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Reoccupation of historical areas by the endangered giant river otter *Pteronura brasiliensis* (Carnivora: Mustelidae) in Central Amazonia, Brazil

Abstract: After decades of banning commercial hunting, the population of the endangered giant river otter in South America is no larger than 5000 animals, with slightly increasing populations, and apparent reoccupation of parts of its historical distribution. In Brazil, which may hold the largest populations, the refinement of distributional data and the conduction of censuses in Amazonia were identified as essential for the conservation of the species. To confirm if the species was, in fact, reoccupying its historical area, we present here data collected between October 2004 and September 2008 in Amanã Reserve, Central Amazonia. A total of 18,181 km along 13 water bodies were surveyed in 465 days of fieldwork, resulting in 711 records. Animals presented a uniform occupation pattern, with expansion to new areas, no vacancy of previously used ones, and with frequent reuse of sites along the years. However, considering the number of records/km and sightings/km were almost constant between years, the local population may be experiencing just a slight increase, with animals probably expanding their home ranges. Although our study witnessed some population growth, giant river otters remained at low numbers during the survey, indicating that such population still have not reached its carrying capacity and require continuous attention.

Keywords: Amanã; ariranha; flooded forest; Lutrinae; species recovery.

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Introduction

The giant river otter *Pteronura brasiliensis* Zimmermann (1780) (Carnivora: Mustelidae) is a large freshwater carnivore, endemic to South America and restricted to aquatic ecosystems in tropical forests and wetlands up to 300 m a.s.l. (Duplaix 1980, Carter and Rosas 1997, Kruuk 2006). In the past, its distribution covered large extensions from Guyana to Venezuela and Colombia, northern Argentina, and eastern parts of the Andes (Carter and Rosas 1997). Currently, the majority of the animals are found in the Pantanal, Brazilian Amazonia, and the regions immediately bordering this area, in French Guiana, Suriname, and Guyana (Kruuk 2006, Duplaix et al. 2008). In all those areas, giant river otters have a patchy distribution. The species is believed to be extinct in Argentina and Uruguay and does not occur in Chile (Duplaix et al. 2008).

Giant river otters prefer – but are not restricted to – clear or black water rivers, creeks, lakes, and ponds (Duplaix 1980, Carter and Rosas 1997), but food and refuge availability, including vegetation cover, shape, structure, accessibility and slope of margins and river banks, as well as water depth, also influence its habitat selection (e.g., Lima et al. 2012). The species seem to be sensitive to habitat disturbance and pollution (Foster-Turley et al. 1990, Parera 1996), and by exploring mainly a restricted range along the margins of water bodies, usually accessible by men, giant river otters are vulnerable to intentional hunting and occasional killing (Foster-Turley et al. 1990). Commercial hunting was the main threat to the species until the late 1970s (Carter and Rosas 1997), with giant river otters being killed for pelt or captured alive to be sold as pets (Schweizer 1992, Carter and Rosas 1997, Javier Díaz and Sánchez 2002, Utreras and Jorgenson 2003). Official

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records indicated that 40.663 skins were exported from Brazil between 1960 and 1967 (Best 1984), but the number of animals effectively killed was much higher as the illegal market was completely unrecorded.

Currently, the increase in the human settlements along the margins of the rivers, with a consequent conversion of pristine habitats into human-altered areas, an increase in boat traffic, pollution, and deterioration of water quality, and conflicts with commercial fishermen are the main threats to the species (Duplaix et al. 2008). Giant river otters are included in the Appendix I of CITES since 1973 (CITES 2013), being currently classified by the IUCN as Endangered (A3cd), mainly due to small populations, a patchy and restricted distribution, and an inferred future population decline due to habitat loss and exploitation (Duplaix et al. 2008). Recent estimates suggested that giant river otter population in South America may contain between 1000 and 5000 animals (Duplaix et al. 2008). In fact, some studies are indicating a slight increase in the population size of giant river otters, with an apparent reoccupation of parts of its historical distribution (Van Damme et al. 2002, Rosas et al. 2008, Uscamaita and Bodmer 2010).

In Brazil, which may hold the largest populations of the species (Kruuk 2006), the refinement of current distributional data and the conduction of population censuses in Amazonia were identified as essential measures for the conservation of the species (Vargas 2007, Rosas et al. 2008, ICMBio 2010). In fact, the number and distribution of studies focused on the giant river otters in the region is increasing (Carvalho Junior et al. 2004, Evangelista 2004, Rosas et al. 2005, 2006, 2007, Silveira and Almeida 2007, Silva and Rosas 2008, Rosas-Ribeiro et al. 2011), but the knowledge on the species there is still patchy and incomplete.

Protected areas are widespread in the Brazilian Amazonia, currently covering nearly 44% of the region (Veríssimo et al. 2011). Owing to its extensive area and location, those areas have an important role in the recovering of giant river otters in the region. The Reserva de Desenvolvimento Sustentável Amanã (Amanã Sustainable Development Reserve, hereafter Amanã SDR), a 2.3 million-ha IUCN category VI reserve in Amazonas State, is an example. According to long-term local residents, giant river otters had disappeared in the area for nearly 30 years, mainly due to overhunting, which had decimated local populations. Amanã SDR was created in 1998, and after some reports of sightings by residents, in 2004 a distributional survey conducted in 13 rivers around the Amanã Lake recorded evidence of the species in the area, but with a single animal observed

(Carvalho Junior et al. 2004). Shortly after, Marmontel and Calvimontes (2004) indicated that, in spite of a reduced population, the area around the headwaters of Amanã Lake could be experiencing a reoccupation by the species. Reports from residents indicated that encounters with groups of animals near human settlements were becoming more frequent. In order to expand the current knowledge on the presence and distribution of giant river otters in the region, and to confirm if the species was in fact reoccupying that area, we present here the results of a 4-year population distribution census conducted around the Amanã Lake.

Materials and methods

Study area

The Amanã SDR ($1^{\circ}35'43"S$ to $3^{\circ}16'13"S$; $62^{\circ}44'10"W$ to $65^{\circ}23'36"W$) is nearly 650 km west of Manaus, at the central portion of Amazonas State, between Negro and lower Japurá river basins (Figure 1). Created in 1998, the area has 2.35 million ha and is one of the largest extensions of protected forests in South America. Most of the area is covered by pristine *terra firme* forests (84%), but there is also seasonally flooded forests dominated by black water systems (*igapós*, 9%), by white water systems (*várzeas*, 6%), and white sand forests (*campinaranas*, 1%), with less than 3% of the total area used by residents for subsistence (Ayres et al. 2005).

Black and white water systems can be found in Amanã SDR (Sioli 1984), with emphasis to the Amanã Lake, with nearly 45 km in extension and 2–3 km in width (Ayres et al. 2005). The lake is supplied by black water in its headwaters, but during the high water season, it is also influenced downstream by white water from Japurá River. The water level in the area may experience a 10-m variation along the year (Junk et al. 1989), with high water usually from November to June. Annual average temperature is around 29°C (Ayres 1993). The area was used as a source of otter (*Lontra longicaudis* and *Pteronura brasiliensis*) and jaguar (*Panthera onca*) pelt by commercial hunters until late 1970. The current human population in the Amanã SDR is around 4000 people, distributed in 84 villages (Amanã's demographic census – 2011).

Within Amanã SDR, the focal area of this study was defined as creeks surrounding Amanã Lake: 120 km along the Urumutum, 20 km along Juacaca, 15 km along Juazinho, and 30 km along Baré, all at the headwaters of the lake; plus 15 km along Juá Grande, 8 km along Ubim,

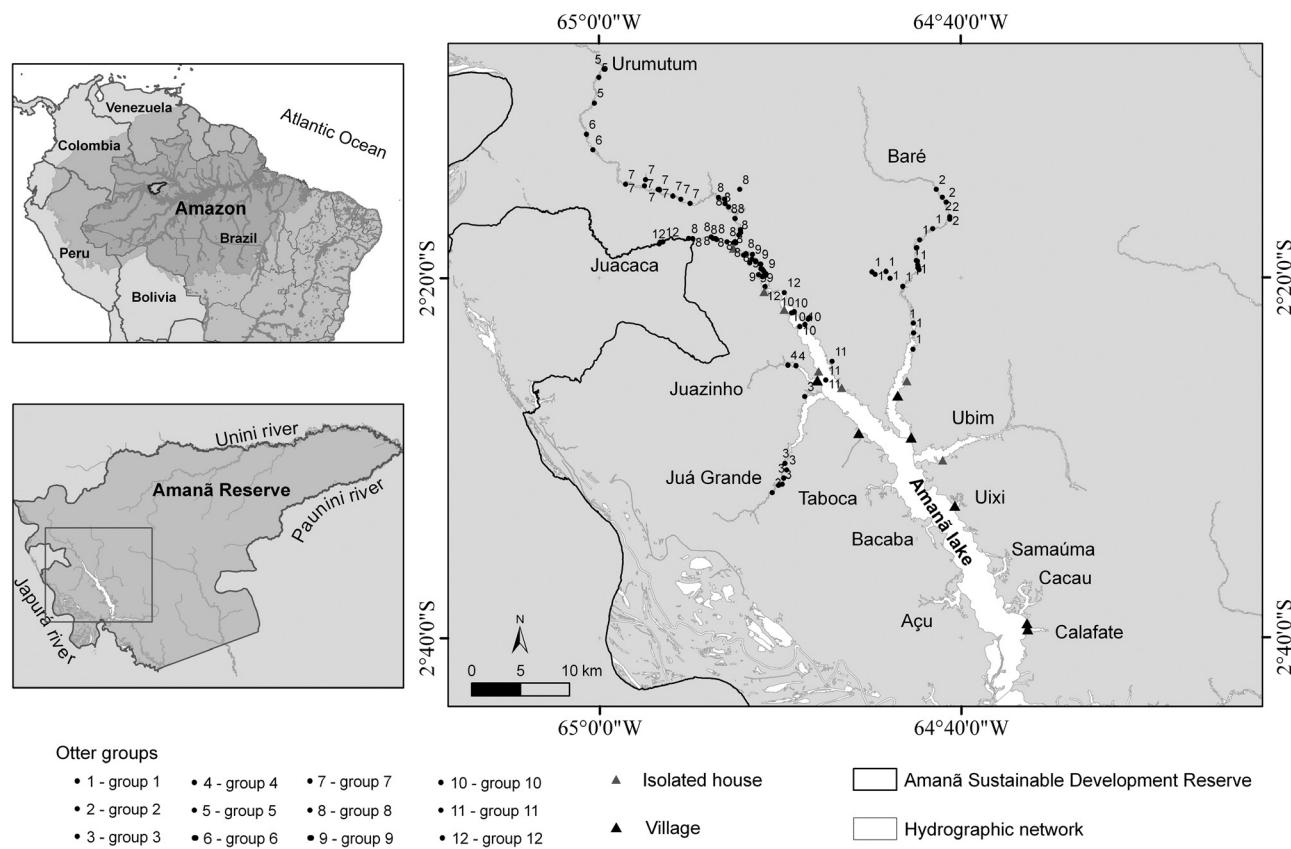


Figure 1 Distribution of giant river otter (*Pteronura brasiliensis*) groups along streams and creeks surrounding the Amaná Lake, in the Amaná Sustainable Development Reserve, Central Amazonia, Brazil, sampled between October 2004 and September 2008.

5 km along Açu, and 3 km along Cacau, the latter two downstream Amaná Lake from our field base. With the exception of white water's Juacaca, all others have black waters. The margins of all those creeks are composed either by terra firme forests, várzea forests, or a combination of both.

Sampling methods

A total of 40 sampling trips were performed between October 2004 and September 2008 in search of signs of the presence and use of margins and banks by giant river otters. Extreme low water levels, restrictions imposed by residents to access the areas they use, and logistic limitations restrained trips in the months of December 2004, April 2005, January, April, July, and August 2006, April 2007, and March 2008. Until September 2007, samplings were restricted to Baré, Urumutum, and Juacaca creeks, as those were the areas previously identified with the presence of giant river otters by Carvalho Junior et al. (2004). Owing to the large extension of the lake and logistical

restrictions, other water courses were included in the survey just after indications of the presence of giant river otters by the residents. Once pieces of evidence of the presence of the species were confirmed, those water courses were then monitored every 2 months.

In October 2007, a total of 13 water courses around Amaná Lake were sampled for the presence of the species. Each trip consisted of nearly 10-day excursions, with a minimum sampling effort of 11 h of search per day. As giant river otters are exclusively diurnal (Carter and Rosas 1997), searches were performed during the day, by motor, or paddle boat, reaching the most distant navigable point. Boat speed never exceeded 10 km/h. Daily distance searched was calculated with a GPS.

Around Amaná Lake, the giant river otter shares its habitat with the neotropical otter (*Lontra longicaudis*) and their respective signs may be confused. To avoid the risk of misidentification, pieces of evidence were photographed or filmed, compared with previous records made in the area (see Groenendijk et al. 2005), and correctly identified by one of the authors (M. Marmontel), who has ca. 20 years working with otters in Amazonia. Vocalizations,

footprints, claw markings, campsites, dens, and resting sites were taken as records, as they are indicative of giant river otter residency in water. Giant river otters were considered present in an area based on direct observation and indirect pieces of evidence (Groenendijk et al. 2005). Records were photographed and/or filmed and had their precise locations taken with the GPS course.

Campsites were defined as sites by the margin of water bodies associated with a latrine or, in some cases, an isolated latrine only; tunnel-shaped holes built on the banks were recorded as dens; resting sites were cleared areas or small holes, cylindrical or semicircular in shape, not associated with latrines (Groenendijk et al. 2005). Such sites remain recognizable even when not continuously used by river otters. In every new trip, previously recorded sites were visited to verify the continuous use of those areas.

Annual censuses were conducted along 63 km of Urumutum creek, 20 km of Juacaca, 15 km of Juazinho, 30 km of Baré, 15 km of Juá Grande, 8 km of Ubim, 5 km of Açu, and 3 km of Cacau. Samplings occurred before extreme water levels, which according to Groenendijk et al. (2005) is the best period for censuses, as low water favors animal sightings, and high waters can cover animal signs. Animal counting followed the methodology described by Groenendijk et al. (2005), which recommends the use of individual's throat marks to avoid potential double counts, and were used to estimate the population size in the area. Areas with clear pieces of evidence of the presence of the species were rechecked at shortened intervals to confirm the presence of animals. Animal observations and counting were performed by two observers using binoculars and digital camcorders, making, whenever possible, the identification of individual throat marks.

Records were divided in sampling years: "Y1", from October 2004 to September 2005; "Y2", from October 2005 to September 2006; "Y3" from October 2006 to September 2007; and "Y4" for data collected between October 2007 and September 2008. Using ArcGis 9.2 software (ESRI, Redlands, CA, USA), all records were plotted on a LANDSAT-5 image, with 30 m spatial resolution. Shape files were then inserted into Autodesk AutoCAD Map 4 software (Autodesk, Inc., San Raphael, CA, USA), producing a grid of 1 km² cells over the water bodies and courses around Amanã Lake (e.g., Sea Otter Recovery Team 2007, Waldemarin 2004, Groenendijk et al. 2005).

Grid cells with recent records of the presence of the species were compared to determine the distribution of giant river otters along the sampling years. A presence index was calculated for each year, dividing the number of records (both direct and indirect) by the total length (in km) of the water body sampled. Presence indexes were

calculated for the total area sampled and for each specific water body, and compared between years. Grid cells with presence of giant river otters were divided by the total number of cells sampled in order to determine the proportion of the area used by the species yearly, both overall and for each water body.

Results

A total of 18,181 km along 13 water bodies were surveyed in 465 days of fieldwork around the Amanã Lake. That survey resulted in 711 records of the presence of giant river otters along eight water courses: Açu, Baré, Cacau, Juacaca, Juazinho, Juá Grande, Ubim, and Urumutum. Among the records, 126 were sighting of social units, 193 campsites, 140 isolated dens, 90 claw markings, 62 resting sites, 43 footprints, 42 dens associated with latrines, and 15 vocalizations. There were signs of reuse for 47.8% (n=291) of the records along the 4 years sampled.

With the exception of Cacau (a single sampling) and Açu creeks, there was an increase both in the total proportion and extension of the areas (in km²) (Table 1) used by giant river otters between the first and last sampling years (Figure 2). Increases varied from 50% (Ubim) up to 260% (Juá Grande). However, differences in the presence index for each water course and for all of them pooled together were not statistically significant (Kruskal-Wallis, H=6.1292, p=0.1055). In Y1, when only Baré, Urumutum, and Juacaca were sampled, the presence index was 0.08 record/km, or one record for every 12.5 km sampled. In Y2, with the inclusion of Juá Grande, the index was 0.12 record/km (one record for every 8.4 km sampled). In Y3, Juazinho, Ubim and Açu were

Table 1 Proportion and extension of the areas (in km²) with records of giant river otter (*Pteronura brasiliensis*) along streams around Amanã Lake, in Amanã Sustainable Development Reserve, Central Amazonia, Brazil, sampled between October 2004 (year 1=Y1) and September 2008 (year 4=Y4).

Stream	Proportion				Extension (km ²)			
	Y1	Y2	Y3	Y4	Y1	Y2	Y3	Y4
Baré	27%	33%	43%	54%	10	12	15	19
Urumutum	27%	41%	46%	51%	22	32	37	40
Juacaca	23%	31%	69%	69%	3	4	9	9
Juá Grande	—	17%	38%	61%	—	3	7	11
Juazinho	—	—	33%	67%	—	—	2	4
Ubim	—	—	23%	31%	—	—	2	3
Açu	—	—	33%	33%	—	—	1	1
Cacau	—	—	—	67%	—	—	—	2

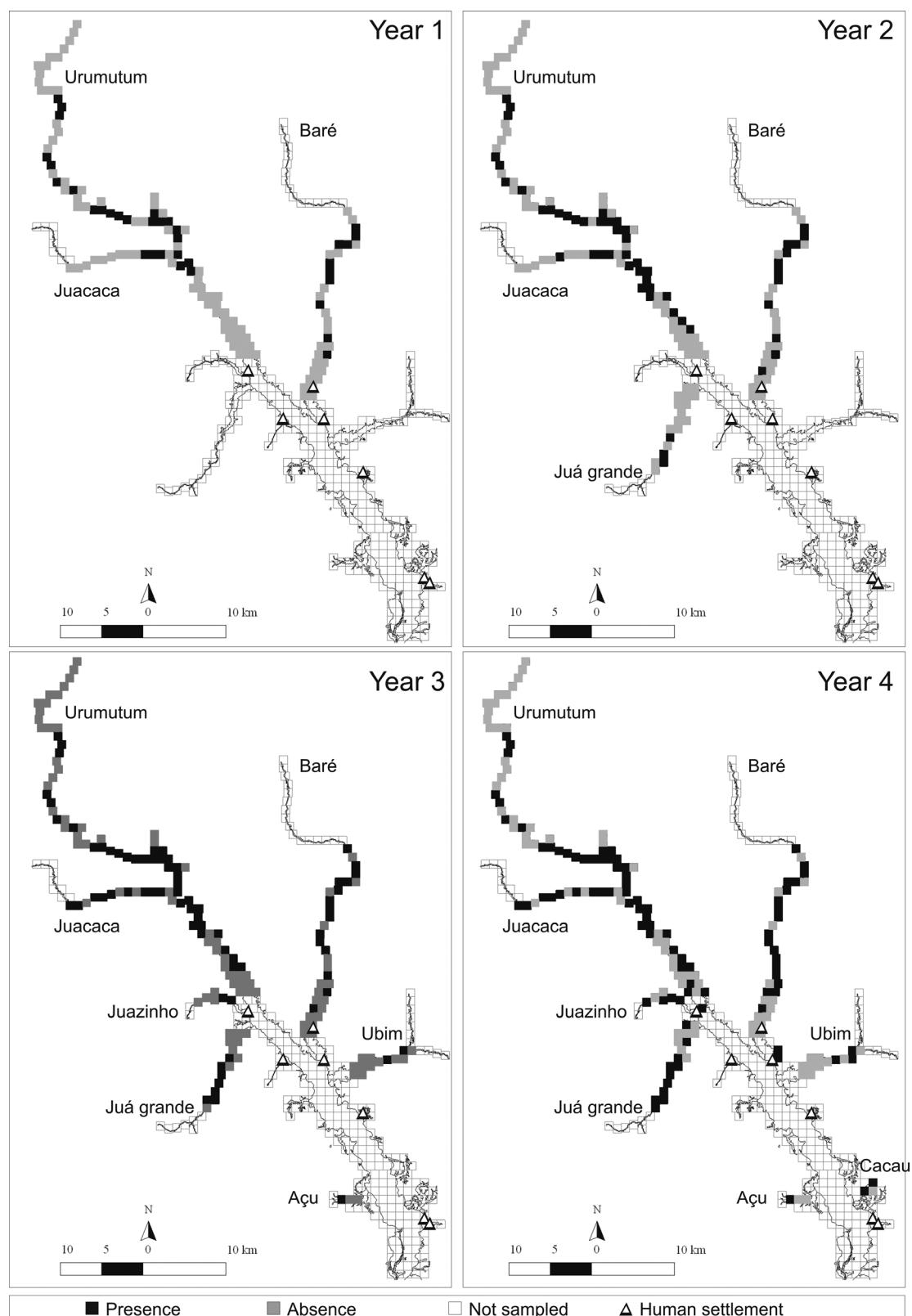


Figure 2 Streams and creeks surveyed for the presence of giant river otters (*Pteronura brasiliensis*) around the Amaná Lake, in Amaná Sustainable Development Reserve, Central Amazonia, Brazil, between October 2004 and September 2008. Grid cells equals 1 km² each.

included in the sample, resulting to 0.09 record/km (one record/11.7 km sampled). With the sampling of Cacau in Y4, a total of eight water courses were sampled, with a presence index of 0.09 record/km (one record/10.6 km sampled).

A total of 9448 km were sampled for population censuses during 223 days in the low water seasons of the 4 years, resulting in 80 sighting events involving 167 individuals. Animals presented a shy behavior, generally promptly running away at the first sight. Individual identification based on throat marks was possible for 32 animals. Social units were observed along Baré, Juá Grande, Juacaca, Juazinho, and Urumutum. No animals were observed along Açu, Ubim, and Cacau, although there were pieces of evidence of the presence of the species along those water courses, and local residents have informed sporadic encounters with otter families there. There was no significant difference in the overall number of sightings between years (0.04 ± 0.01 otter/km), neither for specific water courses independently (Table 2).

Mapping of sighting records between October 2004 and September 2008, together with the individual identification based on throat marks ($n=32$), allowed us to estimate that the population of giant river otters in the sampled area in Y4 was composed by nearly 75 animals distributed in 12 social groups (Figure 2). Urumutum was the water course with the highest number of social units ($n=8$), with an average of 7 ± 3 otter/unit, and the largest social unit (13 animals). That social unit was observed exploring parts of Urumutum and Juacaca creeks. Two social units were observed along Baré, one composed by nine animals, and the other with three. One social unit each was observed along Juazinho and Juá Grande, both with six animals each.

Table 2 Presence index (sightings/km) for giant river otters (*Pteronura brasiliensis*) along streams around Amanã Lake, in Amanã Sustainable Development Reserve, Central Amazonia, Brazil, sampled between October 2004 (year 1=Y1) and September 2008 (year 4=Y4).

Creek	Y1	Y2	Y3	Y4
Baré	0.07	0.12	0	0.08
Urumutum	0.02	0.04	0.04	0.04
Juacaca	0	0.03	0	0.15
Juá Grande	—	0	0.03	0.03
Juazinho	—	—	0	0.08
Ubim	—	—	0	0
Açu	—	—	0	0
Cacau	—	—	—	0

Discussion

Reoccupation and population growth

Considering all the pieces of evidence observed, we detected both an increase in the number of water courses and in the area giant river otters were using between 2004 and 2008 around Amanã Lake, an area of historical occurrence of the species in Amazonas State, in Brazil. Prior to our study, census conducted in the same 13 water courses we sampled indicated the presence of the species in only two of them, both in the headwaters of the lake (Carvalho Junior et al. 2004). Our census indicated the presence of the species downstream Amanã Lake as well, with a 100% increase in the number of water courses in use. Along the 4 years of our sampling, giant river otters around Amanã Lake presented a uniform occupation pattern, with expansion to new areas, with no vacancy of previously used areas, and with frequent reuse of sites along the years. However, considering that both the number of records/km and sightings/km were almost constant between years, we believe that the local population may be experiencing just a slight increase in size, with animals probably expanding their home ranges to larger areas along the water courses.

Based on our best estimate, in 2008, the population of giant river otters around Amanã Lake was composed of 12 familiar groups with, at least, 75 animals whose identification was possible. Our censuses resulted in sightings at intervals between 8.4 and 12.5 km (average 11.9 km), indicating that a population that size is within the values expected for an area still under reoccupation. After the filling of the reservoir of the Balbina Dam, in Amazonas State, 130 animals were observed in an area of 450 km² (Rosas et al. 2007), while in the Brazilian Pantanal, on average, one group was observed at every 7 km sampled along Negro river (Schweizer 1992) and at every 10.8 km along Aquidauana and Miranda rivers (Tomas et al. 2000).

Although our study witnessed some population growth, giant river otters appear to have remained at low numbers during the survey, indicating that such population still have not reached its carrying capacity and requires continuous attention. The effective size of the local population can be larger, considering that there were unverified reports from residents of other river otter groups in the area. Although effective sights were obtained only along Baré, Juá Grande, Juacaca, Juazinho, and Urumutum creeks, pieces of evidence (markings and using sites) obtained along Açu, Cacau, and Ubim, together with reports from the local residents provide support for the occurrence of the species along those water bodies. We recommend further

surveys in those areas in order to quantify the number of animals living there, as well as other important factors such as the sex and age structure of that population, the dispersal capacity of individuals to form new packs, the possibility of a component Allee effect, and restrictions imposed by territory availability limiting the recovery of the population (e.g., Koons et al. 2006, Steinmetz et al. 2010, Brodie et al. 2011, Woodroffe 2011).

Amanã SDR physically links two other important protected areas in Central Amazonia, the adjacent Jaú National Park (2.27 million ha), and Mamirauá Sustainable Development Reserve (1.12 million ha). Together, they form a single block of nearly 5.74 million ha of continuous protected areas, known as the Central Amazonia Ecological Corridor. Owing to its location and extension, Amanã SDR has an important role in the conservation of giant river otters and other large vertebrates in Central Amazonia allowing a physical connection between the other two protected areas and their respective populations. As there are reports of giant river otter populations both in Mamirauá SDR (e.g., Carvalho Junior et al. 2004, Marmontel and Calvimontes 2004) and Jaú National Park (e.g., Silva and Rosas 2008), overall, the findings from these studies are encouraging for managers of those areas and for conservationists charged with preserving giant river otters in the Brazilian Amazonia.

Methodological considerations

In our study, we observed that reports made by local residents on the presence/absence of giant river otters

in some water courses were faithful, indicating that such information is useful for orienting sampling efforts. Similarly, the inclusion of claw markings, resting sites, and vocalizations among the pieces of evidence already suggested as indicators of the presence of giant river otters (see Groenendijk et al. 2005) was essential for a better estimate on the spatial distribution of the species in the studied area. Had we used only sightings, campsites, dens, and footprints (the usual indicators), the number of evidence of the presence of giant river otters would have dropped from 711 to 549, underestimating the real distribution of the species in the area. Therefore, we advocate that claw markings, resting sites, and vocalizations should not be discarded and be also considered as pieces of evidence of the presence of giant river otters in areas with difficult conditions of direct observations of the animals.

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