Technical Assessment

of the Biodiversity and Cultural Heritage

of the Maya Mountains Massif

April, 2008

Technical Assessment of the Biodiversity and Cultural Values of the Maya Mountains Massif

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Acknowledgments

Over 100 participants took part in this Technical Assessment...and we would like to thank all of them - those who participated in the CAP workshops, associated technical meetings, community meetings and RAPPAM process - for ensuring that this output is as accurate as possible based on the data available.

In particular, we would like to thank the other members of the Core Planning Team for their continued support and input:

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... those community, public and private sector individuals who contributed towards the outputs of this Technical Assessment.

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...and, as always, Adam Lloyd, for producing the maps

A full list of participants is included in Annex 1

Technical Assessment of the Biodiversity and Cultural Values of the Maya Mountains Massif

Introduction

This report is one of a series of five produced for the **Forest Department** of Belize and **The Nature Conservancy** (Belize), and summarise the current knowledge and status of the Maya Mountains Massif, and provide recommendations towards more effective management through system-level direction, strategies and programmes:

1. Summary – A Technical Assessment of the Maya Mountains Massif System
2. **A Technical Assessment of the Biodiversity of the Maya Mountains Massif System**
3. A Technical Assessment of the Threats and Opportunities of the Maya Mountains Massif System
4. Socio-Economic Analysis of the Maya Mountains Massif System
5. Management Capacities within the Maya Mountains Massif System

This report, on the **Technical Assessment of the Biodiversity and Cultural Values of the Maya Mountains Massif,** reviews the current knowledge on the biodiversity and cultural importance of the system, and presents the outputs of the technical assessment, highlighting the biodiversity and cultural values of the Maya Mountains Massif, and assess the viability of the selected conservation targets. It investigates Identification of protected areas with high redundancy of species and ecological system protection and a review on the importance and contribution that system continuity and scale in the Massif brings to the larger national and regional conservation objectives.

The report also includes a monitoring plan for assessing the status of targets and effectiveness of recommended strategies.

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Biodiversity and Cultural Assessment of the Maya Mountains Massif

Introduction

Mesoamerica has been recognised under several recent ecoregional planning initiatives as one of the richest biodiversity areas on this planet, ranking second only to the tropical Andes in terms of diversity and endemism (CEPF, 2004). Despite contributing only one percent to the world's terrestrial land area, Mesoamerica is thought to have seventeen percent of all known terrestrial species, with the highest diversity recorded globally for reptiles and second highest for amphibians (CEPF, 2004). This species richness and diversity is due in part to the geological history of the area, forming a transition zone between three biogeographically distinct regions – the Nearctic, Neotropical and the Caribbean.

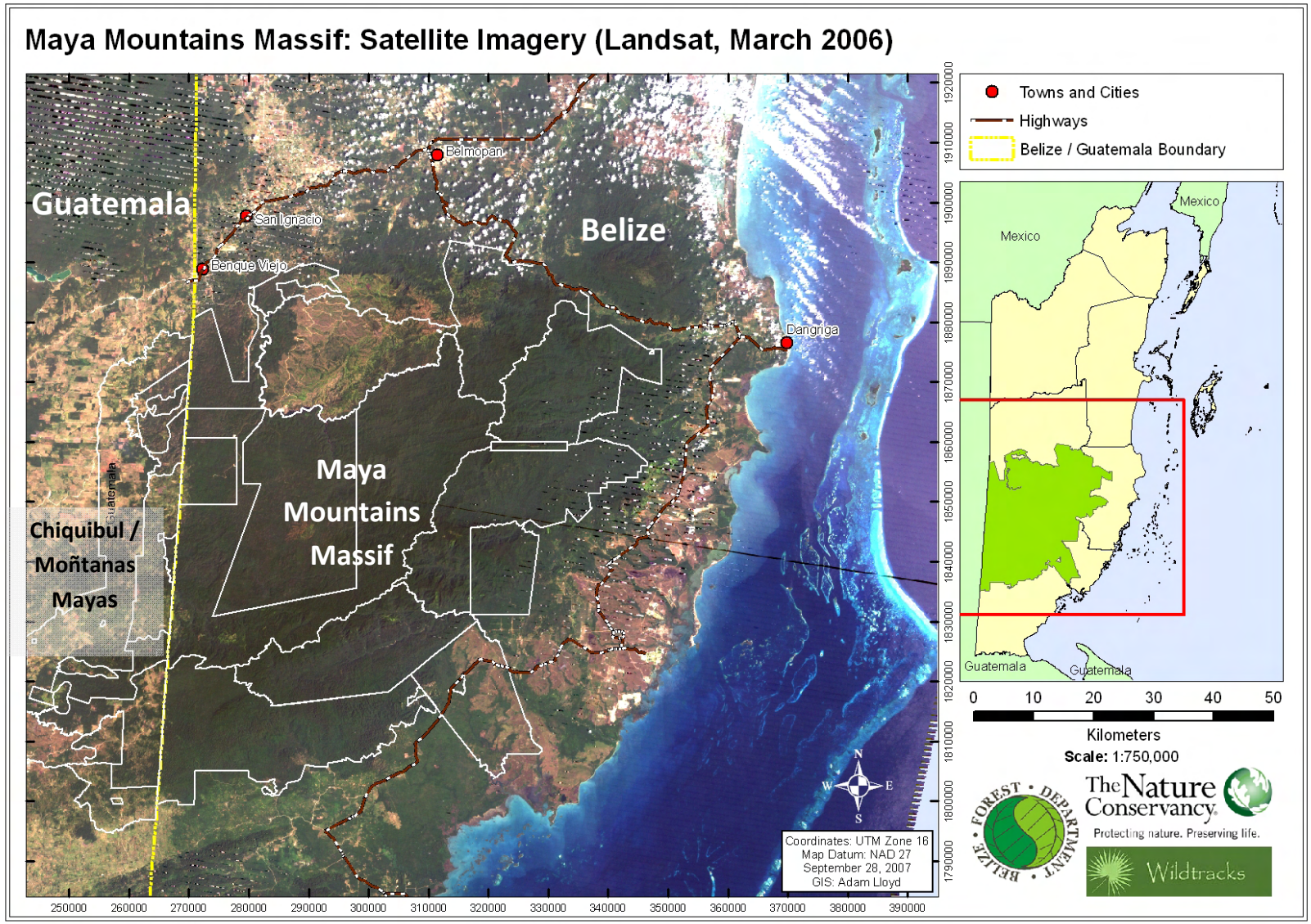
Whilst Belize, with its relatively low topography, lacks many of the endemic species found in high altitudes in the adjacent highland areas of Guatemala, Honduras and Mexico, it is regionally important in its role in maintaining viable populations of many species considered threatened throughout their range, and providing a critical landscape function within Mesoamerica as one of only a few remaining large, intact, contiguous forest blocks within the region. The current low human population density and the network of natural ecosystems within the protected areas system has resulted in Belize providing an important service in the maintenance of regional biodiversity.

Several key reports have recently been produced on the biodiversity of Belize – the Protected Areas System Analysis and the Gap Analysis (both conducted as part of the National Protected Areas Policy and System Plan, NPAPSP, 2005), the identification of Key Biodiversity Areas (Meerman, 2007 – draft), and national reports – the National Biodiversity Strategy, the National Protected Areas System Plan and Policy and the findings from the National Biological Corridors Programme. Each of these assessments highlight the critical importance of the Maya Mountains as one of three national priority areas important in maintaining these high levels of biodiversity. The functioning ecosystems and intact natural vegetation with relatively few human impacts; the range of ecosystems over an altitudinal gradient, with connectivity from mountain ridge to the coastal areas and the Belize Barrier Reef, highlighted for its importance for marine conservation in Mesoamerica; and the importance of the environmental services – the watershed functions, the carbon sequestration functions, the hydrological processes – all add to the importance of these protected areas. Also recognised is its importance as a regional priority under The Nature Conservancy ecoregional planning, and as part of the Selva Maya corridor identified under the CEPF ecoregional planning for northern Mesoamerica as the second largest contiguous area of tropical rainforest in the Americas, after the Amazon (CEPF, 2004).

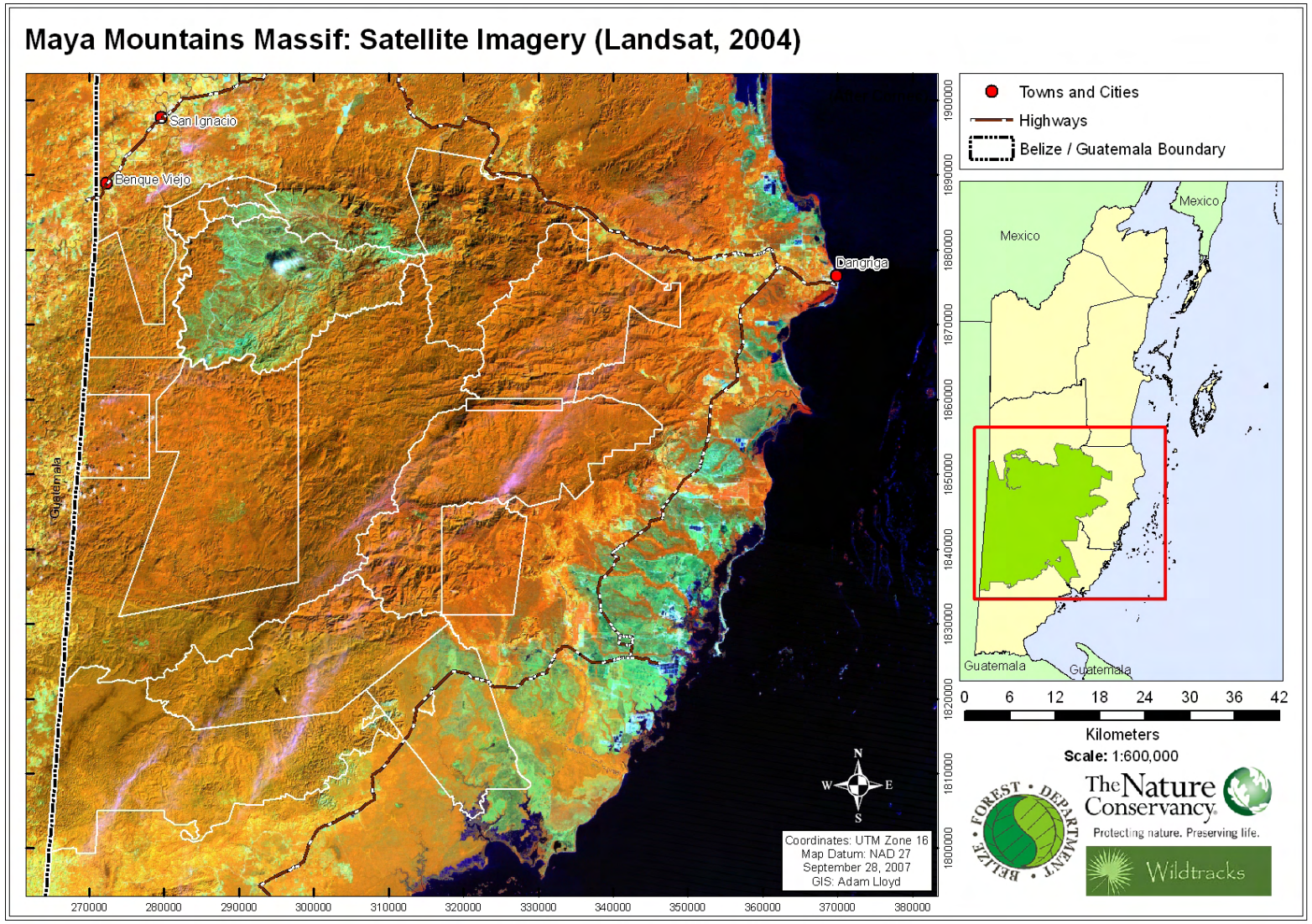
The presence of large numbers of jaguars, considered until recently to be at natural carrying capacity within the protected areas system, suggests that the trophic structure has remained largely intact, with viable populations of prey species. This, however, is changing as pressures, particularly from Guatemala, for natural resources and land drives inhabitants from border communities to enter Belize, through much of the remote Chiquibul and Columbia River forest regions, and harvest these resources to the point of depletion. Increased population pressures and higher levels of poverty within the Belize southern coastal plain communities of Toledo District, are also identified as resulting in a high dependence on the natural resources of the Maya Mountains Massif, with low incomes, low employment opportunities, poor access to education and reliance on subsistence agriculture, being highlighted as primary causes.

Also of importance are the archaeological and cultural resources of the Maya Mountains Massif - in general, the Maya Mountains Massif represents one of the most poorly studied archaeological regions of Belize, as a result of poor accessibility, the rugged nature of a great part of the terrain, and the challenging logistics to conduct archaeological research in this mountainous region. However, current

knowledge suggests that the area was once important to the Maya, with the establishment of Caracol, a major site thought to have been occupied from about the end of the Middle Preclassic period (400 B.C.) through to the Terminal Classic 800-900 A.D., covering more than 25 square kilometers (Chase and Chase, 2001). Satellite communities such as Minanha also sprung up in the more fertile areas of the system, with associated agricultural terracing. Cave systems of ceremonial significance still contain artifacts placed there by the ancient Maya. The more rugged, less fertile areas were also considered to be important for a variety of raw materials that were exploited by the ancient Maya, including vast deposits of granite, volcanics, volcaniclastics, mudstone, siltstone, limestone, pyrites, slate and hematite for mirrors; high quality clays for ceramics; and a host of other minerals for pigments. This considerable resource diversity provided the Maya of the south with substantial economic benefits, with trade and exchange playing an important role in the rise of so many regional centers along the foothills of the Maya Mountain.



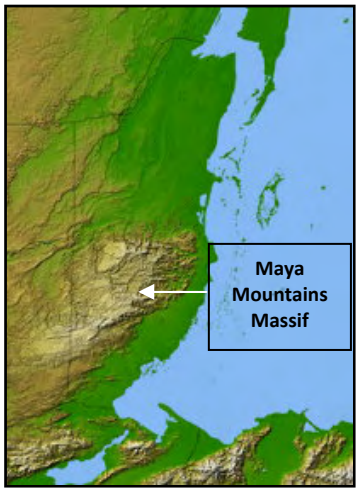
Map 1: The Maya Mountains Massif and Adjacent Chiquibul / Montañas Mayas Biosphere Reserve



Map 2: The Maya Mountains Massif

1.0 Physical Characteristics

Geology and Topography



Map 3: Topography of Belize

The geology of the Maya Mountains Massif dictates to some extent the biodiversity and species distributions, as it is a key determinant factor in the soil characteristics, and therefore the ecosystem distributions within the area. Of perhaps equal importance is the degree of slope and the altitudinal gradients, leading to micro-climatic differences, and also playing a major role in the determination of species distributions.

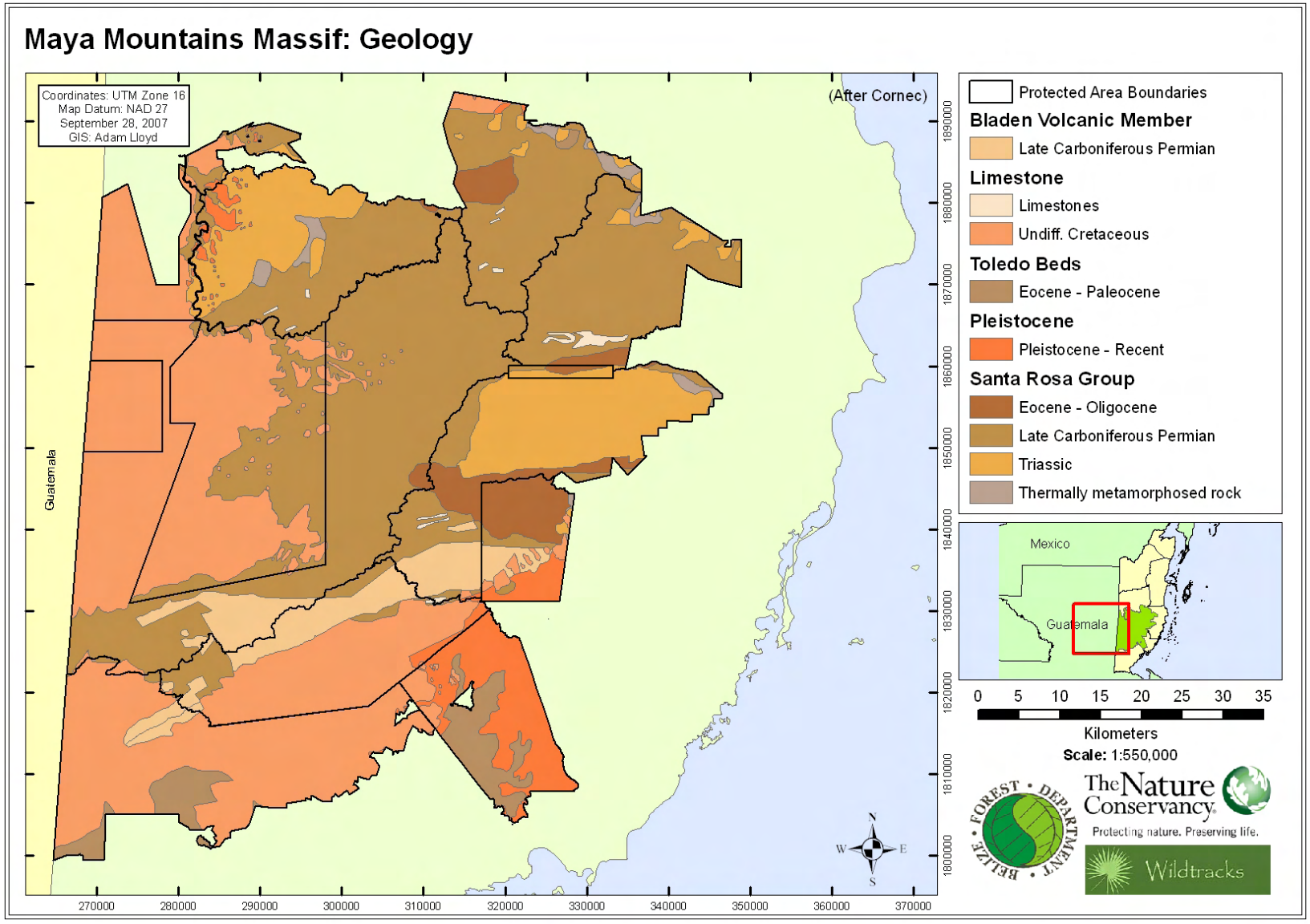
The Maya Mountains Massif forms the prominent elevated area to the south west of Belize (Map 3), and includes the meta-sediments of the Santa Rosa Group, some of the oldest rocks in Central America, deposited in the Carboniferous and Permian Periods some 225 to 350 million years ago (Table 2; Ower, 1928; Dixon, 1956; Bateson and Hall, 1977). The Mountain Pine Ridge-Vaca Plateau regions are formed chiefly from these hard Paleozoic rocks, laid down during two separate stages of sedimentation.

In early Triassic times (195 to 230 million years ago), these metasediments were subjected to tectonic uplift along two major fault systems – the Northern Boundary Fault to the northern edge of the Mountain Pine Ridge area, and the Little Quartz Ridge / Bladen Fault to the south of the Chiquibul Forest area. This uplift was accompanied by granite intrusions, clearly visible in the Mountain Pine Ridge area today. Intruded molten rocks, upon cooling and eventual cementing by silicates, also gave rise to areas of porphyrite and quartzite. By the end of the Jurassic Period, the landmass began to subside and rift valley type basins began to form. In the early Cretaceous Period the entire mountain range was submerged beneath oceanic waters, and dense layers of fossiliferous limestones were deposited over the entire area (Dixon 1956; Wright et al. 1959).

Table 2: Time Scale of Formation of the Maya Mountains Massif

Era	Period	Time Span (million years ago)	Geological Activity
Palaeozoic Era	Permian	225 – 570	Belize covered by a shallow ocean. Sedimentary rocks of the Santa Rosa Group) deposited. Volcanic activity in the Bladen area in the south of Cockscomb (south of Trio Branch)
	Carboniferous		
Mesozoic Era	Triassic Period	190-225	Tectonic uplifts and folding of sedimentary rocks, forming Maya Mountains. Granite intrusion occurs, with contact metamorphosis of adjacent sedimentary rocks to form slate and quartzite
	Jurassic Period	136 – 190	Rift valleys form with erosion of Maya Mountains
	Cretaceous Period	65 – 136	Marine inundation by oceanic water covers the Maya Mountains with limestone.
Cenozoic Era	Tertiary Period	2 – 65	Renewed uplift of Maya Mountains creating present high relief topography. Coastal zone sediments deposited. Erosion of Cretaceous limestone
	Quaternary Period	0 – 2 million	Continued erosion of limestone sequence from Maya Mountains, incision of mountains by streams and rivers

The beginning of the Tertiary Period (65 million years ago) saw renewed tectonic uplift, which has shaped the present topography, resulting in the formation of an upland plateau that dips gently to the west. Weathering of the limestone capping and erosion by stream action has exposed the underlying granite in some areas such as the Mountain Pine Ridge.



Map 4: Geology of the Maya Mountains Massif System

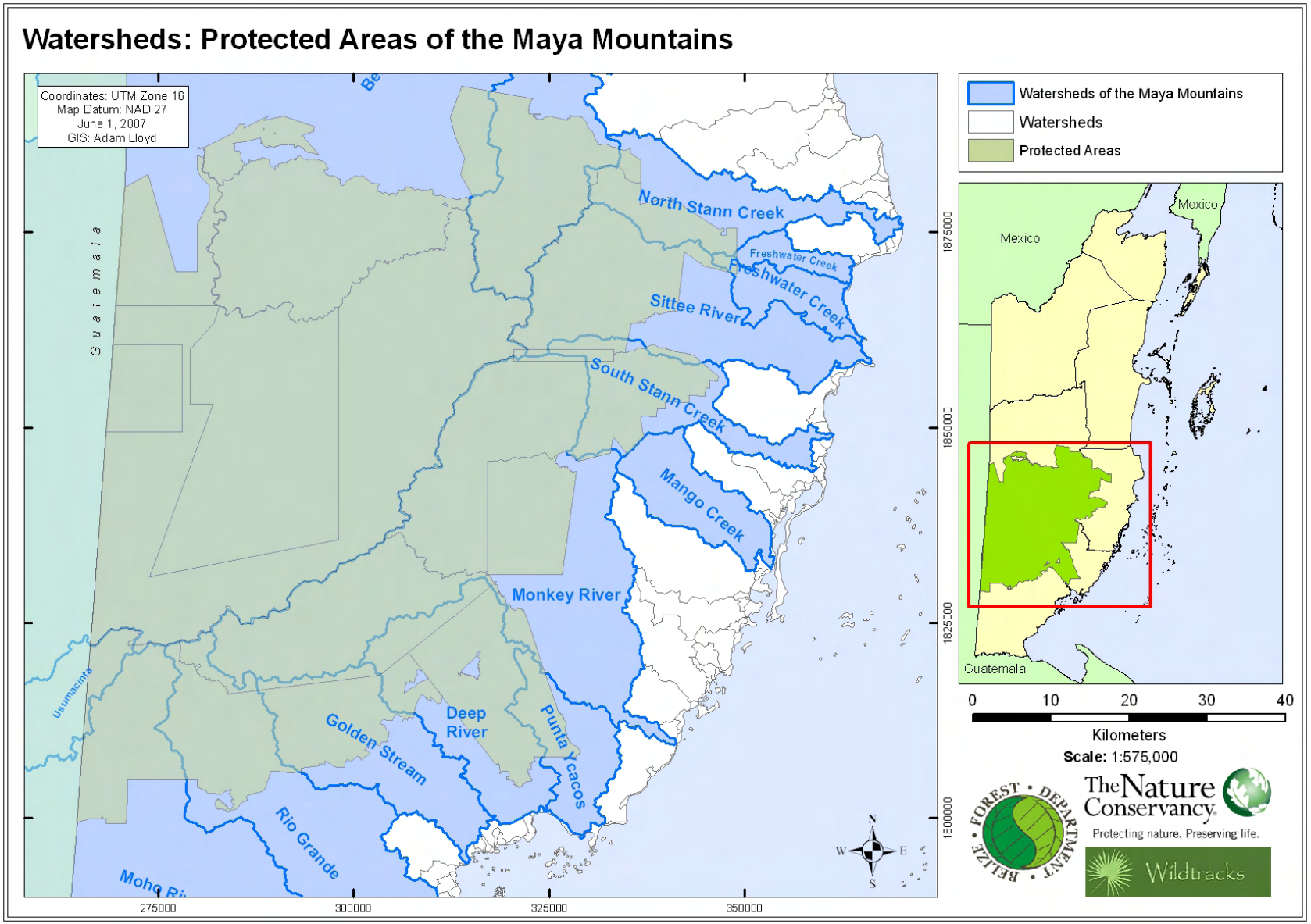
The more easily eroded granite forms the gently rounded low areas of Cockscomb East and West Basins, and is surrounded by the less easily eroded fine-grained metasediments of the Santa Rosa Group. This includes the Cockscomb Range, an erosion resistant ridge of coarse-grained sandstone and quartzite. Since the uplift in the Tertiary Period, much of the Cretaceous limestone, underlying sediments, and the granite (and volcanic porphyry in the Trio Branch area) have been eroded from the eastern slopes of the Maya Mountains, and the bedrock has been deeply incised by streams. However, remnants of the Cretaceous limestone that once blanketed the Maya Mountains can still be seen in the highly karstic southern areas (in Chiquibul, Bladen and Columbia River Forest Reserve), and in the northern margins of the plateau (Vaca Forest Reserve and Elijio Panti National Park). Here, rugged limestone topography of steep, conical hills is pocked by vertical-sided sinkholes, arches, underground streams and caves. Water is scarce in this karst landscape, especially during the dry months, resulting in the presence of a vegetation type adapted to seasonally drier conditions, and a seasonal migration of wildlife to the lowlands. Smaller streams that emerge as springs within the hill slopes then disappear underground again after flowing a short distance – a characteristic of this limestone topography.

Watersheds

The Maya Mountains Massif's role in watershed protection within the area is recognised as particularly important, serving as the headwater region for 12 of the 16 major watersheds for Belize, and with the majority of these watersheds flowing into the Caribbean Sea 15km to the east, and the Belize Barrier Reef - the second largest barrier reef in the world - lying offshore. Fourteen watersheds originate in the Maya Mountains (Map 5), providing clean water and watershed functionality - water supply, water quality, flood control, sediment control, quality of fish stocks, biodiversity, habitat preservation, and recreation - for over 55% of the total land mass in Belize. When at full flood, it will also feed into the coastal wetland areas and central and southern coastal lagoons, such as Placencia Lagoon, important not only for its populations of Antillean manatee and estuarine fish, but also for its aesthetic value as a tourism destination.

The integrity of riparian forests within the MMM is also important, as they play an integral role in maintaining ecosystem structure and function in the watersheds draining the MMM. Much of the headwater regions of the MMM are steep sloped and require continued protected area status, with loss of forest cover in these riparian zones potentially leading to significant impacts from erosion and alteration of the hydrology of the region. In addition, the riparian zones of the headwater reaches provide the organic matter that fuels the aquatic food web, the conservation of riparian zones therefore being critical for the conservation of freshwater biodiversity across the MMM region (Buck et. al., in prep.).

Water is utilized by over 128 communities in Belize, with an estimated population of over 76,531 (BERDS, 2007), and an estimated 180 communities in Guatemala (Selva Maya, 2007), being essential for human consumption and agricultural production, both in Belize and for a significant portion of the Petén in Guatemala.



Map 5: Watersheds of the Maya Mountains Massif

2.0 Biodiversity Characteristics

2.1 Ecoregions

The 'Terrestrial Ecoregions of the World' initiative, under the WWF Conservation Science Programme (Olson et. al., 2001), defines ecoregions as:

> *Relatively large units of land containing a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions…with boundaries that approximate the original extent of natural communities prior to land use."*
>
> **WWF Conservation Science Programme, 2001**

This initiative divides the terrestrial world into eight biogeographic regions and fourteen biomes (major global plant communities, determined by rainfall and climate). The terrestrial ecosystems of Belize lie within the **Neotropic** biogeographic region, and encompass three biomes – **tropical and subtropical broadleaf forest, tropical and subtropical coniferous forest**, and **mangroves.** All three biomes represented within Belize are found within the Maya Mountains Massif area, each represented by a single ecoregion (Table3).

Biome	Ecoregion	Status
Tropical and Subtropical Moist Broadleaf Forest	*Petén-Veracruz Moist Forest*	*Critical/ Endangered*
Tropical and Subtropical Moist Coniferous Forest	*Belizean Pine Forest*	*Critical/ Endangered*
Mangrove	*Belizean Coast Mangrove*	*Vulnerable*

Table 3: Ecoregion Classification for the Maya Mountains Massif area (Olson et. al., 2001),

Of these, only two (**Petén-Veracruz Moist Forest and Belizean Pine Forest)**, both rated as ***Critical/Endangered***, have been included within the conservation planning process for the Maya Mountains Massif. The third, **Belizean Coast Mangroves**, is being included within the parallel Maya Mountain Marine Corridor CAP initiative (Meerman and Salas, in prep.).

Peten-Veracruz Moist Forest

This large block of tropical forest stretches through Belize, Guatemala and southern Mexico, the northern limit being approximately 22°N, towards the northern extent of Veracruz State in Mexico, the southern reach extending to approximately 15°N, just north of the southern border of Guatemala.

Throughout their range, these forests tend to be a matrix of moist tropical forest, bajo, wetlands and riparian habitats. There are a high proportion of tightly linked ecological interactions, and high species-richness, though the number of endemic species is low, with many tree, vertebrate and invertebrate species occur at relatively low densities, resulting in large areas being needed for the support of viable populations, particularly of the larger predators. This ecoregion is classed as 'Critical/ Endangered' (World Wildlife Fund, 2001) as the rate of deforestation increases in the region (1.3% per year regionally (it is suggested that the

Petén-Veracruz Moist Forest

national rate may be much higher, at 2.3% (C. Young, 2007)), with fragmentation of the remaining broadleaf forest blocks. Throughout Central America, this results in not only the loss of key predators, but also secondary local extinctions and changes in species composition when these key species are removed. These forests, despite being adapted for hurricane-dependence in Belize, are very susceptible to change, with understory species being sensitive to even small disturbances in the microclimate, making them particularly vulnerable to habitat fragmentation (Olson et. al., 2001).

In the southern areas of the Maya Mountains Massif, particularly in the Columbia River Forest Reserve, impacts from Hurricane Iris (2001) have significantly altered forest structure, and have been followed by substantial damage from timber salvage activities within the area, and fire damage from escaped milpa fires. Elsewhere in the MMM, recent human impacts on this ecoregion have been primarily forestry, mining, and, overshadowing all other impacts, the widespread illegal harvesting of xate and associated hunting impacts of Guatemalan xateros.

This ecoregion once extended throughout the Petén, but recent Guatemalan Government policies have led to large-scale clearance, particularly for cattle farming, even within the strictest protected area category, the Zona Núcleo.

Landscape of the Petén, following removal of the Petén-Veracruz Moist Forest

Belizean Pine Forest

The Belizean pine forests of the Maya Mountains Massif, both of the Mountain Pine Ridge and the coastal plains, represent one of the few examples of pre-montane pine forest in the Neotropics, and are considered to have a global status of 'critical/endangered' (WWF, 2001). The vegetation is characterized by the presence of the predominant tree species *Pinus caribaea,* with patches of *Pinus oocarpa* in some upper elevation areas*,* and incorporates a range of habitats from pine-dominated stands to mosaics of pine and broadleaf forest and open grass savanna with occasional pine trees. A number of endemic species are restricted to the Pine Forest areas throughout Belize, such as *Dalechampia schippii,* and the ecoregion also supports a distinctive bird fauna, with characteristic species such as the red-tailed hawk and black-headed siskin.

Belizean Pine Forest

Fires, both natural and anthropogenic, are an important process in the maintenance of the pine forest, reducing understory competition by broadleaf species, and assisting in the seed dispersal of the pine trees. Most of the pine forest and savanna areas also show fire impacts, either from natural fires, or from prescribed burns as part of the protected area management. However, the increasing frequency of fires is resulting in a degradation of much of the ecosystem to grass savanna.

The pine forest ecosystems of the Mountain Pine Ridge, dominated by *Pinus caribaea*, have been managed since the 1940's for their timber stocks. Recently, however (2000 - 2002), the extensive standing crop of mature pine trees was decimated by a severe infestation of Southern Pine Bark Beetle, radically changing the forest structure, impacting aesthetic appeal and reducing the wildlife value for tourism. Much of the pine forest areas still show the impacts of the infestation, ranging from the near-

pristine steep valley sides with healthy, mature pine growth and limited Southern Pine Bark Beetle impact, to the near-complete decimation of all mature pines.

The pine stands are slowly recovering through both natural regeneration and reforestation management, though extensive and increasingly frequent fires throughout both the coastal plain and the Mountain Pine Ridge have reduced the speed of recovery. In some areas, a significant understory of younger pines up to 14m in height survived the infestation, and subsequent natural regeneration, coupled with extensive forest restoration work, is speeding the restoration of the aesthetic appeal of the Mountain Pine Ridge, as well as the reestablishment of future timber stocks.

2.2 Ecosystems

Current ecosystem mapping of the vegetation in the Maya Mountains Massif indicates a complex mosaic of 44 tropical broadleaf, pine forest and aquatic ecosystems under the UNESCO system of classification (Map 6), largely dependent on the geology, elevation, slope and soils and rainfall of the area. These can be broadly divided into four different forest categories (Penn et. al., 2004):

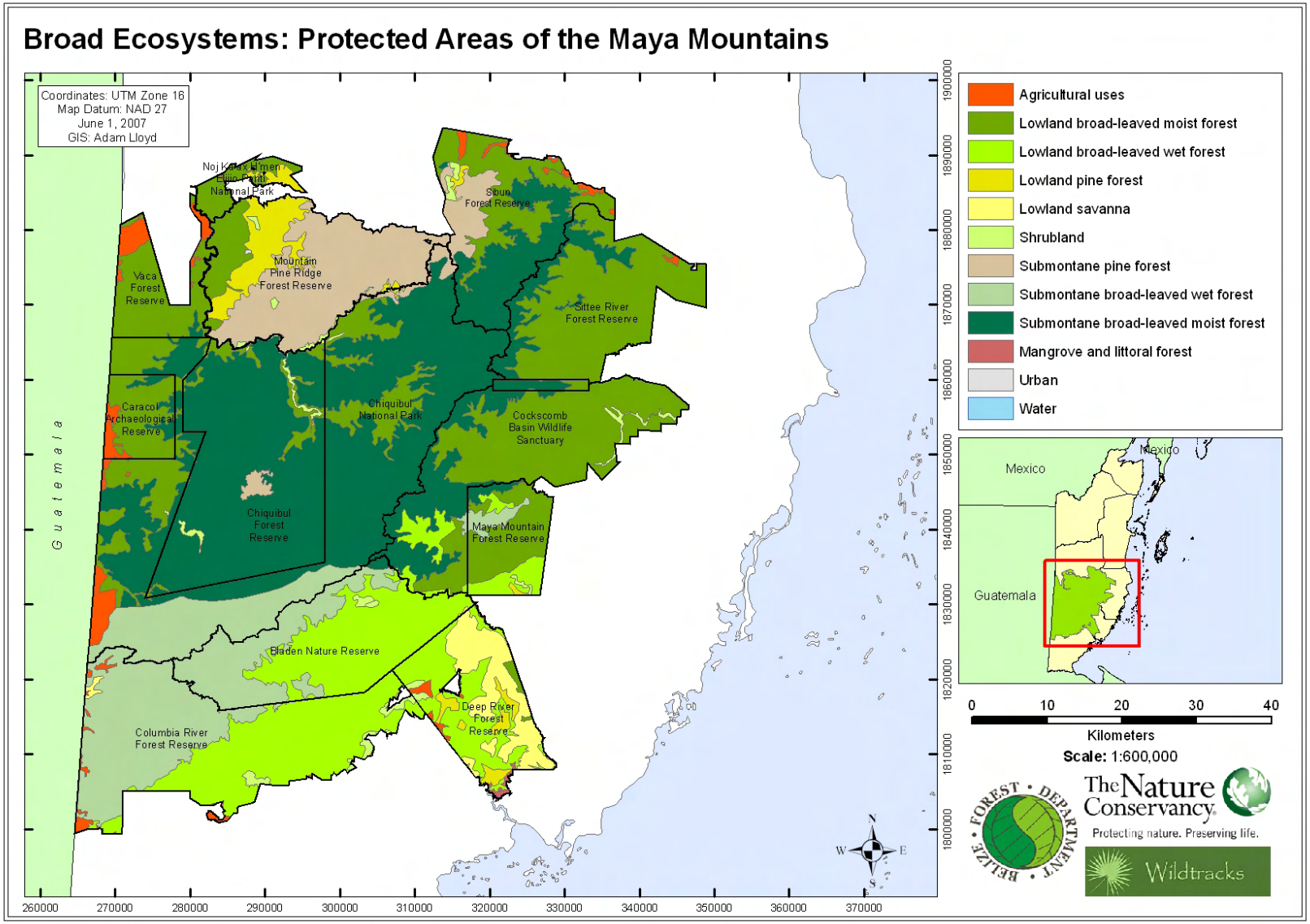
- Semi-deciduous tropical forests — West of the Maya Divide: Chiquibul forest
- Semi-evergreen tropical forests — East facing slopes of the north Maya Divide, encompassing Sittee and Cockscomb Basins
- Evergreen tropical forests — East facing slopes of the south Maya Divide, encompassing Bladen and Columbia River
- Pine savannas and grass — Deep River and Mountain Pine Ridge

There are also a further 3 agricultural systems (representing the agricultural incursion areas), and 2 categories of Caribbean Mangrove forest, mapped within Deep River Forest Reserve, and not covered within this overview (this ecosystem type is covered by the parallel Maya Mountain Marine Corridor and Golden Stream Watershed projects. Approximately 140 hectares is classified as urban, represented primarily by Douglas D'Silva (Meerman, 2004).

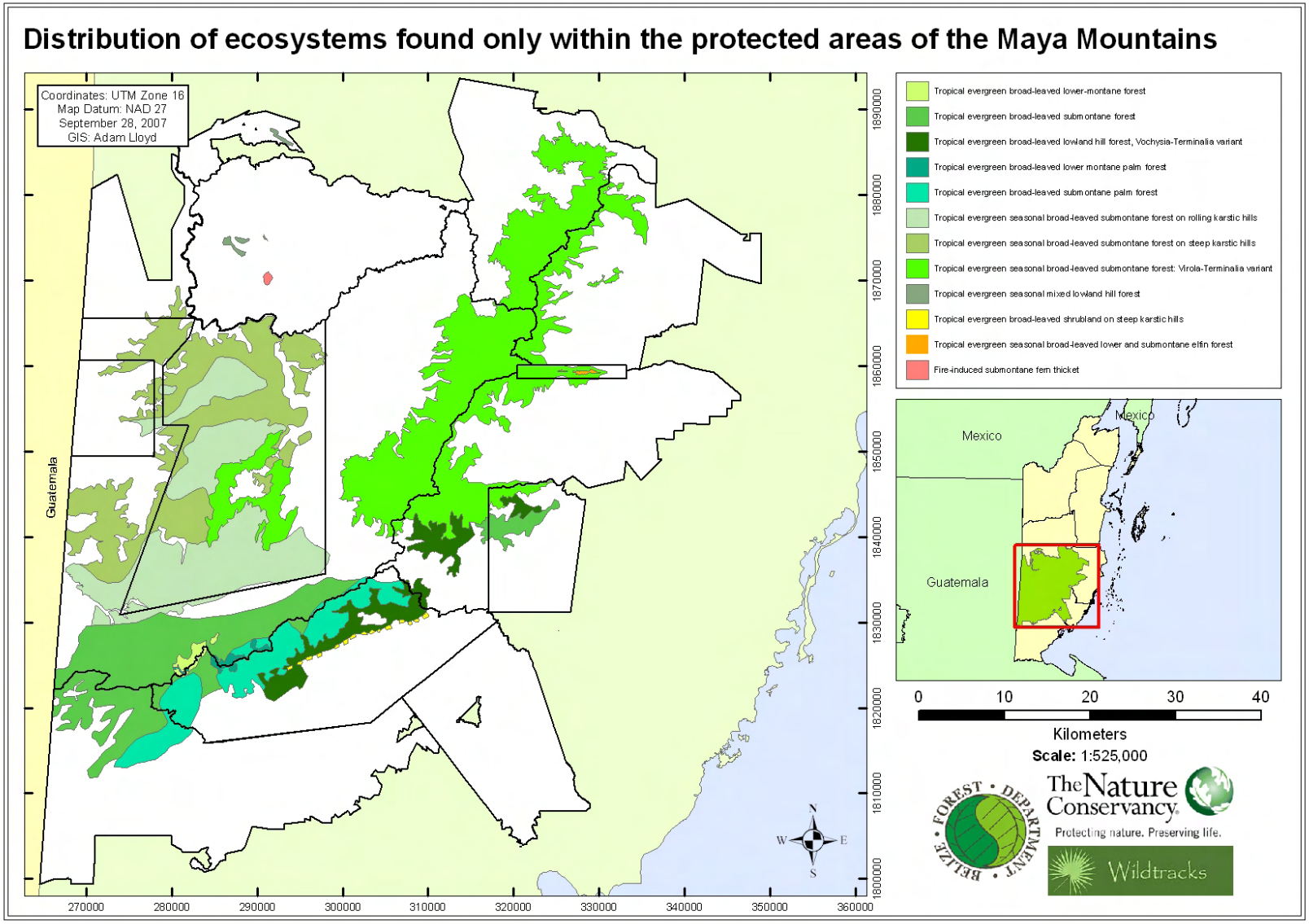
Nationally, thirteen of these ecosystems are found only within the Maya Mountains Massif (Table 4; Map 7), a further 11 have over 80% of their total national extent within the Massif, and eighteen are considered as under-represented within the national protected areas system.

Ecosystems with 100% of national coverage within the Maya Mountains Massif
Fire-induced submontane fern thicket
Tropical evergreen broad-leaved lower-montane forest
Tropical evergreen broad-leaved lower montane palm forest
Tropical evergreen broad-leaved lowland hill forest, Vochysia-Terminalia variant
Tropical evergreen broad-leaved shrubland on steep karstic hills
Tropical evergreen broad-leaved submontane forest
Tropical evergreen broad-leaved submontane palm forest
Tropical evergreen seasonal broad-leaved lower montane elfin forest
Tropical evergreen seasonal broad-leaved submontane elfin forest
Tropical evergreen seasonal broad-leaved submontane forest on rolling karstic hills
Tropical evergreen seasonal broad-leaved submontane forest on steep karstic hills
Tropical evergreen seasonal broad-leaved submontane forest: Virola-Terminalia variant
Tropical evergreen seasonal mixed lowland hill forest

Table 4: Ecosystems with 100% of national coverage within the Maya Mountains Massif



Map 6: Broad Ecosystems of the Maya Mountains Massif



Map 7: Ecosystems only found in Belize in the Maya Mountains Massif

2.3 Species of International Concern

The Maya Mountains Massif is regionally important in its role of maintaining viable populations of at least 30 species of international concern (rated as Critically Endangered, Endangered or Vulnerable under the IUCN, 2007). Two of these are considered Critically Endangered – Morelet's Treefrog (*Agalychnis moreletii*) and *Zamia prasina*, a cycad species, both found primarily in mid to upper elevations.

Morelet's Treefrog (*Agalychnis moreletii*)

Critically Endangered Species of the Maya Mountains Massif IUCN Redlist, 2007	
Morelet's Treefrog *Agalychnis moreletii*	CFR, MPRFR, CAR, BNR, CRFR Assumed to be present in CNP, VFR, EPNP, SRFR, SFR, CBWS, MMFR, DRFR. Only just touches into Sittee River Forest Reserve, and probably not Davis Falls (GAA, 2004 - Based on elevations higher that 300m)
Zamia prasina	CBWS (VP) and CRFR Assumed to be present at other high points, potentially throughout the Maya Mountains

Endangered Species of the Maya Mountains Massif IUCN Redlist, 2007	
Black Howler Monkey *Alouatta pigra*	All (reintroduced into CBWS)
Yellow-headed Parrot *Amazona oratrix*	Deep River. it was once present in Mountain Pine Ridge (M. Windsor, Ulloa, pers. Com)
Bromeliohyla bromeliacia	Gloria Camp, Columbia River Forest Reserve
Craugastor sabrinus	CFR, CNP, CBWS, BNR, CRFR Assumed to be present in MPRFR, CAR, EPNP, SRFR, SFR, DRFR, MMFR
Eleutherodactylus sandersoni	Recorded in CRFR, CBWS (Walker 2007) Assumed to occur in CFR, CNP MPRFR, EPNP, CAR, VFR, BNR
Baird's Tapir *Tapirus bairdii*	All
Trichilia breviflora	CRFR, BNR (M. Meadows)
Fiddlewood, Yax-Nik *Vitex gaumeri*	CFR, CNP, BNR, DRFR, CRFR, VFR (Walker, EIA, 2006) Assumed for MPRFR, EPNP, CAR Query on CBWS, SRFR, SFR, DFalls (presumed for these last three). Is it dependent on limestone?
Zanthoxylum procerum	MPRFR (Rio Frio Caves), CFR, CNP, VFR

Eight species are listed as Endangered, including the black howler monkey (*Alouatta pigra*), an endemic species restricted to a relatively small area of the Yucatan Peninsula, Belize, the Peten of Guatemala. The howler monkey is found throughout the Maya Mountains, though suffered a precipitous population crash in the 1950's from yellow fever, and subsequently from localised hunting pressure. Whilst maintaining low numbers throughout the Maya Mountains Massif, it was considered locally extirpated from the Cockscomb Basin by 1980, following which a successful reintroduction programme was implemented in 1992, re-establishing this species within the Cockscomb Basin Wildlife Sanctuary. Populations are now considered stable, with little hunting pressure from Belizean communities. However, there is increasing pressure from the large population of Guatemalan xateros active in the forests of the Maya Mountains.

Three amphibian species of the Maya Mountains Massif are rated as Endangered (*Craugastor sabrinus*, *Bromeliohyla bromeliacia* and *Eleutherodactylus sandersoni*). A further three species of amphibian are classified as 'Vulnerable' (IUCN, 2007). Following the Global Amphibian Assessment of 2004, there has been increasing recognition of the increasing stresses on these upper elevation species throughout the region. In other Meso-American countries, the advancing agricultural frontier has eroded many of the intact broadleaf forests, resulting in small fragmented patches of upper elevation habitats on mountain tops, surrounded by a matrix of open farmland. Numerous populations of upper elevation amphibians

have suffered catastrophic population crashes in recent years, with several species now being extinct. Chytrid fungus has been implicated in these global declines, with the stresses of habitat fragmentation, agro-chemical pollution (in orographic rainfall) and climate change being highlighted as possible causal factors. Where the *Batrachochytrium dendrobatidis* (the fungus causing chytrid infection) thrives - generally in the cooler, moist conditions in upper elevations - 50% of amphibian species and 80% of individuals can be expected to disappear within 1 year (Lips, et. al., 2006).
Land use change is also affecting species such the Baird's tapir (*Tapirus bairdii*) (Endangered, IUCN, 2008), though the Maya Mountains Massif still remains a stronghold for this species. Increasing reports of hunting in the eastern foothills by Central American seasonal workers, and Garifuna communities resident in the coastal plain show an increased pressure on this species, as does subsistence and commercial hunting within the Chiquibul forest by xateros. Inundation of riparian systems favoured by this species as a result of dam construction has also been highlighted as a pressure on this species.

Also of concern in Belize is the population status of the yellow-headed parrot (*Amazona oratrix*), considered 'Endangered' (IUCN, 2007), and restricted to pine savannas in Belize. Estimates suggest that this species has shown a decline of more than 90% between 1970 and 1990, and a further 68% or more of the remaining population in the past 15 years, to approx. 7,000 mature individuals (Birdlife International). The relatively small population in Belize (exact population estimates are unknown), is considered still viable (though with estimates for the Deep River / Payne's Creek area of between 300 - 500 birds (M. Muschamp, pers. com. 2007), and 200 in the 10,000 ha of pine savanna of Rio Bravo (PfB, 2000). Whilst reports suggest that this parrot once inhabited the Mountain Pine Ridge, as well as the lowland pine savannas, recent records show no evidence of a residual population in this area, and it is thought that past management practices of removing old, dead trees may have led to a lack of suitable nesting sites (M. Windsor, pers. com.). The current main causal factors for yellow-headed parrot decline are considered to be the increasing frequency of anthropogenic fires on the pine savanna, removing suitable nesting trees and causing high chick mortality, as well as the harvesting of chicks for the illegal pet trade, particularly from Honduras and Guatemala, accessing the area from Deep River itself (D. Gomez, pers. com.). This species is covered under the parallel Maya Mountains Marine Corridor CAP process.

Another species highlighted is the **scarlet macaw** (*Ara macao*), the largest of the parrots in Belize, with a national population thought to number fewer than 200 individuals (Matola, 2002). Whilst it was apparently once seen flying over much of the central forested areas of Belize, it is now considered to be restricted to the Chiquibul/ Maya Mountain area, with a nesting range thought to be confined to the Raspaculo River area in the more remote Chiquibul region. A portion of this nesting area, in the upper Macal/Raspaculo River region, has recently been inundated, following the construction of the Chalillo Dam, though it is hoped that the birds will continue to use the area. Illegal xateros are known to kill scarlet macaws within the Chiquibul area to supplement food as they collect xate palm leaves, and it is believed there thought to be an opportunistic illegal trade of nestlings to Guatemala for the pet trade.

Belize Endemic Species found in the Maya Mountains Massif

Plants

- *Anemia bartletti*
- *Axonopus ciliatifolius*
- *Telanthophora bartletti*
- *Calyptranthus bartlettii*
- *Dalechampia schippii*
- *Galactia anomala*
- *Koanophyllon sorensenii*
- *Mimosa pinetorum*
- *Neurolaena schippii*
- *Oxandra proctorii*
- *Pisonea proctorii*
- *Schippia concolor*
- *Scutellaria lundellii*
- *Syngonanthus bartlettii*
- *Zinowiewi pallid*

Vertebrates

- *Poecilia teresae*
- *Rhamdia typhla*
- *Rana juliani*

2.4 Endemic Species

Plants: Forty four plant species have been listed as endemic to Belize (Balick, 2000; BERDS, 2007), many of these being recorded only from the highly restricted Belizean Pine Ecoregion and its fire-adapted savanna ecosystems (Balick, 2000; WWF, 2001). Of these, three have been discounted following review of museum data, as they also occur in Guatemala, Honduras, and/or Mexico (Missouri Botanical Gardens, 2007). Of the remaining forty one species, fifteen (37%) are recorded from the Maya Mountains Massif.

Dalechampia schippii and *Schippia concolor* are common throughout the Mountain Pine Ridge, occurring together in the pine savanna, and are considered indicative of the integrity of the pine ridge ecosystem. *Neurolaena schippii, Scutelleria lundellii* and *Calyptranthus bartlettii* have all been recorded within the Chiquibul Forest.

Fish: Two **endemic** freshwater fish species have been recorded in Belize (Fishbase, 2006). The first, *Poecilia teresae,* is largely confined to the fast flowing streams of the Maya Mountains. It is one of a species assemblage of four that inhabit the species-poor upper reaches of the Mountain Pine Ridge streams such as Rio On and Rio Frio, above waterfalls considered to be barriers to the movement of most fish species (Greenfield and Thomerson, 1997), and is widely distributed throughout the Mountain Pine Ridge area

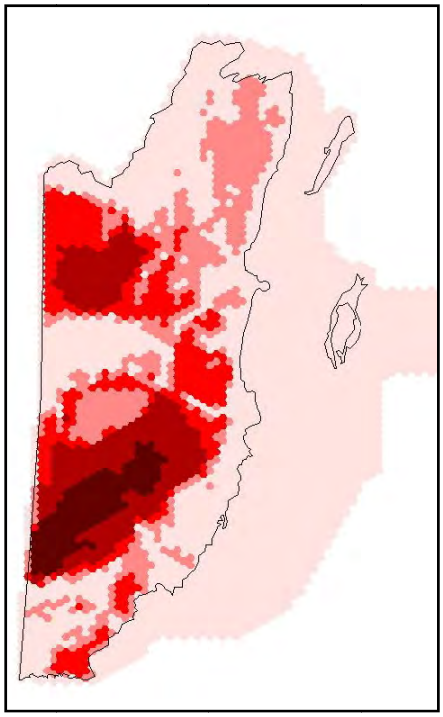
The second endemic species is the cave chulin, or catfish, *Rhamdia typhla*. This species has been recorded only from Las Cuevas cave, in the Chiquibul Forest Reserve, and has been elevated to species status (Greenfield et. al., 1982). Individuals of this species (originally considered a sub-species of *Rhamdia laticauda*), show varying degrees of eye reduction, as a result of evolving in the cave environment.

Amphibians: is currently considered to be Belize's only endemic frog, and whilst restricted to the Maya Mountain Massif, it is considered common in the fast flowing streams, and probably occurs throughout much of the Chiquibul Forest Reserve (Lee, 1996). Ongoing work in the upper elevation areas of the Maya Mountains Massif suggest, however, that there may be more endemic amphibian species still to be identified.

Belize Endemic Frog Species: *Rana juliani*

2.5 Key Biodiversity Areas

The Key Biodiversity Areas analysis (Map 8; Meerman, draft) used the Marxan Analytical Tool to determine biodiversity importance for Belize, based largely upon endangered and/or endemic species, and those considered to be of national concern. The Maya Mountains Massif is consistently highlighted in national and regional planning projects as a primary key conservation area. In the Key Biodiversity Areas assessment, the darker the red, the greater the importance of the area with respect to the conservation of threatened species (Map 5). The analysis is largely based on threatened species-presence data, and does not include overall species richness or ecosystem condition or functionality - additional factors taken into consideration in the current Technical Assessment. (Meerman: Key Biodiversity Areas in Belize Draft, October, 2007). The importance of the less steep, lower lying areas cannot be over emphasised in the maintenance of biodiversity of the Maya Mountains Massif, even though these do not come out as the highest priorities for international species of concern.



Map 8: Draft Belize KBA map
(Adapted from Meerman, 2007)

2.6 RAPPAM Assessment of Biodiversity Importance

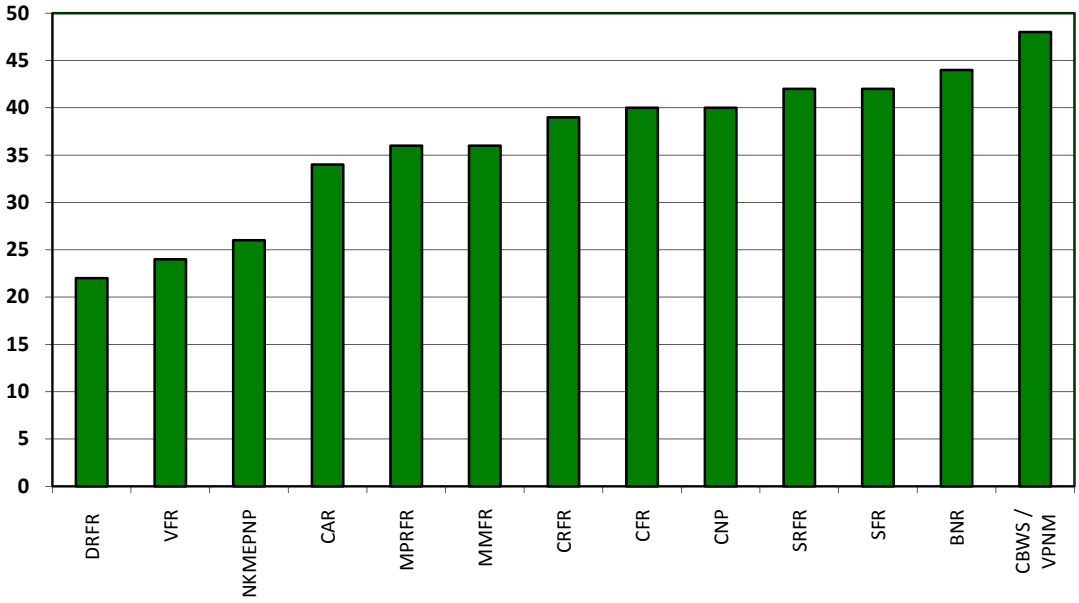
The biodiversity component of the Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) process, conducted at the start of this project, highlighted the value of each of the individual protected areas under the following criteria:

Biological Importance: Indicator Areas

a Number of rare, threatened or endangered species protected by the area
b Relative level of biodiversity
c Degree of endemism within the protected area
d Landscape function of the protected area
e Relative range of biodiversity compared with pre-impacts
f Contribution of protected area to representativeness of biodiversity in the system
g Importance of protected area for sustaining viable populations of key species
h Consistency of structural diversity with historic norms
i Protection of ecosystems with greatly diminished ranges
j Maintenance of the full range of natural processes and disturbance regimes

RAPPAM

The initial results of this analysis are summarized in Graph 1, and highlight the important landscape functions played by the protected areas of the Maya Mountains, particularly those that lie against the Maya Divide. Cockscomb Wildlife Sanctuary, Bladen Nature Reserve, Sittee River Forest Reserve and Sibun Forest Reserve rate as the highest value areas of threatened species protection, species richness, endemism, watershed functionality and maintenance of natural resources and disturbance regimes, with the Chiquibul Forest Reserve / National Park and Columbia River Forest Reserve also being highly rated. These finding are supported by the recent identification of Key Biodiversity Areas (Meerman, draft.).



Graph 1: Relative Biodiversity Importance of the Protected Areas of the Maya Mountains Massif (RAPPAM assessment, 2007)

2.7 Critical Ecosystem and Landscape Functions

The Maya Mountains Massif also performs a number of critical ecosystem and landscape functions at both national and regional level. As one of the largest remaining contiguous blocks of forest in Central America, and as part of the Selva Maya corridor (TNC, 2006), it is recognized for its role in maintenance of the matrix of tropical broadleaf forests that are characteristic of northern Mesoamerica, but are currently greatly diminished in comparison with the historic range.

Until recently, the area was considered to be maintaining the full range of natural processes and disturbance regimes, and to be functioning within the range of acceptability, with no or minimal human intervention, though the Chiquibul Forest Reserve has been selectively (and extensively) logged since the early 1900's. Whilst this selective timber extraction may have altered the species composition, with the depression of timber tree densities, and dissected the forest with many logging tracks, the overall structure of the forest remains intact. Recent pressures from Guatemala are, however, having significant impacts on the biodiversity, and require immediate intervention if the long term degradation of the natural and cultural resources is to be avoided. The major current impact on the Maya Mountains Massif has been identified as the illegal, widespread and unsustainable harvesting of *Chaemadorea ernesti-augustii* (xate), with associated hunting pressure, which has reportedly drastically reduced populations of many game species within the forest, including species not generally hunted within Belize, such as Baird's tapir, scarlet macaw and spider monkeys.

Critical Ecosystem Functions of the Maya Mountains Massif

Direct Products

- *Food*
- *Medicines*
- *Building materials*
- *Craft Materials*
- *Commercial Timber*
- *Xate*

Ecosystem Services

- *Air and Water Purification*
- *Climate Modification*
- *Drought and Flood Control Cycles*
- *Nutrient Cycling*
- *Economic Value – Tourism*
- *Pollination*

Inspirational and Cultural Attributes

- *Cultural products (eg. copal)*
- *Aesthetic Landscapes*
- *Spiritually significant caves*
- *Relaxation*
- *Traditional folklore*
- *National Emblems*
  - *Keel-Billed Toucan*
  - *Baird's Tapir*
  - *Mahogany*
  - *Black Orchid*

2.8 Redundancy in Biodiversity Protection

The assessment has clearly demonstrated and emphasised the very limited availability of species-level biodiversity data for the Maya Mountains Massif of value for detailed conservation planning. The majority of biological assessments and research conducted within the Massif have been site-focussed, with little scope for system-wide comparison, and with the exception of a few broad-ranging key species, distributional data is generalized and predictive, rather than being based on reliable, ground-truthed data. Ecoregional mapping initiatives to predict species distributions based on known ranges and ecological parameters have not yet yielded results that closely resemble known ranges for Belize that are sufficiently accurate for conservation planning uses – at least not at the species level. Significantly more system-wide, multi-taxa, focussed site assessments will need to be conducted before the distribution of more than a handful of non-ubiquitous species can be reliably predicted across the Massif.

Recent and ongoing research (Brewer, S. in prep.) is demonstrating far higher species richness in some areas of the Maya Mountains Massif than would be predicted with current techniques and available data – demonstrating that there are significant risks in looking for redundancy in species or system protection at this time. With multi-taxa discoveries of new species of plants and vertebrates occurring as a result of recent and ongoing initiatives to assess biodiversity in previously unstudied areas of the Maya Mountains Massif (Brewer, S. pers. com; Goodwin, Z. pers. com; Walker, P. pers. obs.), it is increasingly clear that the species diversity of the Maya Mountains may be significantly higher than has been presumed to date. Cautionary principles therefore dictate that whilst there may now be a political need to look for possible redundancy within the Maya Mountains Massif, resultant actions should be deferred until appropriate ground-based comparative field assessments have been implemented.

A further complication to the consideration of potential redundancy in redundancy species and ecosystem redundancy is that of connectivity. This technical assessment, in drawing on the combined knowledge base of biologists conducting research in Belize, has determined that the Massif is not large enough to maintain viable populations of large predators if isolated from currently contiguous forests spreading throughout Belize and into Northern Peten. Connectivity is already tenuous, with one of the two most important linkages being between the Sibun and Manatee Forest Reserves – an area that has already suffered agricultural incursions and de-reservations. If the Maya Mountain Massif is to maintain viable populations of jaguar in the long-term, connectivity must therefore also be included in the equations of assessing possible redundancy.

Recognizing that the current best available data at the species level is not sufficient or accurate enough to be used to determine species-level redundancy in the protected areas of the Massif, redundancy can currently only be considered at the ecosystem level – which in turn may be used as a proxy for some (often ubiquitous) species. A total of 13 Belize's ecosystems occur only in the Maya Mountains Massif, their combined footprint extending into 13 of the 14 protected areas (Deep River Forest Reserve being the only protected area not contributing to these particular ecosystems). The very limited range of each of these 13 ecosystems dictates that there is no redundancy in their protection in system, which in turn dictates that none of the 13 protected areas within their combined footprint can be considered redundant in their entirety.

Recognizing that the core area of the Massif, by its very nature, cannot be considered redundant in either species level or ecosystem level protection, or in its role of watershed protection, the question of redundancy must therefore be focussed along the periphery of the system. As the maintenance of forest cover along the border with Guatemala has been recognized as a preferred policy to help buffer the biodiversity of the core of the Maya Mountains Massif from illegal incursions and extraction (FD,2007), the western boundary of the Maya Mountains Massif is not included in the assessment of potential redundancy in species and/or ecosystem protection. Additionally, whilst much land degradation has taken place within Complejo III of the Guatemala Biosphere Reserve, there remains the need to maintain any and all remaining connectivity with the forest tracts that have persisted to date, as without connectivity to the forests of the Maya Mountains Massif, the Guatemalan forests are now too small to retain their biodiversity in isolation. Examination of ecosystems in the remaining peripheral area of the Massif, and

using the NPAP Gap Analysis indicates that only two ecosystems might be considered to potentially have any redundancy in level of protection.

- **Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain** is identified as exceeding the national target level of protection by 11% (Belize Ecosystem Map (Meerman, 2004). This ecosystem occurs within six of the protected areas of the Massif, and is the predominant ecosystem of the Vaca Forest Reserve and of the Elijio Panti National Park. Subsequent fieldwork in Elijio Panti National Park (Walker & Walker, in prep), however, indicates that the resolution of mapping does not show the lowland hill forest on rolling karstic terrain that occurs in the valleys between the steeper hills, reducing the area of redundancy.

- The Gap Analysis also identified tropical **evergreen broad-leaved lowland forest on poor or sandy soils** as having a level of protection 3% above the national target level; this ecosystem occurs within much of the Deep River Forest Reserve and the south-eastern portion of Maya Mountain Forest Reserve. It should however be noted the overall 3% redundancy was reduced to about 1.5% by the recent de-reservation of part of the Maya Mountain Forest Reserve.

The short grass savanna with shrubs that occupies a significant portion of the Deep River Forest Reserve, was identified as exceeding national protection target levels by 6%, though as the DRFR tract is the only significant example of this ecosystem within the Massif, it cannot be considered as having any redundancy within the Massif itself. Two ecosystems, tropical evergreen broad-leaved lowland hill forest on rolling karstic hills and tropical evergreen broad-leaved submontane on rolling karstic hills, that occur almost exclusively within the Bladen Nature Reserve and the Columbia River Forest Reserve were identified in the Gap Analysis as significantly exceeding (42% and 19% respectively) the national target – but these target figures did not take into account tract size and distribution in relation to accepted minimum dynamic areas for tropical forests. Taking this key viability factor into consideration, then neither of these two ecosystems has any redundancy in protection. A significant portion of the northern and eastern periphery of the Massif is cloaked in broad-leaved lowland hill forest (Simarouba-Terminalia variant) – an ecosystem whose level of protection within the national protected areas is 14% below the target level identified in the NPAPSP Gap Analysis (Meerman, 2005) – and therefore has no redundancy in level of protection. Indeed, as one of the ecosystems occurring on less rugged terrain, this system is believed to be particularly species-rich, and to support higher densities of fauna than the ecosystems occurring on steeper slopes – leading to a concern that perhaps not enough of this ecosystem occurs within the Massif.

Thus in conclusion, based on the NPAPSP Gap Analysis, the main ecosystem coverage that might be considered to have some redundancy in protection would be that in the north-western portion of Vaca Forest Reserve, that of the northern and western portions of Elijio Panti National Park. Cautionary principles relating to current mapping data dictate that possible re-alignment actions, however, should be deferred until such times as appropriate ground-based comparative field assessments (and a parallel assessment of the socio-economic context of these areas) have been implemented. The only other (small) area that might be considered to have any redundancy is the south-eastern corner of Maya Mountain Forest Reserve, as the areas of that same ecosystem type within the Deep River Forest Reserve play a central role in maintaining 'Ridge-to-Reef' connectivity with the Port Honduras Marine Reserve.

2.9 Archaeological and Cultural Characteristics

Introduction

Archaeologically, Belize is located within the eastern Maya lowlands and is part of the Maya sub-area of Mesoamerica. Human prehistory within the Maya Lowland sub-area (and by extension Belize) is generally divided into three major time-frames (Annex One. These include the following phases:

- **Preceramic period (10,000 – 1200 B.C.):** This phase is characterized by the first colonization of Belize by modern homo-sapiens. These first inhabitants predate later Maya settlers and there is still debate as to the genetic relationship between the two groups.

- **Prehistoric Maya occupation (1200 BC to AD 1500):** This phase begins with the establishment of the first agricultural settlements, then continues with the establishment of Maya civilization and its subsequent decline, and terminates with the arrival of Europeans.

- **Historic period (1500 -1900 A.D.):** This phase commences with the initial contacts between Spanish and native populations followed by the conquest of the Maya and attempts by the Spanish to convert them to Catholicism. In Belize this phase ends with eventual British occupation in the early 1700's, and the subsequent establishment of British colonial rule.

Four geo-cultural sub-regions have been identified under the assessment:

- **Mountain Pine Ridge Subregion:**

  The Mountain Pine Ridge is characterized by poor acidic soils, derived from granite, shale, sandstone, quartzite and some limestone, resulting in the region being predominantly unsuited for arable farming (Wright et al. 1959). The agriculturally nonproductive nature of the region has been held responsible for the scarcity of archaeological sites in this sub-region. Few sites have been identified within the actual Pine Ridge, and are predominantly cairns, with a few associated pottery sherds, including incensario fragments. The sub-region is, however, suggested to have been important as a source of granite and slate, exploited by the Maya for the manufacture of manos, metates and non-utilitarian objects. In a "borderland zone" - a projection of the Vaca Plateau into the granitic borders of the Pine Ridge, generally grouped in the Pine Ridge region – lie the Rio Frio Caves A, B, C, D and E, located 3km northwest of the Douglas D'Silva Forest Station. Ceramics and other cultural remains recovered at the sites indicate a Late Classic (A.D. 600-800) date of utilization.

Archaeological Sites of the Mountain Pine Ridge Sub-region

Surface Sites

- *Cooma Cairn*
- *Granite Cairn*
- *Rio On Cairn*
- *Rio Frio Settlement*

Cave Sites

- *Rio Frio Caves A,B,C,D,E**
- *San Luis Cave*

*The Institute of Archaeology is in the process of establishing co-management presence for Rio Frio Caves with Forest Dept.

- **Chiquibul Subregion**

The Chiquibul sub-region is located to the south of the Macal River, and extends to the main divide of the Maya Mountains and bordered to the west by the international boundary with Guatemala. This is a relatively large area that still retains the dense mantle of limestone deposited during the Cretaceous Period (Wright et al. 1959:23), highly karstic in character, resulting in most of the drainage to be subterranean (Johnson and Chaffey, 1973:13). The only surface rivers in the area are the Chiquibul in the south and the Macal and its tributaries to the north. Other small surface streams are either seasonal or tend to siphon underground a short distance from their source.

Prehistoric Maya activity is thought to have commenced in the Chiquibul during the Preclassic period, and been concentrated in the Classic Period, with the presence of considerable terrace systems and settlements around Caracol, the most prominent site in the region. The collective information produced by investigations in the area and archaeological remains recovered at numerous sites and caves suggests that the greater Chiquibul sub-region was intensively occupied by the prehistoric Maya, with Maya occupation beginning sometime in the Preclassic period (400 B.C), intensifying during the Classic period (A.D. 300-800), and declining in the Terminal Classic (A.D. 800-1000).

- **Vaca Sub-region**

The Vaca sub-region remains poorly investigated, with research being sporadic at best, and primarily focused on a relatively few surface sites and cave surveys. Surface sites include the Minanha site, thought to have been first settled sometime during the Middle Preclassic period (600-300 B.C.) and later abandoned in the 9th century A.D. During its apogee Minanha thrived in an area that bordered the large city states of Naranjo to the northwest (in Guatemala), and Caracol to the south. Conflicts between the two larger polities eventually implicated Minanha and the site likely succumbed to the control of its local Vaca overlords, triggering the slow and eventual decline of the center. (Iannone 1999, 2001a, 2001b, 2004, 2006; Iannone et al. 1999, 2000, 2001, 2002, 2003, Birch and Philpot 2002; Schwake 1999, Siebert 2004, Trainor and Sweely 2003)

Located to the north of Minanha is **Camp 6**, a Classic Period site consisting of seven mounds forming two plazuela groups, containing three pyramidal buildings, a range-type "palace" structure, a ballcourt, and several other small mounds (Mason 1928).

Archaeological Sites of the Chiquibul Sub-region

Surface Sites

- *Blue Hole*
- *Caracol*
  - *Ceiba*
  - *Cihquistero*
  - *Cohune*
- *Conchita*
- *Mountain Cow (Tzimin Kax)*
- *Puchituk*
- *Ramonal*
- *Retiro*
- *Zaiden Creek*

Cave Sites

- *Actun Balam*
- *Chiquibul system*
  - *Actun Kabal*
  - *Cebada Cave*
  - *Tunkul*
  - *Xibalba*
- *Cubeta Cave*
- *Eduardo Quiroz*
- *Las Cuevas (Awe Caves)*
- *Starkey Hill Cave*

Archaeological Sites of the Vaca Sub-region

Surface Sites

- *Camp Six*
- *Minanha*

Cave Sites

- *Actun Ixcantini*
- *Morales Cave*
- *Stela Cave*
- *Offering Cave*

Sites of the northern border of Vaca

Surface Sites

- *Las Ruinas de Arenal*

Cave Sites

- *Actun Chapat**
- *Actun Halal*
- *Chechem Ha Cave **
- *Sun of Chapat**
- *Uchetzub**

**Co-management agreements developed or being developed between IoA and co-management partners*

The karstic landscape in the Vaca area has resulted in the presence of many caves, considered important to the Maya culture. Ten caves sites including **Actun Chapat, Actun Chechem Ha. Actun Halal, Cueva de las Ofrendas, Son of Chapat Cave**, and **Stela Cave,** located in the northern boundaries of the Plateau, have been the focus of recent surveys under the Western Belize Regional Cave Project. Initial cave utilization in the area is thought to have extended to as early as the Paleo-Indian - Archaic period, but with greatest human use occurring during the Late Classic (700-900 A.D.) phase of Maya occupation. Only a few sites, like Uchentzub (**Flour Camp Cave**), contain evidence for Maya ritual activity into the Historic Period (Awe 1998, 2004, 2006; Awe et al. 2005; Fegusson 2000; Griffith 2002; Helmke et al. 1998, 2003; Ishihara 200, 2001;; Lohse 2005, Lohse et al. 2004, 2006; Morehart 2002, 2005; Moyes 2002, 2004, 2005, 2006; Moyes et al. 2005, 2006, in press)).

More than a dozen other cave sites have been identified and surveyed in the central Vaca Plateau producing significant information on karstification processes, regional paleo-climates, and ritual cave use in the area (Reeder 1994, 2003; Reeder et al. 1995, 1996, 1998, 1999, 2000, 2003, 2005; Colas 1998, Colas et al. 2000; Polk et al. 2007; Webster 2000, Webster et al. 1999, 2007).

Following the abandonment of most prehistoric cities in Belize, the northern and western districts were subsequently re-populated in the 1800's by other groups of Mayas escaping the Caste wars in Mexico, later joined by other multi-ethnic pioneers seeking their fortunes in western Belize. The incursion of new settlers led to renewed exploitation of the Vaca sub-region in the early 1900's for chicle and mahogany. Whilst eventually abandoned due to the logistical limitations of operating in the steep terrain, the Historic Period tractors and locomotives can still be found strewn across the Vaca countryside, though much as been removed by metal hunters.

- **Southern Sub-Region**

The southern Belize sub-region covers a large geographic area that encompasses the Sibun and Sittee River Forest Reserves, Cockscomb Basin Wildlife Sanctuary, the Maya Mountain, Deep River and Columbia River Forest Reserves, and the Bladen Nature Reserve. Archaeological data for is very disparate, and for some of these areas, practically nonexistent, particularly for the more inaccessible lands adjacent to the Maya Mountain Divide, and for Sibun and Sittee Forest Reserves. Sites for which there is detailed information lie primarily in the foothills and southern coastal plain, along the Southern Highway, and not within the Maya Mountains Massif itself (e.g. Nim Li Punit, Xnaheb, Lubaantun, Hokeb Ha Cave, Uxbenca and Pusilha). Information for these sites, however, unquestionably reflects those of the prehistoric communities that thrived within the actual Maya Mountains Massif, and can provide an insight into the history of the area.

More than 200 sites have been identified and mapped in southern Belize, with economic activities of these centers believed to be focused on resource exploitation and exchange (Dunham et al. 1989; Graham 1983, 1987; Hammond 1975, 1981; Leventhal 1990, 1992; MacKinnon 1989; McKillop and Healy 1989; Wanyerka 2004). The greater Maya Mountains contain a variety of raw materials

Archaeological Sites of the Southern Sub-region

Surface Sites

- *C'hacben K'ax*
- *Ek Xux*
- *Ich Cuhil*
- *Quebrada de Oro*
- *Sand Creek*
- *Twelve Mile*

Sites with Carved Monuments

- *Caterino*
- *Choco*
- *Lagarto*
- *Papayal*
- *Pearce Ruins*
- *Tzimin Che*

Cave Sites

- *Bladen Cave 2*
- *San Miguel Cave*

Sites with Cave Art

- *Aun Dzib*
- *Cayuco Cave*
- *Robert's Cave*

that were exploited by the ancient Maya, including vast deposits of granite, volcanics, volcaniclastics, mudstone, siltstone, limestone, pyrites, slate and hematite for mirrors; high quality clays for ceramics; and a host of other minerals for pigments. This considerable resource diversity provided the Maya of the south with substantial economic benefits, with trade and exchange playing an important role in the rise of so many regional centers along the foothills of the Maya Mountain. Despite this great resource diversity, the cities of the southern Belize sub-region may have eventually capitulated to the same stressors that led to the abandonment of other areas in the Maya lowlands. By the start of the Postclassic period (1000 A.D.), many of the once thriving centres quickly begin their decline, and when Europeans arrive at the start of the 16th century, their reports only hint at the presence of limited and ephemeral native settlements in the area.

3.0 Conservation Action Planning: Conservation Targets

3.1 Selecting Targets

Nine **Conservation Targets,** or elements, were chosen to represent and encompass the biodiversity and cultural values of the area, and to provide a basis for setting goals, developing strategies and actions, and monitoring success.

For the purposes of the Conservation Action Planning Process, the selected biodiversity targets were required to meet the following criteria, where possible (adapted from TNC, 2007):

- **Targets should represent the biodiversity and cultural heritage of the site.** The focal targets should represent or capture the array of ecological systems, communities, species and sites / artefacts of cultural importance at the project area and the multiple spatial scales at which they occur.

- **Targets reflect ecoregion or other existing conservation goals**. Focal targets should reflect efforts at the regional and national level where they exist, such as TNC and CI Ecoregional Assessments, the National Protected Areas System Plan and associated Gap Assessment, the National Biodiversity Action Plan, National Biological Corridors Programme and national cultural heritage priorities. Focal targets that are grounded in the reasons for the project area's current status of protection, and the identification of the Maya Mountains Massif as one of Belize's Key Biodiversity Areas (Meerman, in. prep).

- **Targets are viable or at least feasibly restorable**. Viability (or integrity) indicates the ability of a conservation target to persist for many generations. If a target is on the threshold of collapse, or conserving a proposed target requires extraordinary human intervention, it may not represent the best use of limited conservation resources. Whilst this is a consideration for the Guatemala CAP process, it is not as critical for the Belize process, as the majority of targets are currently considered to be within or close to their natural range of variation

- **Targets are highly threatened**. All else being equal, focusing on highly threatened targets will help ensure that critical threats are identified and addressed through conservation actions.

Six biodiversity targets were selected, and can be divided into three subgroups:

Ecosystem Level: Assemblages of ecological communities that occur together, share common ecological processes, and have similar characteristics. Two terrestrial ecosystems and one encompassing the freshwater aspects of the Maya Mountains Massif have been selected

- ***Broadleaf Forest***
- ***Pine Forest and Savanna***
- ***Aquatic and Riparian Ecosystems***

Species Assemblages: Groups of species that share common natural process or have similar conservation requirements:

- ***Upper Elevation Amphibians***
- ***Forest Products***

Keystone / Umbrella / Flagship Species: Also included is a wide-ranging flagship species, a top predator indicative of the integrity of the trophic structure of the Maya Mountains Massif:

- ***Jaguar***

Three cultural targets were chosen to represent the cultural values of the Maya Mountains Massif:

- ***Archaeological Sites***
- ***Aesthetic Landscapes***
- ***Subterranean Systems***

The last of these, **Subterranean Systems**, does in fact have both biodiversity and cultural elements, but with the acknowledged current gaps in the knowledge of the biodiversity associated with these underground systems, the decision was taken to include this as a cultural target, but with at least one indicator associated with biodiversity viability.

Focal Conservation Targets for the Maya Mountains Massif

Biodiversity Targets

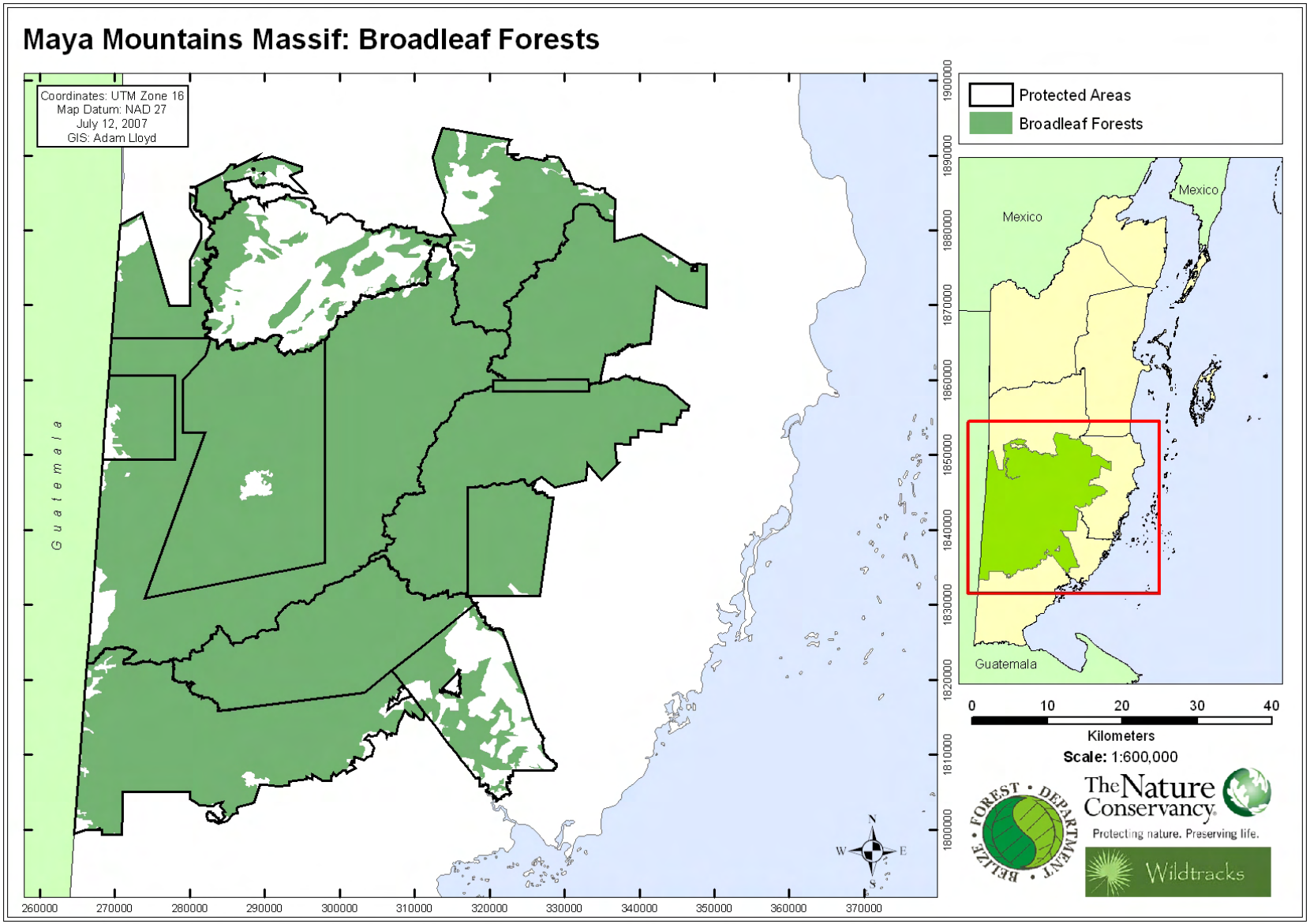
- Broadleaf Forest
- Pine Forest and Savanna
- Aquatic and Riparian Ecosystem
- Upper Elevation Amphibians
- Forest Products
- Jaguar

Cultural Targets

- Archaeological Sites
- Aesthetic Landscapes
- Subterranean Systems

Conservation targets associated with the estuarine and coastal ecosystems of Deep River Forest Reserve have not been included within this assessment, as these are adequately covered within the parallel Maya Mountain Marine Corridor project. It is assumed that conservation of these focal targets will ensure the conservation of all native biodiversity within the functional landscape of the Maya Mountains Massif.

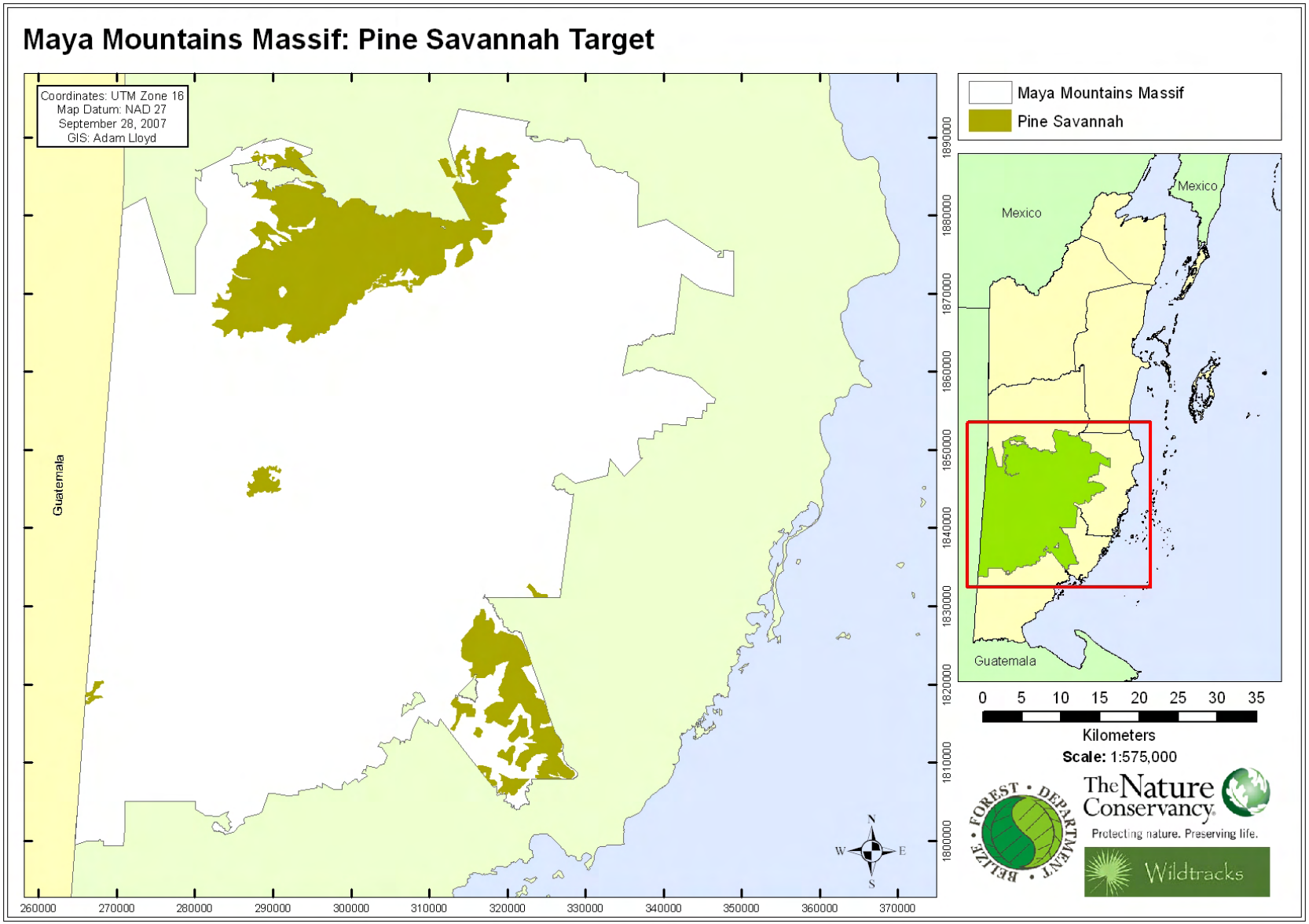
Identification of Conservation Targets: Broadleaf Forest		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Broadleaf forest **Viability Indicators:** ▪ **Total area of contiguous broadleaf forest** ▪ **% of MMM protected areas (excluding Forest Reserves) not logged, or in >30 year regrowth from past selective logging** ▪ **Population of key seed dispersers** ▪ **% of broadleaf forest showing no land use change** NB: % is based on the protected area coverage of October 2007 (an area of approx. 446,766 ha (1,260,800)),	Identified as part of one of the last remaining contiguous large forest blocks in Mesoamerica (TNC, 2006.), the Maya Mountains Massif is predominantly a mosaic of broadleaf forest ecosystems. Broadleaf forest, as a target, is an umbrella for many species, communities and ecological systems, being the dominant ecosystem of the Maya Mountains Massif, covering 448,566 hectares (1,108,430 acres) approx. (88% of the total Maya Mountains Massif area: Map …), and 39.4% of the national coverage), and encompassing 29 ecosystems, ranging from lowland forest to the upper elevation elfin woodland found on peaks in the mountainous areas. The Maya Mountains Massif is part of the Petén-Veracruz Moist Forest ecoregion - a large block of tropical forest that stretches through Belize, Guatemala and southern Mexico. It is classed as 'Critical/ Endangered' (World Wildlife Fund, 2001) in response to increasing rates of deforestation. Top predators associated with this ecoregion typically require large forested areas to maintain viable populations and sustain ecological processes, with buffering from edge effects, and provision for linkage through natural habitat corridors. Throughout Central America, forest loss results in not only the loss of key predators, but also secondary local extinctions and changes in species composition when these key species are removed.	This broad conservation target of 29 ecosystems includes two considered to be under-represented within the national Protected Areas System: **Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain** and **Tropical evergreen seasonal broad-leaved submontane forest on rolling karstic hills**. Species of concern associated with the broadleaf forest ecosystems include the Critically Endangered **Morelet's Treefrog** (*Agalychnis moreletii*) (IUCN, 2007), which is restricted to broadleaf forest over an elevation of 300m. This, and ten other species of threatened amphibians are represented under the Upper Elevation Amphibian target. The Endangered **Yucatan black howler** (*Alouatta pigra*), and Near Threatened **jaguar** (*Panthera onca*) and **great curassow** (*Crax ruber*) are also found in this habitat. A number of species presently considered non-threatened, but highlighted as of national concern are the **white-lipped peccary** (*Tayassu pecari*) and the nationally 'vulnerable' sub-species of **Central American spider monkey** (*Ateles geoffroyi yucatanensis*) and scarlet macaw (*Ara macao*), **ocelot** (*Leopardus pardalis*), **margay** (*Leopardus wiedii*) and j**aguarundi** (*Herpailurus yaguarundi*) (Meerman, 2005). A number of endemic plant species have also been recorded in the area (***Neurolaena schippii, Scutellaria lundellii Calyptranthus bartlett*ii**), as have a number of species of regional interest, such as ***Colpothrinax cookii*** and the national endemic ***Schippia concolor.*** This target also represents the karst areas – the limestone cliffs and caves that are themselves an important geological conservation focus, and the cultural value they represent, as ceremonial sites for the ancient Maya. The recognition of the importance of karst landscapes as a conservation target by the IUCN World Commission on Protected Areas in 1997, and the increasing need for their protection, has led to an evaluation of karstic scenery and its protection throughout Central America (Kueny and Day, 2002). Belize is highlighted as the country with the largest proportional area of karst under protection (68% of the total karst landscape of the country falls within protected areas), however this is being eroded as the karst areas come under increasing pressure from dereservation of forest reserves, whittling away at the protected areas, and to some extent from quarrying for limestone hardcore.



Map 9: Extent of Broadleaf Forest within the Maya Mountains Massif

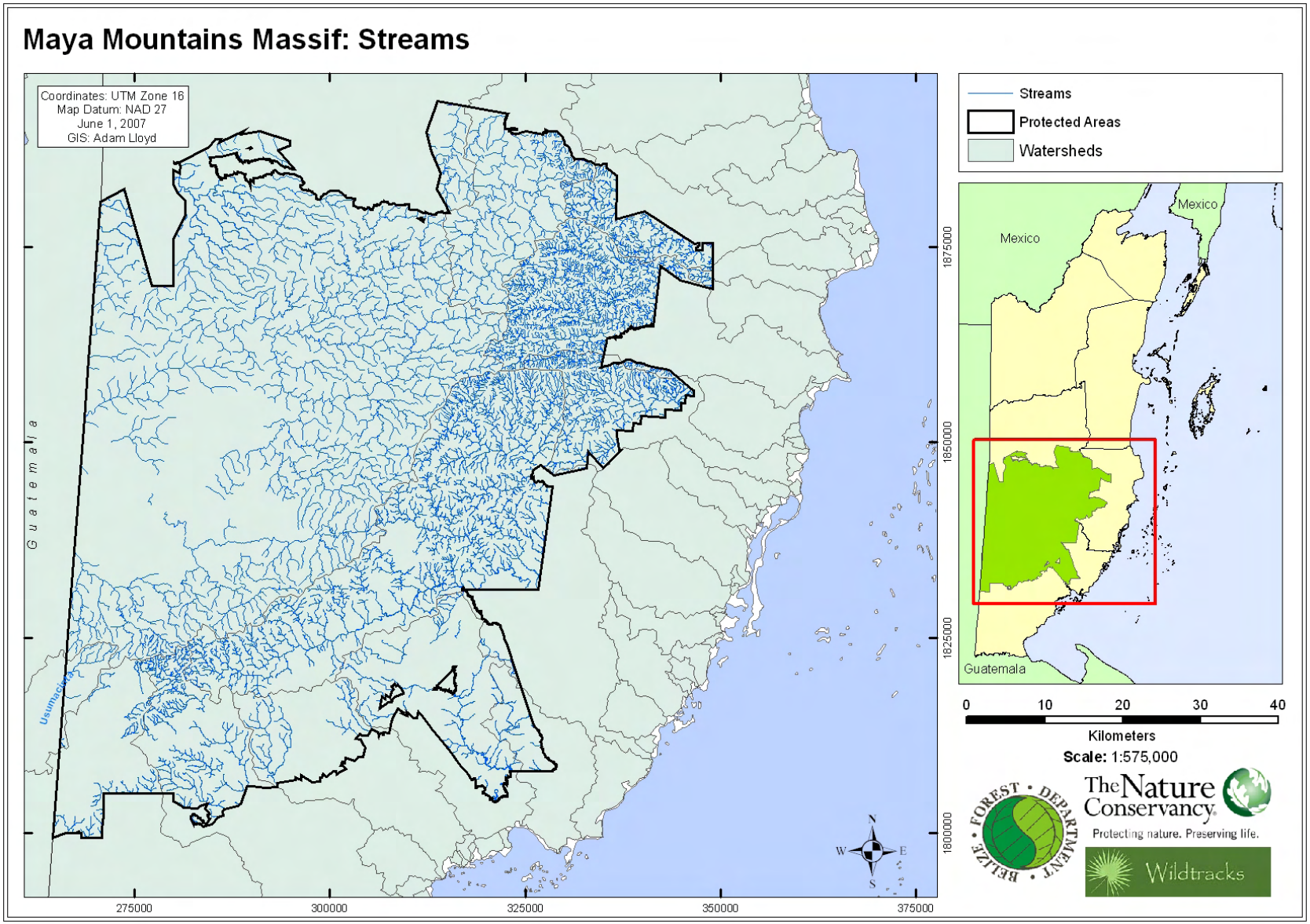
Identification of Conservation Targets

Conservation Target	Justification for Target Selection	Species, Communities or Ecological Systems represented by Target
Pine Forest and Savanna **Viability Indicators:** ▪ **Average fire frequency (no. years between fires)** ▪ **Pine size class distribution** ▪ **Presence of Southern Pine Bark Beetle** ▪ **Yellow-headed parrot population**	The Belizean Pine Forest ecoregion is highlighted as one of the few regional fragments of tropical lowland pine forests (WWF, 2001). It shows a gradient from fully developed pine forest through short grass savanna and pine, to short grass savanna (without pine) dependant on soil type and frequency of fires. Under the WWF categories, it is given the conservation status critical / endangered. The pine forests have been severely impacted by a large scale infestation from the Southern Pine Bark Beetle in 2001/2002, and increasing frequency and intensity of fire, affecting recruitment following past logging pressures. This conservation element is found primarily in two areas of the Maya Mountains Massif – lowland pine forest of the coastal savanna (in Deep River Forest Reserve, with small marginal areas in Bladen Nature Reserve and Cockscomb Basin Wildlife Sanctuary), and the upper pine ridge of the Mountain Pine Ridge Forest Reserve and Eligio Panti National Park, with small patches in several other protected areas, including Chiquibul Forest Reserve and Sibun Forest Reserve. Encompassing nine ecosystems, this conservation element covers **65,421 ha** (161,659 acres) of the Maya Mountains Masssif.	**Tropical Evergreen Seasonal needle-leaved lowland hill forest** is highlighted as one of the ecosystems considered as under-represented within the National Protected Areas System in Belize. **White-tailed deer** (*Odocoileus virginianus*) and **collared peccary** (*Tayassu tajacu*) are represented by this conservation target, as are many other species that use this ecosystem either as prime habitat (**nine-banded armadillo**, for example) or as marginal or transitory habitat (**jaguar** and **white-lipped peccary**). Also nested within this conservation element is the nationally highlighted passionflower species - ***Passiflora urbaniana***. **Palmetto** (*Acoelorraphe wrightii*), an important non-timber forest product, is also present in low densities. The pine savannas of Belize are the last stronghold of the Éndangered **Yellow-headed Parrot** (*Amazona oratrix*), (IUCN, 2007). This species has faced massive declines over the past thirty years - globally, numbers have dropped an estimated 90% to 7,000 in the late 70's Between then and 2000, there has been a further estimated decline of 68% (Birdlife, 2000). At present, with the increasing frequency of fires (burning nesting trees), the theft of nestlings, and increasing pressures from land use changes in the coastal areas, numbers are considered low enough to threaten viability, leading to its upgrade to CITES Appendix. I. The Payne's Creek / Deep River area of Belize is estimated to have a population of between 300 – 500 individuals,but with severe limitations on nest site availability (M. Muschamp, pers. com., 2007). Endemic plant species closely associated with the pine / savanna ecosystem complex are ***Anemia bartletti, Axonopus ciliatifolius***, ***Telanthophora bartletti***, ***Dalechampia schippii***, ***Galactia anomala***, ***Koanophyllon sorensenii***, ***Mimosa pinetorum***, ***Oxandra proctorii***, ***Pisonea proctorii***, ***Schippia concolor***, ***Syngonanthus bartlettii***, and ***Zinowiewi pallida.*** The endemic sub-species of the sedge wren (*Cistothorus platensis russelli*) is only found in the seasonally wet grasslands of northern Toledo / central Stann Creek, and on the highest peaks of Mountain Pine Ridge.



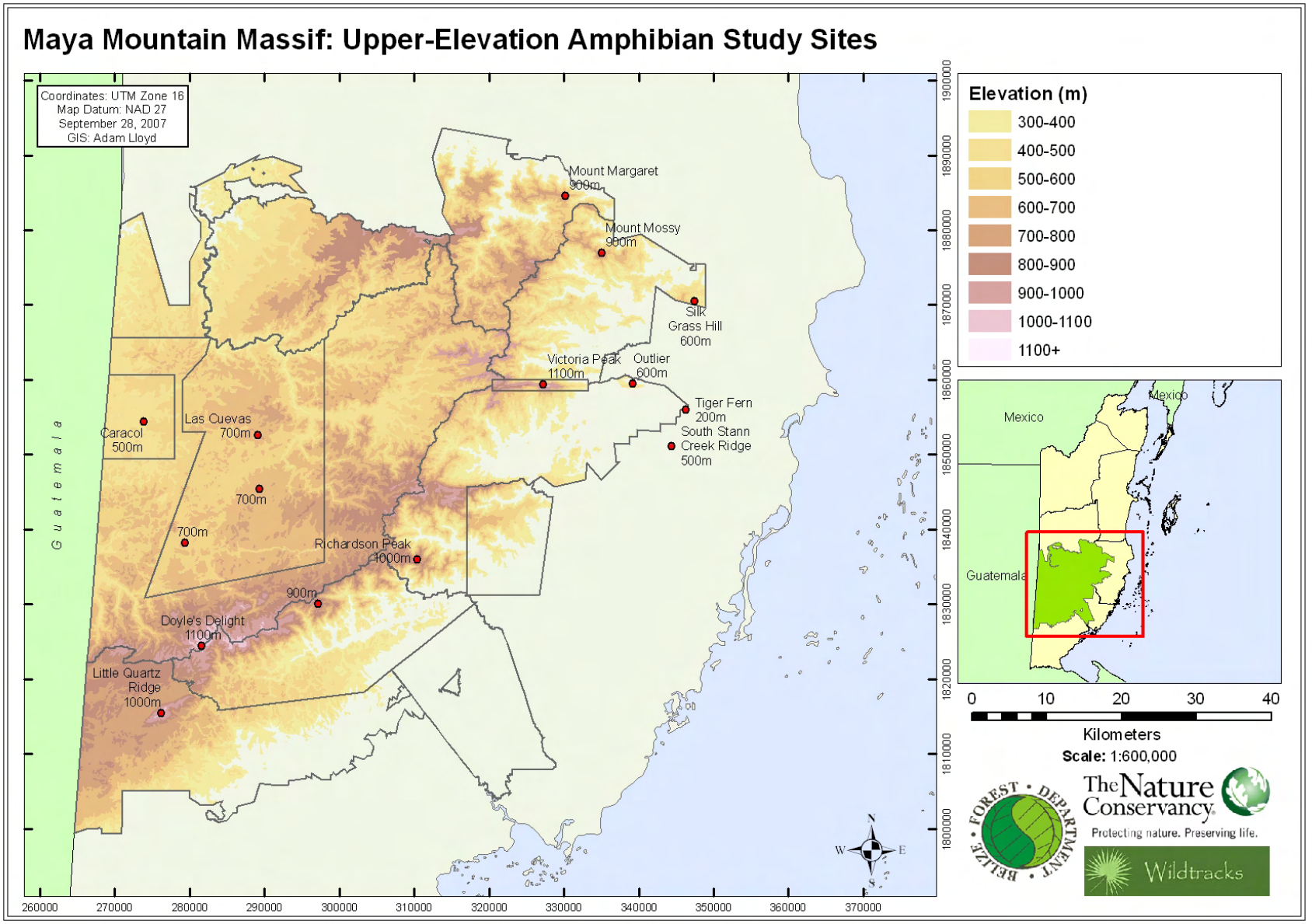
Map 10: Extent of Pine Forest and Savanna within the Maya Mountains Massif

Identification of Conservation Targets: Aquatic and Riparian Ecosystems		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Aquatic and Riparian Ecosystems **Viability Indicators:** ▪ **Orographic rainfall** ▪ **Land use change in coastal plain areas** ▪ **Density of migratory species in headwaters** ▪ **% total upstream length affected by physical barriers** ▪ **% of total stream length with natural riparian vegetation** ▪ **Generic richness of macroinvertebrates in rapids** ▪ **Native fish species richness**	The Maya Mountain aquatic and riparian communities provide an essential resource for both aquatic and non-aquatic species – whether through trophic interactions, or life-cycle requirements. Aquatic ecosystems energetically subsidize the terrestrial – whilst species richness is relatively low compared to terrestrial systems, the aquatic ecosystem is considered to be an energetically important part of the overall Broadleaf Forest Ecosystem, with species playing an important role in converting basal resources into biomass that is available for consumption by other aquatic and terrestrial organisms (Esselman, pers. com.). The associated riparian vegetation and riparian-dependent species also fall within this conservation element. 14 watersheds originate in the Maya Mountains, providing clean water and watershed functionality (flood control, erosion control etc.) for over 55% of the total land mass in Belize (where it is utilized by over 128 communities, with an estimated population of over 76,531 (BERDS, 2007) and for agricultural production) and for a significant portion of the Peten in Guatemala. The protected headwater streams serve as a refuge from temperature and flow extremes, as well as providing a refuge from competition, predation, and invasive species such as *Tilapia*, found within the lower reaches on the coastal plains. Protection from the land use change found lower downstream ensures that there is habitat suitable for spawning sites and rearing areas, and the intact drainage basins maintain a rich source of food within the aquatic system, and a critical source of organic matter. The water courses themselves provide a migratory route/ aquatic corridor through the landscape, from the Maya Mountains Massif to the coast. Maintenance of the 66' buffer vegetation, as stipulated as a national policy, also maintains connectivity for many terrestrial species between the Maya Mountains Massif and the coastal plain (Meyer et al. 2007). Streams contribution within the Maya Mountains Massif Headwater Stream 99.800% of total stream length Small River 0.002% Medium River 0.001%	Several IUCN red-listed species are associated with the aquatic and riparian ecosystems, including the Endangered **Baird's Tapir** (*Tapirus bairdii*), and the **Long-legged and Sanderson's Streamfrogs** (*Craugastor sabrinus* and *Eleutherodactylus sandersoni*) (IUCN, 2007). The **muscovy duck** (*Cairina moschata*), game fish such as **mountain mullet** (*Agonostomus monticola*), **bobo mullet** (*Joturus pichardi*) and **bay snook** (*Petenia splendida*), and the smaller cichlids, livebearers and tetra are found in the mid-stream portions of the aquatic system. These support various vertebrate fish-eating species, including **Morelet's crocodile** (*Crocodylus moreleti*) (IUCN: Lower risk /conservation dependent), the **Neotropical river otter** (*Lutra longicaudis*), and a number of species of freshwater turtles, kingfishers, herons and egrets. Several amphibian species are reliant on the water during part of their life cycle, and macroinvertebrates with aquatic larval stages provide an important resource for insectivorous birds and bats. Associated with the riverine vegetation are species such as Baird's tapir (*Tapirus bairdii*) (IUCN: Endangered) and the Yucatan howler monkey (*Alouatta pigra*) (IUCN: Endangered) and seasonally, migrant birds. A number of endemic species are associated with the headwater and midreach streams of the Maya Mountain, including two fish species (***Poecilia teresae*** and the cave-dwelling ***Rhamdia typhla*****),** and ***Rana juliani*** Belize's single endemic amphibian species. Illegal fishing is currently the major threat to aquatic communities in the east facing slopes of the Maya Mountains. However, there is also a migratory component to the aquatic fauna (such as the Atyid shrimps (eg. *Atya scabra*), important macroconsumers in headwater streams that connect the mountains to the sea (Esselman, pers. com.)) which rely on connectivity with the coastal plain and the coastal waters. Whilst at present, other than in the Macal system, there are no physical barriers to movement of species up and down the rivers, increasing organic runoff from agricultural areas downstream, diversion of water for irrigation and damming of the waterways may, in future, become a significant threat to the viability of these species.

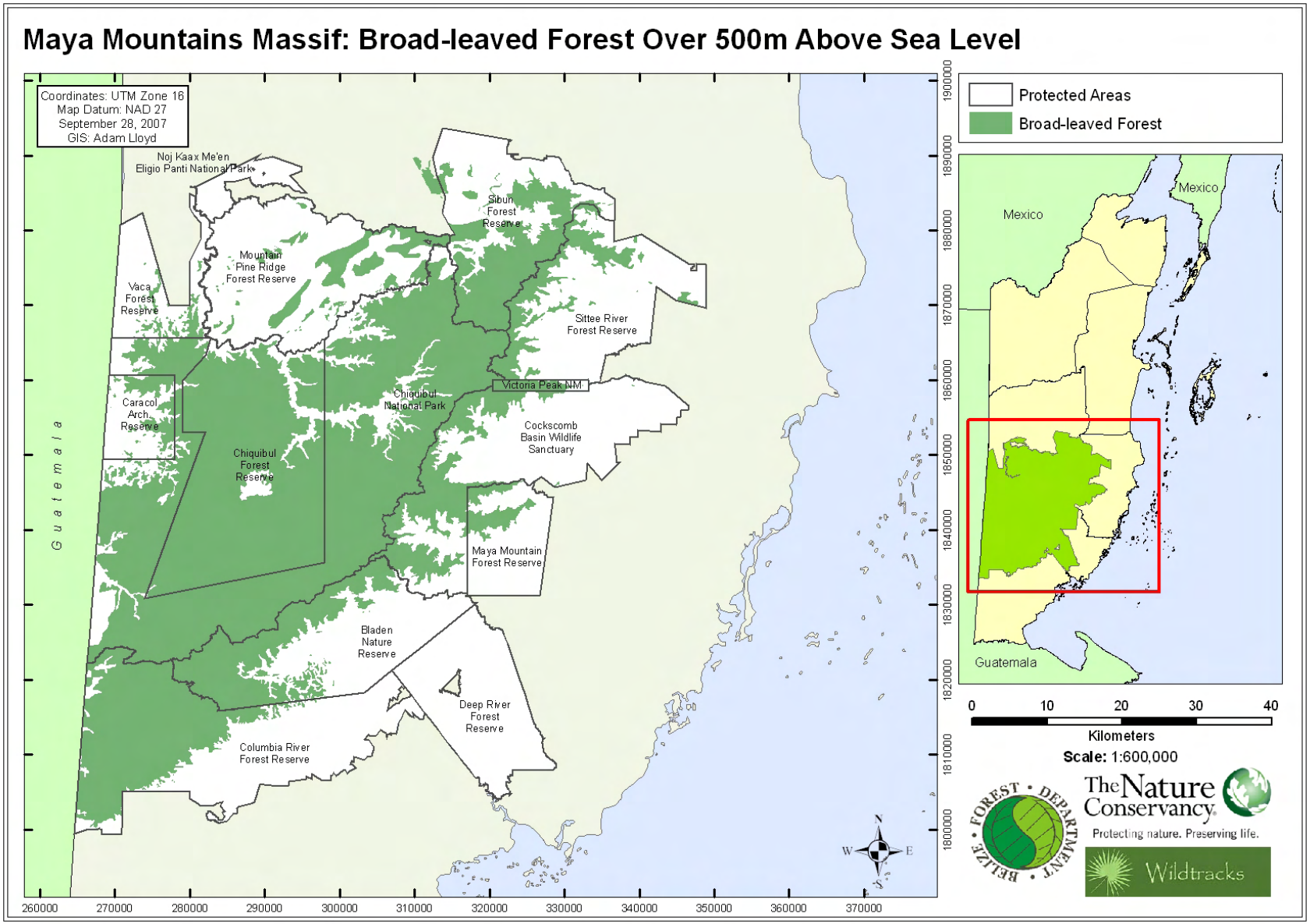


Map 11: Stream systems of the Maya Mountains Massif

Identification of Conservation Targets: Upper Elevation Amphibians		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Upper Elevation Amphibians **Viability Indicators:** ▪ **Extent of sub-montane ecosystems** ▪ **% of key sub-montane sites considered in very good condition as amphibian habitat** ▪ **Changes in site level micro-climate patterns outside the range of natural variation** ▪ **% sites showing presence of chytrid infection** ▪ **% sites showing presence of organophosphates** ▪ **% sites with population sizes of key species within the range of natural variation**	Upper Elevation Amphibians have been chosen as a conservation element due not only to their rapid response to changes in environmental quality and climate change impacts, but also because of the recognition of specific threats that have caused catastrophic population declines and extinctions regionally, and because of specific strategies that may need to be implemented to combat these threats. Within Belize 33% of the amphibian species are considered as being of conservation concern (including Belize's only critically endangered terrestrial vertebrate, *Agalychnis moreletii*), the majority of these being confined to the upper elevation areas of the Maya Mountains. Despite the fact that most of the declines in amphibian populations of pristine areas in Central America have occurred at elevations of over 500 m (Young et al., 2001), little research has been conducted in these areas of Belize, and there is no significant knowledge on the current status of these species, many being assigned default ratings in the Global Amphibian Assessment (2004) based on availability of suitable habitat, due to lack of population data (P. Walker, pers. obs., J. Lee, pers. comm.).	Upper elevation species included within this conservation element are the Critically Endangered **Morelet's treefrog** (*Agalychnis moreletii*), the Endangered **Sabrina's rainfrog** (*Craugastor sabrinus*), **Sanderson's rainfrog** (*Eleutherodactylus sandersoni*) and the Bromeliad treefrog (*Bromeliohyla bromeliacia*), the Vulnerable **limestone rainfrog,** (*Craugastor psephosypharus*)*,* **leprus chirping frog** (*Eleutherodactylus leprus*) and **Alfred's rainfrog** (*Eleutherodactylus alfredi*), the Near Threatened **Chac's rainfrog** (*Craugastor chac*), **Maya Mountain Frog** *(Rana juliani*)*,* and **Campbell's Rainforest Toad** (*Bufo campbelli*) (IUCN, 2006). These amphibians are considered indicative of the health of the upper elevation ecosystems, and also represent nested targets - upper elevation bird species. including the Vulnerable **keel-billed motmot** *Electron carinatum*), the **scaly-throated foliage-gleaner** (*Anabacerthia variegaticeps*) and the **tawny-throated leaftosser** (*Scelurus mexicana*).



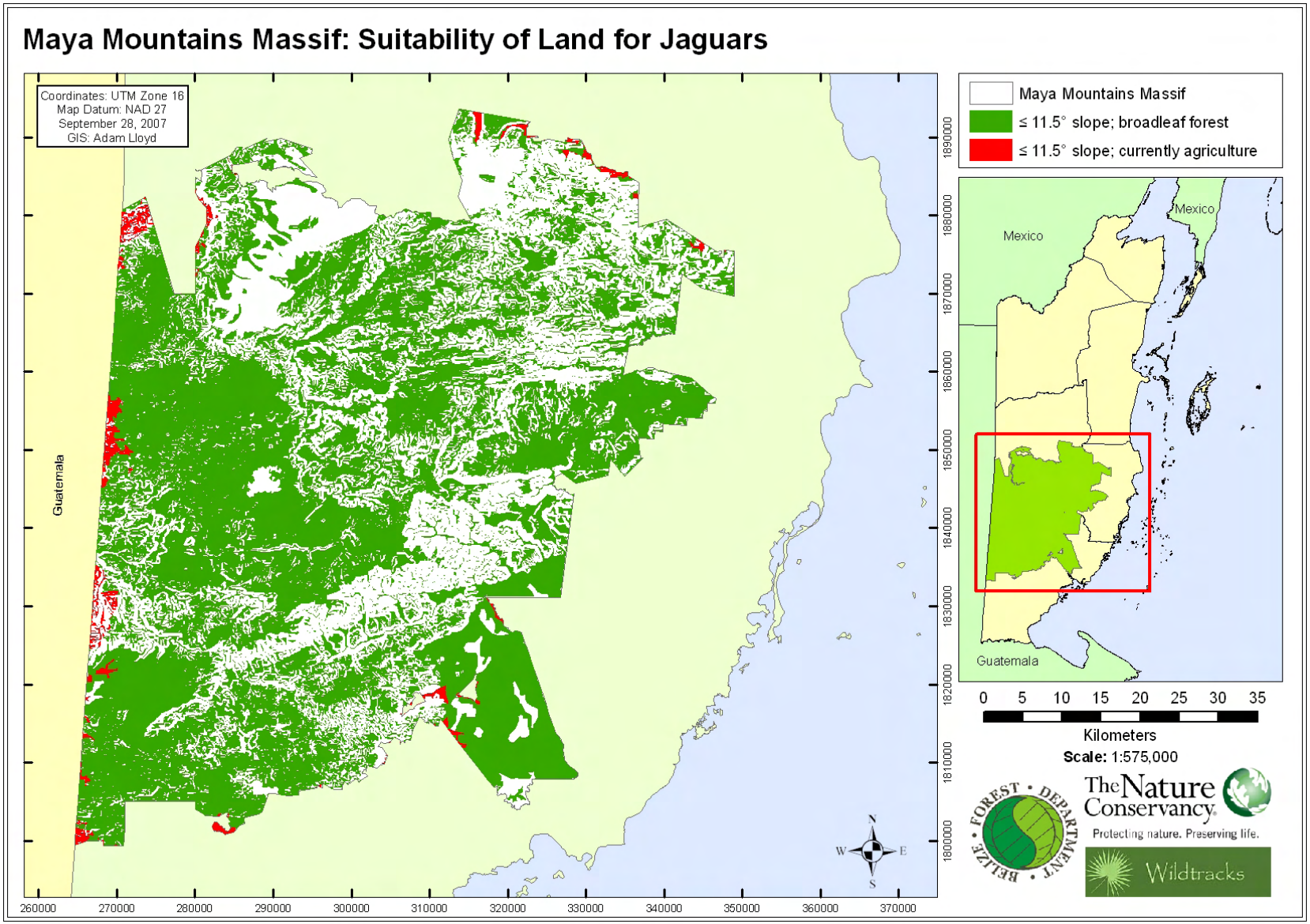
Map 12: Key upper elevation amphibian sites



Map 13: Broadleaf forest over 500m above sea level (upper elevation)

Conservation Target: Forest Products		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Forest Products **Viability Indicators:** ▪ **Average number of xate leaves per plant** ▪ **Average number of xate plants per hectare** ▪ **% of MMM showing no land use change** ▪ **Density of commercial timber**	**Justification for Target Selection** The harvesting of forest products (both timber & non-timber, legal and illegal) is the source (both direct and indirect) of some of the biggest impacts on the biodiversity and cultural resources of the MMM. Hunting associated with illegal xate collection, and poorly controlled 'legal' xate extraction threatens to result in the 'Empty Forest Syndrome' in significant areas of the Maya Mountains Massif if left unchecked. - with dramatic decreases in game species being noted in western Chiquibul. Levels of sustainable harvest for xate and timber are broadly known, but difficult to enforce – such that target viability is decreasing sharply in some areas. Effectively addressing illegal extraction of Forest Products, and improving sustainability mechanisms and levels of legal extraction will significantly enhance biodiversity viability at both the site and system level.	Xate, timber**,** orchids, medicinal plants, palms **Palmetto** (*Acoelorraphe wrightii*) is present in low densities within this ecosystem, and is coming under pressure from stem harvesting for structural materials, and seed harvesting for the relatively new medicinal market. **Xate** (*Chamaedorea ernesti-august*) leaves are extensively harvested, legally and illegally. **Pacaya** (*Chamaedorea tepejilote*) fruit is harvested for consumption by some communities **Contribo** (*Aristolochia spp*.) is one of the more widely used medicinal plants, harvested in some buffer areas of the MMM **Bayleaf, Wano** (*Sabal mauritiiformis*) thatch leaves are harvested over a relatively small area (mostly MPRFR & CFR), mostly for tourism lodges in the MPRFR Enclave. **Mahogany** (*Swietentia macrophylla),* **Mexican Cedar** (Cedrela odorata)**, Santa Maria** *(Calophyllum brasiliense)***, Nargusta** *Terminalia amazonia)***, Sapodilla** *(Manilkara zapota***, Salmwood** *(Cordia alliodora)***, Jobillo** *(Astronium graveolens)***, Cabbage Bark** *(Lonchocarpus castlloi)***, BillyWebb** *(Acosmium panamense)* are among the species harvested commercially. **Vanilla** (*Vanilla spp*.) and **Allspice** (*Pimenta dioica*) are two species in which interest has been voiced re. potential sustainable extraction.

Conservation Target: Jaguar		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Jaguar **Viability Indicators:** ▪ **Total area of contiguous forest** ▪ **% of broadleaf forest in MMM removed by land forest clearance** ▪ **% of MMM over which hunting pressure is considered to be high** ▪ **Density of white-lipped peccary – trap success index** ▪ **Density of jaguars in key areas**	As the top predator, the jaguar (*Panthera onca*) is considered a key umbrella species, representing the biodiversity health and intact trophic structure of the broadleaf forest ecosystems. Whilst densities are considered higher in broadleaf forest, this species also uses pine savanna (M. Kelly, pers. com.).	As an umbrella species, protection of the environmental parameters and implementation of effective conservation measures that are required to maintain a viable population of jaguars should also be adequate to maintain populations of other large ranging species, such as **scarlet macaw, white lipped peccary,** and **harpy eagle.** High jaguar density is also indicative of a healthy prey base, and of the trophic integrity of the Maya Mountains Massif area as a whole.



Map 14: Area considered to be optimal jaguar habitat, based on slope

3.2 Identification of Cultural Targets

Three Conservation Targets were selected:

- **Archaeological Sites (including artifacts)**
- **Aesthetic Landscapes**
- **Subterranean Systems**

A number of criteria are considered important in the selection of targets and identification of nested targets:

1. Intrinsic

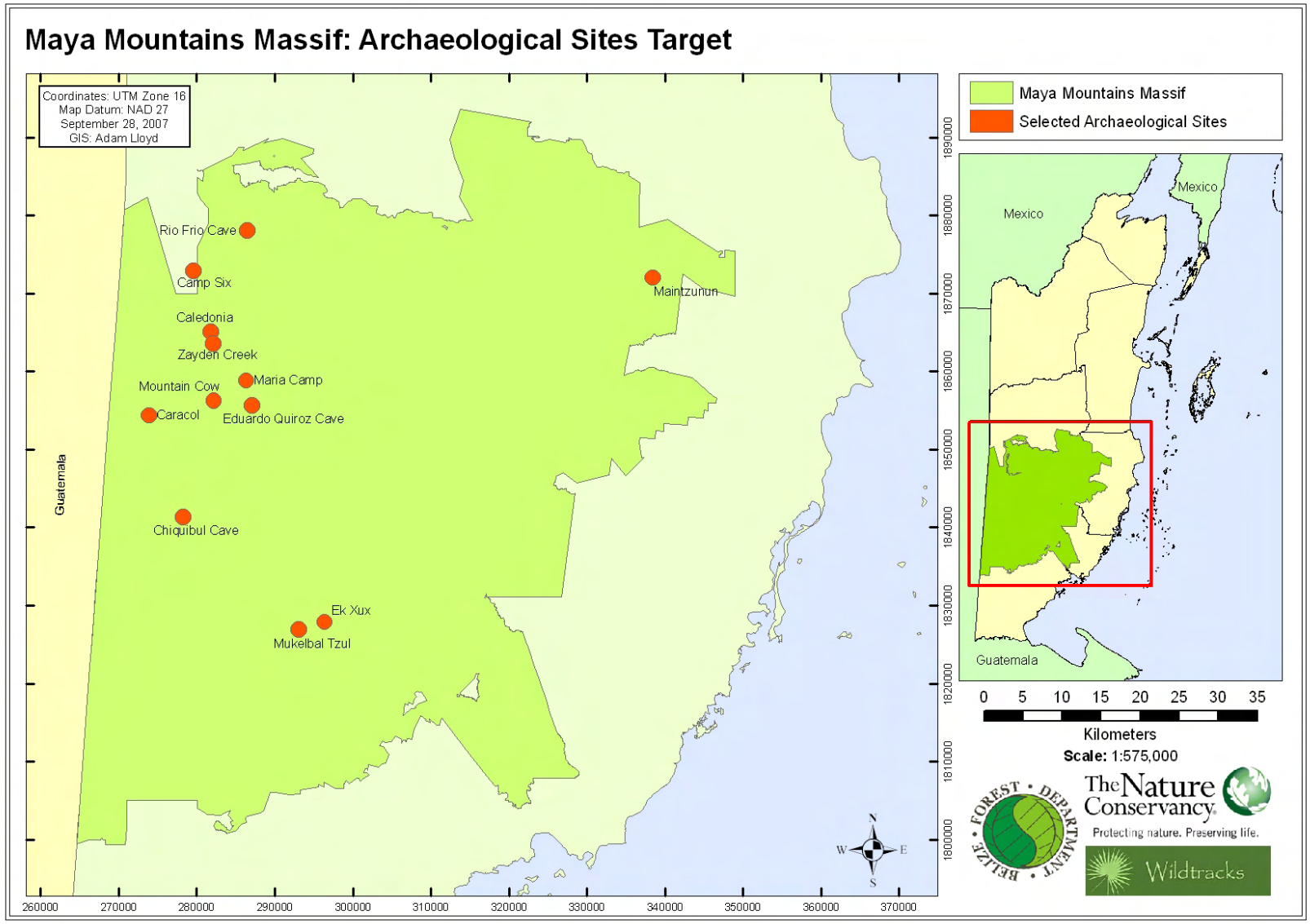
- Representation: they express the characteristics of cultural processes within a region or area.
- Their selection is based on historic, archaeological and ethnohistoric information available.
- Singularity: they constitute unique examples based on their historic period, artistic richness, typology, origins, originality, authenticity, technology used, scientific contribution, etc.
- Integrity: this refers to the extent to which the target maintains its original characteristics, both for what they express as for their physical composition, materials and construction systems which reflect their natural surroundings, socio-cultural values and technological knowledge of the period during which they were built.
- Authenticity: the extent to which a target expresses its true origin, evolution and values (even if some of its components are missing).
- Connectivity: links and historic/cultural relation to different periods and regions and between one generation and another. The cultural target permits a connection to past and future promotes education and strengthening of identity through the vital information it contains.
- Age: this refers to the time during which the target was created, providing it with greater intrinsic value on the basis of the time progressed since its elaboration.

2. Extrinsic

- Management: a focus on highly threatened and vulnerable conservation targets will help ensure that the most important causes leading to deterioration are identified and conservation strategies are developed and implemented.
- Popularity: this term refers to certain cultural targets having a greater acceptance than others among the general public, reason for which their conservation is justified.

Caana, the main structure at Caracol, in the Chiquibul Forest

Viability of Conservation Targets: Archaeological Sites		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Archaeological Sites **Viability Indicators:** ▪ **Number of sites with permanent staff** ▪ **Average % structures looted per site** ▪ **Level of appreciation of sacred sites** ▪ **Number and extent of scientific publications**	The Maya Mountains Massif is important for its historical and cultural value, with a number of important Maya sites lying within the system, including Caracol, considered a major site within the region. Sites are generally restricted to the more fertile valleys of the limestone areas, where evidence of agricultural terracing on the steeper valley sides is widespread, and to caves of ceremonial significance, found throughout the karst areas. The less fertile granite areas are thought to have been important for extractive industries. More recent historical artifacts are also of cultural value, such as the old rail system that used to exist within the Chiquibul. With no continuous occupation of the Maya Mountains Massif, and therefore limited historical cultural connectivity of communities with the landscape, conservation target selection has been based on the following categories (TNC, 2003): ▪ Cultural sites important for their connectivity that express a historic or cultural link to different periods, and which connect the past, present and future and strengthen cultural identity while also having a high educational and informative potential. ▪ Groups of buildings that constitute unique examples, based on their historic period, artistic wealth, typology, origins, integrity, authenticity, technology employed, scientific contribution, etc. ▪ Representative buildings in which the characteristics express the cultural processes of a region or area. Their designation is based on available historical, archaeological or ethno-historic information. ▪ Movable cultural object of exceptional integrity, that maintain their original characteristics for what they express and for their physical and material composition which reflects the natural surroundings, the socio-cultural values and technological knowledge of the period during which they were built. ▪ Structures that are highly vulnerable and seriously threatened	**Archaeological Sites:** Caracol, Tzimin Kax/Mountain Cow, El Retiro, Cahal Pichic, Camp 6, Caledonia, Maria Camp, Minanha, Ec Xux, Uxbenka, Lubaantun, Nim Li Punit **Portable Carved Monuments:** Stelae, altars, ball court markers, lintels, stone spheres **Other Movable Objects:** Ceramic artifacts, stone artifacts (metates, jade, etc.), human and animal reamins, wooden remains, shell, stucoes, organic remains, metal artifacts from Industrial Age, etc. **Rock Art:** Roberto's Cave, Actun Tzib Cave **Cairns:** Cooma Cairn, Granite Cairn, near Río On **Agricultural Terraces:** Widespread in the Massif, particularly in Vaca, Caracol, Chiquibul National Park and Forest Reserve, Eligio Panti National Park. **Sacbeob:** Widespread in the Massif, particularly in Vaca, Caracol, Chiquibul National Park and Forest Reserve, Eligio Panti National Park. **Modified Springs:** Greater Chiquibul, Vaca, Caracol **Quarries:** Caracol, Mountain Pine Ridge FR **Industrial Features:** Puntarrieles (Rail head at Vaca FR), locomotives and tractors, most of the in Chiquibul NP and FR, and Caracol

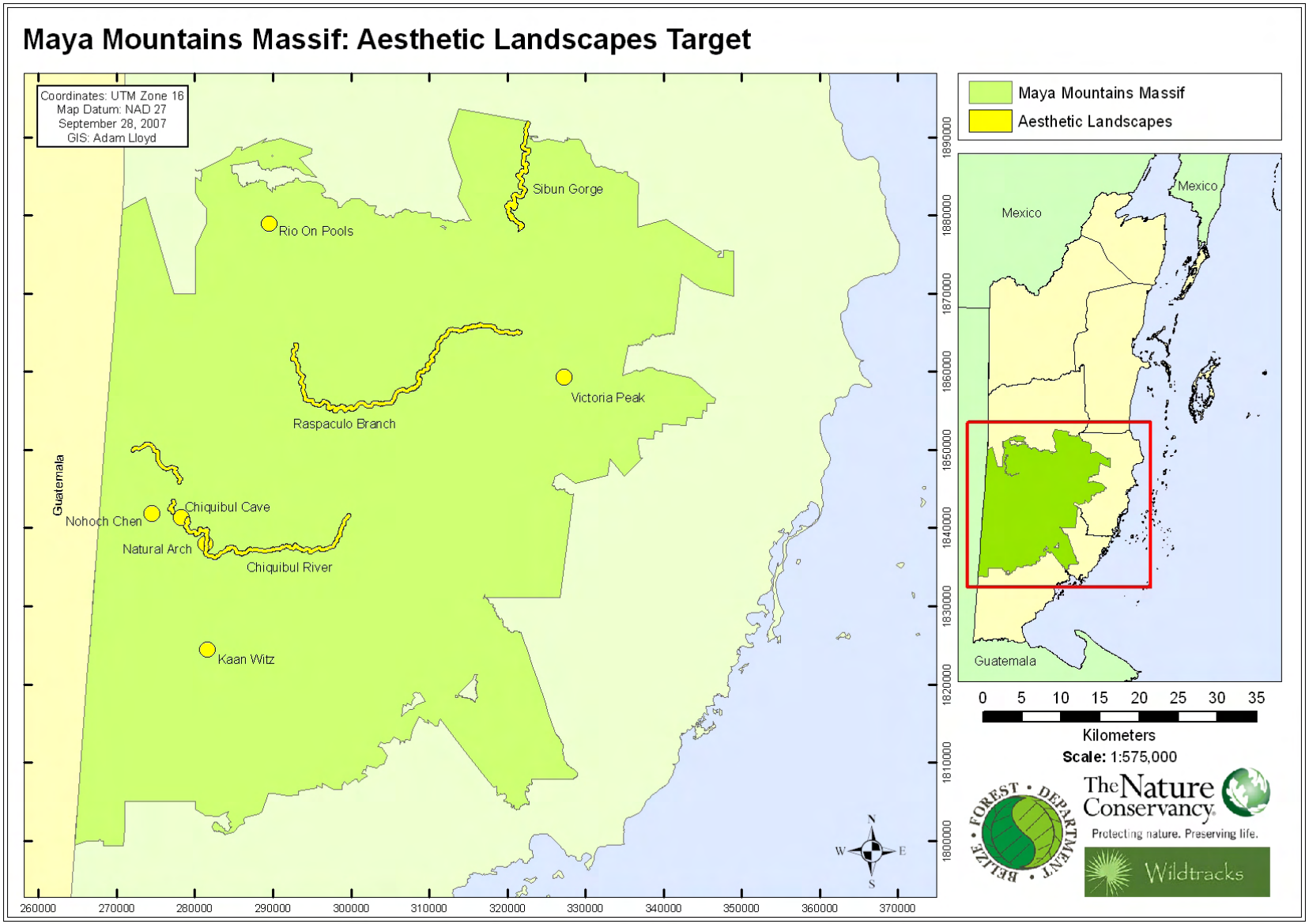


Map 15: A number of the Archaeological Sites identified within the Maya Mountains Massif

Viability of Conservation Targets: Aesthetic Landscapes		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Aesthetic Landscapes **Viability Indicators:** ▪ **Number of aesthetic landscape sites with management presence and monitoring** ▪ **Number of aesthetic landscapes within conservation areas** ▪ **Number of aesthetic landscapes with no visual human impacts**	The aesthetic landscapes of the Maya Mountains Massif are of great importance to many stakeholders, as a recreational resource, as a tourism destination and as part of Belize's natural and national heritage. 9 sites within the Maya Mountains Massif have been identified for their aesthetic value, and include waterfalls, rivers, karstic landscape features and significant mountain peaks.	9 sites within the Maya Mountains Massif have been identified for their aesthetic value: Rio On Pools — Mountain Pine Ridge Forest Reserve Natural Arch — Chiquibul Forest Reserve Chiquibul River — Chiquibul National Park Raspaculo Branch — Chiquibul National Park Sibun Gorge Falls — Sibun Forest Reserve Nohoch Che'en Sinkhole — Chiquibul National Park Victoria Peak — Victoria Peak Natural Monument Ka'an Witz (Doyles Delight) — Chiquibul National Park Baldy Beacon — Mountain Pine Ridge Forest Reserve

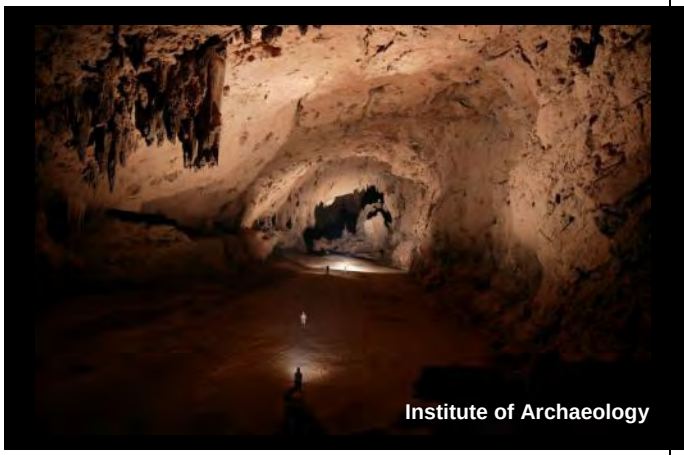
D. Francisco, Belize Audubon Society

Above: Victoria Peak Natural Monument
Left: Big Rock Falls, Mountain Pine Ridge Forest Reserve



Map 16: Aesthetic Landscapes of the Maya Mountains Massif

Viability of Conservation Targets: Subterranean Systems		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Subterranean Systems ▪ **Number of sites with permanent staff** ▪ **Level of appreciation of sacred sites** ▪ **Number and extent of scientific publications**	With the importance of the karstic landscapes, both regionally and within the Maya Mountains Massif, subterranean systems have been highlighted as an important component of the conservation planning. These systems were identified as both natural and cultural targets, the decision being made to combine them under the cultural targets, but with reference to nested biological targets. Approximately 300 caves have been documented in Belize in the past 100 years, including 198 registered archaeological sites, many of these within the Maya Mountains Massif. Caves were used by historical Maya culture for ceremonial activities, with ethnohistoric, ethnographic, iconographic, and archaeological sources indicating that this ritual importance has spanned at least 1,500 years (McNatt, 1996).	Bats and other cavernicoles (cave dwelling organisms) are considered particularly vulnerable to human disturbance - roosting bats and maternity/nursery colonies especially. **Bats:** **Endemic Fish and Other Species:** Many troglobitic species (obligate cavernicoles) are endemic to a single cave - : macrobrachium, pseudothalphusidae, blind catfish, other dry cave species **Archaeological Artifacts:** The Maya considered caves to be of religious significance, leading to offerings, paintings and other artifacts being found within cave systems in Belize.



Chiquibul Cave System – Belize Chamber

Mayan Cave Artefacts, Elijio Panti National Park

4.0 Conservation Action Planning: Viability Assessment

4.1 Introduction

The Viability Assessment conducted under the Conservation Action Planning process has assisted the project team in building an informed structure to guide conservation and research in the Maya Mountains Massif. It has been developed based on established principles of ecology and conservation science, and uses the best available information on the target's biology and ecology in an explicit, objective, and consistent manner, with extensive input from technical and field experts both nationally and internationally.

The Assessment provides:

- An objective, consistent means for determining changes in the status of each focal conservation target over time, allowing the Forest Department to measure success of conservation action planning strategies
- An objective and consistent way to compare the status of a specific focal target with future conditions, and with other projects that focus on that target
- A basis for the identification of current and potential threats to a target and identifies past impacts that require mitigation actions
- A basis for strategy design and the foundation for monitoring
- Guidance in summarizing and document knowledge and assumptions about the biology and ecology of each target, with identification of crucial information gaps and research questions.

4.2 Assessing Biodiversity Viability

The first stage of the viability assessment is the identification of **key ecological attributes** (KEAs) for each of the conservation targets. The key ecological attribute is defined as:

> "an aspect of a target's biology or ecology that if present, defines a healthy target and if missing or altered, would lead to the outright loss or extreme degradation of that target over time".
>
> **TNC, 2007**

For the purposes of this project, and in line with the TNC Conservation Action Planning approach, the Key Ecological Attributes have been grouped into three classes:

- **Size -** a measure of the area or abundance of the conservation target's occurrence.
- **Condition** - a measure of the biological composition, structure and biotic interactions that characterize the occurrence.

- **Landscape context** - an assessment of the target's environment including ecological processes and regimes that maintain the target occurrence such as flooding, fire regimes and other natural disturbances, and connectivity. allowing access to habitats and resources or the ability to respond to environmental change through dispersal or migration.

Whilst the **Key Ecological Attribute** defines the critical requirements for a conservation target, **indicators** have been used to provide a means of measuring the status of the Key Ecological Attributes for each conservation target. An effort has been made throughout the viability assessment to use indicators that are measureable, precise, consistent, sensitive and technically and financially feasible. A viability rating is developed for each indicator, based on the following scale:

- **Very Good** – The Indicator is considered to have an ecologically desirable status, requiring little or no intervention for maintenance.
- **Good** – The indicator lies within the acceptable range of variation, though some intervention is required for maintenance.
- **Fair** – The indicator lies outside the acceptable range of variation, and human intervention is required if the viability of the target is to be maintained
- **Poor** – Restoration of the conservation target is increasingly difficult, and impacts may result in extirpation from the conservation area

The current status and project goals for each indicator were developed during the workshop, with subsequent consultations with protected area managers, co-managers, and technical and field staff to refine the assessment and increase the accuracy of each of the indicator ratings. Specific technical working group meetings were called to focus on particular conservation targets, with Forest Department and the Institute of Archaeology, and a series of target meetings were held to address identified gaps in information. The viability for each conservation target of the Maya Mountains Massif is summarised below, and the background analysis contained in Annex One.

Summary of Biodiversity Target Viability for the Maya Mountains Massif

Conservation Targets	Landscape Context	Condition	Size	Viability Rank
	Grade	Grade	Grade	
Broadleaf Forest	**Very Good**	**Good**	**Very Good**	**Very Good**
Pine Forest and Savanna	**Fair**	**Fair**	**Good**	**Fair**
Aquatic and Riparian Systems	**Fair**	**Very Good**	**Very Good**	**Good**
Upper Elevation Amphibians	**Good**	**Good**	**Good**	**Good**
Forest Products	**Very Good**	**Fair**	**Fair**	**Good**
Jaguar	**Very Good**	**Good**	**Good**	**Good**

4.3 Cultural Viability Assessment

Introduction

The Viability Assessment, as conducted under the Conservation Action Planning process during the CAP1 workshop, and then validated in the Institute of Archaeology workshop, has assisted the project team in building an informed structure to guide conservation management and research of cultural targets in the Maya Mountains Massif. It has been developed based on integrity and the best available information on the target's conceptual meaning, physical condition, and sacredness, in an explicit, objective, and consistent manner, with extensive input from technical and field experts.

Participants:

Institute of Archaeology Workshop – Verification of Results

1st November, 2007

Institute of Archaeology
Jaime Awe
George Thompson
Brian Woodye
John Morris
David Griffith
Wayne Moore
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Jorge Can
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TNC / Consultants
Natalie Rosado (TNC-Belize)
Zoe Walker (Wildtracks)

The Assessment provides:

- An objective, consistent means for determining changes in the status of each focal conservation target over time, allowing the Institute of Archaeology to measure success of conservation action planning strategies
- An objective and consistent way to compare the status of a specific focal target with future conditions, and with other projects that focus on that target
- A basis for the identification of current and potential threats to a target and identifies past impacts that require mitigation actions
- A basis for strategy design and the foundation for monitoring
- Guidance in summarizing and document knowledge and assumptions about the physical condition and cultural significance of each target, with identification of crucial information gaps and research questions.

The first stage of the viability assessment is the identification of **key attributes** for each of the conservation targets, including:

- Historical, aesthetic, scientific and technical attributes
- Social, spiritual-religious, educational attributes, based on identity
- Economic, touristic and productive attributes
- Landscape and scenic attributes

For the purposes of this project, and in line with the TNC Conservation Action Planning approach, the key characteristics have been grouped into three classes - **Conceptual Content, Physical Condition** and **Context**.

Assessment of these three **key characteristics** for each conservation target allows a characterization of a target's cultural integrity within an area, providing a basis on which to analyse the effects of deterioration, and allowing corresponding strategies to be developed:

- **Conceptual Content –** the extent to which a target reflects socio-cultural values of a historical period from which it dates, its authenticity, age, information, messages and meanings it transmits.

- **Physical Condition** - a comparison between a targets original and its current state, based on:

    - How intact or deteriorated it is compared to its original extent
    - How altered it is on a spatial level by changes – justified and non-justified, attachments, stratification etc.
    - How degraded its materials and shapes are

- **Context** – based on the natural and social surroundings including key natural and/or social factors that contribute or impinge upon the conservation or degradation of selected cultural targets

Guidelines to assigning hierarchical values to cultural integrity have been developed (TNC, 2003):

Conceptual Content	
Very Good	Fully expresses in a complete fashion all the historical characteristics of the period which it represents
Good	Expresses almost in its totality the historical characteristics of the period which it represents
Fair	Expresses some of the historical characteristics of the period which it represents
Poor	Expresses a few of the historical characteristics of the period which it represents

Physical Condition	
Very Good	Expresses that it has a complete representation of all of its components and that its spatial, material, structural, morphological characteristics are in good shape
Good	Expresses that its representation is 75% complete, and that has few alterations in its spatial, material, structural, and morphological characteristics
Fair	Its representation is incomplete, with only 50% of many parts intact, and with many modifications in its spatial, material, structural, and morphological characteristics
Poor	With incomplete representation of almost all its parts (only 25% intact) and with significant modifications to its spatial, material, structural, and morphological characteristics

Context	
Natural Context	
Very Good	Almost all natural factors favour conservation of selected cultural target
Good	Most natural factors favour conservation of cultural target
Fair	Many existing natural factors promote the deterioration of cultural target
Poor	The majority of natural factors promote the deterioration of cultural target

Social Context	
Very Good	Almost all social factors favour conservation of cultural target selected
Good	Most social factors favour conservation of cultural target selected
Fair	Many social factors promote a deterioration of cultural target
Poor	The majority of social factors promote a deterioration of cultural target

The assessment of the current state of integrity of the cultural targets was developed during the viability workshop. The results were validated during a second, more focused workshop with members of the Institute of Archaeology, to refine the assessment and increase the accuracy of each of the indicators selected. The results were subsequently refined to align with bi-national results, and have then assisted in the definition of conservation goals for each of the cultural targets.

The viability for each conservation target of the Maya Mountains Massif is summarised below, and the background analysis contained in Annex One.

Conservation Targets	**Conceptual Content**	**Physical Condition**	**Natural Context**	**Viability Rank**
	Rating	**Rating**	**Rating**	
Archaeological Sites	**Good**	**Fair**	**Good**	**Good**
Aesthetic Landscapes	**Very Good**	**Very Good**	**Good**	**Very Good**
Subterranean Systems	**Good**	**Very Good**	**Good**	**Good**

4.4 Combined Biodiversity and Cultural Viability

The results of the two processes can then be combined to determine the overall viability of both biodiversity and cultural targets:

Summary of Overall Conservation Target Viability for the Maya Mountains Massif				
Conservation Targets	Landscape Context	Condition	Size	Viability Rank
	Grade	Grade	Grade	
Broadleaf Forest	Very Good	Good	Very Good	Very Good
Pine Forest and Savanna	Fair	Fair	Good	Fair
Aquatic and Riparian Systems	Fair	Very Good	Very Good	Good
Upper Elevation Amphibians	Good	Good	Good	Good
Forest Products	Very Good	Fair	Fair	Good
Jaguar	Very Good	Good	Good	Good
Archaeological Sites	Good	Fair	Good	Good
Aesthetic Landscapes	Very Good	Very Good	Good	Very Good
Subterranean Systems	Good	Very Good	Good	Good
Biodiversity Health Rank for the Maya Mountains Massif				Good

This gives an overall Biodiversity Health Rank of **GOOD** to the Maya Mountains Massif.

Annexes

Conservation Targets and Viability Indicators

Review of Biodiversity Research

Identification of Conservation Targets: Broadleaf Forest		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Broadleaf forest **Viability Indicators:** ▪ **Total area of contiguous broadleaf forest** ▪ **% of MMM protected areas (excluding Forest Reserves) not logged, or in >30 year regrowth from past selective logging** ▪ **Population of key seed dispersers** ▪ **% of broadleaf forest showing no land use change** NB: % is based on the protected area coverage of October 2007 (an area of approx. 446,766 ha (1,260,800)),	Identified as part of one of the last remaining contiguous large forest blocks in Mesoamerica (TNC, 2006.), the Maya Mountains Massif is predominantly a mosaic of broadleaf forest ecosystems. Broadleaf forest, as a target, is an umbrella for many species, communities and ecological systems, being the dominant ecosystem of the Maya Mountains Massif, covering 448,566 hectares (1,108,430 acres) approx. (88% of the total Maya Mountains Massif area: Map …), and 39.4% of the national coverage), and encompassing 29 ecosystems, ranging from lowland forest to the upper elevation elfin woodland found on peaks in the mountainous areas. The Maya Mountains Massif is part of the Petén-Veracruz Moist Forest ecoregion - a large block of tropical forest that stretches through Belize, Guatemala and southern Mexico. It is classed as 'Critical/ Endangered' (World Wildlife Fund, 2001) in response to increasing rates of deforestation. Top predators associated with this ecoregion typically require large forested areas to maintain viable populations and sustain ecological processes, with buffering from edge effects, and provision for linkage through natural habitat corridors. Throughout Central America, forest loss results in not only the loss of key predators, but also secondary local extinctions and changes in species composition when these key species are removed.	This broad conservation target of 29 ecosystems includes two considered to be under-represented within the national Protected Areas System: **Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain** and **Tropical evergreen seasonal broad-leaved submontane forest on rolling karstic hills**. Species of concern associated with the broadleaf forest ecosystems include the Critically Endangered **Morelet's Treefrog** (*Agalychnis moreletii*) (IUCN, 2007), which is restricted to broadleaf forest over an elevation of 300m. This, and ten other species of threatened amphibians are represented under the Upper Elevation Amphibian target. The Endangered **Yucatan black howler** (*Alouatta pigra*), and Near Threatened **jaguar** (*Panthera onca*) and **great curassow** (*Crax ruber*) are also found in this habitat. A number of species presently considered non-threatened, but highlighted as of national concern are the **white-lipped peccary** (*Tayassu pecari*) and the nationally 'vulnerable' sub-species of **Central American spider monkey** (*Ateles geoffroyi yucatanensis*) and scarlet macaw (*Ara macao*), **ocelot** (*Leopardus pardalis*), **margay** (*Leopardus wiedii*) and j**aguarundi** (*Herpailurus yaguarundi*) (Meerman, 2005). A number of endemic plant species have also been recorded in the area (***Neurolaena schippii, Scutellaria lundellii Calyptranthus bartlett*ii**), as have a number of species of regional interest, such as ***Colpothrinax cookii*** and the national endemic ***Schippia concolor.*** This target also represents the karst areas – the limestone cliffs and caves that are themselves an important geological conservation focus, and the cultural value they represent, as ceremonial sites for the ancient Maya. The recognition of the importance of karst landscapes as a conservation target by the IUCN World Commission on Protected Areas in 1997, and the increasing need for their protection, has led to an evaluation of karstic scenery and its protection throughout Central America (Kueny and Day, 2002). Belize is highlighted as the country with the largest proportional area of karst under protection (68% of the total karst landscape of the country falls within protected areas), however this is being eroded as the karst areas come under increasing pressure from dereservation of forest reserves, whittling away at the protected areas, and to some extent from quarrying for limestone hardcore.

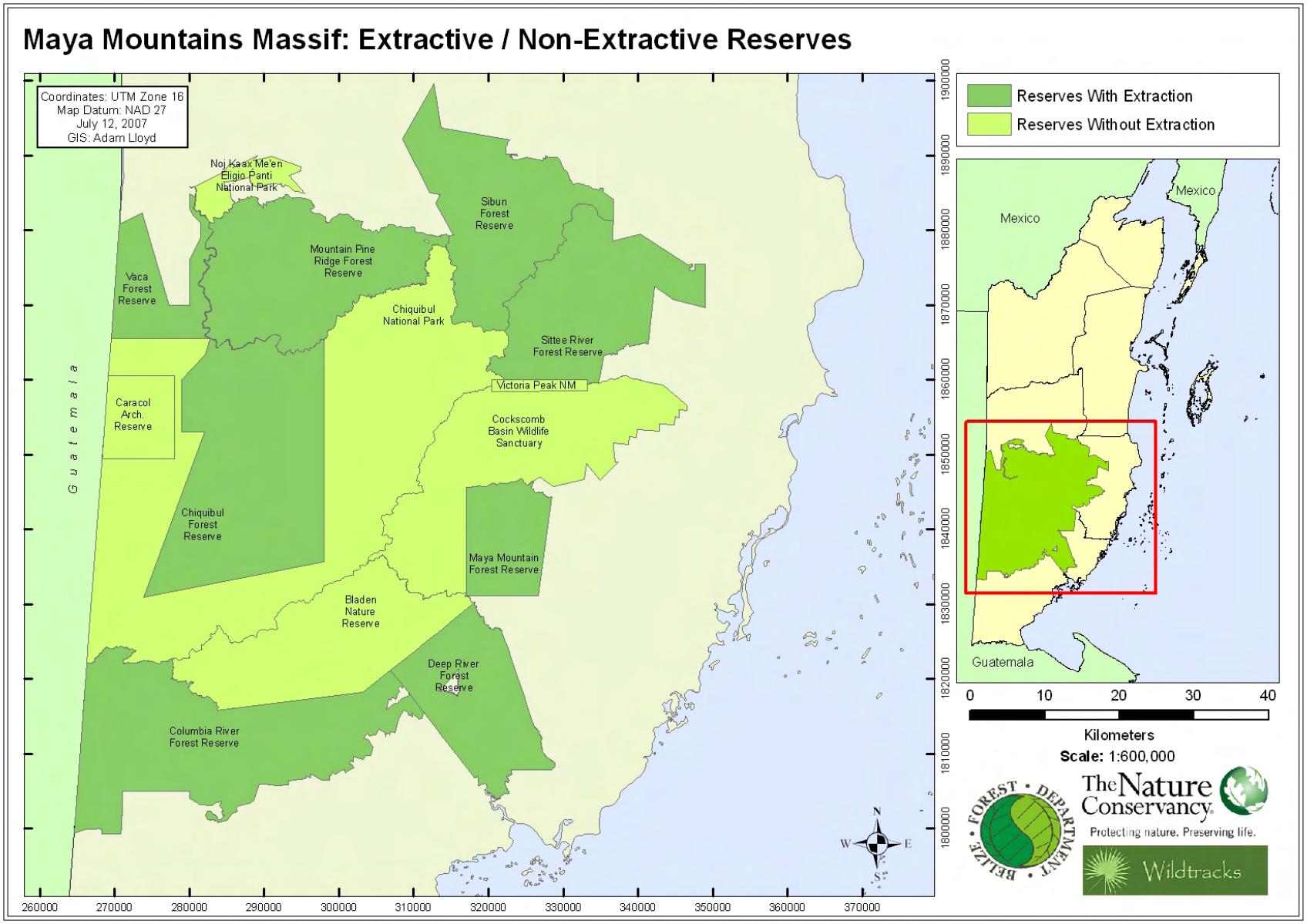
Broadleaf Forest Ecosystems within the Maya Mountains Massif

(Ecosystems included within mapping as components of Broadleaf Forest)

- Evergreen broad-leaved lowland shrubland, Miconia variant
- Tropical evergreen broad-leaved alluvial forest on calcareous soils
- Tropical evergreen broad-leaved lower montane palm forest
- Tropical evergreen broad-leaved lower-montane forest
- Tropical evergreen broad-leaved lowland forest on calcareous soils
- Tropical evergreen broad-leaved lowland forest on poor or sandy soils
- Tropical evergreen broad-leaved lowland hill forest on rolling karstic terrain
- Tropical evergreen broad-leaved lowland hill forest on steep karstic terrain
- Tropical evergreen broad-leaved lowland hill forest, Callophyllum variant
- Tropical evergreen broad-leaved lowland hill forest, Vochysia-Terminalia variant
- Tropical evergreen broad-leaved lowland swamp forest
- Tropical evergreen broad-leaved shrubland on steep karstic hills
- Tropical evergreen broad-leaved submontane forest
- Tropical evergreen broad-leaved submontane forest on rolling karstic hills
- Tropical evergreen broad-leaved submontane forest on steep karstic hills
- Tropical evergreen broad-leaved submontane palm forest
- Tropical evergreen seasonal broadleaf lowland forest over lime-rich alluvium
- Tropical evergreen seasonal broad-leaved lower montane elfin forest
- Tropical evergreen seasonal broad-leaved lowland forest on calcareous soils, Tehuantepec-Peten variant
- Tropical evergreen seasonal broad-leaved lowland forest on poor or sandy soils
- Tropical evergreen seasonal broad-leaved lowland hill forest on steep karstic terrain
- Tropical evergreen seasonal broad-leaved lowland hill forest, on rolling karstic terrain
- Tropical evergreen seasonal broad-leaved lowland hill forest, Simarouba-Terminalia variant
- Tropical evergreen seasonal broad-leaved lowland hill forest, Virola-Terminalia variant
- Tropical evergreen seasonal broad-leaved submontane elfin forest
- Tropical evergreen seasonal broad-leaved submontane forest on rolling karstic hills
- Tropical evergreen seasonal broad-leaved submontane forest on steep karstic hills
- Tropical evergreen seasonal broad-leaved submontane forest, Simarouba-Terminalia variant
- Tropical evergreen seasonal broad-leaved submontane forest: Virola-Terminalia variant

Viability of Conservation Targets: Broadleaf Forest				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Connectivity among communities and ecosystems ▪ **Total area of contiguous broadleaf forest**	Some of the key species required for functionality of the broadleaf forest may require larger areas of forest than is encompassed within the Maya Mountains Massif The indicator ratings are calculated in relation to connectivity issues, mapped in the **Preliminary Report on the Assessment of Threats and Opportunities of the Maya Mountains Massif.**	**Very Good: 1,133,054 ha (2,799,826 acres) or more.** Allowing for connectivity over gaps of less than 100m between forest blocks - this gives connectivity across the Western Highway. (NB. this includes Lowland broadleaved dry forest) **Good: 687,017 ha – 1,133,054 ha.** 687,017 ha is the area of contiguous forest running as far as the Western Highway, and connected by a gap of no more than 50m. The Hummingbird Highway is currently not considered as a barrier to connectivity for broadleaved forest, and rivers are also assumed to not affect connectivity. Forest areas within MPR are considered contiguous. **Fair: 438,593 ha – 687,017 ha** The area of broadleaf forest currently within the MMM is approx 438,593 ha (439,321 ha minus the inundation area of Chalillo (728ha). 687,017 ha is the area of contiguous forest running as far as the Western Highway, and connected by a gap of no more than 50m. **Poor: Less than 438,593 ha** The area of broadleaf forest currently within the MMM, with no connectivity beyond the MMM The area of contiguous forest is calculated using mapping and satellite imagery, and is based on Meerman 2004 edition Belize Ecosystems map. All figures include broadleaf shrubland, as this is included in the broad 'broadleaf forest' categories. NB: Deciduous mixed submontane shrubland over poor soils and Tropical evergreen seasonal mixed lowland hill forest are included in both the pine forest area and the indicator for broadleaf forest connectivity See Map … **Last amended 27/10/07**	**VERY GOOD** Connectivity is considered to exist with the Selva Maya block, through Rio Bravo area, and has not yet been lost to coastal plain Area under agriculture (as of 2004 update of Jan Meerman's map): 9,818.76 ha approx. **NB:** Recent figures (post October 2007) suggest that agricultural incursions have increased to approximately 13,000 acres (not reflected in these figures)	**VERY GOOD** Maintenance of current connectivity and protection of permanent corridor linking MMM with Rio Bravo / Selva Maya forest node. Reforestation of some or all agricultural incursion areas

Viability of Conservation Targets: Broadleaf Forest				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Community Architecture and Species Composition / Dominance ▪ **% of MMM protected areas (excluding Forest Reserves) not logged, or in >30 year regrowth from past selective logging**	Logging activity has had the greatest anthropogenic impact on forest structure to date, reflected by changes in species composition and dominance, age structure and vertical layering, and is relatively easy to monitor.	**Very Good** 75 -100% of PAs (not including FR) **Good** 50 – 74% **Fair** 25 - 49% **Poor** < 25% Based on allocation of the following scores to each protected area across the system: **Score of 1** <10 yr regrowth from past selective logging **Score of 2** 10-20 yr regrowth from past selective logging (Sustainable, well managed selective logging). **Score of 3** 20 - 30 yr regrowth or more from past selective logging **Score of 4** No logging, or >30 yr regrowth from past selective logging **Protected Areas Scoring 1** Vaca Forest Reserve Chiquibul Forest Reserve Maya Mountain Forest Reserve Columbia River Forest Reserve Deep river Forest Reserve Mountain Pine Ridge Forest Reserve **Protected Areas Scoring 2** Sibun Forest Reserve Noj Kaax Me'en Eligio Panti National Park* **Protected Areas Scoring 3** Sittee River Forest Reserve Cockscomb Basin Wildlife Sanctuary* **Protected Areas Scoring 4** Chiquibul National Park* Bladen Nature Reserve* Victoria Peak Natural Monument* Caracol Archaeological Reserve* *6 Protected Areas (excluding Forest Reserves). Data from FD. See Map …	**Good** 67% of the non-extractive protected areas of the Maya Mountains Massif have greater than 30 years regrowth from past logging Logging in Belize is very selective in comparison with many other countries (particularly in comparison with forests of the Chiquibul / Montana Mayas Biosphere Reserve in Guatemala), and retains the basic structure of the forest. Many of the non-extractive protected areas, whilst having a history of past extraction, are recovering, and several will pass the 30 year point in the next ten years. The long term forest licenses currently being issued are also moving towards sustainability of the timber resources. For this reason, Good is considered to range from 50% of the non-extractive protected areas	**Good** Over time, this will become 100% (Very Good). In the absence of further logging in these non-extractive areas, the rating cannot exceed **Good** within the next ten years.


Maya Mountains Massif: Extractive / Non-Extractive Reserves
Coordinates: UTM Zone 16
Map Datum: NAD 27
July 12, 2007
GIS: Adam Lloyd
Noj Kaax Me'en Eligio Panti National Park
Sibun Forest Reserve
Mountain Pine Ridge Forest Reserve
Vaca Forest Reserve
Chiquibul National Park
Sittee River Forest Reserve
Victoria Peak NM
Caracol Arch. Reserve
Cockscomb Basin Wildlife Sanctuary
Chiquibul Forest Reserve
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Protecting nature. Preserving life.
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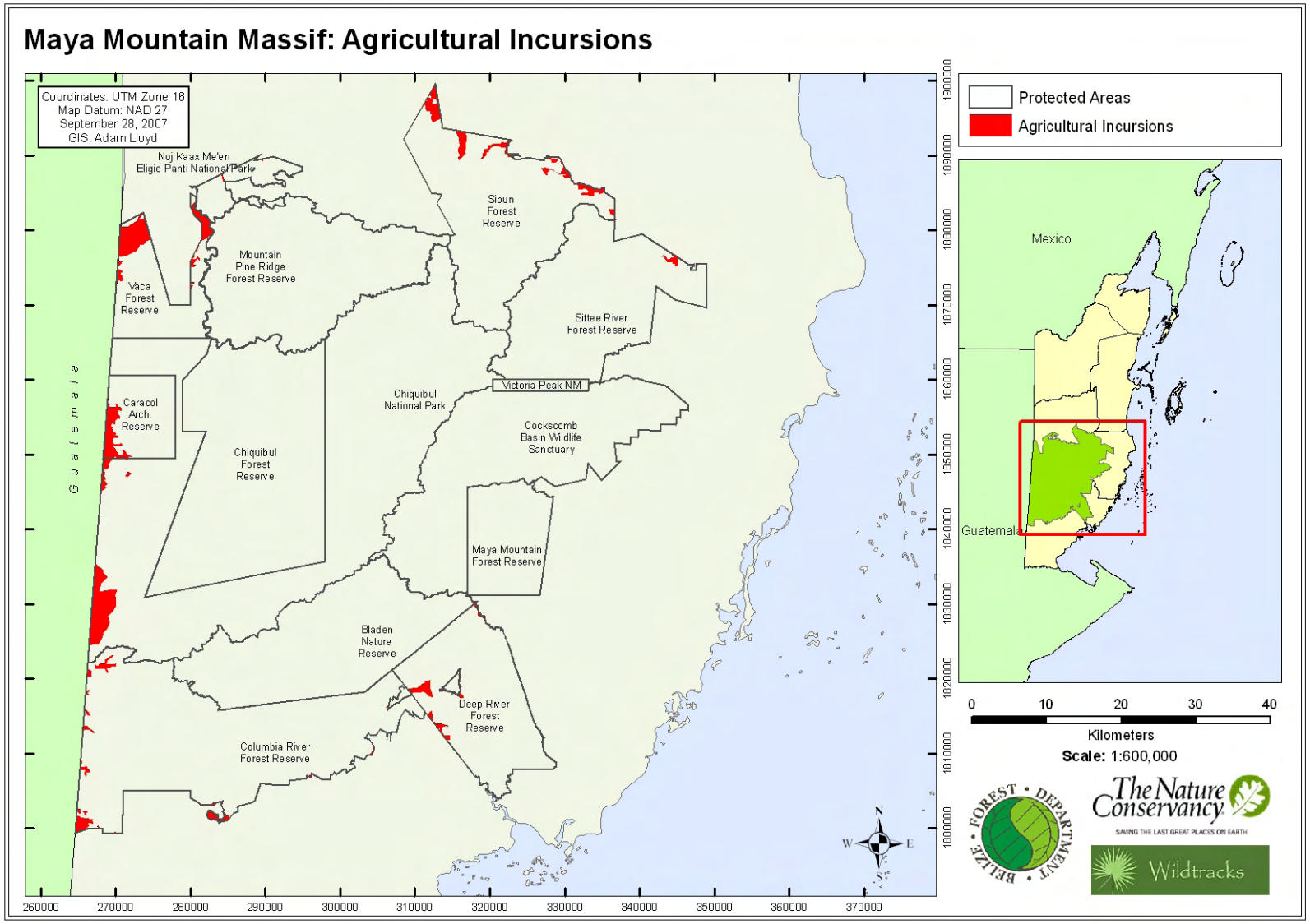
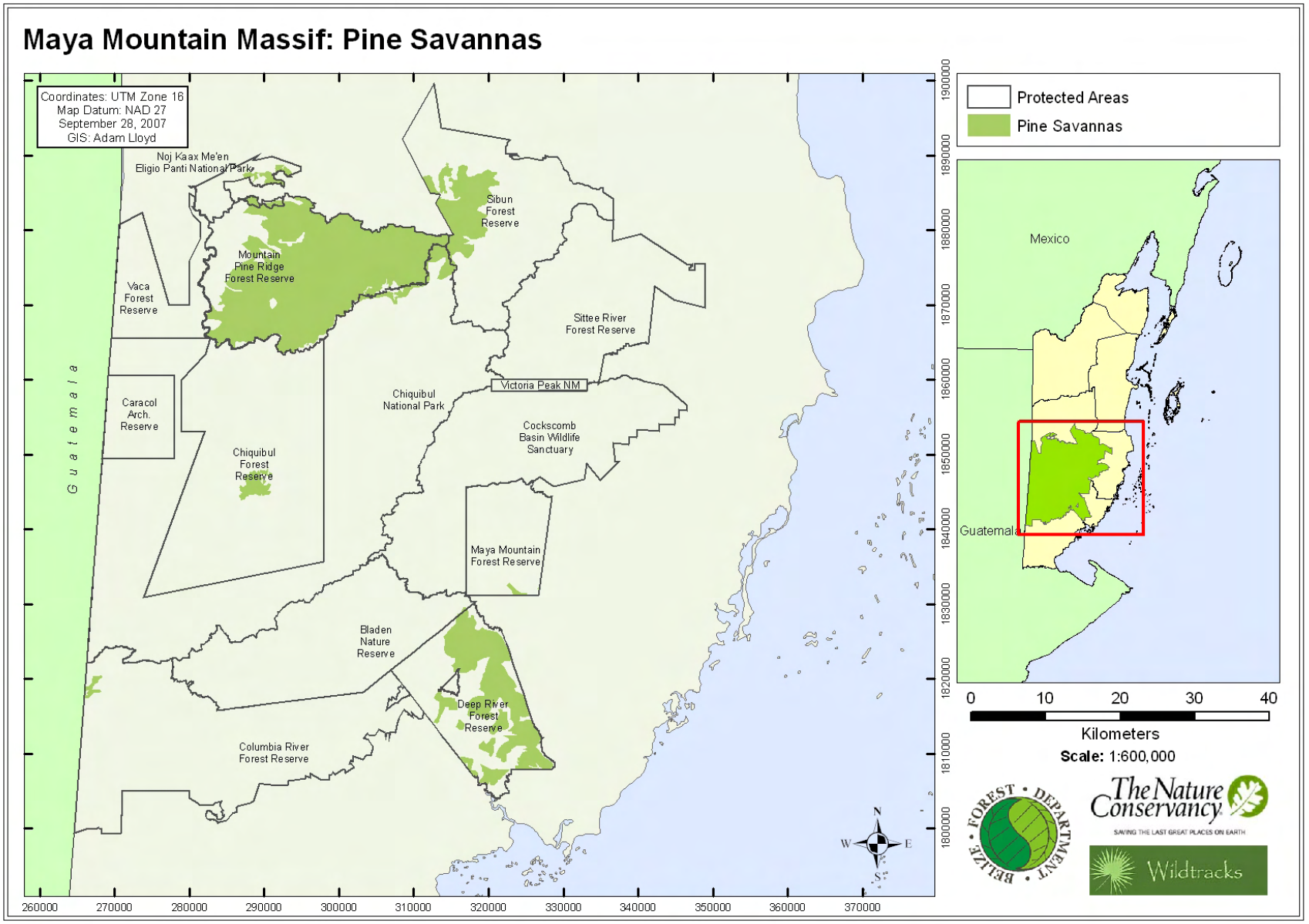
Viability of Conservation Targets: Broadleaf Forest				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Presence / Abundance of Key Functional Guilds ▪ **Population of key seed dispersers**	Seed dispersers (especially game species - eg. paca and curassow) considered one of the Key Functional Guilds, are essential for maintaining the condition of the forest	**Poor:** <1.5 **Fair:** 1.51 – 2.5 **Good:** 2.51 – 3.5 **Very Good:** 3.51 – 4 **Average of protected area scores across the system, based on following scale per protected area:** **Score of 1:** Key seed disperser populations (especially paca, curassow) are considered to be severely reduced, and intervention is required to maintain viability **Score of 2:** Key seed disperser populations (especially paca, curassow) are considered to be reduced, but not severely, and intervention may be required to maintain viability **Score of 3:** Key seed disperser populations (especially paca, curassow) are somewhat reduced but can recover naturally **Score of 4:** Key seed disperser populations (especially paca, curassow) are not considered to be impacted by hunting **Protected Areas Scoring 1** Chiquibul Forest Reserve Chiquibul National Park Caracol Archaeological Reserve **Protected Areas Scoring 2** Vaca Forest Reserve **Protected Areas Scoring 3** Maya Mountain Forest Reserve Columbia River Forest Reserve Deep river Forest Reserve Mountain Pine Ridge Forest Reserve Noj Kaax Me'en Eligio Panti National Park **Protected Areas Scoring 4** Sibun Forest Reserve Bladen Nature Reserve Victoria Peak Natural Monument Sittee River Forest Reserve Cockscomb Basin Wildlife Sanctuary	**GOOD** **Average Score (2007): 2.86** Lower than 'very good' because of impact on seed dispersers by hunting pressure (RAPPAM, 2007, protected area staff and local community feedback).	**GOOD / VERY GOOD** Reduced hunting pressure is projected to increase abundance of key seed dispersers.

Viability of Conservation Targets: Broadleaf Forest				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Size: Size / extent of characteristic communities ▪ **% of broadleaf forest showing no land use change**	Land use change is perhaps the most critical threat to broadleaf forest viability – as agricultural incursions take place, with actual land use change on the ground, this is later compounded by dereservation of the incursion areas, taking them out of protection.	**Poor:** > 65% of 458,385ha **Fair:** 65 – 74% of 458,385ha **Good:** 75 – 89% of 458,385ha **Very Good:** 90 – 100% of 458,385ha The majority of broadleaf forest within the Maya Mountains Massif is considered to be in its natural state, except for those areas impacted by agricultural incursions and dam inundations. The current area (2007) of broadleaf forest within the MMM is approx 446,766 ha (448,566 ha – inundation area of Chalillo (728ha)).The potential area is 458,385 ha (448,566 ha + agriculture incursions (9,819ha) based on Meerman 2004 edition Belize Ecosystems map.	**VERY GOOD** **97.7%** This accounts for date for agricultural incursions and Chalillo as of October, 2007 It doesn't take into account the current dereservation of areas within Sibun, nor the additional agricultural incursions reported in the Chiquibul National Park after the CAP workshops, but this will probably still be under 10% of the total broadleaf forest area. Recheck this figure	**VERY GOOD**



Agricultural Incursion areas

Identification of Conservation Targets		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Pine Forest and Savanna **Viability Indicators:** ▪ **Average fire frequency (no. years between fires)** ▪ **Pine size class distribution** ▪ **Presence of Southern Pine Bark Beetle** ▪ **Yellow-headed parrot population**	The Belizean Pine Forest ecoregion is highlighted as one of the few regional fragments of tropical lowland pine forests (WWF, 2001). It shows a gradient from fully developed pine forest through short grass savanna and pine, to short grass savanna (without pine) dependant on soil type and frequency of fires. Under the WWF categories, it is given the conservation status critical / endangered. The pine forests have been severely impacted by a large scale infestation from the Southern Pine Bark Beetle in 2001/2002, and increasing frequency and intensity of fire, affecting recruitment following past logging pressures. This conservation element is found primarily in two areas of the Maya Mountains Massif – lowland pine forest of the coastal savanna (in Deep River Forest Reserve, with small marginal areas in Bladen Nature Reserve and Cockscomb Basin Wildlife Sanctuary), and the upper pine ridge of the Mountain Pine Ridge Forest Reserve and Eligio Panti National Park, with small patches in several other protected areas, including Chiquibul Forest Reserve and Sibun Forest Reserve. Encompassing nine ecosystems, this conservation element covers **65,421 ha** (161,659 acres) of the Maya Mountains Masssif.	**Tropical Evergreen Seasonal needle-leaved lowland hill forest** is highlighted as one of the ecosystems considered as under-represented within the National Protected Areas System in Belize. **White-tailed deer** (*Odocoileus virginianus*) and **collared peccary** (*Tayassu tajacu*) are represented by this conservation target, as are many other species that use this ecosystem either as prime habitat (**nine-banded armadillo**, for example) or as marginal or transitory habitat (**jaguar** and **white-lipped peccary**). Also nested within this conservation element is the nationally highlighted passionflower species - ***Passiflora urbaniana***. **Palmetto** (*Acoelorraphe wrightii*), an important non-timber forest product, is also present in low densities. The pine savannas of Belize are the last stronghold of the Éndangered **Yellow-headed Parrot** (*Amazona oratrix*), (IUCN, 2007). This species has faced massive declines over the past thirty years - globally, numbers have dropped an estimated 90% to 7,000 in the late 70's Between then and 2000, there has been a further estimated decline of 68% (Birdlife, 2000). At present, with the increasing frequency of fires (burning nesting trees), the theft of nestlings, and increasing pressures from land use changes in the coastal areas, numbers are considered low enough to threaten viability, leading to its upgrade to CITES Appendix. I. The Payne's Creek / Deep River area of Belize is estimated to have a population of between 300 – 500 individuals,but with severe limitations on nest site availability (M. Muschamp, pers. com., 2007). Endemic plant species closely associated with the pine / savanna ecosystem complex are ***Anemia bartletti, Axonopus ciliatifolius*****,** ***Telanthophora bartletti*****,** ***Dalechampia schippii*****,** ***Galactia anomala*****,** ***Koanophyllon sorensenii*****,** ***Mimosa pinetorum*****,** ***Oxandra proctorii*****,** ***Pisonea proctorii*****,** ***Schippia concolor*****,** ***Syngonanthus bartlettii*****,** and ***Zinowiewi pallida.*** The endemic sub-species of the sedge wren (*Cistothorus platensis russelli*) is only found in the seasonally wet grasslands of northern Toledo / central Stann Creek, and on the highest peaks of Mountain Pine Ridge.



Pine Forest within the Maya Mountains Massif
Based on: Meerman (2004). Belize Ecosystem Map

Total Pine Savanna area of the Maya Mountains Massif is calculated at: 65,421 ha (161,659 acres)

This includes

- Deciduous mixed submontane shrubland over poor soils 9,698 ha (23,963 acres)
- Short-grass savanna with scattered needle-leaved trees 1,219 ha (3,012 acres)
- Short-grass savanna with shrubs 9,594 ha (23,706 acres)
- Tropical evergreen seasonal needle-leaved lowland forest 2,400 ha (5,932 acres)
- Tropical evergreen seasonal needle-leaved lowland hill forest 7,468 ha (18,453 acres)
- Tropical evergreen seasonal needle-leaved submontane forest 14,189 ha (35,063 acres)
- Tropical evergreen seasonal mixed lowland hill forest 7,214 ha (17,828 acres)
- Tropical evergreen seasonal mixed submontane forest 13,639 ha (33,702 acres)

NB: Deciduous mixed submontane shrubland over poor soils and Tropical evergreen seasonal mixed lowland hill forest are included in the indicator for broadleaf forest connectivity

Viability of Conservation Targets: Pine Forest and Savanna				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Fire regime - (timing, frequency, intensity, extent) ▪ **Average Fire frequency (no. years between fires)**	The pine savannas of Belize are a fire-maintained ecosystem, but can become threatened if there is a significant change in fire frequency (either too little or too much), primarily from anthropogenic impacts.	**Poor:** < 1.5 **Fair**: 1.6 – 2.5 **Good:** 2.6 – 3.5 **Very Good:** > 3.5 Averaged rating over protected areas containing pine savanna, scored using the following criteria: **1:** Fire every year, or no fires for 8 years **2:** Fire every 1 – 2 years or 6 – 8 years **3:** Fire every 2-3 years or 5 - 6 years **4:** Fire every 3 – 5 years Based on Forest Department recommendations, and Myers (2002), which suggests 3 – 7 year burn cycle for PfB lands. **Protected Areas Scoring 1** Deep river Forest Reserve Mountain Pine Ridge Forest Reserve **Protected Areas Scoring 2** Bladen Nature Reserve **Protected Areas Scoring 3** Noj Kaax Me'en Eligio Panti National Park **Protected Areas Scoring 4** Sibun Forest Reserve Chiquibul Forest Reserve Both MPR and the coastal pine savanna are rated as Fair. Anthropogenic MPR fires result primarily from military training activities in the dry season, whilst fires on the coastal savanna (eg. Deep River FR) are often started by hunters seeking to attract white tailed deer to regenerating grasses, or by escaped milpa fires from adjacent agricultural lands.	**FAIR** **Average Score is 2.5** Fires are currently considered to be too frequent and too intense, especially following the impacts of the Southern Pine Bark Beetle, and the resulting fuel load from dead trees.	**GOOD**

Viability of Conservation Targets: Pine Forest and Savanna				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Population Structure and Recruitment ▪ **Pine size class distribution**	Concerns that the increasing fire frequency is affecting recruitment, with few seedlings reaching maturity	**Poor:** < 10 trees > 45cms dbh / ha and < 200 trees < 5cms dbh / ha **Fair:** 10 - 30 trees > 45cms dbh / ha or 200 - 400 trees < 5cms dbh / ha **Good:** 30 - 50 trees > 45cms dbh / ha or 400 - 600 trees < 5cms dbh / ha **Very Good:** > 50 trees > 45cms dbh / ha and > 800 trees < 5cms dbh / ha Based on Forest Department recommendations	**FAIR**	**GOOD**
Size: Population Size ▪ **Presence of Southern Pine Bark Beetle infestations**	A recent outbreak of Southern Pine Bark Beetle infestation has had a significant impact on the population size and viability of pine forests in the Maya Mountains Massif	**Poor:** Patches > 10 acres **Fair:** Patch development < 10 acres **Good:** Spot infections of >25 trees, and reduced distance between spots and **Very Good:** Widely separated single tree or spot infection with <25 trees Southern Pine Bark Beetle populations occur naturally in single trees or small, scattered groups, as an innocuous scavenger of dead and dying pine trees. During an outbreak, however, the infested spots grow in size and number, and tend to coalesce into large patches. As the outbreak continues to expand, the patches extend over the landscape, with small spots or individual infested trees being found at the leading edge of large outbreaks or in areas where populations are just beginning to build. Signs of outbreak conditions include an increasing number of spots, more infested trees per spot, and spots continuing to enlarge beyond the initial cluster of infested trees.	**VERY GOOD** Currently, there are no outbreaks (patches)	**VERY GOOD**

Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Population Size ▪ **Yellow-headed parrot population**	In Belize, yellow-headed parrots are more or less restricted to pine savanna areas, and are reliant on holes in old pine trees for nesting. This species is therefore considered a good indicator of the viability of the pine savannas.	**Poor**: <200 birds /10,000 ha **Fair:** 201 - 300 **Good:** 301 - 500 **Very Good:** > 500 The population estimate for Rio Bravo (Management Plan, 2000), is 200 birds per 10,000 hectares - this was considered 'POOR'. Estimates for the Deep River / Payne's Creek area are between 300 - 500 birds (M. Muschamp, pers. com. 2007), in an area of over 20,000 ha, though the major limitation is considered to be suitable nesting trees. The Yellow-headed Amazon *Amazona oratrix* is classified as Endangered by IUCN. In Belize, it is restricted to pine savanna, and is thought to be declining rapidly, with increasing frequency of fire removing suitable nesting trees and causing high chick mortality, as well harvesting of chicks for the illegal pet trade. It is estimated that the wild population has declined more than 90% since 1970, and a further 68% or more of the remaining population in the past 15 years, to approx. 7,000 mature individuals (Birdlife International) - this estimate is from 1999/2000 - population figures appear not to have been updated since then). There is considered to be a small viable population in Belize (though exact population estimates are unknown).	**FAIR** 300 – 500 birds in 20,000 ha or more gives a density of between 200 and 250 birds per 10,000 ha	**GOOD**

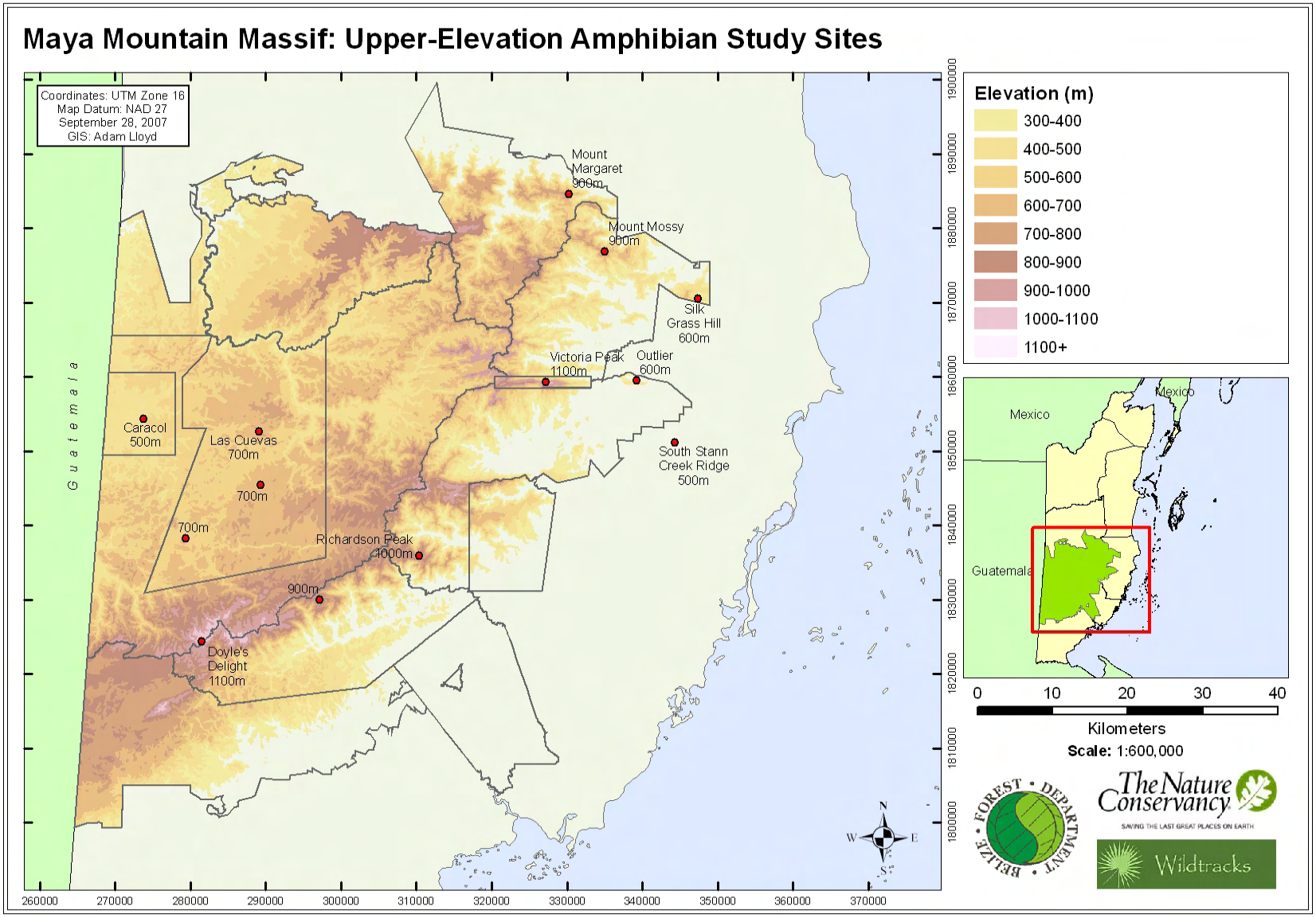
Identification of Conservation Targets: Aquatic and Riparian Ecosystems		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Aquatic and Riparian Ecosystems **Viability Indicators:** ▪ **Orographic rainfall** ▪ **Land use change in coastal plain areas** ▪ **Density of migratory species in headwaters** ▪ **% total upstream length affected by physical barriers** ▪ **% of total stream length with natural riparian vegetation** ▪ **Generic richness of macroinvertebrates in rapids** ▪ **Native fish species richness**	The Maya Mountain aquatic and riparian communities provide an essential resource for both aquatic and non-aquatic species – whether through trophic interactions, or life-cycle requirements. Aquatic ecosystems energetically subsidize the terrestrial – whilst species richness is relatively low compared to terrestrial systems, the aquatic ecosystem is considered to be an energetically important part of the overall Broadleaf Forest Ecosystem, with species playing an important role in converting basal resources into biomass that is available for consumption by other aquatic and terrestrial organisms (Esselman, pers. com.). The associated riparian vegetation and riparian-dependent species also fall within this conservation element. 14 watersheds originate in the Maya Mountains, providing clean water and watershed functionality (flood control, erosion control etc.) for over 55% of the total land mass in Belize (where it is utilized by over 128 communities, with an estimated population of over 76,531 (BERDS, 2007) and for agricultural production) and for a significant portion of the Peten in Guatemala. The protected headwater streams serve as a refuge from temperature and flow extremes, as well as providing a refuge from competition, predation, and invasive species such as *Tilapia*, found within the lower reaches on the coastal plains. Protection from the land use change found lower downstream ensures that there is habitat suitable for spawning sites and rearing areas, and the intact drainage basins maintain a rich source of food within the aquatic system, and a critical source of organic matter. The water courses themselves provide a migratory route/ aquatic corridor through the landscape, from the Maya Mountains Massif to the coast. Maintenance of the 66' buffer vegetation, as stipulated as a national policy, also maintains connectivity for many terrestrial species between the Maya Mountains Massif and the coastal plain (Meyer et al. 2007). Streams contribution within the Maya Mountains Massif Headwater Stream 99.800% of total stream length Small River 0.002% Medium River 0.001%	Several IUCN red-listed species are associated with the aquatic and riparian ecosystems, including the Endangered **Baird's Tapir** (*Tapirus bairdii*), and the **Long-legged and Sanderson's Streamfrogs** (*Craugastor sabrinus* and *Eleutherodactylus sandersoni*) (IUCN, 2007). The **muscovy duck** (*Cairina moschata*), game fish such as **mountain mullet** (*Agonostomus monticola*), **bobo mullet** (*Joturus pichardi*) and **bay snook** (*Petenia splendida*), and the smaller cichlids, livebearers and tetra are found in the mid-stream portions of the aquatic system. These support various vertebrate fish-eating species, including **Morelet's crocodile** (*Crocodylus moreleti*) (IUCN: Lower risk /conservation dependent), the **Neotropical river otter** (*Lutra longicaudis*), and a number of species of freshwater turtles, kingfishers, herons and egrets. Several amphibian species are reliant on the water during part of their life cycle, and macroinvertebrates with aquatic larval stages provide an important resource for insectivorous birds and bats. Associated with the riverine vegetation are species such as Baird's tapir (*Tapirus bairdii*) (IUCN: Endangered) and the Yucatan howler monkey (*Alouatta pigra*) (IUCN: Endangered) and seasonally, migrant birds. A number of endemic species are associated with the headwater and midreach streams of the Maya Mountain, including two fish species (***Poecilia teresae*** and the cave-dwelling ***Rhamdia typhla*****,** and ***Rana juliani*** Belize's single endemic amphibian species. Illegal fishing is currently the major threat to aquatic communities in the east facing slopes of the Maya Mountains. However, there is also a migratory component to the aquatic fauna (such as the Atyid shrimps (eg. *Atya scabra*), important macroconsumers in headwater streams that connect the mountains to the sea (Esselman, pers. com.)) which rely on connectivity with the coastal plain and the coastal waters. Whilst at present, other than in the Macal system, there are no physical barriers to movement of species up and down the rivers, increasing organic runoff from agricultural areas downstream, diversion of water for irrigation and damming of the waterways may, in future, become a significant threat to the viability of these species.

Aquatic and Riparian Ecosystems **Viability Indicators**	**Key attribute and indicator**	**Indicator ratings**	**Current rating**	**Desired rating**
▪ **Orographic Rainfall**	**Hydrologic Regime** (Hydrologic regime - timing, duration, frequency, extent). Hydrologic regime may be affected by forest clearance on the southern coastal plain	**Poor:** **Fair:** **Good:** Change in orographic rainfall patterns **Very Good:** Current There is no baseline data available for this indicator, however the installation of a weather station on Victoria Peak under the CEPF Amphibian project will start providing data on this from early 2008 onwards. Orographic rainfall regime is assumed to be Very Good, however there is scope for it to have been affected by the increased clearance of coastal plain forests for cattle farming, however there have been no studies, and there is therefore no evidence to date of this	**VERY GOOD**	**VERY GOOD**
▪ **Land use change in coastal plain areas**	**Hydrologic Regime** Indicative of changes in vegetation patterns that will influence orographic rainfall patterns	**Poor:** **Fair:** **Good:** **Very Good:** How does Climate Change come into this? How do we differentiate between changes due to land use changes in the catchment area, and changes due to climate change	**FAIR**	**FAIR**
▪ **Density of migratory species in headwaters**	**Instream connectivity** Indicators of instream fragmentation of migratory life history - indicator species – Mountain Mullet (*Agonostomus monticola*)	**Poor:** **Fair:** Density is lower than current conditions **Good:** Current condition **Very Good:** Previous There are currently some barriers to connectivity for migratory species such as the indicator chosen – *Agonostomus monticola* – primarily fishing in the coastal plain - but there are also concerns about chemical barriers from agricultural pollution, from unsustainable fishing practices using poisons, and potential physical barriers – especially hydroelectric dams. Whilst Atyd shrimps may provide a more refined indicator, it is considered more realistic to use the Mountain Mullet as a species easily recognised by field staff in the protected areas. (It is hoped that at least a presence/absence data set will be developed for each protected area by the end of the project. **ZW**)	**GOOD**	**GOOD**

Aquatic and Riparian Ecosystems **Viability Indicators:**	**Key attribute and indicator**	**Indicator ratings**	**Current rating**	**Desired rating**
▪ **% total upstream length affected by physical barriers**	**Instream connectivity** Potential damming of the river systems for hydroelectricity production is identified as one of the greatest threats to connectivity	**Poor:** **Fair:** Increase in % of upstreams affected by physical barriers **Good:** Current connectivity (connectivity impaired on the Macal system and hydromaya) **Very Good:** Instream connectivity intact in all systems Total stream length is being used as a proxy for stream density, with 6,203,869m of stream being mapped within the Maya Mountains Massif area. Current stream length impacted by Mollejon Dam is mapped at ...m, and that impacted by the Hydromaya Dam on the Rio Grande, within the Maya Mountains Massif, is ...m. In total, this represents xx% of the stream length of the Maya Mountains Massif. Attempts should be made to ensure that the footprint of future hydroelectricity projects take into consideration the results of the prioritisation re. biodiversity of watersheds within the Maya Mountains recommended under this project.	**GOOD** There are currently some physical barriers to connectivity – on the Macal system, and Rio Grande	**GOOD** It is unrealistic to consider removing hydroelectricity dams currently in place, so this indicator can never be rated more than **Good** in the future.
▪ **% of total stream length with natural riparian vegetation**	**Riparian Forest Connectivity and Width** 50 meters is a conservative estimate for buffer width necessary to maintain riparian and instream integrity. Maintaining unfragmented riparian forest buffer throughout the watersheds maintains integrity.	**Poor:** < 45% **Fair:** 45% – 69% **Good:** 70% - 85% **Very Good:** >85% The majority of the Maya Mountains Massif is under natural vegetation, and free from human impacts on the riparian vegetation. The greatest current impacts are from agricultural incursions in the Sibun, North Stann Creek and Vaca watersheds, and on the Chiquibul from Guatemalan incursions. There are also minor impacts from activities related to improving tourism access and facilities within the Mountain Pine Ridge Forest Reserve, and minimal clearance for tourism access in Cockscomb Basin Wildlife Sanctuary. There are some logging impacts (primarily roads crossing waterways) but long term forest licenses stipulate the requirement to prevent disturbance.	**VERY GOOD** 90% +	**VERY GOOD**

Aquatic and Riparian Ecosystems **Viability Indicators:**	**Key attribute and indicator**	**Indicator ratings**	**Current rating**	**Desired rating**
▪ **Generic richness of macroinvertebrates in rapids**	**Instream species composition**	**Poor:** < 20 **Fair:** 20 - 30 **Good:** 31 - 40 **Very Good:** > 40 There are no watersheds where headwater richness is considered to have changed from the natural baseline. The indicator ratings are based on the expert opinion; Boles, based on work conducted in 1998. A protocol needs to be developed to assess generic richness at family level, that can be implemented by community and park field staff participants	**VERY GOOD**	**VERY GOOD**
▪ **Native fish species richness**	**Species composition / dominance**	**Poor:** **Fair:** **Good:** **Very Good:** Fish richness will be one of the outputs of the prioritisation of watersheds, recommended under Objective 4, and will give a baseline for this indicator. It is suggested that key monitoring points be set where major streams leave the Maya Mountains Massif.	**GOOD** With the current reports of fishing pressure within the majority of protected areas, this may be optimistic, but until a baseline is developed, this will remain unknown.	**VERY GOOD**

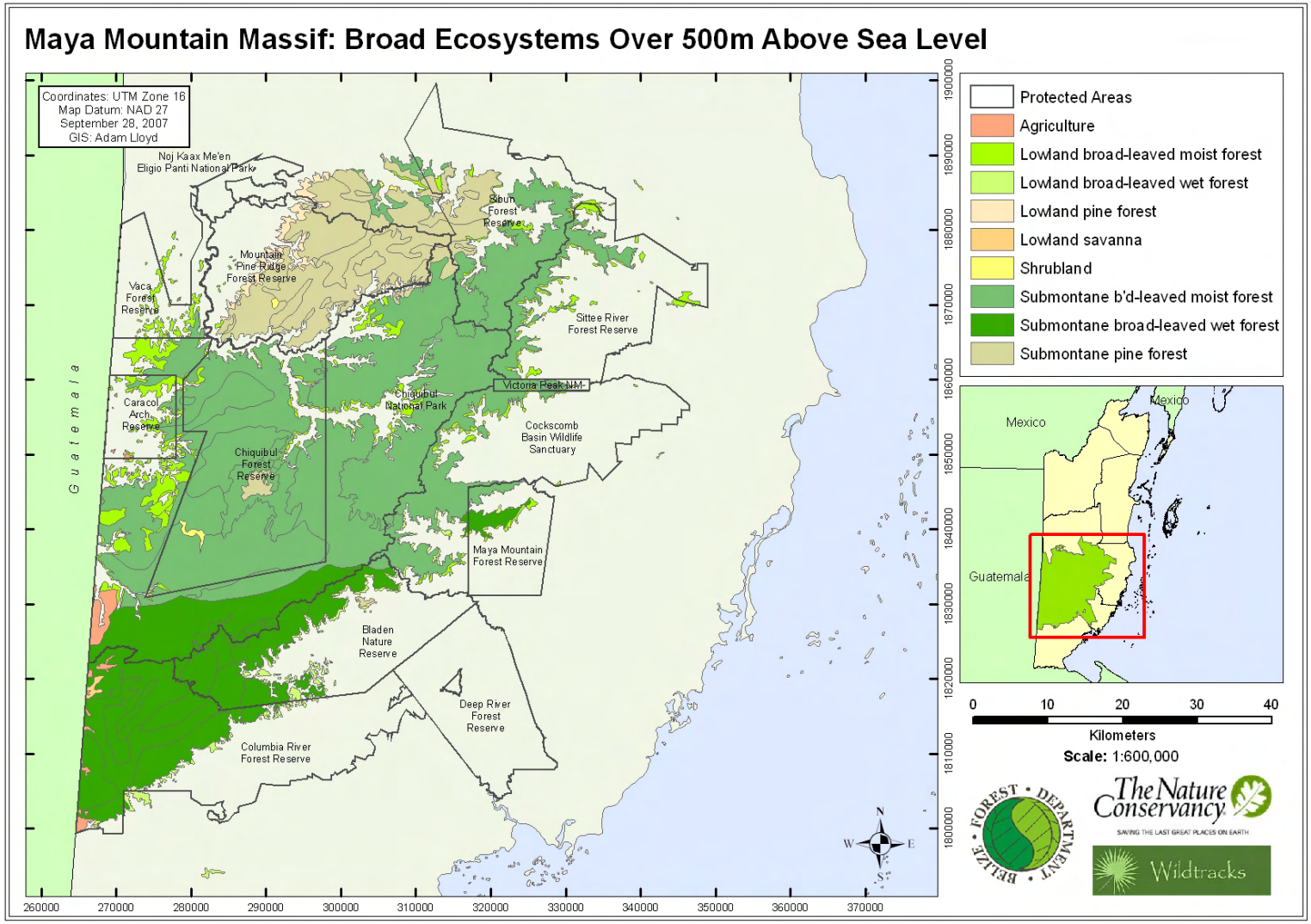
Identification of Conservation Targets: Upper Elevation Amphibians		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Upper Elevation Amphibians **Viability Indicators:** ▪ **Extent of sub-montane ecosystems** ▪ **% of key sub-montane sites considered in very good condition as amphibian habitat** ▪ **Changes in site level micro-climate patterns outside the range of natural variation** ▪ **% sites showing presence of chytrid infection** ▪ **% sites showing presence of organophosphates** ▪ **% sites with population sizes of key species within the range of natural variation**	Upper Elevation Amphibians have been chosen as a conservation element due not only to their rapid response to changes in environmental quality and climate change impacts, but also because of the recognition of specific threats that have caused catastrophic population declines and extinctions regionally, and because of specific strategies that may need to be implemented to combat these threats. Within Belize 33% of the amphibian species are considered as being of conservation concern (including Belize's only critically endangered terrestrial vertebrate, *Agalychnis moreletii*), the majority of these being confined to the upper elevation areas of the Maya Mountains. Despite the fact that most of the declines in amphibian populations of pristine areas in Central America have occurred at elevations of over 500 m (Young et al., 2001), little research has been conducted in these areas of Belize, and there is no significant knowledge on the current status of these species, many being assigned default ratings in the Global Amphibian Assessment (2004) based on availability of suitable habitat, due to lack of population data (P. Walker, pers. obs., J. Lee, pers. comm.).	Upper elevation species included within this conservation element are the Critically Endangered **Morelet's treefrog** (*Agalychnis moreletii*), the Endangered **Sabrina's rainfrog** (*Craugastor sabrinus*), **Sanderson's rainfrog** (*Eleutherodactylus sandersoni*) and the Bromeliad treefrog (*Bromeliohyla bromeliacia*), the Vulnerable **limestone rainfrog,** (*Craugastor psephosypharus*), **leprus chirping frog** (*Eleutherodactylus leprus*) and **Alfred's rainfrog** (*Eleutherodactylus alfredi*), the Near Threatened **Chac's rainfrog** (*Craugastor chac*), **Maya Mountain Frog** *(Rana juliani*), and **Campbell's Rainforest Toad** (*Bufo campbelli*) (IUCN, 2006). These amphibians are considered indicative of the health of the upper elevation ecosystems, and also represent nested targets - upper elevation bird species. including the Vulnerable **keel-billed motmot** *Electron carinatum*), the **scaly-throated foliage-gleaner** (*Anabacerthia variegaticeps*) and the **tawny-throated leaftosser** (*Scelurus mexicana*).



Key Sites identified in the Maya Mountains Massif

Viability of Conservation Targets: Upper Elevation Amphibians				
Viability Indicators:	**Viability Indicators:**	**Viability Indicators:**	**Viability Indicators:**	**Viability Indicators:**
Landscape context: Physical Habitat ▪ **% of sub-montane sites not reduced in extent by anthropogenic impacts**	**Physical Habitat** Precipitous declines and extinctions have been occurring within the region in sub-montane and montane ecosystems. Habitat loss has had a significant impact on upper elevation amphibians in neighbouring countries, but has not been a significant factor in Belize to date. Mineral extraction is an increasing potential threat to some upper elevation sites.	**Poor:** <70% of identified key sites not diminished in size by anthropogenic impact **Fair:** 70-79% of key sites not diminished in size by anthropogenic impact **Good:** 80-89%% of key sites not diminished in size by anthropogenic impact **Very Good:** 90-100% of key sites not diminished in size by anthropogenic impact Current would be 12/15 (80%,) – as actual habitat at Tiger Fern is now significantly smaller, as is that at South Stann Creek Ridge, due to anthropogenic fires. Extent based on Belize Ecosystem Mapping (Meerman, 2004) - area of broadleaf forest above 500m , with additional ground-truthed mapping to be developed under the current Wildtracks Upper Elevation Amphibian Project. As small vertebrates often occur in relatively high densities, amphibian populations may not necessarily require extensive tracts of habitat for long term viability, though there needs to be sufficient habitat for the habitat itself to be viable (minimum dynamic area). The actual rating of this should therefore be rated in terms of minimum dynamic area of the habitat (broadleaf forest > 500m), and therefore relies on information on the extent of impacted area from Hurricane Hattie or other Hurricanes, and subsequent regeneration.	**GOOD** The current extent of the sub-montane ecosystems is considered to be within or near the range of natural variation, though has been reduced by anthropogenic fire on Cabbage Haul and South Stann Creek Ridges. Confidence of the current rating is medium, as current ecosystem mapping is considered best data available, but is at too coarse a scale and lacks adequate ground truthing in these ecosystems. Key sites are being ground truthed during the Upper Elevation Amphibian project (CEPF / Wildtracks), and have been integrated into this CAP workbook as available	**VERY GOOD** This will rely upon control of the coastal savanna fires that are increasingly degrading the eastern and upper slopes on the easternmost ridges of the Maya Mountains. It may also require active habitat restoration to reverse the spread of tiger fern (Dicranopteris sp.) in these areas. Possible future mineral extraction in identified key sites, compounded with current anthropogenic fire impacts would reduce the rating to Fair.

Viability of Conservation Targets: Upper Elevation Amphibians				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Physical Habitat ▪ **% of key sub-montane sites considered in very good condition as amphibian physical habitat**	**Physical Habitat** Precipitous declines and extinctions have been occurring within the region in sub-montane and montane ecosystems. The condition of undisturbed submontane ecosystems is considered a critical factor for continued viability of the key upper elevation amphibian species	**Poor:** < 1.5 **Fair**: 1.6 – 2.5 **Good:** 2.6 – 3.5 **Very Good:** > 3.5 Averaged score from 15 Key sites identified under current Wildtracks Upper Elevation Amphibian project for which baseline information is being developed. This focuses largely on cloud forest and quasi cloud forest, as this is the high risk threat area (and where additional species of concern may still be found). **Very Good (Score of 4)** **Outlier** Cockscomb Basin Wildlife Sanctuary **Mount Margaret:** Sibun Forest Reserve (Except for Helicopter Landing Site cleared at top) **Las Cuevas:** Very Good **Little Quartz Ridge** (Except for HLS and one other area, where tiger fern predominates) **Good (Score of 3)** **South Stann Creek Ridge:** Cockscomb Basin Wildlife Sanctuary. Good (Recent anthropogenic fire has reduced the condition from Very Good; 2008 fires risk reducing it towards Fair) **Chiquibul 1:** Good **Caracol:** Good (though site specific management activities around some breeding pools have seriously degraded suitability for amphibians to Fair) **Mount Mossy:** Unknown **Silk Grass Hill:** Unknown **Chiquibul 2:** Unknown **Bladen:** Unknown **Richardson Peak:** Unknown **Fair (Score of 2)** **Victoria Peak:** Victoria Peak Natural Monument. Fair (Seriously degraded by hurricane and fire, and impacted by ecosystem modification for tourism appreciation at summit) **Tiger Fern:** Cabbage Haul Ridge, CBWS. Fair (Anthropogenic fire originating on Eastern slope has seriously reduced the extent of natural vegetation suitable as amphibian habitat)	**GOOD** Currently: 3.22 Good is given as the default rating for sites with no baseline. Minimal anthropogenic impacts currently affecting the physical habitat at most of these sites.	**VERY GOOD**



Ecosystems above 500m in the Maya Mountains Massif

Based on: Meerman (2004). Belize Ecosystem Map

Viability of Conservation Targets: Upper Elevation Amphibians				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Weather regime ▪ **Changes in site level micro-climate patterns outside the range of natural variation**	Amphibians, with their bi-phasic life cycle and semi-permeable skin, are particularly sensitive to changes in moisture and temperature. Recent work in Costa Rica suggests that climate change may be a key factor in amphibian declines	**Poor:** **Fair:** **Good:** **Very Good:** Climate patterns within range of natural variation Baseline data is needed for upper elevation sites before indicator ratings can be accurately established. Specific monitoring is needed for number of cloud-free days, elevation of cloud base, rainfall regime, horizontal precipitation, and leaf-litter moisture.	**VERY GOOD** Assumption is that climate pattern is within the range of natural variation, though changes are being recorded in Costa Rica (Pounds, et al, 2006)	**VERY GOOD**
Condition: Present Condition ▪ **% sites showing significant presence of chytrid infection**	**Present Condition** Chytrid infection has been associated with most or all of the precipitous declines and extinctions that have occurred in the region	**Poor:** >10% **Fair:** 2 – 10% **Good:** < 2% **Very Good:** 0% Any occurrence of chytrid infection may indicate imminent population collapse, but it should also be borne in mind that lower elevation amphibians may have low level infections of chytrid fungus without sign of disease. Where the *Batrachochytrium dendrobatidis* (the fungus causing chytrid infection) thrives - generally in the cooler, moist conditions in upper elevations - 50% of amphibian species and 80% of individuals can be expected to disappear within 1 year (Lips, et. al., 2006).	**GOOD** Default is 'Good'. Rating is not considered 'Very Good', as there is no reason to suggest that chytrid infections are not occurring in Belize, as they are elsewhere in the region. The first results from chytrid testing implemented under the current Wildtracks project will be available by mid-May 2008, and can then be used to update the assessment.	**VERY GOOD**

Viability of Conservation Targets: Upper Elevation Amphibians				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Water Chemistry ▪ **% sites showing presence of organophosphates at potentially toxic levels**	Organophosphates, precipitated out during orographic rainfall, are considered likely to be one of the causal factors in reducing the resistance of upper elevation amphibians to chytrid fungus, which is associated with the decline in amphibian populations throughout Central America	**Poor:** **Fair:** **Good:** **Very Good:** 0% of key sites with agrochemical pollution measurable in ppm Further research is required to finalize indicator ratings. 'Very good' should be no organophosphates at any key site, though recent studies (Wildtracks in prep) demonstrates disturbing levels of glyphosate at all upper elevation sites sampled – with phytotelmic water concentrations on Mt. Margaret 7 times the US legal level for drinking water, and 50 times the EU limit. Whilst some organophosphates may be fatal to amphibians in concentrations of as low as parts per million, there is a risk that much lower concentrations still may reduce amphibian immune systems and increase the risk of fatal chytrid disease. No data is yet available for threshold levels for reduced immunity, so presence of agrochemicals in concentrations of ppm in phytotelmic water is used by default for the time being.	**GOOD** "Good' by default. Significant possibility that orographic precipitation of several toxic agrochemicals from the coastal plain is taking place in the upper elevation sites in the Maya Mountains **Post-script:** The Wildtracks Upper Elevation Amphibian Project has recently determined the presence of glyphosate at all sites sampled to date – such that the score for this indicator should be downgraded to **Fair** in the next iteration. Tests are ongoing for the presence of a number of other chemicals used on the coastal plain.	**VERY GOOD**

Viability of Conservation Targets: Upper Elevation Amphibians				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Size: Population Size ▪ **% sites with population sizes of key species within the range of natural variation**	Sharp declines and extinctions in upper elevation amphibian populations have been recorded globally and regionally in recent years.	**Poor:** < 80% **Fair:** 80-89% **Good:** 90-94% **Very Good:** 95-100% Very good – 95-100%, as any decrease is considered a risk to viability Low confidence and reliability as data does not exist. However these indicator ratings can be adapted as the current Upper Elevation Amphibian CEPF / Wildtracks project develops a baseline and ongoing monitoring data for the key sites. NB As the populations of small, short-lived vertebrates including many amphibians may oscillate significantly from year to year, caution must be exercised in early interpretation of data. It must also be noted that monitoring data generally reflects activity level rather than actual abundance. May be measured as no. of animals encountered per man-hour of search time, under similar seasonal, temporal & climatic conditions. Very rapid declines should be cause for alarm.	**GOOD** Default rating of good - to be reviewed as the current Upper Elevation Amphibian CEPF / Wildtracks project develops a baseline and ongoing monitoring data for the key sites. Not 'very good', as there is nothing to suggest that the declines happening elsewhere in the region are not occurring in Belize.	**VERY GOOD**

Forest Products **Viability Indicators:** ▪ **Average number of xate leaves per plant** ▪ **Average number of xate plants per hectare** ▪ **% of MMM showing no land use change** ▪ **Density of commercial timber**	**Justification for Target Selection** The harvesting of forest products (both timber & non-timber, legal and illegal) is the source (both direct and indirect) of some of the biggest impacts on the biodiversity and cultural resources of the MMM. Hunting associated with illegal xate collection, and poorly controlled 'legal' xate extraction threatens to result in the 'Empty Forest Syndrome' in significant areas of the Maya Mountains Massif if left unchecked. - with dramatic decreases in game species being noted in western Chiquibul. Levels of sustainable harvest for xate and timber are broadly known, but difficult to enforce – such that target viability is decreasing sharply in some areas. Effectively addressing illegal extraction of Forest Products, and improving sustainability mechanisms and levels of legal extraction will significantly enhance biodiversity viability at both the site and system level.	Xate, timber**,** orchids, medicinal plants, palms **Palmetto** (*Acoelorraphe wrightii*) is present in low densities within this ecosystem, and is coming under pressure from stem harvesting for structural materials, and seed harvesting for the relatively new medicinal market. **Xate** (*Chamaedorea ernesti-august*) leaves are extensively harvested, legally and illegally. **Pacaya** (*Chamaedorea tepejilote*) fruit is harvested for consumption by some communities **Contribo** (*Aristolochia spp*.) is one of the more widely used medicinal plants, harvested in some buffer areas of the MMM **Bayleaf, Wano** (*Sabal mauritiiformis*) thatch leaves are harvested over a relatively small area (mostly MPRFR & CFR), mostly for tourism lodges in the MPRFR Enclave. **Mahogany** (*Swietentia macrophylla),* **Mexican Cedar** (Cedrela odorata)**,** **Santa Maria** *(Calophyllum brasiliense)***,** **Nargusta** *Terminalia amazonia)***, Sapodilla** *(Manilkara zapota***, Salmwood** *(Cordia alliodora)***, Jobillo** *(Astronium graveolens)***, Cabbage Bark** *(Lonchocarpus castlloi)***, BillyWebb** *(Acosmium panamense)* are among the species harvested commercially. **Vanilla** (*Vanilla spp*.) and **Allspice** (*Pimenta dioica*) are two species in which interest has been voiced re. potential sustainable extraction.

Forest Products **Viability Indicators:**	**Key attribute and indicator**	**Indicator ratings**	**Current rating**	**Desired rating**
▪ **Average number of xate leaves per plant**	**Population Structure and Recruitment**	**Poor:** 0 – 1 leaf per plant **Fair:** 2 – 3 leaves per plant **Good:** 3 – 5 leaves per plant **Very Good:** > 5 leaves per plant Average number of leaves per plant for *Chamaedorea ernesti-augustii* in unharvested plots is 6. In harvested plots, is 2.9. (Bridgewater et. al. 2007)	**FAIR**	**GOOD**
▪ **Average number of xate plants per hectare**	**Population Size**	**Poor**: < 110 plants per hectare **Fair:** 110 – 220 plants per hectare **Good:** 220 – 1,100 plants per hectare **Very Good:** > 1,100 plants per hectare This varies throughout the Maya Mountains Massif, as demonstrated by M. Penn (in Bridgewater et. al. 2007). Highest densities are 84 plants per plot (plot size is 20m x 20m), lowest is 0 plants per plot. Average density is 9.1 plants per plot. The huge variation across the Maya Mountains means that any monitoring will require careful selection of plot sites and numbers of plots. 1 plot = 20 x 20m 1 hectare = 25 plots Average density = approx. 228 plants per hectare (9.1 x 25) Maximum density = 2,100 plants per hectare (84 x 25) Median between average and maximum densities = 1,164 plants per hectare	**VERY GOOD**	**VERY GOOD**

Landscape Context: ▪ **% of MMM showing no land use change**	Land use change is perhaps the most critical threat to broadleaf forest viability – as agricultural incursions take place, with actual land use change on the ground, this is later compounded by dereservation of the incursion areas, taking them out of protection.	**Poor:** > 65% of MMM **Fair:** 65 – 74% of MMM **Good:** 75 – 89% of MMM **Very Good:** 90 – 100% of MMM The majority of the Maya Mountains Massif is considered to be in its natural state, except for those areas impacted by agricultural incursions, Douglas D'Silva and dam inundations. The current area (2007) of the MMM is approx 510,227 ha. Land use change: Chalillo (728ha), Agricultural incursions (9,819ha), urban areas (51 ha) based on Meerman 2004 edition Belize Ecosystems map....approximately 2.1%	**VERY GOOD** **97.9%** This accounts for date for agricultural incursions and Chalillo as of October, 2007 It doesn't take into account the current dereservation of areas within Sibun, nor the additional agricultural incursions reported in the Chiquibul National Park after the CAP workshops, but this will probably still be under 10% of the total MMM area.	**VERY GOOD**
▪ **Density of commercial timber**	**Population Density**	**Poor:** **Fair:** **Good:** **Very Good:** Chiquibul data – Percival / Darrel	**FAIR**	**GOOD**

Conservation Target: Jaguar		
Conservation Target	**Justification for Target Selection**	**Species, Communities or Ecological Systems represented by Target**
Jaguar **Viability Indicators:** ▪ **Total area of contiguous forest** ▪ **% of broadleaf forest in MMM removed by land forest clearance** ▪ **% of MMM over which hunting pressure is considered to be high** ▪ **Density of white-lipped peccary – trap success index** ▪ **Density of jaguars in key areas**	As the top predator, the jaguar (*Panthera onca*) is considered a key umbrella species, representing the biodiversity health and intact trophic structure of the broadleaf forest ecosystems. Whilst densities are considered higher in broadleaf forest, this species also uses pine savanna (M. Kelly, pers. com.).	As an umbrella species, protection of the environmental parameters and implementation of effective conservation measures that are required to maintain a viable population of jaguars should also be adequate to maintain populations of other large ranging species, such as **scarlet macaw, white lipped peccary,** and **harpy eagle.** High jaguar density is also indicative of a healthy prey base, and of the trophic integrity of the Maya Mountains Massif area as a whole.

Viability of Conservation Targets: Jaguar				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Connectivity among communities and ecosystems ▪ **Total area of contiguous broadleaf forest**	Some of the key species required for functionality of the broadleaf forest may require larger areas of forest than is encompassed within the Maya Mountains Massif	**Very Good: 1,133,054 ha (2,799,826 acres) or more.** Allowing for connectivity over gaps of less than 100m between forest blocks - this gives connectivity across the Western Highway. (NB. this includes Lowland broadleaved dry forest) **Good: 687,017 ha – 1,133,054 ha.** 687,017 ha is the area of contiguous forest running as far as the Western Highway, and connected by a gap of no more than 50m. The Hummingbird Highway is currently not considered as a barrier to connectivity for broadleaved forest, and rivers are also assumed to not affect connectivity. Forest areas within MPR are considered contiguous. **Fair: 438,593 ha – 687,017 ha** The area of broadleaf forest currently within the MMM is approx 438,593 ha (439,321 ha minus the inundation area of Chalillo (728ha). 687,017 ha is the area of contiguous forest running as far as the Western Highway, and connected by a gap of no more than 50m. **Poor: Less than 438,593 ha** The area of broadleaf forest currently within the MMM, with no connectivity beyond the MMM The area of contiguous forest is calculated using mapping and satellite imagery, and is based on Meerman 2004 edition Belize Ecosystems map. All figures include broadleaf shrubland, as this is included in the broad 'broadleaf forest' categories. NB: Deciduous mixed submontane shrubland over poor soils and Tropical evergreen seasonal mixed lowland hill forest are included in both the pine forest area and the indicator for broadleaf forest connectivity See Map … **Last amended 27/10/07**	**VERY GOOD** Connectivity is considered to exist with the Selva Maya block, through Rio Bravo area, and has not yet been lost to coastal plain **AL:** My initial look at satellite data suggests that this is likely to have changed very little, at least up to mid 2006. Probably a safe bet to go with these areas for now. Area currently under agriculture (as of 2004 update of Jan Meerman's map): 9,818.76 ha approx. 24,262.69 acres approx.	**VERY GOOD** Maintenance of current connectivity and protection of permanent corridor linking MMM with Rio Bravo / Selva Maya forest node. Reforestation of some or all agricultural incursion areas

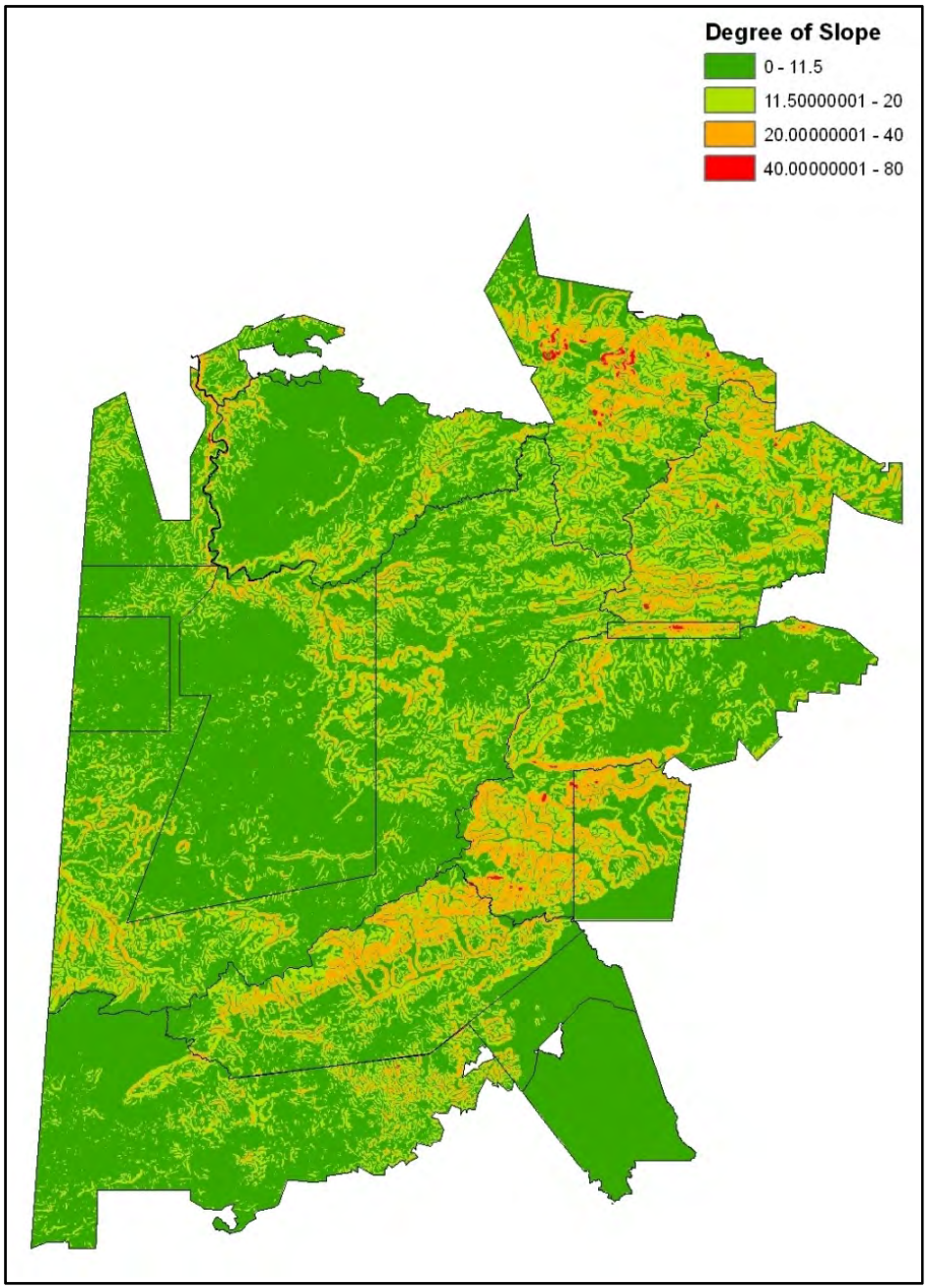
Viability of Conservation Targets: Jaguar				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Size: Size / extent of characteristic communities ▪ **% of broadleaf forest showing no land use change**	Land use change is perhaps the most critical threat to broadleaf forest viability – as agricultural incursions take place, with actual land use change on the ground, this is later compounded by dereservation of the incursion areas, taking them out of protection.	**Poor:** > 65% of 438,593ha **Fair:** 65 – 69% of 438,593ha **Good:** 70 – 79% of 438,593ha **Very Good:** 90 – 100% of 438,593ha The current area (2007) of broadleaf forest within the MMM is approx 438,593ha.The potential area is 448,412 ha (438,593 ha + agriculture (9,819ha) based on Meerman 2004 edition Belize Ecosystems map. The minimum dynamic area of broadleaf forest within the Maya Mountains Massif is considered to be four times the largest known natural disturbance from which the forest has recovered in the past (Anderson, draft, 2001). it is assumed. The area is considered big enough to allow for natural regeneration from past hurricane impacts, as recovery has occurred from Hurricane Hattie, and Hurricane Iris, whilst estimated to have severely impacted broadleaf forest within protected areas on the east facing slopes of the southern Maya Mountains Massif, and a further ... hectares of pine within Deep River Forest Reserve and the foothills of Bladen and Cockscomb is not co0nsdered to have affected the overall viability of the Maya Mountains Massif. This is also supported by the perturbation dependence of the hurricane impacted forests of Belize. NB: Current area of agricultural incursions into broadleaf forest – Meerman (Map 3): Caracol: 988 ha (2,442 acres) Chiquibul NP 2,520 ha (6,227 acres) Columbia River FR 1,054 ha (2,605 acres) These figures represent acreage "directly impacted by agricultural incursions" thus including: active farms, fallow land and burned land (Meerman, pers. com.)	**VERY GOOD** **97.7%** This accounts for agricultural incursions and Chalillo. It doesn't take into account the recent post-October incursion figures (Meerman) nor the dereservation of areas within Sibun, but this will probably still be under 10% of the total broadleaf forest area. NB: There is no way to say at which point dereservation starts to impact the minimum dynamic area	**VERY GOOD**

Viability of Conservation Targets: Jaguar				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Abundance of food resources ▪ **Averaged hunting pressure score for protected areas within the Maya Mountains Massif**	Prey availability is considered an important factor in the viability of jaguar populations. Human hunting pressure, particularly by xateros, is considered to be the primary cause of reduction in prey density. Reflects effective management actions against hunting	**Poor:** <1.5 **Fair:** 1.51 – 2.5 **Good:** 2.51 – 3.5 **Very Good:** 3.51 – 4 **Average of protected area scores across the system, based on following scale per protected area:** **Score of 1:** Hunting is considered to be severely reducing game species populations, intervention is required to maintain their viability **Score of 2:** Hunting is considered to be reducing game species populations, and intervention may be required to maintain viability **Score of 3:** Hunting is considered to be somewhat reducing game species populations, but it is believed that they can recover naturally **Score of 4:** Hunting is not considered to be impacting game species populations **Protected Areas Scoring 1** Chiquibul Forest Reserve Chiquibul National Park Caracol Archaeological Reserve **Protected Areas Scoring 2** Vaca Forest Reserve **Protected Areas Scoring 3** Maya Mountain Forest Reserve Columbia River Forest Reserve Deep river Forest Reserve Mountain Pine Ridge Forest Reserve Noj Kaax Me'en Elijio Panti National Park **Protected Areas Scoring 4** Sibun Forest Reserve Bladen Nature Reserve Victoria Peak Natural Monument Sittee River Forest Reserve Cockscomb Basin Wildlife Sanctuary	**GOOD** **Average Score (2007): 2.86** Lower than 'very good' because of impact on game species by hunting pressure (RAPPAM, 2007, protected area and local community feedback).	**GOOD / VERY GOOD** It is assumed that reduced hunting pressure will increase abundance of food resources

Viability of Conservation Targets: Jaguar				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Abundance of food resources ▪ **Average presence of white lipped peccaries across protected areas**	Prey availability is considered an important factor in the viability of jaguar populations. In Chiquibul, where white-lipped peccary numbers are considered to have fallen to 10% of pre-xatero populations (Nicodemos Bol, Las Cuevas, 2007), a drop has also been recorded in jaguar populations (M. Kelly, 2007)	**Poor:** White lipped peccaries absent **Fair:** Population considered to be declining **Good:** Population considered stable but reduced by hunting pressure **Very Good:** Population considered within the realm of natural variation White lipped peccary are reported to have disappeared from the Peccary Hills / Manatee area as a result of hunting pressure (Gales Point community workshop), and there are now concerns about the status of the east Chiquibul area. Home range size is, not surprisingly, related to herd size, and herd size fluctuates, with sub herds forming and changing, so density is probably the best indicator to use. Camera trap data can give an indicator of 'number of photographic events per 100 camera trap nights' (M. Kelly). In Chiquibul in Jan-March 2002, this was 6.12 trap events per 100 trap nights. However, this data is not available for many sites, so an indicator of simple presence / absence is being developed. Awaiting feedback from the protected area managers. **Present** (considered to be stable): Score 4 Bladen Nature Reserve Victoria Peak Natural Monument Cockscomb Basin Wildlife Sanctuary **Present** (but considered to be declining): Score 3 Chiquibul Forest Reserve Chiquibul National Park Caracol Archaeological Reserve Columbia River Forest Reserve Deep River Forest Reserve **Unknown:** Score 3 Vaca Forest Reserve Sittee River Forest Reserve Sibun Forest Reserve Mountain Pine Ridge Forest Reserve Noj Kaax Me'en Elijio Panti National Park Maya Mountain Forest Reserve	**GOOD** Lower than 'very good' because of impact on white-kipped peccary by xatero hunting pressure in the Chiquibul area. (RAPPAM, 2007, protected area and local community feedback).	**GOOD / VERY GOOD** Reduced hunting pressure will increase abundance of food resources

Viability of Conservation Targets: Jaguar				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Abundance of food resources ▪ **Average Density of jaguars in key monitoring areas**	**Population Density** The jaguar is considered an umbrella species, being a wide-ranging top predator indicative of the health of the ecosystem. Jaguars have been shown to use both broadleaf forest and pine savanna (Marcella Kelly). Population densities are measureable, with monitoring projects already under way in Cockscomb, Chiquibul, and Mountain Pine Ridge. Identified gaps include Bladen, Columbia River, Sittee / Sibun, and the Cuxtabani area of Chiquibul National Park	**Poor:** < 2 jaguar per 100km2 in monitoring sites **Fair:** 2 - 3.9 **Good:** 4 – 8 **Very Good:** > 8 Using the average for Belize (8.06 jaguar per 100km2 – Chiquibul and Cockscomb data), the Maya Mountains, with an area of approx. 5,102 km sq (510, 227ha or 1,260,800 acres), would have an estimated population of approximately 400, assuming all habitat was optimal. It is considered more relevant to rate the population size against the estimated maximum population size for the available habitat within the MMM – otherwise use of this measure as a conservation tool will be lost: we could not demonstrate (for example) that in Chiquibul the population has gone from Very Good to Good (or Fair?) because of combined xatero impacts. It may be better to spatially map jaguar population size (per protected area) wherever possible, otherwise site specific data is largely lost in this analysis. NB: whilst the population of jaguars is rated as Very Good? (relative to maximum potential) within the MMM, its long-term viability is at risk because of lack of connectivity with other populations. BH: Connectivity is very important and if this part disappears the population is not in good shape. RF: MMM alone cannot sustain a viable population in the long term if it becomes isolated from the surrounding jaguar population and therefore conservation efforts need to extend beyond the boundary of MMM to ensure the jaguar population remains viable, i.e. MMM is not large enough to be classified as a single conservation unit for jaguars. MK: If the MMM in Guatemala were better protected, it could be viable. Connectivity of the MMM to the rest of the Peten through the Rio Bravo Conservation area is very important. Degree of Slope is considered to be an important factor in determining the distribution of jaguars within the Maya Mountains Massif (Harmsen, Kelly, Foster, Bol, CAP Viability workshop, 2007). It is generally agreed that when mapping	**GOOD** Using the average for Belize (8.06 jaguar per 100km^2 – Chiquibul and Cockscomb data), the Maya Mountains, with an area of approx. 5,102 km sq (510,227ha or 1,260,800 acres), would have an estimated population of 416. However, if terrain is taken into account, this becomes **FAIR,** with an estimate of approximately 270 (5.3 jaguar per 100 km^2. Belize is certainly Good when compared with other jaguar habitats in Latin America. Would benefit from reduction of hunting of prey (principally by xateros), but population is considered stable, with current connectivity. High confidence in the areas where work is being conducted, unsure about to what level we can extrapolate. Gaps of knowledge in areas	**VERY GOOD** Assumption of reduced population size due to reduced prey populations (and increased xatero activity), particularly in the Chiquibul area. Considered feasible to increase prey density through increased effective enforcement, particularly in the Chiquibul; and reduction of conflict in adjacent farmlands.

Continued….		good jaguar habitat (as opposed to areas that individuals may travel through), the degree of slope should be below 11.5 degrees (Map ...). A. Lloyd recalculated the area based on subtracting areas of steeper than 11.5 degree slope, checked by Harmsen and Kelly. This would reduce the available optimal habitat area from 5,102 sq km to 3,377 sq. km. (834,396 acres) across the Maya Mountains.It is necessary to sample in rugged areas if we are going to extrapolate jaguar population estimates across the MMM, as one assumption is that jaguars use the area equally. This, however, is not considered to be an accurate representation, as prey densities are known to decrease in areas of steep slope and higher elevation, and it is anticipated that jaguars will follow the same trend. Using steepness to model presence / absence of jaguars, Adam Lloyd recalculated the area based on subtracting areas of steeper than 11.5 degree slope, checked by Bart Harmsen and Marcella Kelly. The reduced area of 3,377 sq. km. (834,396 acres) would give a population size of approximately 270 jaguars. Assumptions: 1. The key monitoring areas are those that have ongoing monitoring projects – Chiquibul and Cockscomb, and averaged, are considered representative of the MMM 2. Cockscomb densities would be considered 'Very Good', as there is minimal pressure on the population (eg. hunting of prey species etc.) 3. Chiquibul densities – considered 'Good' but with a negative trend - decreasing density being recorded 4. Male:Female ratio is assumed to be 1:1 Since cameras are in the same places each year, there is very little observer bias in this data. But we should always be careful about using an index – such as trap success - to extrapolate whether a population is increasing or decreasing. However, if there is a substantial decline, this is likely to be reflected in the index (MK).	where no studies are being conducted, and queries of population densities in steeper slope areas and at higher (colder) elevations. Sink areas along Adjacency Zone, and in adjacent farmland areas in Belize; increased prey opportunities with increasing cattle - greater chance of conflict. .	



Degree of Slope is considered to be an important factor in determining the distribution of jaguars within the Maya Mountains Massif (Harmsen, Kelly, Foster, Bol, CAP Viability workshop, 2007). It is generally agreed that when mapping good jaguar habitat (as opposed to areas that individuals may travel through), the degree of slope should be below 11.5 degrees (Map ...). A. Lloyd recalculated the area based on subtracting areas of steeper than 11.5 degree slope, checked by Harmsen and Kelly. This would reduce the available area from 5,156 sq km to 3,377 sq. km. (834,396 acres) across the Maya Mountains.

Viability of Conservation Targets: Archaeological Sites		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Archaeological Sites **Viability Indicators:** ▪ **Number of sites with permanent staff** ▪ **Average % structures looted per site** ▪ **Level of appreciation of sacred sites** ▪ **Number and extent of scientific publications**	Archaeologically, Belize is located within the eastern Maya lowlands and is part of the Maya sub-area of Mesoamerica. Prehistoric Maya occupation in Belize extends from approximately 1200 B.C. to the Sixteenth century, During this extensive phase of occupation ancient Maya populations are estimated to have reached close to one million people in Belize . In general, the Maya Mountains Massif represents one of the most poorly studied archaeological regions of Belize - the result of poor access, the rugged nature of a great part of the terrain, and the challenging logistics to conducting archaeological research in this section of Belize. Exacerbating these problems are current concerns for personal safety, with incursions of armed xateros from Guatemala. The agriculturally nonproductive nature of the region has been held responsible for the lack of archaeological sites in the Mountain Pine Ridge. However, various authors (e.g., Thompson 1939; Bullard 1965; Willey et al. 1965; Rathje 1972, Sidrys and Andresen 1976; Awe 1985, n.d.; Graham 1987; Awe et al. 2004) have suggested that the region was a source of granite and slate that were exploited by the Maya for the manufacturing of manos, metates and non-utilitarian objects.	**Archaeological Sites:** Caracol, Tzimin Kax/Mountain Cow, El Retiro, Cahal Pichic, Camp 6, Caledonia, Maria Camp, Minanha, Ec Xux, Uxbenka, Lubaantun, Nim Li Punit **Portable Carved Monuments:** Stelae, altars, ball court markers, lintels, stone spheres **Other Movable Objects:** Ceramic artifacts, stone artifacts (metates, jade, etc.), human and animal reamins, wooden remains, shell, stucoes, organic remains, metal artifacts from Industrial Age, etc. **Rock Art:** Roberto's Cave, Actun Tzib Cave **Cairns:** Cooma Cairn, Granite Cairn, nearby Río On **Agricultural Terraces:** Widespread in the Massif, particularly in Vaca, Caracol, Chiquibul National Park and Forest Reserve, Eligio Panti National Park. **Sacbeob:** Widespread in the Massif, particularly in Vaca, Caracol, Chiquibul National Park and Forest Reserve, Eligio Panti National Park. **Modified Springs:** Greater Chiquibul, Vaca, Caracol **Quarries:** Caracol, Mountain Pine Ridge FR **Industrial Features:** Puntarrieles (Rail head at Vaca FR), locomotives and tractors, most of the in Chiquibul NP and FR, and Caracol

Viability of Conservation Targets: Archaeological Sites				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Management Presence ▪ **Number of sites with Management Presence**	Management presence on site is considered one of the primary requirements for maintaining the viability of archaeological sites within the Maya Mountains Massif. This is demonstrated at Caracol, where looting and other illegal activities are not being reported from the central, heavily patrolled area, despite extensive xatero and looting activity in surrounding areas	**Poor:** < 4 sites have management presence **Fair:** 4 - 6 **Good:** 7 - 11 **Very Good:** 12 Staff are stationed on-site at three of the twelve identified archaeological sites within the Maya Mountains Massif – Caracol, Num-Li-Punit and Lubaantun.	**POOR** 3 of the 12 identified archaeological sites within the Maya Mountains Massif have permanent, on-site staff. .	**GOOD**
Condition: Present Condition ▪ **% of structures looted**		**Poor:** > 60% of structures looted **Fair:** 31% – 60% **Good:** 10% – 30% **Very Good:** < 10% Mountain Cow - approximately 30% of structures looted Every site has some looting, but for many it is as low as 10%. Greater nearer areas of human population and areas of xatero activity - where there is access, and adjacent communities, the level of looting increases to an average of 60%. Looting is considered to be both opportunistic , when xateros or hunters encounter structures in the forest, and specific. To date, looting has not been reported on the scale seen in northern Peten, where structures are systematically destroyed by looters. NB. New looting has been reported as going on the Bladen area.	**FAIR** Every site has some looting activity, but it is seldom more than 30%. An average is considered to be 35%	**FAIR** It is hoped to prevent looting from destroying more structures in the future

Viability of Conservation Targets: Archaeological Sites				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Condition: Sacredness ▪ **Level of appreciation of sacred sites**		**Poor:** Community members do not use the site for rituals, and do vandalize it **Fair:** Some community members use the site for rituals, while others vandalize it **Good:** Community members use the site for rituals, but do not assist in its protection **Very Good:** Community members use the site for rituals and assist in its protection Only Lubaantun, Nim Li Punit, Uxbenka and cave near Nim Li Punit are presently used as sacred sites for Maya rituals. However, not all community members respect the sacred nature of these sites.	**FAIR** There is evidence of vandalizing in Nim Li Punit and Uxbenka, despite the fact that these two sites are used by villagers from Indian Creek and Santa Cruz, respectively.	**VERY GOOD** New educational and outreach programs for community members by the Institute of Archaeology is expected to increase the level of appreciation for these sites.
Size: Scientific knowledge ▪ **Number and extent of scientific publications**		**Poor:** Limited published information and location of sites **Fair:** Some published information on major sites **Good:** Some published information about all sites **Very Good:** Enough published information about all sites Information is site specific – for example, there is a lot of published information on Caracol, but very little on some of the other sites. It should also be borne in mind that less than 25% of all sites within the Maya Mountains Massif are considered to have been discovered.	**POOR** There is information about Caracol, Minanha and Caledonia, but practically no information about the number of sites and their location within the Massif.	**GOOD** The IoA is encouraging more long-term research projects within the Maya Mountains Massif as a means of increasing knowledge and increasing presence

SOME OF THE MAJOR RECORDED SITES IN MAYA MOUNTAINS MASSIF

CHIQUIBUL SUB-REGION (a more detailed list attached in an excel spreadsheet)

SURFACE SITES:
- Blue Hole
- Caledonia
- Caracol (IOA Management Presence)
- Ceiba
- Chaquistero
- Cohune
- Conchita
- Dos Tumbas
- Maria Camp
- Mountain Cow (Tzimin Kax, Cahal Pichik,
- Puchituk
- Ramonal
- Retiro
- Zaiden Creek

CAVE SITES
- Actun Balam
- *Actun Kabal (part of Chiquibul system)
- Cebada Cave (part of Chiquibul system)
- Cubeta Cave
- Eduardo Quiroz
- Las Cuevas (also known as Awe Caves)
- Starkey Hill Cave
- Tunkul (part of Chiquibul system)
- Xibalba (part of Chiquibul system)

(There are a large number of caves that have been surveyed near the Caracol epicenter. These are listed in the report by Feld in the Caracol references. Feld noted that the majority of these caves contained limited evidence of ancient Maya use, likely because of poor air quality (most of them are deep narrow sinks).

*The Institute of Archaeology is in the process of establishing co-management presence for Chiquibul Cave System with Friends for Conservation

MOUNTAIN PINE RIDGE SUB-REGION

SURFACE SITES
- Cooma Cairn
- Granite Cairn
- Rio On Cairn
- Rio Frio Settlement

CAVE SITES
- *Rio Frio Caves A, B, C, D, E.
- San Luis Cave

The Institute of Archaeology is in the process of establishing co-management presence for Rio Frio Caves with Forestry Dept.

VACA SUB-REGION

SURFACE SITES
- Camp Six
- Minanha

SURFACE SITE NEAR NORTHERN BORDER OF VACA
- Las Ruinas de Arenal

CAVES
- Actun Ixcantini
- Morales Cave
- Stela Cave
- Offering Cave (Co-managed)

CAVES ON NORTHERN BORDER OF VACA
- *Actun Chapat
- Actun Halal
- *Chechem Ha Cave
- *Son of Chapat
- *Uchentzub

The Institute of Archaeology is in the process of establishing co-management presence for Actun Chapat and Son of Chapat, and already has co-management agreement for Actun Chechem Ha with Morales family.

SOUTHERN BELIZE SUB-REGION
- C'hacben K'ax
- Ek Xux
- Ich Cuhil
- Quebrada de Oro
- Sand Creek
- Silver Creek
- Twelve Mile
- Uxbentun

SITES WITH CARVED MONUMENTS
- Caterino
- Choco
- Lagarto
- Lubaantun (IOA Management Presence)
- Nim Li Punit (IOA Management Presence)
- Papayal
- Pearce Ruins
- Pusilha
- Tzimin Che
- Uxbenca
- Xnaheb

CAVES
- Aun Dzib (has cave art)
- Bladen Cave 2
- Cayuco Cave (has cave art)
- *Hokeb Ha Cave
- Roberto's Cave (has cave art)
- San Miguel Cave

Several Cave sites are listed in Prufer's Dissertation as well.

The Institute of Archaeology is in the process of establishing co-management presence for Hokeb Ha Cave with Blue Creek Village Committee.

NB: The indicators for this section are based on the Belize context, and don't reflect the binational validation process.

Viability of Conservation Targets: Aesthetic Landscapes		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Aesthetic Landscapes **Viability Indicators:** ▪ **Number of aesthetic landscape sites with management presence and monitoring** ▪ **Number of aesthetic landscapes within conservation areas** ▪ **Number of aesthetic landscapes with no visual human impacts**	The aesthetic landscapes of the Maya Mountains Massif are of importance to many stakeholders, as a recreational resource, as a tourism destination and as part of Belize's natural and national heritage.	9 sites within the Maya Mountains Massif have been identified for their aesthetic value: Rio On Pools — Mountain Pine Ridge Forest Reserve Natural Arch — Chiquibul Forest Reserve Chiquibul River — Chiquibul National Park Raspaculo Branch — Chiquibul National Park Sibun Gorge Falls — Sibun Forest Reserve Nohoch Che'en Sinkhole — Chiquibul National Park Victoria Peak — Victoria Peak Natural Monument Ka'an Witz (Doyles Delight) — Chiquibul National Park Baldy Beacon — Mountain Pine Ridge Forest Reserve

Viability of Conservation Targets: Aesthetic Landscapes				
Viability Indicators:	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Management Presence ▪ **Number of aesthetic landscape sites with management presence and monitoring**	Without active management presence, sites start to suffer from visitation impacts – increased soil compaction, vandalism, garbage and other human impacts.	**Poor:** < 4 sites have management presence **Fair:** 4 - 6 **Good:** 7 - 8 **Very Good:** 9 The 9 identified focal aesthetic landscapes of the Maya Mountains Massif include: Rio On Pools, Natural Arch, Chiquibul River, Raspaculo Branch of the Macal River, Sibun Gorge Falls, Nohoch Che'en Sinkhole, Victoria Peak, Ka'an Witz (Doyles Delight) and Baldy Beacon,	**GOOD** All identified aesthetic landscapes have some level of management presence and control, with the exception of Sibun Gorge Falls.	**VERY GOOD**
Condition: Site Integrity ▪ **Number of aesthetic landscapes within conservation areas**	Presence within the protected areas of the Maya Mountains Massif protects aesthetic landscapes from unplanned or inappropriate human development	**Poor:** < 4 sites lie within protected areas **Fair:** 4 - 6 **Good:** 7 - 8 **Very Good:** 9 NB: Thousand Foot Falls was originally listed as one of the aesthetic landscapes, but was removed as it does not occur within the footprint of the Maya Mountains Massif	**VERY GOOD** All identified sites currently occur within protected areas of the Maya Mountains Massif	**VERY GOOD** No site is dereserved
Size Aesthetic landscapes uninterrupted by human impacts ▪ **Number of aesthetic landscapes with no visual human impacts**	Aesthetic landscapes in the Maya Mountains are natural – visual human impacts (roads, land use change, structures etc.) reduce the current aesthetic appeal	**Poor:** < 4 **Fair:** 3 - 4 **Good:** 4 - 6 **Very Good:** > 6 or more sites have no visual human impacts **Sites considered pristine (or minimal visual human impacts):** Natural Arch Raspaculo Branch of the Macal River Sibun Gorge Falls Nohoch Che'en Sinkhole Victoria Peak Ka'an Witz (Doyles Delight)	**GOOD**	**VERY GOOD**

		Sites considered to have negative visual human impacts: Baldy Beacon Rio On Pools Chiquibul River		

Viability of Conservation Targets: Subterranean Systems		
Conservation Target	**Justification for Target Selection**	**Sites and other conservation elements represented by Target**
Subterranean Systems ▪ **Number of sites with permanent staff** ▪ **Level of appreciation of sacred sites** ▪ **Number and extent of scientific publications**	Cave monitoring should be conducted to assess the degree of success in the maintenance or establishment of a sustainable and acceptable karst environment... to maintain natural flows and cycles of air and water through the landscape in balance with prevailing climatic and biotic regimes." (Watson et al, 1997, 18). 1. The caves are sensitive indicators of overall environmental health. 2. They are integral to regional hydrology and water supply. 3. They contain significant and specialized biotic communities. 4. They contain significant abiotic resources. 5. They are potentially important recreational sites. 6. They may contain valuable anthropological, archaeological and/or historical evidence.	Bats and other cavernicoles (cave dwelling organisms) are considered particularly vulnerable to human disturbance - roosting bats and maternity/nursery colonies especially. **Bats:** **Endemic Fish and Other Species:** Many troglobitic species (obligate cavernicoles) are endemic to a single cave - : macrobrachium, pseudothalphusidae, blind catfish, other dry cave species **Archaeological Artifacts:** The Maya considered caves to be of religious significance, leading to offerings, paintings and other artifacts being found within cave systems in Belize.

Viability of Conservation Targets: Subterranean Systems				
Viability Indicators	**Indicator Summary**	**Indicator ratings**	**Current rating**	**Desired rating**
Landscape Context: Management Presence ▪ **Number of sites with permanent staff**	Without active management presence, sites start to suffer from visitation impacts – increased soil compaction, vandalism, garbage, disturbance of cave organisms, deterioration of cave structures, theft of archaeological artifacts and other human impacts.	**Poor:** < 4 sites have permanent staff **Fair:** 4 - 6 **Good:** 7 - 11 **Very Good:** 12	**POOR** Only one cave system – Rio Frio and adjacent caves – is considered to have any management presence.	**FAIR**
Condition: Sacredness ▪ **Level of appreciation of sacred sites**		**Poor:** Community members do not use the cave for rituals, and do vandalize it **Fair:** Some community members use the cave for rituals, while others vandalize it **Good:** Community members use the cave for rituals, but do not assist in its protection **Very Good:** Community members use the cave for rituals and assist in its protection	**FAIR** Only Nim Li Punit cave is presently known to be used for rituals purposes in the Massif, and there is no evidence of vandalizing in the cave.	**VERY GOOD** New educational and outreach programs for community members by the Institute of Archaeology is expected to increase the level of appreciation for these subterranean sites.
Size: Scientific knowledge ▪ **Number and extent of scientific publications**		**Poor:** Limited published information and location of caves **Fair:** Some published information on known caves **Good:** Some published information about all caves **Very Good:** Enough published information about all caves Reddell and Veni (1996) compiled an invertebrate inventory list of Chiquibul Cave, but most other cave invertebrate reports from Belize are brief accounts of new species discoveries or opportunistic collections.	**FAIR** There is scientific information about most of the known and named caves in the Massif.	**GOOD** There are ongoing projects investigating caves in the Massif, and the Institute of Archaeology is encouraging an increase in the number of cave research projects in the Massif.
Cave organism indicators		The biota of Belize caves is poorly known. There is no overall estimate of cave-obligate species in Belize, but in the adjacent and comparable Yucatan Peninsula, Reddell (1979) identified 565 cavernicoles, including 34 troglobitic species.	**GOOD** The cave fauna composition, averaged across all the caves within the Maya	

		Of particular importance is the development of a baseline for cave species - particularly roosting bats, maternity/nursery colonies, as these are highly sensitive to human disturbance. Because many troglobitic species (obligate cavernicoles) are endemic to a single cave, have low population numbers, and are K-selected species, most troglobite populations are considered imperiled.	Mountains Massif, is considered to be GOOD by default, as the majority of caves are not impacted by human visitation	

Annex Two

A Review of Biodiversity Information

A number of geological papers and reports have been produced covering the Maya Mountains Massif system as a whole, providing information on the physical environment of the area. **Dixon (1955)** mapped the geology of southern Belize, and **Wright, et. al. (1959)** produced a national map of the geology, soils, and associated vegetation types – the results of extensive studies that have formed the basis for most subsequent ecosystem maps. **Iremonger & Brokaw (1995)** used satellite imagery to update Wright's map, transcribing the vegetation assemblages into then current ecosystem categories. This was further updated and revised by **Meerman & Sabido (2001), Meerman (2004),** to produce the Belize Ecosystem Map – as part of a regional initiative to standardize ecosystem classification and nomenclature. **Penn (2004)** developed an alternative ecosystem classification system and map for the Greater Maya Mountains, though this alternative mapping is not in broad use as that of **Meerman (2004),** which covers the entire country and is integrated within regional maps.

For the biodiversity, the majority of the research and inventory information comes from site-specific surveys – very few studies have been conducted at the system level. There has been a relatively substantial amount of work conducted in the southern protected areas - Cockscomb Basin Wildlife Sanctuary, Bladen Nature Reserve and Columbia River Forest Reserve, providing significant information on the biodiversity of this area, and in several cases, supporting designation as a protected area. This is in comparison with much of the Maya Mountains, where accessibility has limited research.

Cockscomb Basin Wildlife Sanctuary has hosted a number of research studies and biodiversity inventories since first being highlighted as a potential conservation area, following research into jaguar populations **(Rabinowitz A., 1983)**. The majority of these studies have focused on two key mammal species – the jaguar and black howler monkey, though a key baseline report on biodiversity and ecosystems of the area was produced in 1987 **(Kamstra, J, 1987).**

Since then, the Wildlife Conservation Society (WCS) has had a long-term involvement in studies on jaguar through an ongoing series of camera trapping projects **(Harmsen, 2007),** and investigations into jaguar depredation in adjacent large cattle farms **(Foster R., in prep.).** This has also provided data on the other larger mammal and bird fauna of the area.

Following the initial reintroduction of black howler monkeys into Cockscomb **(Horwich et al., 1993),** studies into the behaviour and progress of the translocated groups resulted in several papers, providing feedback on the success of the initial WCS release project **(Crozier, 1995; Silver, 1997; Ostro, 1998; Ostro et. al., 1999).**

A 1999 survey into the bat species of the protected area developed the baseline data for this group of mammals **(Miller and Miller, 1999)**, as did the subsequent small mammal survey **(Silver et. al., 2001)**, which covered a wider array of mammal species, building on the original biodiversity data collected by **Kamstra (1987),** and **Rabinowitz and B. Nottingham (1989).**

Very little work has been conducted within the Cockscomb Maya Mountain extension to the southern end of the Sanctuary, though there is data from Trio and Swasey Branch areas, which were incorporated into a study on the freshwater ecology and fish communities of Monkey River and its tributaries **(Esselman, 2001).**

Stephen Russell collected birds within the Cockscomb area in 1958/1959 (Emmons et. al. 1996), but the bird species of the Sanctuary were first formally inventoried by **Kamstra (1987),** with a number of ornithologists visiting the area since then adding to the species list. However apart from a single research project into hematozoan parasites of birds **(Booth, 2002),** no significant research studies appear to have taken place on this vertebrate group, with little of knowledge in the distribution and densities of species of concern within the protected area.

For the other vertebrate groups in Cockscomb - the reptiles, amphibians and fish - no in-depth surveys have taken place, though a number of rapid assessments have provided some data. By necessity, much of the work has been conducted within the more accessible East Basin, with only an initial survey of West Basin, conducted in 1990, including preliminary surveys of the herpetofauna (Walker) and plants (Meadows). The New York Botanical Gardens compiled a preliminary list of plants identified within the Sanctuary.

Invertebrates have not been studied in depth – an initial report on the lepidoptera and odonata of the area **(Boomsma and Measey, 1992)** provide an inventory of the species observed on trails and along streams near the Cockscomb HQ. Further research on lepidoptera within the protected area is currently underway **(J. Shuey, pers. com.)**, and has updated and enlarged the species list for this group, as well as adding several new records for Belize.

An initial biological survey of the Upper Bladen Watershed by the Manomet Bird Observatory and Missouri Botanical Gardens took place in 1987, covering the environment of the Upper Bladen Branch watershed area (climate, physical features, vegetation, birds and mammals), and providing a brief history of human use, with justifications and management recommendations for the establishment of Bladen as a protected area (**Brokaw N. and Lloyd-Evans, 1987)**. This providing the groundwork towards the protection of the area and leading to its declaration as a Nature Reserve in 1990.

A rapid ecological assessment of Bladen was then conducted in 1994 by The Nature Conservancy, in partnership with Belize Audubon Society and the Ministry of Natural Resources (Belize), as part of the activities supported by the Proyecto Ambiental para Centro America (PACA **(Iremonger, S. & Sayer, 1994)**. This covered a wider range of research fields - vegetation, flora, mammals, birds, reptiles and amphibians, and dragonflies and damselflies – and included a brief human impact analysis of stakeholder communities. Management recommendations were also put forward.

In 2001, a baseline study of the Monkey River was conducted, including the head waters in both Cockscomb and Bladen **(Esselman P., 2001)** providing a much greater understanding of the fish fauna and processes associated with the upper and middle reaches of this watershed.

Between 1992 and 1995, the Maya Mountain Archaeology Project spent several years working in this southern Maya Mountains area, with the discovery of nine major classic and pre-classic Maya sites spread from Cockscomb down to Columbia River Forest Reserve. Several of the expeditions also included baseline observation on wildlife species. **(Dunham P. et. al., 1992 – 1995).**

For both Bladen Nature Reserve and Cockscomb Basin Wildlife Sanctuary, biodiversity research and information has been incorporated into the site-level management plans **(Walker and Walker, 2004, 2006)** summarizing biodiversity knowledge to date.

A detailed synthesis of research conducted in the Columba River Forest Reserve has recently been compiled (**Merman, J.C., 2006)**. Mineral resources were studied in the 1920's (**Ower, L.H., 1928)**, and subsequently updated (**Dixon, D.G., 1955**). Botanical collections and inventories were initiated in the 1920's by Schipp (**Lowden, R.M. 1970**) and followed in the 1950's by Charles Wright (**Wright, et al., 1959**), staff of the Forest Department in the '70s (**Forest Department, 1978**), **Wilson, 1981** and **Evans, 1983**. Subsequent work through the late '80s and 90's was largely focused on timber stock assessments and management (**Bird, 1993, 1994, 1998; Ennion, 1994, 1996; King, 1995; McCalla, 1995; Campbell & Mitchell, 1998).** Permanent botanical plots were established in the mid-'90s (**Bird, 1998**), though many identifications require further verification (**Bridgewater, S., pers. comm.**), and have not been revisited – partly due to access problems resulting from Hurricane Iris in 2001.

A rapid ecological assessments was conducted in Columbia River Forest Reserve in the early 1990's (**Matola, et al. 1991**), yielding new amphibian records for Belize; and was followed by another assessment in 1992 (**Parker, et. al., 1993**), again yielding new amphibian and plant records. The observations of particularly high species diversity on these REA's resulted in eight or more subsequent surveys by assorted researchers over the following years (**Robbins et. al., 1992** – Migratory Birds; **Conway, 1993** – birds; **Boomsma, 1993** – dragonflies; **Meyer, 1993** – amphibians; **Matola, 1995** – general biology; **Meerman & Williams, 1995** – general biology; **Gillardi, 1997** – birds; **Meerman & Matola, 1997** multi-taxa; **Janovec & Neill, 1999** – plants).

As with Cockscomb and Bladen, the archaeological work of **Peter Dunham (Dunham & Pesak 2000** & **Dunham et. al. 1994)** significantly increased archaeological knowledge of the eastern portion of Columbia River Forest Reserve, and yielded rare extensions for several vertebrates as well. **Wicks et. al. (2006**) undertook extensive research on the distribution and abundance of *Chamaedorea* palms. **Bridgewater et. al. (2006)** undertook an economic assessment of commercial *Chamaedorea* palms in the Columbia River and Chiquibul Forest Reserves and the Chiquibul National Park – based on sustainable extraction potential.

An assessment of the hurricane damage and mapping of the relative scale of damage caused by Hurricane Iris to terrestrial ecosystems of Southern Belize in 2001, was conducted by **Meerman J. (2001).**

Sibun and Sittee River Forest Reserves have both had minimal attention, though some biodiversity inventories have take place in adjacent areas, such as the St. Herman's Blue Hole National Park, managed under Belize Audubon Society. Some studies have been conducted into the caves of the karstic areas in this region, both from a speleological and archaeological point of view.

On the west side of the Maya Divide, the main focus for research has been Douglas D'Silva, for forestry research under the Forest Department, and Las Cuevas Research Station, located in the broadleaf forest of the Chiquibul Forest Reserve. Las Cuevas was established in 1992 to investigate the natural and human impacts on the biodiversity, to contribute towards sustainable management and utilization of tropical forests. A number of research projects have been conducted in the Las Cuevas, raising knowledge of the biodiversity of the forest - the most important perhaps, in terms of conservation

management, being a system-level study on xate distribution, growth and economic value (**Bridgewater, et. al., 2006**).

A system-wide assessment of amphibian distribution, viability and threats was initiated in 2006 (**Walker, 2006**) and continues to date to collect baseline data for the conservation management of amphibians – both as the most endangered vertebrate taxon, and as indicators of overall environmental health.

Very little information is available about the mineral resources of the Maya Mountains Massif, with data from past exploration efforts not being generally available. Attention is largely focused on potential deposits of heavy metals in the volcanics along the southwestern portion of the Main Divide (**Craig Moore, pers. comm.**).

All reports reviewed for this project are included in the reference list, and a comprehensive review of archaeological research within the Maya Mountains Massif has also been conducted for this project (Jaime Awe), and is included as a digital report.

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