Preliminary Report on the Scientific and Biodiversity Value of the Macal and Raspaculo Catchment, Belize: A Wildlife Impact Assessment for the proposed Macal River Upper Storage Facility

Following the lodging last week in Belmopan of the five-volume Environmental Impact Assessment for the MRUSF, which includes NHM's Wildlife Impact Assessment (WIA), The Natural History Museum is now permitted by the terms of its contract with AMEC to make freely available the WIA to all third parties explicitly requesting the document (see Article 6f).

We do not at present propose to enter into discussions with third parties on the content of either the WIA (which we view as a preliminary report pending further research) nor the broader EIA, believing that we have now fulfilled our primary obligation of summarising the existing information on wildlife in the catchment.

NHM believes that this report constitutes the best body of data currently available on the wildlife of the area. In line with NHM's existing research objectives, Las Cuevas Research Station staff and their collaborators have energetically gathered substantial amounts of relevant data subsequent to the completion of the contracted WIA data gathering exercise and the submission to AMEC of the WIA on May 24th 2001. A further document detailing this additional information will be made available within a month to any parties requesting this information.

Nonetheless, it is our considered opinion is that even this expanded body of data is insufficient on which to base a sound decision regarding the possible construction of the MRUSF. We will of course continue our efforts to add to current knowledge of the Belize flora and fauna.

Prof. Richard M Bateman
Head, Department of Botany
Natural History Museum
London

05.09.01

Please note - The contents of this PDF file are identical to those of the original hard copy, except that the pagination has increased by one page as a result of including this cover letter

Preliminary Report on the Scientific and Biodiversity Value of the Macal and Raspaculo Catchment, Belize:

A Wildlife Impact Assessment for the proposed

Macal River Upper Storage Facility

Author: **Mr C D Minty BA MSc FRGS**

Contributing Editors: **Dr D A Sutton MA MSc PhD FLS**
Lt. Col A D F Rogers MA FRGS
Prof R M Bateman PhD DSc FLS
Mr M Penn MSc
Mr P J Stafford
Ms L M Sanders BA

Date: 24th May 2001

THE NATURAL HISTORY MUSEUM
CROMWELL ROAD
SOUTH KENSINGTON
LONDON, ENGLAND SW7 5BD
Tel: +44 (0) 20 7942 5282
Fax: +44 (0) 20 7942 5501
email: cuevas@btl.net

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Abbreviations and Acronyms

amsl above mean sea level

CITES	Convention on International Trade in Endangered Species
IUCN	World Conservation Union (International Union for the Conservation of Nature)
MRUSF	Macal River Upper Storage Facility
sp.	Species; this abbreviation is used with a genus name lacking a species name to indicate an organism whose genus, but not species, is known.
spp.	This abbreviation indicates a genus with more than one unnamed species.

EXECUTIVE SUMMARY

This report summarises the results of a wildlife impact assessment on the proposed Macal River Upper Storage Facility (MRUSF), Belize, Central America. The assessment was undertaken by The Natural History Museum (NHM), London, UK and focused on the Macal and Raspaculo Rivers watershed. A desk-based assessment and field monitoring survey was undertaken between 1 January 2001 and 1 April 2001. This was designed to identify and evaluate populations, feeding patterns and habitat ranges of a very small number of specific indicator species, in order to assess the likely impact on wildlife of the development, and to propose appropriate mitigation measures.

As the time available for these studies was inadequate for a comprehensive and thorough field assessment, additional data from previous NHM work in the area were included. However, our understanding of the area is still undesirably data-deficient. It is temporally constrained, by having been conducted only in the dry season, and geographically constrained by having focused on the immediate area proposed for inundation. Also, any attempts to use the Mollejon Dam as an extant yardstick are hampered by its much smaller scale and the absence of pre-dam wildlife inventories.

Ecological Status and Importance of the Macal/Raspaculo Watershed

This study confirms that the area contains a rare and discrete floral floodplain habitat, classified as “riparian shrubland in hills” (Meerman 1999), which acts as both a conduit and critical habitat for resident and non-resident fauna and avifauna. The maintenance of this exceptional habitat relies on the flow of oxygenated water and severe but temporary seasonal flooding of the river system following intense rain. This habitat, which does not occur elsewhere in Belize, will suffer approximately 80% permanent inundation if the project proceeds as planned, a figure now supported by interpretation of satellite images (Penn & Sutton in press).

Based on the data collected on this survey and data accumulated over a ten year period by The Natural History Museum (Rogers & Sutton 1991, 1993, 1995, 1997, 2000), we conclude that:

- the remoteness and strongly seasonal hydrodynamics of the Macal and Raspaculo watershed make it one of the most biologically rich and diverse regions remaining in Central America.

- a seasonal shortage of food in the region for both herbivores and carnivores means the relatively rich floodplain habitat becomes a critical seasonal food source for many species during the dry season. It is also a key staging post for many bird species migrating to and from North America.

- we confirm that the watershed provides an important habitat for many endangered vertebrate species of international value, including:

  Cites Appendix I
  Jaguar (*Panthera onca goldmani)*, rare in Belize, IUCN status vulnerable,
  Ocelot (*Leopardus pardalis pardalis*), rare in Belize, IUCN status vulnerable,
  Margay (*Leopardus wiedii yucatanica*) rare in Belize, IUCN status vulnerable,
  Neotropical Otter (*Lutra longicaudus annectens*), rare in Belize, IUCN status vulnerable,
  Baird’s Tapir (*Tapirus bairdii*), rare in Belize, IUCN status vulnerable,
  Morelet’s Crocodile (*Crocodylus moreletii*), rare in Belize, IUCN status endangered,

the recently-described Central American Scarlet Macaw (*Ara macao cyanoptera*), rare in Belize, IUCN status vulnerable.

Cites Appendix II
Puma *(Puma concolor mayensis)*, rare in Belize, IUCN status threatened, extinct over much of range,
Black Howler Monkey (*Alouatta pigra pigra*), rare in Belize, IUCN status threatened,
Spider Monkey (*Ateles geoffroyi*), rare in Belize, IUCN status vulnerable,
White-lipped Peccary (*Tayassu pecari ringens*), rare in Belize, IUCN status threatened,
Collared Peccary (*Tayassu tajacu*), rare in Belize, IUCN status threatened.

Other nationally, regionally or globally significant species
Solitary Eagle (*Harpyhaliaetus solitarius*), Ornate Hawk-eagle (*Spizaetus ornatus vicarius*), Ocellated Turkey (*Agriocharis ocellata*), Crested Guan (*Penelope purpurascens*), Great Curassow (*Crax rubra*), Brown-hooded Parrot (*Pionopsitta haematotis*), Keel-billed Motmot (*Electron carinatum*), and the Belizean endemic Julian's Mountain Frog (*Rana juliani*).

We further conclude that:

- the riparian shrubland is a critical habitat for *Tapirus bairdii* during the dry season, due to the ample herbaceous vegetation found in the floodplain habitat.

- the large population of Morelet's Crocodile (*Crocodylus moreletii*) in the watershed is richer in juveniles than are other populations in Belize, suggesting that this is an important breeding area for this species. More mature individuals probably migrate outwards from these breeding sites.

- the entire profile of the floodplain habitat of both the Upper Macal and Raspaculo Rivers is considered crucial to the continued sustenance and population viability of a unique Scarlet Macaw subspecies (*Ara macao cyanoptera*), providing one of the last remaining habitats for an isolated population of an estimated 60-100 individual birds.

Significant Predicted Impacts

Based on the results from primary and secondary data sources, we predict that the resulting static water body and profound alteration to the highly seasonal river flow regime from the proposed development will negatively impact wildlife by the:

- the immediate loss of 70-80% of critical habitat (riparian shrubland) for local populations of Baird's Tapir and the Scarlet Macaw during the **dry season**.

- similarly a loss of 20-22% of critical habitat for Baird's Tapir, Morelet's Crocodile and Scarlet Macaw during the **wet season**.

- more critically, loss of ca. 80% of the unique riparian shrubland habitat in Belize; also the loss of 22.5 km (ca. 75%) of riverine habitat on the Macal and loss of 18 km of riverine habitat on the Raspaculo.

- imposition of a dispersal barrier that will seriously curtail national and regional links among populations, fragmenting the remaining habitat and thereby reducing genetic exchange.
- radical changes in the ecological function of the river ecosystem by modifying water quality and flow patterns downstream and replacing a dynamic, rapidly fluctuating, highly oxygenated water body with a larger and near-static water body.
- alteration of turbidity and sedimentation levels to which downstream species and ecosystems are adapted.
- effects of road construction, human settlement and expansion associated with the dam and reservoir, which will have a significant negative overall impact on wildlife populations throughout the region.

For these reasons the project is likely to cause:

- significant and irreversible reduction of biological diversity in Belize, initially at the population level but later potentially at the species level, some of the species affected being of international importance.
- fragmentation of the proposed Mesoamerican Biological Corridor.
- rapid reduction in the already endangered population of the Scarlet Macaw subspecies (*Ara macao cyanoptera*), leading to population inviability and probable eventual extirpation from Belize.
- reduction in the numbers of migratory birds from the United States and Canada over-wintering in the area or feeding temporarily en route to South America.
- reduction in nutrients and essential biological debris materials that facilitate the productivity of downstream ecosystems.
- negative impacts on biodiversity and ecological interactions extending well beyond the dam and its impoundment.
- serious negative (and probably long-term) accumulative impacts from illegal hunting and settlers as a result of increased access to the area caused by improved roads and more navigable waterways.

Mitigation Options

From a purely wildlife conservation perspective, three options (summarised below) are presented in the Section 4 of this report:

1. "No Build" – The natural riparian habitat will remain biologically rich and ecologically functional.
2. "Alternative Site" – Several tributaries in the Mountain Pine Ridge have been identified that, if dammed, could potentially supply the required volume of water to the existing dam

at Mollejon**,** reducing the impact otherwise caused by inundation of the floodplain habitat and associated wildlife.

3. “Proceed as Planned” – It will not be possible to mitigate against the long-term impacts on the biodiversity of the catchment, particularly those associated with habitat loss, if the dam is constructed as planned. Equally, it will not be possible to mitigate against the impacts at a broader regional level. However, if this option is chosen, identified measures to partially ameliorate some of the short-term local impacts should follow standard, environmentally sensitive guidelines for dam construction and operation. Implementation would in practice require that these commitments be made legally binding.

Areas for Further Study

We are confident that this three-month preliminary survey and resulting report satisfactorily addresses the Terms of Reference as delineated in Schedule “A” of the contract between AMEC and NHM (April 2001), and is sufficient to establish the likelihood of the impacts identified. However, in order to detail more closely the magnitude of the identified impacts, and to assess other affects on wildlife, it would be necessary:

- to conduct further studies earlier in the wet season and later in the dry season, to determine the full year-round dispersal pattern and population sizes for at least the three target species, and to extend the geographical coverage of those studies.

- to extend the study to account for other species and communities of flora and fauna that will also be impacted by this project, and to confirm the presence or absence of other important wildlife species previously reported in the Upper Macal River (e.g. Harpy Eagle, *Harpia harpyja*).

- further multi-year studies, including investigations of seasonal movements between different geographical areas over the total range of the Selva Maya population of Scarlet Macaw (*Ara macao cyanoptera*), will be necessary to understand the long-term population fluctuations of the Scarlet Macaw throughout its range.

We strongly recommend that, if either the "Proceed as Planned" or "Alternative Site" options are still considered viable, a far more thorough and long-term integrated study of all potential sites for both options is pursued. Much more information is required for an informed and defensible decision.

1. INTRODUCTION

1.1 OBJECTIVES

The aims of this study were to conduct a survey sufficiently detailed to determine the impacts of the proposed Macal River Upper Storage Facility (MRUSF) on certain indicator species of wildlife and to produce a mitigation strategy appropriate to the nature of these impacts. This report constitutes a support document to the main Environmental Impact Assessment, where more elaborate descriptions of the physical, social and economic aspects of the project can be found (Agra CI Power/BEL 1999).

The aim of this assessment has been attained through the completion of both desk and field studies that document existing wildlife conditions in the area.

In particular:

- obtain site-specific data on the three selected indicator species:
    1. Baird's Tapir
    2. Morelet's Crocodile
    3. Scarlet Macaw
- document the presence of other regionally or nationally significant vertebrate species.
- document other vertebrate fauna and relative densities present in the study area (emphasizing the floodplain vegetation).
- overview insofar as possible the effect of the existing Mollejon Dam upon the three target species.
- predict the impacts that the proposed Chalillo Dam will have on populations of the three target species.
- predict impacts that the proposed Chalillo Dam will have on other associated wildlife.
- identify any feasible mitigation measures for the conservation of the three target species.

1.2 GENERAL HABITAT

The remoteness of the Macal and Raspaculo river valleys preserves one of the most biologically diverse regions in the Selva Maya. Habitat fragmentation and human disturbance in other regions of Central America has made the area an important refuge for many endangered species. In particular, because the study area contains unique riparian floodplain vegetation classified as "Riparian Shrubland in Hills" (Meerman 1999a), this area provides critical habitat for a number of endangered species.

Although surrounding areas have also been assessed, this river habitat has been the primary focus for this survey, as much of the area will be permanently inundated if the project proceeds. As seasonal flooding heavily influences the valley, including both annual floods and stochastic events such as that recorded in 1990 (Rogers & Sutton 1991), analytical emphasis has focused on the importance of the river's seasonality with regard to wildlife. The results of this and earlier surveys have allowed a fascinating picture of this habitat to emerge.

Upon first glance, the vegetation appears to be a disorganised clutter of thick herbaceous undergrowth and lianas. A recent vegetation survey (Penn & Sutton in press) shows that this habitat is localized to the upper reaches of the Macal and Raspaculo river systems. It does not extend below the rapids at Chalillo, and only isolated pockets reach as far upriver as Cushta-Bani (MS7) on the Raspaculo or beyond Kinlock Camp (MS5) on the Macal.

Meerman (1999a) calculated that the proposed dam would flood about 200 ha of riparian thicket vegetation along the Macal and Raspaculo rivers. Penn & Sutton (in press) have used satellite images to map the distribution of this vegetation class across the Maya Mountains, and conclude that the dam would permanently flood approximately 80% of the total area of the riparian shrubland in Belize.

Typical components of this vegetation are small trees and shrubs with wiry stems, such as *Inga vera*, which flank the riverbanks and are able to bend and withstand both the force of the river and debris carried by the extreme flow, especially in seasonal floods. A few large trees survive in this zone, most characterised by broad, spreading root systems and large buttresses, such as *Ficus ovalis*. Many of the most visible plant species in this zone are herbaceous and characterised by large or extensive underground storage organs such as rhizomes or stolons. Typical are large grasses, such as species of *Tripsacum,* together with Asteraceae, *Heliconia*, Araceae and Marantaceae.

When the river floods the above-ground elements are stripped away but the dense root mat prevents the underlying deep soils from being washed away. This growth pattern allows sediments from less extreme flooding to accrete and probably accounts for the deep organic soils found in this zone. Once the flood has receded, the plants sprout from subterranean growing points in a matter of days and grow rapidly, given effectively unlimited resources of nutrient-rich soil and a continuous water supply.

Several lines of evidence indicate that this is an important and unique habitat in Belize (Penn & Sutton in press). The forests of the Chiquibul differ from the stereotypical view of tropical forests in other parts of the world, because Belize lies on the northern edge of the tropics and, while both the Macal and Raspaculo valleys have a relatively high overall rainfall of at least 2500 mm, much of this falls in 8 months of the year. The remaining months can be extremely dry for the tropics; in some years little rain is recorded during the dry season. The net effect is that much of the biological activity, both for plants and animals, is focussed on the riparian margin of the river valley during the dry season.

Many tree species in the Chiquibul are semi-deciduous, and in an exceptionally dry year they lose all of their leaves. Both flowering and fruiting behaviour are frequently correlated with this pronounced seasonality, so that seeds and seedlings are not exposed to the desiccating effects of the drought. Throughout the year, therefore, the behaviour, feeding patterns and spatial distribution of animals, from insects to birds and mammals, is inextricably linked to the functioning of the vegetation.

The riverine habitat is also exceptional in this area as the preponderance of herbaceous plants results in an abundance of food at ground level. It is unusual in a tropical forest where much of the palatable leaves, flowers and fruit are in the canopy and only available to arboreal species. The riverine habitat is therefore critical in the dry season for animals that feed on ground level vegetation such as Baird's Tapir *(Tapirus bairdii*) and Peccaries (*Tayassu* sp.), and for those species that prey on the same herbivores such as Jaguar *(Panthera onca*). Although tree-fall gaps in the forest will also have short-lived patches of herbaceous vegetation, the fact that these are on dry, shallow, infertile soils provides very different nutritional value. Observations on Baird’s Tapir during this and other studies (Matola 1991) demonstrated that the majority of food intake consisted of a grass species which was only recorded in the riverine habitat and on the larger parts of the first-order tributaries. Fragoso (1983) recorded that the majority of the food plants for the tapirs came from this flood-plain vegetation. Brocket Deer and other small herbivores were also recorded, and the relative abundance of the larger cat species observed on the various surveys (Rogers & Sutton 1991-2000) suggests that the populations of all of these species depend heavily on the riverine shrubland habitat during the dry season.

Perhaps the most conspicuous of the resident bird populations is the Scarlet Macaw (*Ara macao cyanoptera*). The concentration of sightings at various locations along the Macal and Raspaculo rivers throughout the survey probably reflects the availability of food during the dry season until the end of May, when post-breeding flocking takes place. A much broader range of migrant birds is also heavily dependent on the riverine habitat, which is a core feeding and breeding area. Mallory (1991) carried out a range of sampling techniques, including fixed-point visual and audible recording, with a number of mist net sampling points along a transect from the upper northern edge of the valley to the river. The distribution of species was not random; rather, most of the migrant bird species were confined to the riverine vegetation.

In summary, it is critical to note that Belize sits in the important Central American corridor for birds migrating between North America and South America, and as a nation, Belize is particularly strategic as it has some of the most intact forests left in the whole of Central America. The Chiquibul Forest is regionally part of the Selva Maya, the largest surviving remnant of tropical forest in all Central America. Mallory’s observations show that the nutritionally rich riverine habitat has a much higher value for these migrant birds than the closed canopy covering much of the rest of the Chiquibul Forest; it is particularly valuable to birds that are summer visitors to the United States and Canada but over-winter in South America.

2. METHODS

2.1 GENERAL APPROACH

The Chalillo Dam would be constructed on the Macal River Valley, approximately 5 km upstream from Guacamallo Bridge. The reservoir would flood up to an elevation of 400 m above mean sea level, extending upstream for approximately 20 km almost to Kinloch's Camp on the Macal River, and to Chapayal on the Raspaculo River (see Figure 1). The study area includes:

- the proposed reservoir and surrounding lands (to 420 m a.m.s.l.)
- the Macal River between Devils Drive (MS1) and Mollejon Dam (MS15)
- the Raspaculo River between Cushta-Bani (MS7) and Macal Junction (MSD)
- the Monkey Tail River between Monkey Tail (MSK) and Chapayal (MSL)

together with a few relevant locations in the Chiquibul Forest Reserve and National Park.

Previous researchers working in the Selva Maya (Wilson et al. 1996; Miller & Miller 1999; Meerman 1999) have established an effective standard for this type of wildlife survey, and there exists extensive literature on ecological and wildlife monitoring (e.g. Spellerberg 1993; New 1998). This study follows the ethos, principles and standards of these methodologies and protocols, though additional modifications are incorporated where necessary. Nevertheless, the methods employed remained as simple as possible to ensure the capacity to replicate. In an attempt to make the study comparable to other studies in the region, recording of all species has been conducted in accordance with Biological Monitoring in the Selva Maya (Miller & Miller 1999).

Wildlife was considered at three levels:

- species
- habitat and landscape
- ecological function

and status confirmed using IUCN Threatened Species List (2000), the world's most comprehensive inventory of plants and animals that uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies.

During our assessment, we increasingly recognised that the concept of critical habitat is fluid, changing profoundly during the annual climatic cycle. In general, critical habitat of keystone species greatly contrasts during the dry season, placing far greater emphasis on the rich riparian shrubland habitat in the Macal/Raspaculo catchment.

2.2 PHASE 1: DESK-BASED ASSESSMENT

Belize is a signatory to the Environmental Protection Act (1992), Environmental Impact Assessment Regulations (1995), the Wildlife Protection Act (1981), the Forest Act (1973), the National Park Systems Act (1981) and CITES Appendix I & II, IUCN Red List of Threatened Species and International Conventions related to wildlife. These were therefore consulted to determine the presence and extent of any existing protective status of species within the proposed development area.

An examination of Directorate of Overseas Survey 1:50,000 map coverage of Belize was made, together with other readily available earlier cartographic sources held by the Map Library of the Royal Geographic Society (London) and the National Aerial Photographic Library of Scotland. Vertical and oblique aerial photographs in the collection of The Natural History Museum and the Department of Geography, University of Edinburgh were also examined.

The excellent on-line database consisting of a list of species and locations present in Belize (Belize Biodiversity Information System) was reviewed to assess all previous sightings of indicator species within the area. Finally, an extensive literature review of all relevant references, in particular the JSSEUR reports and all previous impact and feasibility studies related to Mollejon and Chalillo, was conducted. Mollejon proved to be an unsatisfactory case-study for comparison with Chalillo, due to its small scale and the paucity of data on wildlife present prior to construction of the Mollejon Dam.

2.3 PHASE 2: FIELD SURVEY

Thirty two monitoring stations, all set more than 3 km apart, were established (Table 1) at various locations on both rivers and at strategic locations in the remainder of the Chiquibul Forest (Figure 1a). The wildlife survey began in early January 2001 and continued until 15 April 2001, inclusive; thus, data accumulated relate only to the dry season. Survey methods consisted of regular monitoring (nocturnal and diurnal) at these sites, combined with walking transects perpendicular to the flow of the river and through several monitoring sites on both sides of the river for at least 500 m. Canoe-based surveys (nocturnal and diurnal) were also carried out between river based monitoring stations.

In all cases two or more observers were present. Species were recorded mostly by chance observations or evidential signs (i.e. tracks, trails, scats, scrapes, food remnants, smells, sounds), location (habitat), time of day. Any other relevant information, such as number, size, age and sex if possible, was also recorded.

Diurnal walking surveys were conducted between 05.30 and 09.00 hrs, nocturnal between 19.00 and 23.00 hrs, and static monitoring and canoe surveys between 06.00 and 17.00 hrs, each with minimal noise and disturbance. Bright headlamps were used for nocturnal surveys to facilitate "eye shine" observations from mammals. One lamp was covered with a red filter with a 4 mm diameter hole to avoid startling animals; the other was used without modification for difficult identifications. Positive identifications were not always possible; therefore a "*not confirmed*" sighting was recorded.

Table 1 shows the location as recorded by Global Positioning System (Garmin 12XL), along with the zones referring to groups of different sites. Monitoring stations suffixed with a number (e.g. MS1) are outside the area of impoundment and those suffixed with a letter (e.g. MSA) are inside.

Additional specialist reports on aquatic microinvertebrate communities and organisms constituting health hazards to humans are provided in Annex's B and C, respectively.

Table 1: Monitoring Site Names and UTM Grid Locations

Site ID	Name	GPS Reading 16Q	UTM
		Zone 1	
MS1	Devils Drive	0202793	1870893
MS2	Big Bend	0201843	1870421
MS3	Straight Stretch	0201762	1869213
MS4	Otter Camp	0200213	1868421
MS5	Kinlock Camp	0299894	1867578
MS6	BB Top	0200131	1865941
		Zone 2	
MS7	Cushta-Bani	0208639	1859801
MS8	Flood Plain	0206701	1857793
MS9	Junction End	0204802	1855999
MS10	U Bend Camp	0202341	1855604
MS11	Fallen Tree	0297030	1855001
		Zone 3	
MSA	BB End	0298421	1865246
MSB	Francelia	0296753	1864394
MSC	Deep Pool	0295865	1864074
MSD	Ras/Mac Junction	0292906	1863431
MSE	Fig Stone	0291674	1864628
MSF	Tapir Bend	0288854	1865507
MSG	Macal Tree	0287031	1864334
MSH	Croc Pool 1	0285737	1864123
MSI	Croc Pool 2	0285573	1864605
MSJ	Chalillo	0285508	1865058
		Zone 4	
MSM	Floating Log	0295201	1855894
MSN	Hot Pepper	0293788	1857698
MSO	White Rock	0293776	1859207
MSP	Blue Post	0293172	1860920
MSQ	Bromeliad Tree	0292469	1861666
		Zone 5	
MS12	LC Bird Tower	0287444	1850559
MS13	New Maria Camp	TBA	TBA
MS14	Smokey Branch	TBA	TBA
MS15	Mollejon	TBA	TBA
MS16	Monkey Tail	0293810	1851839
MS17	Chapayal	0297030	1855304

Monitoring stations were selected based on potential of wildlife observations and ability for observers to remain comfortable but undetected. Monitoring sites were grouped into one of five zones relating to position either inside or outside the area of impoundment. Zone 1 is the group upstream of the potential reservoir on the Macal and Zone 2 is a group upstream on the Raspaculo, Zone 3 is the predicted area of impoundment on the Macal and Zone 4 is the same on the Raspaculo. Zone 5 refers to all other monitoring stations outside the potential reservoir area.

3. SPECIES SURVEYS

3.1 GENERAL INTRODUCTION

This section presents the results of the wildlife survey and summarises findings of past NHM studies in the watershed area. Results are first presented in tabular form for mammals, reptiles/amphibians and avifauna, followed by detailed discussion on the three indicator species. A separate support document in the main Environmental Impact Assessment (AMEC/BEL 2001) offers further descriptions of indicator species based on an extensive literature review.

Belize's position on the Central American "land bridge" and the endemism reflecting the geological history of the area since the Cretaceous period have left the country with a diverse and interesting fauna (e.g. the Belizean avifauna numbers in excess of 530 species). Furthermore, due to comparative lack of population pressure, the country retains relatively large numbers of threatened and endangered species. Many species of international importance, vanishing elsewhere, have one of their last strongholds in Belize. The existence of undisturbed areas such as the Upper Macal and Raspaculo Rivers has played a key role in maintaining healthy populations of these increasingly rare birds and animals, many of which cannot survive even limited disturbance.

The present survey was conducted with the aim of recording numbers of mammal species present, placing particular emphasis on the distribution and ecology of Belize's National Animal, Baird's Tapir.

Table 2: Summary of Mammal Observations During Present Survey

	Number of Individual Recordings																			
	Macal River				Raspaculo River				Macal & Raspaculo Impoundment Area								Chiquibul Forest			
Species	Zone 1				Zone 2				Zone 3				Zone 4				Zone 5			
	V	A	T	S	V	A	T	S	V	A	T	S	V	A	T	S	V	A	T	S
Primates																				
Black H. Monkey										1				2		1	1	*		
Spider Monkey													1				1			
Carnivora																	1			
Jaguar									1		2	2	1		1	1			2	1
Kinkajou	1																1			
Margay			1						1											
Neotropical Otter					4		1	2	1	1		*	3			*	2	1		*
Ocelot			1								1	1			2		4		2	
Puma					1					1	1			2				2	1	
White-nosed Coati									1				1							
Perissodactyla																				
Baird's Tapir	4	2	+	+	5	1	+	+	18	3	+	+	3		2	*	2		+	
Ariodactyla																				
Collared Peccary		+															3		+	
Red B. Deer	1										2						2			
W. Lipped Peccary	2						+	+		1										
White-Tailed Deer			2										1	+			3			
Rodentia																				
C. American Agouti																			3	
Paca			3				7								3				+	
Edentata																				
Nine-B. Armadillo							1						1		1					
Lagomorpha																				
Forest Rabbit			2																	
Marsupialia																				
Four-Eyed Opossum							1						1							

Key:

V	Visual
A	Audible
T	Tracks/Trails
S	Scats/Markings
*	greater than 5
+	greater than 10

3.2 BAIRD'S TAPIR

3.2.1 Introduction

Baird's Tapir (*Tapirus bairdii*) is the largest terrestrial mammal in the Neotropics. As a perissodactyl, it is related to Old World horses and rhinoceros and comes from the Tapiridae family that has existed in Central America for some 70-100 million years.

Tapir are characterised by a long elongated upper lip (proboscis) and have a short hairless tail. When fully-grown they can weigh between 150 and 300 kg and reach lengths of about 2 m. Because of hunting pressure and loss of habitat the species is listed on CITES Appendix 1 and classified as (VU) Vulnerable by IUCN (2000). In 1997, IUCN established a specialist group with the aim of producing a conservation action plan and to coordinate efforts to conserve its diminishing habitat. Under the Wildlife Protection Act (1981) it has legally protected status in Belize, however the animal is still hunted as meat by locals and increasingly by Asian immigrants (Matola pers. comm.).

A further support document by Kamstra (2001) in the main Environmental Impact Assessment (AMEC/BEL 2001) offers further descriptions of the species based on an extensive literature review.

3.2.2 Observations

Table 3 summarises the number of observations of Tapir throughout the study site, and Figure 3 shows the extent of its habitat. During the survey, *T. bairdii* were visually observed on 32 separate occasions. Approximately 57% of all sightings occurred within the impoundment area, principally between MSD and MSF. Approximately 76% of all observations were from riparian shrubland whilst grazing on shrubs and herbaceous plants. Remaining observations were of lone tapir either swimming across the river, wading through or exiting the water at the riverbank. One observation was of a female and her young at MSA and a further prolonged observation was of what appeared to be an old male grazing between MSN and MSO. Over 130 individual tracks or trails were counted either on the riverbanks, in the floodplain habitat or on sand bars (we stopped counting at 130). Scats were found throughout the Macal River Valley, most close to or on the river's edge. Baird's Tapir is a largely nocturnal animal, though the majority of direct observations occurred during daylight hours.

Table 3: Observations of Baird's Tapirs

Site ID	Name	Visual	Tracks	Scats	Sounds
	Zone 1				
MS1	Devils Drive	1	+		nocturnal
MS2	Big Bend				
MS3	Straight Stretch	1			
MS4	Otter Camp				
MS5	Kinlock Camp				
MS6	BB Top	2	+	+	nocturnal
	Zone 2				
MS7	Cushta-Bani	2	+	*	
MS8	Flood Plain	1	*	*	
MS9	Junction End	1	*		
MS10	U Bend Camp				
MS11	Fallen Tree	1	*		
	Zone 3				
MSA	BB End	1	*	*	
MSB	Francelia	1	*	*	
MSC	Deep Pool	2	+		
MSD	Ras/Mac Junction	6	+	+	diurnl/nocturnal
MSE	Fig Stone	2	*		
MSF	Tapir Bend	5	*		
MSG	Macal Tree	1	+		nocturnal
MSH	Croc Pool 1				
MSI	Croc Pool 2				
MSJ	Chalillo				
	Zone 4				
MSM	Floating Log				
MSN	Hot Pepper	1	+		
MSO	White Rock				
MSP	Blue Post	1			
MSQ	Bromeliad Tree		+		
	Zone 5				
MS12	LC Bird Tower				
MS13	New Maria Camp				
MS14	Smokey Branch	1			
MS15	Mollejon Reservoir	1	+		
MS16	Monkey Tail	2	+		
MS17	Chapayal		+		

* - less than 10
\+ - greater than 10

3.2.3 Food Sources

Emmons (1990) suggested that Tapirs spend about 90% of their time eating and foraging on a variety of plants, including leaves of woody shrubs, saplings, herbs and some aquatic plants, as well as fruits. From our observations the early successional grasses and shrubs found on the flatter areas of the riparian habitat appear to be the preferred food during the dry season. This type of food source is thought to provide significant benefits to grazers as the newer vegetation has a greater nutritional value and fewer secondary toxic compounds than plants in mature habitats (Freeland and Janzen 1974).

We confirm, from a very rudimentary assessment of the numerous faeces found through-out the upper Macal and Raspaculo Rivers, that the local Tapir diet consists of fibrous grass-like material. Tapir spoor was found mostly on the edge of, or in, the water, most likely providing a significant contribution to the food webs of many aquatic species.

The density of new trails seems most evident at the confluence of the two rivers where the riparian shrubland provides a lush food source. Vegetation was noted as being trampled down or crushed in a seemingly complex network of trails throughout the flat area around MSD. Audible evidence of nocturnal foraging was collected at MSD, MSE, MSF and MFG, usually in the early hours of the morning. This section of the river has been identified as an important feeding ground for Tapir by Kamstra (1982), who suggested that they may take cover in nearby forest during the heat of the day and forage at night.

Daylight audible evidence from MSE and the remains of half-eaten figs with Tapir oral markings, indicate the species is feeding on fallen fruit from trees in the riparian habitat during the dry season. It has been suggested that because of their inefficient digestion many of the seeds from fruits, which pass through the animal, are still viable (Janzen 1982b; Williams 1984), emphasising Tapir's important role as an agent for seed dispersal.

3.2.4 Habitat

Monitoring observation from MSD confirm that Tapirs spend considerable time near or in water feeding, wading and swimming (Williams 1984), although we did not see any walking submerged along the bottom. One individual was observed just before MS15 at the reservoir before Mollejon Dam; however, the vegetation type found on the edge of the reservoir is distinctly different from the riparian vegetation that defines the healthy population on the Macal and Raspaculo, and we consider the Mollejon Reservoir is unlikely to support a robust and healthy community.

Matola (1994) suggested that habitat conditions were ideal for tapir three years after an intense flooding event. Evidence of intense flooding was noted in several locations along the riparian shrubland, such as high-water marks in trees and dislodged vegetation between MSC and MSE (presumably from rains associated with Hurricane Keith during the previous year's wet season in September 2000). It was also apparent that the early successional vegetation had already recolonized the floodplains by January 2001 with Tapirs occupying the resulting habitat; therefore, we conclude that ideal habitat conditions developed more rapidly than previously supposed.

3.2.5 Population Status and Current Range

The Belize Biodiversity Information System (Miller & Miller 1998) has recorded sightings of Baird's Tapir in virtually all protected areas in Belize and it has been estimated that the population is between 680-3300 individuals (Matola 1997). However, despite protection Tapir numbers do appear to be declining in Belize, due to habitat loss, continued hunting, and possible susceptibility to disease introduced by horses (Miller pers. comm.).

Based on a predicted inundated area of 1039 ha^2, we estimate that 20% of the critical habitat for Baird's Tapir during the wet season would be immediately lost, with additional areas adjacent to the lake degraded by habitat change and human impact. Greater isolation of the remaining populations is also likely.

The populations found in the study area are considered to be significantly more robust than in other parts of Belize, due to the ample amount of herbaceous vegetation found in the floodplain habitat, the absence of man and extensive areas to establish territory. Therefore, we suggest that the species maintains a viable population in the Chiquibul Forest, with individuals occupying territories throughout the area particularly associated with the Macal and Raspaculo watershed during the dry season. No observations were made in either the Smokey Branch or the Chiquibul River. However, further studies extended over wet and dry seasons in other isolated areas would be needed to establish the size of the population of the species in relation to the rest of Belize.

3.3 OTHER SIGNIFICANT MAMMALS

A survey was conducted of all other mammals in present in the study site, with the aim of recording significant species and their habitats. Currently, we know of 58 mammal species (excluding bats) occurring within the study area. Of these, 8 are on the IUCN Red List for Threatened Animals (IUCN 2000) and an additional 28 are considered rare or uncommon in Belize. Thus, approximately 62% of mammals in the study area are in need of conservation measures to ensure their continued existence at a national level. A summary of all significant mammal sightings recorded from the Macal/Raspaculo catchments demonstrates that the entire watershed is an important habitat for these endangered species. Therefore, any loss of seasonal habitat will have a negative impact.

Table 4: Summary of Mammal Observations From All Sources

Species	**Zone 1**				**Zone 2**				**Zone 3**				**Zone 4**				**Zone 5**			
	V	**A**	**T**	**S**	**V**	**A**	**T**	**S**	**V**	**A**	**T**	**S**	**V**	**A**	**T**	**S**	**V**	**A**	**T**	**S**
Primates																				
Black H. Monkey	P	R			P	R			P	R				R		R	R	R		
Spider Monkey					P	P		P	P			P	P				P			P
Carnivora																				
Jaguar	P		P		P	R	R			R	R	R	R		R		P		P	R
Kinkajou	R				P						P				P		P			
Margay			R		P				P								P	P	P	P
Neotropical Otter	R			R	P	P	P	P	R			R				R	P			P
Ocelot								P			P	P			P		P		P	
Puma							P			R				R			P	P		
White-nosed Coati									R				R				P			
Perissodactyla																				
Baird's Tapir	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Ariodactyla																				
Collared Peccary	P		R		P	P	P	P	P	P	P	P	P	P	P	P	R	P	R	P
Red B. Deer	R						P		P		R		P	P	P	P	R	P	P	P
W. Lipped Peccary	R							R	P	R							P	P	P	P
W.Tail Deer			R		P				P				R	R			R	P	P	P
Rodentia																				
C. American Agouti	P				P				P		P		P		P		P		R	
Paca	R		R		P		R		P				P		R		P		R	
Edentata																				
Nine-B. Armadillo							R						R		R					
Marsupialia																				
Four-Eyed Opossum	P				P		R		P				R				P			

Key: *V* *Visual* *A* *Audible*
T *Tracks/Trails* *S* *Scats/Markings*
R *Recent NHM Survey (1/1/2001 – 1/4/2001)*
P *Past NHM Survey (Published and unpublished sources)*

Quantitative and qualitative information regarding species associated with the watershed is severely deficient; further long-term seasonal studies are needed to understand with more clarity behavioural and seasonal movement patterns.

However, what has emerged from this and previous studies is that food is of primary importance to inhabitants of the area. The riparian habitat associated with the rivers is maintained in an early successional state by seasonal flooding, allowing the development of high-quality food sources along both rivers during the key period of the dry season; herbivores thereby derive maximum benefit. The resulting healthy and robust herbivore populations equally provide an optimal food source for predators.

Any loss therefore to the habitat, ecological fuction and flow regime of the river will have a significant and negative impact on many species, including those CITES/IUCN listed:

Black Howler Monkey *(Alouatta pigra pigra)*
Cites Appendix II, rare in Belize, IUCN status vulnerable.

Collared Peccary *(Pecari tajacu)*
Cites Appendix II, uncommon in Belize, hunted.

Jaguar *(Panthera onca)*
Cites Appendix I, rare in Belize, IUCN status vulnerable.

Margay *(Leopardus wiedii yucatanica)*
Cites Appendix I, rare in Belize, IUCN status vulnerable.

Neotropical Otter (*Lutra longicaudus annectens*)
Cites Appendix I, rare in Belize, IUCN status vulnerable.

Ocelot *(Leopardus pardalis)*
Cites Appendix I, rare in Belize, IUCN status vulnerable.

Puma *(Puma concolor mayensis)*
Cites Appendix II, rare in Belize, IUCN status threatened, extinct over much of range.

Red Brocket Deer (*Mazama americana*)
Cites Appendix III, uncommon in Belize, hunted.

Spider Monkey *(Ateles geoffroyi)*
Cites Appendix II, rare in Belize, IUCN status vulnerable.

White lipped Peccary *(Tayassu pecari ringens)*
Cites Appendix II, rare in Belize, IUCN status threatened.

White-tail Deer *(Odocoileus virginianus truei)*
Cites Appendix III, uncommon in Belize, hunted.

3.4 MORELET'S CROCODILE

3.4.1 Introduction

Although, Morelet's Crocodile occupies a wide range of habitats, including lagoons, rivers, oxbows, lakes, swamps, and marshes (Platt 1996), it has a relatively small range extending from the southeastern lowlands of Guatemala through Belize and on to northern Guatemala and southern Mexico (Lee 1995). Although hunting still occurs throughout its range for skins and meat, persecution of the species within the Chiquibul Forest is no longer evident, due to the absence of people. Indeed, the significant increase in Morelet's Crocodile populations in Belize over the past two decades indicates the resilience of the species and its ability to adapt to changing habitats.

Unlike Baird's Tapir, crocodiles have a high potential reproductive rate, which has facilitated their increase since the skin trade declined. Predation of eggs and hatchlings limit reproduction, but the larger crocodiles have few enemies other than man. Data on the Belize Biodiversity Information System confirm the presence of Morelet's Crocodile in all districts except Stann Creek (although present there according to Abercrombie et al. 1982; Platt 1999) and from many protected areas (wildlife reserves, forest reserves, nature reserves) on the coastal plain. It was considered Endangered by the IUCN (1990), but has recently been designated as Data Deficient (IUCN 2000) and is listed in Appendix I of CITES; it is also recognized as endangered on the US Endangered Species Act (Code of Federal Regulations 1977).

In Belize, Morelet's Crocodile occurs mainly in slow moving waters of the lowland coastal plain in the north and southeastern part of the country. A population also occurs in the flowing waters of the upper Macal River watershed in the Maya Mountains, up to at least 440m a.m.s.l. along the upper Raspaculo River (Stafford 1991) (Figure 2).

3.4.2 Observations

During the survey, adult *C. moreletii* were visually observed on ten separate occasions, approximately 60% occurring within the impoundment area, principally between MSG and MSJ. The majority (80%) of adult observations were of lone crocodiles submerged just below the surface in areas of deep, slow-moving water, usually where the river describes a long curved bend and one bank of the riparian edge is relatively flat. Most sightings were brief; those from the diurnal canoe surveys and encounters would generally be of individuals swimming across the river from bank to bank. Remaining adult observations were of lone adults basking on sandbars at MSM and MS15.

Table 5: Observations of Morelet's Crocodiles

Site ID	Name	Visual		Tracks	Dens	Nests
		Adults	Young			
	Zone 1					
MS1	Devils Drive					
MS2	Big Bend					
MS3	Straight Stretch					
MS4	Otter Camp					
MS5	Kinlock Camp					
MS6	BB Top	1	2			
	Zone 2					
MS7	Cushta-Bani	1	3			
MS8	Flood Plain		1			
MS9	Junction End					
MS10	U Bend Camp					
MS11	Fallen Tree					
	Zone 3					
MSA	BB End					
MSB	Francelia		4			
MSC	Deep Pool	1	2			
MSD	Ras/Mac Junction					
MSE	Fig Stone					
MSF	Tapir Bend		7			
MSG	Macal Tree	1	2			
MSH	Croc Pool 1	1	2	1	1	
MSI	Croc Pool 2	2	3			
MSJ	Chalillo	1				
	Zone 4					
MSM	Floating Log	1	2			
MSN	Hot Pepper					
MSO	White Rock					
MSP	Blue Post					
MSQ	Bromeliad Tree					
	Zone 5					
MS12	**LC Bird Tower**					
MS13	New Maria Camp					
MS14	Smokey Branch					
MS15	Mollejon	1				
MS16	Monkey Tail					
MS17	Chapayal					

* - less than 10

+ - greater than 10

3.4.3 Food Sources

Like many crocodilians, Morelet's Crocodile is an opportunistic predator that will eat whatever prey species are readily available. Different food sources are important at the various life stages. For juveniles, insects and other arthropods consisting of both aquatic and terrestrial forms are important food sources. A variety of insect groups were identified, of which beetles were most important (Platt 1996). Snails are also an important food source for juveniles.

Larger crocodiles are able to consume fish, amphibians, turtles, birds and mammals, depending on successful capture rates. The high numbers of *Iguana iguana* in areas that harbour crocodiles indicates a possible food source, although we did not observe any feeding.

3.4.4 Habitat

Adult Morelet's Crocodiles are known to construct dens with submerged entrances (Alvarez del Toro 1974; Platt 2000). Factors influencing den construction remain largely unknown, but are probably related to the availability of suitable micro-sites. Dens may remain in continuous use for many years and protect larger *C. moreletii* from terrestrial predators such as Jaguars, as well as provide refugia for nesting females and neonates (Platt 2000). Varying water levels may force temporary abandonment of dens. During the field survey we only found one active den, at MSH. Its entrance was not submerged, although it had been during higher water levels. Dens tend to be constructed in heavy clay soils and can be up to 4.6 m long, terminating in a widened chamber. At the same location what appeared to be an active nest mound was approximately 2 m in diameter and 25 cm high; it was constructed from dead vegetation, mostly grass and decaying woody material.

3.4.5 Population Status and Current Range

Abercrombie et al. (1980, 1982) conducted population surveys through much of Belize, and estimated a population of 2200-2500 Morelet's Crocodiles in the country.

From the Macal and Raspaculo rivers, our results suggest that whilst the juvenile populations are relatively high, the adult population appears comparatively low. The reasons for this could be numerous and complex, and further research would have to be conducted to determine which factors dictate the ratio of births to deaths. From the available evidence, it is clear that adults are essentially confined to the larger deeper stretches of the river suggesting that habitat restrictions may be affecting population size. Platt (1996) found that rivers and creeks support significantly lower densities than either alluvial or non-alluvial lagoons in Belize, and suggested that other creeks of the Chiquibul Forest may be too small and disconnected to maintain permanent crocodile populations. We estimate that 22% of the immediate wet season habitat would be lost to inundation, with further degradation of adjacent areas.

Some researchers suggest that, due to its isolation and higher elevation habitat, Morelet's Crocodiles in the Upper Macal River could be genetically distinct from those elsewhere in Belize. This hypotheses requires testing by population-level sampling for genetic analysis.

3.5 OTHER AMPHIBIANS AND REPTILES

A survey was conducted of all other reptiles and amphibians in the study area with the aim of recording the number of species present (Appendix 1). A total of 31 species were recorded, representing ca. 40% of those in Belize known to inhabit rainforest and forest river systems. Snakes constitute the greatest percentage of herpetofauna recorded (38.7%), followed by lizards (22.6%), and this pattern is known to be true of the faunal area as a whole (Campbell & Vannini 1989). Given the limited time available and inclemently dry weather conditions during the survey, the number of species recorded is likely to be an under-estimate.

3.5.1 Observations

Cane Toad (Giant Toad), *Bufo marinus*
A number of specimens were observed moving about after dark; this species is associated most often with disturbed and/or deforested habitats, so its occurrence in the area was unexpected.

Campbell's Toad, *Bufo campbelli*
2 specimens, both males of different colour variants. This is a montane, humid forest species now recognised as distinct from *B. valliceps* (Mendelson 1994). Unlike those of *B. valliceps*, the males of this species may not form breeding aggregations, as has been reported for a closely related form recently described from the Caribbean versant of north-central Honduras, *B. leucomyos* (McCranie & Wilson 2000).

Vaillante's Frog (Green River Frog), *Rana vaillante*
Multiple records. This is a common species in the area, usually being observed at night in aquatic margin habitats.

Chac's Rain Frog, *Eleutherodactylus chacii*
Several individuals were observed vocalizing discreetly from beneath forest floor debris after rain. Anecdotal observations on the advertisement call of this species were provided by Stafford (1991), although it is not clear whether vocal sacs are present.

Morelet's Tree Frog, *Agalychnis moreletii*
1 adult male, representing an additional species record for the area. The specimen was disturbed from beneath the frond of a small understory palm. A second species, *A. callidryas*, occurs synoptically with *A. moreletii* at MS7.

Green Iguana, *Iguana iguana*
Several large adult males, females, and numerous smaller individuals were observed in many riverside trees.

Lesser Scaly Anole, *Norops uniformis*
Several examples of small species were observed on the ground amongst leaves, and leaping between the leaves of sapling palms.

Ghost Anole, *Norops lemurinus*
Two individuals, both male, were observed perched head downwards on the sides of small trees.

Central American Ameiva, *Ameva festiva*
1 adult male was collected as it emerged from a hole in the ground. The lizard had an SVL of 112 mm and an exceptionally long tail measuring 3138 mm.

Mussurana, *Clelia clelia*
A second individual of this impressively large colubrid snake was found foraging near the river's edge, in the same location and at almost exactly the same time as a specimen collected in 1997.

Montane Yellow-bellied Snake, *Coniophanes fissidens*
1 specimen. This is the common *Coniophanes* of the area and one of the most frequently observed snakes. The specimen was found on the river bank apparently in pursuit of a specimen of *Ninia sebae* (see below). The diet of this species frequently includes others snakes. A specimen in 1997 was found feeding on a large adult *Rana vaillante*.

Lizard-eater (Dryad Snake), *Dryadophis melanolomus*
3 specimens. One exceptionally large individual had an SVL of 850 mm and total length of 1165 mm; this exceeds the maximum size previously reported for the species. The general dorsal coloration of the specimen was olive brown with a light mottling of grey beneath the chin and throat. Examples of the species from Belize are normally dark brown or red-brown, and mottling of the throat may be either conspicuous or absent.

Northern (Spotted) Cat-eyed Snake, *Leptodeira septentrionalis*
1 juvenile specimen, representing a new species record for the area. The snake was observed foraging on the ground at after dark.

Red Coffee Snake, *Ninia sebae*
1 specimen was observed being pursued by the *Coniophanes* described above.

False Coral Snake, *Urotheca elapoides*
1 specimen, disturbed during the day (1400 hrs) from beneath litter in quadrate U05. SVL ca. 280 mm, tail autotomized; 11 black body bands (including nuchal), 2-3 dorsal scales in length; yellow bands 1-2 dorsal scales long; leading edges of red dorsal scales marked with black. The resemblance of this species to examples of *Micrurus* in the area is striking. Throughout its range, *Urotheca* is known to imitate several different species of coral snake, even mimicking their locally specific colour variants. A specimen collected in January 1991 contained 5 well developed oviducal eggs (Stafford 1996b); the abdominal cavity of this specimen was also heavily parasitized with cestode larvae.

Coral Snake, *Micrurus diastema x hippocrepis*
2 adult specimens. Analysis of variation in the coral snakes of Belize (Stafford 2000) has confirmed the existence of only two nominal taxa, and not three as had been previously reported for the country (Neill 1965). *Micrurus diastema* and *M. hippocrepis* are remarkably similar and share many of the same colour pattern and scuttelation features. The two species also have similar karyotypes (Gutiérez et al. 1988). Specimens from the MS7 site exhibit features intermediate between *M. diastema* and *M. hippocrepis,* suggesting that in this area the two species intergrade, or possibly that only a single, highly variable taxon exists. Further research is needed on the relationships of *Micrurus* populations in Belize, preferably using DNA-based techniques.

Jumping Pitviper, *Atropoides nummifer*
1 subadult female with an approximate total length of 450 mm disturbed from amongst leaf litter at 1600 hrs at top of hill behind camp. Activity in this species appears to be less constrained to the wet season than other viperids in the area. Several specimens have been observed during the dry season months, although usually after short periods of rain. Only *Bothrops asper* has otherwise been recorded from the Raspaculo (Rogers et al. 1994), although on ecological grounds two other

rainforest species known from adjacent areas, *Bothriechis schlegelii* (Eyelash Palm Pitviper) and *Porthidium nasutum* (Rainforest Hog-nosed Pitviper) almost certainly occur here.

Brown Forest Skink, *Sphenomorphus cherriei*
1 specimen of this small, litter-dwelling species was collected amongst limestone boulders at the rim of the sinkhole. The specimen had an SVL of 41 mm and tail length of 47 mm.

Yellow-spotted Night Lizard, *Lepidophyma flavimaculatum*
1 adult specimen disturbed from beneath a fallen log adjacent to the camp.

Smooth Anole (Slender Anole), *Norops rodriguezii*
1 adult male, collected in the sinkhole on the trunk of a sapling tree ca. 1.5 m from ground.

Variable Coral Snake, *Micrurus diastema*
1 specimen, collected from beneath a fallen log. The specimen is clearly attributable to *M. diastema*, having 36 black body rings and a pale spot on snout. The number of black body rings is unusually large, and more than has been reported previously for the species in Belize (see also aforementioned note on *Micrurus*). Following capture the specimen regurgitated a partially digested snake (unidentifiable).

Central American Leopard Frog, *Rana berlandieri*
A common species at Millionario, inhabiting a roadside pool. Populations of anurans at this pool are currently being monitored under the MAYAMON initiative (see above).

White-lipped Mud Turtle, *Kinosternon leucostomum*
4 specimens, all observed in the pool at Millionario.

Central American Ameiva, *Ameiva festiva*
An adult female and juvenile were found beneath boards discarded around the camp.

Greater Scaly Anole, *Norops tropidonotus*
Several examples of this dry forest species were observed at Las Cuevas. *Norops tropidonotus* is the common anole at this locality, although four other species have been recorded within close proximity, *N. capito*, *N. lemurinus*, *N. rodriguezii* and *N. uniformis* (P. Stafford pers. obs.).

Red Coffee Snake, *Ninia sebae*
1 specimen, a juvenile, found crossing the path to the cave at MS12.

Degenhardt's Scorpion-eating Snake, *Stenorrhina degenhardtii*
1 specimen, a large adult male, found freshly killed on the main service road to Las Cuevas, ca. 500 m from the station. The snake has an SVL of 640 mm and tail length of 172 mm; ventrals 147; subcaudals. The snake is uniform olive-brown above with the faint indication of a dark lateral stripe on scale rows 3-4. The venter is pale yellow with an indistinct row of dark medial spots, more pronounced on the tail. *Stenorrhina degendardtii* is known in Belize from only four other records

Jumping Pitviper, *Atropoides nummifer*
1 juvenile specimen, found by day at the side of the path leading down to the cave. The snake had recently consumed a large meal.

3.5.2 Analysis of Species Composition

Over the course of five expeditions to the Macal and Raspaculo watershed during the last ten years, a total of 53 species of amphibians and reptiles have been recorded. Although this probably does not represent the true number of species present (surveys during wet season months are likely to reveal more amphibians), the data now accumulated enables at least some basic analysis of species composition in the area, as well as comparison with the herpetofaunas of adjacent regions. In order to assess the similarities and differences between reptilian faunas of different parts of Belize, Stafford & Meyer (2000) designated three physiographic regions in the country: the northern region (extending from the valley of the Belize River in the south, northward to the Mexican border, and bounded in the east by the Caribbean Sea and in the west by Guatemala), the southern lowlands (occupying the coastal plain between the Maya Mountains and the Caribbean), and the southern uplands (encompassing the mountainous terrain of the southern half of Belize). Due to the wealth of offshore cayes encompassed by Belize, the existence of a fourth 'marine region' may be recognized, but these islands are poorly known faunally (thus, in the following discussion, introduced, marine and insular species are not included). The majority of observations were made at MS7 (Cushta Bani), which lies in the heart of the southern uplands region: it may be assumed that the herpetofauna of this area is representative of the region as a whole.

Table 6: **Summary of Herpetological species composition in physiographic regions of Belize. [1]data from Stafford & Meyer (2000); [2]extrapolated from locality records in Lee (1996) and Meyer & Farneti Foster (1996). Figures in parentheses represent the number of taxa specific to that region and not reported from others.**

	Northern Lowlands	**Southern Lowlands**	**Southern Uplands**
No. of reptile species[1]	87 (9)	86 (1)	91 (5)
% of total reptile fauna	77.7	76.8	81.3
No. of amphibian species[2]	19 (3)	21 (0)	34 (13)
% of total amphibian fauna	48.7	53.85	87.2
Total no. species	106 (12)	107 (1)	125 (18)
% of total species assemblage	70.2	70.9	82.8

Campbell & Vannini (1989) used the Faunal Resemblance Factor (FRF) to measure faunal similarities among regions in Guatemala, and this measure is used here to examine the similarities of the Southern Uplands (enclosing the Raspaculo site) with the two other Belizean physiographic regions. The FRF is calculated as $FRF = 2C/N_1 + N_2$, where N_1 = the number of species in the first region, N_2 = the number of species in the second region, and C = the number of species common to both regions. It appears from the data that the three physiographic regions have relatively diverse and comparable herpetofaunas (Table 6). Each region has between 70.2 and 82.8% of the total Belizean fauna, and reptile taxa are relatively evenly represented in each region (76.8-81.3%). Amphibian species, however, are significantly more numerous in the Southern Uplands (87.2%).

Table 7: Comparison of amphibians and reptile faunas among physiographic regions in Belize. Numbers on the diagonal indicate total faunas for each region; numbers above the diagonal indicate proportion of shared species; values below represent the Faunal Resemblance Factor (FRF = $2CN/N_1+N_2$).

	Northern Lowlands	Southern Lowlands	Southern Uplands
Northern	**106**	83	80
Southern Lowlands	0.78	**107**	94
Southern Uplands	0.69	0.81	**125**

The FRF similarity coefficients for Belizean amphibians and reptiles of 0.69-0.81 (Table 7) indicate that overall there is a relatively high degree of sharing between the three regions and that, with the possible exception of the Southern Uplands, they cannot be considered to be distinct herpetofaunal areas. It is of significance, however, that the herpetofaunas of the Northern and Southern Upland sectors include an appreciable number of species (7.9% of total number of species; *N*=12 and 11.9%, *N*=18 respectively) unique to those regions.

3.5.3 Conclusions

The Macal/Raspaculo catchment is an important habitat for reptiles and amphibians, with species richness concentrated along river margins. *Rana juliani*, endemic to the Maya Mountains, is dependent on fast-flowing water and occurred at two sites (MSH, MSJ) close to the proposed dam site. Within the Yucatan, Morelet's Tree-frog (*Agalychnis moreletii*) is found only in the Maya Mountains, forming healthy populations at MS12. A large population of Narrow-mouthed Toad (*Gastrophryne elegans*), rarely recorded in Belize, was detected close to the Raspaculo. Chac's Rain Frog (*Eleutherodactylus chacii*), rare and unique in the Neotropics, is abundant in the vicinity of both the Macal and Raspaculo rivers, and several other species, including *Rana vaillante*, were found only in the immediate vicinity of the water courses.

The presence of three putative species of Coral Snake (*Micrurus*) is noteworthy, as this is the dominant terrestrial group of snakes in Belize. However, it also emphasises the need for greater taxonomic research, as one of the three supposed species may in reality reflect hybridization.

Ecologically, the large population of Green Iguana (*Iguana iguana*) sustains a wide range of predatory species, especially large raptors. The amphibians limit arthropod populations while constituting vital prey for many reptiles, mammals and birds.

We conclude that the majority of these taxa are unlikely to successfully adjust to a radically modified flow regime. We also suspect that a more detailed survey spanning the full range of seasons would reveal an even richer herpetological fauna, revealing the presence of additional species that characterize Neotropical rain-forests of this latitude.

3.6 FISH

The current survey revealed three fish species: the Catfish (*Ictalurus furcatus*), a major food source of the Neotropical River Otter, was frequently recorded, and two cichlid species were observed in the upper Macal and lower Raspaculo.

Table 8 compares fish species recorded during the present brief survey with those listed by three previous studies (Glaholt 1992; Greenfield & Thommerson 1997; Boles 1999). The low species number recorded during the present survey probably reflects time constraints, especially lack of wet-season data, and possibly barrier effects of the Mollejon Dam.

The aggregate fish fauna documented in Table 8 reveals adaptation to fast-flowing oxygenated water, suggesting that any reductions in flow regime would be detrimental. Changes in nutrient levels and sedimentation rates resulting from dam construction are also likely to impact on fish populations downstream, but current data are insufficient to address issues such as feeding and breeding concentrations and migration patterns.

Wet-season surveys are desirable, together with assessments on the possible impact of any non-native fish species that could be introduced, either accidentally or deliberately, into the less turbulent and colder waters of the dammed lake.

Table 8: Fish species recorded in the Macal/Raspaculo catchment during four recent surveys.

Taxon	NHM (2001)	Boles (1999)	Greenfield & Thommerson (1997)	Glaholt (1992)
Astyanax aeneus		x	x	
Astyanax fasciatus				x
Belonesox belizanus			x	
Helerandria bimaculata			x	x
Poecilia mexicana			x	
Poecilia teresae		x	x	x
Xiphophorus helleri		x	x	x
Xiphophorus maculates			x	
Cichlasoma salvini		x	x	x
Cichlasoma spilurum	x	x		x
Cichlasoma intermedium	x	x		
Rhamadia guatemalensis			x	
Rhamdia laticuda				x
Ictalurus furcatus	x	x		
Aguilla rostrata		x		

3.7 SCARLET MACAW

3.7.1 Introduction

The Scarlet Macaw *(Ara macao)* is a conspicuous, large, long-tailed red parrot with patches of yellow and blue on its wings, characterised by its high pitched squawk. It is an inquisitive, highly intelligent bird that originally ranged from the southern states of Mexico to the Amazon region of Brazil. The recently described northern subspecies, *Ara macao cyanoptera* (Wiedenfeld 1994), is found in Belize and it prefers wet lowland tropical forest habitat, frequently nesting near rivers and associated floodplains (Matola 1999a).

In recent years habitat loss and the growing international pet trade has put the species in immediate danger of extinction. It has already become extinct from much of its former range on the Pacific slopes of Mexico, Honduras and Nicaragua, and it was completely extirpated from El Salvador several decades ago (Daugherty 1972; Thurber et al. 1987). In Guatemala it occurs mainly in the western Petén Department, where only six small isolated populations remain (Billy 1999).

In Belize, Scarlet Macaws had been recorded from the Hummingbird Highway, Mountain Pine Ridge and Southern Stann Creek (Russell 1964), but the species has been lost from all of these areas during the last few decades, probably due to human encroachment and habitat loss. At present the species is very rare and largely confined to the river valleys of the Macal and Raspaculo. During the dry season it has been recorded making sojourns into the Cockscomb Basin from the Raspaculo via the Swaszey River (Matola 2000) to exploit a variety of seasonal food resources at Red Bank and San Pablo. Small numbers of isolated pairs have also been recorded during this survey at Smokey Branch, Las Cuevas and New Maria Camp.

Because the Scarlet Macaw is declining throughout its range and is in high demand for the pet trade, it is listed in Appendix 1 of CITES, which prohibits trade in the species. The IUCN Parrot Specialist Group has prepared an action plan to review status and recommend conservation programs for all threatened psitticines, including the Central American Scarlet Macaw (Enkerlin-Hoeflich 1999).

3.7.2 Observations

The range of this species, graded according to relative importance, is given in Figure 4. During this survey, individual macaws and groups of macaw were observed on 85 separate occasions. Of these, 63 were in groups between 1 and 3, 25 were of groups between 4-6 and 7 were of groups greater than 6 all from within the area to be flooded. 5 nest sites were identified, 4 within the area of impoundment and 1 outside.

Table 9: Observations of Scarlet Macaws

Site ID	Name		Group Size			
		Nest	1-3	4-6	7+	
	Zone 1					
MS1	Devils Drive		2			
MS2	Big Bend					
MS3	Straight Stretch					
MS4	Otter Camp					
MS5	Kinlock Camp					
MS6	BB Top					
	Zone 2					
MS7	Cushta-Bani		2			
MS8	Flood Plain	N	1			
MS9	Junction End			2	2	
MS10	U Bend Camp			1		
MS11	Fallen Tree		1	1		
	Zone 3					
MSA	BB End	N	4	2		
MSB	Francelia		2	1		
MSC	Deep Pool		4			
MSD	Ras/Mac Junction	N	6	1		
MSE	Fig Stone	N	3			
MSF	Tapir Bend					
MSG	Macal Tree			1	5	
MSH	Croc Pool 1					
MSI	Croc Pool 2					
MSJ	Chalillo		1			
	Zone 4					
MSM	Floating Log					
MSN	Hot Pepper		1	7		
MSO	White Rock					
MSP	Blue Post					
MSQ	Bromeliad Tree			1		
	Zone 5					
MS12	LC Bird Tower	N	22			
MS13	New Maria Camp		1	2		
MS14	Smokey Branch		1			
MS15	Mollejon					
MS16	Monkey Tail		3			
MS17	Chapayal		1	6		

It was not possible to distinguish between different individuals; therefore it is likely that multiple sightings sometimes represent the same individuals.

Most observations were made of pairs of macaws, flying low over the canopy in either an east-west/west-east orientation on the Macal River or a north-south/south-north orientation on the lower Raspaculo, essentially following the course of the river. Most sightings of flight occurred between 05.30 and 09.30 and between 14.30 and 17.30, although sightings did occur outside these hours. Most observations of pairs (male and female) came from the Las Cuevas bird tower (MS12), where a nest was discovered in the vicinity of the San Pastor plot.

A flock of 24 macaws was observed at MSG along the Macal River at 13.20 on 19th February feeding on a fig tree (*Ficus*) in the floodplain of the river. Earlier that day at 07.40 10 macaws were observed flying low over the canopy north of the site. The flock stayed around the tree most of the day, with sub-groups leaving and returning at various intervals. All individuals had left the tree by 17.30. A further flock of 13 was seen on the 20th March again feeding on a fig tree, around mid-day at MS9, east of confluence of the Raspaculo with Monkey Tail Branch approximately 20 km outside of the impoundment area.

No other large flocks were observed along the river, but several groups of 6 and 4 were observed at various locations flying low over the canopy or feeding.

3.7.3 Food Sources

The diet of macaws consists mainly of seeds and unripe fruit pulp, and to a lesser extent leaves (Munn 1988). During the short period of field observation in this study, macaws were observed feeding on 13 species of trees, principally at MSD, MSG and MS12. A further 15 tree species and 2 vine species have been identified as food sources from previous observations throughout the Chiquibul over the last two years (Renton 1998). Our observations confirm that the species is a canopy feeder with the bulk of its diet consisting of unripe fruit pulp and seeds. Macaws were observed eating fruit, flowers and leaf stems of Quamwood (*Schizolobium parahyba*) and Stinging Chaya (*Cnidoscolus* sp.) at MSD and MSG.

Table 10: Food Sources Identified for the Scarlet Macaw (data gathered by N. Bol)

Local Name	Scientific Name	Organ Eaten	Mon. Station
Fig	*Ficus* sp.	Fruit/Seed	D,G,E
Bri Bri	*Inga densiflora*	Flowers/Fruit	E,K,12
Cedar	*Cedrela odorata*	Seed	G,8
Ceiba	*Ceiba pentandra*	Seed/Fruit	12
Cohune Palm	*Attalea cohune*	Nut	K
Gumbo Limbo	*Bursera simaruba*	Seed	12
Hogplum	*Spondias mombin*	Seed/Fruit	G,D
Prickly Yellow	*Zanthoxylum belizense*	Seed	14
Quamwood	*Schizolobium parahyba*	Seed/Leaf/Stem	G,8
Stillbrush Vine	*Byttneria catalpifolia*	Flowers	D
Stinging Chaya	*Cnidoscolus* sp.	Seed	D,G
Trumpet	*Cecropia obtusifolia*	Seed	12

The concentration of sightings at various locations along the Macal and Raspaculo rivers, both within and outside the impoundment area, probably reflects the availability of food during the dry season until the end of May, when post-breeding flocking takes place (Mallory 1994).

3.7.4 Nest Sites

Macaws seem to prefer natural cavities for nest sites, as they are unable or reluctant to excavate cavities themselves (Renton 1998). These natural cavities form when trees are damaged and the decaying trunk produces a cavity or when fallen branches leave suitable holes in trunks. Studies have shown that the birds prefer nest sites away from prevailing winds, and frequently nest in large trees (Iñigo-Elias 1996). It therefore follows that the density of nest sites will closely correlate with the density of large damaged trees. As the density of large trees in the Chiquibul Forest is higher on or near river floodplains more suitable sites tend to be found in the river valleys. King (1999) also found that the density of different tree-size classes within broadleaf forest was significantly correlated to seasonally flooded rivers, predicting that the density of macaw nest sites will be highest near seasonally flooded rivers. This is supported by Meerman (1999a) who suggested that the floodplain vegetation of the Upper Macal provides optimal nesting habitat because periodic seasonal flooding subjects isolated tall trees on floodplains to stem damage, promoting a higher incidence of cavity development than in the surrounding upland forest. In addition, Meerman (1999a) stated that isolated trees, as present on the upper Macal floodplains, give nesting macaws a “sense of security” in that they can readily view the surrounding terrain.

Four macaw nest sites were identified during this survey near the river in the vicinity of MS8, MSA, MSD and MSE, all in Quamwood (*Schizolobium parahyba*) trees, while a fifth was located near Las Cuevas (MS12). Due to an understandable reluctance by researchers (shared by the authors) to accurately identify nest locations we cannot be certain whether these sites have previously been documented. However, three nests were found and monitored in 1998 by Renton and two in 1999 by Matola (1999a), all in Quamwood near the river, emphasising the importance of the Upper Macal valley as a breeding ground. All nest sites, with the exception of the site in the vicinity of Las Cuevas that was more closely observed, were discovered late in the dry season. The majority of sightings of groups of two macaws indicated that the nests were still being established by both the male and female, and egg-laying had not yet taken place.

Mating pairs spend a lot of time searching for, inspecting and then defending nest sites (Renton 1998). During this survey one pair was observed consistently throughout February from the Las Cuevas bird tower (MS12), apparently searching for trees with suitable nest cavities. From the middle to the end of March observations noted only a single male, indicating that the female was in a nest either prior to or after egg laying. It has been suggested that early in the nesting season the male brings food 3-6 times per day but later increases to 5-9 times per day (Iñigo-Elias 1996), and that the nest site will be defended for the duration of occupation (Renton 1998). Therefore, close, non-intrusive observations of the site will continue throughout April and May.

3.7.5 Population and Distribution

The total Belizean Scarlet Macaw population is difficult to determine because of the remoteness of its habitat, the wide-ranging nature of the birds and the bias of observations. Mallory (1994) suggested that the population is between 30 and 60 birds, based on a maximum observed number of 31. Renton (1998) estimated the population at about 200, Matola (1999) at less than 250. Although these estimates are variable, the population is certainly low and restricted within Belize.

During the present study, a single flock of 24 macaws were observed at MSG in January. With several locations being monitored simultaneously, a further six birds were observed in groups of two to four, and with a further 38 being reported during a separate study at San Pablo Villages by Matola in January 2001, giving a total of 68. Therefore, a revised estimate of macaw population of Belize should be between 60 and 100 individuals. As this figure is only based on the maximum numbers recorded at any one time it can only be considered a first-order estimate that may significantly under-represent the Belizean macaw population.

Observations of macaws in the Chiquibul Forest over the last four years have been incorporated into a Geographic Information System database to produce a distribution map (Figure 3) correlated with various environmental parameters, such as rivers, vegetation type and altitude. From this distribution we estimate that the current range of the Belize population is restricted to areas west and north of the Maya Mountain divide and that the Macal river valley represents the current northern limit of the species, with the Guatemalan border as the western limit. It is therefore reasonable to assume that the Belize population of Scarlet Macaws is isolated from other populations of the species, thus preventing immigration and promoting genetic separation, which can lead to a high probability of extinction (Harrison 1991).

During all surveys in Belize, Macaws have been most frequently observed near rivers. It is now widely accepted that the area of the Raspaculo and Macal River is very important to the macaws of Belize (Mallory 1994), and this view has been strengthened by the sighting of a large flock of 30 birds near MSG during our survey. The observations given in Appendix 1 show that the Monkey Tail sites (MS16, MS12) are other areas favoured by the macaws.

As Las Cuevas Research Station (MS12) has had permanent residents since July 1994, it has been possible to put together the most comprehensive collection of macaw observations in Belize. A full list of recorded sightings from February 1995 to December 2000 have been passed on to Dr. Elizabeth Mallory for detailed analysis. Over half of the sightings were of single pairs, reflecting the observations of Mallory (1994). During certain times of the year, most Belizean macaws flock together (Mallory 1994).

For example, during the second half of June 1995 a flock of at least 20 macaws spent the daylight hours in the trees on the edge of the Las Cuevas clearing, almost always in one or more of three specific trees: the Barbajolote (*Pithecellobium arboreum*) and the Fig (*Ficus* sp.) to the west of the main building, and the Jobillo (*Astronium graveolens*) in the north-west corner of the clearing. In 1996, a flock of 27 flew past Las Cuevas on the 17th June, without stopping in the clearing. A large number of macaw pairs have been observed over the last six years around Las Cuevas, but most were on their way to and from Monkey Tail and the Raspaculo and Macal Watershed, where flocks of greater than 20 birds were seen. The timing of flocking is thought to coincide with the end of the breeding season (Mallory 1994). However, combining the results given in Mallory (1994) and the observations from Las Cuevas, flocks of 20+ macaws have been reported in Belize in all months of the year except January, April, October and December.

Staff of Las Cuevas have crossed the Guacamallo bridge on average 3-4 times a week for 6 years, often stopping for a while, yet there have been no macaw sightings, suggesting that the macaws stay east of the bridge. Equally, staff of Las Cuevas have spent a considerable amount of time at Grano de Oro, but only twice have macaws been reported from that area.

During the times of low macaw activity at Las Cuevas (February to mid-May and mid-October to mid-April), macaws were observed in fairly large groups in the areas of the Monkey Tail, Raspaculo and Macal. It is therefore possible that during the dry weather the macaws are centred on the riverine areas and then during the wetter weather they moved further from the rivers, centring their activity in the vicinity of Las Cuevas.

It should be noted that while most of the Scarlet Macaw reports have been either from Las Cuevas or along the Upper Macal River, Monkey Tail and Raspaculo Branch, this area has benefited from the greatest intensity of survey effort. Macaws have also been reported from other riparian habitats in the Chiquibul Forest Reserve; on the Chiquibul River, Smokey Branch and Rio Ceiba Grande, sightings are usually of isolated pairs with no big flocks. Whilst these riparian habitats in the rest of the Chiquibul appear similar they often lack the favoured trees of the Scarlet Macaw and have steeper geological profiles that limit the growth of the important riparian shrubland and large trees. Thus, they are unlikely to support a viable population of macaws.

Scarlet Macaws have been reported on the east side of the Maya Mountains in the Cockscomb Basin, near the villages of Red Bank and San Pablo, which is just south of the Cockscomb Basin. As many as 32 macaws have been seen there at one time. The composition and early successional structure of the vegetation is probably the reason for the macaw feeding concentrations (Meerman 1999c), and the population is universally considered by researchers as being the same as that observed in the Raspaculo and Macal river valleys.

We estimate that 21% of the wet season critical area for Macaws would be flooded, but the impact would be further exacerbated by the loss of ca. 80% of the riparian shrubland, which constitutes the critical habitat during the dry season when food sources are much more restricted.

3.8 OTHER BIRDS

Birds were studied by mist-netting and census techniques between sites MS7 and MSJ, yielding a total of 214 bird species. These consisted of 169 permanent residents, 41 winter residents and four summer residents. A full list is given in Annex A.

It would be inappropriate to over-interpret these framework figures; further studies are recommended over a significantly longer time-frame. Nonetheless, it is clear that species diversity is greatest in the riparian habitats, presumably reflecting their relatively high productivity; they are therefore seen as critical to both permanent and winter residents.

4. POTENTIAL IMPACTS AND POSSIBLE MITIGATION

This section presents possible impacts to wildlife caused by dam construction, impoundment and operation. It details appropriate measures to mitigate some of those impacts. An overview of dam impacts on wildlife is followed by a description of the approach adopted for the assessment of impacts, which are defined according to their magnitude, direction, duration and scope, and are summarised in tabular form.

4.1 BACKGROUND

Riverine ecosystems are impacted when large obstacles interrupt natural processes along the course and direction of a river. Hydroelectric dams constitute such obstacles, and their construction inevitably results in the permanent destruction of terrestrial ecosystems through inundation. They also produce impacts associated with the conversion of a running water (lotic) environment into a lake (lacustrine) environment (Bizer 2000).

As a result of damming, all terrestrial plants disappear from the area of impoundment, and animals and birds either drown, relocate or adapt to the new lacustrine conditions. The resulting reservoir will trap sediments, debris and nutrients, and obstruct migration pathways for some aquatic species. Variations in flow regime, magnitude of daily and seasonal flow fluctuations, water chemistry and sediment load all cause impacts that are often immediate and obvious. Other impacts, such as river flow, frequency and temperature on life cycles of native fish species in tropical riparian habitats, are less obvious and unpredictable.

Equally, dams may impact ecosystems at locations away from the immediate vicinity of the project site; for example, changes in land-water interactions may result in reduced nutrient flows to the marine environment, which in turn may have negative implications for fish and other fauna in the food chain. Alteration of natural abiotic processes often leads to changes in species composition, loss of spawning areas, the decomposition of natural vegetation, generation and accumulation of toxic chemicals and a reduced dissolved gas regime. All of these factors will strongly affect many species.

In attempting to determine the multiple, varied and complex impacts of a particular dam, relationships between the new abiotic conditions created by the construction and alterations in the ecological function of the river system need to be fully understood before potential impacts can be identified and an effective mitigation strategy implemented (Bizer 2000). Predictions of impacts are difficult when our understanding of these relationships is inadequate; this is particularly true of tropical climates, where there is very limited research. On balance, the impacts caused by a dam are complex and varied, often affecting the biodiversity, stability and resilience of ecosystems. In many cases they have led to significant and irreversible loss of species and habitats (WCD 2000).

Increasing awareness in recent years of the importance to human survival of ecological resilience has culminated in a new paradigm in environmental management, namely the ecosystem approach (Bizer 2000). This aims to maintain the functionality of a particular ecosystem by managing its natural resources in an integrated, environmentally conscious way. The Conference of the Parties of the Convention on Biological Diversity endorses the ecosystem approach as the primary framework for action under the Convention. Funding agents such as the World Bank now strongly encourage this approach, as do the International Committee on Large Dams (ICOLD), who support environmental awareness in developing guidelines for dam construction. In Belize this approach is of particular relevance because of the increasingly important income generated by the natural environment through ecotourism.

4.2 DETERMINATION OF SIGNIFICANCE OF IMPACTS

The generic nature of the impacts of large dams on ecosystems, biodiversity and wildlife is becoming increasingly well known (WCD 2000). Dorcey et al. (1997) provided a checklist for key potential environmental and social impacts of large dams, and a burgeoning body of literature reveals many examples of impacts to wildlife and the environment. Therefore, whilst many of the impacts identified in this section should be considered specific to the project, the majority pertain wherever blocking the natural flow of a river creates a man-made reservoir in a tropical climate.

It is recognised that the significance of an impact is determined by a value judgement, based on both quantitative and qualitative data. Using standard accepted environmental impact assessment methods, residual impact significance was evaluated and determined on the basis of the following four criteria:

- Magnitude: the relative change in the parameter
- Direction: the direction of change
- Duration: the recovery time to normal conditions
- Scope: the spatial influence

Table 11: Definitions of Terms used to Describe Environmental Impacts

Magnitude	Major: Moderate: Minor: Negligible:	**1** **2** **3** **4**
Direction	Increase: Decrease: No Change:	**I** **D** **NC**
Duration	Short-term (<1year) Med-term (1-10years) Long-term (>10 years)	**ST** **MT** **LT**
Scope	Local: Regional: National: International:	**LOC** **REG** **NAT** **INT**

Based on the value of the definition of the impact, possible mitigation measures have been suggested.

4.3 IMPACTS ON WILDLIFE ASSOCIATED WITH MRUSF

The plant and animal species associated with the Macal and Raspaculo Rivers exist in a delicate, dynamic and balanced ecosystem in which seasonal variations to the flow of both rivers is crucial to its biodiversity and function. Therefore, modifications to the flow regime of either river are likely to have an adverse impact on those species that rely for their survival on the dynamic nature of the riparian habitat. As the resulting reservoir created by the project will inundate approximately 80%

of this habitat (Penn & Sutton in press), it will no longer function as a dynamic and balanced ecosystem. Associated wildlife, unable to adapt to the new conditions created by the reservoir, will either drown, starve or less likely relocate to other areas.

General impacts have been determined for three phases of project progression: construction phase, impoundment phase and operation phase. We will consider each in turn:

4.4 CONSTRUCTION PHASE

The construction of the dam will initiate the upgrading of the Chiquibul Road to all-weather access routes through the Mountain Pine Ridge (MPR) and onwards to the dam site at Chalillo. The main section of this road is currently being upgraded, but further improvements will be needed to accommodate heavy construction vehicles. Preparation of the roadbed will expose soils to potential erosion and discharge sediments to the numerous small rivers and streams throughout the MPR, as well as into the Macal at the dam site. This impact will be compounded by the ongoing loss of vegetation cover in the MPR caused by a chronic and severe infestation of Pine Beetle that has rapidly destroyed approximately 80% of the forest (Chun pers. comm.).

Similarly, clearing of staging areas, opening of quarries, and foundation excavations for the dam will result in changes to both aquatic and terrestrial habitats. As construction progresses, disposal of spoil material, concrete batching, maintenance of equipment, use of hazardous materials and within-site movement of vehicles will affect wildlife (terrestrial and aquatic) within the immediate vicinity of the construction site and degrade local atmospheric conditions. As soon as construction of all roads and staging areas is completed, the disturbed land should immediately be re-planted with native vegetation to prevent erosion and the accumulation of sediments in adjacent streams and rivers, reducing the impacts to aquatic life.

Additional roads will be required for transmission lines and to allow approaches to different sections of the reservoir. Selection of the alignment of both access roads and transmission lines should be designed to minimise fragmentation of wildlife habitat, particularly through the broadleaf forest. These roads will also increase access into the more remote areas beyond the dam site by construction workers and the general public for illegal hunting and poaching. New roads will also facilitate the influx of illegal settlers into the area. These impacts could be major, long-term and regional (Meerman 1999b). Further potential impacts on wildlife from a labour force include the generation and disposal of sanitary wastes in the area immediately surrounding the construction. The impacts would be minor, short term and local, and could easily be mitigated by providing effective waste disposal.

Increased heavy construction vehicles on the Chiquibul and Ballerina roads may present a threat to wildlife crossing in front of oncoming traffic. The impact would be minor, short-term and local, and can easily be mitigated by ensuring safe and defensive driving skills by contractors. However, the basic noise disturbance is likely to have a high and immediate impact, forcing animals to relocate in less appropriate habitats.

During construction it will be necessary to divert the flow of the river through low-level conduits. Impacts downstream will be minimised if the flow is maintained at the natural flow rate for the appropriate time of year.

4.5 IMPOUNDMENT PHASE

Following river closure at the start of the impoundment phase and the end of the second dry season, it will be necessary to maintain an environmental flow to minimise impacts on species downstream. Technically, filling starts when the diversion conduits are closed and the flow of the river is reduced. It is estimated to take 60 days (Agra/CI Power 1999) for the reservoir to fill with an average flow of at least 24 m^3/s. This rate of flow should be maintained throughout the impoundment phase.

As the water level rises, fish species that feed from the base of the river will migrate upstream in an attempt to maintain habitat conditions. Species that feed on fish will also migrate upstream following the food source. Little can be done to prevent either consequence.

It is unlikely that Neotropical Otter and Green Iguana would overcome the impact of impoundment. Many individuals would eventually starve through loss of food sources. The Neotropical Otter feeds extensively on crustacea from highly oxygenated water and would not find an alternative food supply in the impoundment area.

It is expected that Baird's Tapir would avoid the immediate dam vicinity during construction. As water levels rise and the riparian shrubland is incrementally lost, tapirs (and many other species) will attempt to relocate in search of new food sources. Although habitats suitable for tapirs exists along other major creeks and rivers in the Chiquibul Forest, in most cases these are occupied by other individuals with established territories. Individuals will probably co-exist in the wet season, whilst sufficient food is available, but as it becomes critical in the dry season it is anticipated that the majority of individuals will make their way down-river in search of food in areas less productive than the Upper Macal and Raspaculo, eventually coming into contact with human settlements and being subjected to increased hunting. Any costly efforts to rescue individuals and relocate them would have little effect on the overall viability of the local population.

The project may significantly affect the food supply for Morelet's Crocodile, causing losses of fish populations and smaller wildlife occurring in riparian thicket vegetation (Meerman 1999a). Water levels, both within the reservoir and the run between Chalillo and Mollejon Dams, will fluctuate greatly and frequently (AGRA CI Power 1999). Given their breeding behaviour, the crocodiles will be unable to reproduce under these circumstances. Barren areas may be created along the shoreline of the reservoir, limiting available cover for the species. The dam itself is likely to form a barrier to the movement of crocodiles between upstream and downstream areas. Meerman (1999b) observed three crocodiles using the relatively small reservoir of the Mollejon Dam. He noted that there was little vegetation along the immediate shoreline, and the steeper shorelines of the reservoir are coated with mud, indicating sedimentation during fluctuating water levels. These conditions are unlikely to be favourable to crocodiles, particularly in the larger impoundment zone created by Chalillo.

It is predicted that the Scarlet Macaw population will be impacted by direct loss of habitat, food source and nesting sites, and by increased access by hunters and poachers. The creation of similar habitat conditions elsewhere to compensate for these losses is unlikely to succeed due to the sensitivity of the subspecies to artificial nesting sites and complex reproductive behaviour (Renton pers. comm.). Protection and enhancement of the remainder of Chiquibul Forest Reserve, where known food sources exist, will in the short term provide sanctuary for the species. However, it is predicted that by the following dry season few if any birds will breed and by the end of the dry season the population will be in serious decline, being unable to find adequate or sufficient food in the critical months. It is therefore likely that they will eventually become extirpated from Belize. If this situation is accepted and the project proceeds, it would be reasonable to expect the dam owners to assume financial responsibility for studies and protective measures aimed at Scarlet Macaw conservation in Guatemala, to help conserve the species at a regional level.

Julian's Mountain Frog has limited distribution, occurring only in the swift-flowing, rocky streams that drain the Maya Mountains. It is expected that they, and many other species dependent on fast-flowing habitat, will become locally extinct.

The loss of food sources and nesting sites within the impoundment zone will effect other species. It is anticipated that local populations of Black Howler Monkey, Spider Monkey, Jaguar, Margay and Ocelot will attempt to relocate to other less suitable habitats in the Chiquibul, increasing demand for food sources that are likely to become critical during the following dry season.

Migrant birds transiting the Central American isthmus between North and South America will be impacted though this loss of habitat and from the human disturbance associated with the project. This impact will be major, long-term and regional in extent.

The probable infestation of the impoundment by aquatic weeds (including algae and cyanobacteria) may lead to significant degradation of dissolved oxygen concentrations, due to increased productivity of those plants. In extreme cases, water may become anoxic, leading to the generation of toxic and noxious compounds (e.g. methane, hydrogen sulfide). This will have an adverse effect on aquatic wildlife and the quality of water supplies for human populations living down river.

Other factors that may lead to problems with dissolved oxygen concentrations in the reservoir include decomposition of vegetation and discharge of sanitary wastes from the construction site into the reservoir. A common measure to prevent low dissolved oxygen concentrations during the first years of operation of new impoundments is to clear the impoundment zone prior to inundation. Due to the large volume of vegetation, the morphology of the river and the lack of merchantable timber in the impoundment zone, this operation is likely to be prohibitively expensive. However, any decision to clear the impoundment zone of vegetation should be made on the basis of valid determination of the anticipated dissolved oxygen regime and its effect on aquatic species, rather than financial viability.

It is considered that the most significant and far-reaching impact will be at the landscape level over a broad geographic area. For some species, such as Jaguar and Baird's Tapir, the resulting habitat fragmentation will likely impact on regional conservation efforts far beyond the river valleys and indeed beyond the borders of Belize. The value of this large contiguous block of land in Belize can clearly be seen from regional corridor maps.

4.6 OPERATION PHASE

Following impoundment, it is very likely that operational requirements designed to maximise electrical generation may exacerbate shoreline erosion through the scrubbing action of the resulting variable water level fluctuations. Some vegetation and wildlife may adapt to the new conditions created where these fluctuations are minimal in the upper reaches of the impoundment zone. However, in the main reservoir area between Chalillo and MSC (Macal) and MSP (Raspaculo), barren areas of impenetrable sediments along the immediate shoreline will likely develop. Therefore, vegetation will be unable to re-colonise, limiting the value of the habitat to support wildlife. It will be important to establish a long-term wildlife-monitoring programme to determine the ability of vegetation and wildlife to re-colonise over time throughout the impoundment zone.

Mitigation for this impact should be aimed at minimizing the magnitude of the daily fluctuation by ensuring release simulates natural flow regimes on a seasonal basis. In reality, however, it is expected that water levels, both within the reservoir and in the run between Chalillo and the Mollejon Dam, will unavoidably fluctuate greatly on a daily and seasonal basis.

Operations of Chalillo should be modified to improve river migration conditions for fish. During the juvenile fish migration, water could be spilled and flows augmented to aid migration. Water released from a dam should not come from the bottom of the reservoir, where temperatures will be much colder than normal, potentially impacting native fish populations by disrupting the natural conditions and pattern of flow vital in life history stages such as migrations, spawning and feeding. Sufficient volume of flow should be maintained at all times, and zero discharge from the dam should be avoided at all costs. The impact associated with temperature of water can be mitigated if water is released from higher levels in the reservoir and at times and durations that reflected natural flows. Construction of an outlet structure near the surface of the impoundment would release water more reflective of natural conditions.

Lastly, it is important to monitor impacts over time. One of the most serious information gaps is the lack of follow-up information on the environmental and biodiversity impacts following the construction of Mollejon Dam, which have seriously impaired our attempts to assess its impact on wildlife. If the Chalillo Dam is constructed one, five, 10, 15, 20 and 25 year follow-up studies on the impact of the project should be made obligatory.

Table 12: Mitigation During Construction Phase (see Table 7 for Key to Residual Impact Terms)

Project Activity	Potential Impact	Mitigation Measure	Wildlife Affected	Residual Impact
Transportation of construction materials	loss of wildlife through road kill	safe and clear guidelines to drivers	All	3/D/MT/Loc
Road construction: influx of construction influx of general public	increased hunting and illegal settling	siting of roads and other facilities to avoid sensitive habitats prohibit all hunting and settling in area; decision to be enforced by GOB agency	SM/BT/MC SRO/WTD BD/WP	2/D/LT/Loc
site clearing and burning	increased fire risk	produce fire protection and management plan in consultation with GOB agency	All terrestrial	2/D/MT/Reg
transmission lines	potential barrier with loss of canopy to certain species	not identified; need to conduct separate EIA	TBA	TBA
river diversion	downstream changes in ecological function	maintain environmental flow of at least $21m^3/s$	Aquatic invertebrate	3/D/LT/Reg

Table 13: Mitigation During Impoundment Phase

Project Activity	Potential Impact	Mitigation Measure	Wildlife Affected	Residual Impact
Flooding	loss of riparian habitat	none possible	All	1/D/LT/Int
Flooding	loss of individual species	none possible	All	1/D/LT/Nat
Flooding	loss of population viability	none possible	SM	1/D/LT/Int

Table 14: Mitigation During Operation Phase

Project Activity	Potential Impact	Mitigation Measure	Wildlife Affected	Residual Impact
water level fluctuations	downstream impacts	maintain seasonality of flow	Fish and aquatic life	2/D/MT/Loc
infestation by aquatic weeds decomposition of natural vegetation	changes in dissolved gas regime production of toxic chemicals	re-aerate water before release down-stream none possible	Fish and aquatic life	2/D/LT/Loc
sedimentation	creation of turbid conditions	periodic dredging/periodic flushing	Fish and aquatic life	3/D/ST/Loc
thermal stratification	thermal stratification downstream effect on life cycles	release water from top of reservoir	Fish and aquatic life	2/D/LT/Reg
all operational activities	all operational impacts	long-term monitoring of all relevant biological parameters	All	To be assessed

5. CONCLUSIONS

The Macal and Raspaculo watershed is undoubtedly a biologically rich and diverse region, preserved by its remoteness from human disturbance and the key ecological roles played by its rivers. Because of the isolated nature of this area, wildlife populations in and around the watershed appear to have remained healthy and robust.

The rare floodplain habitat, classified as "riparian shrubland in hills" (Meerman 1999), is confirmed as being a lush seasonal food source for several herbivores who in turn support healthy populations of predators. Indeed, we conclude that the riparian habitat is crucial to the continued sustenance and health of individuals of IUCN recognised endangered species such as the Jaguar (*Panthera onca goldmani*), Neotropical Otter (*Lutra longicaudus annectens*), Baird's Tapir (*Tapirus bairdii*), Morelet's Crocodile (*Crocodylus moreletii*), the subspecies of Scarlet Macaw (*Ara macao cyanoptera*), and the endemic Julian's Mountain Frog (*Rana juliani)*.

We also conclude that:

- the riparian shrubland is a critical habitat for local populations of Baird's Tapir during the dry season, due to the ample amount of herbaceous vegetation found in the floodplain habitat.

- juvenile populations of Morelet's Crocodile found in the region are large relative to adults, suggesting that this is an important breeding area for this species.

- the entire profile of the floodplain habitat of the watershed is crucial to the continued sustenance and population viability of a unique Scarlet Macaw subspecies (*Ara macao cyanoptera*), providing the last remaining habitat for an isolated population of an estimated 60-100 individual birds.

- the habitat acts as an important transit location for migrant avifauna from North America.

Furthermore, we confirm the presence of additional species, recognized as regionally, nationally or globally significant, including Solitary Eagle, Ornate Hawk-Eagle, Ocellated Turkey, Crested Guan, Great Curassow, Brown-hooded Parrot, Keel-billed Motmot, Howler Monkey, Spider Monkey, White-lipped Peccary and Julian's Mountain Frog.

For these reasons we conclude that the Macal River Upper Storage Facility is likely to cause 80% (Penn & Sutton in press) of the riparian shrubland to be lost and numerous individual animals to die, most probably forcing the local extinction (extirpation) of some species of internationally important conservation concern.

Although the immediate impact of habitat loss will be significant for the species mentioned, we predict that the impacts of the project will be much greater in the surrounding landscape, reaching considerably beyond the localized area of the dam and its impoundment. The watershed constitutes part of the Selva Maya, which is now recognized as the largest contiguous block of forestland remaining in Central America (Miller pers. comm.). As habitat loss accelerates in neighbouring countries, large intact blocks of wild space are becoming increasingly scarce, making the conservation of this habitat regionally imperative.

6. RECOMMENDATIONS

The Environmental Protection Act (1992) of Belize states that: *"Every project, programme or activity shall be assessed with a view to the need to protect and improve human health and living conditions and the need to preserve the reproductive capacity of ecosystems as well as the diversity of species."*

Few if any environmental impact assessments in Belize have addressed impacts on the scale of this project so there is little information on mitigation that is specific for the country (or indeed for the region) with regard to large dams; this fact is evident in the Mitigation section of this report. However, the World Commission on Large Dams Report (2000) concluded that the negative impacts identified for wildlife associated with dams are usually irreversible and that mitigation efforts are often ineffective.

We conclude by applying wildlife conservation criteria to three fundamental options:

1. **Do not build the Chalillo dam**.

2. **Select an alternative site for damming** (preferably damming one or more tributaries instead of main rivers).

3. **Proceed as planned** (but design and operate the dam more carefully and more expensively to minimize ecosystem damage, subsequently implementing any ecosystem correction measures judged likely to achieve at least moderate success).

The most obvious opportunity to avoid profound impacts on key aquatic and terrestrial wildlife is not to construct the dam. This option should be considered seriously, especially if costs identified in reviews of the technical, socio-economic and environmental assessments and feasibility studies are considered to outweigh the benefits of meeting the growing demand and utilization of electrical energy by increasingly criticised hydroelectric projects.

Based on the rarity of the habitat to be inundated, and the dependence on this habitat by several endangered species, the **"No Build"** option is highly recommended as the most suitable and appropriate option for the long-term viability and conservation of wildlife in Belize.

A number of tributaries in the Mountain Pine Ridge have been identified (N. Bol pers. comm.) that, if dammed, could potentially supply the required volume of water to the existing dam at Mollejon**,** reducing the impact by inundation on the floodplain habitat and associated wildlife. This **"Alternative Site"** option could in theory ensure that the natural riparian habitat of the watershed remains biologically rich and ecologically functional while addressing the increasing demand for cheaper electricity. However, it would of course require technical, economic and environmental surveys far more rigorous than those applied thus far to the Chalillo site.

Under the **"Proceed as Planned"** option, it has become clear that it will not be possible to satisfactorily mitigate against most of the long-term impacts on the biodiversity associated with habitat loss if the dam is constructed as planned. Equally, it will not be possible to mitigate against the long-term impacts at a landscape or regional level. However, if this option is selected, identified measures to partially alleviate some of the short-term local impacts during construction and operation phases identified in the previous section should follow best practices for environmentally sensitive management of dam construction and operation.

If the dam is built it should be explicitly recognised that incorporating mitigation and compensation measures into large dams often fails because developers/owners may initially agree to implement various mitigation or compensation programs but then do not implement the programs at the appropriate time during the construction or operation of the project. Often, they view the measures as unnecessary or find that they do not have the capacity to implement mitigation measures. Thus, if construction proceeds, legal compliance agreements (and mechanisms for redress in the event of non-compliance) should be established at an early planning stage.

It is also essential to engage a wide range of environmental experts at early stages and high levels of the planning process, as well as during construction, impoundment and operation phases. Belize is fortunate to have access to a pool of native and non-native environmental scientists from various government and non-government organizations that collectively have considerable expertise in the taxonomic, ecological and environmental management of the watershed. Many have expressed their willingness to become actively involved in such assessments.

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Annex A

Complete Species and Observations List

MAMMAL SPECIES RECORDED IN THE MACAL RASPACULO WATERSHED

CLASS Mammalia

Family	***Species***
Didelphidae	*Common Opossum Didelphis marsupialis tabascensis*
	Virginia opossum Didelphis virginiana
	Gray four-eyed opossum Philander opossum pallidus
	Water opossum Chironectes minimus argyrodytes
	Mexican mouse opossum Marmosa mexicana mayensis
	Robinson's mouse opossum Marmosa robinsoni ruatanica
	Alston's mouse opossum Micoureus alstoni nicaraguae
	Central American Woolly Opossum Caluromys derbianus fervidus
Myrmecophagidae	*Giant anteater Myrmecophaga tridactyla centralis*
	Tamandua Tamandua m. mexicana
	Silky anteater--Cyclopes didactylus mexicanus
Dasypodidae	*Northern Naked-tailed Armadillo Cabassous centralis*
	Nine-banded armadillo Dasypus novemcinctus mexicanus
Sorcidae	*Blackish small-eared shrew Cryptotis mayensis*
	Least shrew Cryptotis parva tropicalis
Cebidae	*Black howler monkey Alouatta p. pigra*
	Spider monkey Ateles geoffroyi

Sciuridae	
	Variegated squirrel Sciurus variegatoides
	Deppe's squirrel Sciurus deppei vivax
Geomidae	*Hispid pocket gopher Orthogeomys hispidus*
Heteromyidae	*Gaumer's spiny pocket mouse Heteromys gaumeri*
	Desmarest's spiny pocket mouse Heteromys d. desmarestianus
Muridae	*Marsh rice rat Oryzomys couesi*
Sigmodontinae	*Marsh rice rat Oryzomys couesi pinicola*
Subfamily Murinae	*Brown rat-- Rattus rattus*
	Norway rat--Rattus norvegicus
	House mouse-- Mus musculus brevirostris
Erethizontidae	*Mexican porcupine Sphiggurus m. mexicanus*
Dasyproctidae	*Agouti Dasyprocta punctata*
Agoutidae	*Paca Agouti paca nelsoni*
Leporidae	*Forest rabbit Sylvilagus brasiliensis truei*
Canidae	*Coyote Canis latrans goldmani*
	Gray fox Urocyon cinereoargenteus fraterculus

Procyonidae	*Cacomistle Bassariscus sumichrasti* *Raccoon Procyon lotor shufeldti* *White nosed Coati Nasua narica* *Kinkajo Potos flavus chiriquensis*
Mustelidae	*Long-tailed weasel Mustela frenata perda* *Grison Galictis vittata canaster* *Tayra Eira barbara senex* *Spotted skunk Spilogale putorius yucatanensis* *Hog-nosed skunk Conepatus mesoleucus* *Striped hog-nosed skunk Conepatus semistriatus yucatanicus* *Neotropical River Otter Lontra longicaudis annectens*
Felidae	*Ocelot Leopardus p. pardalis* *Margay Leopardus wiedii yucatanica* *Jaguarundi Herpailurus yagouaroundi fossata* *Puma Puma concolor mayensis* *Jaguar Panthera onca goldmani*
Tapiridae	*Baird's tapir Tapirus bairdii*
Tayassuidae	*Collared peccary Pecari tajacu* *White-lipped peccary Tayassu pecari ringens*
Cervidae	*White-tailed deer-- Odocoileus virginianus truei* *Red brocket deer--Mazama americana*

BIRD SPECIES RECORDED IN MACAL RASPACULO WATERSHED

AVIFAUNA

FAMILY	SPECIES	COMMON NAME	STATUS	KEY
TINAMIDAE	TINAMOUS			
	Crypturellus soui	Little Tinamou	PR	***PR - Permanent Resident***
	Crypturellus boucardi	Slaty-breasted Tinamou	PR	***WR - Winter Resident***
				SR - Summer Resident
PODICEPEDIDAE	GREBES			***T - Transient***
	Tachybaptus dominicus	Least Grebe	PR	
ARDEIDAE	BITTERNS and HERONS			
	Egretta caerualea	Little Blue Heron	WR	
	Butorides striatus	Green-backed Heron	PR	
	Nycticorax sp.	Night-Heron sp.	PR	
CATHARTIDAE	AMERICAN VULTURES			
	Cathartes aura	Turkey Vulture	PR	
	Sarcoramphus papa	King Vulture	PR	
ACCIPITRIDAE	KITES, EAGLES, HAWKS and ALLIES			
	Leptodon cayanensis	Gray-headed Kite	PR	
	Elanoides forficatus	American Swallow-tailed Kite	SR	
	Harpagus bidentatus	Double-toothed Kite	PR	

	Buteogallus urubitinga	Great Black-Hawk	PR
	Spizaetus tyrannus	Black Hawk-Eagle	PR
	Spizaetus ornatus	Ornate Hawk-Eagle	PR
FALCONIDAE	CARACARAS and FALCONS		
	Micrastur ruficollis	Barred Forest-Falcon	PR
	Micrastur semitorquatus	Collared Forest-Falcon	PR
	Falco rufigularis	Bat Falcon	PR
CRACIDAE	CURASSOWS and GUANS		
	Ortalis vetula	Plain Chachalaca	PR
	Penelope purpurascens	Crested Guan	PR
	Crax rubra	Great Curassow	PR
PHASIANIDAE	TURKEYS and QUAIL		
	Odontophorus thoracicus	Spotted Wood-Quail	PR
RALLIDAE	RAILS, GALLINULES and COOTS		
	Aramides cajanea	Gray-necked Wood-rail	PR
COLUMBIDAE	PIGEONS and DOVES		
	Columba speciosa	Scaled Pigeon	PR
	Columba nigrirostris	Short-billed Pigeon	PR
	Claravis pretiosa	Blue Ground-Dove	PR
	Leptotila cassinii	Gray-chested Dove	PR
PSITTACIDAE	PARROTS		

	Ara macao	Scarlet Macaw	PR
	Amazona albifrons	White-fronted Parrot	PR
	Amazona farinosa	Mealy Parrot	PR
CUCULIDAE	CUCKOOS and ALLIES		
	Piaya cayana	Squirrel Cuckoo	PR
STRIGIDAE	TYPICAL OWLS		
	Otus guatamalae	Vermiculated Screech-Owl	PR
	Pulsatrix perspicillata	Spectacled Owl	PR
	Glaucidium minutissimum	Least Pygmy-Owl	PR
	Glaucidium brasilianum	Ferrugious Pygmy-Owl	PR
	Ciccaba virgata	Mottled Owl	PR
CAPRIMULGIDAE	GOATSUCKERS		
	Nyctidromus albicollis	Common Pauraque	PR
APODIDAE	SWIFTS		
	Chaetura vauxi	Vaux's Swift	PR
TROCHILIDAE	HUMMINGBIRDS		
	Phaethornis superciliosus	Long-tailed Hermit	PR
	Phaethornis longuemareus	Little Hermit	PR
	Campylopterus curvipennis	Wedge-tailed Sabrewing	PR
	Campylopterus hemileucurus	Violet Sabrewing	PR
	Amazilia candida	White-bellied Emerald	PR
	Amazilia tzacatl	Rufous-tailed Hummingbird	PR

TROGONIDAE	TROGONS		
	Trogon violaceus	Violaceous Trogon	PR
	Trogon collaris	Collared Trogon	PR
	Trogon massena	Slaty-tailed Trogon	PR
MOTMOTIDAE	MOTMOTS		
	Hylomanes motmotula	Tody Motmot	PR
	Motmotus motmota	Blue-crowned Motmot	PR
	Electron carinatum	Keel-billed Motmot	PR
ALCEDINIDAE	KINGFISHERS		
	Chloroceryle amazona	Amazon Kingfisher	PR
	Chloroceryle americana	Green Kingfisher	PR
BUCCONIDAE	PUFFBIRDS		
	Malacoptila panamensis	White-whiskered Puffbird	PR
GALBULIDAE	JACAMARS		
	Galbula ruficauda	Rufous-tailed Jacamar	PR
RAMPHASTIDAE	TOUCANS		
	Aulacorhynchus prasinus	Emerald Toucanet	PR
	Pteroglossus torquatus	Collared Aracari	PR
	Ramphastos sulfuratus	Keel-billed Toucan	PR
PICIDAE	WOODPECKERS		

	Melanerpes pucherani	Black-cheeked Woodpecker	PR
	Melanerpes pygmaeus	Red-vented Woodpecker	PR
	Melanerpes aurifrons	Golden-fronted Woodpecker	PR
	Veniliornis fumigatus	Smoky-brown Woodpecker	PR
	Piculus rubiginosus	Golden-olive Woodpecker	PR
	Celeus castaneus	Chestnut-colored Woodpecker	PR
	Dryocopus lineatus	Lineated Woodpecker	PR
	Campephilus guatamalensis	Pale-billed Woodpecker	PR
FURNARIIDAE	OVENBIRDS		
	Synallaxis erythrothorax	Rufous-breasted Spinetail	PR
	Automolus ochrolaemus	Buff-throated Foliage-gleaner	PR
	Xenops minutus	Plain Xenops	PR
	Sclerurus guatamalensis	Scaly-throated Leaftosser	PR
DENDROCOLAPTIDAE	WOODCREEPERS		
	Dendrocincla anabatina	Tawny-winged Woodcreeper	PR
	Dendrocincla homochroa	Ruddy Woodcreeper	PR
	Sittasomus griseicapillus	Olivaceous Woodcreeper	PR
	Glyphorynchus spirurus	Wedge-billed Woodcreeper	PR
	Xiphocolaptes promeropirhynchus	Strong-billed Woodcreeper	PR
	Dendrocolaptes certhia	Barred Woodcreeper	PR
	Xiphorynchus erythropygius	Ivory-billed Woodcreeper	PR
	Lepidocolaptes souleyettii	Streak-headed Woodcreeper	PR
FORMICARIIDAE	ANTBIRDS		

	Taraba major	Great Antshrike	PR
	Thamnophilus punctatus	Barred Antshrike	PR
	Thamnistes anabatinus	Russet Antshrike	PR
	Microrhopias quixensis	Dot-winged Antwren	PR
	Ceromacra tyrannina	Dusky Antbird	PR
	Formicarius analis	Black-faced Antthrush	PR
TYRANNIDAE	TYRANT FLYCATCHERS		
ELAENIINAE	TYRANNULETS, ELAENIAS and ALLIES		
	Ornithion semiflavum	Yellow-bellied Tyrannulet	PR
	Mionectes oleagineus	Ochre-bellied Flycatcher	PR
	Leptopogon amaurocephalus	Sepia-capped Flycatcher	PR
	Oncostoma cinereigulare	Northern Bentbill	PR
	Todirostrum sylvia	Slate-headed Tody-Flycatcher	PR
	Rhynchocyclus breviostris	Eye-ringed Flatbill	PR
	Tolmomyias sulphurescens	Yellow-olive Flycatcher	PR
	Platyrinchus cancrominus	Stub-tailed Spadebill	PR
FLUVICOLIINAE	FLUVICOLINE FLYCATCHERS		
	Onychorhynchus coronatus	Royal Flycatcher	PR
	Myiobius sulphureipygius	Sulphur-rumped Flycatcher	PR
	Contopus borealis	Olive-sided Flycatcher	T
	Empidonax flaviventris	Yellow-bellied Flycatcher	T&WR
	Empidonax virescens	Acadian Flycatcher	T&WR
	Empidonax trailii	Willow Flycatcher	T
	Empidonax minimus	Least Flycatcher	T&WR
	Sayornis phoebe	Black Phoebe	PR

TYRANNINAE	TYRANNINE FLYCATCHERS		
	Attila spadiceus	Bright-rumped Attila	PR
	Rhytipterna holerythra	Rufous Mourner	PR
	Myiarchus tuberculifer	Dusky-capped Flycatcher	PR
	Myiarchus crinitus	Brown-crested Flycatcher	PR
	Pitangus sulphuratus	Great Kiskadee	PR
	Megarhynchus pitangua	Boat-billed Flycatcher	PR
	Myiozetetes similis	Social Flycatcher	PR
	Legatus leucophaius	Piratic Flycatcher	PR
TITYRINAE	TITYRAS AND BECARDS		
	Pachyramphus cinnamomeus	Cinnamon Becard	PR
	Pachyramphus polychopterus	White-winged Becard	PR
	Pachyramphus aglaiae	Rose-throated Becard	PR
	Tityra semifasciata	Masked Tityra	PR
PIPRIDAE	MANAKINS		
	Schiffornis turdinus	Thrushlike Manakin	PR
	Manacus candei	White-collared Manakin	PR
	Pipra mentalis	Red-capped Manakin	PR
CORVIDAE	JAYS		
	Cyanocorax yncus	Green Jay	PR
	Cyanocorax morio	Brown Jay	PR
TROGLODYTIDAE	WRENS		

	Campylorhynchus zonatus	Band-backed Wren	PR
	Thryothorus maculipectus	Spot-breasted Wren	PR
	Henicorhina leucosticta	White-breasted Wood-Wren	PR
	Microcerculus philomela	Nightingale Wren	PR
MUSCICAPIDAE	MUSCICAPIDS		
SYLVIINAE	GNATCATCHERS		
	Ramphocaenus melanurus	Long-billed Gnatwren	PR
	Polioptila caerulea	Blue-gray Gnatcatcher	P&WR
	Polioptila plumbea	Tropical Gnatcatcher	PR
TURDINAE	SOLITAIRES, THRUSHES and ALLIES		
	Hylocichla mustelina	Wood Thrush	T&WR
	Turdus grayi	Clay-colored Robin	PR
	Turdus assimilis	White-throated Robin	PR
MIMIDAE	MOCKINGBIRDS		
	Dumetella carolinensis	Gray Catbird	T&WR
VIREONIDAE	VIREOS		
	Vireo flavifrons	Yellow-throated Vireo	T&WR
	Hylophilus ochraceiceps	Tawny-crowned Greenlet	PR
	Hylophilus decurtatus	Lesser Greenlet	PR
	Vireolanius pulchellus	Green Shrike-Vireo	PR
EMBERIZIDAE	EMBERIZIDS		
PARULINAE	WOOD WARBLERS		

	Vermivora pinus	Blue-winged Warbler	T&WR
	Dendroica pensylvancia	Chestnut-sided Warbler	T
	Dendroica magnolgia	Magnolia Warbler	T&WR
	Dendroica virens	Black-throated Green Warbler	T&WR
	Mniotilta varia	Black-and-white Warbler	T&WR
	Setophaga ruticilla	American Redstart	T&WR
	Protonotaria citrea	Prothonotary Warbler	T&WR
	Helmitheros vermivorus	Worm-eating Warbler	T&WR
	Seiurus aurocapillus	Ovenbird	T&WR
	Seiurus noveboracensis	Northern Waterthrush	T&WR
	Seiurus motacilla	Louisiana Waterthrush	T&WR
	Oporornis formosus	Kentucky Warbler	T&WR
	Geothlypis trichas	Common Yellowthroat	T&WR
	Wilsonia citrina	Hooded Warbler	T&WR
	Wilsonia pusilla	Wilson's Warbler	T&WR
	Basileuterus culicivorus	Golden-crowned Warbler	PR
	Icteria virens	Yellow-breasted Chat	T&WR
COEREBINAE	BANANAQUITS		
	Coereba flaveola	Bananaquit	PR
THRAUPINAE	TANAGERS		
	Tangara larvata	Golden-Masked Tanager	PR
	Chlorophanes spiza	Green Honeycreeper	PR
	Cyanerpes cyaneus	Red-legged Honeycreeper	PR
	Euphonia gouldi	Olive-backed Euphonia	PR
	Thraupis abbas	Yellow-winged Tanager	PR

	Lanio aurantius	Black-throated Shrike Tanager	PR
	Habia rubica	Red-crowned Ant-Tanager	PR
	Habia fuscicauda	Red-throated Ant-Tanager	PR
	Piranga rubra	Summer Tanager	T&WR
	Piranga leucoptera	White-winged Tanager	PR
	Ramphocelus sanguinolentus	Crimson-collared Tanager	PR
	Ramphocelus passerinii	Scarlet-rumped Tanager	PR
CARDINALINAE	CARDINALS and ALLIES		
	Saltator coerulescens	Buff-throated Saltator	PR
	Saltator atriceps	Black-headed Saltator	PR
	Caryothraustes poliogaster	Black-faced Grosbeak	PR
	Cyanocompsa cyanoides	Blue-black Grosbeak	PR
EMBERIZINAE	EMBERIZINES		
	Arremon aurantiirostris	Orange-billed Sparrow	PR
	Arremonops chloronotus	Green-backed Sparrow	PR
ICTERINAE	BLACKBIRDS and ALLIES		
	Dives dives	Melodius Blackbird	PR
	Icterus dominicensis	Black-cowled Oriole	PR
	Icterus mesomelas	Yellow-tailed Oriole	PR
	Icterus galbula	Northern Oriole	T&WR
	Amblycercus holosericeus	Yellow-billed Cacique	PR
	Psarocolius montezuma	Montezuma Oropendola	PR

AMPHIBIANS REPTILES RECORDED IN MACAL AND RASPACULO WATERSHED

CLASS AMPHIBIA

ORDER	FAMILY	*SPECIES*
Gymnophiona	**Caeciliade**	*Caecilian Gymnopis syntrema*
Caudata	**Plethodontidae**	*Galliwasp Bolitoglossa mexicana*
Anura	**Rhinophrynidae**	Mexican Burrowing Toad *Rhinophyrnus dorsalis*
	Leptodactylidae	Black-backed Frog *Leptodactylus melanonotus* Broad-headed Rainfrog *Eleutherodactylus laticeps* Chac's Rainfrog *Eleutherodactylus chac* Limestone Rainfrog *Eleutherodactylus psephosypharus* Rugulose Rainfrog *Eleutherodactylus rugulosus*
	Bufonidae	Rainforest Toad *Bufo campbelli* Marine Toad *Bufo marinus* Gulf Coast Toad *Bufo valliceps*
	Hylidae	Blue-spotted Treefrog *Smilisca cyanosticta* Bromeliad Treefrog *Hyla bromeliaca* Mexican Treefrog *Smilisca baudinii* Morelet's Leaf Frog *Agalychnis moreletii* Red-eyed Leaf Frog *Agalychnis callidryas* Veined Treefrog *Phrynohyas venulosa*

	Ranidae	Rio Grande Leopard Frog *Rana berlandieri* Maya Mountains Frog *Rana juliani* Masked Mountain Frog *Rana maculata* Vaillant's Frog *Rana vaillanti*
CLASS REPTILA		
Crocodylia	**Crocodylidae**	Morelet's Crocodile *Crocodylus moreletii*
	Kinosternidae	White-lipped Mud Turtle *Kinosternon leucostomum*
Suborder Sauria	**Eublepharidae**	*Escorpion Coleonyx elegans*
	Corytophanidae	Striped Basilisk *Basiliscus vittatus* Old Man *Corytophanes cristatus* Casque-headed Iguana *Laemanctus longipes*
	Iguanidae	Green Iguana *Iguana iguana*
	Polychrotidae	*Anolis verde Anolis biporcatus* *Anole Anolis lemurinus* *Lagartija chipojo Anolis rodriguezii* Lesser scaly Anole *Anolis uniformis*
	Scincidae	*Sumichrast's skink Eumeces sumichrasti* *Ground skink Sphenomorphus cherriei*

	Teiidae	*Lagartija parda Ameiva festiva*
Suborder Serpentes	**Bioidae**	*Imperial Boa Boa constrictor*
	Colubridae	*Culebra zacatera Adelphicos quadrivirgatus*
		Mussurana Clelia clelia
		Culebra panza amarilla Coniophanes fissidens
		Black-naped forest racer Dendrophidion nuchale
		Dryad snake Dryadophis melanolomus
		Black-tailed indigo snake Drymarchon corais
		Blunt-headed tree snake Imantodes cenchoa
		Tropical kingsnake Lampropeltis triangulum
		Cat-eyed snake Leptodeira septentrionalis
		Green tree snake Leptophis ahaetulla
		Green-headed snake Leptophis mexicanus mexicanus
		Mexican green tree snake Leptophis mexicanus hoeversi
		Tropical whipsnake Masticophis mentovarius
		Ring-necked coffee snake Ninia diademata
		Red coffee snake Ninia sebae
		Red-banded snake Oxyrhopus petola
		Shovel-toothed snake Scaphiodontophis annulatus
		Scorpion-eating snake Stenorrhina freminvillei
		Yucatan centipede snake Tantilla schistosa
		Yucatan dwarf short-tailed snake Tantillita lintoni
		False coral Urotheca elapoides
		False Fer-de-lance Xenodon rabdocephalus
	Elapidae	*Many-ringed coral snake Micrurus diastema*

Viperidae	*Jumping pitviper Atropoides nummifer* *Eyelash palm pitviper Bothriechis schlegelii* *Fer-de-lance Bothrops asper*

SCARLET MACAW SIGHTINGS Jan 2000 - Jan 2001

ZONE	*SPECIES*	SITE ID	DATE	TIME	EVIDENCE	HABITAT	No.	NOTES
5	Scarlet Macaw *Ara macao*	MS12	5-Jan-00	9:15 AM	V	O	3	come from north
5	Scarlet Macaw *Ara macao*	MS16	6-Jan-00	11:30 AM	V	O	2	flew over monky tail camp going east
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-00	5:30 AM	V	O	4	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-00	6:30 AM	V	O	2	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-00	1:00 PM	V	O	4	come from north land on quam wood tree
5	Scarlet Macaw *Ara macao*	MS12	16-Jan-00	8:20 AM	V	O	2	in jobillo tree fly off south-west
5	Scarlet Macaw *Ara macao*	MS12	5-Feb-00	8:10 AM	V	O	2	flew south of cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Feb-00	5:15 AM	V	O	4	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Feb-00	6:10 AM	V	O	6	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS16	7-Feb-00	10:30 AM	V	O	4	seen at monky tail camp going east
5	Scarlet Macaw *Ara macao*	MS12	5-Mar-00	8:30 AM	V	O	2	flew south of cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Mar-00	6:00 AM	V	O	6	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Mar-00	1:30 PM	V	O	8	pitch on jobillo tree till 13:45
5	Scarlet Macaw *Ara macao*	MS12	5-Apr-00	7:15 AM	V	O	5	flew south of cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	6-Apr-00	5:00 AM	V	O	8	sitting on quam new maria
5	Scarlet Macaw *Ara macao*	MS12	7-Apr-00	5:45 AM	V	O	8	come from north land on quam wood tree
5	Scarlet Macaw *Ara macao*	MS12	7-Apr-00	6:10 AM	V	O	2	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	5-May-00	8:00 AM	V	O	2	come from east
5	Scarlet Macaw *Ara macao*	MS12	7-May-00	6:00 AM	V	O	2	come from the N/W pitch on fig tree
5	Scarlet Macaw *Ara macao*	MS16	7-May-00	6:30 AM	V	O	10	seen at monky tail camp going east
5	Scarlet Macaw *Ara macao*	MS12	4-Jun-00	11:00 AM	V	O	4	at monky tail camp
5	Scarlet Macaw *Ara macao*	MS12	5-Jun-00	8:30 AM	V	Fsd	2	land on jobillo tree then head off north
5	Scarlet Macaw *Ara macao*	MS12	5-Jul-00	6:30 AM	V	O	1	flew south of cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	9-Jul-00	7:30 AM	V	O	3	fly over cuevas going north
5	Scarlet Macaw *Ara macao*	MS12	1-Sep-00	7:25 AM	V	O	4	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS16	1-Sep-00	12:15 PM	V	O	4	flew over monky tail camp going south
5	Scarlet Macaw *Ara macao*	MS12	1-Sep-00	4:45 PM	V	O	2	were feeding bread nuts tree by tower road
5	Scarlet Macaw *Ara macao*	MS12	5-Oct-00	6:15 AM	V	O	3	flew south of cuevas going west

5	Scarlet Macaw *Ara macao*	MS12	9-Oct-00	9:00 AM	V	O	4	come from the N/E land on fig tree
5	Scarlet Macaw *Ara macao*	MS12	3-Nov-00	3:30 PM	V	O	2	flew over 50 hactar plot going N/E
5	Scarlet Macaw *Ara macao*	MS13	8-Nov-00	8:35 AM	V	Fsd	8	seen at new maria on cieba tree
5	Scarlet Macaw *Ara macao*	MS12	3-Dec-00	11:00 AM	V	O	2	south of cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	6-Dec-00	2:30 PM	V	O	4	flew over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Dec-00	5:50 AM	V	O	2	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS12	7-Dec-00	7:15 AM	V	O	2	fly over cuevas going west
5	Scarlet Macaw *Ara macao*	MS13	10-Dec-00	7:15 AM	V	O	4	at millionario on cabbage bark tree
5	Scarlet Macaw *Ara macao*	MS12	2-Jan-01	3:40 PM	V	O	1	circuling nest location
2	Scarlet Macaw *Ara macao*	MS7	6-Jan-01	5:10 PM	A	Fsd		squack
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-01	8:45 AM	V	O	2	Flying towards Monkey Tail
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-01	12:00 PM	V	O	2	Flying towards LCRS
5	Scarlet Macaw *Ara macao*	MS12	7-Jan-01	06:07 AM	V	O	2	Flying towards Monkey Tail
5	Scarlet Macaw *Ara macao*	MS12	8-Jan-01	12:00 PM	V	O	2	feeding on quamwood near LCRS
5	Scarlet Macaw *Ara macao*	MS12	8-Jan-01	5:20 PM	V	O	2	feeding on quamwood near LCRS
4	Scarlet Macaw *Ara macao*	MSP	10-Jan-01	8:20 AM	V	O	4	flying downstream towards Blue hole
4	Scarlet Macaw *Ara macao*	MS17	10-Jan-01	4:00 PM	V	O	4	flying downstream towards Blue hole
5	Scarlet Macaw *Ara macao*	MS16	11-Jan-01	6:00 AM	A	O		squawking
5	Scarlet Macaw *Ara macao*	MS12	11-Jan-01	10:48 AM	Nest	Fsd	2	appear to be looking for nest near LC Bird Tower
5	Scarlet Macaw *Ara macao*	MS16	16-Jan-01	7:27 AM	A	O		squawking
5	Scarlet Macaw *Ara macao*	MS16	16-Jan-01	3:00 PM	V	O	2	
5	Scarlet Macaw *Ara macao*	MS16	19-Jan-01	4:50 AM	V	O	2	
5	Scarlet Macaw *Ara macao*	MS17	23-Jan-01	7:00 AM	V	O	3	
4	Scarlet Macaw *Ara macao*	MSN	24-Jan-01	9:36 AM	V	O	2	
4	Scarlet Macaw *Ara macao*	MSQ	26-Jan-01	4:48 AM	V/A	Fsd	4	early morning squaking in tree
1	Scarlet Macaw *Ara macao*	MS1	30-Jan-01	9:30 AM	V	O	2	Flying North
3	Scarlet Macaw *Ara macao*	MSB	30-Jan-01	9:50 AM	V	O	2	Flying East
3	Scarlet Macaw *Ara macao*	MSB	30-Jan-01	3:20 PM	V	O	2	Flying East
1	Scarlet Macaw *Ara macao*	MS1	30-Jan-01	6:00 PM	V	O	2	Flying North
1	Scarlet Macaw *Ara macao*	MS1	31-Jan-01	9:50 AM	V	O	2	Flying East
3	Scarlet Macaw *Ara macao*	MSB	3-Feb-01	6:45 AM	V	O	4	Flying South
3	Scarlet Macaw *Ara macao*	MSB	3-Feb-01	7:15 AM	V	O	2	Flying Northeast

3	Scarlet Macaw *Ara macao*	MSB	3-Feb-01	5:00 PM	V	O	1	Flying East to West
3	Scarlet Macaw *Ara macao*	MSC	5-Feb-01	7:15 AM	V	O	2	Flying North-east
3	Scarlet Macaw *Ara macao*	MSC	5-Feb-01	2:35 PM	A	O		Squawking
3	Scarlet Macaw *Ara macao*	MSC	5-Feb-01	5:30 PM	V	O	2	Flying over campsite area
5	Scarlet Macaw *Ara macao*	MS12	6-Feb-01	7:00 AM	V	O	2	Flying East to West
5	Scarlet Macaw *Ara macao*	MS12	6-Feb-01	8:30 AM	V	O	2	Fly near LC Bird Tower East to West
2	Scarlet Macaw *Ara macao*	MS10	6-Feb-01	8:31 AM	V	Fsd	5	Came from East and land on Fig tree
5	Scarlet Macaw *Ara macao*	MS12	6-Feb-01	10:15 AM	V	O	2	Flying East to West
3	Scarlet Macaw *Ara macao*	MSA	6-Feb-01	3:30 PM	V	O	2	Flying South
3	Scarlet Macaw *Ara macao*	MSA	6-Feb-01	6:30 PM	V	O	4	flying north
2	Scarlet Macaw *Ara macao*	MS11	7-Feb-01	7:30 AM	V	O	2	Flying West
2	Scarlet Macaw *Ara macao*	MS11	7-Feb-01	8:15 AM	V	Fsd	5	in Quamwood
5	Scarlet Macaw *Ara macao*	MS13	7-Feb-01	12:00 PM	V	Fsd/O	4	Eating on Quamwood
5	Scarlet Macaw *Ara macao*	MS13	7-Feb-01	4:45 PM	V	Fsd/O	4	Eating on Schzalobium
3	Scarlet Macaw *Ara macao*	MSC	8-Feb-01	7:30 AM	V	O	3	Flying North-east
3	Scarlet Macaw *Ara macao*	MSC	8-Feb-01	7:40 AM	V	O	3	Flying South
5	Scarlet Macaw *Ara macao*	MS12	8-Feb-01	10:02 AM	V	O	1	Flying West to East
5	Scarlet Macaw *Ara macao*	MS12	8-Feb-01	12:00 PM	V	Fsd/O	2	Fly near LC Bird Tower West to East
5	Scarlet Macaw *Ara macao*	MS12	8-Feb-01	5:45 PM	V	Fsd/O	1	Flying East going South
3	Scarlet Macaw *Ara macao*	MSA	10-Feb-01	10:45 AM	V	O	2	
3	Scarlet Macaw *Ara macao*	MSA	11-Feb-01	3:00 PM	V	O	2	Flying East
3	Scarlet Macaw *Ara macao*	MSD	12-Feb-01	7:46 AM	V	Fsd	2	Perched on Sapodilla tree
3	Scarlet Macaw *Ara macao*	MSD	12-Feb-01	12:30 PM	V	O	6	Flying Southeast of river
3	Scarlet Macaw *Ara macao*	MSD	13-Feb-01	5:30 AM	V	O	2	Flying North-east
3	Scarlet Macaw *Ara macao*	MSD	13-Feb-01	6:00 AM	Nest	Nest		no observed SM activity but obvious nest
3	Scarlet Macaw *Ara macao*	MSD	13-Feb-01	8:00 AM	V	Nest	1	Flying West
3	Scarlet Macaw *Ara macao*	MSD	13-Feb-01	05:30	V	O	2	Flying North
3	Scarlet Macaw *Ara macao*	MSE	14-Feb-01	9:00 AM	V	O	2	
3	Scarlet Macaw *Ara macao*	MSE	14-Feb-01	11:30 AM	V	Fsd	2	Flying North
3	Scarlet Macaw *Ara macao*	MSE	14-Feb-01	12:45 PM	Nest	Nest		no observed SM activity but obvious nest
3	Scarlet Macaw *Ara macao*	MSE	14-Feb-01	4:00 PM	V	O	2	Flying North-East
3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	6:30 AM	V	O	22	Flying South

3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	8:45 AM	V	O	10	Flying North
3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	10:30 AM	V	Fsd	24	Feeding in tree (?)
3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	10:45 AM	V	O	6	Flying West
3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	1:45 PM	V	Rm	9	Feeding on Fig tree
3	Scarlet Macaw *Ara macao*	MSA	19-Feb-01	7:12 AM	V	Rm	2	Feeding on Cohune palm
3	Scarlet Macaw *Ara macao*	MSG	19-Feb-01	08:08	V	O	12	Flying Northeast
5	Scarlet Macaw *Ara macao*	MS16	25-Feb-01	5:30 PM	V	Fsd/O	2	Feeding on Schzalobium Flowers
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	6:45 AM	V	O	2	Flying East to West
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	8:00 AM	A	O		Squawking
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	8:30 AM	V	O	2	Flying west
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	11:00 AM	V	O	2	Flying South-West
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	4:30 PM	V	O	2	Flying East
5	Scarlet Macaw *Ara macao*	MS16	27-Feb-01	6.46 PM	V	O	1	Flying West
5	Scarlet Macaw *Ara macao*	MS16	28-Feb-01	10:30 AM	A	O		Squawking
5	Scarlet Macaw *Ara macao*	MS16	28-Feb-01	10:30 AM	A	O		Squawking
5	Scarlet Macaw *Ara macao*	MS16	28-Feb-01	1:15 PM	A	O		Squawking
5	Scarlet Macaw *Ara macao*	MS16	28-Feb-01	2:50 PM	A	O		Squawking
5	Scarlet Macaw *Ara macao*	MS16	28-Feb-01	4:45 PM	V	O	1	Flying Southwest
5	Scarlet Macaw *Ara macao*	MS16	1-Mar-01	9:30 AM	V	O	2	
5	Scarlet Macaw *Ara macao*	MS16	1-Mar-01	12:35 PM	V	O	2	
5	Scarlet Macaw *Ara macao*	MS16	1-Mar-01	1:45 PM	V	O	1	Flying West
5	Scarlet Macaw *Ara macao*	MS16	1-Mar-01	5:30 PM	V	O	2	Flying Northwest
5	Scarlet Macaw *Ara macao*	MS17	2-Mar-01	10:15 AM	V	Fsd	5	Feeding on Fig tree
5	Scarlet Macaw *Ara macao*	MS17	2-Mar-01	10:30 AM	V	O	6	Fly off from fig tree
5	Scarlet Macaw *Ara macao*	MS17	2-Mar-01	1:00 PM	V	Fsd	5	Flying Northwest
5	Scarlet Macaw *Ara macao*	MS17	2-Mar-01	4:15 PM	V	O	4	Flying West
5	Scarlet Macaw *Ara macao*	MS17	2-Mar-01	6:00 PM	V	Rm/O	6	Feeding on Fig tree
4	Scarlet Macaw *Ara macao*	MSN	3-Mar-01	7:00 AM	V	O	5	Feeding the Quamwood
4	Scarlet Macaw *Ara macao*	MSN	3-Mar-01	9:00 AM	V	O	6	Flying West
4	Scarlet Macaw *Ara macao*	MSN	3-Mar-01	12:00 PM	V	O	4	Flying Northwest
4	Scarlet Macaw *Ara macao*	MSN	3-Mar-01	6:00 PM	V	O	5	Flying Northeast
4	Scarlet Macaw *Ara macao*	MSN	12-Mar-01	9:15 AM	V	O	6	Flying high in sky going north/east

4	Scarlet Macaw *Ara macao*	MSN	12-Mar-01	10:30 AM	V	O	6	Flying down river
4	Scarlet Macaw *Ara macao*	MSN	12-Mar-01	10:30 AM	V	O	5	Flying East low
5	Scarlet Macaw *Ara macao*	MS12	15-Mar-01	6:00 AM	A	O		squawking
5	Scarlet Macaw *Ara macao*	MS12	15-Mar-01	8:30 AM	V	O	2	Flying South
5	Scarlet Macaw *Ara macao*	MS12	15-Mar-01	8:50 AM	V	R	2	circling around canopy
5	Scarlet Macaw *Ara macao*	MS12	15-Mar-01	9:00 AM	V	Fsd	2	Stayed five minutes around campus
5	Scarlet Macaw *Ara macao*	MS12	15-Mar-01	2:00 PM	V	O	2	Flying North
2	Scarlet Macaw *Ara macao*	MS7	19-Mar-01	11:45 AM	V	O	3	Flying East
2	Scarlet Macaw *Ara macao*	MS7	19-Mar-01	2:35 PM	V	O	3	Flying North
2	Scarlet Macaw *Ara macao*	MS9	20-Mar-01	8:55 AM	V	Fsd	13	Came from East and land on Fig tree
2	Scarlet Macaw *Ara macao*	MS8	20-Mar-01	10:00 AM	V	O	2	Flying West
2	Scarlet Macaw *Ara macao*	MS9	20-Mar-01	10:15 AM	V	O	4	Squawking overhead at canoe
2	Scarlet Macaw *Ara macao*	MS9	20-Mar-01	6:30 PM	V	O	12	Landed on Fig tree
5	Scarlet Macaw *Ara macao*	MS12	25-Mar-01	3:20 PM	V	Fsd/O	1	flying low
5	Scarlet Macaw *Ara macao*	MS12	27-Mar-01	10:30 AM	V	Fsd/O	1	
5	Scarlet Macaw *Ara macao*	MS12	27-Mar-01	1:45 PM	V	Fsd/O	1	flying low over canopy
5	Scarlet Macaw *Ara macao*	MS12	28-Mar-01	6:25 PM	V	O	1	flying east
5	Scarlet Macaw *Ara macao*	MS12	29-Mar-01	4:15 PM	V	O	1	flying towards Monkey Tail
1	Scarlet Macaw *Ara macao*	MS6	3-Apr-01	9:25 AM	V	Nest	1	2 x SM nesting in cavity of Quamwood
5	Scarlet Macaw *Ara macao*	MS12	6-Apr-01	7:12 AM	V	O	1	circling nest location

BAIRDS TAPIR (DRY SEASON)

ZONE	*SPECIES*	SITE ID	DATE	TIME	EVIDENCE	HABITAT	No.	AGE	SIZE	NOTES
1	*Baird's tapir Tapirus bairdii*	MS3	2-Jan	13.20	V	R	1		fg	wading across shallow water
2	*Baird's tapir Tapirus bairdii*	MS8	6-Jan	10.30	V/T/S	R	1	A		bathing on edge/tracks everywhere
2	*Baird's tapir Tapirus bairdii*	MS9	8-Jan	NR	V/T/S	Rm	1			brief sighting on single trail - scats found
3	*Baird's tapir Tapirus bairdii*	MSE	10-Jan	NR	T	Rm	many			on sand bar
5	*Baird's tapir Tapirus bairdii*	MS17	10-Jan	NR	V/T/S	R	1	A	fg	swimming across confluence
3	*Baird's tapir Tapirus bairdii*	MSF	11-Jan	6.00	V	Rm	1 (2)	A		saw adult but also heard young
3	*Baird's tapir Tapirus bairdii*	MSF	11-Jan	NR	T	Rm	many			trails everywhere
3	*Baird's tapir Tapirus bairdii*	MSC	15-Jan	NR	T	Rm				again !
5	*Baird's tapir Tapirus bairdii*	MS16	18-Jan	9.15	V	Rm		?		what appeared to be old male in long grass by HLS
5	*Baird's tapir Tapirus bairdii*	MS16	18-Jan	NR	T	Fsd	1			from river to MT camp
3	*Baird's tapir Tapirus bairdii*	MSD	26-Jan	14.10	V	Rm	2	A/J		feeding on dumbcane
3	*Baird's tapir Tapirus bairdii*	MSD	26-Jan	14.15	A	Rm	1	A		running through bush
3	*Baird's tapir Tapirus bairdii*	MSD	26-Jan	NR	T	Fsd	many			many leading from forest
1	*Baird's tapir Tapirus bairdii*	MS1	30-Jan	21.00	A/V	Rm	1			feeding at night - eye shine
1	*Baird's tapir Tapirus bairdii*	MS1	30-Jan	NR	T	Fsd	1			many from broadleaf forest to river
1	*Baird's tapir Tapirus bairdii*	MS6	5-Feb	14.30	T/S	Rm	2			leading to river-both sides
2	*Baird's tapir Tapirus bairdii*	MS11	7-Feb	9.20	V	R	1	A	fg	wading up river away from site
2	*Baird's tapir Tapirus bairdii*	MS11	7-Feb	9.50	V	R	1	A		same Tapir swam across river
2	*Baird's tapir Tapirus bairdii*	MS11	7-Feb	NR	T	Rm	many			in mud on river bank
3	*Baird's tapir Tapirus bairdii*	MSC	9-Feb	4.30	V	Fsd				eye shine by camp
3	*Baird's tapir Tapirus bairdii*	MSD	12-Feb	20.00	V	Rm	2	A/J		feeding on dumbcane (mon 45min)
3	*Baird's tapir Tapirus bairdii*	MSD	13-Feb	6.30	V	R	1	?		waded across river
3	*Baird's tapir Tapirus bairdii*	MSD	13-Feb	6.31	V	Rm	1	J		running off with mother
3	*Baird's tapir Tapirus bairdii*	MSE	13-Feb	11.00	V	Fsd	1	?		brief sighting - feeding on figs
3	*Baird's tapir Tapirus bairdii*	MSE	13-Feb	12.45	V	R	1	A		came down to waters edge and was shoot back in bush
3	*Baird's tapir Tapirus bairdii*	MSF	13-Feb	16.00	V	Rm	1			by waters edge very briefly went back into bush
3	*Baird's tapir Tapirus bairdii*	MSF	14-Feb	6.20	V	R	2	A/J		2 by waters edge - mother and young
3	*Baird's tapir Tapirus bairdii*	MSG	14-Feb	15.30	V	R	1	?		wading up river
3	*Baird's tapir Tapirus bairdii*	MSB	19-Feb	15.20	V	Fsd	1			just seen running up trail
3	*Baird's tapir Tapirus bairdii*	MSC	19-Feb	17.40	V	R	1			farside of river in dumbcane

3	*Baird's tapir Tapirus bairdii*	MSA	19-Feb	NR	V/T/S	Rm	1			scats in water and trails by edgeTapir just seen
4	*Baird's tapir Tapirus bairdii*	MSN	3-Mar	13.30	V	Rm	1	A	fg	feeding on dumbcane
4	*Baird's tapir Tapirus bairdii*	MSN	3-Mar	NR	T	Rm				trail in and out of river on sand bar
5	*Baird's tapir Tapirus bairdii*	MS16	5-Mar	10.00	V	Rm	1	?		up by raleigh camp
5	*Baird's tapir Tapirus bairdii*	MS15	6-Mar	7.15	T	R	1			single track through pine forest
5	*Baird's tapir Tapirus bairdii*	MS15	6-Mar	16.10	V	R	1	?		crossing river up from resevoir
4	*Baird's tapir Tapirus bairdii*	MSP	13-Mar	NR	V	Rm	1	A		no notes !
4	*Baird's tapir Tapirus bairdii*	MSQ	15-Mar	NR	T	Rm				on sandy bed
2	*Baird's tapir Tapirus bairdii*	MS7	17-Mar	17.20	V	R	1	?		swam down river
2	*Baird's tapir Tapirus bairdii*	MS7	17-Mar	17.30	V	R	1	J		swam down river after adult
5	*Baird's tapir Tapirus bairdii*	MS16	1-Apr	NR	T	Fsd				fresh leading from Monkey Tail
1	*Baird's tapir Tapirus bairdii*	MS6	2-Apr	18.45	A/V	R	2	A/J	fga	walking across river - mother audible
5	*Baird's tapir Tapirus bairdii*	MS14	2-Apr	NR	V	R	1	A		near Army camp wading in waters edge

MORELET'S CROCODILE (DRY SEASON)

ZONE	*SPECIES*	SITE ID	DATE	TIME	EVIDENCE	HABITAT	No.	AGE	SIZE	NOTES
2	*Morelet's crocodile Crocodylus moreletii*	MS8	7-Jan	6.30	V	R	1	J	10"	floating in rivers edge roots
3	*Morelet's crocodile Crocodylus moreletii*	MSC	29-Jan	20.10	V	R	1	A	4'	swimming under water surface (ES)
3	*Morelet's crocodile Crocodylus moreletii*	MSB	2-Feb	21.20	V	Rm	1	J	10"	in tree roots
3	*Morelet's crocodile Crocodylus moreletii*	MSB	2-Feb	22.10	V	Rm	1	J	15"	on river bed
3	*Morelet's crocodile Crocodylus moreletii*	MSB	2-Feb	22.30	V	Rm	1	J	1'	in tree roots
3	*Morelet's crocodile Crocodylus moreletii*	MSB	3-Feb	23.30	V	R	1	J	?	young croc swimming upstream
1	*Morelet's crocodile Crocodylus moreletii*	MS6	5-Feb	21.15	V	R	2	J	5"/12"	floating still by tree roots
1	*Morelet's crocodile Crocodylus moreletii*	MS6	5-Feb	12.55	V	R	1	A	6'	swimming just under waters edge
1	*Morelet's crocodile Crocodylus moreletii*	MS6	5-Feb	13.20	V	R	1	A	6'	duplicate sighting
1	*Morelet's crocodile Crocodylus moreletii*	MS6	5-Feb	19.45	V	R	2	JJ	5"/12"	same pair/same location
3	*Morelet's crocodile Crocodylus moreletii*	MSC	5-Feb	10.00	V	Rm	1	A	4'	sliding into water
3	*Morelet's crocodile Crocodylus moreletii*	MSC	8-Feb	20.30	V	R	1	A	4'	monitored
3	*Morelet's crocodile Crocodylus moreletii*	MSC	8-Feb	21.00	V	R	2	JJ	1'	both under water surface
3	*Morelet's crocodile Crocodylus moreletii*	MSF	15-Feb	22.30	V	R	7	J		total of 7 counted all less than 1'
3	*Morelet's crocodile Crocodylus moreletii*	MSG	19-Feb	7.45	V	R	1	A	?	very brief sighting swam under water
3	*Morelet's crocodile Crocodylus moreletii*	MSG	19-Feb	22.00	V	R	2	JJ	18"	on river bed - possible same one twice
3	*Morelet's crocodile Crocodylus moreletii*	MSH	21-Feb	23.30	V	R	2	JJ		in deep pool on bend
3	*Morelet's crocodile Crocodylus moreletii*	MSH	22-Feb	9.15	V	R	1	A	6'	floating and resting on top of river
3	*Morelet's crocodile Crocodylus moreletii*	MSH	24-Feb	9.00	T/N	Rm				nest discovered on sand bar with tracks
3	*Morelet's crocodile Crocodylus moreletii*	MSI	24-Feb	22.00	V	R	3	J	10"	all in various still water
3	*Morelet's crocodile Crocodylus moreletii*	MSI	24-Feb	22.00	V	R	2	A	6'	same one twice ?
3	*Morelet's crocodile Crocodylus moreletii*	MSJ	25-Feb	15.20	V	Rm	1	A	6'	lying on bed rock
4	*Morelet's crocodile Crocodylus moreletii*	MSM	3-Mar	3.00	V	R	1	A	5'	basking on sand bar
4	*Morelet's crocodile Crocodylus moreletii*	MSM	3-Mar	19.00	V	R	1	J	1'	on river bed
4	*Morelet's crocodile Crocodylus moreletii*	MSM	3-Mar	20.35	V	R	1	J	10'	floating on top of water
5	*Morelet's crocodile Crocodylus moreletii*	MS15	6-Mar	11.30	V	R	1	A	5'	edge of Mollejon resevoir
2	*Morelet's crocodile Crocodylus moreletii*	MS7	17-Mar	19.20	V	Rm	1	A	5'	dived in water when seen canoe
2	*Morelet's crocodile Crocodylus moreletii*	MS7	17-Mar	22.00	V	R	1	A	5'	in deep pool on bend
2	*Morelet's crocodile Crocodylus moreletii*	MS7	18-Mar	9.30	V	R	1	A	5'	swimming across river bend
2	*Morelet's crocodile Crocodylus moreletii*	MS7	18-Mar	13.00	V	Rm	1	A	5'	lying on the river bank

2	*Morelet's crocodile Crocodylus moreletii*	MS7	18-Mar	21.15	V	R	3	J	>10"	hiding in tree roots very still

SIGNIFICANT MAMMAL SIGHTINGS (DRY SEASON)

ZONE	*SPECIES*	SITE ID	DATE	TIME	EVIDENCE	HABITAT	No.	AGE	SIZE	NOTES
1	*Neotropical River Otter Lontra longicaudis annectens*	MS4	2-Jan	NR	S	R	many			on rock by river (fresh)
5	*Black howler monkey Alouatta p. pigra*	MS12	4-Jan	5.45	A	Fsd	++			Calling north of station
5	*Black howler monkey Alouatta p. pigra*	MS12	5-Jan	6.20	A	Fsd				single male roaring
2	*Neotropical River Otter Lontra longicaudis annectens*	MS7	6-Jan	NR	S	R	2	A	M/F	protecting nest
2	*Jaguar Panthera onca*	MS8	7-Jan	NR	T	Fsd	1			track following trail
5	*Collared peccary Pecari tajacu*	MS17	10-Jan	NR	V	Fsd	20 +			walking down to river
5	*Jaguar Panthera onca*	MS16	15-Jan	NR	A	Rm				late at night (time NR)
5	*Neotropical River Otter Lontra longicaudis annectens*	MS16	15-Jan	NR	S	Rock				fresh on boulder in river
5	*Tayassu pecari ringens*	MS16	18-Jan	9.30	V	Fsd				
5	*Neotropical River Otter Lontra longicaudis annectens*	MS16	19-Jan	5.45	V	R	1			
5	*Neotropical River Otter Lontra longicaudis annectens*	MS16	19-Jan	6.20	V	R	2			
5	*Puma Puma concolor mayensis*	MS16	19-Jan	8.00	A	Pf	1			
4	*Tayra Eira barbara*	MSM	23-Jan	13.20	V	Fsd				
4	*Puma Puma concolor*	MSN	23-Jan	21.00	A	Fsd				call
4	*White lipped peccary Tayassu pecari*	MSO	24-Jan	13.00	A	Rm				
4	*Jaguar Panthera onca*	MSP	24-Jan	19.20	T	Fsd				
4	*Puma Puma concolor*	MSQ	25-Jan	23.00	A	Fsd				call
4	*Neotropical River Otter Lontra longicaudis annectens*	MSP	25-Jan	NR	S	R				on rocks down from site - quite fresh
1	*Collared peccary Pecari tajacu*	MS5	1-Feb	NR	T	Fsd	many			footprints in wet mud NB could be WL
1	*Green Iguanas Iguana iguana*	MS5	1-Feb	NR	V	Rm/Fsd	many			on fig tree
1	*Margay Leopardus wiedii*	MS5	1-Feb	NR	T	Rm	1			very faint print by waters edge, unconfirmed
1	*Neotropical River Otter Lontra longicaudis annectens*	MS6	2-Feb	14.20	V	R	2	A		watching canoe - duplicate sighting
1	*Neotropical River Otter Lontra longicaudis annectens*	MS6	2-Feb	NR	S	R	small			on rock by river (fresh)
3	*Neotropical River Otter Lontra longicaudis annectens*	MSA	4-Feb	NR	S	R				fresh on rock
1	*Neotropical River Otter Lontra longicaudis annectens*	MS6	5-Feb	9.20	V	R	1	A		swimming on back
1	*Neotropical River Otter Lontra longicaudis annectens*	MS6	5-Feb	15.30	V	R	2	AA	fg	swimming in river/same pair
3	*Neotropical River Otter Lontra longicaudis annectens*	MSC	5-Feb	16.30	V	R	1			Swimming in pool near campsite
2	*White lipped peccarry Tayassu pecari*	MS10	5-Feb	NR	V	Rm	10+			noisy group in dumbcane - counted 10
3	*Neotropical River Otter Lontra longicaudis annectens*	MSA	6-Feb	17.30	V	R	1			
2	*Gray four-eyed opossum Philander opossum pallidus*	MS10	6-Feb	NR	T	Fsd				feeding trail

2	*Common Opossum Didelphis marsupialis tabascensis*	MS11	7-Feb	NR	T	Fsd	-			feeding trail
3	*Neotropical River Otter Lontra longicaudis annectens*	MSC	8-Feb	11.30	V	R	1			
3	*Jaguar Panthera onca*	MSC	8-Feb	18.15	A	Rm				Roaring
3	*Jaguar Panthera onca*	MSC	8-Feb	23.20	A	Rm				and again
3	*Neotropical River Otter Lontra longicaudis annectens*	MSD	12-Feb	NR	S	R				
3	*Neotropical River Otter Lontra longicaudis annectens*	MSD	13-Feb	8.00	V	R	1			
3	*Puma Puma concolor*	MSF	15-Feb	6.10	A	Fsd	1			early morning calling
3	*Northern Raccoon Procyon lotor*	MSF	15-Feb	10.00	T	Rm				trial through vegetation (? Species)
3	*Jaguar Panthera onca*	MSF	15-Feb	14.00	S	Rm				
3	*Jaguar Panthera onca*	MSJ	22-Feb	9.00	T	Rm				Fresh
3	*Puma Puma concolor*	MSJ	22-Feb	18.35	A	Fsd				calling
3	*Northern Tamandua Tamandua mexicana*	MSJ	24-Feb	8.30	V	Fsd	1			Looking for food
5	*Green Iguanas Iguana iguana*	MS17	2-Mar	6.20	V	Rm	2			
5	*White lipped peccary Tayassu pecari*	MS17	2-Mar	10.30	A	Fsd				Only scent and noise
4	*White lipped peccarry Tayassu pecari*	MSM	2-Mar	18.20	V	Rm	20 +			overnight camp
4	*White lipped peccay Tayassu pecari*	MSN	3-Mar	8.30	V	Rm				Walking on the river bank
4	*Green Iguanas Iguana iguana*	MSO	3-Mar	13.20	V	Rm				
4	*Jaguar Panthera onca*	MSO	4-Mar	14.20	V	Rm				drinking from river - quickly ran off
4	*Neotropical River Otter Lontra longicaudis annectens*	MSO	4-Mar	NR	S	R				old scats on white rock
4	*Neotropical River Otter Lontra longicaudis annectens*	MSO	4-Mar	NR	S	R				fresh scats on white rock
5	*Jaguar Panthera onca*	MS13	6-Mar	0.30	A	Fsd				crying at night
5	*Jaguar Panthera onca*	MS13	6-Mar	23.30	A	Fsd				roaring
5	*Neotropical River Otter Lontra longicaudis annectens*	MS15	8-Mar	NR	V	Rm				scats
5	*White lipped peccarry Tayassu pecari*	MS13	13-Mar	NR	V	Rm				
5	*White lipped peccarry Tayassu pecari*	MS13	13-Mar	NR	V	Rm				
4	*Northern Tamandua Tamandua mexicana*	MSM	14-Mar	NR	V	Fsd	1			
5	*Northern Raccoon Procyon lotor*	MS12	15-Mar	16.50	V	Fsd	1			
5	*Puma Puma concolor mayensis*	MS16	16-Mar	6.30	V	Pf	1			
2	*Green Iguanas Iguana iguana*	MS8	19-Mar	NR	V	Rm	many			high in most fig trees
5	*Tayra Eira barbara*	MS14	29-Mar	12.25	V	Fsd				
5	*Green Iguanas Iguana iguana*	MS14	29-Mar	13.00	V	Rm	4			In fig tree
5	*Black howler monkey Alouatta p. pigra*	MS14	30-Mar	14.30	V	Fsd	6	2A4J		calling aggressivley at team
1	*Neotropical River Otter Lontra longicaudis annectens*	MS6	2-Apr	16.00	V	R	2	AA	fg	surface swimming up river/same pair
1	*Paca Agouti paca nelsoni*	MS5	2-Apr	23.20	V	Fsd	1			scaveging around camp

1	*Hispid pocket gopher Orthogeomys hispidus*	MS5	3-Apr	5.30	V	Fsd	1	still in tree roots
1	*Deppe's squirrel Sciurus deppei vivax*	MS5	3-Apr	6.00	V	Fsd	1	running up tree
1	*Kinkajo Potos flavus chiriquensis*	MS6	3-Apr	8.30	V	Fsd	1	climbing up tree
1	*Gray fox Urocyon cinereoargenteus fraterculus*	MS6	3-Apr	12.40	V	Rm	1	sniffing around dead catfish

Annex B

Aquatic macroinvertebrate communities of the Macal Raspaculo Watershed, Belize

David Bowden

Benthic Ecology Research Group, Department of Biological Sciences University of Plymouth, UK

Introduction

The ecology of river and stream systems in the tropics is poorly understood; comparatively little research has been conducted in this area, despite the importance of such systems both to human activities and to wider ecosystem function. Benthic macroinvertebrate communities are typically the most diverse fauna in freshwater habitats and as such are increasingly used as biomonitors of environmental change and ecosystem status, particularly in relation to anthropogenic disturbance. Such studies have been undertaken in North America, Europe, South Africa and Australia (e.g. Karr 1991; Chessman 1995; Chutter 1995; Dallas 1997). The techniques used in assessment of ecological disturbance through the study of macroinvertebrate communities range from sophisticated multivariate analyses (e.g. Rundle *et al.* 1993) to the comparison of simple, univariate, indices which permit rapid assessment of samples using limited analytical resources (e.g. Chessman 1995; Dallas 1997). Common to all these approaches, however, is the need for accurate base-line information on the composition of macroinvertebrate communities in areas that have not been subject to human impacts. Such data are of importance for any objective assessment of change, whether in terms of monitoring change at a particular location or for use as control data against which the ecological status of other comparable locations can be assessed. The aim of this first study of stream macroinvertebrate fauna from the Upper Raspaculo River was to gather representative community data for the area which, in addition to its intrinsic scientific interest, should be of use as base-line data against which changes due to future disturbance can be assessed.

Site description

General

Detailed descriptions of the terrain, geology, climate and vegetation of the Upper Raspaculo river basin are fully described elsewhere in this Report and in previous JSSEUR reports. The area lies within an extensive region of mature tropical rainforest that has been almost entirely free from human habitation and anthropogenic disturbance since the end of the Mayan civilisation. The region is characterised by highly seasonal rainfall that causes significant annual spate events during which river levels may rise by several meters and considerable transport of bedload and destruction of riparian vegetation may occur. On a decadal time scale the region is also subject to severe physical disturbance from hurricanes and tropical revolving storms that may uproot or damage mature trees over a wide area.

This study was conducted during March 2000, at the end of the dry season. At the time of sampling no rainfall had been reported for approximately two months and in consequence water-levels in the main watercourses were low and many smaller tributaries were completely dry.

Study sites

A total of 16 sites were sampled, separated by a maximum distance of 18 km, and at an average elevation of 440 m above sea level. The sites encompass four broad groupings that represent: two tributary streams of the Upper Raspaculo river ("Stream 1" and "Stream 2"); a section of the upper Raspaculo river ("Raspaculo 1") and a section of the main Raspaculo river ("Raspaculo 2"). The grid references and altitudes of the sample sites are given in table 1. [Grid references refer to Military Survey series E755-MIL, sheet 29, edition 1-GSGS, 1993.]

Table 1. Raspaculo stream sampling sites

Region	Sample	Altitude (m)	Grid Reference
Stream 1	A1	440	096578
	A2	440	087581
	A3	440	092580
	A4	450	104582
	A5	450	102579
Raspaculo 1	B1	460	104616
	B2	460	104615
	B3	460	104613
Stream 2	B4	460	106615
	B5	460	108616
	B6	460	105615
Intermediate	B7	430	084582
Raspaculo 2	C1	420	047560
	C2	420	047559
	C3	400	952560
	C4	400	952560

Methods

Physicochemistry

Mean stream width and depth were recorded at each sampling point and an assessment of the substratum composition was made in terms of approximate percentages of the stream bed over the sampled area. Flow rate was roughly estimated by timing floating objects over a measured distance and water clarity was assessed on a subjective scale. Water pH and temperature were measured *in situ* (Jenway 3200 meter), and water samples were taken at each site for laboratory analysis of major ion content (Varian Spectra AA 600).

Macroinvertebrate sampling

A semi-quantitative sampling method was used based on the South African Scoring System (SASS4) protocol (see Dallas 1997, and references therein). This protocol is similar to those developed in other countries (e.g. the Environmental Protection Agency in the U.S.A.) for the purpose of rapid biological assessment and provides a simple, standardised technique that allows valid comparison of data between sites and times. Invertebrate stream fauna were collected from riffle areas (fast-flowing, shallow stream sections with hard substrata) by means of a 2 minute kick sample taken with a 25 cm x 25 cm hand net (1 mm mesh). Marginal vegetation and bank overhangs, where present, were swept back and forwards for two minutes and any other biotopes present, such as stones out of current, logs and leaf-packs, were sampled for a maximum of 30 s each. Net contents were emptied into a sorting tray and live organisms were picked, without magnification, and preserved directly in 70% ethanol. All samples were picked, on site, by two field workers for a period of 30 minutes.

On return to the U.K. all samples were identified to family level, in the laboratory, using low-power microscopy. Previous studies have shown that family level identification is sufficient for assessing important ecological patterns at the community level (e.g. Rutt *et al*. 1990; Rundle *et al.* 1993; Chessman 1995) and that the family richness of aquatic insects in stream samples is highly correlated with species richness (Bournaud *et al.* 1996; Wright, Moss & Furse 1997). Furthermore, the families of aquatic insects present in streams are remarkably consistent across all the major continents (Hynes 1970; Dudgeon 1999), with the exception of Australia. Thus, for areas such as Belize where specific local identification keys are not available and it is likely that many species have not have been described, accurate family-level identification can be undertaken using taxonomic keys developed in other areas of the world and measurements of diversity at this level can be used as estimates of species-level diversity. Macroinvertebrates in this study were identified using Merritt & Cummins (1978), Nilsson (1996) and Dudgeon (1999).

Data treatment

Similarity in overall faunal structure among the 16 individual samples was analysed using the software package PRIMER (Plymouth Routines in Multivariate Ecological Research; Clarke & Warwick 1994) to construct a dendrogram and an MDS (Multi-dimensional scaling) plot. Both of these techniques are based on non-parametric calculations of similarity between samples using the full dataset matrix. The SIMPER (similarity percentages routine) programme within PRIMER was used to calculate the percentage similarity between samples from different tributaries and different elevations along the Raspaculo river.

In addition to multivariate analyses, a range of univariate indices was calculated to enable comparison with stream invertebrate data from other studies. These comparisons have not yet been completed but the calculated figures for the Belize samples are presented here for reference. The indices calculated are: number of families per order; Margalef's richness index (D); Pielou's eveness index (J); Shannon-Wiener diversity (H'); Simpson's diversity index (SI); Hill's 1 ($e^{H'}$); Hill's 2 (1/SI); SASS4 (South African Scoring System) index and its associated ASPT (average score per taxon) index. [Note: throughout this report error values given represent one standard error (SE) unless specified otherwise.]

Results

Stream chemistry and physiography

Mean water temperature across all sites was 25±2C, the coolest sites being those from the two tributary streams and the warmest being from the lower altitude sites on the main Raspaculo. pH varied in the range 6.1 to 7.6; the samples taken at the lowest altitude on the main body of the Raspaculo (sites C1-4) had a significantly lower pH (ANOVA $p<0.05$) than those from the upper

Raspaculo and its tributaries (sites A1-5, B1-6) (Table 2). Stream width at the sample sites varied from 2m (sites B4-6) up to 9m (sites C3, 4) whereas depths ranged from 10 cm to 50 cm within most sample sites, the only consistently shallow sites being those on stream 2 (sites B4-6). Flow-rate at all sites was in the range 0.5ms^{-1} to 1.0ms^{-1}. Stream bed substrata were predominantly a mixture of bedrock, stones and pebbles but at some sites patches of gravel occurred and site C2 (lower Raspaculo) was 80% gravel. Water clarity was excellent at all sites.

Table 2. Physico-chemical measurements from Raspaculo stream sample sites. Ion concentrations are in parts per million.

Region	Sample	Temp (C)	pH	Ca	Mg	Al	Cu	Zn
Stream 1	A1	23	6.2	1.83	2.31	.034	.012	.003
	A2	24	7.0	2.68	2.32	.093	.003	.006
	A3	26	7.1	2.04	2.16	.145	.007	.006
	A4	23	7.3	3.47	2.22	.188	.001	.006
	A5	25	7.1	2.61	2.18	.075	.003	.006
Raspac. 1	B1	25	6.9					
	B2	26	7.4	3.84	2.74	.116	.001	.007
	B3	26	7.5	2.39	2.62	.118	.006	.013
Stream 2	B4	24	7.5	4.77	10.0	.067	.003	.008
	B5	22	7.6					
	B6	23	6.4	10.5	10.3	.159	.003	.010
[Int]	B7	25	7.4	8.14	3.89	.212	.004	.010
Raspac. 2	C1	26	7.0	3.88	3.34	.197	.003	.004
	C2	24	6.5	5.23	3.23	.289	.008	.004
	C3	27	6.1	3.26	3.23	.419	.000	.003
	C4	27	6.2					

Multivariate analysis

Construction of a 2-dimensional MDS plot (based on Bray-Curtis similarities from fourth-root transformed data to downweight the influence of very abundant taxa) indicated only a weak tendency for sample sites to differentiate on the basis of the main sampling areas (stream 1, stream 2, Raspaculo 1 and Raspaculo 2). Consideration of the dendrogram of between-sample similarities indicated that all samples were similar at the 53% level and that all except three samples (A2, A3, B4) were similar at the 66% level. SIMPER comparisons confirmed that the maximum dissimilarity between any pair of sampling areas was less than 37% (Stream 2 and Raspaculo 2, 36.67%). This suggests that there are no major differences in macroinvertebrate communities between the four areas sampled and that the 16 samples may therefore legitimately be pooled to characterise the stream fauna of the region.

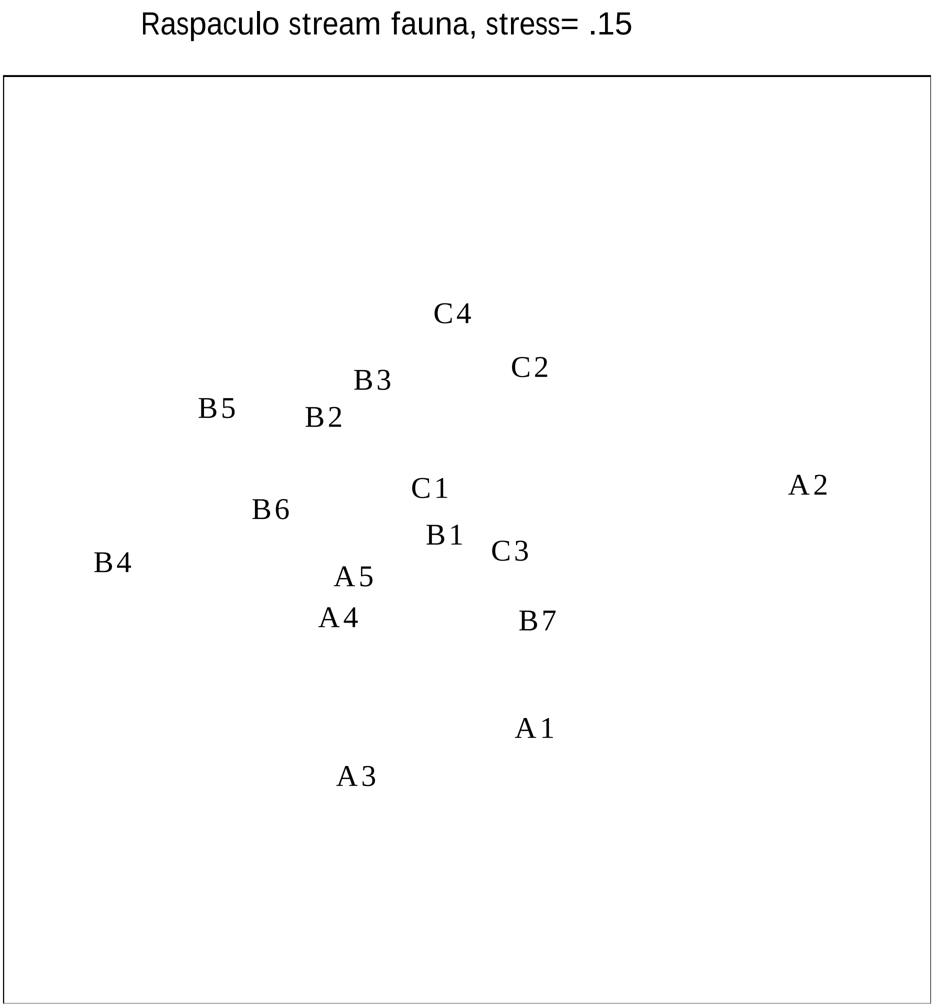

Figure 1. Multi-dimensional scaling plot (MDS) of stream invertebrate samples from the Raspaculo basin. Symbol positions are based on Bray-Curtis similarities of fourth-root transformed data and the distance between samples is proportional to their relative similarity. Thus, samples which are close together are more similar than those which are far apart. Axes have no units.

Distribution and abundance of macroinvertebrates

A total of 1906 invertebrates were collected, representing 37 families from 10 orders. Of these, 9 were insect or arachnid (Hydrachnida) orders and the larvae and adults of insect taxa constituted more than 95%, by number of individuals, of all samples. Gastropod snails (Thiaridae) were abundant at all sites and crabs were either seen or captured in kick samples at all but two sites. However, the sampling technique employed greatly under-samples these taxa, so they were ommitted from numerical analyses. It was also noted that the aquatic angiosperm *Marathrum modestum* was abundant on submerged rocks at several sample sites.

Table 3. Insect families collected in kick-samples from sixteen sites on the Raspaculo river and tributary streams.

Order	Family	Mean abundance and range (min.-max.)

Ephemeroptera	Baetidae	3.38	(0-11)
	Oligoneuriidae	0.19	(0-2)
	Heptageniidae	3.44	(0-20)
	Ephemerellidae	3.50	(0-12)
	Siphlonuridae	0.13	(0-1)
	Leptophlebiidae	25.06	(0-51)
Odonata	Gomphidae	0.63	(0-2)
	Libellulidae	3.00	(0-8)
	Calopterigidae	1.00	(0-5)
	Euphaeidae	2.25	(0-20)
	Protoneuridae	0.88	(0-3)
	Platycnemedidae	10.44	(0-37)
	Coenagrionidae	0.06	(0-1)
Plecoptera	Perlidae	11.50	(2-21)
Heteroptera	Veliidae	1.75	(0-16)
	Naucoridae	6.94	(0-26)
Megaloptera	Corydalidae	2.81	(0-8)
Trichoptera	Philopotamidae	14.44	(0-41)
	Polycentrodidae	0.31	(0-3)
	Hydropsychidae	5.38	(1-16)
	Helicopsychidae	0.13	(0-1)
	Odontoceridae	1.13	(0-5)
	Limnephilidae	0.44	(0-3)
	Leptoceridae	0.06	(0-1)
	Calamoceratidae	0.13	(0-2)
Lepidoptera	Pyralidae	1.13	(0-5)
Coleoptera	Elmidae (larva)	3.25	(0-20)
	Elmidae (adult)	5.38	(1-12)
	Psephenidae (Larva)	2.44	(0-18)
Diptera	Chironomidae	0.31	(0-2)
	Simuliidae	2.50	(0-14)
	Athericidae	1.25	(0-7)
	Limoniidae	3.69	(0-18)
	Diptera indet.	0.13	(0-2)
Hydrachnida	Mite (indet.)	0.13	(0-1)

The mean total abundance of macroinvertebrates per sample was 119.2±7.3 and the mean number of invertebrate taxa per sample was 18.3±0.7. The most abundant taxa across all samples were the Ephemeroptera (mean abundance per sample 35.7±5.4), followed by Trichoptera (22.0±3.7) and Odonata (18.3±2.6). Mean abundances per order per sample are shown in Figure 1.

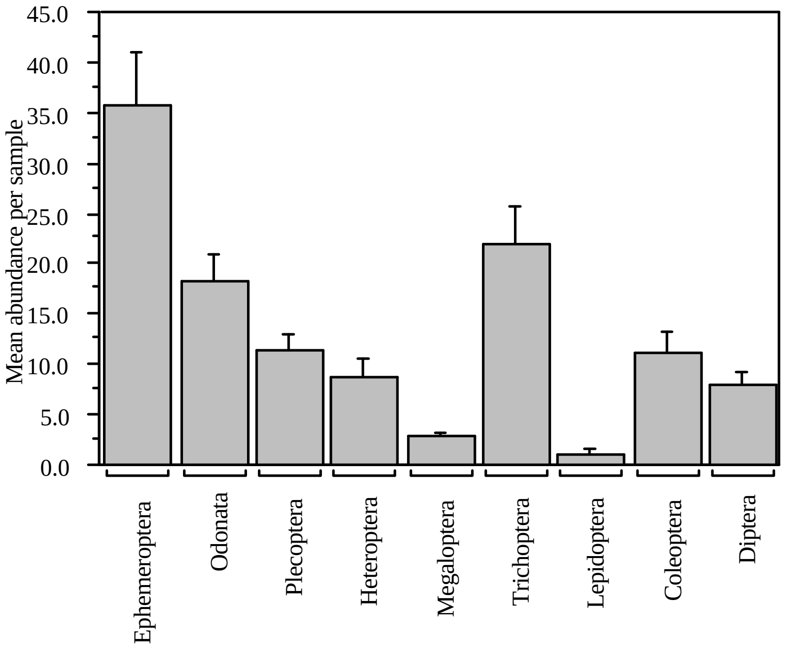

Figure 2. Mean abundance of aquatic macroinvertebrate taxa in samples from the Raspaculo river and tributary streams.

Comparisons of taxon-richness at the family level (Figure 2) revealed that Ephemeroptera and Odonata exhibited the greatest family-richness (3.50±0.22 and 3.50±0.41 per sample respectively), followed by Trichoptera (2.88±22) and Diptera (2.31±0.28). Of the other insect orders present in the samples, Plecoptera, Megaloptera and Lepidoptera were each represented by a single family, while Coleoptera and Heteroptera contained two families. Within the Ephemeroptera, however, Leptophlebiidae was by far the most abundant family (mean 25.0±3.48 per sample) with the next most abundant families, Ephemerellidae, Heptageniidae and Baetidae being considerably scarcer (3.52±0.91, 3.44±1.47, 3.38±0.90 per sample respectively). Within the Odonata the high family-level richness is largely due to the Zygoptera, five families of which were identified. Of these, Platycnemedidae were the most numerous and widespread, others being generally less abundant and more patchily distributed. Euphaiidae (Zygoptera) were present only in samples from the two

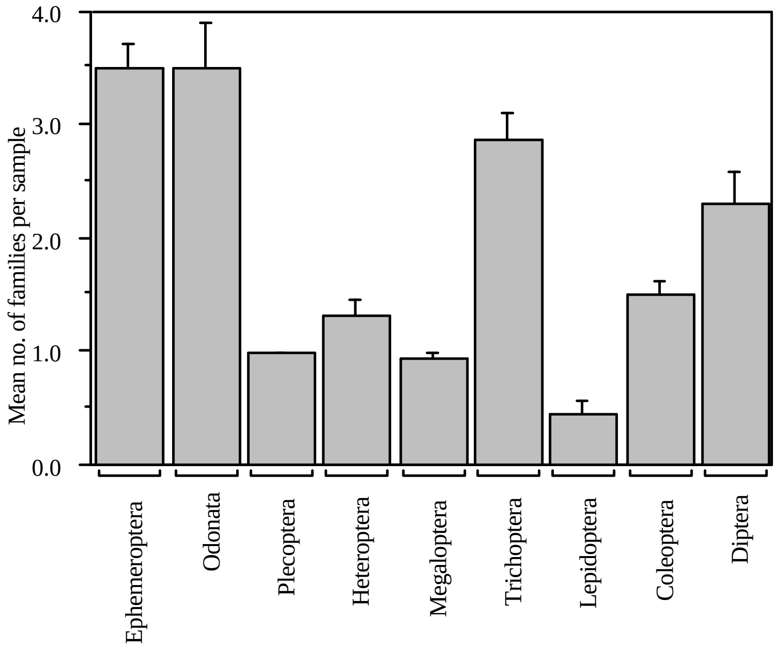

Figure 3. Mean number of families per macroinvertebrate order in samples from the Raspaculo river and tributary streams.

tributaries (samples A1, A4, A5 and B4-6) and not in those from the Raspaculo itself. Eight families of the order Trichoptera were identified. Of these the numerically dominant taxon was Philopotamidae (14.44±3.61) but occurrence of this family was patchy, with numbers per sample ranging from 41(sample C1) to 0 (samples B2, 4, 5). Hydropsychidae, by contrast, were less numerous (5.38±1.28) but more evenly distributed. Coleoptera were poorly represented in samples, with only Elmidae adults and larvae being common in all samples and Psephenidae larvae being locally abundant but patchily distributed. Diptera were present in generally low abundance but Simuliidae, Athericidae and Limoniidae were recorded in most samples. Corydalidae (Megaloptera) were ubiquitous in samples and although only present in relatively small numbers represent a distinctive element of the fauna due to their large size, individuals frequently exceeding 50 mm in length and the largest preserved specimen measuring 65 mm.

Univariate indices

Table 3 lists all indices calculated by site and region, together with overall means and standard errors. These indices have no absolute meaning but provide a standardised means by which communities from different sites, regions, times or studies may be compared.

Table 3. Univariate indices of richness (D), eveness (J) and diversity (H', SI, Hill's 1, Hill's 2), together with the biotic integrity indices SASS4 and ASPT for stream macroinvertebrate samples from the Raspaculo basin.

Region	Sample	Richness (D)	Eveness (J)	H'loge	SI	Hill 1 ($e^{H'loge}$)	Hill 2 (1/SI)	SASS4	ASPT
Stream1	A1	3.13	0.798	2.21	0.147	9.15	6.79	151	9.25
	A2	3.76	0.908	2.52	0.098	12.4	10.2	118	7.69

	A3	4.12	0.856	2.52	0.109	12.4	9.19	175	9.16
	A4	4.22	0.806	2.45	0.133	11.6	7.52	166	7.90
	A5	4.18	0.837	2.55	0.109	12.8	9.14	149	7.38
Raspac1	B1	4.07	0.827	2.52	0.111	12.4	9.03	166	8.00
	B2	3.32	0.860	2.44	0.111	11.4	9.01	129	7.71
	B3	3.65	0.817	2.40	0.127	11.1	7.87	118	6.58
Stream2	B4	2.93	0.805	2.23	0.150	9.32	6.68	124	8.25
	B5	4.04	0.828	2.52	0.108	12.4	9.29	154	7.62
	B6	4.38	0.783	2.45	0.145	11.6	6.92	178	8.09
[int]	B7	3.09	0.826	2.24	0.148	9.35	6.76	130	9.20
Raspac2	C1	3.79	0.762	2.28	0.154	9.81	6.48	148	7.70
	C2	3.03	0.728	1.97	0.211	7.18	4.73	101	7.27
	C3	3	0.819	2.22	0.158	9.19	6.35	135	9.00
	C4	3.62	0.747	2.16	0.178	8.66	5.62	142	8.33
Mean (SE)		3.65 (0.12)	0.81 (0.01)	2.36 (0.04)	0.14 (0.01)	10.67 (0.43)	7.60 (0.39)	142.7 (5.5)	8.07 (0.19)

Discussion

The results of this limited study indicate that the running water habitats of the upper Raspaculo basin support a rich and diverse macroinvertebrate fauna. The principal taxa present, their relative abundances and overall measures of diversity appear to be very similar to communities reported by Jacobsen *et al*. (1997) from lowland (100-600 m elevation) streams in Ecuador. Furthermore, they are broadly consistent with patterns found in comparable habitats worldwide, Ephemeroptera, Trichoptera, Plecoptera and Odonata being the most abundant orders. Within this framework, greatest family-level taxon-richness is in the Ephemeroptera, the Odonata, and to a lesser extent, the Trichoptera. Again, this is consistent with the general observations that the Odonata reach their greatest diversity in the tropics (Corbet 1980) and that the Ephemeroptera and Trichoptera are diverse in both tropical and temperate ranges (Ross 1967), whereas the Plecoptera, represented here by only one family, are primarily a temperate order (Illies 1967).

An illustration of the general similarity of freshwater stream invertebrate communities worldwide is afforded by initial comparisons of data from the present study with that from high-altitude (~2000 m) tropical grassland streams in Malawi (Bowden & Mahto 2000). Despite wide biogeographic separation and pronounced differences in habitat type, geology and vegetation, similarities at the order and family level are apparent both in patterns of abundance and family-richness within orders. Perhaps the most striking difference between communities in the two habitats, however, is the much greater proportion of predatory taxa, especially Odonata, Heteroptera and Megaloptera, in the Raspaculo samples. On average these taxa contributed approximately 25% of all individual organisms and their generally large size and ubiquity in samples suggests that they play a significant role in structuring the macroinvertebrate community. Fox (1977) has proposed that the effect of greater predation in stream macroinvertebrate communities may be to increase overall diversity by reducing the population densities of prey species, thus reducing interspecific competition and allowing more prey species to coexist. It seems likely that such predator-mediated coexistence may be a factor in the maintenance of the high level of diversity suggested by the present results.

In estimating absolute levels of biodiversity from family-level analyses, it is interesting to note that Jacobsen *et al*. (1997) conclude that South American aquatic insect families contain substantially more species than do families in temperate North American or Europe. It is also clear from the literature that, overall, there are more species of aquatic insects in the tropics than at higher latitudes. Knowledge of tropical South and Central American freshwater macroinvertebrate species is very incomplete but given these two trends, it seems reasonable to expect that species-level diversity of aquatic macroinvertebrates in the Raspaculo and its tributaries is high. The present study, however, was of limited scope, and further work is required for a more comprehensive picture of the stream invertebrate ecology of the region to be gained. Such work might involve a wider sampling area to enable comparisons between macroinvertebrate communities in the Raspaculo catchment and other river catchments in Belize. As base-line data from an area of tropical forest unaffected by anthropogenic disturbances, the results from this study may be of use in such comparisons for detecting the effects on river catchments of human impacts such as logging and agriculture.

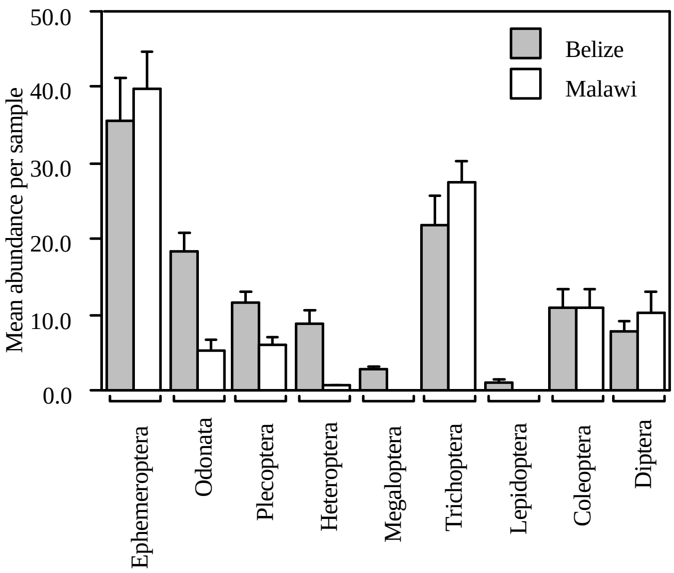

Figure 4. Comparisons of mean abundance per order for stream macroinvertebrate samples from the Raspaculo river catchment, Belize, and the Nyika plateau, Malawi.

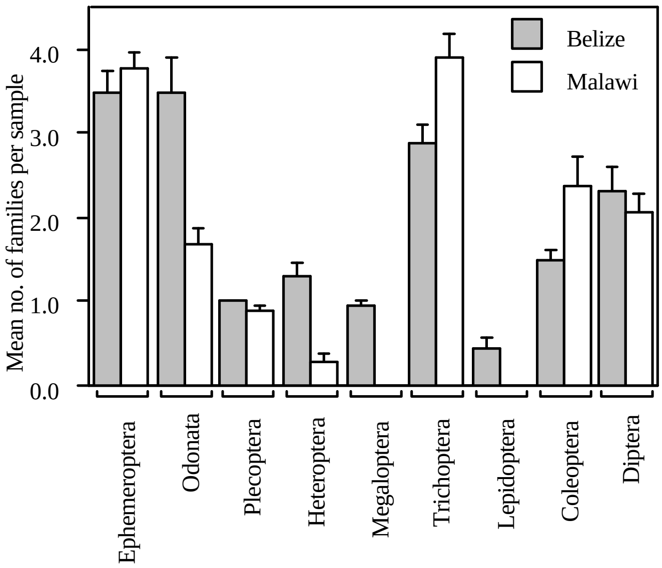

Figure 5. Comparisons of mean number of families per order for stream macroinvertebrate samples from the Raspaculo river catchment, Belize, and the Nyika plateau, Malawi.

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Annex C

Health Implications of the Chalillo Dam in Belize, with special reference to Simuliidae

Dr A. J. Shelley

Head of Simuliidae and Onchocerciasis Programme, Entomology Department, The Natural History Museum, London, UK

General principles

The following short report briefly outlines the effects of dam building on vector-borne diseases and the possible changes as a result of the Chalillo Dam, with special reference to simuliid blackflies.

Water resource development is a major component of rural development in Latin America. This is most obviously seen in Brazil, where there are now over 400 hydroelectric dams with many more proposed in the future in order to satisfy the increasing demand for electricity. This development also has negative effects in terms of ecological disruption at the construction site, which may affect human health in a variety of ways. The main factors influencing disease epidemiology in areas where dams are constructed are the migration of people and parasites causing diseases, and the effects of these migrations on invertebrate vector populations. Dams may be responsible for disseminating disease as infected people leave the area before flooding occurs, construction workers may bring diseases to the dam site from endemic areas and development of secondary industries following dam completion may also attract people and their diseases to the area. Changes in the river system may be responsible for the disappearance of vector species and the diseases that they transmit or alternatively may create ideal conditions for breeding of vector species previously absent from the area. There is no set formula for predicting the effects of dams on health because each dam is unique; for example, in Brazil the Itaipu Dam was responsible for an increase in malaria transmission, whereas the Tucurui Dam produced an enormous increase in *Mansonia* mosquitoes that severely hindered agricultural development because of enormous biting densities. In Latin America malaria is the disease most often associated with dam building, followed by schistosomiasis. Publications dealing with water resource development in relation to public health are appended to this Annex.

In Belize no human diseases are present in the immediate area of the dam site because it is uninhabited. The following observations based on the fragmentary data available outline the future possibilities of disease outbreaks during or after dam construction.

Mosquito-borne disease

Sporadic cases of malaria are recorded in Belize. Nine species of anopheline mosquito species have been recorded for the country (survey 1990-1993), of which four are vectors. The most likely species currently present in the area of the proposed dam are *Anopheles vestitipennis, A. pseudopunctipennis, A. arg*yritarsis and *A. punctimacula,* of which only the first is a known vector of malaria. However, the building of a dam and the subsequent formation of a lake will provide breeding grounds for the vector species *A.darlingi*, which occurs in many of the river systems (Dr R. E. Harbach, Natural History Museum, London). Recent surveys (1995-2000) around the Serra da Mesa hydroelectric dam in central Brazil recorded *A. darlingi* breeding in the newly formed lake and sporadic cases of malaria in an area previously cleared of the disease. Immigrants to the area involved with dam building, agriculture, fisheries and tourism probably re-introduced the disease (Prof. A. Guimaraes, FIOCRUZ, Brazil). Therefore, malaria outbreaks may occur in the area during dam construction.

Dengue fever transmitted by *Aedes aegypti* has also been reported in Belize, but the vector is only likely to appear around the new dam if a township ever becomes established at the site.

Snail-borne diseases

Surveys of potential snail vectors of schistosomiasis, a disease not transmitted in Belize, showed the presence of *Biomphalaria heliophila,* but this was not susceptible to experimental infection with *Schistosoma mansoni.* Similar surveys in neighbouring Mexico, Guatemala and Honduras recorded this snail species (other species of the same genus also occur in Guatemala) but no populations were susceptible to experimental infection with the parasite (Prof. W. L. Paraense, FIOCRUZ, Brazil pers. comm.). Therefore, it is unlikely that the new dam will be a possible future source of schistosomiasis transmission.

Simuliid blackflies and onchocerciasis

Data collected over 40 years ago (Lewis, D.J. & Garnham, P.C.C. 1958. The Simuliidae (Diptera) of British Honduras. *Bull. Ent. Res*. 50, 703-710) were gathered to establish whether human onchocerciasis had become established in Belize as a result of migration of infected Guatemalans from a focus of the disease 300 km to the west on the Pacific seaboard of Guatemala and to determine the presence or absence of simuliid vector species. At that time, little was known about the vector species of onchocerciasis in the Americas, but the vector *S. metallicum* was present in Belize. As a result of the two surveys carried out in the Mountain Pine Ridge area the following man-biting species have now been recorded: *Simulium callidum, gonzalezi, haematopotum, metallicum, ochraceum, quadrivittatum, sanguineum* and *veracuzanum*. Of these species, only *S. sanguineum* is not a known vector of onchocerciasis.

No records exist of the effects of dam building on blackfly populations in Latin America so it is impossible to speculate on the effect of the dam on blackfly species populations in the area. In Africa the main onchocerciasis vector *S. damnosum* colonizes dam spillways in enormous numbers, but I am unaware of any Latin American species using this habitat. In Africa dam construction eliminates the running water breeding grounds of *S. damnosum* upstream from the dam as a lake forms, and below the dam may either eliminate or create breeding grounds, depending on local conditions.

If construction workers on the dam are recruited from Mexico and Guatemala the Belizean government should be aware that foci of onchocerciasis occur on the western seaboards of both countries and although control campaigns are underway not all infected individuals are treated; additionally, if the 8-year treatment regime is interrupted treated individuals can again become positive for the infection. The disease may already be present in the country because of the large numbers of Guatemalan immigrants (who are not screened for onchocerciasis) employed in the orange groves and banana plantations in Belize.

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Figure 1a - Locations of monitoring sites

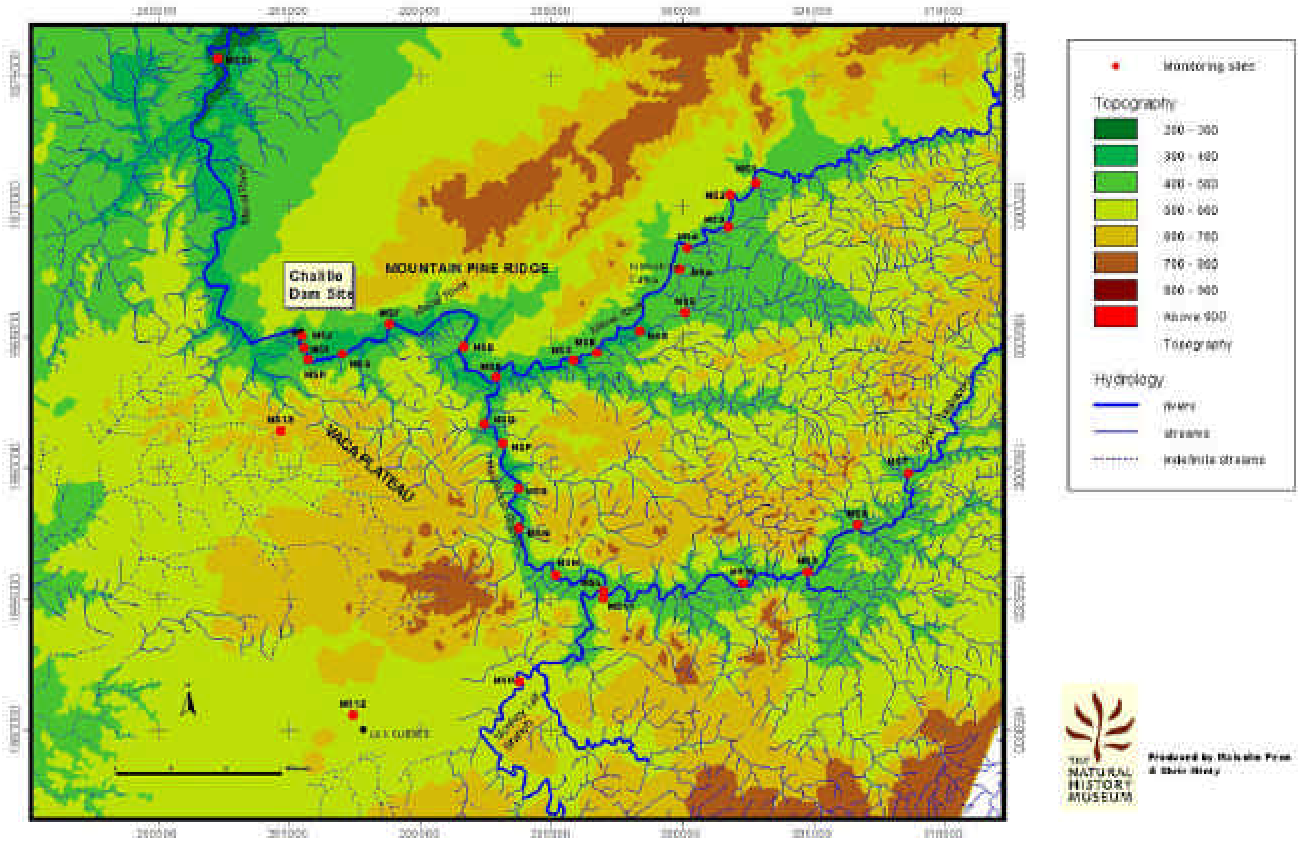

Figure 1b - Area of flooding and impoundment

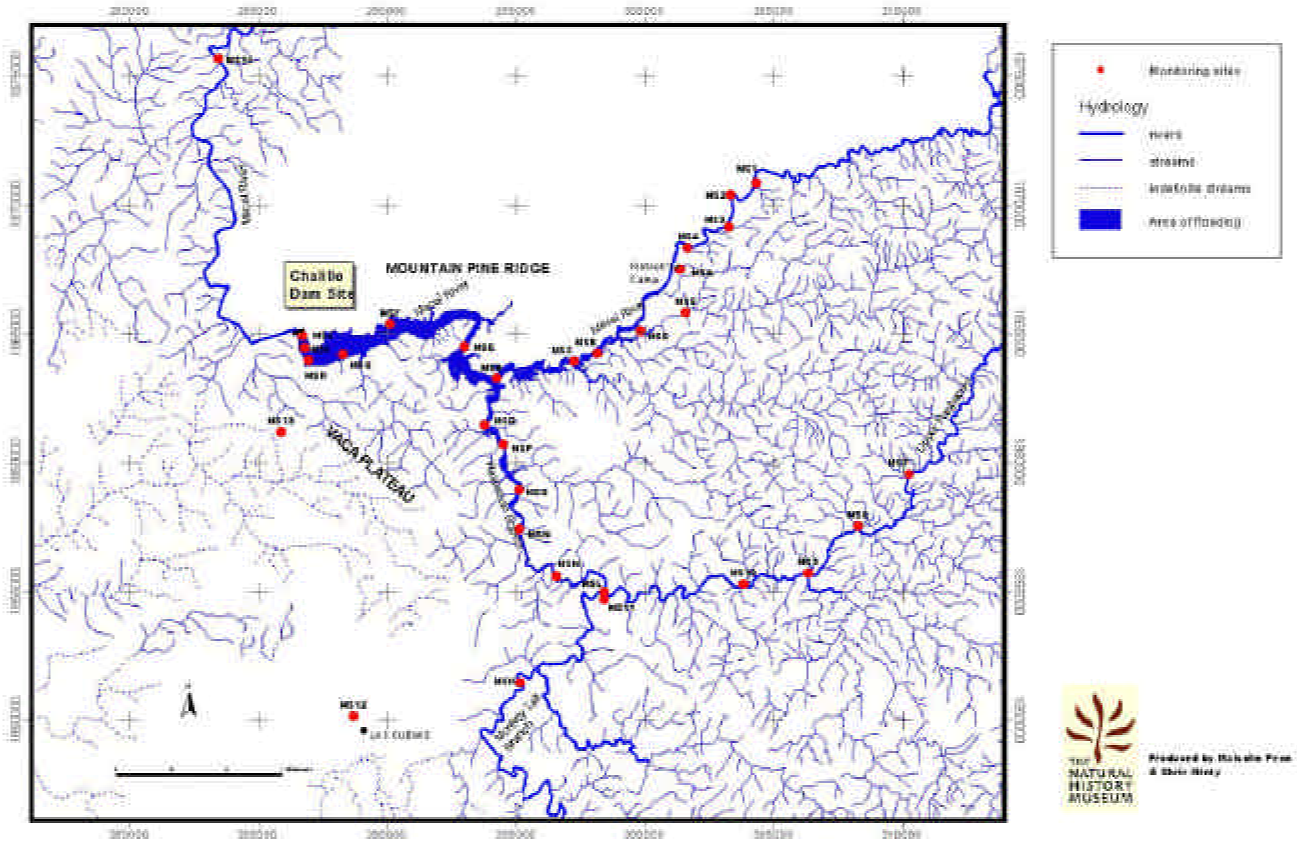

Figure 2 - Habitat of Morelet's crocodile

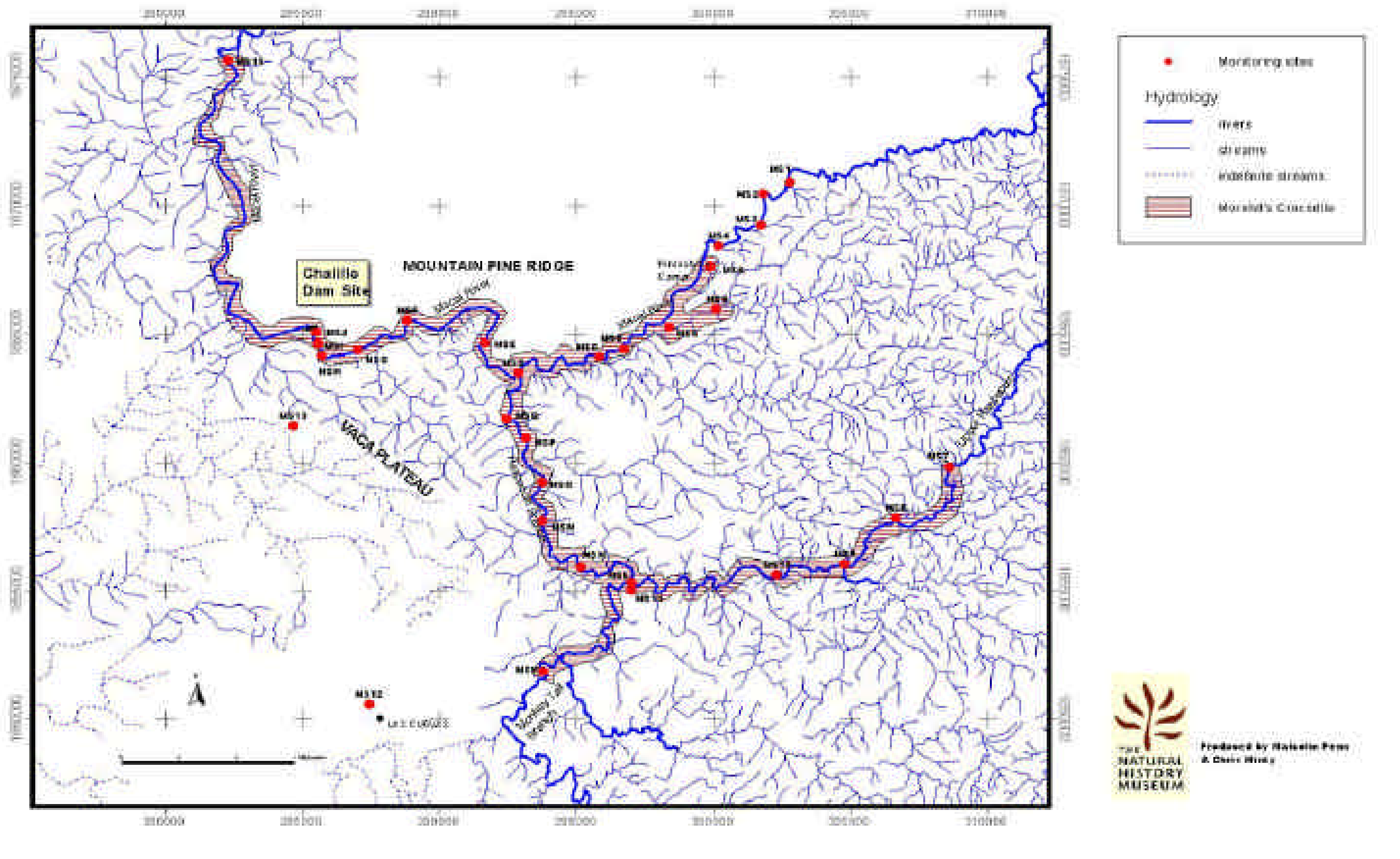

Figure 3 - Habitats of Bairds tapir

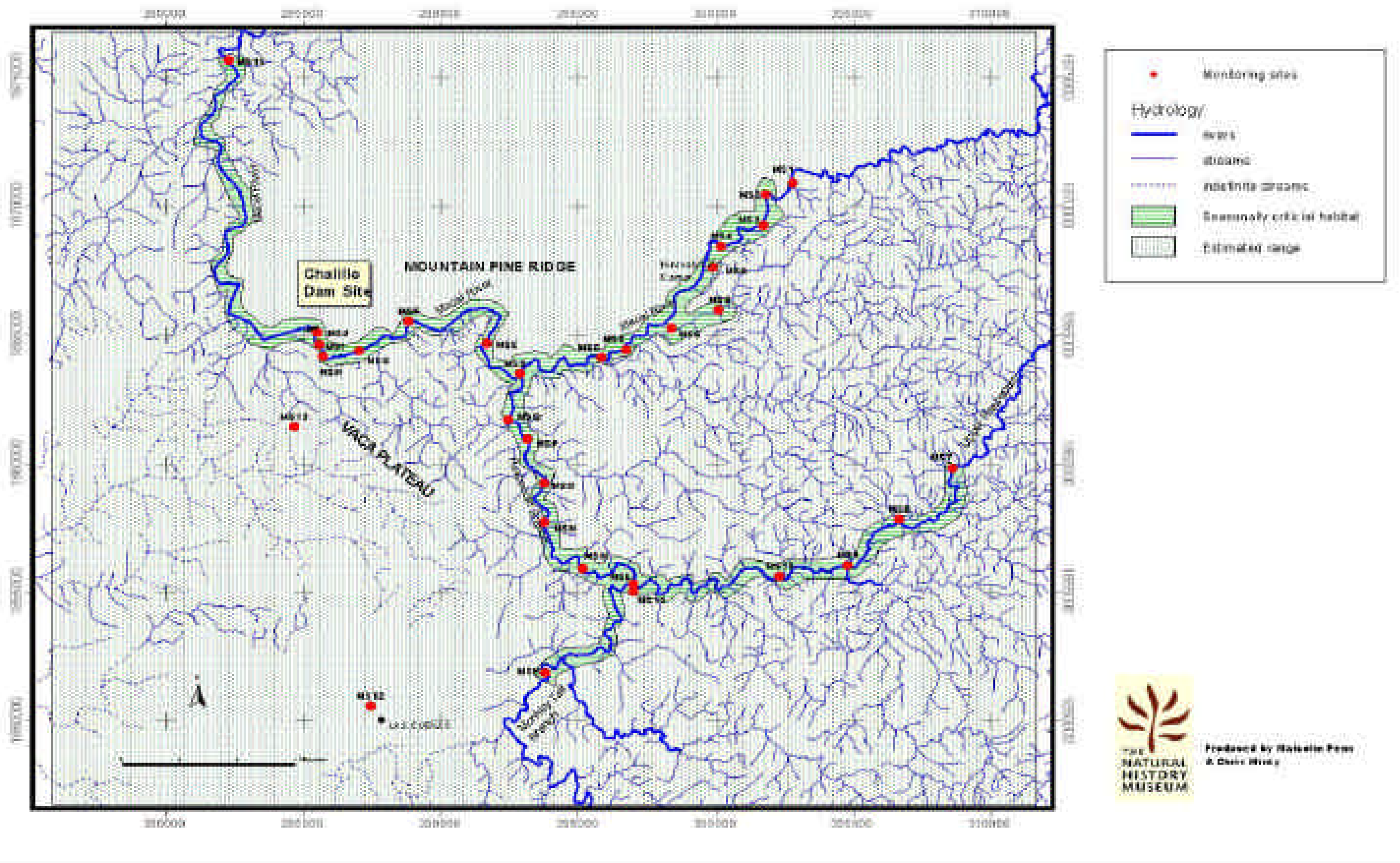

Figure 4. Habitats of Scarlet macaw