

Parrot populations and habitat use in and around two lowland Atlantic forest reserves, Brazil

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Abstract

We estimated population sizes of parrots in a large (Sooretama/Linhares) and a small (Porto Seguro) lowland Atlantic forest reserve, and examined their habitat associations within the reserves, and their use of forest fragments. In Sooretama, most species had estimated populations between 1000 and 20,000 individuals, but in the smaller reserve population densities were low and all but one species had population estimates < 500. Two Amazons, including the ‘Endangered’ *Amazona rhodocorytha*, were strongly linked to primary forests whereas the ‘Vulnerable’ *Pyrrhura cruentata* was associated with non-pristine forest. There was considerable movement of parrots between the Sooretama reserve and the surrounding country with *Amazona* species tending to fly into the reserve during the mornings, and the macaw *Propyrrhura maracana* flying out. Other species, notably *P. cruentata* and *P. leucotis*, were never recorded away from the reserve. Most parrot populations in the region are likely to be small, and the substantial populations around Sooretama make this reserve a parrot stronghold. It is crucial that fire, illegal logging and parrot capture are adequately controlled within Sooretama, and there is a strong argument for extending conservation management efforts to areas immediately outside the reserve. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Parrots; Atlantic Forest; Population sizes; *Amazona*; *Pyrrhura*.

1. Introduction

The Atlantic Forest once covered around 1 million km² in the now heavily populated eastern part of Brazil (Fonseca, 1985). Less than 10% of the forest remains in most states, with deforestation being particularly heavy in some of the coastal lowlands (Fonseca, 1985; Viana et al., 1997). Much of what is left of the forest is highly fragmented, and little is officially protected (Viana et al., 1997; Ranta et al., 1998). Areas outside forest reserves are dominated by sugar cane, pasture, coffee and *Eucalyptus* plantations.

The region holds around 200 endemic bird species, many of which are believed to be threatened, primarily due to habitat alteration (Sick, 1993; Collar et al., 1994;

Goerck, 1997) but, in some species, also through direct exploitation (Martuscelli, 1995; Galetti et al., 1997). Altogether, 21 parrot species occur in the region, of which seven are classified as Endangered and two Vulnerable (Collar et al., 1994). The Sooretama/Linhares reserve complex in Espírito Santo state has been identified as a stronghold for lowland parrot species such as blue-chested parakeet (*Pyrrhura cruentata*) (Forshaw, 1989; Wege and Long, 1995), and research on the status, population sizes, and habitat use of parrots in, and around the reserve has been identified as high priority (Snyder et al., 2000).

We aimed to assess the conservation status of parrots in Sooretama/Linhares, and in forest fragments around the reserve. We also compared the status of parrots in this large reserve complex with that in the small reserve at Porto Seguro, 600 km away in Bahia state (Fig. 1). Specifically, we aimed to:

1. Estimate population densities and total population sizes of parrots in each area.

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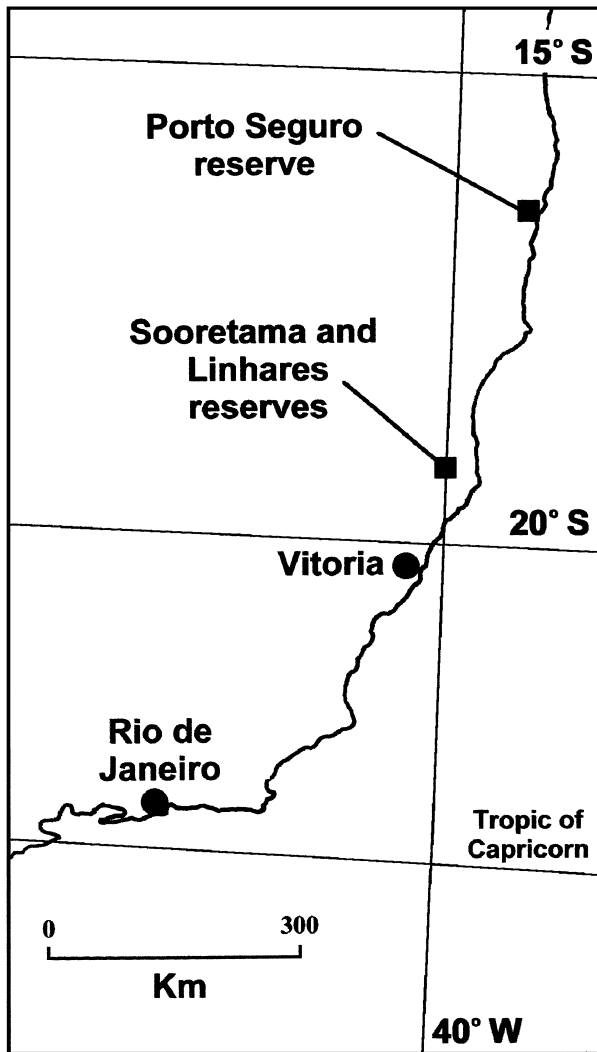


Fig. 1. South-eastern Brazil showing the positions of the Porto Seguro and Sooretama/Linhares reserves.

2. Identify the habitat associations of parrots, to determine the effects of habitat change on individual species.
3. Examine the movements of parrots between Sooretama reserve and surrounding forest fragments to gauge the importance of unprotected areas outside the reserve for parrots.

2. Methods

2.1. Study sites and parrot species

The Porto Seguro complex in Bahia state ($16^{\circ} 27'S$ $39^{\circ} 15'W$) comprises 6000 ha of the Florestas Rio Doce SA private Forestry Reserve, which is contiguous with 600 ha of forest at the CEPLAC (Comissão Executiva do Plano da Lavoura Cacaueira) Pau-Brasil Ecological Station (Fig. 2). This isolated forest complex is situated

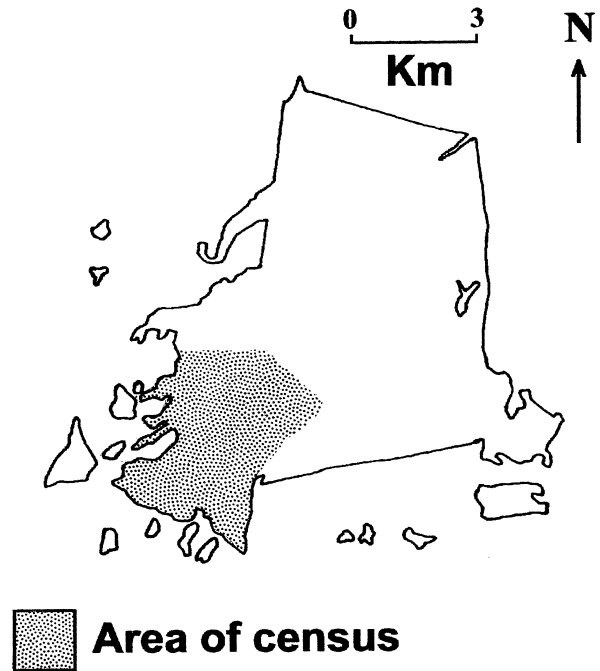


Fig. 2. The Porto Seguro reserves. Areas outside the reserve are dominated by pasture and arable farmland.

close to sea level c. 10 km inland from the town of Porto Seguro, amidst pasture, coffee plantation, and arable farmland (Wege and Long, 1995). Much of the forest in Florestas Rio Doce SA Reserve has been recently selectively logged, but the CEPLAC Pau-Brasil Reserve, in which most bird surveying was done, has not been logged recently.

The Sooretama/Linhares complex of east-central Espírito Santo state, comprises the 24,250 ha Sooretama Federal Biological Reserve ($19^{\circ} 03'S$ $40^{\circ} 00'W$), which lies adjacent to the 21,800 ha Linhares Forestry Reserve ($19^{\circ} 10'S$, $39^{\circ} 55'W$), owned by Companhia Vale de Rio Doce (Wege and Long, 1995; Chiarello, 1999). The reserves lie close to sea level, and are composed mostly of 'terra firme' forest up to 40 m in height, with some 'mussununga' forest containing much smaller trees on sandier soils (Simão et al., 1997). There is a history of logging within the reserves (illegal logging persists in Sooretama) and some areas of forest are secondary growth. Much of the area around the reserve has been deforested, although some private preserves remain. Major land uses in the vicinity of the reserves include pasture, extensive *Eucalyptus* plantations, arable farmland and coffee plantation. So far, 14 and seven parrot species have been documented as occurring in Sooretama/Linhares and Porto Seguro, respectively (Table 1).

Parrot surveys were made between 21 July and 16 October 1998 in the Porto Seguro forestry reserve and in the Sooretama/Linhares reserve and in 31 forest fragments between 10 and 150 ha within 7 km of this latter area (Fig. 3). The survey period corresponds to

Table 1
Status of parrots known to occur within the study areas and/or recorded during our fieldwork^{a, b}

Species	Status	Sooretama/Linhares	Porto Seguro
Blue-winged macaw <i>Propyrrhura maracana</i>	Vulnerable	a,b	
Peach-fronted parakeet <i>Aratinga aurea</i>		a,b	
White-eyed parakeet <i>Aratinga leucophthalmus</i>		b	
Blue-chested parakeet <i>Pyrrhura cruentata</i>	Vulnerable	a,b	a,b
Maroon-faced parakeet <i>Pyrrhura leucotis</i>		a,b	
Blue-winged parrotlet <i>Forpus xanthopterygius</i>	Endangered	a,b	a,b
Golden-tailed parrotlet <i>Touit surda</i>		a	a
Plain parakeet <i>Brotogeris tirica</i>		a,b	a,b
Scaly-headed parrot <i>Pionus maximiliani</i>	Endangered	a,b	
Blue-headed parrot <i>Pionus menstruus</i>		a,b	a,b
Orange-winged Amazon <i>Amazona amazonica</i>		a,b	b
Mealy Amazon <i>Amazona farinosa</i>	Endangered	a,b	a
Red-browed Amazon <i>Amazona rhodocorytha</i>		a,b	a,b
Blue-fronted Amazon <i>Amazona aestiva</i>		a	
Blue-bellied parrot <i>Triclaria malachitacea</i>	Endangered	a,b	

^a Status is the IUCN red list category for that species in the Parrot Action Plan (Snyder et al., 2000).

^b a previously recorded (e.g. Parker and Goerck, 1997), b recorded at any time during current study.

the dry, cold season prior to the main breeding season for parrots in the region (Forshaw, 1989; Martuscelli, 1995).

2.2. Parrot surveys

Four weeks prior to the census were spent practising bird identification and distance estimation. All parrot surveying was done by a pair of observers (with M.W. always the primary recorder). A variable circular plot method (Reynolds et al., 1980; Jones et al., 1995), tailored for parrot census (Marsden, 1999), was used to calculate density estimates (individuals per km²) for parrots inside the reserves and in forest fragments. The distance sampling method used allows for unidentified bird contacts, so long as all birds encountered at and very close to the recorder are identified (Buckland et al., 1993; Marsden, 1998).

In all areas sampled, transects were set up along existing paths of width <3 m. Census stations were marked out along these transects at intervals of 200 paces (c. 200 m). Parrots were counted at each point twice, on different days, points being visited in reverse order on the second visit. Surveys were carried out between 0700 and 1130 hours and only in the absence of rain or heavy mist. Birds were counted at each census station for a period of 10 min. The distance from the recorder to each bird encountered was estimated. The number of individuals in each encounter was recorded, if ascertainable. When approaching a census station any birds that were disturbed (flushed) from the plot these were recorded as being present during the census period. The census period commenced immediately on arrival at the station.

Records of parrots in flight at census stations were omitted from the density calculations because aerial

birds violate an assumption of the census method used (Marsden, 1999). For contacts where birds were only heard, the mean group size for visual contacts with that species was substituted for the missing group size

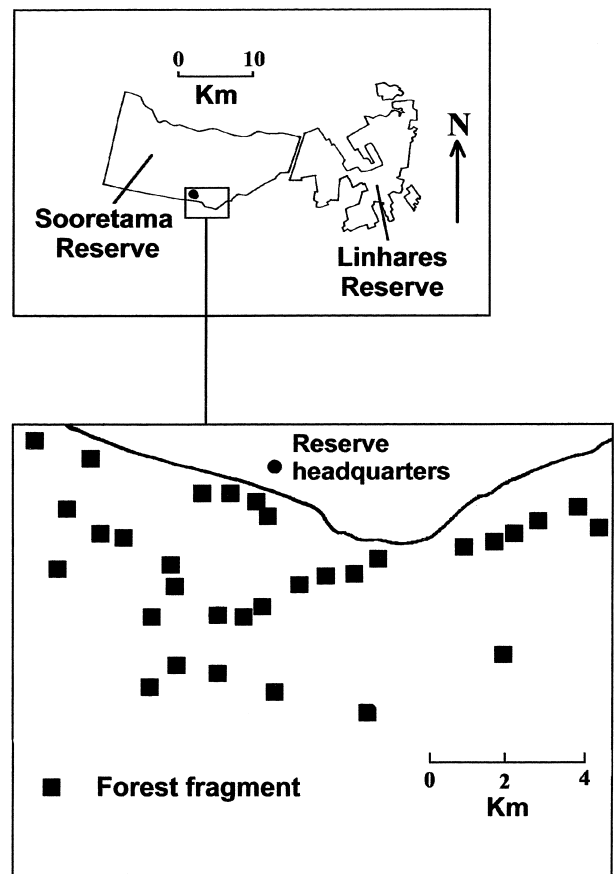


Fig. 3. The Sooretama and Linhares reserves showing the positions of the 31 forest fragments surveyed.

values. Such contacts need to be included in the calculations because excluding any parrot contact at or close to the recorder will result in underestimation of densities (Marsden, 1999).

2.3. Habitat recording

At each census station, the two trees of largest girth within 25 m of the station's central point were selected, their girths at breast height measured, and their heights estimated using a clinometer. The percentage vegetative cover within 25 m of the central point, at canopy level, mid-level (10–20 m), and ground levels were estimated to the nearest 10%. The number of palms (*Astrocaryum*, *Schellea* and *Bactris*) of dbh > 0.6 m within 25 m of the plot's central point were counted, and the presence or absence of bamboo and *Cecropia* spp. trees recorded.

2.4. Study of parrot movements

On 26 dates between 12 August and 4 October, the flight movements of parrots between the Sooretama reserve and outlying countryside were recorded from the forest edge. Two watches were done each day, one in the morning from 0600 to 0800 and one in the afternoon between 1600 and 1800 (parrots were also watched at other times and from other sites but these data are not considered here). All watches were done by the same recorder (LS) and were undertaken from a point close to the park headquarters along the road bordering the edge of the reserve (19°03.340' S 40°08.039' W). All parrots flying either into or out of the reserve within a distance of 500 m either side of the recorder were noted. All Amazons within this range were readily identifiable, but some medium-sized parrots had to be recorded as *Pionus* sp. and some parakeets as *Pyrrhura/Brotogeris*. For each parrot group encountered, the time of the encounter was noted along with the species, group size, direction of flight and where birds landed, if this was ascertainable.

2.5. Data analyses

Parrot abundance is first expressed as encounter rates (number of groups of a parrot species recorded per 10 point counts). For some species, density estimation was possible using the DISTANCE 3.5 program (Laake et al., 1994). However, for only some species were there sufficient records to calculate density estimates based only on the detection function for that reserve or habitat. In other species, records from both the reserves and the fragments were combined to produce a single detection function, from which specific density estimates were calculated for each reserve and fragments (Laake et al., 1994; Marsden, 1999). Density estimates with their associated standard errors were used to estimate total

population sizes in the two reserves, using the areas of the reserves given in Wege and Long (1995).

For each species, a logistic regression was used to identify differences in habitat between the positive stations (those at which the species was recorded on either visit) and negative stations, at which the species was not recorded (Norušis, 1993; Dettmers et al., 1999; Marsden and Fielding, 1999). All variables were entered in the analysis simultaneously. Two analyses were performed for each species, one for all stations together (both reserves plus forest fragments = 440 points), and one including only points in Sooretama/Linhares (273 points). Analysis was restricted to species recorded at more than 20 points altogether. Six habitat variables were considered in the analyses. Presence/absence of bamboo and *Cecropia* spp. were entered as categorical data, while the number of palms was entered as a continuous count. The remaining variables (tree sizes and vegetative covers) were simplified to a smaller number of orthogonal factors using principal component analysis (Norušis, 1993).

Data on the movements of parrots are expressed as the mean number of bird groups and individuals per hour (\pm S.D.) flying to and from the reserve during the morning and afternoon. For each species and each period, the numbers entering the reserve were compared to the numbers leaving the reserve using Wilcoxon signed-rank tests.

3. Results

3.1. Population parameters

In total, 134 counts were made at 67 points at Porto Seguro, 546 counts were made at 273 points at Sooretama/Linhares, and 200 counts at 100 points in forest fragments. These figures equate to one point count per 49 ha at Porto Seguro, and one per 84 ha at Sooretama/Linhares. All but two of the 14 parrot species previously recorded from either reserve were recorded during the fieldwork. Those exceptions were golden-tailed parrotlet (*Touit surda*) and blue-fronted Amazon (*Amazona aestiva*). One additional species, white-eyed parakeet (*Aratinga leucophthalmus*), was recorded occasionally in forest fragments and at the forest edge at Sooretama but is not previously listed for that reserve. Blue-bellied parrot (*Triclaria malachitacea*) was recorded only once at the forest edge in Sooretama, and blue-winged parrotlet (*Forpus xanthopterygius*) was recorded only once at Porto Seguro (neither was recorded during formal surveys). In total, 13 species were recorded in Sooretama/Linhares, eight in fragments around Sooretama, and only six species in Porto Seguro. Encounter rates were generally higher in Sooretama than in fragments or particularly in Porto Seguro (Table 2).

Table 2

Parrot encounter rates (no. groups encountered per 10 point counts) and total numbers of groups encountered (figures in parentheses) in Porto Seguro and Sooretama/Linhares reserves, and in forest fragments around Sooretama^a

	Porto Seguro	Sooretama	Fragments
	(n = 134)	(n = 546)	(n = 200)
<i>Propyrrhura maracana</i>	0	0.11 (6)	0.05 (1)
<i>Aratinga aurea</i>	0	0.02 (1)	0
<i>Aratinga leucophthalmus</i>	0	0	0.05 (1)
<i>Pyrrhura cruentata</i>	0.07 (1)	0.49 (27)	0
<i>Pyrrhura leucotis</i>	0	0.44 (24)	0
<i>Forpus xanthopterygius</i>	0	0.02 (1)	0.1 (2)
<i>Brotogeris tirica</i>	0.37 (5)	0.55 (30)	0
<i>Pionus maximiliani</i>	0	0	0.05 (1)
<i>Pionus menstruus</i>	0.15 (2)	0.13 (7)	0.05 (1)
<i>Amazona amazonica</i>	0.37 (5)	0.37 (20)	0.25 (5)
<i>Amazona farinosa</i>	0	0.11 (6)	0.1 (2)
<i>Amazona rhodocorytha</i>	0.15 (2)	0.60 (33)	0.45 (9)

^a n = number of point counts (including repeats).

In all species for which density estimation was possible, densities in Sooretama were higher than at Porto Seguro or in the forest fragments (Table 3). The three parakeets (*Pyrrhura* and *Brotogeris*) had population estimates within Sooretama in excess of 10,000, while other parrots had estimates in excess of 1000 individuals. In contrast, only one species (*B. tirica*) had a population estimate in excess of 500 in Porto Seguro.

3.2. Habitat associations

Principal component analysis extracted three factors, which together accounted for 84% of variation in the five habitat readings. Factor 1 (eigenvalue = 1.9) was strongly positively correlated with average tree heights ($r = +0.91$) and tree girths ($r = +0.91$), while factor 2 (eigenvalue = 1.2) was positively correlated with ground cover ($r = +0.90$) and negatively correlated with canopy cover ($r = -0.67$). The third factor (eigenvalue = 1.1) was composed almost entirely of differences in mid-level vegetation cover ($r = +0.95$).

There were sufficient records of five parrot species to examine habitat associations using logistic regression

(Table 4). For all areas, three species including two *Amazona* were associated with high scores on factor 1 (associated with large trees), while *Pyrrhura cruentata* was associated with areas containing *Cecropia* and full vegetation cover at canopy and mid-level (low scores on factor 2 and high scores on factor 3). Considering only Sooretama/Linhares, *Cecropia* was again important for *P. cruentata* suggesting it is a bird of regenerating forest. The two Amazons were strongly linked to large trees, but also with relatively open canopies.

3.3. Parrot movements

Parrots made more frequent flights into and out of the Sooretama reserve in the mornings than the afternoons (Table 5). There was a significant net flow of *P. maracana* out of the reserve in the mornings and back in again in the afternoon. Two Amazon species moved in the opposite direction, with many individuals flying into the reserve, presumably having roosted outside the reserve. Mean numbers of *Pionus* recorded flying in and out of the reserve were high, given that the two species were not common in the reserve. *B. tirica* did tend to leave the reserve in the mornings, but there was very little movement of parakeets between the reserve and the surrounding areas — particularly given the high population densities of all three species.

Of 65 parrot groups seen to land outside the reserve, 72% landed in forest fragments, 22% in orange groves, and 6% in isolated fruit trees. Excluding *P. maracana* which landed in orange groves 12 of 22 times, the remaining species landed in forest fragments on 39 of 43 occasions.

4. Discussion

Brazil's Atlantic forest has been described as one of the world's most threatened ecosystems (Myers, 1988). Forest loss continues, as does degradation of remaining forest through logging. Remnant forest patches are increasingly isolated, and outside reserves there may be an increase in land uses, such as sugar cane, that are of

Table 3

Density estimates \pm coefficients of variation (D.E. \pm C.V.) and population estimates (P.E. \pm S.E.) for parrots in Porto Seguro and Sooretama/Linhares reserves, and in forest fragments around Sooretama

	Porto Seguro (66.0 km ²)		Sooretama/Linhares (461 km ²)		Fragments
	D.E. \pm C.V.	P.E. \pm S.E.	D.E. \pm C.V.	P.E. \pm S.E.	D.E. \pm C.V.
<i>Pyrrhura cruentata</i>	4.8 \pm 100	317 \pm 317	41 \pm 22	19,000 \pm 4180	
<i>Pyrrhura leucotis</i>			42 \pm 25	19,300 \pm 4840	
<i>Brotogeris tirica</i>	18 \pm 51	1180 \pm 602	28 \pm 25	12,800 \pm 3210	
<i>Pionus menstruus</i>	1.0 \pm 100	66 \pm 66	2.3 \pm 47	1060 \pm 498	1.3 \pm 100
<i>Amazona amazonica</i>	1.5 \pm 62	100 \pm 62	3.1 \pm 25	1430 \pm 357	2.2 \pm 67
<i>Amazona rhodocorytha</i>	3.6 \pm 73	238 \pm 174	13 \pm 28	5990 \pm 1680	7.8 \pm 43

Table 4
Results of logistic regression for parrots in all areas/habitats, and, in parentheses, in Sooretama/Linhares reserve only^a

	<i>P. cruentata</i>	<i>B. tirica</i>	<i>A. rhodocorytha</i>	<i>A. amazonica</i>
Positive stations	25 (24)	33 (27)	37 (27)	26 (19)
<i>Habitat variables</i>				
Factor 1		+ *	+ * (+ ***)	+ * (+ ***)
Factor 2	–*		(+ **)	(+ *)
Factor 3	+ *		(–*)	(+ *)
Palms				
Bamboo				
<i>Cecropia</i>	+ * (+ *)			

^a A plus sign denotes that high values of that variable are associated with species presence (a minus sign mean high values associated with species absence). * $P < 0.05$, ** $P < 0.005$, *** $P < 0.0005$.

Table 5
Mean±S.D. numbers of individual parrots recorded flying out of, and into the Sooretama reserve during 2-h periods of the mornings and afternoons^{a,b}

	Mornings (06h00–08h00)		Afternoons (16h00–18h00)	
	Flying out	Flying in	Flying out	Flying in
<i>P. maracana</i>	5.1±6.4	1.9±3.9*	0.11±0.60	3.4±6.2 *
<i>P. cruentata</i>	0.93±2.9	0.0	0.0	0.0
<i>P. leucotis</i>	0.18±0.94	0.14±0.76	0.0	0.0
<i>B. tirica</i>	5.5±7.3	2.6±4.8*	0.0	0.07±0.38
<i>Pyrrhura/Brotogeris</i>	0.50±2.5	3.3±11	0.0	0.08±0.39
<i>P. maximiliani</i>	0.92±2.7	0.69±2.7	0.08±0.39	0.31±1.6
<i>P. menstruus</i>	0.27±0.96	0.27±1.0	0.0	0.0
<i>Pionus</i> sp	3.1±5.3	3.0±4.9	0.07±0.39	0.0
<i>A. amazonica</i>	1.7±1.7	4.6±4.8**	2.4±4.1	0.21±1.1**
<i>A. farinosa</i>	0.23±0.65	0.54±1.3	0.08±0.39	0.08±0.39
<i>A. rhodocorytha</i>	1.5±2.2	8.9±11**	0.81±1.9	0.48±0.85

^a Differences in mean numbers flying in and out were tested using Wilcoxon signed-ranks tests. * $P < 0.05$, ** $P < 0.005$.

^b In all cases, $n = 26$ (two-hour periods).

little or no use to parrots. Of 21 parrot species occurring in lowland Atlantic forest, nine are threatened with extinction (Collar et al., 1994).

While areas of the forest are under protection through a system of federal and state reserves, privately-owned reserves, and privately-owned forest patches, most reserves are small, and viable populations of very rare species may be preserved in only a few large reserves. There are only two areas larger than Sooretama/Linhares, and only six larger than Porto Seguro, that are actually known to hold populations of either the Vulnerable *P. cruentata* or the Endangered *A. rhodocorytha*, (Table 6; data from Wege and Long, 1995). Furthermore, the status of these two species in the two largest areas is far from clear. *P. cruentata* has been recorded from one section of the Chapada Diamantina National Park in the 1980s, while there is a single record of four *A. rhodocorytha* from Serra da Bocaina in 1994 (Wege and Long, 1995). Clearly, for some parrot species, there are few if any populations bigger than those reported in this paper.

Two parrot species listed as occurring in Porto Seguro and two listed for Sooretama were not found during our surveys. Of most concern was the lack of records from both reserves of the ‘Endangered’ golden-tailed parrotlet (*Touit surda*) which, although known from a number of locations, may occur in most areas at very low population densities (Forshaw, 1989; Wege and Long, 1995). In general, however, we found or expected significant populations of most species in the large reserve complex of Sooretama/Linhares. For example, an aggregation of 84 blue-winged macaws (*P. maracana*) (listed as Vulnerable) was recorded at Sooretama, whereas, previously, just one or two pairs have been reported from the reserve. The importance of Sooretama as a stronghold for parrots and other threatened bird species, such as red-billed curassow (*Crax blumenbachii*), cannot be overstated, and such reserves must form the cornerstone of efforts to preserve the region’s threatened endemics in the long term.

In contrast, some parrot species were absent from Porto Seguro and populations of almost all species were

Table 6
 Sizes of key areas known to hold populations of *P. cruentata* and/or *A. rhodocorytha* (from Wege and Long, 1995)^a

Key area and status	Size (ha)	<i>P. cruentata</i>	<i>A. rhodocorytha</i>
Chapada Diamantina (National Park)	152,000	+	
Serra da Bocaina (National Park)	100,000		+
Sooretama/Linhares (Federal/Private Reserve)	46,050	+	+
Rio Doce (State Park)	35,973	+	+
Monte Pascoal (National Park)	22,500	+	+
Desengano (State Park)	22,500	+*	+*
Porto Seguro (CEPLAC/Private Reserve)	6600	+	+
Nova Lombardia (Federal Reserve)	4492		+
Córrego do Veado (Federal Reserve)	2392	+	+
Córrego Grande (Federal Reserve)	1504	+	+
Ibitipoca (State park)	1488		+
Caratinga (Private Reserve)	880		+
Barrolândia (Private Reserve)	710	+	

^a A plus sign indicates the parrot species has been recorded within, or +* nearby the reserve.

low. It is not known why population densities of parrots were low in this reserve, but habitat alteration, direct exploitation, and problems of small population size may all have contributed to species rarity. What does seem clear is that this is a situation mirrored in other forest remnants in the region with fewer parrot species and lower numbers of parrots being recorded in the small reserves (e.g. Wege and Long, 1995). It seems likely that such small populations of parrots as were found in Porto Seguro may be open to problems of viability in the long-term (Franklin, 1980; Lynch and Lande, 1998).

Indications are that hunting pressure in the reserves was high despite continuing patrols at Sooretama. At Porto Seguro, several hunting ‘perches’ were sited in trees beside the trails, while hunting trails parrot trappers’ ladders, and hunters themselves were encountered at Sooretama and in nearby forest fragments. While it is not known what precise effect illegal trapping is having on parrots around either reserve, trapping, particularly of young from nests, is seen as a major threat to some species elsewhere (Collar and Juniper, 1992; Martuscelli, 1995).

A more general threat in both areas is habitat alteration. Much of the forest surveyed had been heavily logged, and habitat alteration, both due to encroachment at the reserve borders and the poaching of large trees for timber from inside the reserves was seen to remain a problem during our survey. This is not to say that all forest alterations are necessarily bad for all parrot species: we found *P. cruentata* to be associated with areas containing high proportions of the pioneer tree family Cecropiaceae, the fruits/seeds of which are a chosen food of *Pyrrhura* and *Brotogeris* (Pizo et al., 1995; Simão et al., 1997). However, several species, particularly *Amazona* were strongly associated with ‘big-tree’ forest and were absent from large areas of Sooretama. These, and probably other species, may continue to be affected by extraction of large trees, particularly through illegal logging. In addition to logging, Sooretama has a history

of forest fires, and during our fieldwork a large forest fire burnt c. 4000 ha of forest (c. 20% of the Sooretama reserve area). Little is known of the full effects of such fires on parrot populations or ecology, and given the importance of fire in and around the region’s forests, research on this aspect of parrot ecology is needed.

Because Sooretama is so important as a reserve for parrots, it may be that areas around this reserve should be identified as having higher priority in terms of management for threatened species than areas away from conservation strongholds. Our study shows that even small forest fragments can be of considerable value to some parrot species. However, whether such fragments are used by species may depend in part on their proximity to large tracts of forest, and the ability of parrots to travel between areas. We found *Amazona*, *Pionus* and the macaw *P. maracana* to fly regularly between reserve and forest fragments, and such flights are well known elsewhere (Forshaw, 1989; Martuscelli, 1995). Other species, notably two *Pyrrhura* and one *Brotogeris* parakeets were not recorded in forest fragments during the survey, and were rarely observed leaving the reserve. These species generally tolerate disturbed forests (Ridgely, 1981; Forshaw, 1989), suggesting that it may be unwillingness to pass between reserve and forest fragments, and not unsuitability of (generally disturbed) forest in the fragments, that stopped the parakeets from using patches outside the reserve.

Little has been documented as to the usage of agricultural and other man-altered land uses by Atlantic forest parrots. Some habitats are certainly of little use to parrots, and these include *Eucalyptus* plantations, pasture, and sugar cane and other arable crops. Other habitats outside reserves are more important and these include forest fragments and ‘Cabrucagem’ shade cocoa plantations. Some of the more traditional cocoa growing regimes have been identified as useful for nature conservation (Johns, 1998), and may be well utilised by parrots such as *P. cruentata* (Forshaw, 1989).

It may be that the preservation and regeneration of forest fragments around certain stronghold reserves may yield high returns for species conservation at comparatively low cost. It is also likely that considerations of the shape and connectiveness of such patches, and/or the promotion of more sympathetic land uses between forested areas, will extend the benefit offered to a wider range of species (Saunders et al., 1991; Lamb et al., 1997).

For such conservation management regimes to be properly proposed and justified, more needs to be known about the ecology of wildlife in and around the large reserves. For the formulation of a successful parrot conservation strategy in the region, the following are seen as priorities for research:

1. Identification of a critical set of parrot strongholds, and the assessment of population sizes within these areas, as a basis for long-term monitoring.
2. Research into the precise usage of strongholds by key parrot species, in terms of how their requirements for breeding, feeding and roosting can be fulfilled by forest within reserves and in surrounding habitats.

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