Medium- and large-bodied mammals and ground birds of the Barima Mora Passage, Region 1, Guyana

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Introduction

Hunting intensity has already reached unsustainable levels across much of the tropics, representing the most pressing threat to game mammal and bird populations after habitat loss (Redford, 1992; Fa & Peres, 2001; Nasi et al., 2011; Wilkie et al., 2011; Maxwell et al. 2016; Ripple et al. 2016; Young et al. 2016). Under moderate and heavy hunting intensities, game mammal and bird species' abundances can decline by an average of 83% and 58% respectively (Wilkie et al. 2011; Benitez-Lopez et al. 2017). For tropical forest species, determining sustainable levels of harvest has become increasingly important to ensure the long-term survival of hunted species, while at the same time maintaining a reliable, low-cost source of protein for subsistence-based communities.

The Guyana Marine Conservation Society and Rupununi Wildlife Research Unit camera trap monitoring of the proposed Barima Mora Passage Special Protected Areas (referred to as "BMPSPA" from here on) focused on medium- and large-bodied species that tend to carry a higher risk of extinction from overhunting. This increased risk is due to a combination of particular biological traits (i.e. low reproductive rates, and naturally low population densities), behavioral traits (i.e. diurnally active, high visibility, slow moving, repeated use of den/resting sites), and external environmental factors (i.e. limited geographic range; Arita et al. 1990, Cardillo et al. 2005; Fa & Brown 2009; Wilkie et al. 2011). Little of the substantial plant biomass present in tropical forests (DeWalt & Chave 2004) is readily available as food for the large, terrestrial frugivores and herbivores preferred by hunters (Peres 2001; Ripple et al. 2016). In tropical forests, browse and forage resources tend to be either out of reach in the upper canopy or indigestible (Waterman & McKay 1989; Fa & Peres 2001; Fa & Brown 2009).

In the Neotropics, studies have shown that a preference for large-bodied frugivorous and herbivorous mammals among hunters (Abernathy et al. 2013) has resulted in local population declines of lowland tapir (*Tapirus terrestris*), red brocket (*Mazama americana*) and white-tailed deer (*Odocoileus virginianus*), white-lipped peccary (*Tayassu pecari*), and giant armadillo (*Priodontes maximus*) (Cullen et al. 2000; Peres 2001; Weber & Gonzales 2003; Di Bitetti et al. 2008; Superina et al. 2014). Declines in the populations of key species can have significant negative effects on the tropical forest ecosystems through decreased seed dispersal and seedling survival, changes in vegetation cover and composition, and functional compensation (Peres &

Dolman 2000; Terborgh et al. 2001; Peres & van Roosmalen 2002; Stoner et al. 2007; Wright et al. 2007; Beck et al. 2013).

In Guyana, the demand for wild meat is steadily increasing in the country's growing urban centers. It is estimated that 625 tons of wild meat per year (0.2 tons/km2/year) are consumed in Guyana's capital (Puran et al. 2017). A lack of employment opportunities, coupled with increasing access to markets (Wilkie et al. 2000; Laurance et al. 2006; Puran et al. 2017), means that many hunters in the country's interior have shifted from hunting as a predominately subsistence activity, to hunting that yields enough to meet subsistence needs and supplement incomes. A combination of improved road infrastructure, increased access to communication technology, vehicles, refrigeration, and firearms, desire for cash-based income and commercial goods, rejection of traditional culture and livelihoods by young people, and increasing demand from wild meat markets on Guyana's coast and mining concessions in the interior may already be driving an increase in commercial hunting (Puran et al. 2017).

A recent study focused on the impact of hunting in and around the Kanuku Mountains Protected Areas (KMPA, Region 9) did not identify any statistically significant impacts of current hunting intensity on game species frequently targeted by hunters, however trends in the data suggest that increasing or even sustaining current hunting intensity over time may result in declines of frequently hunted species (lowland paca, red brocket deer) or those with biological traits that make them the most susceptible to overhunting (lowland tapir, giant armadillo; Hallett et al. 2019). It is reasonable to assume that hunting intensity in the BMPSPA is likely higher than that of the Kanuku Mountains due to increased accessibility and proximity to markets in coastal cities and mining areas, while baseline population density of game species is likely lower due to natural differences in food production between habitat types (lowland and upland forest in the KMPA vs. mangrove and swamp forest in the BMPSPA).

Considering hunting often drives depletion or even local extinction of mammalian populations (Peres 1990, Redford 1992, Cullen Jr et al. 2000, Hill et al. 2003), understanding the diversity, abundance, and distribution of species in this guild is essential for both traditional and modern local livelihoods. Monitoring of large mammal species serves as an important tool for assessing overall ecosystem function and integrity, since their large home range requirements and slow life histories render them particularly sensitive to hunting and other disturbances by humans (Purvis et al. 2000, Brashares 2003, Cardillo et al. 2004). Additionally, the abundant and wildlife-rich forests of Guyana currently sit near a precipice, with coming lucrative offshore oil development, infrastructure improvements, demand for natural resources, and desire to re-establish the agricultural sector, it is hard to predict what future may hold. Guyana has already lost more than three-quarters of its mangroves over the past 50 years and today, the most abundant mangrove coverage consists of mangal, that are found along Guyana's rivers and estuaries. Over 80% of the country's remaining mangrove areas are found in Barima-Waini (Region 1) and the Pomeroon River basin in Region 2. This study seeks to establish a current baseline which will assess the impact of subsistence and commercial hunting in the in the Barima Mora Passage Special Protected Area (BMPSPA) of Region 1, Guyana.

Methods

Study Area

Region 1 is a ~20,339 km² administrative region of NW Guyana. It borders the Atlantic Ocean to the north, the Pomeroon-Supenaam (Region 2) to the east, the Cuyuni-Mazaruni (Region 7) to the south, and Venezuela to the west. Region 1 is mainly composed of forested highlands bordered by a narrow strip of low coastal plain running along the Atlantic coast. The BMPSPA is located in the northwestern part of Region 1, sharing the southern border of the Shell Beach Protected Area, near the Venezuelan border north of the town of the regional capital of Mabaruma and adjacent to the indigenous Warrau settlement of Morawhanna at the intersection of the mouth of the Barima and Aruka rivers (Figure 1). This area is considered one of the most biologically and socio-culturally diverse coastal ecosystems in Guyana (Ryan & Ramessar 2020).

The BMPSPA consists of a mosaic of freshwater and brackish wetlands, rivers and estuaries, which include the largest and most intact mangrove forests (both coastal and riverine) in Guyana (SBMP 2013), mixed swamp forests, open swamps (herbaceous, cattail and saltwater swamps), nonnative Nypa palm (introduced from SE Asia), smallholder agriculture, and seasonally flooded palm savannahs (Charles et. al. 2004). The dynamic mangal ecosystem at the heart of the BMPSPA is driven by the tides, floods, and rainfall. There are three or four mangrove species, which are closely linked to the surrounding freshwater swamps and tidal wetlands found along the rivers, tidal creeks, and estuarine areas. The BMPSPA mangrove-swamp ecosystems is largely composed of black (*Avicennia germinans*), red mangroves (*Rhizophora mangle*), white mangroves (*Laguncularia racemosa*), freshwater (palustrine) wetlands, tidal wetlands, freshwater swamps and marsh forests (*Symphonia globulifera*, *Ficus* spp., *Virola surinamensis*, and *Euterpe oleracea*, which can be mixed with old *A. germinans* stands). Mangrove ecosystems provide invaluable ecosystem services to local populations, valued at around $3.4 billion per annum (Ryan & Ramessar 2020).

Mangals are critical ecosystems that are found at the interface between the land and the sea and are nourished by daily tidal cycles that deliver nutrient, eggs, and larvae of many species. These rivers and creeks serve as critical habitat for a wide range of aquatic species of commercial importance and conservation concern, such as giant river otter (*Pteronura brasiliensis*), West Indian manatee (*Trichechus manatus*), Guiana dolphin (*Sotalia guianensis*), and Atlantic tarpon (*Megalops atlanticus*). Additionally, the forested cover provided by mangal and mangrove-swamp ecosystems form biological corridors for a number of terrestrial species of conservation concern, including jaguar (*Panthera onca*), lowland tapir (*Tapirus terrestris*), white-lipped peccary (*Tayassu pecari*), giant anteater (*Myrmecophaga tridactyla*), black curassow (*Crax alector*), and yellow-footed tortoise (*Chelonoidis denticulatus*), among others

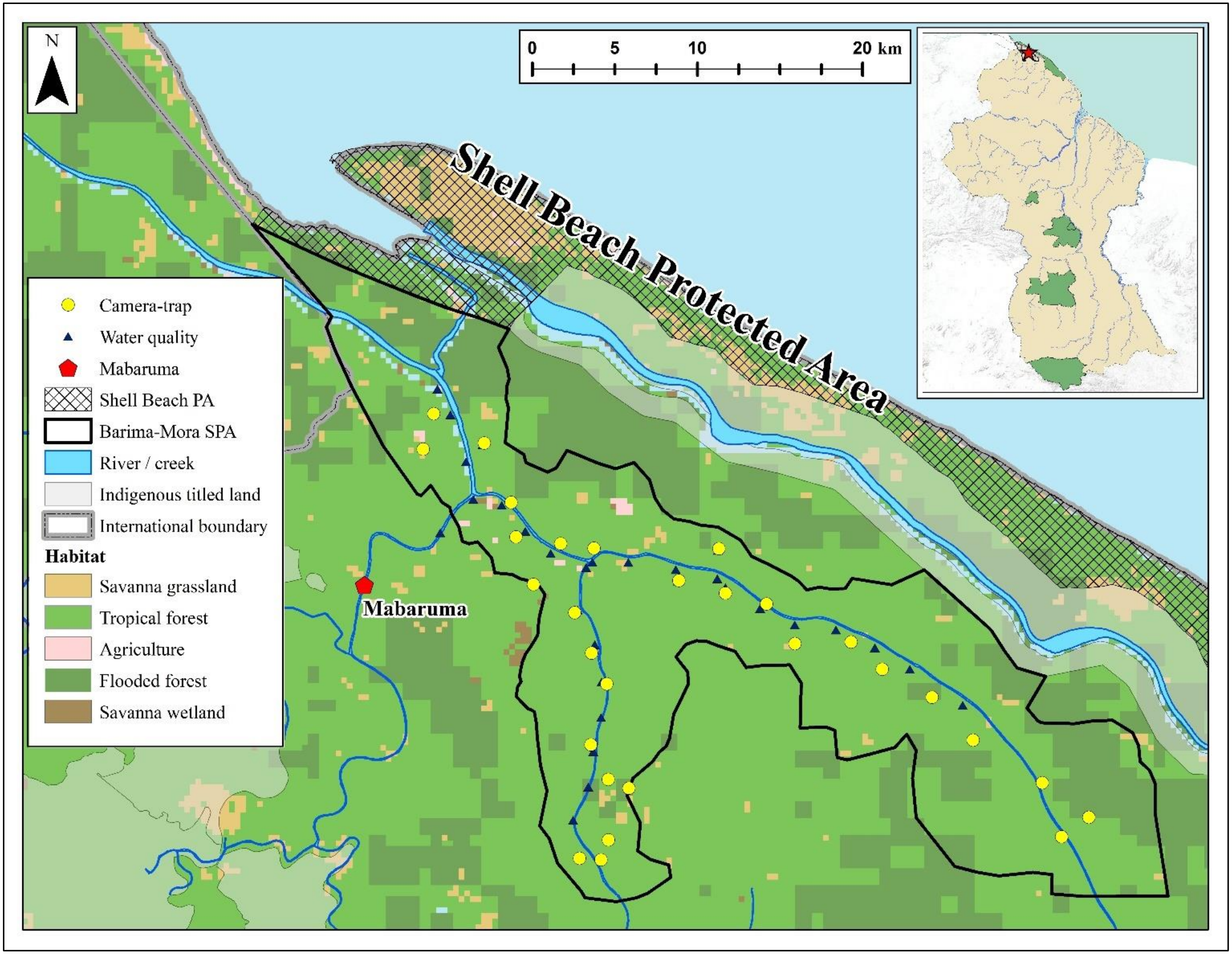


Figure 1: Map of the proposed Barima Mora Special Protected Area (BMPSPA), showing camera-trap locations (circles) and water quality sampling locations (triangles), as well as the boundaries of the BMPSPA (solid line), Shell Beach Protected Area (hatching), and indigenous community titled lands (transparent polygons) (Arino et al., 2012; Environmental Systems Research Institute (ESRI), 2015

Water quality
Thirty (30) surface water samples were collected at an approximate interval of 2 km over a two day (May 22-23, 2021) period by a team from the Hydrometeorological Service (Hydromet) of the Guyana Ministry of Agriculture in association with camera-trap collection. Hydromet teams measured temperature (°C), pH, salinity (mg/L), conductivity (µS/cm), total dissolved solids (TDS, mg/L), dissolved oxygen (DO, mg/L), and nitrate (mg/L) at each sample location.

Camera-trap survey
Camera-traps have proven to be an effective tool for surveying medium and large mammals in tropical rainforest environments (Tobler et al. 2008), an assertion that has been reinforced by previous research conducted in Guyana (Hallett et al. 2019; 2021a; 2021b). Visual and auditory surveys and direct trapping have proven inefficient, offering low returns compared to cost and effort (Emmons 1993; Lim & Engstrom 2005; Pickles et al. 2011). Despite being touted as the most effective method for detecting richness in rapid assessments (Silveira et al. 2003), line transects surveys have routinely under detected species of interest for this project (paca, deer, peccary, tapir; Fragoso et al. 2016) – showing promise only in surveys of very common and/or conspicuous species (red-rumped agouti, large primates; Bicknell & Peres 2010). While camera trap surveys may have their limitations when it comes to surveying small mammals, arboreal species, and those with specialized habitat requirements (Sollman et al. 2013), they have proven to be the most efficient and effective method for mammal species of interest for the BMPSPA.

Camera-trap photos were obtained as part of a multi-species camera-trap study of the BMPSPA, following well-established methods for camera-trap research (Karanth and Nichols, 1998; Silver, 2004). Camera-traps (Bushnell Trophy Cam #119739C, 119876C, 119936C, 119938C, Bushnell®, KS, USA) were set 2–3 km apart, with a single camera at each trap location, set 30–40 cm from the ground in proximity to observed animal sign. Cameras were active 24 h per day, with a 1 second delay between captures, recording the date and time with each 3-image sequence. Images of the species of interest that occurred at the same trap site within a period of 30 min were excluded to ensure that photo occasions were independent (Silver, 2004). In an effort to reduce wariness around cameras and avoid biased capture rates, no scents or lures were used, and all cameras employed were equipped with infrared flash.

Camera-trap sites were selected for inclusion in this study based on their location within the proposed BMPSPA. This included areas surveyed within Mabaruma township, Amazon Caribbean (Guyana) Ltd (AMCAR) forestry concession, and the titled lands of two indigenous settlements (Morawhanna, Smith's Creek). Camera-traps were left in the field for 100–106 trap nights between February and May 2021.

To broadly characterize community structure and functional diversity, we will assigned general trophic categories (i.e. carnivore, herbivore, insectivore, omnivore) and estimated body size for each species based on information from the literature (Emmons 1997). Functional diversity was estimated using functional dispersion index (FDis), the mean of the distance between species in a multivariate functional space to the community centroid, weighted by occupancy for each species (Etienne & Pierre 2010) using package FD for R (Etienne & Bill 2010). Species richness, Shannon diversity, evenness and dominance were calculated using standard methods (Pielou

1966; Magurran 1988; Colwell et al. 2004) using the package BiodiversityR (Kindt & Coe 2005).

Considering the goal of assessing a broad group of 'marked' and 'unmarked' predators and game species, statistical analysis of the BMPSPA camera trap data will be structured into three tiers in an effort to better to understand the (1) occupancy and (2) relative abundance of wildlife species. Although exceptions exist, prevailing theory and most empirical evidence on abundance-occupancy relationships predicts that species will exhibit a positive interspecific and intraspecific relationship between regional occupancy and local abundance (Zuckerberg et al. 2008). Naïve occupancy is calculated by dividing the number of sites where a species was detected during the survey by the total number of sites surveyed. Although inherent detection biases mean that relative abundance indices (RAI) do not accurately reflect population density (Sollmann et al. 2013), we will calculate (RAI) for each species because it may provide valuable supplementary information (i.e. the location of frequently used sites and key resources) that will aid in interpreting the results of occupancy models. RAI is calculated by dividing the number of occurrences of each species by the number of nights at each camera and standardizing for 100 trap nights (O' Brien 2011).

Results

Water quality

The highest recorded salinity value was 7.66 mg/L, taken at sample point 26 in the Barima River, while the lowest recorded value was 0.03 mg/L at points seven (7) and eights (8) in the Kaituma River. Surface water temperature remained relatively consistent across all sites, ranging from 27.1-30.3°C, with a mean of 28.44°C (median = 28.6°C, standard deviation = 0.74°C).

pH fluctuated among sample locations with the highest recorded value of 7.25 at sample point 23 in the Barima River and the lowest recorded value of 4.26 at sample point eight (8) in the Kaituma River. Both rivers were found to have a slight average acidic nature, with a mean of 5.65 (median = 5.73, standard deviation = 0.85). The highest and lowest readings were recorded in the Barima River; sample points twenty seven (27) and fifteen (15) recorded a value of 4.89 and 0.52 respectively. Dissolved oxygen did not fluctuate greatly during this exercise.

The recorded values showed a fluctuation in reading. Where there is relatively high recorded values for conductivity, TDS also showed high readings. The highest value of 480.0ppm was recorded in the Kaituma River at sample point five (5), while the lowest was recorded in the Barima River at sample point twenty eight (28) with a value of 1.03ppm. Some sample points were above the standard while a large number of points were below.

The lowest recorded value was at sample point two (2) in the Kaituma River with a reading of 1.24 while the highest was recorded in the Barima River at a value of 8.70 at sample point twenty five (25).

Table 1: Temperature (°C), pH, salinity (mg/L), conductivity (μS/cm), total dissolved solids (TDS, mg/L), dissolved oxygen (DO, mg/L), and nitrate (mg/L) at each sample location

Sample ID	**Temperature (°C)**	**pH**	**Salinity (mg/L)**	**Conductivity (μS/cm)**	**TDS (mg/L)**	**DO (mg/L)**	**Nitrate (mg/L)**
1	29.3	5.88	2.32	14.85	7.86	4.79	2.1
2	29.4	5.46	2.59	14.87	8.32	1.12	1.24
3	28.9	5.22	1.89	4.31	2.79	1.48	2.45
4	28.6	4.8	0.95	2.18	1.4	1.12	2.51
5	28.7	4.6	0.32	742	480	0.95	1.31
6	30.3	4.42	0.04	82.5	56.1	0.88	3.44
7	28.9	4.43	0.03	69.6	45.1	0.95	4.22
8	28.7	4.26	0.03	59.1	38.2	0.9	4.87
9	29.1	5.86	2.53	5.76	3.74	1.54	7.31
10	29	5.34	1.37	4.46	2.31	1.63	4.52
11	28.6	5.9	1.74	3.98	2.58	1.57	3.52
12	29	5.86	1.35	3.08	2	1.37	4.3
13	27.8	5.07	0.97	2.29	1.43	1.28	7.23
14	28.3	5.78	1.16	2.7	1.72	1.47	4.67
15	27.1	4.98	0.21	497	305	0.52	6.11
16	27.7	5.73	1.2	2.84	1.78	1.26	6.39
17	28.7	5.79	1.1	2.53	1.63	1.46	1.43
18	28.1	5.73	0.91	2.12	1.35	1.4	1.25
19	27.5	5.4	0.75	1.8	1.12	1.13	6.71
20	28.3	6.7	3.43	7.94	5.07	1.55	8.47
21	27.9	7.06	3.78	8.91	5.6	2.3	6.36
22	27.5	7.2	4.33	10.26	6.4	1.92	5.23
23	27.5	7.25	4.43	10.49	6.55	1.81	5.12
24	27.4	7.04	3.76	8.96	5.58	1.5	6.73
25	27.5	4.34	0.16	388	238	0.62	8.7
26	29.4	6.61	7.66	17.25	9.61	2.26	6.24
27	28.3	5.74	1.06	2.46	1.57	4.89	3.49
28	28.6	5.72	0.7	1599	1.03	1.21	1.25
29	28.7	5.66	0.29	664	424	1.26	3.39
30	28.4	5.55	0.04	85.4	55.1	1.3	2.22

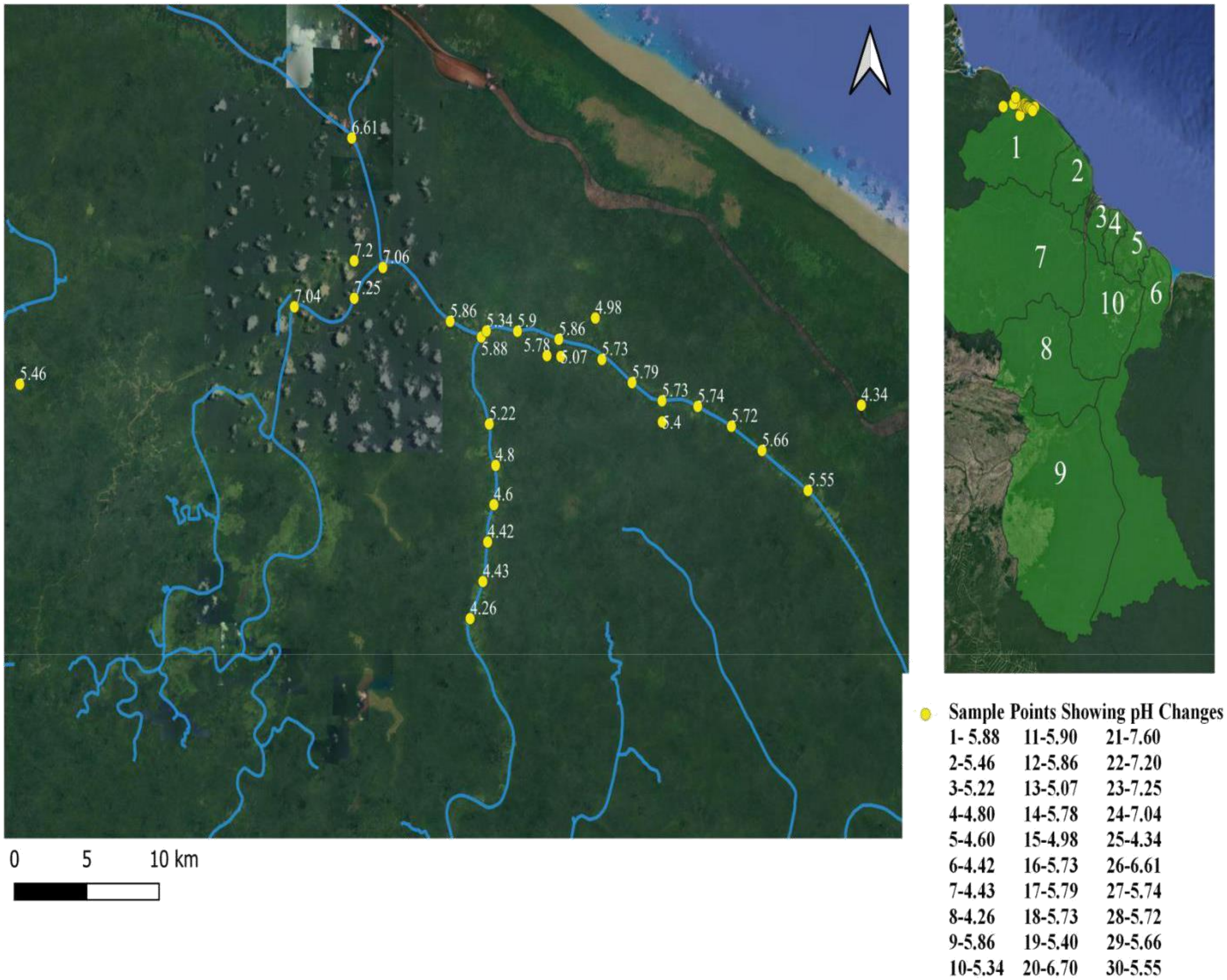


Figure 2: Map showing change in pH from Barima and lower Kaituma rivers

Camera-trap survey

In total, our sample includes 30 camera-trap locations (Figure 1) and 3,018 trap nights, which resulted in 41,452 photographs of 4,066 occasions. Camera-traps detected a total of 64 species (28 mammals, 36 birds, 1 reptile), including 14 species of conservation concern (one ‘Endangered’, six ‘Vulnerable’, six ‘Near Threatened’, and one ‘Data Deficient’ species) and two domestic species (Table 4). Naïve occupancy (ψ) and relative abundance (RAI) of species captured by camera-traps during the survey are available in Table 4, with ψ and RAI of mammal species shown as graphs in Figures 2 and 3, respectively. We directly observed an additional 78 species (3 mammals, 70 birds, 5 reptiles) during the survey that were not caught by camera-traps, including 4 species of conservation concern (three ‘Vulnerable’, two ‘Near Threatened’ species), for a total of 142 species documented across the camera-trap survey (Table 4).

In terms of functional diversity, camera-traps documented a total of 8 species of carnivores, 9 native omnivores (total includes dogs and humans), 5 herbivores, and 4 insectivores. In terms of biomass, camera-traps documented a total of 6 native species of large mammals (>15 kg) (total includes humans), 15 native medium-sized mammals (2-15 kg) (total includes domestic dogs), and 5 small mammals (<2 kg) (Table 2).

Table 2: Functional diversity and biomass of mammal community from camera-traps in the BMPSPA

Functional diversity	# of species
Carnivore	8
Omnivore	9 (11)
Herbivore	5
Insectivore	4
Biomass	**# of species**
Large (>15 kg)	6 (7)
Medium (2-15 kg)	15 (16)
Small (<2 kg)	5

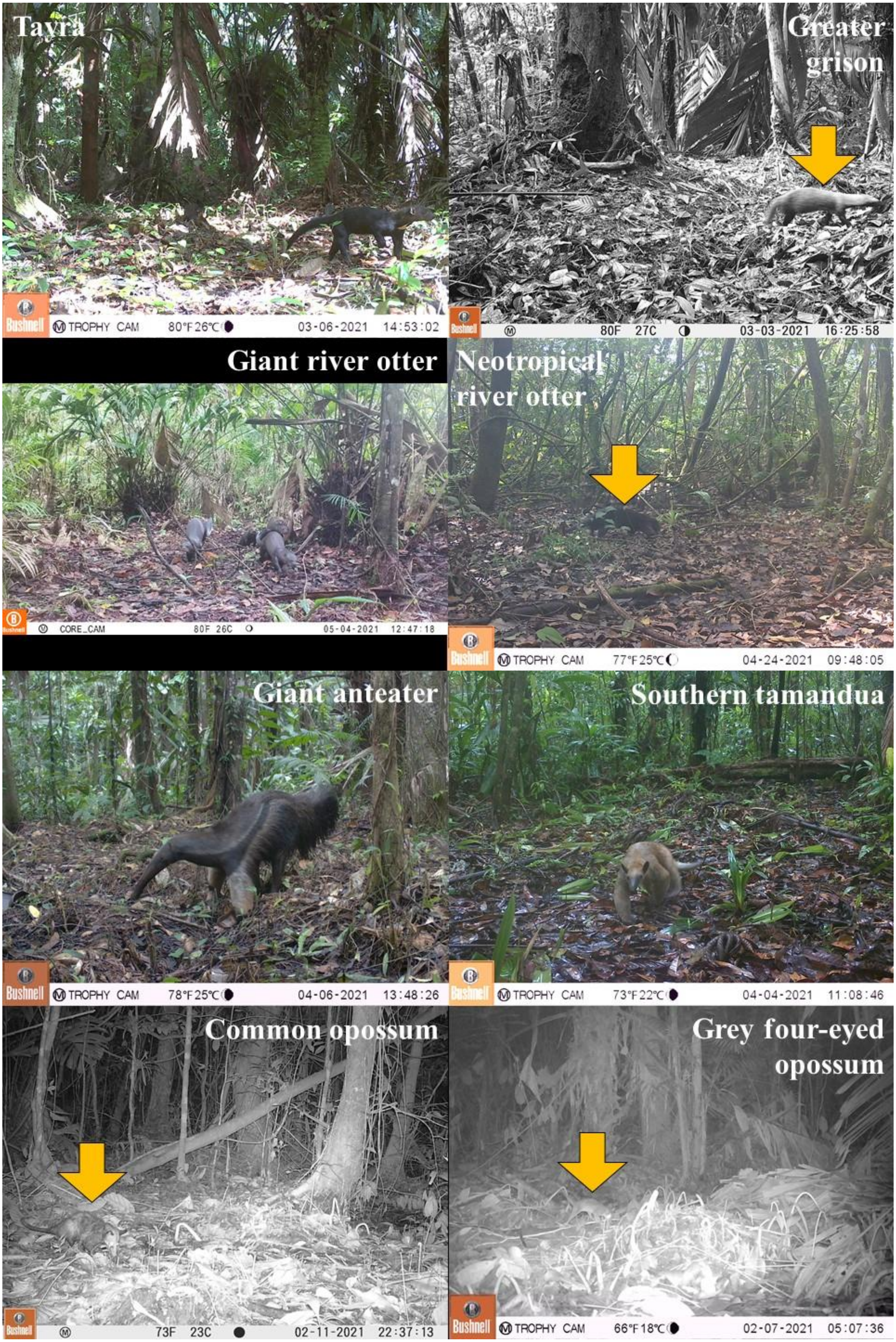
Camera-traps in the BMPSPA documented a total of 25 species of non-volant native mammal (28 species in total but dogs, humans, and an unidentified bat species were removed for the purpose of this analysis). The non-volant native mammal community in the BMPSPA showed a Shannon's diversity index score of 1.64, a Simpson's diversity index score of 2.85, and a species evenness metric score of 0.51 (Table 3).

Table 3: Species richness and diversity indices (Shannon's index, species evenness metric, and Simpson's index) of the non-volant native mammal community from camera-traps in the BMPSPA

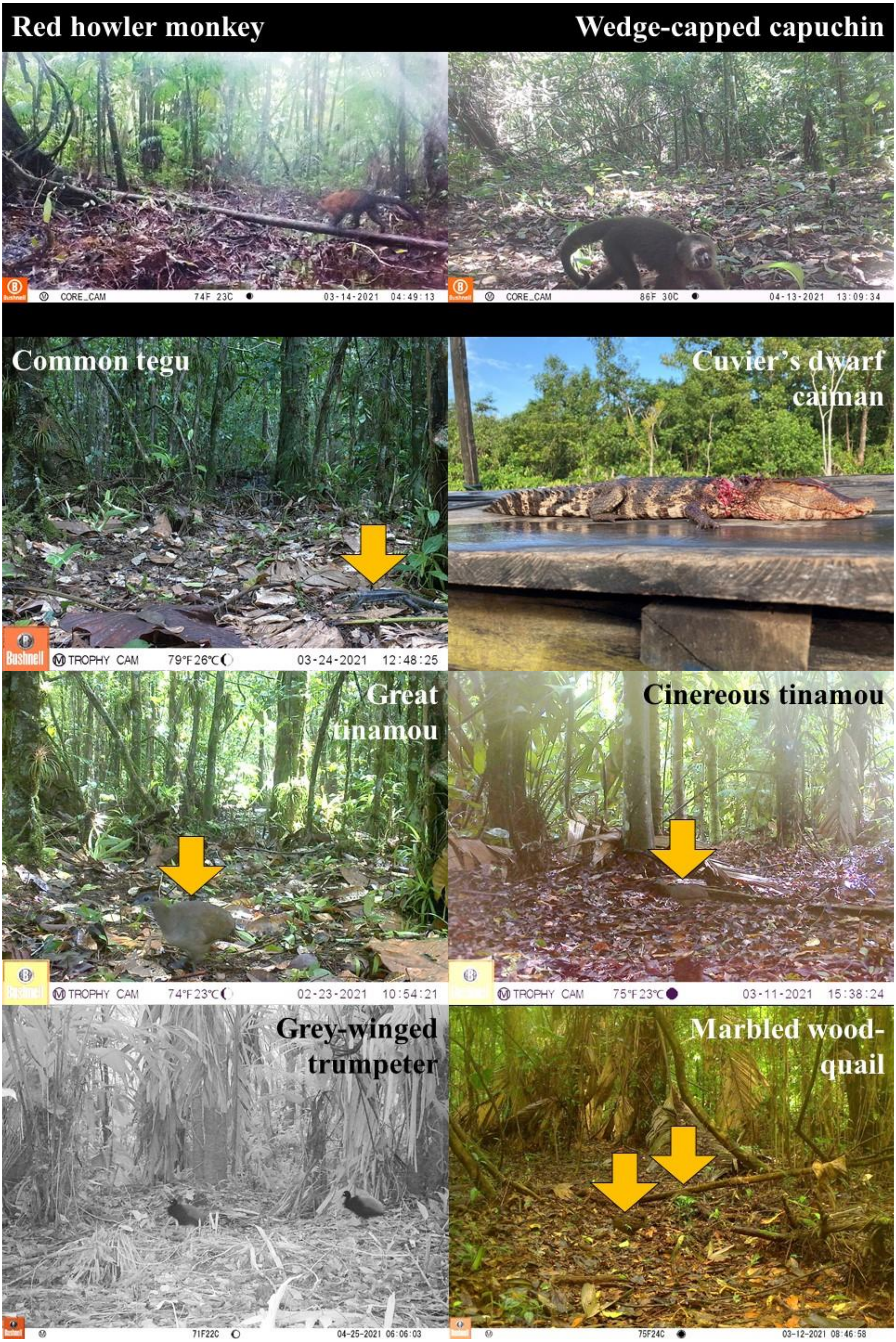
Community metric	Mammal community
Species richness (s)	25
Shannon's index (H)	1.64
Evenness (SEM)	0.51
Simpson's index (D)	2.85

Red-rumped agoutis were the most common species captured on camera-traps, followed by common opossum, terrestrial spiny rat, red brocket deer, lowland paca, white-lipped peccary, four-eyed opossum, and tayra (Figures 2 & 3). All six of Guyana's wild cats were captured on camera traps in the BMPSPA, with ocelots the most common. Species of conservation concern captured on camera-traps included jaguar (NT), margay (NT), oncilla (VU), giant river otter (EN), Neotropical river otter (NT), white-lipped peccary (VU), red brocket deer (DD), giant anteater (VU), great tinamou (NT), black curassow (VU), and marbled wood quail (NT) (Table 4). Lowland tapir and all armadillo species were absent from the survey. Lowland tapir tracks were observed while setting camera-traps, along with West Indian manatees and Guiana dolphins observed in the Barima River.

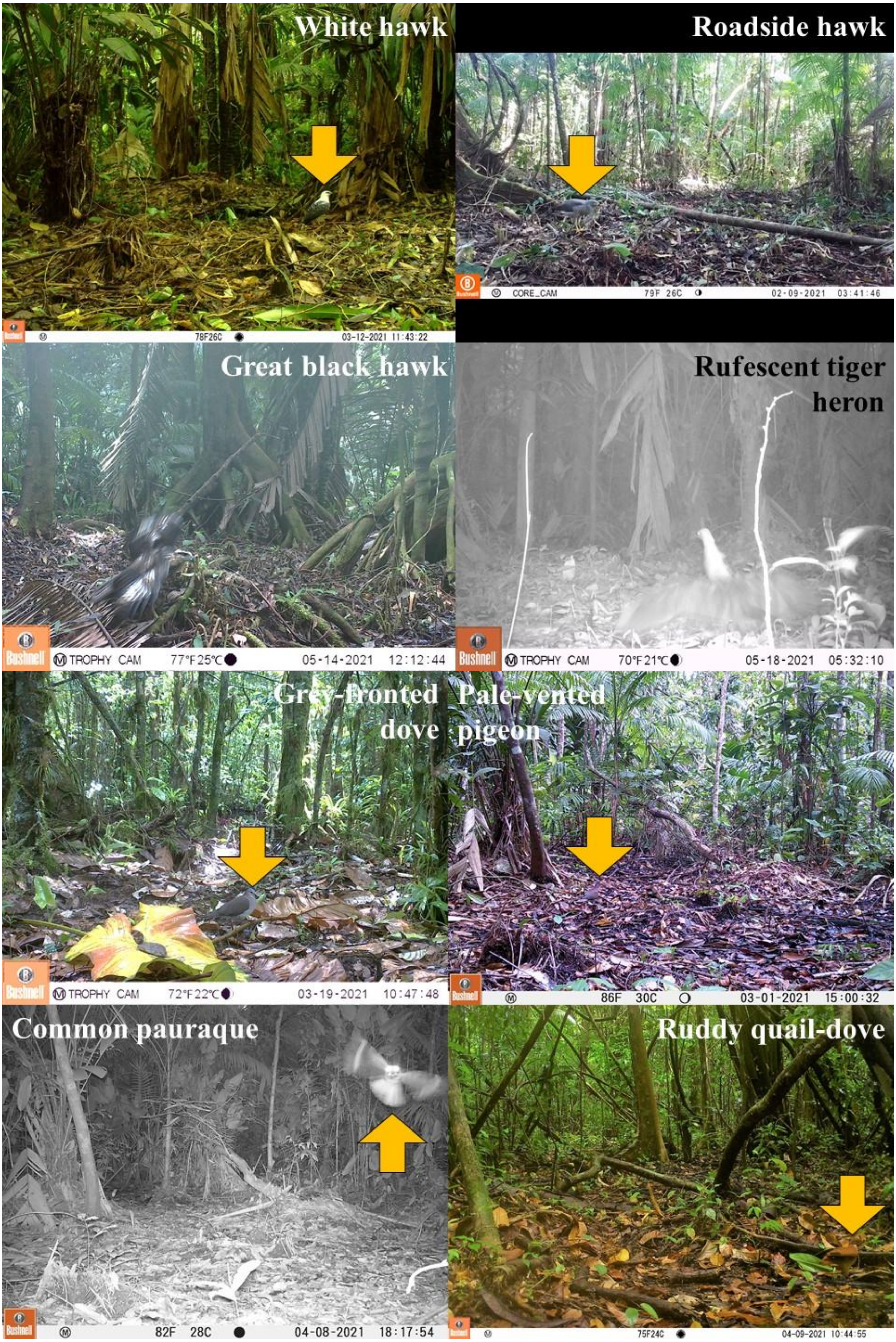
Jaguar
Puma
CORE_CAM 81F 27C 03-22-2021 01:30:46
CORE_CAM 83F 28C 04-06-2021 16:33:49
Ocelot
Margay
Bushnell TROPHY CAM 79°F 26°C 04-12-2021 12:13:08
Bushnell TROPHY CAM 73°F 22°C 04-04-2021 05:34:44
Oncilla
Crab-eating raccoon
Bushnell TROPHY CAM 81°F 27°C 04-13-2021 11:49:00
Bushnell 73F 23C 02-14-2021 00:23:22
Kinkajou
South American coati
CORE_CAM 72F 22C 02-11-2021 04:28:54
CORE_CAM 79F 26C 05-02-2021 16:43:48


Tayra
TROPHY CAM 80°F 26°C 03-06-2021 14:53:02
Greater grison
80F 27C 03-03-2021 16:25:58
Giant river otter
CORE_CAM 80F 26C 05-04-2021 12:47:18
Neotropical river otter
TROPHY CAM 77°F 25°C 04-24-2021 09:48:05
Giant anteater
TROPHY CAM 78°F 25°C 04-06-2021 13:48:26
Southern tamandua
TROPHY CAM 73°F 22°C 04-04-2021 11:08:46
Common opossum
73F 23C 02-11-2021 22:37:13
Grey four-eyed opossum
TROPHY CAM 66°F 18°C 02-07-2021 05:07:36


Domestic dog
Bushnell TROPHY CAM 77°F 25°C 03-06-2021 10:20:10
Red brocket deer
Bushnell TROPHY CAM 73°F 22°C 03-26-2021 10:08:32
White-lipped peccary
Bushnell TROPHY CAM 75°F 23°C 04-15-2021 07:09:07
Collared peccary
Bushnell CORE_CAM 80F 26C 02-14-2021 01:18:43
Lowland paca
Bushnell 71F 22C 02-09-2021 21:35:30
Red-rumped agouti
Bushnell TROPHY CAM 77°F 25°C 03-16-2021 16:43:01
Terrestrial spiny rat
Bushnell 75F 24C 02-11-2021 23:40:12
Human
Bushnell TROPHY CAM 80°F 26°C 04-14-2021 16:17:09


Red howler monkey
CORE_CAM 74F 23C 03-14-2021 04:49:13
Wedge-capped capuchin
CORE_CAM 86F 30C 04-13-2021 13:09:34
Common tegu
Bushnell TROPHY CAM 79°F 26°C 03-24-2021 12:48:25
Cuvier's dwarf caiman
Great tinamou
TROPHY CAM 74°F 23°C 02-23-2021 10:54:21
Cinereous tinamou
TROPHY CAM 75°F 23°C 03-11-2021 15:38:24
Grey-winged trumpeter
71F22C 04-25-2021 06:06:03
Marbled wood-quail
75F24C 03-12-2021 08:46:58

Black curassow
Bushnell
TROPHY CAM
83°F 28°C
04-15-2021 13:20:19
Blue-throated piping guan
Bushnell
TROPHY CAM
77°F 25°C
05-10-2021 14:33:22
Spix's guan
Bushnell
75F 24C
03-01-2021 09:27:07
Variable chachalaca
Bushnell
77F 25C
03-03-2021 17:51:51
Muscovy duck
Bushnell
77F 25C
05-11-2021 07:38:58
Green ibis
Bushnell
CORE_CAM
78F 25C
02-17-2021 04:27:41
Grey-cowled wood-rail
Bushnell
TROPHY CAM
69°F 20°C
04-13-2021 06:39:07
Sunbittern
78F26C
05-12-2021 13:39:43


White hawk
78F26C
03-12-2021 11:43:22
Roadside hawk
CORE_CAM
79F 26C
02-09-2021 03:41:46
Great black hawk
Bushnell
TROPHY CAM
77°F 25°C
05-14-2021 12:12:44
Rufescent tiger heron
Bushnell
TROPHY CAM
70°F 21°C
05-18-2021 05:32:10
Grey-fronted dove
Bushnell
TROPHY CAM
72°F 22°C
03-19-2021 10:47:48
Pale-vented pigeon
86F 30C
03-01-2021 15:00:32
Common pauraque
82F 28C
04-08-2021 18:17:54
Ruddy quail-dove
75F24C
04-09-2021 10:44:55

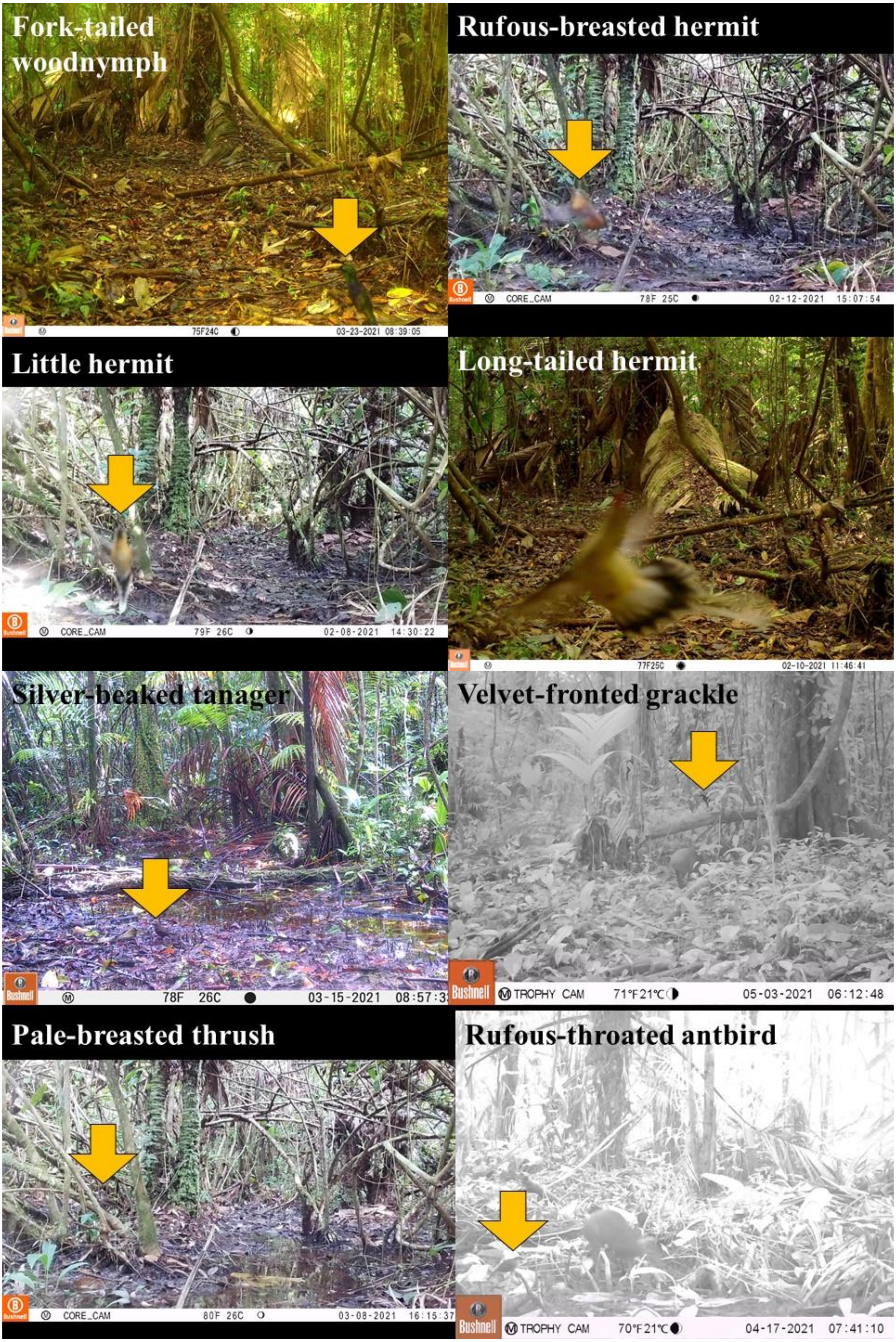

Fork-tailed woodnymph
75F24C
03-23-2021 08:39:05
Rufous-breasted hermit
CORE_CAM
78F 25C
02-12-2021 15:07:54
Little hermit
CORE_CAM
79F 26C
02-08-2021 14:30:22
Long-tailed hermit
77F25C
02-10-2021 11:46:41
Silver-beaked tanager
Bushnell
78F 26C
03-15-2021 08:57:3
Velvet-fronted grackle
Bushnell
TROPHY CAM
71°F21°C
05-03-2021 06:12:48
Pale-breasted thrush
CORE_CAM
80F 26C
03-08-2021 16:15:37
Rufous-throated antbird
Bushnell
TROPHY CAM
70°F21°C
04-17-2021 07:41:10

Table 4: Observation type (CT = camera-trap, DO = direct observation, TR = track), relative abundance (occasions / 100 trap nights), naïve occupancy (proportion of trap locations detected), and IUCN status (EN = endangered, NT = near threatened, VU = vulnerable, DD = data deficient, LC = last concern) of species documented during Barima Mora Passage survey

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
MAMMALS	**MAMMALIA**				
Carnivores	CARNIVORA				
Cats	Felidae				
Jaguar	*Panthera onca*	CT, TR	0.066269	0.066667	NT
Puma	*Puma concolor*	CT	0.198807	0.166667	LC
Ocelot	*Leopardus pardalis*	CT	2.021206	0.733333	LC
Margay	*Leopardus wiedii*	CT	0.530152	0.233333	NT
Oncilla	*Leopardus tigrinus*	CT	0.099404	0.066667	VU
Jaguarundi	*Herpailurus yagouaroundi*	CT	0.033135	0.033333	LC
Dogs	Canidae				
Domestic dog	*Canis familiarris*	CT, DO	1.524188	0.433333	LC
Weasels	Mustelidae				
Tayra	*Eira barbara*	CT	2.750166	0.766667	LC
Greater grison	*Galictis vittata*	CT	0.298211	0.233333	LC
Giant river otter	*Pteronura brasiliensis*	CT	0.231942	0.033333	EN
Neotropical river otter	*Lontra longicaudis*	CT	0.033135	0.033333	NT
Semi-arboreal carnivores	Procyonidae				
Crab-eating raccoon	*Procyon cancrivorus*	CT, TR	1.855533	0.533333	LC
South American coati	*Nasua nasua*	CT	0.066269	0.066667	LC
Kinkajou	*Potos flavus*	CT	0.033135	0.033333	LC
Odd-toed ungulates	PERISSODACTYLA				
Tapirs	Tapiridae				
Brazilian tapir	*Tapirus terrestris*	TR	n/a	n/a	VU
Even-toed ungulates	ARTIODACTYLA				
Peccaries	Tayassuidae				
White-lipped peccary	*Tayassu pecari*	CT, TR	3.048376	0.2	VU
Collared peccary	*Pecari tajacu*	CT	0.165673	0.1	LC
Deer	Cervidae				
Red brocket deer	*Mazama americana*	CT, TR	3.644798	0.8	DD
Oceanic Dolphins	Delphinidae				
Guiana dolphin	*Sotalia guianensis*	DO	n/a	n/a	NT
Manatees	SIRENIA				
Manatees	Trichechidae				
West Indian manatee	*Trichechus manatus*	DO	n/a	n/a	VU
Rodents	RODENTIA				
Agoutis	Dasyproctidae				
Red-rumped agouti	*Dasyprocta leporina*	CT, TR	59.24453	1	LC

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
Pacas	Cuniculidae				
Lowland paca	*Cuniculus paca*	CT, TR	3.51226	0.633333	LC
Spiny rats	Echimyidae				
Terrestrial spiny rat	*Proechimys sp.*	CT	6.129887	0.666667	LC
Anteaters & sloths	PILOSA				
Three-toed sloths	Bradypodidae				
Pale-throated sloth	*Bradypus tridactylus*	GMTCS	n/a	n/a	LC
American anteaters	Myrmecophagidae				
Giant anteater	*Myrmecophaga tridactyla*	CT	0.430749	0.233333	VU
Southern tamandua	*Tamandua tetradactyla*	CT, DO	0.960901	0.566667	LC
Opossums	DIDELPHIMORPHIA				
American opossums	Didelphidae				
Lutrine opossum	*Lutreolina crassicaudata*	CT	0.066269	0.066667	LC
Grey four-eyed opossum	*Philander opossum*	CT	2.7833	0.533333	LC
Common opossum	*Didelphis marsupialis*	CT	17.79324	0.933333	LC
Primates	PRIMATES				
Small new world monkeys	Cebidae				
Common squirrel monkey	*Saimiri sciureus*	GMTCS	n/a	n/a	LC
Wedge-capped capuchin	*Cebus olivaceus*	CT, DO	0.099404	0.066667	LC
Sakis	Pitheciidae				
White-faced saki	*Pithecia pithecia*	GMTCS	n/a	n/a	LC
Large new world monkeys	Atelidae				
Red-faced spider monkey	*Ateles paniscus*	GMTCS	n/a	n/a	VU
Guianan red howler monkey	*Alouatta macconnelli*	CT, DO	0.033135	0.033333	LC
Great apes	Hominidae				
Human	*Homo sapiens*	CT, DO	2.451955	0.533333	LC
Bats	CHIROPTERA				
Sheath-tailed bats	Emballonuridae				
Greater sac-winged bat	*Saccopteryx bilineata*	GMTCS	n/a	n/a	LC
Leaf-nosed bats	Phyllostomidae				
Pallas's long-tongued bat	*Glossophaga soricina*	GMTCS	n/a	n/a	LC
Tent-making bat	*Uroderma bilobatum*	GMTCS	n/a	n/a	LC
Fishing bats	Noctilionidae				
Greater bulldog bat	*Noctilio leporinus*	GMTCS	n/a	n/a	LC
Unidentified bats					
Unidentified bat sp.	*n/a*	CT	0.066269	0.066667	LC
BIRDS	**AVES**				
Tinamous	TINAFORMES				
Tinamous	Tinamidae				
Great tinamou	*Tinamus major*	CT, DO	3.180915	0.466667	NT
Cinereous tinamou	*Crypturellus cinereus*	CT	0.198807	0.166667	LC
Undulated tinamou	*Crypturellus undulatus*	DO	n/a	n/a	LC

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
Unidentified tinamou	Tinamou sp.	CT	1.159708	0.433333	
Ground feeding birds	GALLIFORMES				
Guans, chachalacas, curassows	Cracidae				
Variable chachalaca	*Ortalis motmot*	CT	0.165673	0.1	LC
Spix's guan	*Penelope jacquacu*	CT, DO	0.331345	0.233333	LC
Blue-throated piping guan	*Pipile cumanensis*	CT	0.695825	0.3	LC
Black curassow	*Crax alector*	CT, DO	5.765408	0.533333	VU
Quail	Odontophoridae				
Marbled wood quail	*Odontophorus gujanensis*	CT	0.762094	0.166667	NT
Aquatic birds	ANSERIFORMES				
Water fowl	Anatidae				
Black-bellied whistling-duck	*Dendrocygna autumnalis*	DO	n/a	n/a	LC
Blue-winged teal	*Spatula discors*	DO	n/a	n/a	LC
Muscovy duck	*Cairina moschata*	CT, DO	0.165673	0.066667	LC
Shorebirds	CHARADRIIFORMES				
Sandpipers	Scolopacidae				
Whimbrel	*Numenius phaeopus*	DO	n/a	n/a	LC
Willet	*Tringa semipalmata*	DO	n/a	n/a	LC
Solitary sandpiper	*Tringa solitaria*	DO	n/a	n/a	LC
Spotted sandpiper	*Actitis macularia*	DO	n/a	n/a	LC
Plovers	Charadriidae				
Southern lapwing	*Vanellus chilensis*	DO	n/a	n/a	LC
Skimmers	Rynchopidae				
Black skimmer	*Rynchops niger*	DO	n/a	n/a	LC
Gulls	Laridae				
Yellow-billed tern	*Sternula superciliaris*	DO	n/a	n/a	LC
Hummingbirds & swifts	APODIFORMES				
Hummingbirds	Trochilidae				
Little hermit	*Phaethornis longuemareus*	CT	0.099404	0.066667	LC
Long-tailed hermit	*Phaethornis superciliosus*	CT, DO	0.132538	0.133333	LC
Sooty-capped hermit	*Phaethornis augusti*	CT	0.066269	0.066667	LC
Rufous-breasted hermit	*Glaucis hirsutus*	CT	0.29821	0.133333	LC
Fork-tailed woodnymph	*Thalurania furcata*	CT	0.066269	0.066667	LC
Diving birds	SULIFORMES				
Frigatebirds	Fregatidae				
Magnificent frigatebird	*Fregata magnificens*	DO	n/a	n/a	LC
Anhingas	Anhingidae				
Anhinga	*Anhinga anhinga*	DO	n/a	n/a	LC
Cormorants	Phalacrocoracidae				
Neotropic cormorant	*Phalacrocorax brasilianus*	DO	n/a	n/a	LC

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
Fishing birds	PELECANIFORMES				
Wading birds	Ardeidae				
Rufescent tiger heron	*Tigrisoma lineatum*	CT, DO	0.066269	0.066667	LC
Yellow-crowned night-heron	*Nyctanassa violacea*	DO	n/a	n/a	LC
Capped heron	*Pilherodius pileatus*	DO	n/a	n/a	LC
Tricolored heron	*Egretta tricolor*	DO	n/a	n/a	LC
Little blue heron	*Egretta caerulea*	DO	n/a	n/a	LC
Striated heron	*Butorides striata*	DO	n/a	n/a	LC
Great egret	*Ardea alba*	DO	n/a	n/a	LC
Snowy egret	*Egretta thula*	DO	n/a	n/a	LC
Cattle egret	*Bubulcus ibis*	DO	n/a	n/a	LC
Ibis & spoonbill	Threskiornithidae				
Roseate spoonbill	*Platalea ajaja*	DO	n/a	n/a	LC
Scarlet ibis	*Eudocimus ruber*	DO	n/a	n/a	LC
Green ibis	*Mesembrinibis cayennensis*	CT, DO	0.530152	0.233333	LC
Crane-like birds	GRUIFORMES				
Sunbittern	Eurypygidae				
Sunbittern	*Eurypyga helias*	CT	0.198807	0.1	LC
Rails, gallinules, & coots	*Rallidae*				
Grey-cowled wood-rail	*Aramides cajaneus*	CT	1.457919	0.133333	LC
Rufous-necked wood-rail	*Aramides axillaris*	CT			LC
Trumpeters	Psophiidae				
Grey-winged Trumpeter	*Psophia crepitans*	CT	0.132538	0.066667	NT
Vultures	CATHARTIFORMES				
New world vultures	Cathartidae				
Black vulture	*Coragyps atratus*	CT, DO	0.033135	0.033333	LC
Turkey vulture	*Cathartes aura*	DO	n/a	n/a	LC
Birds of prey	ACCIPITRIFORMES				
Ospreys	Pandionidae				
Osprey	*Pandion haliaetus*	DO	n/a	n/a	LC
Hawks, eagles, & kites	Accipitridae				
Plumbeous kite	*Ictinia plumbea*	DO	n/a	n/a	LC
Double-toothed kite	*Harpagus bidentatus*	DO	n/a	n/a	LC
Swallow-tailed kite	*Elanoides forficatus*	DO	n/a	n/a	LC
White hawk	*Pseudastur albicollis*	CT	0.033135	0.033333	LC
Roadside hawk	*Rupornis magnirostris*	CT, DO	0.331345	0.2	LC
Rufous crab hawk	*Buteogallus aequinoctialis*	DO	n/a	n/a	NT
Great black hawk	*Buteogallus urubitinga*	CT	0.066269	0.066667	LC
Grey-lined hawk	*Buteo nitidus*	DO	n/a	n/a	LC
Zone-tailed hawk	*Buteo albonotatus*	DO	n/a	n/a	LC

Common Name	Sci name	Obs. Type	RAI	Naïve Occ.	IUCN Status
Falcons & caracaras	FALCONIFORMES				
Falcons & caracaras	Falconidae				
Bat falcon	*Falco rufigularis*	DO	n/a	n/a	LC
Yellow-headed caracara	*Milvago chimachima*	DO	n/a	n/a	LC
Red-throated caracara	*Ibycter americanus*	DO	n/a	n/a	LC
Trogons	TROGONIFORMES				
Trogons	Trogonidae				
Green-backed trogon	*Trogon viridis*	DO	n/a	n/a	LC
Raven-like birds	CORACIIFORMES				
Motmots	Momotidae				
Amazonian motmot	*Momotus momota*	DO	n/a	n/a	LC
Kingfishers	Alcedinidae				
Ringed kingfisher	*Megaceryle torquatus*	DO	n/a	n/a	LC
Green kingfisher	*Chloroceryle americana*	DO	n/a	n/a	LC
Green-and-rufous kingfisher	*Chloroceryle inda*	CT, DO	0.033135	0.033333	LC
American pygmy kingfisher	*Chloroceryle aenea*	DO	n/a	n/a	LC
Puffbirds & jacamars	GALBULIFORMES				
Puffbirds	Bucconidae				
Spotted puffbird	*Bucco tamatia*	DO	n/a	n/a	LC
Greater pied puffbird	*Notharchus tectus*	DO	n/a	n/a	LC
Parrots	PSITTACIFORMES				
True parrots	Psittacidae				
Brown-throated parakeet	*Eupsittula pertinax*	DO	n/a	n/a	LC
Yellow-crowned parrot	*Amazona ochrocephala*	DO	n/a	n/a	LC
Black-headed parrot	*Pionites melanocephalus*	DO	n/a	n/a	LC
Blue-and-gold macaw	*Ara ararauna*	DO	n/a	n/a	LC
Nightjars and allies	CAPRIMULGIFORMES				
Nightjars and allies	Caprimulgidae				
Common pauraque	*Nyctidromus albicollis*	CT	1.424785	0.266667	LC
Woodpeckers & toucans	PICIFORMES				
Woodpeckers	Picidae				
Cream-colored woodpecker	*Celeus flavus*	DO	n/a	n/a	LC
Lineated woodpecker	*Lepidocolaptes lineatus*	DO	n/a	n/a	LC
Toucans	Ramphastidae				
White-throated toucan	*Ramphastos tucanus*	DO	n/a	n/a	VU
Doves & pigeons	COLUMBIFORMES				
Doves & pigeons	Columbidae				
Pale-vented pigeon	*Patagioenas cayennensis*	CT, DO	0.033135	0.033333	LC
Ruddy pigeon	*Patagioenas subvinacea*	DO	n/a	n/a	LC
Ruddy quail-dove	*Geotrygon montana*	CT	0.099404	0.033333	LC
Common ground dove	*Columbina passerina*	DO	n/a	n/a	LC
Grey-fronted dove	*Leptotila rufaxilla*	CT, DO	5.93108	0.666667	LC

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
Cuckoos	CUCULIFORMES				
Cuckoos	Cuculidae				
Little cuckoo	*Coccycua minuta*	DO	n/a	n/a	LC
Squirrel cuckoo	*Piaya cayana*	DO	n/a	n/a	LC
Passerines	PASSERIFORMES				
Swallows	Hirundinidae				
Black-collared swallow	*Pygochelidon melanoleuca*	DO	n/a	n/a	LC
White-winged swallow	*Tachycineta albiventer*	DO	n/a	n/a	LC
Manakins	Pipridae				
White-crowned manakin	*Pseudopipra pipra*	DO	n/a	n/a	LC
Cotingas	Cotingidae				
Screaming piha	*Lipaugus vociferans*	DO	n/a	n/a	LC
Thrushes and allies	Turdidae				
Cocoa thrush	*Turdus fumigatus*	CT	0.033135	0.033333	LC
Pale-breasted thrush	*Turdus leucomelas*	CT, DO	0.066269	0.033333	LC
Mockingbirds	Mimidae				
Tropical mockingbird	*Mimus gilvus*	DO	n/a	n/a	LC
Tyrant flycatchers	Tyrannidae				
Drab water tyrant	*Ochthornis littoralis*	DO	n/a	n/a	LC
Short-crested flycatcher	*Myiarchus ferox*	DO	n/a	n/a	LC
Yellow-bellied elaenia	*Elaenia flavogaster*	DO	n/a	n/a	LC
Lesser kiskadee	*Pitangus lictor*	DO	n/a	n/a	LC
Tropical kingbird	*Tyrannus melancholicus*	DO	n/a	n/a	LC
Ovenbirds	Furnariidae				
Red-billed woodcreeper	*Hylexetastes perrotii*	DO	n/a	n/a	LC
New World Warblers	Parulidae				
Riverbank warbler	*Myiothlypis rivularis*	CT	0.033135	0.033333	LC
Typical antbirds	Thamnophilidae				
White-flanked antwren	*Myrmotherula axillaris*	CT	0.033135	0.033333	LC
Rufous-throated antbird	*Gymnopithys rufigula*	CT	0.033135	0.033333	LC
Blackbirds	Icteridae				
Crested oropendola	*Psarocolius decumanus*	DO	n/a	n/a	LC
Red-rumped cacique	*Cacicus haemorrhous*	DO	n/a	n/a	LC
Carib grackle	*Quiscalus lugubris*	DO	n/a	n/a	LC
Velvet-fronted grackle	*Lampropsar tanagrinus*	CT, DO	0.033135	0.033333	LC
Wrens	Troglodytidae				
House wren	*Troglodytes aedon*	DO	n/a	n/a	LC
Buff-breasted wren	*Cantorchilus leucotis*	DO	n/a	n/a	LC
Tanagers	Thraupidae				
Silver-beaked tanager	*Ramphocelus carbo*	CT, DO	0.099404	0.066667	LC
Blue-gray tanager	*Thraupis episcopus*	DO	n/a	n/a	LC
Palm tanager	*Thraupis palmarum*	DO	n/a	n/a	LC

Common Name	**Sci name**	**Obs. Type**	**RAI**	**Naïve Occ.**	**IUCN Status**
Amphibians	**AMPHIBIA**				
Frogs & toads	ANURA				
Tree frogs	Hylidae				
Lesser treefrog	*Dendropsophus minutus*	GMTCS	n/a	n/a	LC
Marmorea frog	*Dendropsophus marmorata*	GMTCS	n/a	n/a	LC
Red-snouted treefrog	*Scinax ruber*	CSBD	n/a	n/a	LC
Emerald-eyed treefrog	*Boana crepitans*	GMTCS	n/a	n/a	LC
Paradox frog	*Pseudis paradoxa*	CSBD	n/a	n/a	LC
Southern frogs	Leptodactylidae				
Common toad-frog	*Leptodactylus mystaceus*	GMTCS	n/a	n/a	LC
True toads	Bufonidae				
Cane toad	*Rhinella marina*	DO, CSBD	n/a	n/a	LC
Reptiles	**REPTILIA**				
Crocodiles	CROCODILIA				
Spectacled caiman	*Caiman crocodilus*	DO	n/a	n/a	LC
Cuvier's dwarf caiman	*Paleosuchus palpebrosus*	DO	n/a	n/a	LC
Lizards	SQUAMATA				
Whiptails	Teiidae				
Giant ameiva	*Ameiva ameiva*	DO, CSBD	n/a	n/a	LC
Striped forest whiptail	*Kentropyx calcarata*	GMTCS	n/a	n/a	LC
Rainbow whiptail	*Cnemidophorus lemniscatus*	CSBD	n/a	n/a	LC
Common (or gold) tegu lizard	*Tupinambis teguixin*	CT	0.563287	0.133333	LC
Skinks	Scincidae				
South American spotted skink	*Copeoglossum nigropunctatum*	GMTCS	n/a	n/a	LC
Iguanas	Iguanidae				
Green iguana	*Iguana iguana*	DO, CSBD	n/a	n/a	LC
Ground lizards	Tropiduridae				
Collared tree runner	*Plica plica*	GMTCS	n/a	n/a	LC
Brown tree runner	*Uranoscodon superciliosus*	DO	n/a	n/a	LC
Geckos	Gekkonidae				
Bridled forest gecko	*Gonatodes humeralis*	CSBD	n/a	n/a	LC
Turnip-tailed gecko	*Thecadactylus rapicauda*	CSBD	n/a	n/a	LC
Rear-fanged snakes	Colubridae				
Brown-banded water snake	*Helicops angulatus*	GMTCS	n/a	n/a	LC
Indigo snake	*Drymarchon corais*	CSBD	n/a	n/a	LC
Mangrove snake	*Erythrolamprus cobella*	CSBD	n/a	n/a	LC
Boas	Boidae				
Amazon tree boa	*Corallus hortulanus*	GMTCS	n/a	n/a	LC
Boa constrictor	*Boa constrictor*	GMTCS	n/a	n/a	LC

Common Name	Sci name	Obs. Type	RAI	Naïve Occ.	IUCN Status
Green anaconda	*Eunectes murinus*	GMTCS	n/a	n/a	LC
Vipers	Viperidae				
Fer-de-lance	*Bothrops atrox*	DO, CSBD	n/a	n/a	LC
Turtles	TESTUDINES				
Neotropical wood turtles	Geoemydidae				
Spot-legged wood turtle	*Rhinoclemmys punctularia*	GMTCS	n/a	n/a	LC
Mud & musk turtles	Kinosternidae				
Scorpion mud turtle	*Kinosternon scropiodes*	GMTCS	n/a	n/a	LC
Tortoises	Testudinidae				
Yellow-footed tortoise	*Chelonoidis denticulata*	DO	n/a	n/a	VU

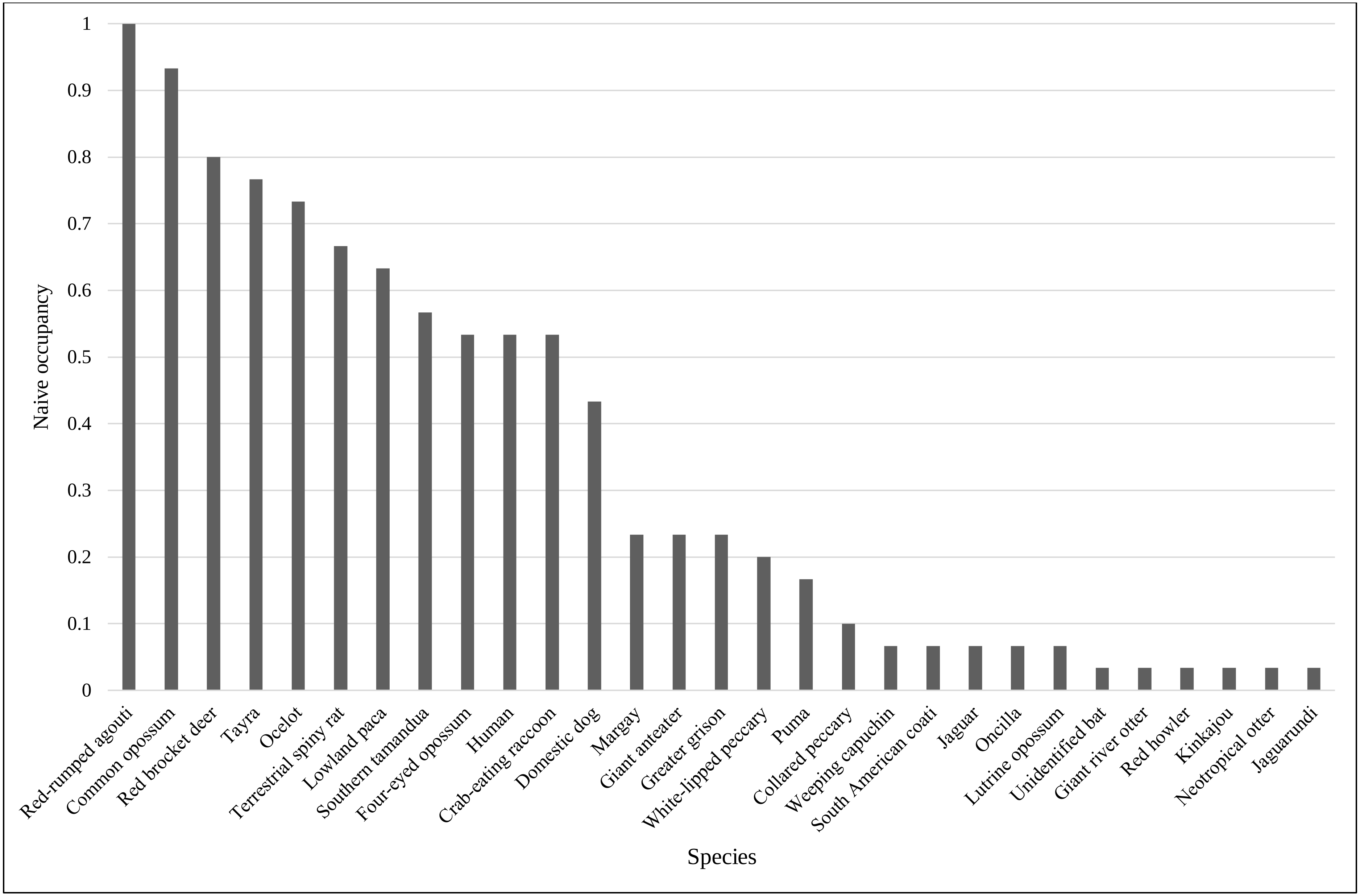


Figure 2: Naïve occupancy of the mammals captured on camera-traps in the BMPSPA

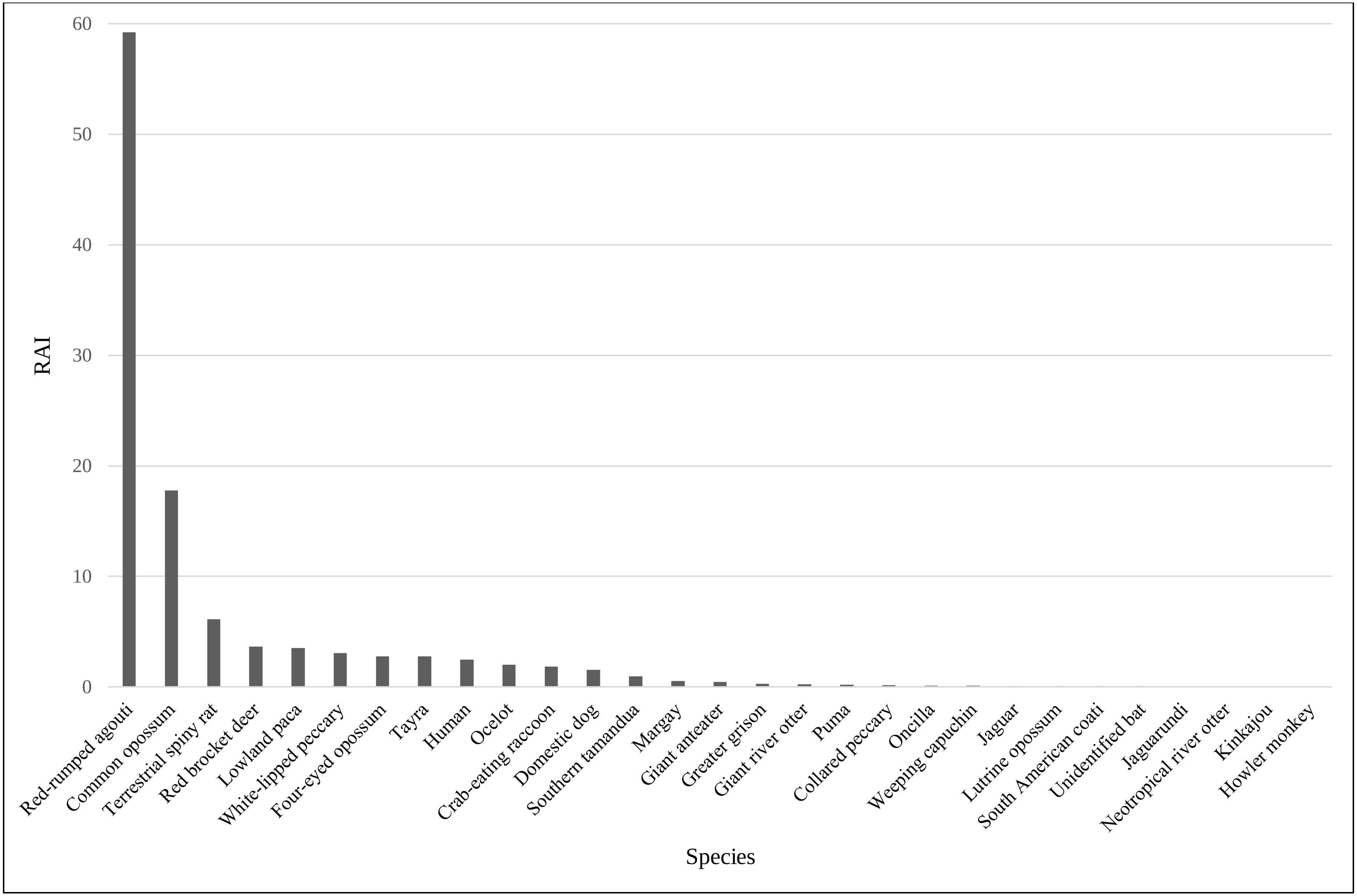


Figure 3: Relative abundance (RAI) of mammals captured on camera-traps in the BMPSPA

Discussion

Water quality

Overall, salinity fluctuated almost as expected, with the sites showing highest salinity occurring nearest to the Mora Passage and Atlantic Ocean and the lowest occurring up the Kaituma River, however some variation was driven by the tides and timing of sampling. The amount of oxygen that can be dissolved in water depends on several factors, including temperature, salinity and atmospheric pressure, with DO that is too high or too low potentially harming aquatic life. Temperature and dissolved oxygen did not very greatly across the survey.

Erosion and pollution from upstream mining around Port Kaituma and agricultural runoff represent the current primary anthropogenic inputs into aquatic systems the BMPSPA. Both the Barima and Kaituma rivers were found to have a slightly acidic nature on average (mean pH = 5.65). pH is influenced by both natural and anthropogenic activities, however the average pH of drinkable surface water ranges from 6.5-9 (WHO 2017), with the average pH in the ocean at around 8.1. The acidic nature of the surface waters within the BMPSPA may indicate a physiological stress to the system. The fact that the pH from all the samples taken from the Kaituma River were <5 and descended the closer that the survey moved towards Port Kaituma indicates that pollution from ongoing mining activities (discharged mine effluent and seepage from tailing ponds) may be negatively effecting water quality. Negative effects on human health related to the direct consumption of low pH are known (). However, mercury, a common heavy metal used in the amalgamation process in gold mining that is known to affect the gastrointestinal tract, the nervous system, and the kidneys, also accumulates more readily in fish and other organisms that are consumed by local communities in low pH conditions.

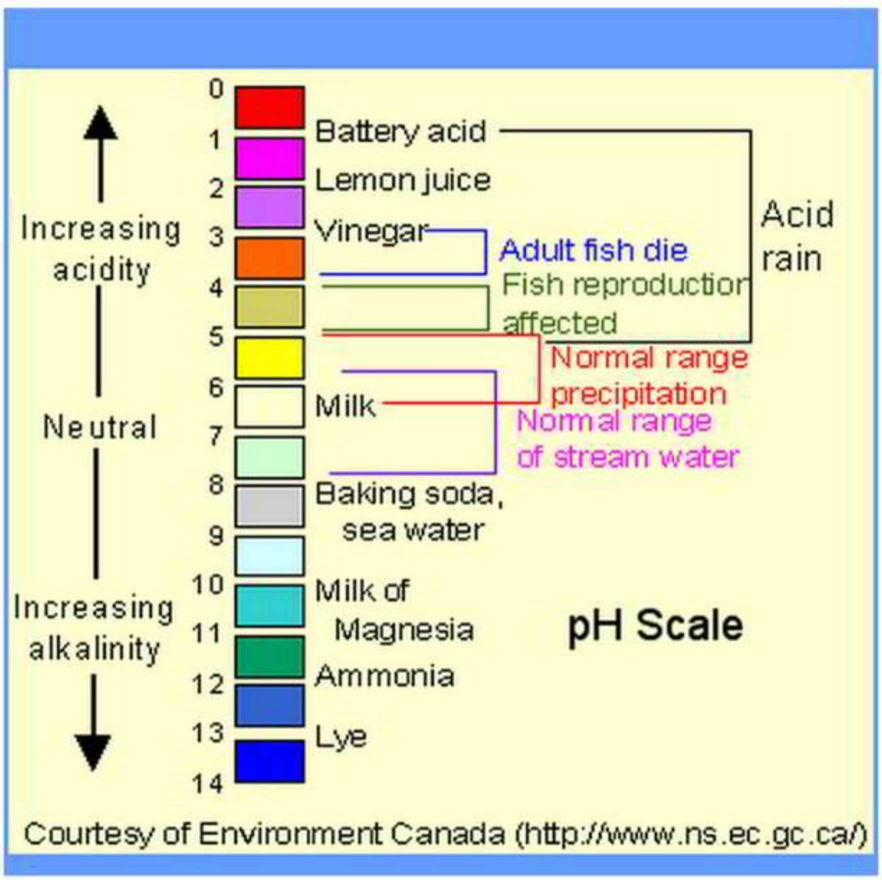


Figure 3: Relationship between pH and aquatic communities

Total dissolved solids (TDS) concentration describes the present of inorganic salts and small amounts of organic matter in water and electrical conductivity (EC) is the measure of water capacity to conduct electrical current. The sources of material in TDS and EC can come from nature, i.e. geological condition and seawater, and from human activities, i.e. domestic and industrial waste and also agriculture (Rusydi 2018). TDS concentration is influenced by inorganic salts (calcium, magnesium, potassium etc), as well as organic matter present in water. EC is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). For health reason, desirable limit for TDS is between 500 mg/L and 1,000 mg/L and for EC is no more than 1,500 µS/cm (WHO 2017). While the majority of sample points in the survey showed low values, a few points recorded very high readings. The sites that showed high conductivity also coincided with sites that showed a high level of total dissolved solids (TDS). Additionally multiple sites showed high nitrate values. These results combined indicate that land activities are having an influence on water quality within the BMPSPA. Conductivity, total dissolved solids, and nitrate content may be influence by agricultural runoff, discharge of sewage effluent, and certain industrial wastes.

Surface water in the Barima and Kaituma rivers may have already been rendered undesirable for drinking by the influx of saltwater that came with the digging of the Barima-Mora passage, however preliminary data suggests that current activities within the region (agriculture, mining, sewage) may be further impacting water quality, and aquatic communities by proxy. Spills resulting from offshore oil development represent another potential threat to aquatic and terrestrial communities in the BMPSPA. Further data collection, including water sampling at various depths, is required for modelling of potential future impacts of offshore oil development. That said, surface water testing done as part of this study detected saltwater mixing >35 km from the mouth of the Barima-Mora passage. Because fresh water flowing from inland rivers (such as the Barima and Kaituma) into the ocean is less salty and less dense than water from the ocean, it often floats on top of the heavier seawater. The amount of mixing between fresh water and seawater depends on the direction and speed of the wind, the tidal range (the difference between the average low tide and the average high tide), the shape of the river mouth, and the volume and flow rate of river water entering the estuary. Seawater is known to sink below outflowing freshwater and continue flowing upstream for hundreds of miles. These factors would put BMPSPA ecosystems and the species that they support at risk if a spill were to occur offshore.

Mammal community

Functional diversity refers to those components of biodiversity that influence how an ecosystem operates or functions. The biological diversity, or biodiversity, of a habitat is much broader and includes all the species living in a site, all of the genotypic and phenotypic variation within each species, and all the spatial and temporal variability in the communities and ecosystems that these species form. Functional diversity, which is a subset of this, is measured by the values and range in the values, for the species present in an ecosystem, of those organismal traits that influence one or more aspects of the functioning of an ecosystem. Functional diversity is of ecological importance because it, by definition, is the component of diversity that influences ecosystem dynamics, stability, productivity, nutrient balance, and other aspects of ecosystem functioning (Tilman 2001).

The biomass is the mass of living biological organisms in a given area or ecosystem at a given time. Biomass can refer to species biomass, which is the mass of one or more species, or to community biomass, which is the mass of all species in the community. Mammal species categorized into large (>15 kg), medium (2-15 kg), and small (<2 kg) based standard classifications for biomass (Emmons 1997).

Species richness is the number of different species– simply a count of species. Diversity indices provide more information about community composition, as they also take the relative abundances of different species into account. The Shannon index is a similarity index (increases as diversity increases) and values typically range from 1.5-3.5 (rarely >4). Species evenness tells you how evenly distributed the species are in a designated community. The Simpson index is a dominance index, giving more weight to common or dominant species (the higher the value the lower in diversity).

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