OPERATION WALLACEA 2012 FIELD SEASON REPORT: BIODIVERSITY MONITORING IN THE CALAKMUL BIOSPHERE RESERVE, MEXICO

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Introduction

REDD+ Programme

The term "biosphere" was introduced by UNESCO to refer to a protected area larger than 10,000 hectares that contains one or more important biological zones and this includes significant pristine, or wilderness, areas that are untouched by people. The purpose of these reserves is three fold: to conserve biological diversity, to develop and serve as models of sustainable land use, and to provide areas for environmental research, monitoring, training, education and sustainable tourism. However, obtaining sufficient funds for reserve management and development projects with local communities can be difficult.

One potential solution to the problem is the Reduction in Emissions from Deforestation and Forest Degradation (REDD+ scheme) run by the United Nations. REDD+ aims to reduce carbon emissions caused by the burning of forest to make way for agriculture, and in doing so conserve forest biodiversity and provide economic benefits for forest communities through sustainable resource management. The basic concept is that developed countries can reduce their carbon footprint by investing in large stands of forest in developing countries, where the money can be used for sustainable land management and development projects with local communities to reduce reliance on forest resources. Applications for REDD+ funding must provide details of the total area of forest, carbon contained within the forest, biodiversity within the forest, number of communities associated with the forest and their economic status, and a detailed plan of how money received will be used to manage the forest, which includes details of the protocols for monitoring forest coverage and biodiversity.

Forest Corridors

Forest corridors are important for maintaining gene flow between animal populations and for ensuring that animal populations can withstand localized natural disasters such as droughts, forest fires, hurricanes and floods. Forest connectivity also ensures viable populations of animals with large home ranges such as spider monkeys, tapir and jaguar. Mexico's National Strategy on Climate Change (2007) called for establishing biological corridors between protected areas to "improve the adaptive capacities of ecosystems and species." One effort was the incorporation of five ecosystems in southeast Mexico into the Mesoamerican Biological Corridor Project, sponsored by the World Bank's Global Environment Facility. The corridors feature regions of high biodiversity, including dry and moist forests in Tehuantepec, Campeche and Yucatan, cloud forests in Chiapas, savannas in Tabasco, and wetlands in Quintana Roo. However, even within each ecosystem, forest connectivity is threatened by human population growth and urbanization.

Calakmul Biosphere Reserve

Calakmul is a large expanse of tropical forest that is continuous with the Maya Biosphere Reserve in the Petén Province of Northern Guatemala. Calakmul biosphere reserve covers an area of 723,000 hectares, but is attached to two state reserves Balam-kim and Balam-ku which run the entire length of the western side of the biosphere. The total area covered by these connected reserves is 1,200,000 hectares, but these reserves are surrounded by more forest giving rise to over 4 million hectares of forest. This Mexican forest is connected to the even more forest over the border in Guatemala, resulting in approximately 11 million hectares of continuous forest. Unlike the majority of forest in the Yucatan, the forest in Calakmul has not been used for timber production nor has it been burned for farming and ranching and as such, it is one of the last remaining stands of virgin forest in Mexico. The northern parts of Calakmul contains tropical deciduous forest, where trees typically have a canopy 8-20m high and lose their leaves in the dry season (December to May), but the majority of the reserve contains tropical semi-deciduous trees. Tropical semi-deciduous forest has a canopy ranging between 15-40m in height although the majority of trees are from 20-30m. The canopy can be closed or partially open and in the dry season, 20% to 40% of the trees lose their leaves. The dominant tree species in this forest are ramon (*Brosimium alicastrum*), zapote (*Manilkara zapota*), ceiba (*Ceiba pentandra*), guanacaste (*Enterolobium cyclocarpum*), cedro (*Cedrela mexicana*), copal (*Protium copal*), Tzalam (*Lysiloma bahamensis*) and caoba or mahogany (*Swietenia macrophylla*). Calakmul also contains numerous

temporary lakes known as aguadas, which form during the rainy season and may last well into the dry season. Wildlife in Calakmul includes jaguar, puma, ocelot, jaguarundi, tapir, brocket deer, peccary, howler and spider monkeys, in addition to over 50 species of reptile and amphibian and 350 species of resident and migratory birds.

Over 20,000 people live in and around Calakmul in traditional Mayan villages where the major sources of income are slash and burn agriculture and logging for timber. Protecting the forest is therefore not just a case of creating a reserve, but educating and enabling local communities to utilise the forest resources in a sustainable manner. Buffer zone communities continue to grow in size and thus hunting of forest mammals is another major concern for the reserve. Some mammals (fast-producing species that live in high densities) may be hunted sustainably, but it is not possible to calculate sustainable hunting quotas for buffer zone communities until population density of mammals has been determined. The landscape has also been subjected to recent change due to the development of the main highway that bisects the northern and southern parts of the reserve.

Research Aims and Objectives

Operation Wallacea is a UK based NGO that specializes in biodiversity assessment and monitoring of protected areas using the expertise of university academics and students. The aim of this long-term project is therefore to assess the abundance, diversity and distribution of flora and fauna in the Calakmul Biosphere Reserve and monitor changes to this diversity over time. The data produced from this project may then be used to assist with management decisions for the reserve, government decisions regarding further development of highway 186 that bisects the reserve in terms maintaining animal access to the northern section of the reserve, and funding applications to the REDD+ programme.

These broad project aims can be broken down into a series of specific objectives as follows:

1. To investigate the abundance, diversity and geographical distribution of flora and fauna in Calakmul reserve, specifically that of trees, birds, bats, herpetofauna (reptiles and amphibians), and large mammals
2. To utilize survey data and existing GIS maps of the reserve to produce species distribution models for each taxonomic group
3. To estimate the forest coverage and carbon tonnage within the reserve
4. To utilise baseline biodiversity data, forest cover and carbon estimates for funding application to the REDD+ programme
5. To design and implement a forest coverage monitoring protocol for the reserve
6. To design and implement a biodiversity monitoring protocol for the reserve
7. To create and manage a biodiversity database for Calakmul that may be used by all relevant parties to assist with management of the reserve

Methods

Research Design

Data collection was conducted in 5 different locations with the Calakmul Biosphere Reserve (Figure 1). In 2012, three survey locations were used: km20 (which includes transects in km15 and km27), Nadzca'an, and the Zona Arqueológica. These camp locations were chosen due to their accessibility during the wet season and because they cover the full geographical and vegetation range of the reserve. Each camp contains four 2km long transect lines for data collection, with some additional shorter transect lines close to Km20 (km15 to the north and km27 to the south). Shorter transects were due to seasonal flooding that made it impossible to reach the end of transects that had been cut during the dry season. A complete list of transects and their exact lengths is presented in Table 1. Each transect line was mapped using a GPS unit. Five sample sites were located along each transect line at 400m intervals, giving rise to 100 sample sites across the 5 research camps in the reserve. Each sample site consisted of a 20m x 20m area adjacent to the transect line. These sample sites were marked with spray paint and the GPS location recorded. The main base camp was located 20km south from the entrance to the reserve, where student training and data entry was conducted in addition to biodiversity surveys. This was also the location of the archaeological museum and teaching rooms.

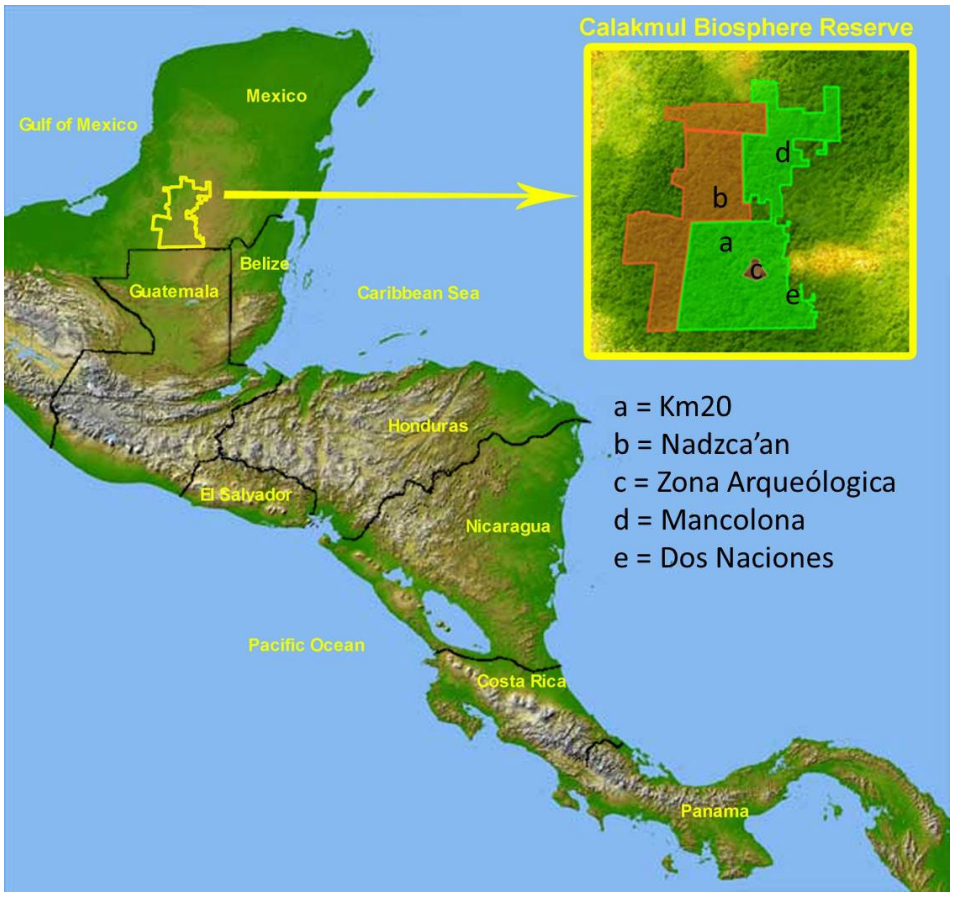

Figure 1: Location of Calakmul Biosphere Reserve and Operation Wallacea Research Locations with the reserve.

Table 1: Exact length (km) of each transect in the various research locations in Calakmul used during the 2012 field season.

Transect	Survey Location				
	KM20	KM15	KM27	Nadzca'an	ZA
1	2	1.5	1.5	2	2
2	2			1.5	2
3	2				2
4	2				2
5	1.8				

Data Collection

All data were collected between June-August by teams of students lead by university academics and local field guides. The number of students participating in the project varied from week to week, but efforts were made to divide students across different field camps to facilitate simultaneous data collection in multiple camps and minimize environmental impact at each camp site. Students in each camp were divided into groups of 8 or less individuals in order to rotate around the different forms of data collection (see example schedule in Appendix A) to ensure that the number of people using each transect at any given time was kept to a minimum.

Habitat Data

Habitat surveys were conducted in each of 20m x 20m survey sites to investigate tree diversity and basal area, and to estimate carbon biomass within the reserve. All trees with a circumference greater than 30cm were marked in the plot, and the species, DBH, height of each tree, and whether the tree was alive or dead was recorded on datasheets. Tree were identified to local name with the assistance of local field guide and were subsequently identified to species name use a CD ROM called "Arboles Tropicales Comunes del Área Maya: Sistema de Identificación Taxonómica" (Ogata et al. 1999). DBH was measured using 50m tape measures and tree height was calculated using Suunto PM5 clinometers and tape measures (tree height can be estimated based on the distance of the observer from the base of the tree and the angle from the observer to the top of the tree). Estimates of carbon tonnage should include both live and dead trees, in addition to fallen dead wood. Consequently, the DBH, species and length of each fallen tree within the plot was also recorded. A more detailed description of the habitat survey methods is located in Appendix B.

Carbon tonnage calculations must also incorporate wood density for each tree. Variation in wood density within species is sufficiently low that the same density value may be used for all trees of the same species. Published wood density tables are available for a wide variety of species, but if not available for all species in the reserve then one density sample (core sample) must be taken per tree species (although this does not need to occur within the reserve). Carbon biomass calculations will not commence until all habitat surveys have been completed, and thus core samples and wood density tables were not included in the 2012 surveys.

Amphibians and Reptiles

Amphibian and reptile data was collected using active searching at a fixed width of 5m either side of the transect line during the day and at night when reptiles and amphibians are most active. The total search times for each survey were recorded so that herpetofauna abundance and diversity can be compared across transects based on constant survey effort. For all observed animals the GPS position was recorded. Preferentially, animals are to be identified from a distance, but sometimes animals have to be captured for a secure identification. All captured animals were sexed, weighed, measured and photographed (back, side and close up of head). In the case of reptiles, scale clippings were taken for the purpose of marking captures.

Birds

Bird data was primarily collected using mist nets, put opportunistic data of canopy-dwelling and ground-dwelling species were collected along the transects where possible. The abundance and diversity of understory birds was assessed using mist nets. Mist nets are unable to sample canopy and mid-canopy species adequately, but do allow for quantitatively reliable data to be produced for tropical understory birds, allows for the identification of birds that are shy or seldom vocal, minimises observer bias, and produces results that are easily repeatable. Mist nets surveys ran 6 days per week at each research camp using a suitable existing clearing along one of the sample routes with enough space to erect six 12m long mist nets 2.5 meter high. The locations of the netting sites were marked and the GPS location recorded. All mist netting was conducted at the same site per camp. Mist netting occurred in the mornings between 6:00am and 9:00am and in the afternoons between 4.30pm and 6:00pm.

The opening and closing time of the nets was recorded each session and nets were checked every 20 minutes for the duration of the survey. When birds are found in the net, the time of capture was noted. The birds were taken out of the net, placed in a cotton bag for holding whilst other birds are being processed. As previous studies of avifauna in Calakmul have indicated that recapture rates are extremely low, a banding system using nail varnish of 10 different colours was used to mark birds when captured. The birds were weighed (to the nearest gm) and standard morphological measurements taken. The birds were released close to the net site but far enough away to avoid them being immediately re-trapped.

Bats

Bat mist nets surveys ran 6 nights per week at each research camp using a suitable existing clearing along the sample routes with enough space to erect six 12m long mist nets 2.5 meter high. The location of each mist net site was marked and the GPS location recorded. Mist netting was conducted between 6:00pm and 12am, but as data collection was sometimes affected by rain, the exact opening and closing time of the nets was recorded during each session. The nets were checked every 15 to 20 minutes during the first 3 hours of sampling and every 30 minutes for the last three. All the bats were extracted from the nets following standardized protocols so as to minimize the

stress and were kept in a capture bags for 30mins, maximum. This time varied depending on the size of the bat and the sex; pregnant females will be measured and released. Bats were weighed and sexed, and species, reproductive status, the length of the forearm, feet and leg were measured.

Primates and Large Mammals

Primates and large terrestrial mammals were surveyed along line transects (that were placed without any pre-determined knowledge of the distribution of the animals: Peres, 1999), using distance sampling (Buckland et al., 2001). The entire length of the transect line was walked by small groups of 4-5 observers walking quietly and slowly (500-1,000 m/hr) starting at 6.30am, when the majority of animals are most active and are easiest to detect. Each time an animals was encountered, the species, whether the animals was seen or heard, number of individuals (visual sightings only), perpendicular distance from the individual to the transect line, habitat, time, distance travelled along the transect line and weather conditions were recorded. Each transect line was surveyed a minimum of four separate occasions.

The distance sampling method is only suitable when animals are relatively easy to detect and is therefore unsuitable for monitoring elusive species living a low densities such as jaguar. Thus, an additional method was used to monitor these species: patch occupancy sampling (Mackenzie, 2005). Patch occupancy sampling involves detecting animals based on tracks and faeces rather that visual or vocal sightings of the animals. These data will be collected as students walk back along the transect line to camp (i.e. after the distance sampling).

Results

Habitat

The habitat team surveyed 26 pots of 20m x 20m: 20 plots in km20, 1 in Zona Arqueológica and 5 in Nadzca'an. 72 different species were identified in total. Carbon biomass calculations will not commence until data has been collected from all 120 plots, but preliminary analyses of the relative abundance of each tree species per camp and mean basal area per species, per camp are presented in Table 2.

Table 2: Relative abundance and mean basal area of trees surveyed in each field camp

Local Name	Genera	Species	Relative Abundance KM20 (20 plots)	Average Basal Area KM20	Relative Abundance Nadzca'an (5 plots)	Average Basal Area Nadzca'an	Relative Abundance ZA (1 plot)	Average Basal Area ZA
Árbol de Caña	*Cassia*	*Fistula*	0.15	59.97	0.00	0.00	0.00	0.00
Árbol flor de mayo	*Plumeria*	*rubra*	0.05	121.04	0.00	0.00	0.00	0.00
Arrocillo	*Hamelia*	*patens*	0.25	34.90	0.00	0.00	0.00	0.00
Bojon negro	*Cordia*	*gerascanthus*	0.15	435.93	0.00	0.00	4.00	116.76
Cafecillo	*Xylosma*	*sp*	14.90	82.28	4.60	165.38	2.00	50.05
Campanillo	*Trohpis*	*racemosa*	0.10	81.37	0.00	0.00	0.00	0.00
Caoba	*Swietenia*	*macrophylla*	0.10	267.58	0.00	0.00	1.00	53.79
Cascarillo	*Croton*	*glabellus*	8.30	77.82	1.00	124.79	8.00	90.01
Catzin	*Acacia*	*gaumeri*	1.55	202.51	0.00	0.00	1.00	127.32
Cedrillo	*Guarea*	*glabra*	0.30	53.18	0.00	0.00	1.00	97.48
Ceiba	*Ceiba*	*pentandra*	0.00	0.00	0.00	0.00	1.00	23.00
Chaca	*Bursera*	*simaruba*	2.30	198.06	3.60	291.11	1.00	66.92
Chacahuante	*Sickingia*	*salvadorensis*	1.65	165.95	0.40	108.94	0.00	0.00
Chacha de Pavo	*Cupania*	*guatemalensis*	2.20	88.78	0.00	0.00	0.00	0.00
Chacteviga	*Caesalpinia*	*platyloba*	1.40	180.86	1.60	549.60	4.00	67.93
Chechem	*Metopium*	*brownei*	1.20	253.01	0.20	401.15	3.00	68.41

Chechen Blanco	*Sebastiania*	*longicuspis*	0.10	32.15	0.40	215.89	1.00	509.30
Chintok	*Krugiodendron*	*ferreum*	0.05	35.09	0.00	0.00	5.00	322.79
Chu'ul	*Lonchocarpus*	*rugosus*	7.20	128.05	7.80	213.44	9.00	41.28
Ciricote	*Cordia*	*dodecandra*	0.30	353.22	0.00	0.00	0.00	0.00
Ciruelillo	*Acacia*	*tequilana*	0.10	33.62	0.00	0.00	0.00	0.00
Copal	*Protium*	*copal*	0.20	49.60	0.00	0.00	4.00	122.85
Espino	*Acacia*	*pennatula*	0.00	0.00	0.00	0.00	1.00	38.52
Fierrillo	*Dialium*	*guianense*	3.95	98.21	3.20	68.89	7.00	68.66
Govillo			0.05	108.94	0.00	0.00	0.00	0.00
Granadillo	*Dalbergia*	*cubiliquitzensis*	0.15	409.23	0.20	17.90	1.00	45.84
Guaya	*Talisia*	*oliviformis*	1.85	170.80	4.80	380.02	2.00	240.72
Guayabillo	*Colubrina*	*arborescens*	4.10	132.46	0.20	108.94	1.00	23.00
Guayacan	*Guaiacum*	*sanctum*	1.70	154.88	1.00	104.69	1.00	31.83
Gusanillo	*Lippia*	*umbelata*	1.75	220.65	0.20	76.47	0.00	0.00
Gusano	*Lanchocarpus*	*guatemalensis*	0.00	0.00	0.00	0.00	8.00	86.71
Higuera	*Ficus*	*carica*	0.10	56.86	0.00	0.00	0.00	0.00
Hojancha	*Alchornea*	*latifolia*	0.05	25.78	0.00	0.00	0.00	0.00
Jabin	*Piscidia*	*piscipula*	0.00	0.00	1.20	39.12	0.00	0.00
Jobillo	*Astronium*	*graveolens*	0.10	962.89	1.40	103.52	0.00	0.00
Jobo	*Spondias*	*mombin*	0.30	230.43	2.20	423.69	1.00	25.78
Laurel	*Cordia*	*sp*	0.70	136.67	0.00	0.00	0.00	0.00
Laurelillo	*Licaria*	*campechiana*	4.35	78.23	0.80	80.41	0.00	0.00
Lechoso	*Brosimum*	*utile*	0.10	62.47	0.00	0.00	0.00	0.00
Llaiti			0.05	0.00	0.00	0.00	0.00	0.00
Majagua	*Belotia*	*campbellii*	0.20	73.97	0.00	0.00	3.00	585.72
Mazahua	*Verbena*	*carolina*	0.85	64.94	0.00	0.00	0.00	0.00
Melina	*Gmelina*	*arborea*	0.05	76.47	0.00	0.00	0.00	0.00
Mora	*Morus*	*rubra*	0.05	215.18	0.00	0.00	0.00	0.00
Nance Agrio	*Byrsonima*	*crassifolia*	0.40	154.54	0.00	0.00	0.00	0.00
Naranjillo	*Capparis*	*verrucosa*	3.35	126.89	0.40	76.55	2.00	14.16
Palmache	*Geonoma*	*sp*	0.45	147.97	0.00	0.00	0.00	0.00
Palo de Gas	*Amyris*	*sylvatica*	2.30	71.85	0.00	0.00	3.00	206.78
Palo de Rosa	*Sickingia*	*salvadorensis*	0.20	66.33	0.00	0.00	0.00	0.00
Papelillo	*Bursera*	*simaruba*	0.00	0.00	0.00	0.00	1.00	31.83
Pata de venado	*Calliandra*	*mexicana*	1.50	1724.80	0.60	480.52	0.00	0.00
Pimienta	*Pimenta*	*dioica*	0.20	742.33	0.00	0.00	0.00	0.00
Pomol che	*Jatropha*	*gaumeri*	0.40	106.47	1.60	33.55	0.00	0.00
Poso Lagro			0.00	0.00	0.00	0.00	1.00	42.10
Posolillo	*Neea*	*psychotrioides*	0.05	140.37	0.00	0.00	0.00	0.00
Pucte	*Bucida*	*buceras*	0.10	261.33	0.00	0.00	7.00	118.42
Rabo de Lagarto	*Zanthoxylum*	*sp*	0.25	349.60	0.00	0.00	2.00	47.79
Ramón	*Brosimum*	*alicastrum*	4.85	139.89	9.20	279.63	1.00	58.01
Salansillo			0.60	71.82	0.00	0.00	0.00	0.00
Salchaca			0.25	607.86	0.00	0.00	0.00	0.00
Sangrillo	*Paramachaerium*	*gruberi*	0.05	62.39	0.00	0.00	0.00	0.00
Tabanillo			0.70	81.48	0.00	0.00	0.00	0.00
Telecebolla			1.05	271.94	0.00	0.00	0.00	0.00
Tinto	*Haematoxylon*	*campechianum*	0.35	246.41	0.00	0.00	3.00	105.24
Tzalam	*Lysiloma*	*bahamensis*	0.30	166.06	1.20	125.94	5.00	113.22

Verde vacero			0.05	827.92	0.00	0.00	0.00	0.00
Yaxnik	*Vitex*	*guameri*	0.95	254.17	0.00	0.00	4.00	106.74
Yaya	*Casearia*	*arborea*	0.80	28.94	0.00	0.00	3.00	55.62
Zapote	*Manilkara*	*zapota*	5.50	536.97	9.60	874.50	6.00	300.15
Zapotillo	*Pouteria*	*campechiana*	3.20	72.59	0.60	33.56	3.00	66.85

Large Mammals

The large mammal team completed 57 repetitions of the survey transects (95.9km in total: Table 3). Nineteen different species of large and medium sized were recorded (Figures 2a and 2b). A full list of species (with common names in English and Spanish) is located in Appendix C. The sites with the highest relative abundance of large and medium mammals were km27 and km15 (Figures 2a and 2b), most likely due to the presence of water and large fruiting trees at these sites. However, the relative abundance estimates for all terrestrial mammals was calculated from tracks rather than sightings, and thus true estimates of abundance should be calculated using the PRESENCE software package for patch occupancy sampling. These calculations will be completed after the 2013 field season once data has been collected from a larger selection of survey sites.

Table 3: Number of repetitions of each transect in each camp completed by the mammal monitoring team

Transect	Measures	KM15	KM20	KM27	Nadzca'an	ZA
1	**Repetitions**	4	2	6	4	4
	Dist. total (km)	6	4	8.8	8	8
2	**Repetitions**		7		3	3
	Dist. total (km)		14		4.5	6
3	**Repetitions**		6			4
	Dist. total (km)		12			8
4	**Repetitions**		7			2
	Dist. total (km)		14			3
5	**Repetitions**		5			
	Dist. total (km)		8.4			

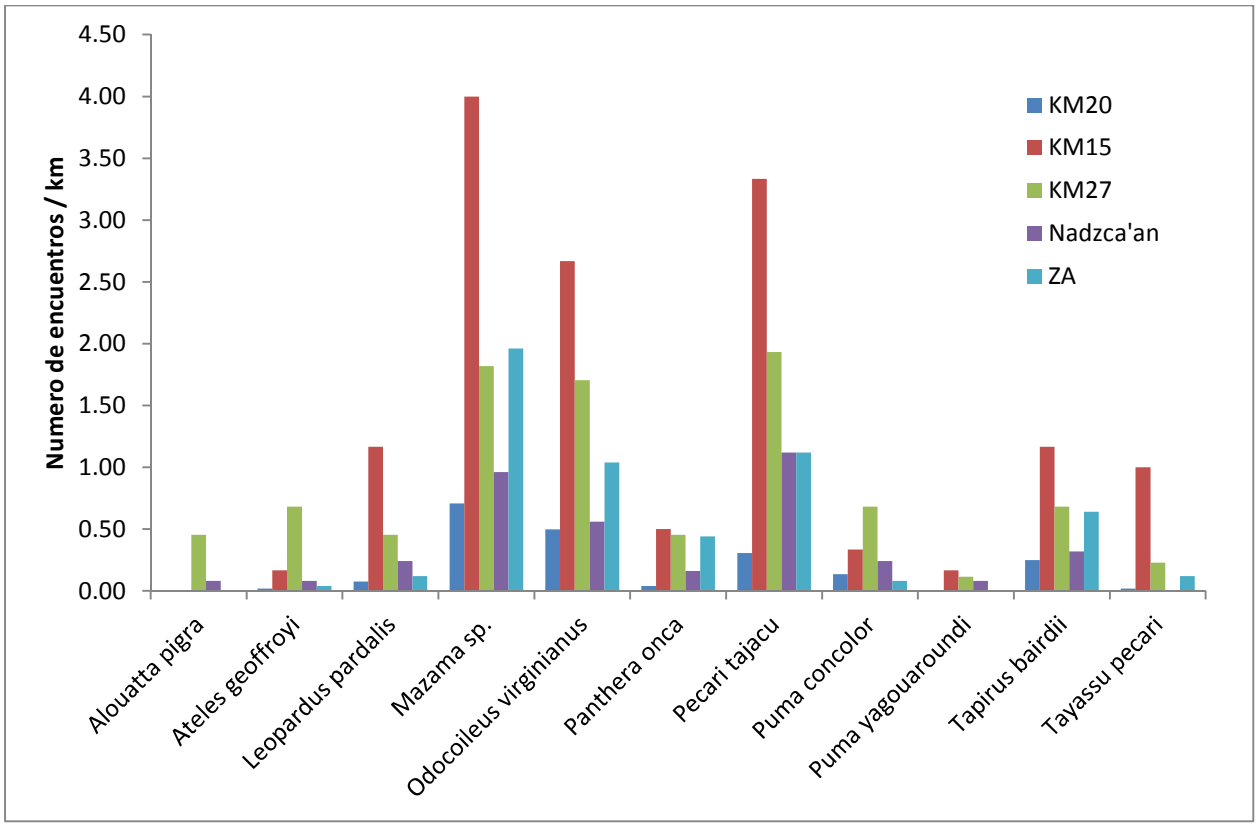

Figure 2a: Relative abundancia (encounters / km) of large mammals in each research location surveyed in 2012.

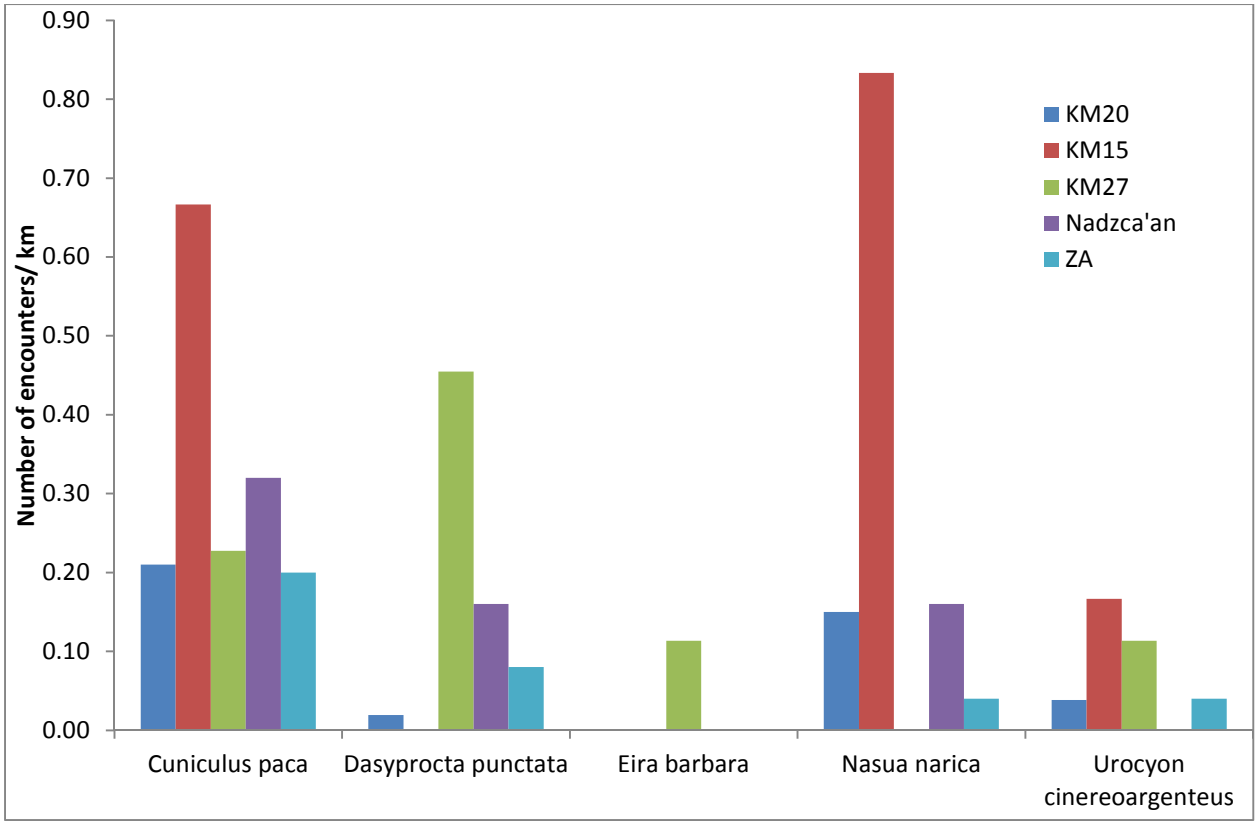

Figure 2b: Relative abundance (encounters / km) of medium sized mammals for each research location surveyed in 2012.

Bats

The bat team completed 48 mist netting occasions across the various survey sites, giving rise to a total netting effort of 26013 m^2*h (Table 4). A full list of species (with common names in English and Spanish) is available in Appendix C. Seventeen species of bat were captured in total (Figure 3). The majority of species were captured on just one occasion and only seven species were captured relatively frequently. As the majority of the bat species in the reserve are insectivorous with echolocation that can easily detect a mist net and avoid capture, a full investigation of bat species composition in the reserve would require a combination of mist net surveys and transect surveys using a bat detector.

Table 4: Number of repetitions of each mist net location in each camp completed by the bat monitoring team.

Transect	Measures	KM15	KM20	KM27	Nadzca'an	ZA
1	Repetitions		3	3	3	
	Effort (m2*h)		1341	1560	1725	
2	Repetitions		9		3	
	Effort (m2*h)		5010		1482	
3	Repetitions		5			4
	Effort (m2*h)		3186			2466
4	Repetitions		5			
	Effort (m2*h)		3270			
In Camp	Repetitions	5	8			
	Effort (m2*h)	2595	3378			
Total Repetitions		5	30	3	6	4
Total Effort		2595	16185	1560	3207	2466

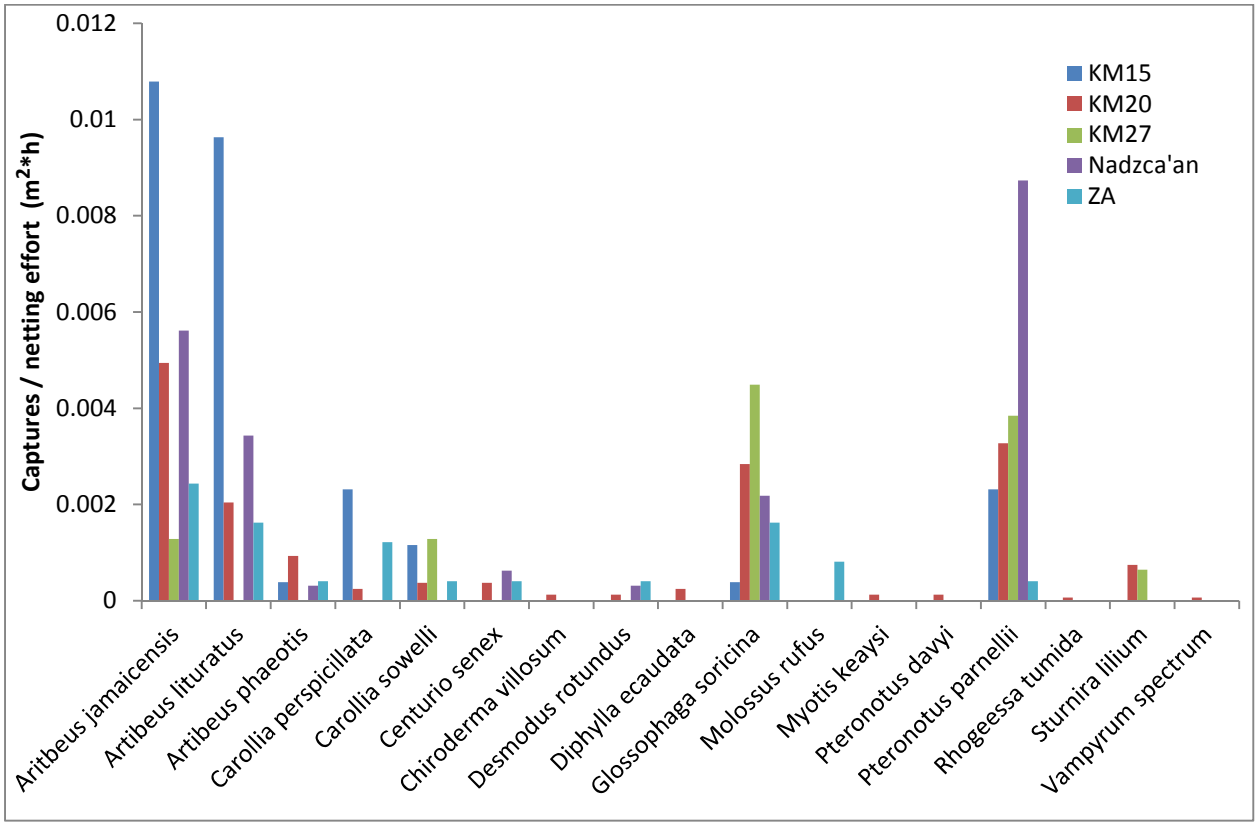

Figure 3: Relative abundance (captures by mist netting effort [m^2*h]) of bats for each research location surveyed in 2012

Herpetofauna

The herpetofauna team completed 84 repetitions of the survey transects (138.4km en total: Table 5). 51 species of reptile were encountered across the different survey sites: one species of crocodile and 6 species of turtle (Table 6a 19 species of lizard (Table 6b), and 25 species of snake (Table 6c). Seventeen species of amphibian (Table 7) were encountered across the various survey locations. A full list of herpetofauna species (with common names in English and Spanish) is located in Appendix C. In general, the abundance was very low, but that is to be expected in dry forest conditions found in most of Calakmul. Hardly any reptiles or amphibians were encountered in Zona Arqueológica despite that fact that two of the four transects passed by aguadas. Further investigation in the area is required to determine if the low abundance is representative of the area or just an artefact of the specific times of our survey (e.g. due to weather conditions).

Table 5: Number of repetitions of each transect in each camp completed by the herpetofauna monitoring team.

Transect	Measures	KM20	KM27	Nadzca'an	ZA
1	**Repetitions**	4	6	14	3
	Dist. total (km)	4	8.6	22.5	6
2	**Repetitions**	9		12	2
	Dist. total (km)	17		15.5	4
3	**Repetitions**	3			1
	Dist. total (km)	4			2
4	**Repetitions**	3			0
	Dist. total (km)	5			0
5	**Repetitions**	12			
	Dist. total (km)	20.8			
Road North	**Repetitions**	8			
	Dist. total (km)	18			
Road South	**Repetitions**	5			
	Dist. total (km)	11			

Table 6a: Relative abundance (encounters / km) of turtles and crocodiles for each research location surveyed in 2012

Common Name	Species	KM20	KM27	Nadzca'an	ZA
Morlete's Crocodile	*Crocodylus mareletii*	0.01	0.00	0.05	0.00
Narrow-bridged Musk Turtle	*Claudius angustatus*	0.00	0.35	0.00	*
Creaser's Mud Turtle	*Kinosternon creaseri*	0.01	0.00	0.03	0.00
White-lipped Mud Turtle	*Kinosternon leucostomum*	0.03	0.12	0.11	*
Scorpion Mud Turtle	*Kinosternon scorpioides*	0.03	0.00	0.03	0.00
Furrowed Wood Turtle	*Rhinoclemmys areolata*	0.04	0.00	0.05	0.00
Meso-American Slider	*Trachemys venusta*	0.03	0.12	0.00	*

Table 6b: Relative abundance (encounters / km) of lizards for each research location surveyed in 2012. * signifies that the encounter was opportunistic and thus it was not possible to calculate relative abundance based on survey effort.

Common Name	Species	KM20	KM27	Nadzca'an	ZA
Barred Whiptail	*Amieva undulate*	0.01	0.00	0.18	*
Yucatan Whiptail	*Aspidoscelis angusticeps*	0.05	0.12	0.03	0.00
Striped Basilisk	*Basiliscus vittatus*	0.04	0.00	0.00	*
Yucatan banded gecko	*Coleonyx elegans*	0.16	0.00	0.11	0.00
Helmeted Basilisk	*Corytophanes cristatus*	0.01	0.12	0.00	0.00
Yucatan Spiney-Tailed Iguana	*Ctenosaura defensor*	0.00	0.00	0.03	*
Serrated Casquehead Iguana	*Laemanctus serratus*	0.01	0.00	0.00	0.00
Schwart's Skink	*Mesoscincus schwartzei*	0.00	0.00	0.03	0.00
Crested Anole	*Norops cristellatus*	0.01	0.00	0.00	0.00
Ghost Anole	*Norops lemurinus*	0.16	0.12	0.05	0.08
Yucatan Smooth Anole	*Norops rodriguezii*	0.03	0.23	0.08	*
Brown Anole	*Norops sagrei*	0.06	0.00	0.00	0.00
Silky Anole	*Norops seirceus*	0.06	0.00	0.00	0.00
Greater Scaly Anole	*Norops tropidonotus*	0.01	0.12	0.00	0.00
Sumichrast's Skink	*Plestiodon sumichrasti*	*	0.00	0.00	0.00
Yellow-spotted Spiny Lizard	*Sceloporus chrysostictus*	0.03	0.00	0.29	*
Dwarf Gecko	*Sphaerodactylus glaucus*	0.01	0.00	0.00	0.00
Central American Smooth Gecko	*Thecadactylus rapicauda*	*	0.00	0.00	0.00

Table 6c: Relative abundance (encounters / km) of snakes for each research location surveyed in 2012. * signifies that the encounter was opportunistic and thus it was not possible to calculate relative abundance based on survey effort.

Common Name	Species	KM20	KM27	Nadzca'an	ZA
Yucatan Cantil	*Agkistrodon bilineatus*	0.01	0.00	0.03	0.00
Boa Constrictor	*Boa constrictor*	0.01	0.00	0.08	0.00
Fer-de-lance	*Bothrops asper*	0.05	0.00	0.00	0.00
Black-striped Snake	*Coniophanes imperialis*	0.04	0.00	0.03	0.00
Faded Black-striped Snake	*Coniophanes schmidti*	0.03	0.00	0.05	0.00
Central American Rattlesnake	*Crotalus simus*	0.01	0.00	0.03	0.00
Snail-eating Thirst Snake	*Dipsas brevifacies*	0.01	0.00	0.00	*
Brown Racer	*Dryadophis melanolomus*	0.00	0.00	*	0.00
Speckled Racer	*Drymobius margaritiferus*	0.01	0.00	0.05	0.00
Central American Rat Snake	*Elaphe flavirufa*	*	0.00	0.00	0.00
Blotched Hook-nose Snake	*Ficimia publia*	0.01	0.00	0.00	0.00
Blunt-headed Tree Snake	*Imantodes cenchoa*	0.01	0.00	0.00	0.00
Yucatan Blunt-headed Snake	*Imantodes tenuissimus*	0.01	0.00	0.00	*
Cat-eyed Snake	*Leptodeira frenata*	0.05	0.00	0.03	0.00
Green-headed Tree Snake	*Leptophis mexicanus*	0.03	0.12	0.00	0.00
Salmon-bellied Racer	*Mastigodryas melanolomus*	0.01	0.00	0.00	0.00
Coral Snake	*Micrurus diastema*	0.00	0.00	0.03	0.00

Red Coffee Snake	*Ninia sebae*	0.01	0.00	0.00	*
Brown Vine Snake	*Oxybelus aeneus*	0.00	0.00	*	0.00
Yellow-red Rat Snake	*Pseudelaphe flavirufa*	0.03	0.00	0.00	0.00
Puffing Snake	*Pseustes poecilonotus*	*	0.00	0.00	0.00
Pygmy Snail Sucker	*Sibon sanniola*	0.01	0.00	0.00	0.00
Tropical Rat Snake	*Spilotes pullatus*	0.00	0.12	0.00	0.00
Banded Snail Sucker	*Tropidodipsas fasciata*	0.00	0.00	0.03	0.08
Terrestrial Snail Sucker	*Tropidodipsas sartorii*	0.02	0.00	0.03	0.00

Table 7: Relative abundance (encounters / km) of amphibians for each research location surveyed in 2012. * signifies that the encounter was opportunistic and thus it was not possible to calculate relative abundance based on survey effort.

Common Name	Species	KM20	KM27	Nadzca'an	ZA
Yucatan Salamander	*Bolitoglossa rufescens*	0.00	0.00	0.00	0.00
Rufescent Salamander	*Bolitoglossa yucatana*	0.01	0.00	0.00	0.00
Gulf Coast Toad	*Incilus valliceps*	0.34	0.00	0.37	*
Cane Toad	*Rhinella marina*	0.00	0.12	0.00	*
Mexican Burrowing Toad	*Rhinophrynus dorsalis*	*	0.00	0.00	0.00
Variegated Treefrog	*Dendropsophus ebraccata*	0.15	0.00	0.00	0.00
Yellow Treefrog	*Hyla microcephala*	0.01	0.00	0.00	0.00
Cricket Treefrog	*Hyla picta*	0.05	0.00	0.00	0.00
Sheep Frog	*Hypopachus variolosus*	0.11	0.00	0.16	0.00
White-lipped Frog	*Leptodactylus fragilis*	0.04	0.00	0.00	0.00
Leopard Frog	*Lithobates berlandieri*	0.15	0.00	0.00	0.00
Valliant's Frog	*Lithobates vaillanti*	0.05	0.00	0.00	0.00
Stauffer's Treefrog	*Scinax staufferi*	0.03	0.00	0.00	0.00
Mexican Treefrog	*Smilisca baudinii*	0.13	0.00	0.21	0.00
Loquacious Treefrog	*Tlalocohyla loquax*	0.10	*	0.00	0.00
Veined Treefrog	*Trachycephalus venulosa*	0.05	0.12	0.05	0.00
Yucatan Casque-headed Treefrog	*Triprion petasatus*	0.00	*	0.00	0.00

Aves

Eighty three species bird species were recorded during opportunistic surveys along transects and standardized mist net surveys: 38 non-passerine and 45 passerines. A full list of species (with common names in English and Spanish) is located in Appendix C. The bird team completed 56 mist netting occasions, giving rise to a total netting effort of 51502 m^2*h (Table 8). Thirty three species were captured during mist net surveys, and the abundance of each species was very low. The apparent low abundance of understory birds is likely due to the extremely dense forest in the survey areas, in which the majority of birds are upper canopy specialists. Although data from standardized mist net surveys is the best method for monitoring changes to bird populations over time, point count surveys are more suitable for investigating species diversity. Consequently, in subsequent years, both point counts and mist net surveys will be used to monitor the resident bird population in Calakmul.

Table 8: Mist netting effort (number of occasions and netting effort) for each research location surveyed in 2012.

Transect	Measures	KM15	KM20	Nadzca'an	ZA
1	Repetitions	3	3	6	
	Effort (m2*h)	2784	3469.2	3599.88	
2	Repetitions		9	6	
	Effort (m2*h)		9928.08	4470	
3	Repetitions		9		3
	Effort (m2*h)		9181.8		2503.2
4	Repetitions		9		
	Effort (m2*h)		8797.74		
5	Repetitions		8		
	Effort (m2*h)		6768		
	Total Repetitions	3	38	12	3
	Total Effort	2784	38144.82	8069.88	2503.2

Table 10: Relative abundance (captures by mist netting effort [m^2*h]) of understory birds for each research location surveyed in 2012

Common Name	Species	KM15	KM20	Nadzca'an	ZA
White-bellied emerald	*Amazilia candida*	0.00000	0.00005	0.00000	0.00000
Buff-bellied hummingbird	*Amazilia yucatanensis*	0.00000	0.00013	0.00050	0.00120
Ruby-throated hummingbird	*Archilochus colubris*	0.00000	0.00000	0.00012	0.00000
Green-backed sparrow	*Arremonops chloronotus*	0.00036	0.00016	0.00050	0.00000
Roadside hawk	*Buteo magnirostris*	0.00000	0.00003	0.00000	0.00000
Wedge-tailed sabrewing	*Campylopterus curvipennis*	0.00036	0.00010	0.00012	0.00000
Blue bunting	*Cyanocompsa parellina*	0.00000	0.00016	0.00050	0.00000
Tawny-winged woodcreeper	*Dendrocincla anabatina*	0.00000	0.00024	0.00099	0.00000
Ruddy woodcreeper	*Dendrocincla homochroa*	0.00000	0.00034	0.00025	0.00000
Amazonian barred woodcreeper	*Dendrocolaptes certhia*	0.00000	0.00005	0.00000	0.00040
Northern barred woodcreeper	*Dendrocolaptes sanctithomae*	0.00000	0.00005	0.00000	0.00000
Yellow warbler	*Dendroica petechia*	0.00000	0.00003	0.00000	0.00000
Grey-headed tanager	*Eucometis penicilata*	0.00072	0.00000	0.00000	0.00000
Bat falcon	*Falco rufigularis*	0.00000	0.00003	0.00000	0.00000
Grey-throated chat	*Granatellus sallaei*	0.00000	0.00005	0.00012	0.00000
Red-throated ant tanager	*Habia fusicauda*	0.00000	0.00100	0.00062	0.00080
Red-crowned ant tanager	*Habia rubica*	0.00000	0.00003	0.00037	0.00000
Tody motmot	*Hylomanes momotulo*	0.00000	0.00000	0.00000	0.00040
Tawny-crowned greenlet	*Hylophilus ochraceiceps*	0.00000	0.00005	0.00000	0.00000
White-tipped dove	*Leptotila verreauxi*	0.00000	0.00000	0.00012	0.00000
Golden-fronted woodpecker	*Melanerpes aurifrons*	0.00000	0.00000	0.00000	0.00080
Collared forest falcon	*Micrasturs ruficollis*	0.00000	0.00005	0.00000	0.00000
Blue-crowned motmot	*Oncostoma cineiregulare*	0.00000	0.00010	0.00000	0.00000
Royal flycatcher	*Onychorhynchus coronatus*	0.00000	0.00010	0.00037	0.00000
Stub-tailed spadebill	*Platyrinchus cancrominus*	0.00036	0.00052	0.00000	0.00000

Eye-ringed flatbill	*Rhynchocyclus brevirostris*	0.00000	0.00003	0.00025	0.00000
Olivaceous woodcreeper	*Sittasomus griseicapillus*	0.00036	0.00010	0.00000	0.00000
White-browed wren	*Thryothorus albinucha*	0.00000	0.00005	0.00012	0.00000
Carolina wren	*Thryothorus ludovicianus*	0.00000	0.00008	0.00000	0.00040
Spot-breasted wren	*Thryothorus maculipectus*	0.00000	0.00008	0.00025	0.00000
White-bellied wren	*Uropsila leucogatsra*	0.00000	0.00024	0.00099	0.00000
Smokey brown woodpecker	*Veniliornis fumigatus*	0.00000	0.00005	0.00000	0.00000
Ivory-billed woodcreeper	*Xiporynchus flavigaster*	0.00000	0.00021	0.00025	0.00040

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Appendix A: Example Weekly Schedule of Biodiversity Monitoring and Teaching Activities

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
6:00am		Birds T3 (B4 (8))	Birds T4 (C5 (4))	Birds T2 (C6 (8))	Bird Point Count T2 & T4 (2)	KM27 Birds T1 (B3 (8))	Birds T1 (B2 (8))
6:30am		Mammals T2 & T4 (C6 (8))	KM27 Mammals T1 (C5 (4))	ZA Mammals T3 & T4 (A1 (8))	Mammals T1 & T3 (A2 (8))	KM15 Mammals T1 & T2 (B4 (8))	Mammals T4 & T5 (B3 (8))
Breakfast		**7.00am**	**7.00am**	**7.00am**	**7.00am**	**7.00am**	**7.00am**
7:30am			**GROUP A to KM20 GROUP B to NDZ**		**GROUP B to KM20 GROUP C to NDZ**	ZA Herps T3 (A2 (8))	**GROUP C TO KM20 All schools in camp**
08:00am		KM15 Herps T1 (B3 (8))	Habitat Data Entry	KM27 Herps T1 (C5 (8))	Herps Road North (A1 (8))		Herps T2 (sign up (8))
8:30am		Habitat T5 (C5 (8))	Herps T3 (C6 (8))	Habitat T5 (A2 (8))	Habitat Data Entry	Habitat T2 (A1 (8))	Habitat T3 (sign up (8))
11:00am		Museum Tour B3	Museum Tour C5	Museum Tour C6	Museum Tour A2	Museum Tour B4	Museum Tour A1
Lunch	**1.30pm**	**1.30pm**	**1.30pm**	**1.30pm**	**1.30pm**	**1.30pm**	**1.30pm**
2:00pm	Camp tours		ZA Habitat T1 & T2 (C5 & C6 (16))		ZA Habitat T1 & T2 (B3 & B4 (16))		
2:30pm	Tent allocations	Lecture 1 Groups B&C	Lecture 1- Group A	Lecture 3 Groups A&C		Lecture 3 B3 & B4	Lecture 5 All
3:00pm	Welcome lecture, health & safety briefing	Mammal & Habitat Teams Habitat Survey T5 (4)	Mammal & Herp Teams Habitat Survey T1 (4)	Mammal & Habitat Teams Habitat Survey T3 (4)	Mammal Team Habitat Survey T2 (A1 (8))	Habitat T2 (A2 (8))	
3:30pm	**GROUP A to NDZ**	Lecture 2 Groups B&C	Lecture 2- Groups A	Lecture 4 Groups A&C		Lecture 4 B3 & B4	Lecture 6 All
4:00pm					KM27 Birds T1 (A2 (8))	KM27 Birds T1 (A1 (8))	
4:30pm		Birds T3 (sign up (8))	Birds T4 (sign up (8))	Birds T2 (sign up (8))			Pack!!! (Feedback, photo collection, videos etc)
Dinner	**7pm**	**7pm**	**7pm**	**7pm**	**7pm**	**7pm**	**7pm**
8:00pm	Bats (sign up)	ZA Bats T3 (sign up (8)	Bats T2 (sign up (8))	Bats T4 (sign up (8))	KM27 Bats (sign up (8))	Bats T1 (sign up (8))	**Movie Night!**
8:00pm	Herps (sign up)	Herps T1 (sign up (8))	Herps T5 (sign up (8))	Herps Road South (sign up (8))	Herps T4 (sign up (8))	Herps Road North (sign up (8))	

Appendix B: Operation Wallacea Habitat Survey Methods for Estimating Carbon Biomass

Sample plots

A stratified sample of at least 120 habitat survey sites should be created for the study area. Each habitat plot should be of equal size. The minimum acceptable size for a habitat plot is 20m x 20m, but larger plots (eg. 50m x 50m) are also acceptable. Within each plot, every standing tree (alive or dead), fallen trees and cut stumps over 15cm in circumference should be measured. Measurements include DBH and height (see sections below). For each tree measured, the corresponding tree species should be identified and the state of the tree (alive or dead) recorded.

Tree height and diameter measurements

Tree (Dbh) measurement

Tree diameter is measured over bark, at 1.3m breast height above the ground (see Figure 1) with the exception of particular cases mentioned below. Measurement may be carried out with the help of a diameter tape (tape whose diameter unit is in centimetres) or with the use of a calliper. In order to avoid overestimation of the volume and to compensate measurement errors, diameter is measured in cm and adjusted in a decreasing sense (example: 16.8 cm become 16 cm).

Figure 1: Position for diameter measurement at breast height in flat terrain. One single dotted line indicates the place for Dbh measurement. If there are two lines on the stem because of a defective tree, the appropriate place to do the measurement is thus indicated.

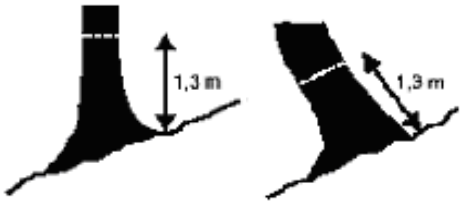

Figure 2: Dbh measurement position for a tree on steep terrain.

Fork tree: Several cases exist, according to the point where the fork divides the stem.

If the fork begins (the point where the core is divided) below 1.3 m height, each stem having the diameter required (≥20 cm in the whole plot, ≥10 cm for rectangular subplots) will be considered as a tree and will be measured. Diameter measurement of each stem will be taken at 1.3 m height. If the fork begins between 30 cm and 1.3 m, each stem will be considered as separate tree and will be measured. The diameter measurement will be taken at 1 meter above the fork origin. If the fork begins at 1.3 m or a little higher, the tree will be counted as a single tree. The diameter measurement is thus carried out below the fork intersection point, just below the bulge that could influence the Dbh.

Coppice: Coppice shoots originate between ground level and 1.3m on the stem of a dead or cut tree. These are considered in the same way as forked trees, except that the coppice shoots do not necessarily reach 1/3 diameter of a dead tree. Coppice shoots originating below 30 cm are measured at 1.3 m above the ground; those that originate between 30 cm and 1.3 m are measured at 1 meter above the originating point.

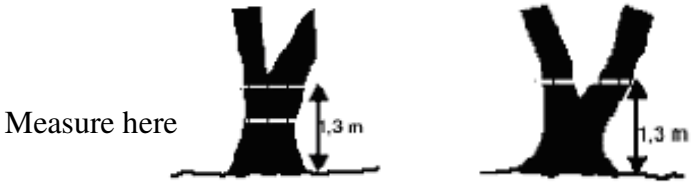

Figure 3: Measurement point for trees with forks or coppice.

Trees with an enlarged stem base or buttressed tree: diameter measurement is made at 30 cm above the enlargement or main width of buttress, if the buttress/enlargement reaches more than 90 cm height above the ground (see Figure 4).

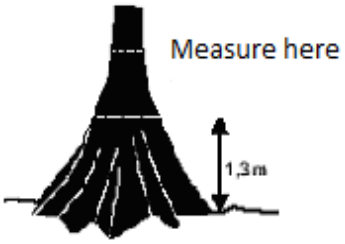

Figure 4: Dbh measurement position for buttressed tree

Trees with aerial roots: diameter measurement is done at 1.3m from the limit between the stem and roots (see Figure 5).

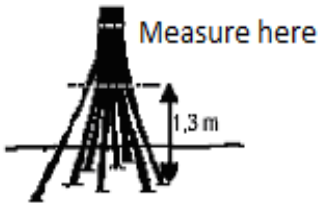

Figure 5: Dbh measurement position for a tree with aerial roots

Trees with irregular stem at 1.3m: trees with bulges, wounds, hollows and branches, etc. at breast height, are to be measured just above the irregular point, there where the irregular shape does not affect the stem (see Figures 5 and 6).

Figure 6: Dbh measurement position for a tree with branch enlargement at 1, 3m

Inclined trees: diameter measurement is made at 1.3 m. The stem height is measured where the stem base and the ground meet forming an angle (see Figure 7).

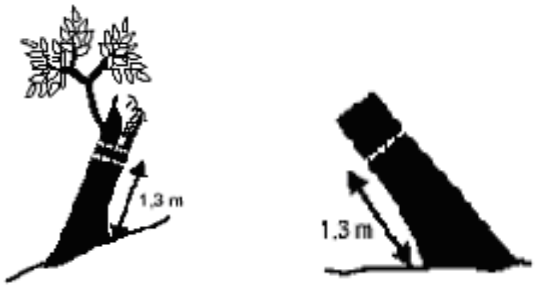

Figure 7: Dbh measurement position for an inclined tree.

Fallen tree: diameter measurement is made at 1.3 m from the transition point between the stem and the root (see Figure 8).

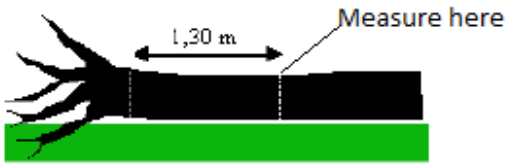

Figure 8: Dbh position for a fallen tree.

Measurement for a living tree lying on the ground with branches in the shape of a vertical tree: When a living tree is laying on the ground and its vertical branches (at <45° vertical position) grow from the main stem, it is recommended to determine first if the main stem is above the litter or not. If this is the case, use the same rules applied to a forked tree, if the pith of the main stem is under the litter, do not take the main stem into account and treat each one of the branches in the shape of a tree, as a separate tree. Dbh may be measured (and its height too) at 1.3 m from the ground, but not from the top of the laying stem. If the top of the laying stem forms a vertical curve, compared to the ground, treat this tree portion as if it was an individual tree, beginning at the point where the pith detaches from the litter (see Figure 9).

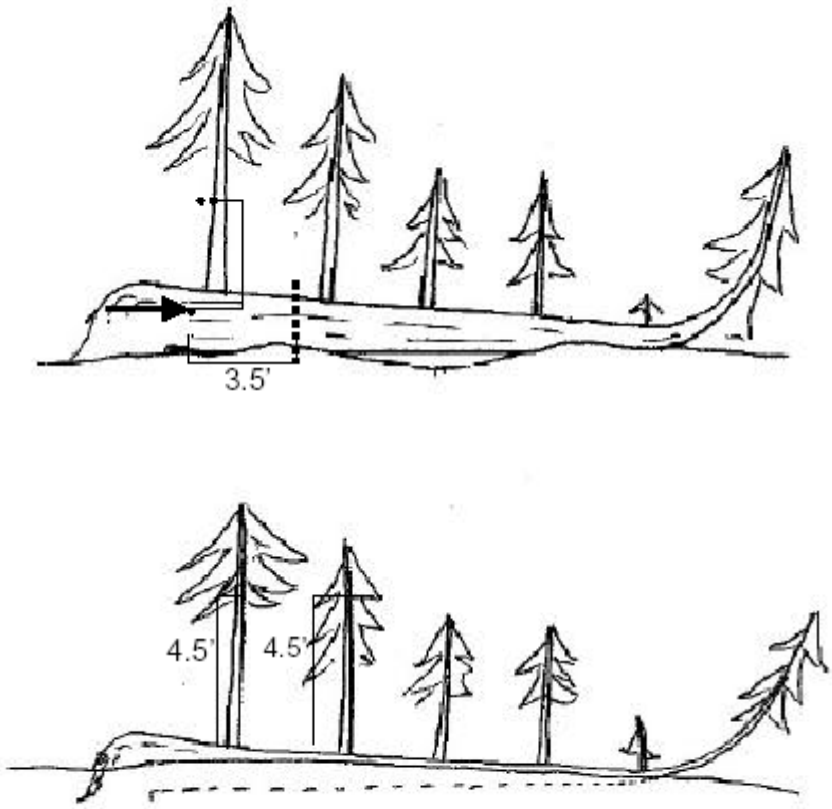

Figure 9: Dbh position for a live tree with horizontal stem.

If the Dbh is not measured at 1.3 m from the ground, indicate the height where it was measured. Measure and separately indicate the branch Dbh that originates at a lower height than 1.3 m.

In the case of stump, if the stump height is less than 1.30 m, stump diameter is measured outside bark at stump height, immediately under the cutting point (felling cut) and perpendicular to the longitudinal. If the bark is damaged or missing, a judged addition for bark is done.

6.2.2 Tree height measurement

Tree height measurement may be carried out by means of several instruments such as: dendrometric table, Blume-Leiss, Suunto, Haga, Blitterlich Relascope. Operation Wallacea use the Suunto PM-5/360 PC Clinometer to measure the angle of the tree top from the observer, and a tape measure to record the distance of the observer from the tree base. Using these measurements, the height of the tree can be calculated using trigonometry. However, when the terrain is mountainous, care must be taken to incorporate the angle of the observer to the base of the tree (see Figure 11).

Height measurement is made during several stages:

1. To avoid measurement errors, the distance of the observer from the tree when calculating tree height should be roughly equivalent to the tree height. For example if a tree is roughly 20m high then try to measure it from 20m away.

2. Observation of the tree crown

3. Observation of the tree base

4. Addition or subtraction of the two observation results according to the case: addition if the operator is standing uphill (see Figure 10a), subtraction if the operator is standing downhill in relation to the tree (see Figure 10b).

5. Slope correction

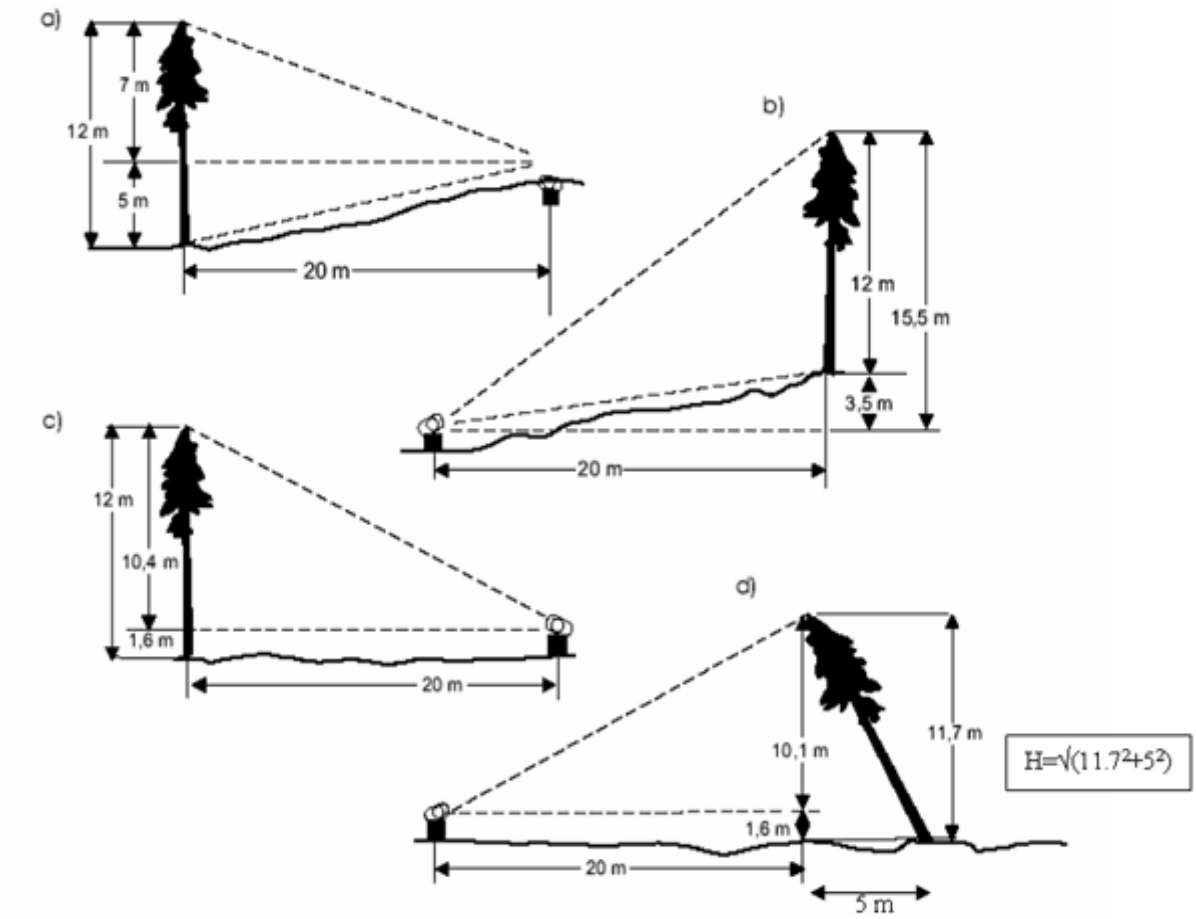

Figure 10: Tree height calculation

Note: You may find out the height of a tree (12m for a, b, and c, and 11.7m for d):

a) By adding the results above and under the horizontal measurement

b) By subtracting from the total, the distance between the base of the tree and the horizontal line

c) By adding to the height of the instrument from the ground, the distance measured above the horizontal line

d) By adding the instrument measurement from the ground to the distance measured from the crown of the tree up to a point located just below on the horizontal (use the telescopic rod), the height is Ho. If D is the distance from the base of the tree to the point located below the horizontal of the top of the tree then the tree height H is calculated by applying the formula: $H= \sqrt{(H^2+D^2)}$

Calculating Carbon Biomass

For each tree (live and dead, upright and fallen) in each habitat plot, the DBH and height values can be used to calculate tree volume. For each tree in each plot, the corresponding tree species will be recorded and thus it is

possible to find out wood density for that species based on published wood density tables. Using these data it is possible to calculate carbon biomass for each tree and thus for each habitat plot.

Once the carbon biomass for the 120 different habitat plots has been determined an estimation of total carbon biomass of the study area can be calculated based on the mean carbon biomass value for a given forest type and the proportion of these forest type present in the study area.

Appendix C: Presence of species in each survey location surveyed during the 2012 Operation Wallacea monitoring programme.

Large Mammals

Spanish Common Name	English Common Name	Species	KM15	KM20	KM27	Nadzca'an	ZA
Mono Alluador	Black Howler Monkey	*Alouatta pigra*		1	1	1	1
Mono Araña	Spider Monkey	*Ateles geoffroyi*	1	1	1	1	1
Tigrillo	Ocelot	*Leopardus pardalis*	1	1	1	1	1
Venadito Rojo	Brockett Deer	*Mazama sp.*	1	1	1	1	1
Venado cola blanca	White-tailed Deer	*Odocoileus virginianus*	1	1	1	1	1
Tigre	Jaguar	*Panthera onca*	1	1	1	1	1
Pecarí de Collar	Collared Peccary	*Pecari tajacu*	1	1	1	1	1
Puma	Puma	*Puma concolor*	1	1	1	1	1
Leoncillo	Jaguarundi	*Puma yagouaroundi*	1		1	1	
Danta	Baird's Tapir	*Tapirus bairdii*	1	1	1	1	1
Pecarí de Labios Blancos	White-lipped Peccary	*Tayassu pecari*	1	1	1		1

Medium-sized Mammals

Spanish Common Name	English Common Name	Species	KM15	KM20	KM27	Nadzca'an	ZA
Tepezcuintle	Paca	*Cuniculus paca*	1	1	1	1	1
Agutí	Agouti	*Dasyprocta punctata*		1	1	1	1
Viejo de Monte	Tayra	*Eira barbara*			1		1
Tejon	Coati	*Nasua narica*	1	1		1	1
Zorro Gris	Grey Fox	*Urocyon cinereoargenteus*	1	1	1		1

Bats

Spanish Common Name	English Common Name	Species	KM15	KM20	KM27	Nadzca'an	ZA
Murciélago Frutero Jamaicana	Jamaican Fruit Bat	*Artibeus jamaicensis*	1	1	1	1	1
Murciélago Frutero Gigante	Great Fruit Bat	*Artibeus lituratus*	1	1		1	1
Murciélago Frutero Pigmeo	Pygmy Fruit Bat	*Artibeus phaeotis*	1	1		1	1
Murciélago Cola Corta Seba	Seba's Short-tailed Bat	*Carollia perspicillata*	1	1			1
Murciélago Cola Corta Sedosa	Sowell's Short-tailed Bat	*Carollia sowelli*	1	1	1		1
Murciélago Cara Arrugada	Wrinkle-faced Bat	*Centurio senex*		1		1	1
Murciélago Ojón Áspero	Hairy Big-eyed Bat	*Chiroderma villosum*		1			
Vampiro Común	Common Vampire Bat	*Desmodus rotundus*		1		1	1
Murciélago Pata Peludo	Hairy-legged Vampire Bat	*Diphylla ecaudata*		1			
Murciélago Lenguetón de Pallas	Common Long-tongued Bat	*Glossophaga soricina*	1	1	1	1	1
Murciélago	Black Mastiff Bat	*Molossus rufus*		1			1
Miotis Pata Peluda	Hairy-legged Myotis	*Myotis keaysi*		1			
Murciélago Lomo Pelón Menor	Davy's Naked-backed Bat	*Pteronotus davyi*		1			
Murciélago Bigotudo de Parnell	Common Mustached Bat	*Pteronotus parnellii*	1	1	1	1	1
Murciélago Amarilla Ala Negra	Central American Yellow Bat	*Rhogeessa tumida*		1			
Murciélago de Charrateras Menor	Little Yellow-shouldered Bat	*Sturnira lilium*		1	1		
Falso Vampiro Gigante	Great False Vampire Bat	*Vampyrum spectrum*		1			

Snakes

Spanish Common Name	English Common Name	Species	KM20	KM27	Nadzca'an	ZA
Cantil	Yucatan Cantil	*Agkistrodon bilineatus*	1		1	
Boa	Boa Constrictor	*Boa constrictor*	1		1	
Nauyaca	Fer-de-lance	*Bothrops asper*	1		1	
Culebra Rayada	Black-striped Snake	*Coniophanes imperialis*	1		1	
Culebra Rayada	Faded Black-striped Snake	*Coniophanes schmidti*	1		1	
Cascabel	Central American Rattlesnake	*Crotalus simus*	1		1	
Chupa Caracoles	Snail-eating Thirst Snake	*Dipsas brevifacies*	1			1
Ranera	Brown Racer	*Dryadophis melanolomus*			1	
Ranera	Speckled Racer	*Drymobius margaritiferus*	1		1	
Ratonera	Central American Rat Snake	*Elaphe flavirufa*	1			
Culebrita	Blotched Hook-nose Snake	*Ficimia publia*	1			
Bejuquillo	Blunt-headed Tree Snake	*Imantodes cenchoa*	1			
Bejuquillo	Yucatan Blunt-headed Snake	*Imantodes tenuissimus*	1			1
Culebra Nocturna	Cat-eyed Snake	*Leptodeira frenata*	1		1	
Ranera Verde	Green-headed Tree Snake	*Leptophis mexicanus*	1	1		
Ranera	Salmon-bellied Racer	*Mastigodryas melanolomus*	1			
Coralillo	Coral Snake	*Micrurus diastema*			1	
Coral Falso	Red Coffee Snake	*Ninia sebae*	1			1
Bejuquillo Parda	Brown Vine Snake	*Oxybelus aeneus*			1	
Ratonera	Yellow-red Rat Snake	*Pseudelaphe flavirufa*	1			
Ratonera	Puffing Snake	*Pseustes poecilonotus*	1			
Culebrito	Pygmy Snail Sucker	*Sibon sanniola*	1			
Voladora	Tropical Rat Snake	*Spilotes pullatus*		1		
Culebra	Banded Snail Sucker	*Tropidodipsas fasciata*			1	1
Culebra	Terrestrial Snail Sucker	*Tropidodipsas sartorii*	1		1	

Lizards

Spanish Common Name	English Common Name	Species	KM20	KM27	Nadzca'an	ZA
Lagartija Metálica	Barred Whiptail	*Amieva undulata*	1		1	1
Huico Yucateco	Yucatan Whiptail	*Aspidoscelis angusticeps*	1	1	1	
Toloque	Striped Basilisk	*Basiliscus vittatus*	1			
Geco Manchado	Yucatan banded gecko	*Coleonyx elegans*	1		1	1
Toloque	Helmeted Basilisk	*Corytophanes cristatus*	1	1		
Iguana Negra	Yucatan Spiney-Tailed Iguana	*Ctenosaura defensor*			1	1
Toloque Verde	Serrated Casquehead Iguana	*Laemanctus serratus*			1	
Lagartija	Schwart's Skink	*Mesoscincus schwartzei*	1			
Lagartija	Crested Anole	*Norops cristellatus*	1			
Lagartija Chipojo	Ghost Anole	*Norops lemurinus*	1	1	1	1
Lagartija Chipojo Liso	Yucatan Smooth Anole	*Norops rodriguezii*	1	1	1	
Lagartija Café	Brown Anole	*Norops sagrei*	1			
Lagartija de Abanico Azul	Silky Anole	*Norops seirceus*	1			
Lagartija	Greater Scaly Anole	*Norops tropidonotus*	1	1		
Lagartija	Sumichrast's Skink	*Plestiodon sumichrasti*	1			
Lajartija de Pintas Amarillas	Yellow-spotted Spiny Lizard	*Sceloporus chrysostictus*	1		1	1
Gequillo Collarejo	Dwarf Gecko	*Sphaerodactylus glaucus*	1			
Geco Patudo	Central American Smooth Gecko	*Thecadactylus rapicauda*	1			

Turtles and Crocodiles

Spanish Common Name	English Common Name	Species	KM20	KM27	Nadzca'an	ZA
Cocodrilo de Pantano	Morlete's Crocodile	*Crocodylus mareletii*		1		
Talmame	Narrow-bridged Musk Turtle	*Claudius angustatus*	1		1	1
Pochitoque	Creaser's Mud Turtle	*Kinosternon creaseri*	1		1	
Pochitoque	White-lipped Mud Turtle	*Kinosternon leucostomum*	1	1	1	1
Pochitoque	Scorpion Mud Turtle	*Kinosternon scorpioides*	1		1	
Mojina	Furrowed Wood Turtle	*Rhinoclemmys areolata*	1		1	
Jicotea	Meso-American Slider	*Trachemys venusta*	1	1		1

Amphibians

Spanish Common Name	English Common Name	Species	KM20	KM27	Nadzca'an	ZA
Salamandra de Yucatán	Yucatan Salamander	*Bolitoglossa rufescens*	1			
Salamanquesa	Rufescent Salamander	*Bolitoglossa yucatana*	1			
Ranita Amarillenta	Variegated Treefrog	*Dendropsophus ebraccata*	1			
Sapo Común	Gulf Coast Toad	*Incilus valliceps*	1		1	1
Ranita Arborícola	Yellow Treefrog	*Hyla microcephala*	1			
Ranita Pintada	Cricket Treefrog	*Hyla picta*	1			
Rana Ovejera	Sheep Frog	*Hypopachus variolosus*	1		1	
Ranita Labios Blancos	White-lipped Frog	*Leptodactylus fragilis*	1			
Rana Leoparda	Leopard Frog	*Lithobates berlandieri*	1			
Rana Verde	Valliant's Frog	*Lithobates vaillanti*	1			
Sapo Gigante	Cane Toad	*Rhinella marina*		1	1	1
Sapo Borracho	Mexican Burrowing Toad	*Rhinophrynus dorsalis*	1			
Ranita Arborícola	Stauffer's Treefrog	*Scinax staufferi*	1			
Rana Trepadora	Mexican Treefrog	*Smilisca baudinii*	1		1	
Ranita Arborícola	Loquacious Treefrog	*Tlalocohyla loquax*	1	1		
Ranita Arborícola	Veined Treefrog	*Trachycephalus venulosa*	1			
Rana de Casco Yucateca	Yucatan Casque-headed Treefrog	*Triprion petasatus*	1	1	1	

Non Passerine Birds

Spanish Common Name	English Common Name	Species	KM15	KM20	ND	ZA
Aguililla caminera	Roadside hawk	*Buteo magnirostris*	1	1		1
Carpintero lineado	Lineated woodpecker	*Dryocopus lineatus*	1	1	1	1
Carpintero frentidorado	Golden-fronted woodpecker	*Melanerpes aurifrons*			1	1
Carpintero atabacado	Smokey brown woodpecker	*Veniliornis fumigatus*		1		1
Carpintero piquiclaro	Pale-billed woodpecker	*Campephilus guatemalensis*	1	1	1	1
Chachalaca común	Plain chachalaca	*Ortalis vetula*	1	1	1	1
Colibrí vientre blanca	White-bellied emerald	*Amazilia candida*	1	1		
Colibrí yucateco	Buff-bellied hummingbird	*Amazilia yucatanensis*		1	1	1
Colibrí garganta rubí	Ruby-throated hummingbird	*Archilochus colubris*			1	
Colibrí colicuña	Wedge-tailed sabrewing	*Campylopterus curvipennis*	1	1	1	1
Cuco ardilla	Squirrel cuckoo	*Piaya cayana*			1	
Halcón murcielaguero	Bat falcon	*Falco rufigularis*		1		1
Halcón guaco	Laughing falcon	*Herpetotheres cachinnans*				1
Halcón collarejo	Collared forest falcon	*Micrasturs ruficollis*		1		
Hocofaisán	Great currasow	*Crax rubra*		1		1
Loro frentiblanco	White-fronted parrot	*Amazona albifrons*		1	1	1
Loro frentirojo	Red-lored parrot	*Amazona autumnalis*	1	1		1
Loro coroniblanco	White crowned parrot	*Pionus senilis*	1		1	1
Momoto cejiturquesa	Turquoise-browed motmot	*Eumomota superciliosa*		1	1	
Momoto coroniazul	Blue-crowned motmot	*Oncostoma cineiregulare*		1		1
Momoto enano	Tody motmot	*Hylomanes momotulo*	1			1
Paloma aliblanca	White-winged dove	*Zenaida asiatica*		1	1	
Paloma Caminera	White-tipped dove	*Leptotila verreauxi*	1		1	
Paloma piquirroja	Red-billed pigeon	*Columba flavirostris*	1	1	1	1
Paloma cabeciblanca	White-crowned pigeon	*Columba leucocephala*	1	1	1	1
Paloma escamosa	Scaled pigeon	*Columba speciosa*		1		1
Pava cojolita	Crested guan	*Penelope purpurascens*		1		1
Pavo de monte	Ocellated turkey	*Agriocharis ocellata*	1	1	1	1
Perico pechisucio	Olive-throated parakeet	*Aratinga nana*	1	1		1
Tecolotito rayado	Ferruginous pygmy owl	*Glaucidium brasilianum*		1		1
Tinamú canelo	Thicket tinamou	*Crypturellus cinnamomeus*	1	1	1	
Tórtola azul	Blue ground dove	*Claravis pretiosa*				
Trogón cabecinegro	Black-headed trogon	*Trogon melanocephalus*		1	1	1
Trogón violáceo	Violaceus trogon	*Trogon violaceus*	1	1	1	1
Tucancillo collarrejo	Collared aracari	*Pterglossus torquatus*	1	1	1	
Tucán pico canoa	Keeled-billed toucan	*Ramphastos sulfuratus*	1	1	1	1
Zopilote aura	Turkey vulture	*Cathartes aura*	1		1	1
Zopilote negro	Black vulture	*Coragyps atratus*		1		1

Passerine Birds

Spanish Common Name	English Common Name	Species	KM15	KM20	ND	ZA
Atila	Bright-rumped attila	*Attila spadiceus*				1
Atrapamoscas vientre-amarillo	Sulphur-bellied flycatcher	*Myiodynastes luteiventris*		1	1	1
Atrapamoscas gregario	Social flycatcher	*Myiozetetes similis*	1	1	1	
Atrapamoscas real	Royal flycatcher	*Onychorhynchus coronatus*		1	1	
Bolsero capecanegro	Black-cowled oriole	*Icterus dominicensis*		1	1	1
Bolsero yucateco	Orange oriole	*Icterus auratas*	1		1	1
Bolsero campero	Altamira oriole	*Icterus gularis*		1	1	
Capita negra	Lesser goldfinch	*Carduelis psaltria*		1		1
Chara café	Brown jay	*Cyanocorax morio*	1	1	1	1
Chara verde	Green jay	*Cyanocorax yncas*	1	1	1	1
Chara yucateca	Yucatan jay	*Cyanocorax yucatanicus*	1	1	1	1
Chipe amarillo	Yellow warbler	*Dendroica petechia*		1	1	
Chivrín cejas blancas	White-browed wren	*Thryothorus albinucha*		1	1	
Chivrín de Carolina	Carolina wren	*Thryothorus ludovicianus*		1		1
Chivrín pecho manchado	Spot-breasted wren	*Thryothorus maculipectus*	1	1	1	
Chivrín pecho blanco	White-breasted wood wren	*Henichorhina leucosticta*	1	1		
Chivrín vientre blanco	White-bellied wren	*Uropsila leucogatsra*		1	1	
Colorín Azulnegro	Blue bunting	*Cyanocompsa parellina*		1	1	
Eufonia gargantinegra	Yellow-throated euphonia	*Euphonia hirundinacea*				
Gorrión dorsiverde	Green-backed sparrow	*Arremonops chloronotus*	1	1	1	1
Granatelo yucateco	Grey-throated chat	*Granatellus sallaei*			1	
Maullador gris	Grey catbird	*Dumetella carolinensis*		1		
Mosquero pico chato	Stub-tailed spadebill	*Platyrinchus cancrominus*	1	1		
Mosquero pico curvo	Northern bentbil	*Oncostoma cinereigulare*	1		1	
Oropéndola Moctezuma	Montezuma orpendola	*Psarocolius montezuma*		1	1	1
Perlita azulgris	Blue-grey knatcatcher	*Polioptila caerulea*	1		1	
Piquiplano de anteojos	Eye-ringed flatbill	*Rhynchocyclus brevirostris*		1	1	
Saltator cabecingro	Black-headed saltator	*Saltator atriceps*		1	1	1
Semilero oliváceo	Yellow-faced grassquit	*Tiaris olivaceus*		1	1	
Tangara cabecigris	Grey-headed tanager	*Eucometis penicilata*	1		1	
Tangara-hormiguera gorjiroja	Red-throated ant tanager	*Habia fusicauda*		1	1	1
Tangara-hormiguera coroniroja	Red-crowned ant tanager	*Habia rubica*		1	1	
Titira enmascarada	Masked tityra	*Tityra semisfaciata*		1		1
Tordo cantor	Melodius blackbird	*Dives dives*	1	1	1	1
Trepatroncos alileonado	Tawny-winged woodcreeper	*Dendrocincla anabatina*	1	1	1	
Trepatroncos rojizo	Ruddy woodcreeper	*Dendrocincla homochroa*		1	1	
Trepatroncos barrado	Amazonian barred woodcreeper	*Dendrocolaptes certhia*	1	1		1
Trepatroncos barrado	Northern barred woodcreeper	*Dendrocolaptes sanctithomae*		1	1	
Trepatroncos oliváceo	Olivaceous woodcreeper	*Sittasomus griseicapillus*	1	1		1
Trepatroncos piquiclaro	Ivory-billed woodcreeper	*Xiphorhynchus flavigaster*		1	1	1
Verdillo leonado	Tawny-crowned greenlet	*Hylophilus ochraceiceps*		1		
Vireo ojo blanco	White-eyed vireo	*Vireo griseus*		1	1	
Vireo ojo rojo	Red-eyed vireo	*Vireo olivaceus*		1	1	
Vireo manglero	Mangrove vireo	*Vireo pallens*	1		1	
Vireón ceja rufa	Rufous-browed peppershrike	*Cyclarhis gujanensis*		1	1	1