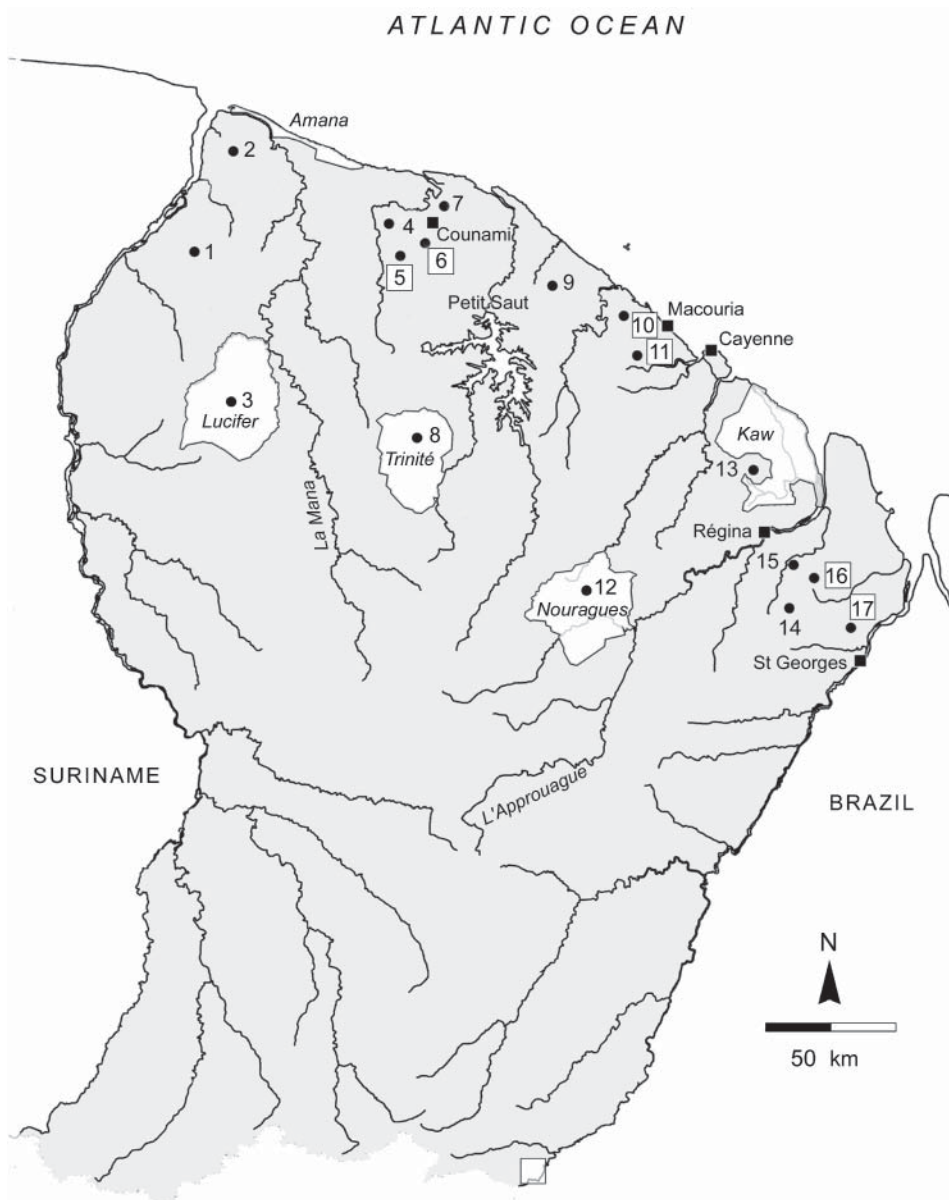


Fig. 1 French Guiana, showing main protected areas (Kaw, Trinité, Nouragues and Amana nature reserves and Lucifer biological reserve), and study sites of the primate surveys (1–17, see Table 1). Numbers within boxes are sites where game harvests were evaluated (see text for details).

species), the principle use of the meat (subsistence or commerce, including price), amount of game harvested, and location of harvests using a map with 5*5 km grid cells. The sum of these cells represented the total hunting area, but in order to avoid distortion from unusually long hunting trips by a limited number of hunters, we considered only the 'core' hunting area, from where 95% of game biomass was extracted. Areas used by hunters from the four settlements were surveyed with a greater effort than other areas to obtain a larger sample of sightings, necessary for calculation of animal densities (Peres, 1999). In the hunting areas of each settlement two separate line transects were surveyed, and data pooled to allow calculation of primate densities using Distance Sampling (Buckland *et al.*, 1993).

Sustainability of harvests in the hunting areas surrounding the four settlements was assessed using the offtake model of Robinson (2000). The observed harvest is the number of primates harvested annually in the hunting area. This observed offtake is compared to a maximal offtake, which is the number of primates that could be hunted in the same area with no significant risk of overharvesting. Calculation of this maximal offtake requires data on the density of primates, size of the hunting area, and a threshold value derived from life history and species growth rate data. For primates this threshold value is 3% of the population, and offtake is calculated as density * catchment core area size * 0.03. (Robinson, 2000). As far as possible we attempted to test the accuracy of data we collected in the field before applying the model.

Table 1 The 17 sites in which primates were surveyed (numbers refer to locations in Fig. 1), with forest type, occurrence of any logging, mean transect length and total survey length.

Site	Forest type	Logging	Mean transect length (km \pm SE)	Total survey length (km)
1. Maurice	upland moist forest	none	4.1 \pm 0.5	91
2. Coswine	marsh forest	none	4.0 \pm 0.5	100
3. Lucifer	submontane moist forest	none	3.5 \pm 0.1	110
4. Counami T	upland moist forest	none	4.8 \pm 0.3	94
5. Counami A	upland moist forest	none	5.0 \pm 0.2	104
6. Counami B	upland moist forest	recent	4.8 \pm 0.0	101
7. Patagaï	upland moist forest	old	5.4 \pm 0.0	113
8. Trinité	upland moist forest	none	4.1 \pm 0.2	93
9. Barthod	transition forest	old	4.0 \pm -0.1	92
10. Matiti	transition forest	old	4.6 \pm 0.0	101
11. Balata	upland moist forest	none	5 \pm 0.1	100
12. Nouragues	upland moist forest	none	3.5 \pm 0.0	91
13. Kaw	upland moist forest	none	4.0 \pm 0.1	150
14. Régina T	upland moist forest	none	4.9 \pm 0.2	101
15. Régina 1	upland moist forest	none	5.0 \pm 0.1	100
16. Régina 2	upland moist forest	none	5.1 \pm 0.3	102
17. St Georges	upland moist forest	none	4.5 \pm 0.5	97

Table 2 Details and results of interviews conducted in four settlements (see Fig. 1 for locations) in northern French Guiana.

	Counami	Tonate	Régina	St Georges
Communities*	Br, BN, Am, Cr, Eu, As	Am	Br, BN, Am, Cr, As	Am, Br
No. hunters interviewed	28	41	32	105
Study length	8 months	8 months	8 months	10 months
Primary reason for hunting	subsistence	commerce	commerce	commerce
Secondary reason for hunting	commerce	subsistence	subsistence	subsistence

*Br, Brazilians; BN, Bush Negroes; Am, Amerindians; Cr, Creoles; Eu, Europeans; As, Asians

Firstly, the observed harvest could have been underestimated. By cross-referencing information obtained from different local people, we obtained evidence that the key informant of each settlement underestimated harvests by *c.* 20%, mainly because of the numerous routes used to access each hunting area. Secondly, we focused on the size of the hunting areas. The 5*5 km map grid cells were an efficient way to identify the location of harvests during interviews, but hunters also reported that, in most cases, the total distance of most hunting trips did not exceed 5 km. Within each hunting area, we identified all tracks and rivers used by hunters, and using a geographic information system we demarcated a potentially hunted area of 2.5 km width along each of these features. Superimposition of this area on a map of all grid cells used by hunters showed that the latter method may overestimate the harvested area by up to 10% (Fig. 2).

Results

Primate richness and abundances

The tufted capuchin, howler monkey, white-faced saki, and golden-handed tamarin are wide-ranging in French Guiana, and were recorded in all forest habitats. The

wedge-capped capuchin was observed only in upland forests, and the squirrel monkey was restricted to marsh and transition forests. The spider monkey was observed only in upland forest. The number of primate species sighted during surveys was 3–6 per site, and was negatively correlated with hunting pressure (Spearman rank $r_s = -0.831$, $P < 0.001$).

Degree of hunting pressure and primate relative abundances and mean group sizes are given in Table 3. There were negative correlations between relative abundances and hunting pressure for three of the larger species, the howler monkey ($r_s = -0.809$, $P < 0.0001$), spider monkey ($r_s = -0.890$, $P < 0.0001$) and tufted capuchin ($r_s = -0.804$, $P < 0.0001$) but not for other species, and a negative correlation between mean group size and hunting pressure for the tufted capuchin ($r_s = -0.207$, $P = 0.02$).

Primates as game species

Hunting is either for subsistence, hobby, or commerce, although selling any primate species is prohibited by law. Table 4 shows the size of the total area used by each of the four settlements for hunting, and of the core area where hunting is concentrated. Interviews showed that

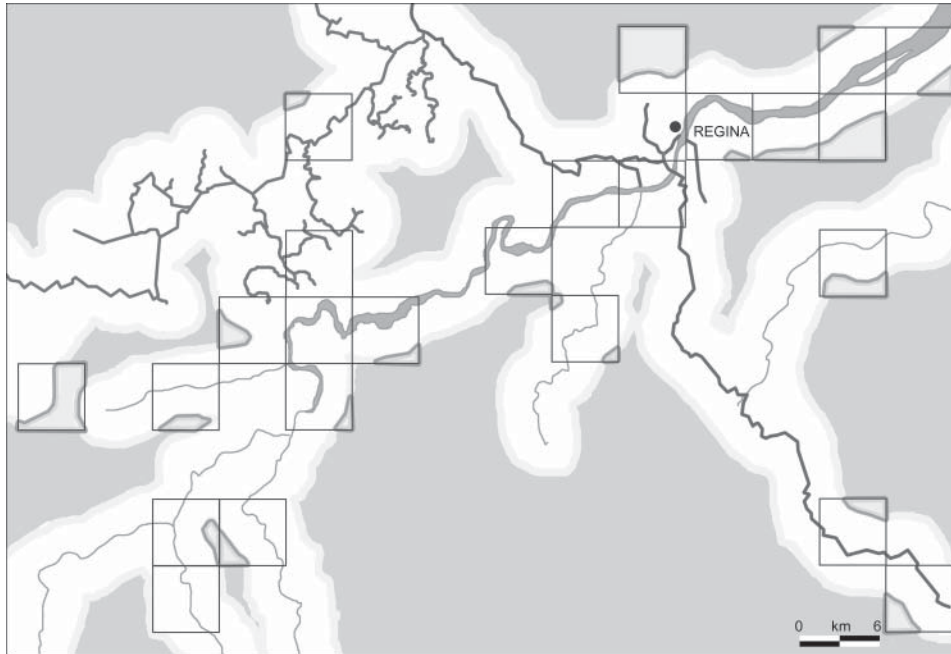


Fig. 2 Use of forest areas by hunters of the community of Régina. Rivers and tributaries are in light grey, and tracks and roads in dark grey. Each square is a 5 * 5 km area from which game was harvested, as reported during interviews. Areas in white lie within a distance of 2.5 km of access routes. Within each 5 * 5 km square the area that lies at a distance of >2.5 km (the maximum distance travelled by most hunters) from an access route is highlighted. These areas represented *c.* 10% of the area of the grid squares, and this is therefore the potential overestimation of the hunting area.

five species may be consumed, although black spider and howler monkeys and the tufted capuchin are the more commonly hunted. The total harvested game biomass per hunter is 100–330 kg per year; the contribution of primates to this biomass depends on the human communities rather than on the destination of the meat. Amerindians (the Palikur tribe at Tonate and St Georges, the Kaliña tribe at Counami) hunt proportionally more primates than other communities, either for subsistence or commerce, although the latter is opportunistic. In contrast, the harvest of primates by professional hunters from Régina and St Georges, working in close relationships with markets, is low. Prices of primate meat are similar to the prices of other game species (for example at St Georges, red howler and black spider monkeys are 2.5\$ kg⁻¹ and peccaries and tapir 2.8\$ kg⁻¹). In Régina and St Georges the sale of game meat provides a high income for hunters compared to incomes from other forms of employment available in the settlements.

The offtake model was applied to the recorded harvests after making two corrections to the data: an increase of the harvest by 20% and a reduction of the harvested area by 10%. As calculated primates densities were expressed as a mean \pm 95% confidence interval they resulted in a range for the theoretical maximal sustainable harvest for each site hunting area and each species (Table 5). Harvests that are within or greater than this range are likely to be unsustainable. In areas hunted

around two of the settlements, Tonate and Counami, harvests of red howler monkey and wedge-capped capuchins appear to be unsustainable.

Discussion

Hunting pressure is the main factor structuring primate communities in northern French Guiana. In species, such as primates, that are particularly sensitive to harvesting, hunting pressure conceals the influence of other factors such as forest productivity (Peres, 2000) and other human disturbances (Lopes & Ferrari, 2000). Spider monkeys, howler monkeys and capuchins are strongly affected by overhunting (Bodmer *et al.*, 1997) because of their low rates of reproduction, gregarious social structure, and non-cryptic behaviour. Significant reductions in the biomass of large-bodied primates have been documented in numerous neotropical sites subject to hunting pressure (Sussman & Phillips-Conroy, 1995; Peres, 1997; Carillo *et al.*, 2000; Lopes & Ferrari, 2000; Wright *et al.*, 2000; Bennett *et al.*, 2001). Local extinctions of frugivorous species in French Guiana will have expected consequences on seed dispersal and predation, plant species composition, and predator-prey interactions (Redford, 1992).

Other than the filling of the Petit Saut hydroelectric dam in 1994–1995, which resulted in the flooding of

Table 3 Hunting pressure at the 17 survey sites (numbers indicate location on Fig. 1 and in Table 1), and relative abundances (sighting rate, as individuals per km) and observed mean group size of seven primates, with sites ordered by degree of hunting pressure.

Site	Hunting pressure	Black spider monkey <i>Ateles paniscus</i>		Red howler monkey <i>Alouatta seniculus</i>		Tufted capuchin <i>Cebus apella</i>		Wedge-capped capuchin <i>Cebus olivaceus</i>		White-faced saki <i>Pithecia pithecia</i>		Squirrel monkey <i>Saimiri sciureus</i>		Golden-handed tamarin <i>Saguinus midas</i>	
		Sighting rate	Group size	Sighting rate	Group size	Sighting rate	Group size	Sighting rate	Group size	Sighting rate	Group size	Sighting rate	Group size	Sighting rate	Group size
4. Counami T	none	0.11	2.5	0.71	5.1	0.77	10.6	0.06*	6*	0.08*	2.7*	0	0	0.8	5.1
14. Régina T	none	0.17	3.0	0.52	4.0	0.80	7.2	0.06*	6.7*	0		0	0	0.27	5.0
12. Nouragues	none	0.42	5.0	0.32	6.0	0.34	12.0	0.27	ND	P		0	0	0.19	5.0
3. Lucifer	none	0.03*	3.0*	0.33	3.4	1.00	5.8	0.23	6.3	0.15	1.7	0	0	0.5	4.3
15. Régina 1	light	0		0.60	3.8	0.58	6.9	0.35	8.9	0.06*	3.0*	0	0	0.38	6.3
5. Counami A	light	0.03*	3.0*	0.35	5.1	0.22	5.8	0.05*	5*	0.11	3.0	0	0	0.5	5.2
8. Trinité	light	0.19	3.4	0.41	4.6	0.70	7.8	0		0.01	1*	0	0	0.38	3.5
16. Régina 2	light	0		0.67	4.5	0.70	6.5	0.06*	6.0*	0.04	3.0*	0	0	0.32	5.2
13. Kaw	light	0.01	2.0*	0.30	4.4	0.39	7.1	0		0.01	2.0*	0	0	0.16	ND
1. Maurice	heavy	0		0.14	3.6	0.33	4.5	0.27	3.5	0.20	2.3	0	0	0.25	5.0
9. Barthod	heavy	0		0.03*	3.0*	0		0		0.21	2.0	0	0.05*	2.80	5.0
6. Counami B	heavy	0		0.08*	1.5*	0.15*	4*	0.10	4.3	0.12	2.2	0	P	0.28	4.7
7. Patagäi	heavy	0		0.23	5.2	0		0.39	9.0	0.05*	2.0*	P	P	0.32	5.6
11. Balata	heavy	0		0.07*	3.5*	0.51	6.8	0		0.04	2.0*	0	0	0.28	4.7
17. St Georges	heavy	0		0.09*	4.5*	0.06*	5*	0		0		0	0	0.27	5.4
2. Coswine	heavy	0		0		0.22	5	0		0.13	2.0	P	P	1.00	4.8
10. Maititi	heavy	0		0.07*	3.5*	0.2	6.7	0		0.04	1.7	34.0	12.8	2.00	5.6

* < 4 sightings; ND, not determined; P, present, but not recorded during transect surveys

Table 4 Primates harvested by people in four settlements (see Fig. 1 for locations) in northern French Guiana.

Sites	Counami	Tonate	Régina	St Georges
Survey numbers (see Table 1)	5, 6	10, 11	15, 16 ¹	16, 17 ¹
Total hunting area (km ²)	525	650	600	1,250 ²
Core area from which 95% of biomass extracted (km ²)	250	400	475	950
Total biomass harvested per hunter per year (kg)	145.2	100.8	212.4	332
Mean income per hunter per month (€)	–	27	40	74
Primate biomass/total game biomass (%)	1.9	6.4	0.5	0.3
Primate biomass sold (%)	26	75	70	66
No. harvested per year				
Black spider monkey	1		7	1
Red howler monkey	8	35		5
Tufted capuchin	4	47	12	18
Wedge-capped capuchin		6		
White-faced saki		3		

¹Survey 16 crossed an area used by people of both Régina & St Georges

²40% of the area is in Brazil

Table 5 The offtake model (Robinson, 2000) applied to harvested primates. Corrected actual harvests (see text for details) that are within or greater than the maximal offtake range are in bold.

		Counami	Tonate	Régina	St Georges
Mean density ±	Black spider monkey			1.8*	1.8*
95% CI (no. km ⁻²)	Red howler monkey	3.2 ± 1.9	1*		3.1 ± 1.8
	Tufted capuchin	3.7 ± 2.7	5.2 ± 3.4	4.6 ± 2.9	4.5 ± 2.7
	White-faced saki		2.0 ± 1.5		
Maximal	Black spider monkey			23*	46*
sustainable	Red howler monkey	22 ± 12	11*		83 ± 48
harvest ± range	Tufted capuchin	24 ± 19	56 ± 37	58 ± 38	117 ± 75
(no. yr ⁻¹)	White-faced saki		20 ± 15		
Corrected (+20%)	Black spider monkey			8	2
actual harvest	Red howler monkey	10	35		6
(no. yr ⁻¹)	Tufted capuchin	5	52	14	22
	White-faced saki		4		

*No confidence interval or range as data set is small

365 km² of forest (Vié, 1999), logging is the main pressure on forest in northern French Guiana. Because the logging is selective, however, damage is limited. Four tree species account for more than 70% of timber volume: *Dicorynia guiananensis*, *Vouacapoua americana*, *Ocotea rubra* and *Qualea rosea*. Although primates are partly dependent on these species (Hammond *et al.*, 1996) we did not find any evidence of the direct impact of logging activities on primate communities. However, logging results in increased accessibility to upland forest (Peres & Lake, 2003). As most game extraction occurs within 2.5 km of access routes, we estimated potential accessibility along rivers and tributaries and along the 2,400 km of existing logging roads, and found that 80% of the 8,500 km² of forests managed for logging are accessible and therefore at risk of faunal depletion (Wilkie *et al.*, 1992). In most cases inaccessible areas are too patchily distributed to play a major role as refuges or as sources for population restocking (Laurance *et al.*, 2000; Novaro *et al.*, 2000). The impact of hunting pressure acts

synergetically with habitat disturbance (Johns, 1985; Peres, 2001), and the two sites where sustainable thresholds for primate hunting have been surpassed are also those where hunting areas are organized around logging tracks.

Traditional Amerindian communities often have a high proportion of primates in their diet (Vickers, 1991; Mena *et al.*, 2000). In a Wayãpi village in southern French Guiana (Renoux, 1998) the total annual game biomass harvested was 190 kg per hunter. This was comparable to harvests that we recorded amongst northern Amerindian communities, except that in the south primates accounted for 15% of the harvest rather than 0.5–6%. Improvement of socioeconomic conditions, as has happened in the north, contributes to a decrease in pressure from subsistence harvesting (Jorgenson, 2000), and lower primate densities, from overhunting, may also have resulted in the hunting of other game species.

The current policy for conservation of biodiversity and natural resources in French Guiana still follows a colonial

type model (Child, 1996), with measures restricted to decrees for the protection of some areas and species. Strictly protected areas are an essential element for sustainable hunting (Peres, 2000), but they require adequate surveillance, education and public awareness. The countries of the Guianas require a network of protected areas of the size, design, and means appropriate for the maintenance of their ecological functions and the conservation of their flora and fauna. For primates, because of their poor ability to sustain harvesting, an additional and immediate necessity is their full protection by law. Poaching, although limited, will otherwise continue to represent a threat.

The government of French Guiana currently owns 92% of the country's forests. This is a guarantee against large-scale threats and accounts for the relatively healthy status of the forests. However, the national land laws do not recognize the rights of land use by indigenous communities. Conservation, management and sustainable use of natural resources, and requests concerning the rights and traditional lifestyles of the local communities in their use of forest products (Hill, 2002), remain poorly considered in government policies in French Guiana. It will be necessary to integrate these matters into forthcoming forest and environment laws to prevent conflicts harmful to wildlife and conservation. An additional concern is that pressures for the occupation and development of the southern areas of French Guiana will undoubtedly increase in the future. Gold mining is occurring on most rivers and tributaries throughout the country, and is becoming an increasingly significant force in destabilizing traditional socioeconomic structures.

In summary, hunting is the main pressure on primates in French Guiana and, for at least some species, appears to be unsustainable. Habitat loss is occurring at only a low rate, although a significant part of game harvesting is facilitated by selective logging, which provides access to previously inaccessible areas. Comprehensive legal protection is required for the country's primate species, but conservation efforts need to be urgently focused on habitat management. This will facilitate protection of primates and provide opportunities for improving the sustainable use of other forest species.

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Appendix

The appendix for this article is available online at <http://journals.cambridge.org>

Biographical sketches

Benoit de Thoisly is a conservation biologist working for Kwata, a non-governmental organization in French Guiana. Projects developed by Kwata are focused on threatened species and natural resources management, including game and timber harvests.

François Renoux has worked for several French scientific institutions in French Guiana during the last 8 years. Specializing in human ecology, he has studied relationships between the social organization of human communities and foraging for natural resources in neotropical rainforests.

Catherine Julliot has worked since 1988 on the relationships between animals, especially primates, and natural forest regeneration and biodiversity in tropical rainforests of French Guiana, Gabon and Madagascar.

Hunting in northern French Guiana and its impact on primate communities

Benoit de Thoisy, François Renoux and Catherine Julliot

Appendix

Format used for interviewing hunters from the settlements of Counami, Tonate, Régina and St Georges (see Table 2).

Date ____/____/____

Hunter code _____ or Name _____ Age _____

Settlement _____

Hunting location _____

Map _____ Reference _____

From _____ to _____

Route _____

Transport foot
 canoe
 car
 motorbike

Type of gun: Calibre 12
 Calibre 16
 Type of cartridge: lead shot 6
 lead shot 4
 lead shot 2
 lead shot 2/0
 Chevrotine

Type of speedboat motor _____

Hunting day

Time of day morning Time _____
 afternoon Time _____
 day Time _____
 night Time _____

Organization
 alone
 several people, no. _____
 with a dog

Hunting trek

No. of days _____

No. of people _____

Game surveys

Species	Male	Female	Juvenile	Adult	Kept	Sold
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Game observed but not shot _____

Preservation of game

- Fresh
- Icebox
- Smoked