Rapid Ecological Assessment Sarstoon Temash National Park Toledo District, Belize

Volume I

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in Partnership with
the Garifuna and the Q'eqchi Maya People
of the Sarstoon Temash Region.

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List of Acronyms

CBO = Community Based Organization

cm = centimeter

dbh = diameter at breast height

ESTAP = Environment and Social Technical Assistance Project

GEF = Global Environmental Facility

GIS = Global Information System

ID = Identification

IDB = Inter-American Development Bank

IFAD = International Fund for Agricultural Development

m = meter

NGO = Non Government Organization

PACT = Protected Area Conservation Trust

REA = Rapid Environmental Assessment or Rapid Ecological Assessment

SATIIM = Sarstoon Temash Institute for Indigenous Management

SI = Statutory Instrument

STNPSC = Sarstoon Temash National Park Steering Committee

TOR = Terms of Reference

1 INTRODUCTION

The Sarstoon Temash National Park was created in 1994 (SI 42 of 1994, and amended in SI 22 of 2000). With approximately 41,000 acres it is one of the largest National Parks in the country. The Park is located in the south-eastern corner of Belize along the border with Guatemala. The common perception of the park's importance is that the park has important stands of red mangrove forest. However, this perception was not based on actual data. Previous to this document, no specific species lists for flora and fauna existed, and even the local residents were uncertain about the full variety of wildlife that may occur in the park. This document reports on the first comprehensive assessment of the biological resources within Sarstoon-Temash and is expected to confirm the global significance of the Park's wet forest ecosystems.

Figure 1. Location of the STNP in Belize.

The project got of the ground when five indigenous communities in the Sarstoon Temash region (four Q'eqchi' Maya and one Garifuna communities) indicated that they wished to continue to actively participate in the preservation of their ancestral lands, which included the Sartsoon Temash National Park. The five communities initially formed the informal Sarstoon Temash National Park Steering Committee (STNPSC) to pursue such activities, yet needing financial assistance to implement their vision for the future, the International Fund for Agricultural Development (IFAD) and the World Bank were approached to explore Global Environmental Facility (GEF) concept eligibility. This resulted in the STNPSC being succeeded by the Sarstoon Temash Institute for Indigenous Management (SATIIM), a formally registered NGO.

The mission statement of SATIIM is; *"to safeguard the ecological integrity of the Sarstoon Temash Region and employ its resources in an environmentally sound manner for the economic, social, and spiritual well-being of its indigenous peoples"*.

The objective of the project is to reduce land degradation and conserve globally significant biodiversity resources in the Sarstoon Temash National Park and its buffer zones. The project will be complementary to the baseline Community Initiated Agricultural Resource Development (CARD) project and will build on that project's organizational, institutional and infrastructural framework for sustainable intensification of agricultural production and other income generating activities. The proposed project also involves some substitution activities, as CARD resources in and around the Sarstoon Temash National Park will be reoriented to support its objectives. Proposed activities are based on the concept of co-management, as the most effective means for addressing open access problems related to indigenous peoples and natural resource use.

Co-management aims to reconstitute the incentives at the local level in a way that those closest to the resource – the local indigenous people - are given a greater stake in its long-run viability and to directly involve the population in the effective protection of resources. In practice, this means increasing the feasibility of exclusion (promoting a sense of responsibility for the resource, improving control) and creating awareness for joint benefits of the resource (biodiversity, soil and water conservation). Specific biodiversity conservation and natural resource management activities supported by the project will be based upon Belize's Biodiversity Strategy and Action Plan from 1998, developed under the GEF financed 'Biodiversity Enabling Activity', and the Regional Development Plan for Southern Belize (2000) prepared by the Inter-American Development Bank (IDB) financed Environment and Social Technical Assistance Project (ESTAP).

1.1 OBJECTIVES FOR THE RAPID ECOLOGICAL ASSESSMENT

The underlying objectives of the consultancy are:

- To carry out a detailed rapid ecological assessment
- To complete a field methodologies training programme with selected members of buffer communities
- To compile a detailed species list (flora and fauna taxa) with both common and scientific names
- Conduct both terrestrial and aquatic assessments (during both the wet and dry season)
- To produce a detailed ecosystems map
- To identify indicator, keynote and/or flagship species, establishing benchmarks, from which to monitor ecosystem change
- To establish a standardised field methodology for the monitoring programme
- To produce a detailed report on the outcomes of the consultancy.

The TOR for the REA was originally designed for two separate consultants. However, in this case it was decided to combine floristic and faunistic survey efforts. In this way there is a better integration between data, leading to a better ecological understanding.

Some map information already existed but the information in this study is largely based on verification (ground-truthing) of that information. For example: the ecosystems map for Belize (Meerman & Sabido: Central American Ecosystems map: Belize, 2001) will be updated using the data collected during this project.

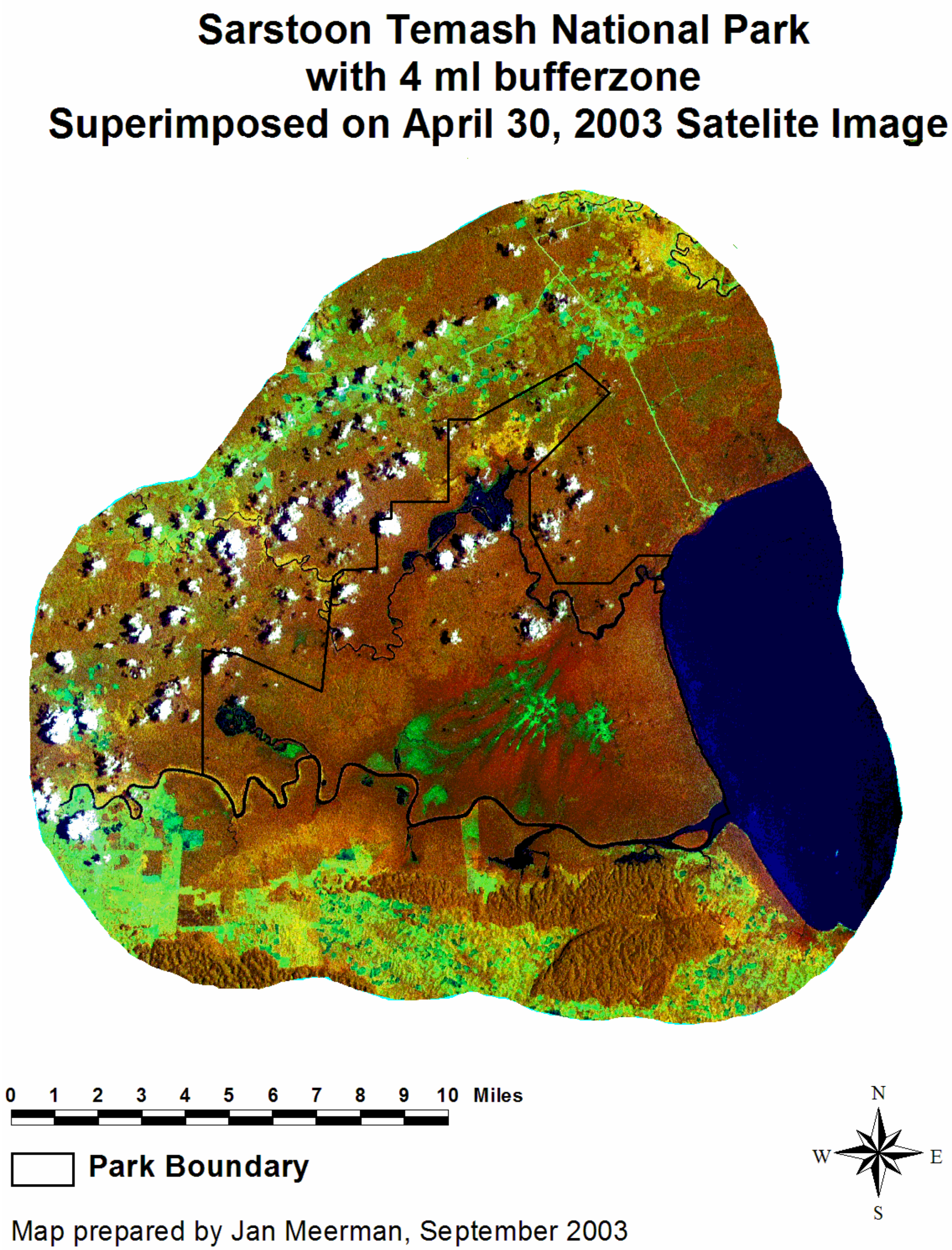


Figure 2*. above shows a satellite view (April 30, 2003) of the project area. Indicated is the Protected Area Boundary and the extend of the project area is limited to a 4 mile "bufferzone" This whole region including the protected area is considered "the milieu of Garifuna and the Q'eqchi Maya of Southeastern Belize".*

1.2 METHODOLOGY

The Sarstoon Temash National Park REA is different from a "normal" REA in the fact that the information collected needed to be socially applicable. While the data collected will be as broad as possible, there is a need for information that is relevant to the residents living near the protected area. A link had to be created between science and livelihood.

Figure 3. Communities and Settlements

One consequence of this approach is that the REA was not restricted to the protected area itself. The entire region is the milieu of the indigenous people that do not necessarily recognize any park boundaries. To define the actual project area, a four mile "buffer"-zone around the reserve was drawn (see figure 3). The legally recognized communities of Graham Creek, Crique Sarco, Sunday Wood, Conejo, Midway, and Barranco and the very recent (2003) settlements of Tamagas and Tushville are all within the thus defined project area. The communities of Santa Anna and Boom Creek are exactly on the 4 mile limit (see figure 3).

Another consequence of the current approach is for the groups of organisms targeted for inventory. Mammals, Birds and Fish are all hunted for food but also have tourism potential and thus have a large socio-economic importance. Flora is also essential with the large number of plants that are collected as either food, medication or building material. Other taxonomic groups were recorded as well, but only opportunistically. Superimposed over these groups of organisms, stands ecosystem information which is essential to the ecological understanding of all organisms in the area.

Most of the fieldwork within the project has addressed these groups although each group had different approaches and requirements. A three person multidisciplinary team was organized to deal with these various aspects. In brief, the approach to each biodiversity grouping was as follows:

1.2.1 Flora

Based on satellite imagery, an attempt was made to assess the various vegetation types / ecosystems present in and around the park boundaries. The most current satellite that is entirely cloud free for the project area is of May 1996. This is quite acceptable for ecosystem purposes but does not reflect recent land use changes. For this reason, a very recent (April, 2003) image was acquired as well even though it was not fully cloudless for the project area.

The main ecosystems thus identified were visited and a species assessment was made. In the most important ecosystems, standardized transects were established in order to assess species composition, diversity and vegetation structure.

The methodology used for the vegetation transects has been adapted from the methodology used by the Forest Planning and Management Project in Belize (Shawe, 1997). This methodology involved the opening of a 200 meter long line through the vegetation under study. The actual transect consists of a 4 m wide band along the cut line. In this transect, all trees with a diameter at breast height (dbh) of more than 10 cm are counted, dbh measured and where possible identified.

With the data thus obtained, several biodiversity indices were calculated for each transect. These data are important to calculate biodiversity in the area. With vegetation being the basis for ecosystems and biodiversity, the floristic biodiversity can be assumed to be a proxy for overall ecosystem biodiversity.

1.2.2 Birds

Birds were assessed during walk-over surveys and spot counts. Identification was by both visual and vocal characteristics. The bird inventory was linked to the vegetation / ecosystem types identified during the floristic survey. Again this method of inventory gives a good indication of diversity on the transects.

1.2.3 Aquatic fauna and habitats.

The aquatic habitats are of great importance in the Sarstoon Temash National Park. Large areas are virtually inundated during much of the rainy season and the ecosystem at this scale is unique within Belize. For this reason, inventory of aquatic organisms, in this case the fish fauna is of great interest. Not only for ecological reasons but also because of its high socio-economic relevance. The focus was on the inland (fresh water) fishes. The fish fauna of Belize is relatively well understood and identification of the species was generally no problem. Baited traps as well as locally used fishing methods were being employed in order to record as many species as possible.

1.2.4 Mammals

A thorough mammal survey involves a number of methodologies. Most notably, camera "traps" can be set for larger mammals and live traps can be set for smaller mammals. Nearly every species requires a separate approach. Overall, the success rate of these methodologies is very low, and it often takes several years to get meaningful data. For this reason, mammals were assessed only on an opportunistic basis. Most important was identification by tracks but some visual observations were also possible. The community participants provided much of the information on those mammal species that are hunted in the area.

1.2.5 Amphibians and Reptiles

Amphibians and reptiles were not the main focus of the inventory. Nevertheless, they were recorded on a opportunistic basis. Typically, amphibians (and more specifically frogs and toads) are monitored at the breeding sites during times of mating activity that usually takes place in the months of June through September. Outside these months, reliable amphibian monitoring is not possible and dependent on opportunistic observations as is the case for reptiles.

1.2.6 Invertebrates

Butterflies (Lepidoptera) and other invertebrates were not the main focus for the inventory. Nevertheless, some butterfly species were recorded since they are interesting ecosystem indicators. The Lepidoptera fauna of the area remains largely unknown. This group presents an opportunity for further research.

1.2.7 Team

The REA team was composed as follows:

Jan Meerman, San Antonio, Cayo District. Principal consultant. Biodiversity specialist. The principal consultant has extensive experience in REA studies and protected area management and is author of various biodiversity papers. The consultant is the principal author of the recent ecosystem map of Belize and co-author of the Central-American Ecosystems-map. The office of the principal consultant has in-house GIS capacity as well as other computer facilities.. Specific fields of expertise: Flora, Reptiles, Amphibians and Butterflies. See also information provided at http://biological-diversity.info

Augustin Howe, San Antonio, Cayo District. Tree identification specialist. Extensive taxonomic knowledge. Trainee of the Forest Planning and Management Project. Collected herbarium material for various institutions such as the Missouri Botanical Gardens and Mary Selby Botanical Gardens. Participated in the Mayflower and Spanish Creek Rapid Ecological Assessments. Member of the Yucatec Maya culture, and as such has a wide interest in local flora for the use of medication and other traditional uses.

Peter Herrera, Belize City, Belize District. Originally from Rancho Dolores, Belize district, Mr. Herrera is a successful tour guide but also received professional ornithological training from the Wisconsin based organization "Birds without Borders". Also participated in the Mayflower and Spanish Creek Rapid Ecological Assessments.

Apart from relying on the team experts, this project utilized local expertise and knowledge. In total 19 volunteers from 5 villages were trained in REA methodology in order to make optimal use of local knowledge and to assure that this knowledge can be translated to biological monitoring and ecosystem management. A list of participants and the period they participated is represented in the table 1.

1.2.8 Training

An integral part of the program was the training component. From each of the participating communities, four individuals were selected by SATIIM to participate in this training. A general introduction training workshop was held in Barranco Village. This training workshop was called together and organized by SATIIM with the above three team members being the facilitators. Aspects covered during the workshop included:

- Satellite imagery and interpretation,
- use of GPS,
- preparation and execution of a vegetation transect,
- plant identification,
- fish collecting, butterfly collecting,
- bird observation and
- bird transects.

Following this SATIM training workshop, the trainees assisted the REA team in the fieldwork and thus got acquainted with biological data collecting methods. For practical reasons, the park was assessed from multiple points, essentially starting in each of the participating villages. The trainees from these starting villages were the ones assisting in the research into the area that they were most familiar with.

***Table 1**. List with Community Participants for the REA*

Name	Village	April 23-25	May 3-5	May 20-22	May 27-29	August 26	Sept 8-11
Aurelio Pop	Sunday Wood	x					
Maximiliano Tush	Sunday Wood	x	x				
Adriano Tush	Sunday Wood	x	x				
Alberto Salam	Sunday Wood	x	x				
Alfonso Makin	Conejo	x	x				
Armando Coc	Conejo	x	x				
Juakin Cucul	Conejo	x	x				
Valentin Makin	Conejo	x	x				
Daniel Sam	Midway	x			x		
Rolando Caal	Midway	x			x		
Manuel Cab	Midway	x			x		
Ricardo Rash	Barranco	x		x		x	
Raymon Ramirez	Barranco	x		x		x	
Egbert Valencio	Barranco	x		x		x	
Beatrice Mariano	Barranco	x		x		x	
Luis Medina	Barranco			x			
Marcus Coy	Crique Sarco	x					x
Wayne Bo	Crique Sarco	x					
Juan Pop	Crique Sarco	x					x
Mateo Ceh jr.	Crique Sarco	x					x

2 VEGETATION/ECOSYSTEMS

2.1 INTRODUCTION

Vegetation is relatively easy to monitor. Although the state of the vegetation cover is never stable, changes are normally so slow to occur that it does not really matter whether a survey is carried out on a particular time of day or during particular weather conditions. In some cases it may differ during different times of the year, some vegetation types, such as herbaceous types may change considerably over the year. For forest vegetation types, this is a less pressing issue, apart from the fact that flowering is usually not spread evenly over the year and many plant species are easiest identified when flowering.

Vegetation cover is easiest assessed by interpreting satellite images. A great problem is that most satellite images of Belize are troubled by heavy cloud cover. The Landsat satellite makes a pass over Belize approximately twice per month and it is rarely so that a particular site under study is cloud free at that one particular moment.

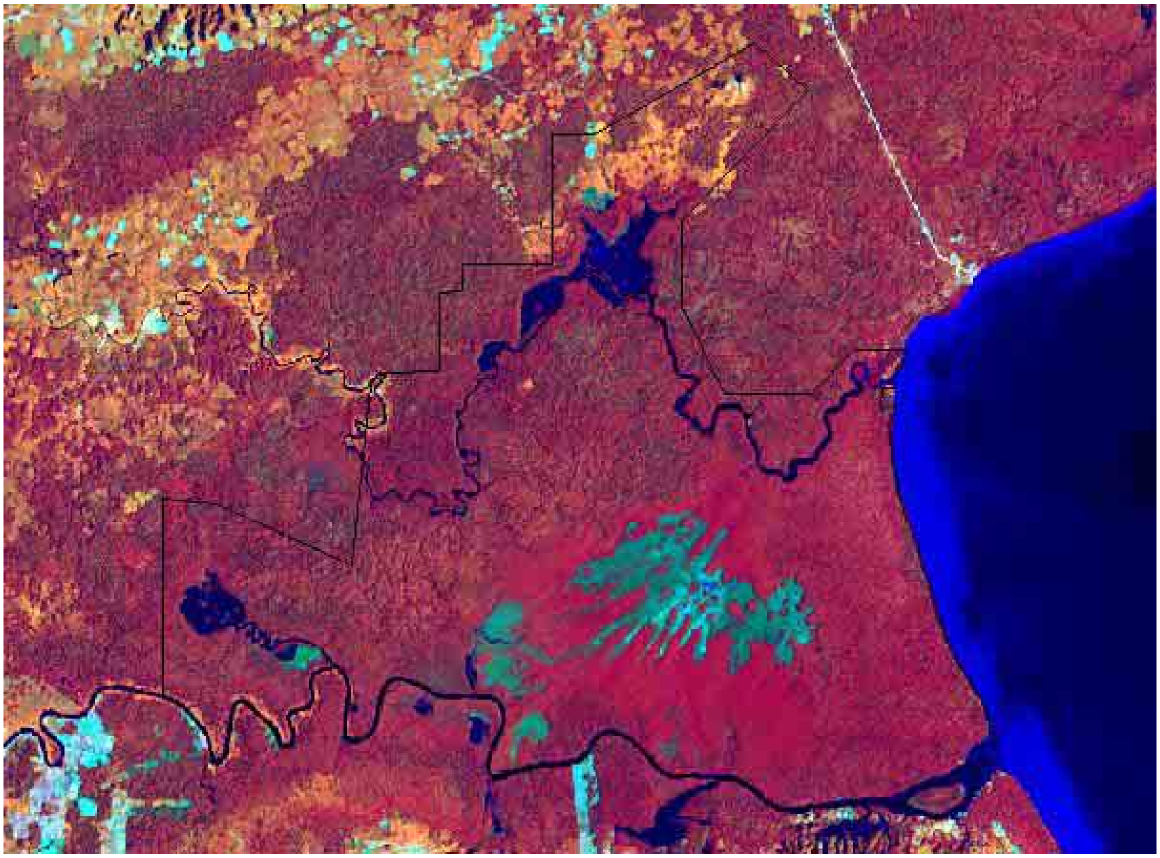


Figure 4. *Landsat Satellite image (May 17, 1996) of project area with park boundary indicated. The image is in false color. Reddish brown colors indicate closed vegetation. Orange indicates disturbed vegetation and aqua blue is an indicator for open terrain with sparse or no vegetation.*

The youngest Landsat image available entirely without cloud-cover over the project area was taken at May 17, 1996 (see figure 4 on previous page). The image was obtained from Michigan State University. A more recent image was obtained in order to compare changes in land use. This recent image was dated April 30, 2003, and although not entirely cloud free, it was sufficiently clear to allow an assessment of land use changes (see figure 5 below, note the slightly different coloration caused by a different technology used to separate the colors).

Figure 5. *Landsat Satellite image (April 30, 2003) of project area with park boundary indicated. The image is in false color. Reddish brown colors indicate closed vegetation. Shades of green indicate disturbed vegetation and/or open terrain with sparse or no vegetation.*

2.2 METHODOLOGY

Based on the 1996 Landsat satellite imagery, an attempt was made to assess the various vegetation types / ecosystems present within the protected area boundaries. Based on this, locations were selected for vegetation transects as a means to assess species composition and vegetation structure. The methodology used for the vegetation transects has been adapted from the methodology used by the Forest Planning and Management Project in Belize (Shawe, 1997). This methodology involved the opening of a 200 meter long line through the vegetation under study. Care was taken not to remove any of the trees along the transects. The cut line only served to facilitate access. The actual transect consists of a 4 m wide band along the cut line (2 m to the left, 2 m to the right). For practical purposes, the 200 m long transect was divided into 20 separate, 10 m long segments. Within this transect, all trees with a diameter at breast height (dbh or approximately 1.30 m height) of more than 10 cm were counted, dbh measured and where possible identified. Only those stems were counted that had their base within the transect (important in the case of leaning trees).

With the data thus obtained, several biodiversity indices were calculated (Ludwig and Reynolds, 1988).

There are, literally, an infinite number of diversity indices. The units of these indices differ greatly, making comparisons difficult and confusing, which adds to the interpretation problem. Ludwig & Reynolds state that the series of *diversity numbers* presented by Hill are probably the easiest to interpret ecologically.

In equation form, **Hill's** family of diversity numbers are

$$NA = \sum_{i=1}^{s} (P_i)$$

(8.4)

where p_i is the proportion of individuals (or biomass, etc.) belonging to the *i*th species. The derivation of this equation is given in Hill (1973b). Hill shows that the Oth, 1st, and 2nd order of these diversity numbers [i.e., A = 0, 1, and 2 in Eq. (8.4)] coincide with three of the most important measures of diversity. Hill's diversity numbers are

NUMBER 0: **NO** = S

(8.5a)

where S is the total number of species,

NUMBER 1: Nl - $e^{H'}$

(8.5b)

where H' is Shannon's index (defined below), and

NUMBER 2: **N2 - l/λ**

(8.5c)

where λ is Simpson's index (defined below).

These diversity numbers, which are in units of number of species, measure what Hill calls the *effective number of species* present in a sample. This effective number of species is a measure of the degree to which proportional abundances are distributed among the species. Explicitly, NO is the number of *all* species in the sample (regardless of their abundances), N2 is the number of *very abundant* species, and N1 measures the number of *abundant* species in the sample. (N1 will always be intermediate between NO and N2.) In other words, the effective number of species is a measure of the number of species in the sample where each species is weighted by its abundance.

Shannon's index, H'. The Shannon index (H') has probably been the most widely used index in community ecology. It is based on information theory (Shannon and Weaver 1949) and is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong. This average uncertainty increases as the number of species increases and as the distribution of individuals among the species becomes even. Thus, H' has two properties that have made it a popular measure of species diversity: (1)" $H' = 0$ if and only if there is one species in the sample, and (2) H' is maximum only when all S species are represented by the same number of individuals, that is, a perfectly even distribution of abundances.

The equation for the Shannon function, which uses natural logarithms (ln), is

$$H' = -\sum_{i=1}^{s*} (p_1 \ln p_1) \quad (8.8)$$

where H' is the average uncertainty per species in an infinite community made up of S* species with known proportional abundances pl, p2, p3, . .., ps*. S* and the pi's are population parameters and, in practice, H' is estimated from a sample as

$$\hat{H}' = \sum_{i=1}^{s} \left[\left(\frac{n_i}{n} \right) \ln \left(\frac{n_i}{n} \right) \right] \quad (8.9)$$

where n_i is the number of individuals belonging to the ith of S species in the sample and n is the total number of individuals in the sample. Equation (8.9) is the most frequent form of the Shannon index used in the ecological literature. However, this estimator is biased because the total number of species in the community (S*) will most likely be greater than the number of species observed in the sample *(S)*. Fortunately, if n is large, this bias will be small.

When all species in a sample are equally abundant, it seems intuitive that an evenness index should be maximum and decrease toward zero as the relative abundances of the species diverge away from evenness.

EVENNESS INDEX 5 (E5). E5 is known as the modified Hill's ratio:

$$E5 = \frac{(1/\lambda)-1}{e^{H'}-1} = \frac{N2-1}{N1-1}$$
(8.15)

It has been shown that $E5$ approaches zero as a single species becomes more and more dominant in a community (unlike $E4$, which approaches one). This is clearly a desirable property for an evenness index.

RAREFRACTION. An alternative to richness indices is to use direct counts of species numbers in samples *of equal size*. Not only is this a very simple procedure, it also avoids some of the problems of using indices of the type described above. In situations where sample sizes are not equal (probably the usual situation), a statistical method known as *rarefraction* may be used to allow comparisons of species numbers between communities. To use the rarefraction method we assume that sample size biases or sampling differences between communities can be overcome by some underlying sampling model that applies to all communities concerned. We give an example of such a model below.

The number of species that can be expected in a *sample* of *n* individuals [denoted by $E(S_n)$] drawn from a *population* of N total individuals distributed among S species is

$$E(S_n) = \sum_{i=1}^{s} \left\{ 1 - \left[\binom{N - n_i}{n} \Big/ \binom{N}{n} \right] \right\} \qquad (8.3)$$

where ni is the number of individuals of the ith species. In words, Eq. (8.3) computes the expected number of species in a random sample of size n as the sum of the probabilities that each species will be included in the sample.

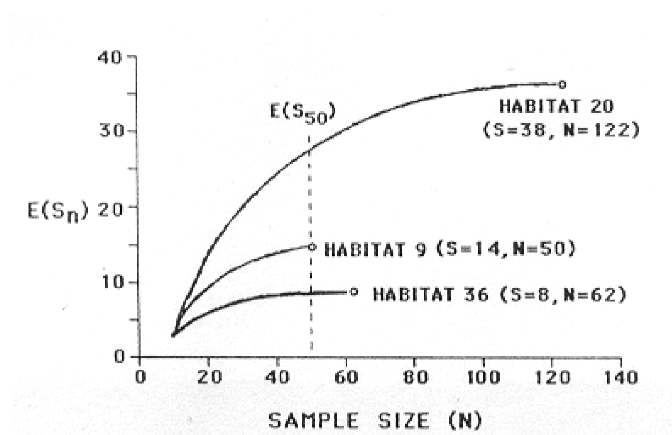


Figure 6. Sample rarefraction curves for three imaginative avian habitats showing the expected number of species as a function of sample size. (Ludwig and Reynolds, 1988)

Also per transect a number of structural data can be abstracted such as

- The average stem dbh,
- The number of multi-stemmed trees,
- The number of dead trees and
- The space per living tree in m2.

These data also give some indication on the dynamics of the transect (large dbh and no dead trees: static; many multi-stemmed and dead trees: dynamic).

Unfortunately, not all of these structural data were consistently collected by all teams.

The map on the following page (figure 7) shows the location of the various transects and other data collection points.

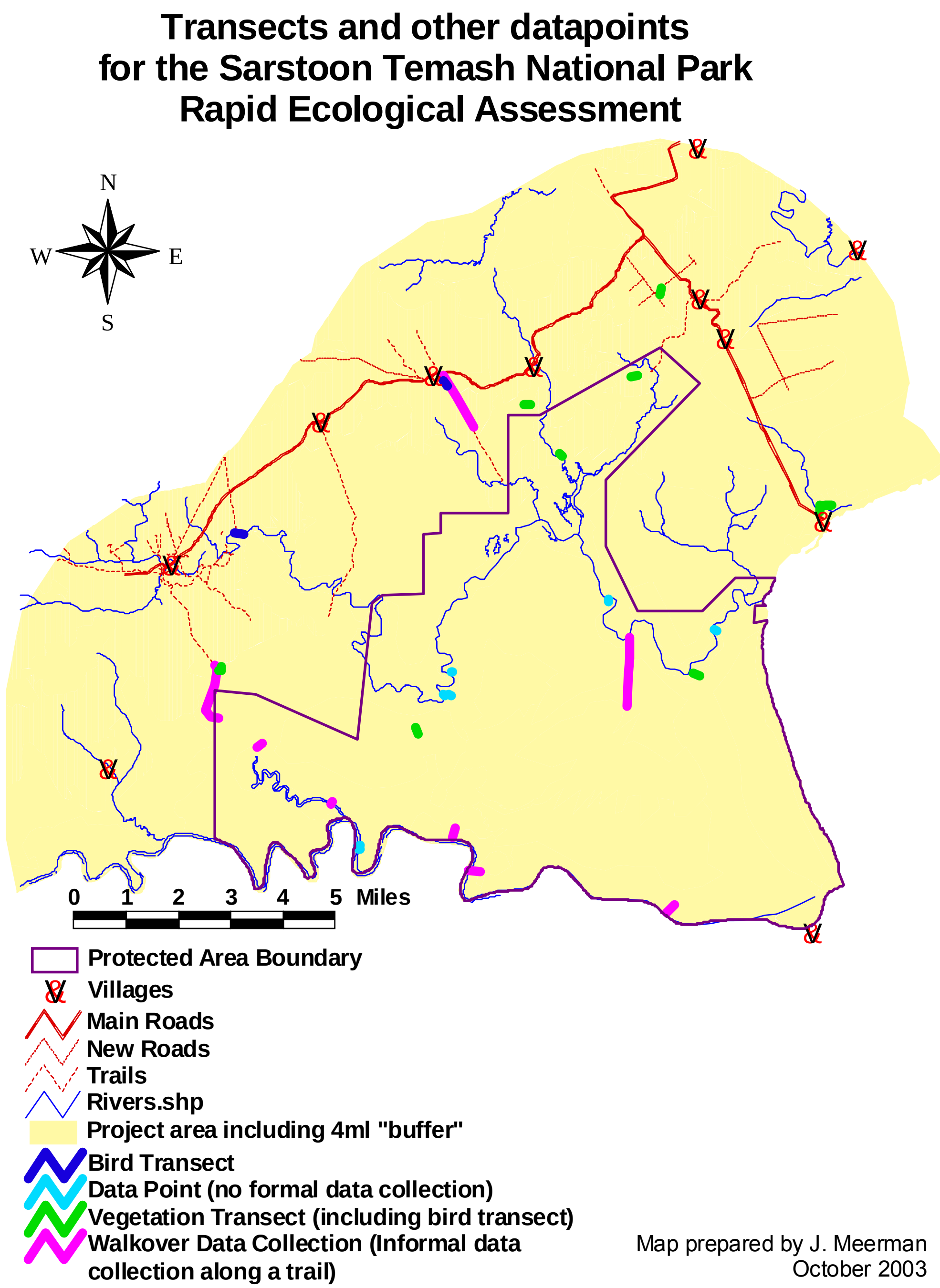
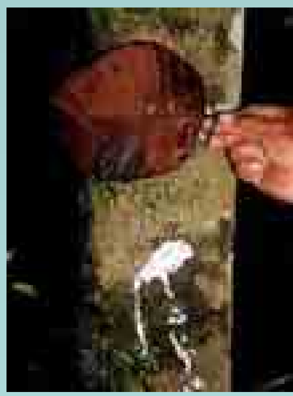


Figure 7. Data Collecting Sites

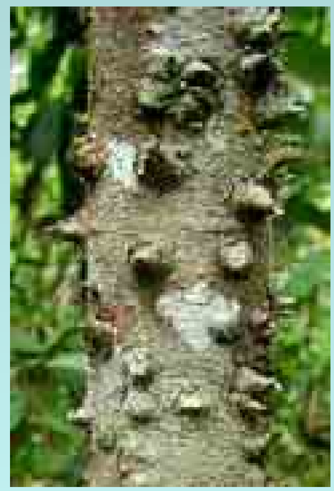
Intermezzo 1.

Some of the more interesting tree species found in the project area are depicted here. Quite a number of these belong to the Apocynaceae family.

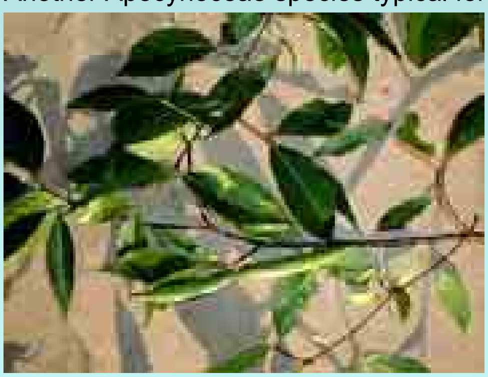


Couma macrocarpa is recognized by the curious leaves that come in whorles of three. Like most Apocynaceae, the tree procuces abundant white sap when damaged.

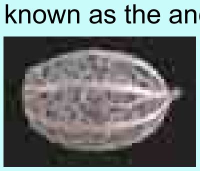
The sap from most Apocynaceae is highly toxic. In a few cases however, the sap is apparently not toxic and even edible. This is the case in *Lacmella standleyi*, Although the sap of this species has been reported as edible, the indigenous people of the project area appeared unaware of this. The most distinctive feature of the latter species is the thorny stem.



Another Apocynoceae species typical for the area is *Malouetia guatemalensis*, This small tree was found to be very common in many of the swamp forests visited. Again the stem produces copious milky sap, but the most distinctive feature in this case are the curious paired fruits which are very long and elongated and develop exactly opposite each other.



The Bongo wood or *Grias cauliflora* is the only representative in Belize of the Lecythidaceae. A family typical for the South American Rainforests. This family includes several lumber trees of South America, as well as the famous Brazil nut (*Bertholletia excelsa*). Bongo wood is also known as the anchovy pear and is supposed to have edible fruit used for pickles. Unfortunately we did not encounter any flowers or fruits during our field visits. The tree can be recognized by the very large spatula shaped leaves. It is a typical swamp forest associate. In Belize it occurs only southward from Monkey River.



2.3 RESULTS

A total of 386 plant species were identified at least up to genus name. This number includes the species identified on the transects but also includes many species that were noted elsewhere in the project area. Clearly, this number is not exhaustive; many more plants (especially herbs) remain to be recorded. But at least, some of the more dominant tree species can be expected to have been identified. The list of species can be found in the appendix.

The species composition encountered clearly set the project area apart from the rest of Belize. Some were common species encountered throughout much of Belize, such as (table 2):

Table 2. Tree species common both in the project area and in the rest of Belize.

Species Name	Common name	Q'eqchi/Garifuna name	Family
Xylopia frutescens	Polewood		Annonaceae
Dendropanax arboreus	White Gumbo-Limbo	Chamalte	Araliaceae
Attalea cohune	Cohune	Mocooch	Arecaceae
Rhizophora mangle	Red Mangrove		Rhizophoraceae
Bursera simarouba	Gumbo Limbo	Cahah	Burseraceae
Vitex gaumeri	Fiddlewood	Quamo	Verbenaceae
Vochysia hondurensis	Yemeri	San Juan	Vochysiaceae

There is a fair number of species that in Belize, appear to be restricted to the wet south. Some interesting species that are part of this group include (table 3 but also see intermezzo's for descriptions of some of these species):

Table 3. Tree species special to the project area.

Species Name	Common name	Q'eqchi/Garifuna name	Family
Couma macrocarpa			Apocynaceae
Lacmella standleyi			Apocynaceae
Malouetia guatemalensis			Apocynaceae
Grias cauliflora	Bongo Wood		Lecythidaceae
Carapa guianensis			Meliaceae
Manicaria saccifera	Comfrey	Comfra	Arecaceae
Sterculia mexicana		Chicot	Sterculiaceae
Vitex kuyleni		Quamo[1]	Verbenaceae
Zamia variegata	Variegated Zamia		Zamiaceae

[1] Note that in Q'eqchi' no distinction is made between *V. gaumeri* and *V. kuyleni*. This is a common phenomenon. Indigenous peoples usually only have names for plants/animals that they have a use for, and organisms with the same use/purpose are often lumped under the same name.

Intermezzo 2: *Sterculia mexicana*, Sterculiaceae.

During fieldwork in the Crique Sarco region, we encountered a large tree that initially eluded our efforts to identify it. In many aspects it resembled a Cotton-tree or *Ceiba pentrandra* (Bombacaceae). However, although the trunk was very Bombacaceae-like in aspect, it did not bear any the spines that are so diagnostic for *Ceiba*. Most importantly the large (unfortunately old and partly decomposed), fruits and seeds below the tree did not resemble those of *Ceiba* at all.

Identification efforts back in the office, revealed that the tree actually was *Sterculia mexicana,* a relative of the well known Bay-Cedar or Pixoi (*Guazuma ulmifolia*). Although we have never encountered this tree elsewhere in Belize, it is a species well known from the area. Already Schipp (1933-34) stated that this was the largest tree in the Temash region.

Since the habitats throughout the project area are not uniform, not all species are found equally distributed. For example, the area of the Midway Karst hill, revealed 50 identified species of which 24 (48%) were not noted anywhere else in the area. Since this area is over limestone, the soil characteristics are quite different and hence the plant species composition is different. Not surprisingly, the species encountered here are species found elsewhere in Belize on limestone (table 4):

Table 4. Flora typical to limestone karst.

Species Name	Common name	Family
Chamaeodorea ernesti-augusti		Arecaceae
Begonia sp		Begoniaceae
Pseudobombax sp		Bombacaceae
Forchammeria trifoliata		Capparidaceae
Brosimum sp	Ramon	Moraceae
Deheraina smaragdifolia		Theophrastaceae
Celtis sp.		Ulmaceae
Trema micrantha		Ulmaceae

While not disregarding the diversity of ecosystems and species in the project area, the dominant ecosystem is swamp forest and thus dominating species are swamp forest trees. Of the species listed before, the true flag-ship species of the park is the Comfra palm or *Manicaria saccifera*. See the intermezzo 5 for more details on this species.

Intermezzo 3: Bribri: *Inga vera* Papilionaceae: Mimosoideae.

A tree/shrub that is not at all uncommon in Belize but that barely occurs in the actual protected area is the Bribri. This is a plant that plays an important ecological role in the aquatic ecosystems of the project area. The Bribri is one of the most common riverside shrubs in Belize but it does not tolerate high salinity. In the project area it is thus found around Crique Sarco and downstream from there it occurs more or less up to the park boundary.

There is still some uncertainty about the actual identification of the species occurring here. In the past Bribri was know under the scientific name of *Inga edulis*. But now it is recognized that *I. edulis* is restricted to South America and that in Belize we have two very similar species: *I. vera* and I. *affinis*. Since no flowers could be collected during the fieldwork, the correct ID remains tentative.

The ecological importance of the Bribri lies in the abundant fruit. People like to peal open the seedpods and suck on the white, spongy aril that surrounds the actual seed. But not just people like it. The local fish fauna depends to a large extend on the fruit of this species as a food source. Even the Hickatee turtle *Dermatemys mawii* is to a great extend dependant of fallen fruits of this species. Not surprisingly, the local people use Bribri seed as bait on their fishing lines!

The importance of the Bribri is to such an extend that without the Bribri the fish population in the upper reaches of the rivers and all that depends on it would certainly collapse

Intermezzo 4: Bastard Mahogany: *Carapa guianensis*, Meliaceae.

The Bastard Mahogany is a relative of the real Mahogany *Swietenia macrophylla*. Equally, the timber is of great value. However, it seems that in Belize, the tree does not normally attain a large size.

In Belize the tree is typical component for wet forests in the south. It is rare or absent north of Monkey River village.

The tree produces a brown, woody, four-cornered nut some 3–4 inches across that resembles a chestnut. The nut contains several oil-rich kernels or seeds averaging about 63% oil which has a long history of use in Central and South America as well as commercial value. The oil burns well and is used as a natural lamp fuel in the rainforest. In the early 1800's the street lamps of Belém Brazil were fueled with this oil. Not only does it burn cleanly with little smoke, it also repels mosquitoes, flies and other pests.

Throughout the trees' range, indigenous people brew the bark and sometimes leaves, into a tea for fevers and intestinal worms, and also apply this tea externally for ulcers, skin problems and skin parasites.

Intermezzo 5: Comfra Palm *Manicaria saccifera*

This unique and handsome palm has a deeply ringed stem from ten to fifteen feet high. The leaves are very large, entire, rigid and furrowed, and have a serrated margin; they are often thirty feet long and four or five wide; and split irregularly with age. The petioles are slender with a broadly expanded fibrous-edged sheath at the base. These sheaths are persistent and often cover the stem to the ground.

The "Comfra" supposedly produces the largest entire leaves of any known palm, and for this reason, as well as on account of their firm and rigid texture, they form the very best and most durable thatch. The leaves are split down the midrib and the halves laid obliquely on the rafters, so that the furrows formed by the veins lie in a nearly vertical direction and serve as so many little gutters to carry off the water more rapidly. A well-made thatch of "Comfra" will last ten or twelve years.

In some regions, the spathe that covers the fruits, is much valued, furnishing the people with an excellent and durable cloth. Taken off entire it forms bags in which to keep stuff. Or it is even stretched out to make a cap…

Manicaria saccifera has rather a wide distribution. It occurs in much of the Amazon basin and in much of Central America. In Belize it reaches the northern limit of its distribution. Typically the species is found in low-lying coastal areas or near rivers.

The fruits are typically knobbed and often fused to clusters of two or three seeds. The seeds are large but very light and thus facilitate distribution by water. Fruits have been found washed ashore as far as the USA's southern states.

Although *Manicaria saccifera* is by no means rare, within Belize it is a very unusual species and is found only in the Toledo district. What's more, the known distribution falls virtually entirely within the Sarstoon Temash National Park. Outside the park it is known from two stands near Barranco village and possibly it occurs along the lower reaches of the Moho river.

Of all the plants, The Comfra is the true flagship species of the park.

2.3.1 Ecosystems

Essential to the understanding of the ecological functioning of an area is knowledge of the ecosystems of an area. In this case the term “ecosystem” is synonymous with “vegetation type”. The reasoning behind this is that vegetation cover is one of the main determining factors for ecological factors and it can be assumed that vegetation cover is a proxy for ecosystem identification.

The map of figure 8 indicates the ecosystem/vegetation types found in the project area. The basis of this map and the description of these ecosystems is based on the Ecosystems Map of Belize (Meerman & Sabido, 2001). But fieldwork carried out during the project has allowed to correct some misidentified ecosystems and to add considerable detail to the map of the project area. These new data will be incorporated in a future update of the Belize Ecosystems Map.

One of the most important findings of this study is that the common belief that Sarstoon Temash is special for its healthy stands of Mangrove is a misconception. Indeed, there area healthy stands of Mangrove but these stands are not particularly large nor unique. Instead, the real value of the Sarstoon Temash National Park lies in the fact that there exist a number of ecosystems that are not at all presented elsewhere in the National Protected Areas Systems Plan. Some are even unique to the Sarstoon Temash National Park.

2.3.2 Ecosystem Descriptions

In the pages following the ecosystems map are descriptions of the ecoystems identified. This description is based on the Belize Ecosystems Map (Meerman & Sabido, 2001) but has some annotations pertinent to the project area. Also note that a map indicating the distribution of that ecosystem within Belize is presented.

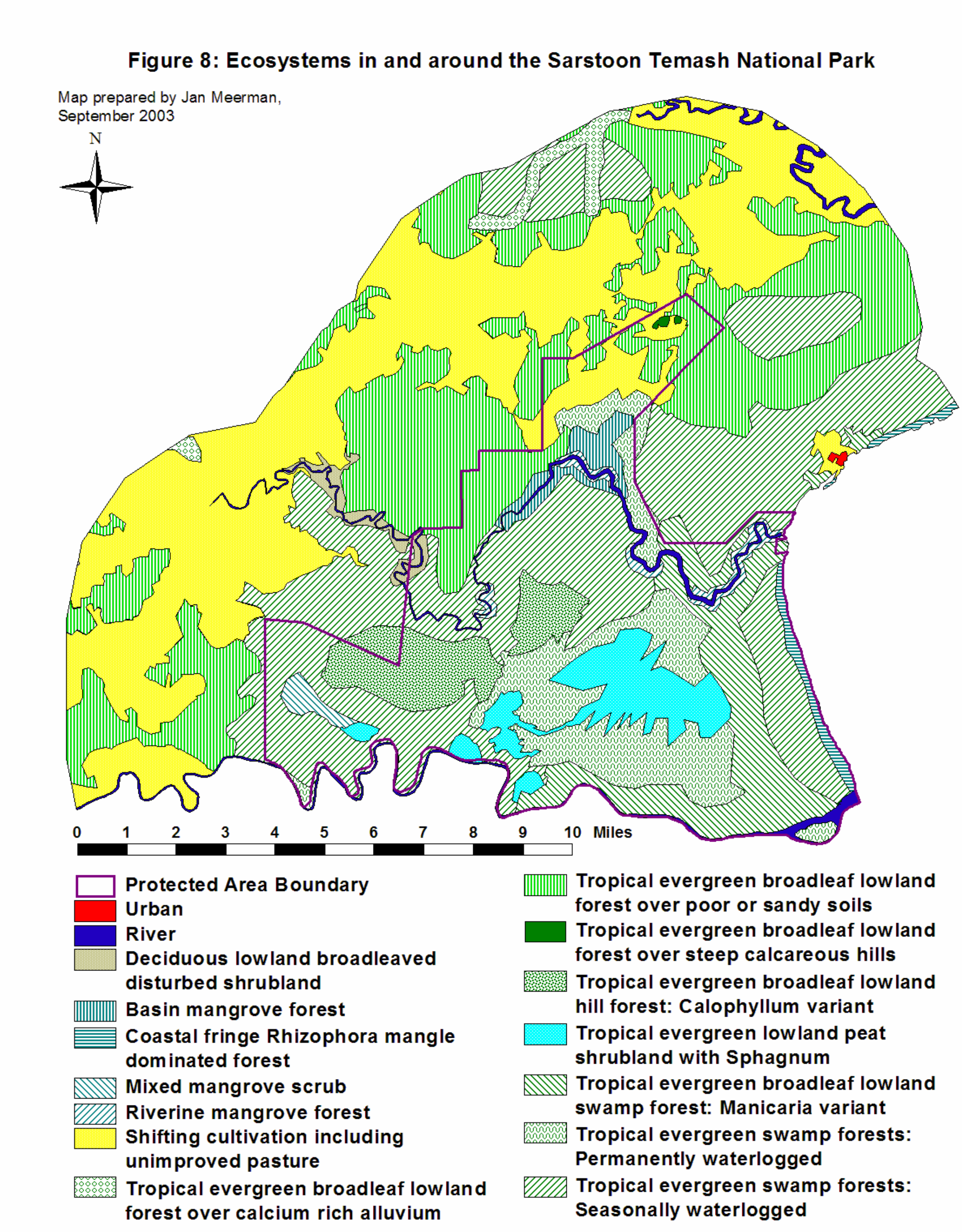
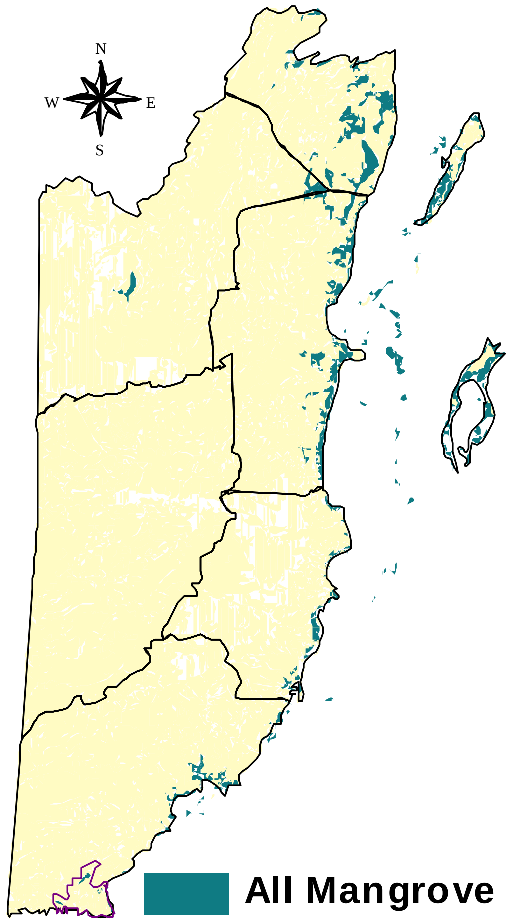


Figure 1. Ecosystems in and around the Sarstoon Temash National Park



2.3.2.1 Basin mangrove forest

UNESCO Code: I.A.5.b.(1).(f).

Found nationwide along coastal lagoons and in land-locked coastal depressions. Species composition and structure in these communities are highly variable depending on frequency and depth of inundation, nutrient exchange and water salinity levels.

Red Mangrove (*Rhizophora mangle*) dominates in areas which receive frequent tidal flooding or where flood waters are predominantly deeper than 15 cm. Where water depth is less and tidal flushing, amplitude and kinetic energy of floodwaters decrease, other mangrove species and associates invade. Such as Black Mangrove (*Avicennia germinans*) and White Mangrove (*Laguncularia racemosa*). When the ecosystem gets disturbed the fern *Acrostichum aureum* becomes the dominant species.

2.3.2.2 Coastal fringe *Rhizophora mangle*-dominated forest

UNESCO Code: I.A.5.b.(1).(d).

Found nationwide along the coast as a narrow fringe of scrub to high mangrove with a height of 2-14 m located along beaches and river mouths. This ecosystem develops in conditions of permanent inundation. Red Mangrove: *Rhizophora mangle* is characteristically dominant in these communities.

2.3.2.3 Riverine mangrove forest

UNESCO Code: I.A.5.b.(1).(e).

Found nationwide along rivers, often far inland. These systems are nutrient-rich from river deposited alluvium. Soils are mostly waterlogged. Canopy height varies from 5 to 30 m. Red Mangrove: *Rhizophora mangle* is the dominant species. Occasionally White Mangrove: *Laguncularia racemosa* can dominate.

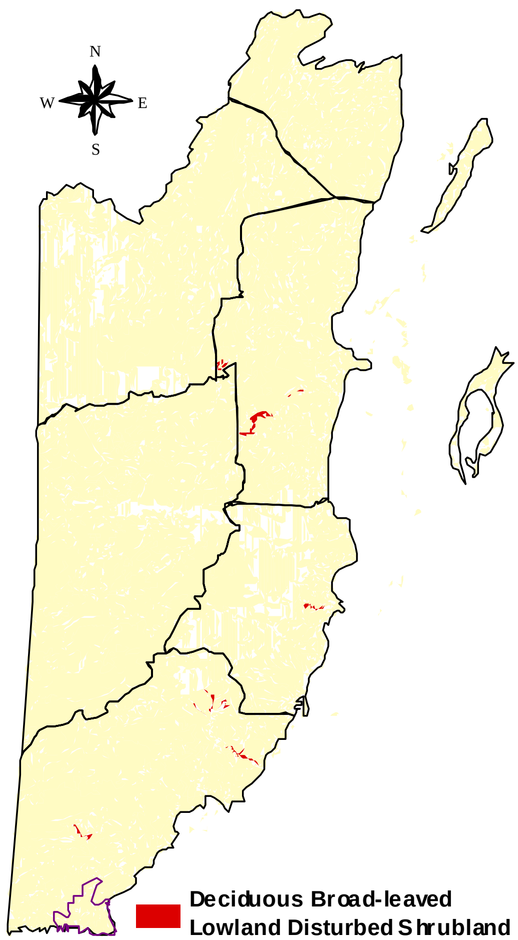
2.3.2.4 Mixed mangrove scrub

UNESCO Code: I.A.5.b.(1).(c).

Mixed mangrove communities found nationwide, but generally in coastal areas. All three mangrove species occur: *Avicennia germinans*, *Laguncularia racemosa*, and *Rhizophora mangle*. Other frequent species include *Acoelorraphe wrightii*, *Acrostichum aureum*, *Conocarpus erectus*, *Eragrostis prolifera*, *Myrica cerifera* and *Rhabdadenia biflora*.

2.3.2.5 Deciduous broad-leaved lowland disturbed shrubland

UNESCO Code: III.B.1.b.(a).2.



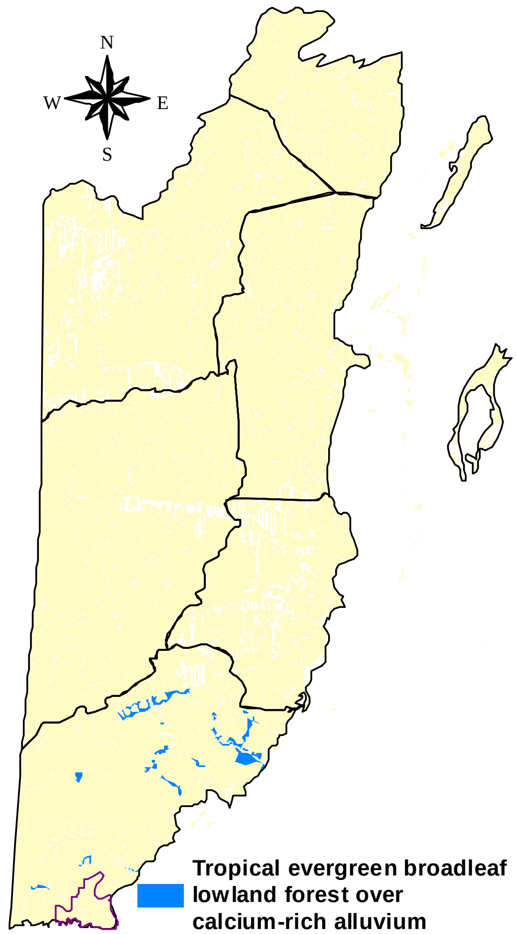
The distribution of this ecosystem is nationwide, but due to the scarcity of rivers in the north, it is more common in Southern Belize. It is probably more common than indicated on the map here due to the scale of mapping. Most polygons of this ecosystem are quite narrow.

This community varies much according to its topographic position. Disturbance may be natural, such as the displacement by a river after flooding, or it may be anthropogenic as when land is cleared and left fallow or disturbed by fire. Soils are mostly well drained. The ecosystem is frequently exposed to human induced fires.

Species composition is variable. Consists mostly of "weedy" species. Grasses often dominate.

2.3.2.6 Tropical evergreen broadleaf lowland forest over calcium-rich alluvium

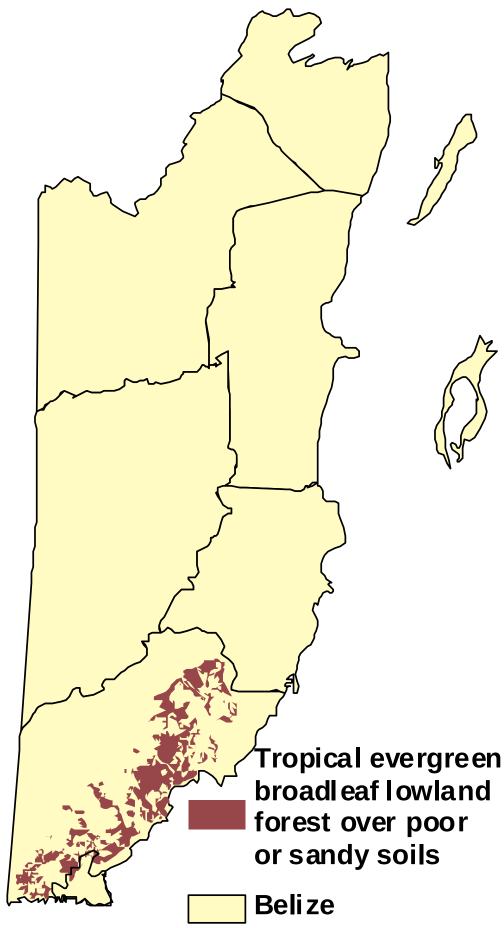
UNESCO Code: I.A.1.f.(2).(a).K



Tall lowland forests on deep soils in the wetter areas of Belize. Commonly developed on riverbanks in the south of the country where occasional flooding deposits fresh calcium-rich alluvium. Their canopy is often very broken and floods may periodically destroy part of the forest.

Frequently encountered species include *Acosmium panamense*, *Attalea cohune*, *Brosimum* sp., *Calophyllum brasiliense*, *Carapa guianensis*, *Castilla elastica*, *Ceiba pentandra*, *Celtis schippii*, *Dendropanax arboreus*, *Dialium guianense*, *Ficus guajavoides*, *Ficus* sp., *Grias cauliflora*, *Guarea glabra*, *Guarea grandifolia*, *Inga affinis*, *Licania platypus*, *Nectandra* sp., *Ochroma lagopus*, *Poulsenia armata*, *Pouteria durlandii*, *Pouteria mammosa*, *Protium schippii*, *Pseudolmedia* sp., *Pterocarpus rohrii*, *Quararibea funebris*, *Rheedia sp.*, *Sabal mauritiiformis*, *Schizolobium parahybum*, *Simira salvadorensis*, *Symphonia globulifera*, *Vochysia hondurensis*. Palms are a significant feature of the understory (3-4 m), particularly *Astrocaryum mexicanum*, *Bactris* sp., *Calyptrogyne ghiesbreghtiana*, and the rattan *Desmoncus orthocanthos*. Soils are deep, fertile and well drained, the fertility being maintained by seasonal silt deposition. Where the rivers break their banks the forests may periodically be destroyed, and patches of Spiny Bamboo *Guadua longifolia* and *Dieffenbachia seguine* occur.

2.3.2.7 Tropical evergreen broadleaf lowland forest over poor or sandy soils



UNESCO code: I.A.1.a.(1).(b).P

Generally dense forests with a broken canopy that are restricted to the Toledo District.

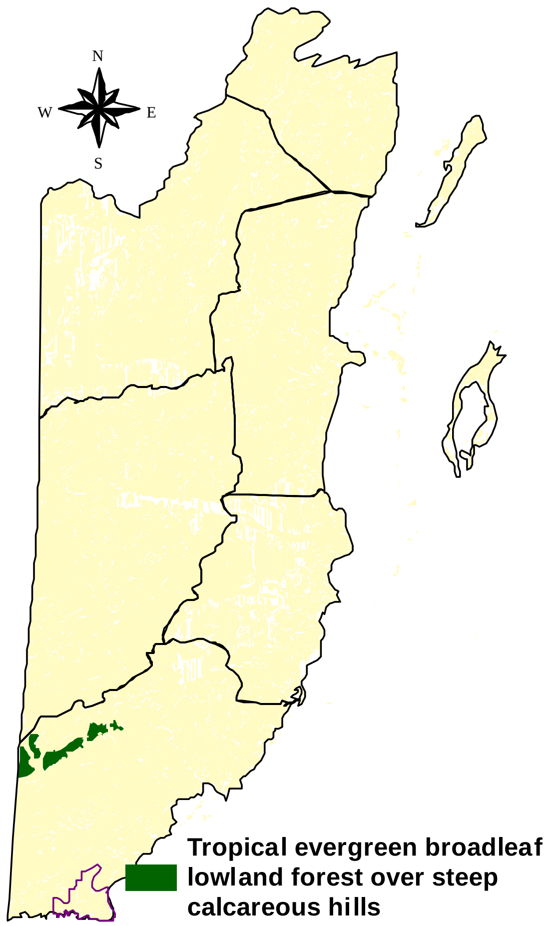
Corresponding to where they occur, soils are acidic and may be dull reddish-brown, brown or gray clays, often mottled and/or stony. The drainage varies but generally they are ill drained.

Where fires have penetrated this system, small patches of scrubby "savanna" occur with associated species such as Craboo: *Byrsonima crassifolia* and Pine: *Pinus caribaea* appearing. High rainfall figures in these areas prevent major expansion of these savannas but under a regime of recurring droughts and increased human pressure, these forests may well degenerate towards savanna.

Distinctive species include *Acosmium panamense, Acoelorrhaphe wrightii, Aspidosperma cruenta, Attalea cohune, Bactris* sp., *Calophyllum brasiliense, Chrysobalanus icaco, Clidemia spp., Coccocypselum herbaceum, Dialium guianense, Dicranopteris, Erblichia odorata, Ficus* sp., *Guarea* sp., *Guettarda combsii, Licania hypoleuca, Licania platypus, Miconia* spp., *Mouriri exilis, Mouriri myrtilloides, Pouteria mammosa, Psychotria poeppigiana, Pterocarpus rohrii, Scleria bracteata, Simarouba glauca, Spondias mombin, Symphonia globulifera, Terminalia amazonia, Tetracera volubilis, Tococca* sp., *Virola koschnyi, Vismia ferruginea, Vochysia hondurensis* and *Xylopia frutescens.*

2.3.2.8 Tropical evergreen broadleaf lowland forest over steep calcareous hills.

UNESCO Code: I.A.1.a.(1).(a).K-s



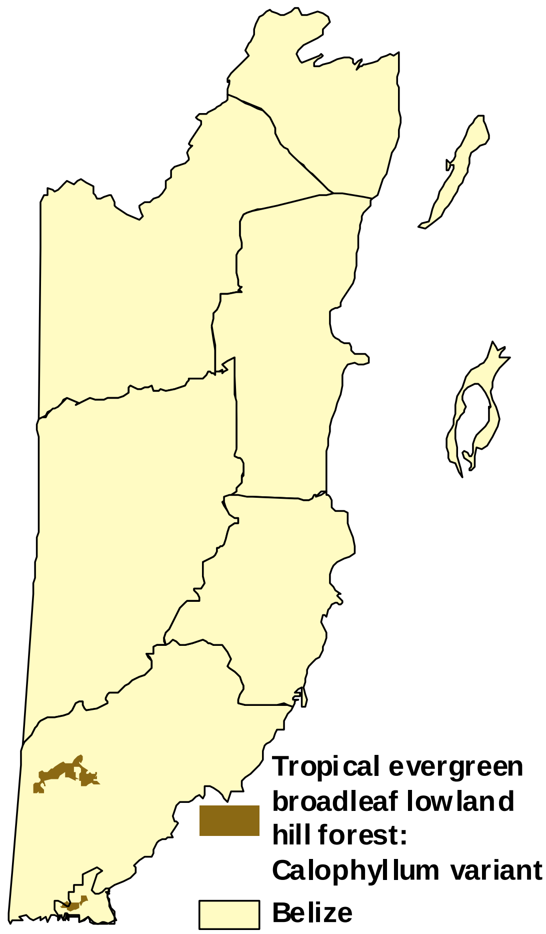
Found in steep terrain over calcareous rocks (In the project area only at the Midway Quarry site), often where there is more non-vegetated ground surface, particularly bare rock. Soils are mostly well drained and may be extremely organic due to the leaching of the mineral soil and the build-up of organic matter in the limestone cracks and fissures.

Fires can do tremendous damage to this ecosystem. The soil at the base of steep limestone hills is often quite fertile and sought after for slash and burn agriculture. Agricultural fires associated with this practice frequently escape and creep up the hills, commonly doing relatively minor damage at the lower elevations but completely destroying the tops of the hills. The vegetation of such hilltops is then replaced by vines such as *Bidens squarrosa* and *Calea* sp. or more commonly with the fern *Pteridium caudatum*.

Altitude is less important than steepness and the vegetation cover is dictated by the seasonal droughtyness. But because of the high rainfall figures in southern Belize, deciduousness is not a conspicuous feature even on these steep hills. Normally the valleys between these steep hills have an ecosystem that should be termed IA1a(1)(a)K-r but the current mapping effort does not allow this type of detail. The canopy tends to reach 25-30 m.

Distinctive species include: *Acalypha* sp., *Achimenes erecta, Alseis yucatenensis, Aphelandra scabra, Astronium graveolens, Bauhinia divaricata, Bernoullia flammea, Brosimum* spp., *Bursera simaruba, Ceiba aesculifolia, Clusia* sp., *Coccoloba acapulcensis, Crysophila stauracantha, Dendropanax arboreus, Desmoncus orthacanthos, Drypetes brownii, Louteridium donnell-smithii, Manilkara zapota, Malmea depressa, Metopium brownei, Oreopanax obtusifolius, Pimenta dioica, Piper psilorrhachis, Piper* spp., *Plumeria rubra, Pouteria campechiana, Pouteria reticulata, Protium copal, Pseudobombax ellipticum, Sapindus saponaria, Sebastiania tuerckheimiana, Trichilia minutiflora* and *Vitex gaumeri.*

2.3.2.9 Tropical evergreen broadleaf lowland hill forest: *Calophyllum* variant.



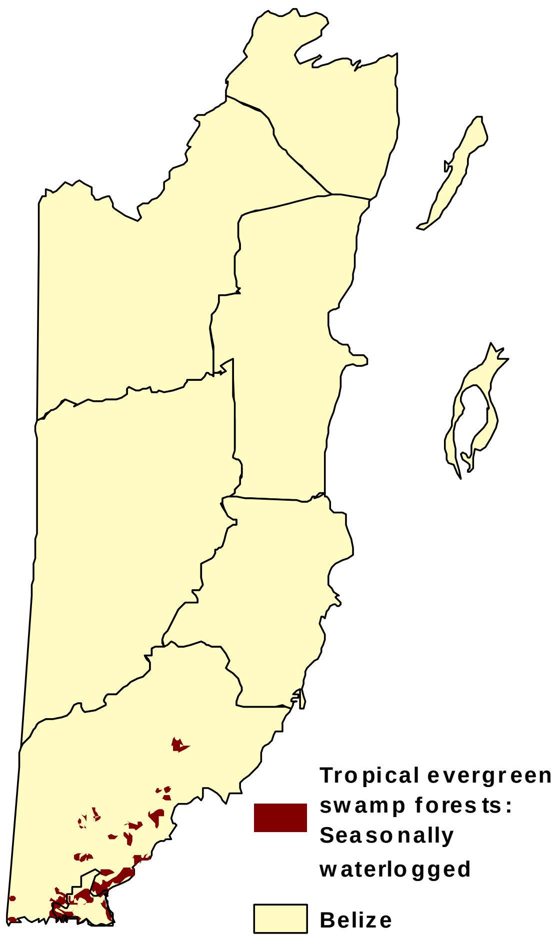
<u>UNESCO Code: I.A.1.a.(1).(a).C</u>

Usually tall forest of 20 – 30 m height in the South of Belize where there is abundant rainfall. They are on non-calcareous soils of the Toledo uplands. The soils are mostly well drained and very sensitive to erosion.

The classification of this ecosystem is somewhat uncertain at this stage. Ecologically, the description fits, but topographically, the patches with this ecosystem in the Sarstoon Temash National Park can hardly be called "hills" Definitely a "rare" ecosystem.

Frequently encountered trees include *Acosmium panamense, Aspidosperma cruenta, Attalea cohune, Calophyllum brasiliense, Erblichia odorata, Guarea glabra, Licania platypus, Orbignya cohune, Pouteria mammosa, Pouteria* sp., *Simarouba glauca, Terminalia amazonia, Virola koschnyi, Vismia ferruginea, Vochysia hondurensis, and Xylopia frutescens.* In places where drainage is impeded *Ficus* sp., *Dialium guianense, Pterocarpus officinalis, Spondias mombin,* and *Symphonia globulifera* occur.

2.3.2.10 Tropical evergreen broadleaf lowland swamp forest: Seasonally waterlogged.



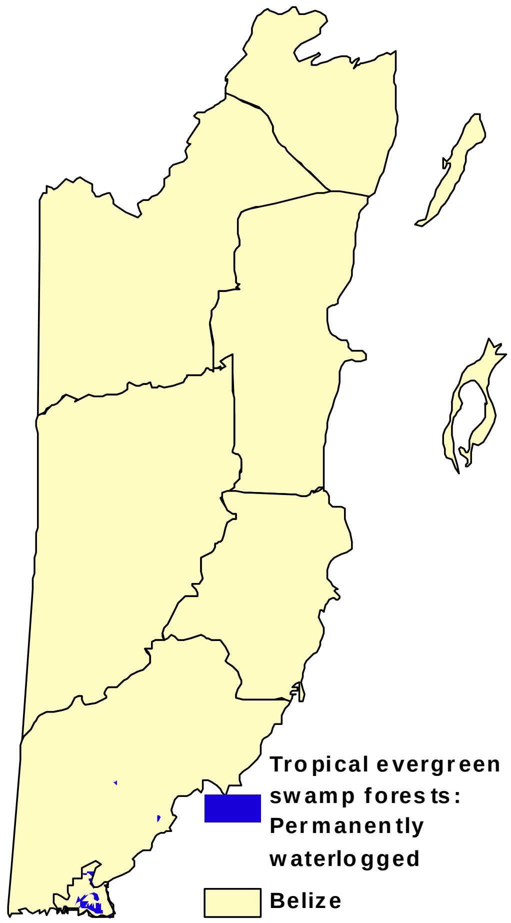
<u>Unesco Code: I.A.1.g.(1).(a)</u>

Swampy thickets of thin stemmed trees and shrubs without emergents in the high rainfall areas of southern Belize. Some hog-wallow micro-relief exists. Soils are mostly calcium poor, Ill drained and waterlogged for part of the year.

Frequently encountered plants in these forests are *Acosmium panamense*, *Aspidosperma cruenta*, *Astrocaryum mexicanum*, *Attalea cohune*, *Bactris* spp., *Bucida buceras*, *Calyptranthes chytraculia*, *Clidemia* sp., *Coccoloba* sp., *Crysophila stauracantha*, *Dalbergia cubilquitzensis*, *Dalbergia stevensonii*, *Dialium guianense*, *Dracaena americana*, *Guettarda combsii*, *Heliconia vaginalis*, *Hirtella racemosa*, *Inga* sp., *Jacquinia paludicola*, *Miconia* sp., *Mouriri exilis*, *Mouriri myrtilloides*, *Pachira aquatica*, *Psychotria glomerulata*, *Psychotria poeppigiana*, *Scleria bracteata*, *Swietenia macrophylla*, *Symphonia globulifera*, *Terminalia amazonia*, *Virola koschnyi*, *Vismia ferruginea*, *Vitex kuylenii*, *Vochysia hondurensis and Xylopia frutescens.* On richer soils *Pterocarpus officinalis* is found; on poorer soils more *Melastomataceae* and *Acoelorraphe wrightii.*

2.3.2.11 Tropical evergreen broadleaf lowland swamp forest: Permanently waterlogged.

UNESCO Code: I.A.1.g.(1).(b)



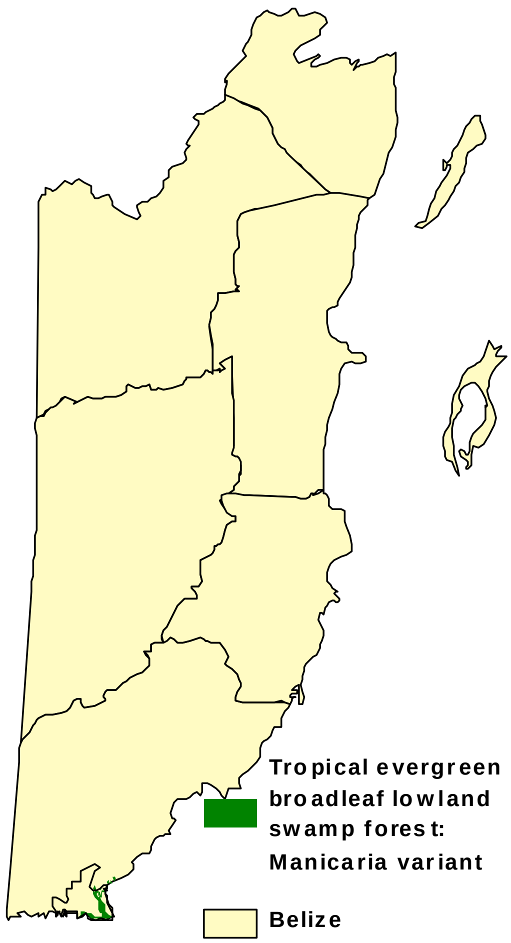
This ecosystem is confined to the Toledo District and there found nearly exclusively within the Sarstoon Temash National Park.

Soils range from gray clays to loams and sandy loams, in places having a surface mat of fibrous peat, which has a high live root content. The soils are Ill drained and waterlogged for most of the year.

Frequently encountered species include: *Acacia* sp., *Acosmium panamense*, *Acrostichum aureum*, *Astrocaryum mexicanum*, *Attalea cohune*, *Bactris* spp., *Bucida buceras*, *Calophyllum brasiliense*, *Calyptranthes karlingii*, *Calyptrogyne ghiesbreghtiana*, *Carapa guianensis*, *Cassipourea guianensis*, *Chrysobalanus icaco*, *Coccoloba belizensis*, *Crysophila stauracantha*, *Dalbergia stevensonii*, *Dendropanax arboreus*, *Desmoncus orthacanthos*, *Erythroxylum guatemalense*, *Euterpe precatoria*, *Grias cauliflora*, *Guettarda combsii*, *Hirtella racemosa*, *Inga affinis*, *Lindsaea lancea*, *Lonchocarpus rugosus*, *Manilkara zapota*, *Manicaria saccifera*, *Maytenus schippii*, *Montricardia arborescens*, *Mouriri exilis*, *Pachira aquatica*, *Pterocarpus officinalis*, *Randia* sp., *Rhabdadenia paludosa*, *Rhizophora mangle*, *Rinorea hummelii*, *Sabal mauritiformis*, *Strychnos panamensis*, *Symphonia globulifera*, *Terminalia amazonia*, *Virola koschnyi*, *Vitex kuylenii*, *Vochysia hondurensis* and *Xylopia frutescens*.

2.3.2.12 Tropical evergreen broadleaf lowland swamp forest: *Manicaria* variant

UNESCO Code: I.A.1.g.(2).(b).M



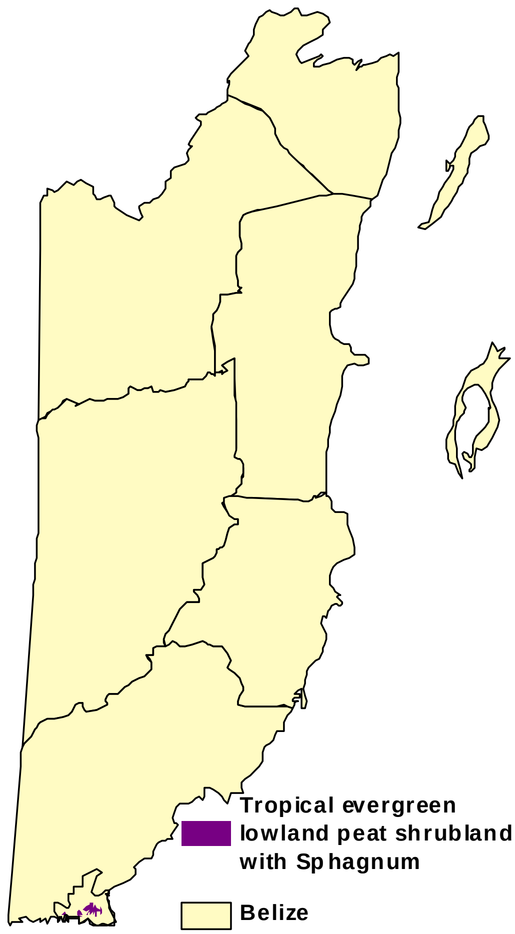
Found in coastal areas just above sea level. Soils are peaty to a depth of 25-30 cm, and below the peat is fairly tight gray clay. The soil water table is more or less permanently within at least a few cm of the soil surface, although some hog-wallow relief suggests at least temporary drying of the topsoil.

Found only in the Toledo district and there virtually confined to the Sarstoon Temash National Park

Dominated by the Comfrey Palm *Manicaria saccifera*. Other common species include: *Astrocaryum mexicanum*, *Bucida buceras*, *Calophyllum brasiliense*, *Ceratozamia robusta*, *Connarus lambertii*, *Euterpe precatoria*, *Mouriri exilis*, *Mouriri myrtilloides*, *Pachira aquatica*, *Pterocarpus officinalis* and *Symphonia globulifera*.

2.3.2.13 Tropical Evergreen Lowland Peat Shrubland with Sphagnum.

UNESCO Code: III.A.1.f.



Restricted to the Sarstoon Temash National Park. Identified only during this study. Unique in Belize and Central America!

Soils are nearly entirely organic having a surface mat of fibrous peat, which has a high live root content. The area is ill drained and waterlogged for most of the year.

This is a shrubland with an open canopy of no more than 10 m, mostly lower. The soil water table is more or less permanently at least within a few cm of the soil surface, if not above it.

The understory of the shrubland consists of lumps of the moss *Sphagnum* (*subsecundum*?), interspersed with sedges (*Hypolytrum longifolium*?). Shrubs and small trees found in the area include *Cyrilla racemiflora, Clusia cf. massoniana, Connarus lamberti. Schizocardia belizensis Symphonia globulifera, Ouratea* sp., *Acoelorraphe wrightii, Blechnum* ferns, *Palicourea cf. crocea, Calophyllum brasiliense* and a few as yet unidentified species.

2.3.3 Biodiversity indices within ecosystems

As explained before, the vegetation transects established within the various ecosystems allow comparison of diversity indices and are the only way to establish some reliable biodiversity statistics. Previous research in other areas has resulted in similar data from these areas and some of these data are represented in table 7 here in order to allow comparison.

Based on the data collected (table 6), the high forest south of Conejo village (*Tropical evergreen broadleaf lowland forest over poor or sandy soils: I.A.1.a.(1).(b).P*) was the most diverse as far as the tree cover was concerned. Lowest biodiversity was displayed by the *Manicaria* forest along the Temash (*Tropical evergreen broadleaf lowland swamp forest: Manicaria variant: I.A.1.g.(2).(b).M*) and in the two forest transects near Barranco (*Tropical evergreen broadleaf lowland swamp forest: Seasonally waterlogged: I.A.1.g.(1).(a)*).

This low tree biodiversity in the Manicaria swamp is not surprising given the extreme growth conditions in that habitat and the dominance of one single species (Comfra palm). The low tree biodiversity of the Barranco transects is probably explained by the fact that these were likely in secondary growth. Based on the combined transect data, the most dominant tree species are (table 5):

Table 5. Most dominant tree species recorded

Scientific Name	Indigenous Names
Attalea cohune	Mocooch
Calophyllum brasiliense	Lech
Dendropanax arborea	Koh, Chamalte
Grias caulifora	Bongo Wood
Guarea sp	Unrecorded
Guatteria sp	Rash Ampak, Cacao che, Pata Che
Guettarda combsii	Salche, Pomte, Pata-che
Ilex guianensis	Lyderciguana
Laetia sp	QuolQuol
Mannicaria saccifera	Comfra
Pachyra aquatica	Sapoton
Pterocarpus officinalis	Bilix
Sabal mauritiiformis	Sha'n
Symphonia globulifera	Lech
Vitex gaumeri	Quamo
Vochysia hondurensis	San Juan, Emery
"No1"	Unrecorded

The Barranco sites have a very low evenness and rarefraction. These figures probably indicate that the transects were made in secondary growth. Indeed, the sites were very near the village and the presence of cultivated species such as pineapple support this assumption.

The Conejo Swamp Forest also has a very low evenness and rarefraction. In this case these low figures are likely to be caused by the extreme conditions in which the forest grew (seasonally inundated). Extreme conditions cause stress, and only a limited number of species will be able to deal with this stress. High stress environments therefore typically have a low biodiversity.

The nearby Conejo High Forest is the exact opposite of this. The land is high, undisturbed by agriculture and not subject to flooding. As a result the biodiversity indices are high.

The Midway High Forest although high ground and undisturbed condition had only an average biodiversity. This seems to be contrary the findings at the Conejo High Forest but based on information gathered by the geology and soil specialist, the soils at this site are very poor and the lack of fertility just presents another form of stress.

The Midway Quarry Transect also gives an average biodiversity. This was somewhat surprising since the soils here seemed to be better. However, there were signs of disturbance (nearby farming) and the dominance of Cohune may act as a suppression factor for other species. This site contained many species not found in the other transects.

The Temash "dry hill" Forest again has an average diversity index. The site seemed undisturbed and well drained. Interesting here was that there were no really dominant species. Also interesting was the density of trees here which is expressed in the low available space per tree.

The Crique Sarco Swamp Forest transect was clearly richer than the Conejo Swamp Forest Transect. The effects of flooding here are probably less severe. The abundance of Hog Plum *Spondias* may indicate some past disturbance of the site.

The Comfra (*Manicaria*) transect scores very low again for biodiversity. Again, the seasonally inundated conditions present a stress which (in this case) the Comfra palm can handle and thus has become the dominant species here.

Comparison with identically executed transects in other lowland forest sites in Belize (table 7) shows that the tree biodiversity indices of the various Sarstoon Temash transects do not indicate a spectacular biodiversity even though the figures appear slightly above average when compared to the other sites (all of Central Belize).

Table 6. Table comparing vegetation transects recorded in and around the Sarstoon Temash National Park in 2003. Values in red indicate low values, values in green indicate values that are above average.

	Barranco 1	Barranco 2	Conejo swamp	Conejo high forest	Midway high forest new layout	Midway Quarry	Temash "dry hill" forest	Crique Sarco swamp	Comfrey swamp
N_0 *= Number of species*	17	14	15	28	24	20	25	21	14
N_1 *= Abundant species*	8	8	10	24	19	17	20	18	8
N_2 *= Very abundant species*	5	5	8	41	22	24	22	28	6
H' = Shannon's div. index	2.11	2.08	2.29	3.19	2.96	2.83	2.98	2.91	2.1
Evenness E_5	0.53	0.64	0.84	1.74	1.17	1.43	1.12	1.56	0.71
Rarefraction at sample size of 20 trees	9	9	9	16	14	14	10	14	9
Rarefraction at sample size of 30 trees	12	11	11	23	19	NA	13	18	11
Living stems > 10 cm dbh (incl. vines)	53	51	60	37	46	35	63	36	56
Average stem dbh in cm	15	43	23	22	19.6	30	17	27	14
Number of trees (non vines)	53	51	60	43	52	43	71	59	70
Space per living tree in m^2	15.1 m2	15.7 m2	13.3m2	21.6 m2	17.4 m2	22.9 m2	12.7 m2	22.2 m2	14.3 m2
Total species	20	32	25	40	42	38	39	43	29
Dominant tree species (> 10% of total, >10cm dbh)	*Ilex guianensis, Vochysia hondurensis*	*Ilex guianensis, Pachyra aquatica*	*Symphonia globulifera, Pterocarpus officinalis, Calophyllum brasiliense*	*Guatteria sp., Laetia sp.*	*Vitex gaumeri, Guettarda combsii*	*Attalea cohune*	*None*	*Spondias sp.*	*Mannicaria saccifera, No.1*
Dominant woody species	*Ilex guianensis, Vochysia hondurensis*	*Ilex guianensis, Pachyra aquatica*	*Symphonia globulifera, Pterocarpus officinalis, Calophyllum brasiliense, Grias caulifora*	*Guatteria sp., Laetia sp., Sabal mauritiiformis*	*Vitex gaumeri, Guettarda combsii*	*Attalea cohune, Guarea sp.*	*None*	*Attalea cohune, Dendropanax arborea*	*Mannicaria saccifera, No.1*
Largest biomass	Ilex guianensis	Ilex guianensis	Symphonia globulifera	Matayba opositifolia	Vitex gaumeri	Attalea cohune	Licania hypoleuca	Bursera simarouba	Calophyllum brasiliense

Table 7. Table showing vegetation transect results for other locations in Belize, this for comparison with the Sarstoon Temash Data

	Mayflower Lowland Gmelina	Mayflower Lowland TauWitz	Mayflower Slope TauWitz	Mayflower Slope waterpipe	Mayflower Crest waterpipe	Mayflower Crest Antelope	Cayo district Maya Ranch Karst Hill
N_0 = Number of species	12	12	17	23	25	19	20
N_1 = Abundant species	4	9	13	16	20	15	14
N_2 = Very abundant species	3	9	13	15	24	15	15
H' = Shannon's div. Index	1.49	2.21	2.55	2.8	3	2.69	2.74
Evenness E_5	0.48	1	1.05	0.9	1.2	0.99	0.94
Rarefraction sample size of 20 trees	6	9	12	12	14	12	13
Rarefraction sample size of 30 trees	na	11	15	16	18	14	16
Living stems > 10 cm dbh (incl. vines)	70	40	35	63	51	76	52
Average stem dbh in cm	20	24	21	29	19	15	19.08
Number of trees (non vines)	130	66	100	150	121	232	52
Space per living tree in m^2	11.4	20	22.9	12.7	15.7	10.5	15.4
Total species identified	55	56	60	67	63	63	40
Dominant tree species (> 10% of total, >10cm dbh)	Gmelina arborea, Inga sp.	Inga sp., Trichospermum grewiifolium, Guazuma ulmifolia	Pouteria campechiana, Attalea cohune	Attalea cohune, Pterocarpus rorhrii, Pouteria campechiana	Spondias mombin	Licania hypoleuca, Xylopia frutescens	Dendropanax arboreus
Dominant woody species(>10% of total including stems < 10 cm dbh)	Gmelina arborea, Attalea cohune, Luhea sp.	Attalea cohune, Casearia	Attalea cohune, Casearia	Attalea cohune, Pouteria campechiana, Protium sp., Pterocarpus rorhrii	Protium sp., Attalea cohune, Cordia sp., Pouteria campechiana	Licania hypoleuca	Dendropanax arboreus
Largest biomass species with stems > 10 cm dbh	Gmelina arborea, Inga sp.	Musa balbisiana, Inga sp., Trichospermum grewiifolium	Pterocarpus rohri, Pouteria sapota, Inga sp.	Attalea cohune, Manilkara zapota, Pterocarpus rohrii	Spondias mombin, Cordia alliodora, Cordia sp., Bursera simaruba, Attalea cohune	Licania hypoleuca, Xylopia frutescens	Dendropanax arboreus

Intermezzo 6:

Variegated Cycad: *Zamia variegata* Warsz., Allg. Gartenzeitung 32: 252-253 (1845).

Zamia picta (Miq.) Dyer. *Biologia Centrali-Americani; Botany.* 3(16): 194. 1884. {*Biol. Cent.-Amer., Bot.*}

Zamia muricata var. *picta* Miq. *Tijdschrift voor de Wis en Natuurkundige Wetenschappen,* 1: 198-199. 1848.

The cycads are a small group of plants with many unique features, an ancient origin and a very long history. Cycads are known to have lived in the Permian era, over 200 million years ago - even before the dinosaurs roamed the earth. Although once abundant across the globe, the cycads are now greatly reduced in both numbers and distribution. There are now only about 250 species.

Zamia variegata is a cycad species with a subterranean tuberous stem bearing one to rarely more than three upright leaves of 3-10 ft long. The leaflets are in 16-33 pairs and are dark green with spots and flecks of cream or yellow, individual plants may be lightly or densely variegated. The natural habitat ranges from wet lowland forest to higher elevation pine-oak forest (sea level to 1600 ft). The known distribution is: Guatemala; watershed of the Rio Motagua from about Gualan to Puerto Barrios on the Caribbean, perhaps also near the Mexican border in the vicinity of Sayaxche, Guatemala), Mexico: reported from Chiapas state: Belize: coastal areas. The geographic range of *Zamia variegata* is large for a *Zamia* species if the total area is indeed covered by only one species. There is a decided possibility that more than one taxon may be involved because of the disjunct areas of distribution in Mexico and Guatemala. The 2003 study by the IUCN Cycad specialist group concluded that the current status of *Zamia variegata* is "Endangered" and estimates a population size of 250 – 500 individuals in the wild. The listed source of its decline is severe habitat destruction. However, the study only lists the species for Mexico and Guatemala. The Belize population remains largely unstudied. From the little information available, this species in Belize occurs only in the Toledo district, but the exact range and population density remains unknown. Threats to the species, if any, also remain undocumented.

The species was not found to be common in or near in the Sarstoon Temash National Park, but it was found on all field visits and even recorded from many transects. The conclusion is that the species is well represented in the area, and if the older information of its rarity is correct than it should be concluded that the Sarstoon Temash National Park is one the last strongholds for this species.

2.3.4 A new Ecosystem for Belize:

On the Landsat Satellite Image, a distinctive feature is visible more or less in the center of the National Park, midway between the Sarstoon and Temash Rivers. The bluish color on this image suggests a very open habitat, not a forest at all. Unfortunately this habitat is very difficult to reach as it is surrounded by dense swamp forest that is inundated through much of the year. Consequently, no scientists that we know of ever visited the area.

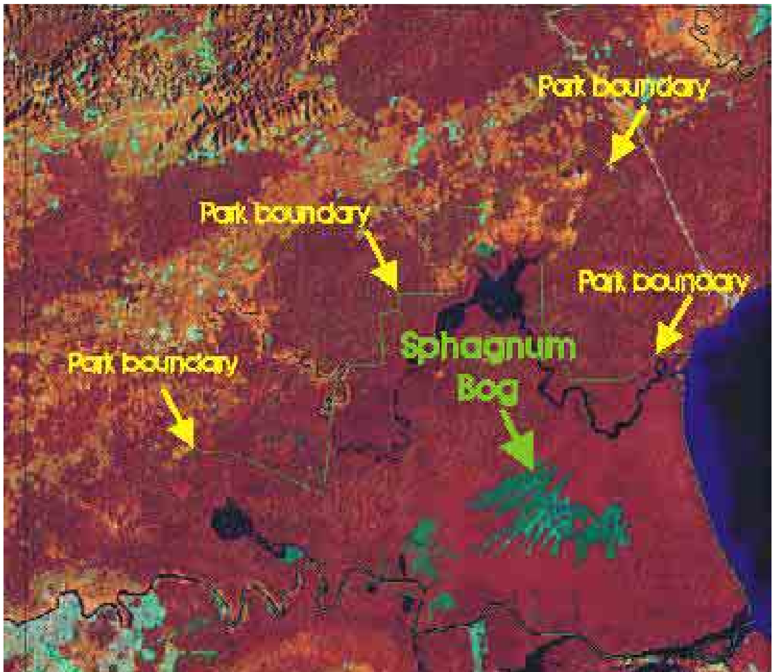


Figure 9. Satellite image showing location of the new ecosystem in Belize

During the 2003 REA, the Barranco trainees made an attempt to reach this enigmatic area while it was still at the peak of the dry season (May). We approached the habitat from the north, cutting our way for 2 km (1.3 ml) through the swamp forest. This forest, although not inundated at this stage was still wet and very difficult to walk through.

What we found was a very unusual ecosystem. Not very scenic and very hard to traverse. The landscape consisted of low, dense, but open canopied scrubland with a dense understory of sedges (*Hypolytrum longifolium*?), all of this growing on a bog of Sphagnum moss (probably *Sphagnum subsecundum*). Sphagnum moss is rare in Belize and restricted to higher elevations such as Victoria Peak and the Mountain Pine Ridge. Finding it in Belize at sea-level in these quantities was nothing less but astounding.

Figure 10. Sphagnum (subsecundum?)

Because of the difficulty penetrating the area, we managed to reach only the outer perimeter of the whole ecosystem. If the ecosystem is as uniform as the satellite image suggest, the whole ecosystem is no less than 2700 acres (1100 ha) large!

Sphagnum is intolerant of nutrients, limestone, salt and drought. Consequently it is found in situations where it is rain-fed.

For the Sarstoon Temash situation this means that the area does not receive any overflow from any of the rivers (which contain salts, nutrients and lime).

Typically a peat bog develops when a wetland fills in with organic matter forming a thick layer of fenn peat. This fenn peat can have different origins such as; reeds, sedges and tree-leaves. Once the wetland has been filled in, a swamp forest forms. If this swamp forest does not receive any outside nutrients, but is wet year round, Sphagnum moss can develop. Under the right conditions this Sphagnum moss can outgrow the trees and completely envelop them, forming a raised Sphagnum bog.

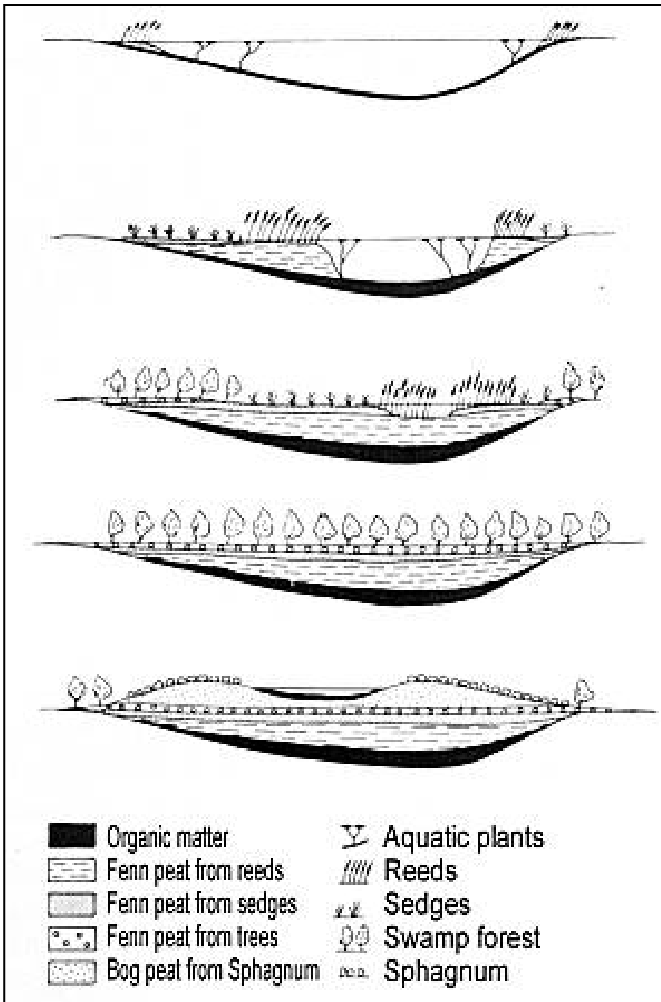


Figure 11. Typical process leading to the formation of a sphagnum bog

The bog in the Sarstoon Temash NP appears to be in-between the two last stages. From here it could technically be expected to grow in a real raised bog but many factors such as drought or fire could interrupt this process.


Figure 12. Schizocardia belizensis flowers

The vegetation in the bog apart from the sedge (*Hypolytrum longifolium*?) and the moss *Sphagnum* (*subsecundum*?), proved to be very species poor and consisting of species that are otherwise mostly known only from higher elevation areas on very poor acidic soils such as the Mountain Pine Ridge. A very attractive shrub was *Schizocardia belizensis* (left). Other species included *Cyrilla racemiflora, Clusia cf. massoniana, Connarus lamberti. Symphonia globulifera, Ouratea* sp., *Acoelorraphe wrightii, Blechnum* ferns, *Palicourea cf. crocea, Calophyllum brasiliense* and a few as yet unidentified species.

Wildlife was very poorly represented. Which is not surprising given the inhospitable conditions. There were even very few birds. The butterfly *Calospila sudias* was quite common but the most unusual form of wildlife was the incredible amount of Stick Insects (Phasmidae) seen.

3 INVERTEBRATES

Invertebrates were not a focus of the REA. But some interesting observations were made.

Sarstoon Temash National Park is home to only one tarantula spider species. The Red-rump Tarantula *Brachypelma vagans* is a common species with a red abdomen. It is often found in open, disturbed areas at low elevation.

A common insect in the Sphagnum swamps was a stick-insect. This represents an as yet unidentified species and was extremely common on all Sphagnum sites visited. The species is clearly associated with this habitat. I have not seen this species elsewhere in Belize.

Figure 13. Stick insect (Phasimidae)

More attractive insects are the butterflies (Lepidoptera). During the entire period of the REA, 46 butterfly species were noted. These include:

*Chetone angulosa;*Arctiidae
*Thecla (Ocaria) thales;*Lycaenidae
*Adelpha basiloides;*Nymphalidae
*Adelpha sp.;*Nymphalidae
*Aeria eurimeda;*Nymphalidae
*Anartia fatima;*Nymphalidae
*Anartia jatrophae;*Nymphalidae
*Archaeoprepona sp.;*Nymphalidae
*Caligo memnon;*Nymphalidae
*Caligo uranus;*Nymphalidae
*Catenophele mexicana;*Nymphalidae
*Catenophele numilia;*Nymphalidae
*Chlosyne gaudealis;*Nymphalidae
*Cissia hermes;*Nymphalidae
*Cissia libyoidea;*Nymphalidae
*Cissia ocirrhoe;*Nymphalidae
*Colubura dirce;*Nymphalidae
*Danaus gilippus;*Nymphalidae
*Dryadula phaetusa;*Nymphalidae
*Dryas iulia;*Nymphalidae
*Hamadryas laodamia;*Nymphalidae
*Hamadryas sp.;*Nymphalidae
*Heliconius charitonia;*Nymphalidae
*Heliconius cydno;*Nymphalidae
*Heliconius erato;*Nymphalidae
*Heliconius hecale;*Nymphalidae
*Heliconius ismenius;*Nymphalidae
*Heliconius sapho;*Nymphalidae
*Mechanitis polymnia;*Nymphalidae
*Morpho peleides;*Nymphalidae
*Morpho theseus;*Nymphalidae
*Phycoides vesta;*Nymphalidae
*Pierella luna;*Nymphalidae
*Taygetis sp.;*Nymphalidae
*Tegosa anieta;*Nymphalidae
*Heraclides anchisiades;*Papilionidae
*Papilio thoas/cresphontes;*Papilionidae
*Parides sesostris;*Papilionidae
*Parides sp.;*Papilionidae
*Protographium philolaus;*Papilionidae
*Eurema sp.;*Pieridae
*Phoebis sp.;*Pieridae
*Calephelis sp.;*Riodiniidae
*Calospila sudias;*Riodiniidae
*Riodinid sp. Nr. umbra;*Riodiniidae
*Automeris sp.;*Saturniidae

Most interesting species among these is *Morpho theseus*, a relative of the well known Blue Morpho (*Morpho peleides*). *Morpho theseus* does not have a common name but could be called a "Brown Morpho". This large butterfly was commonly seen sailing over the forest canopy on many of the locations visited. Normally this species is rare elsewhere in Belize.

4 FISHES

The fish fauna of Sartsoon Temash National Park was one of the main foci of the REA. Numerous observations were made and these observations were augmented with data provided in the book of Greenfield and Thomerson (1997). A total list of 42 fish species was compiled. This number is likely to be augmented, especially in the marine area.

With 25 of these species essentially being marine fish (59% of the total), the marine component of the Sartsoon Temash National Park fish fauna was most noticeable. This is not surprising given the coastal location of the area and the presence of two large rivers (Sarstoon & Temash that penetrate deep into the area. While freshwater output in both rivers is substantial during the rainy season, during the 4 month dry season, saltwater penetrates far up the rivers allowing marine fish to reach even up to Crique Sarco. The falls above Crique Sarco, essentially form the final barrier for this marine influence and above these falls, the fish-diversity can be expected to drop as the number of species is no longer augmented by marine fish.

An important family within the freshwater fishes, are the Cichlidae, fishes often locally known as "Tuba" or "Crana". Of these species, the "mojarra de oro" *Cichlasoma bocourti*, is the most interesting since, it is limited to a small area in Eastern Guatemala and Southern Belize. From Belize it is only known from the Temash, Moho and Rio Grande. A species in this group that needs confirmation is *Cichlasoma europthalmus*. This is a species from Northern Belize. Unfortunately the specimen on which the ID was based was caught in a trap and was partly decomposed.

Noteworthy is the virtual absence of aquatic vegetation. The consequence of this is that there is a limited basis for primary aquatic production in the area. Algae are probably the most important primary producers. What is left are two main sources of nutrient input. First one is marine in origin. Essentially, anything that swims its way up river. Second source of input: anything that comes <u>down</u> river. Very important here are fruits and seeds from riverside vegetation. A large number of fish is dependant on fallen fruit. A phenomenon that is not uncommon in tropical fish. In the Case of the Temash River, the most important food source is the Bribri *Inga vera*. See the intermezzo on that shrub in the vegetation section.

Noticeable was the relative scarcity of fish and relative scarcity of fish predators such as Crocodiles, Cormorants, Anhingas etc. This paucity of predators raises the suspicion that the fish population is depressed. Whether this depression is by natural causes (lack of primary producers?) or over-fishing, is not clear at the moment. Over-fishing by humans must play a role. This suspicion is augmented by stories about over-fishing (by outsiders but with assistance of local people) since the completion of the road from Crique Sarco to Punta Gorda. From the seaside, there is a high fishing pressure, not just by local fishermen but notably by fishermen from the community of Sarstun in Guatemala as we witnessed ourselves during field work.

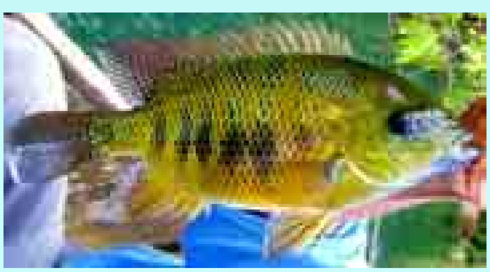
Intermezzo 7: some fish species

Pufferfish: *Sphoeroides testudineus*, a marine species

A goby: *Lophiogoius cyprinoids*, a marine Species

The Jack: *Caranx latus,* a marine species.

The “sleeper” *Erotelis smaragdus*, a marine species

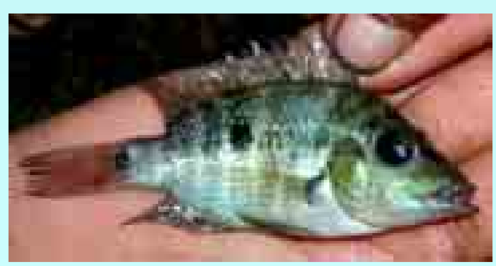


The Cichlid *Cichlasoma bocourt*i, a fresh water species.

The mudeel: *Ophisternon aenigmaticum,* a fresh water species.

The Cichlid *Cichlasoma spilurum*. A fresh water species.

The Cichlid *Cichlasoma maculicauda*, a fresh water species.



The Cichlid *Cichlasoma robertsoni*, a fresh water species.

5 AMPHIBIANS

The number of amphibians encountered was very disappointing. The timing of the surveys no doubt caused this apparent paucity of amphibians. Most amphibians (specifically frogs and toads) in Belize reproduce after the first heavy rains of the rainy season. Even then, it is often important to be there at the right moment, since in many species the reproductive effort is limited to one or very few nights after the first heavy rains.

An additional problem in identifying amphibians in the area may be the extreme wet and often inundated nature of much of the terrain. Most frogs and toads prefer to breed in temporary pools since these are free of predators such as fish. With much of the terrain being accessible to fish, the area may not be the most suitable for many frogs and toads.

The number of species noted was very small and include: *Bufo marinus, Leptodactylus melanonotus* and *Rana vaillanti.* The latter was interesting because it was found (amongst other locations) in the Conejo Creek which was distinctly saline at the moment of observation.

Undoubtedly more species occur, possibly as many as 22 (based on type of terrain and nearby presence of other species), but with the possible exception of the specialized species in the Sphagnum bog, no rare or unusual species should be expected.

6 REPTILES

Reptiles can be difficult to assess. Most species lead secretive lives and are encountered only by chance. Such chance meetings combined with literature records (Lee, 1996), revealed 22 species for the project area (see appendix).

None of these species are unique to the area. The Green Iguana *Iguana iguana* appears widespread but most common along the Upper Temash River near Crique Sarco. One interesting species is (*Norops pentaprion*). This is a very widespread but extremely rarely encountered species. The only known records from this species were previously all from the Cayo district.

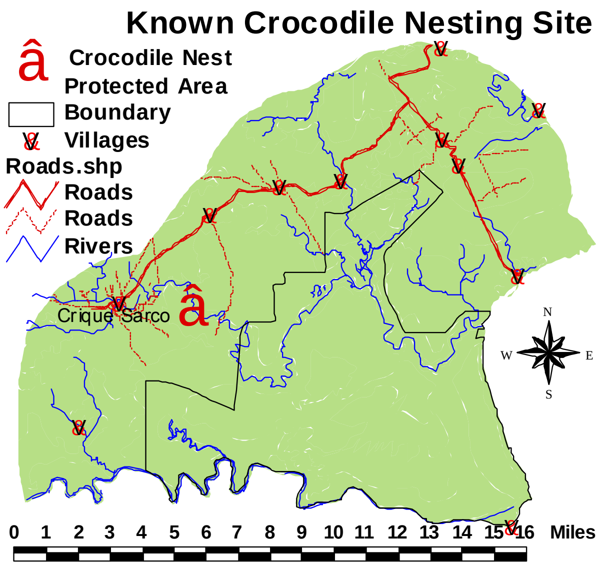


Figure 14. Known crocodile nesting site

Crocodiles do occur in the area and even breed here. No crocodiles could be caught and thus identification remains uncertain although it is believed that all crocodiles in the area belong to the species *Crocodylus moreletii*.

Crocodiles were surveyed along the lower Temash and appeared to be very uncommon here. A survey was held between UTM 288100/1767300 and 285900/1770200 (4.4km) and the density was only 0.7 individuals per km of river shore. Crocodiles are reportedly more common further upstream and are known to nest near Crique Sarco. One reputed nesting site was visited and based on experience with other nesting sites in Belize, the location indeed looked very suitable for the species. The Crique Sarco volunteers claimed that people from the village collected crocodile eggs (for human consumption) here on an annual basis but that in some years one or more nests would escape discovery and subsequently baby crocodiles would be seen. The heavy predation on eggs together with the high fishing pressure (depletion of prey base) may be responsible for the low crocodile count along the river.

Figure 15. Hickatee in the Temash

Important is the presence of the Hickatee *Dermatemys mawii*. This species is under high pressure as a result of heavy hunting in most of its range. Along the Temash River, it is supposed to occur mostly between the falls above Crique Sarco and the Temash Lagoon. Below that the rivers is getting too saline for this species. The fact that no less than three individuals were seen simultaneously during fieldwork near Crique Sarco is considered a possible indication that the Hickatee population in the area is still viable. People in the area hunt Hickatees by striking them with spears or by diving for them. Sometimes they will take hooks baited with Bribri.

7 BIRDS

7.1 METHODS

As part of this rapid ecological assessment avian surveys were conducted by Peter Herrera. As much as possible, Mr. Herrera used the same vegetation transects to do his bird counts. Throughout the REA, general site walkover surveys were conducted, and the species and numbers of all birds encountered were recorded or estimated each day (Appendix #).

Most transect surveys were conducted between 05:45 and 08:15, with the first survey each morning beginning at first light when the first diurnal species begin to vocalize. Raw transect data, transect dates and times, weather conditions at the time of survey and a compilation of transect results is presented in appendix #.

Each established transect was 200 meters long and as straight as the terrain would allow. Wherever possible, the bird transect was the same as one of the vegetation transects. Birds were counted at five points along the transect, with each point spaced 50 meters apart. Because of the short distance between points, most individual birds could be heard from multiple points along the transect. Every effort was made to not count the same individual twice. Only new individuals encountered at each point were recorded. In a sense, these surveys were modified point counts, in that many species could be heard from all five points along the transect. Ideally, bird transect surveys should be at least one kilometer in length, with points spaced at least 200 meters apart, but this is not always practical in dense forest and rugged terrain.

7.2 RESULTS

A total of 226 bird species was recorded during the REA. This is a fairly high number for a singe REA and no doubt the number can still be augmented. A number of these species was encountered throughout. 22 species were encountered in 80% or more of the data points. These "omnipresent" species are (table 8):

Table 8. Bird species found throughout the project area

Great Tinamou	Turkey Vulture	Short-billed Pigeon
Olive-throated Parakeet	Brown-hooded Parrot	Red-lored Parrot
Little Hermit	Rufous-tailed Hummingbird	Black-headed Trogon
Slaty-tailed Trogon	Golden-fronted Woodpecker	Ivory-billed Woodcreeper
Black-faced Anttrush	Dusky-capped Flycatcher	Great Kiskadee
Tropical Kingbird	Northern Bentbill	Brown Jay
Spot-breasted Wren	White-breasted Wood-Wren	Red-throated Ant-Tanager
Montezuma Oropendula.		

None of these species is really unique for the area. The only unique presence we found was the large density of White-necked Jacobin that was noticed during fieldwork along the Temash near Crique Sarco. Nowhere in Belize have we seen this many White-necked Jacobins together. Whether this was a seasonal occurrence or standard in this area is impossible to say.

As interesting as these "omnipresent" species are the absent or virtually absent species. One very common species throughout most of Belize is the Blue-Crowned Motmot. This species was surprisingly absent apart from the Quarry at Midway. This absence is probably the result of the scarcity of suitable nesting sites (cliffs) for this species.

In spite of the designation of the area as a "wetland" the number of wading birds (such as herons) encountered was extremely low. In spite of the wetness of the area, the available water is either under the forest canopy or is too deep for waders. Only forest waders such as the Bare-throated Tiger-heron and the Agami Heron find a good habitat here.

But if the water is deep, then at least it should be good for aquatic birds such as Cormorants and Anhinga. But even these birds were uncharacteristically scarce. This is very puzzling and the question is raised whether the prey situation (fish) for these species is not depressed.

Other species that are absent or rare are the larger species that are usually considered good game species. Absolutely no Great Currasow's were recorded and only a few Crested Guans and Muscovy Ducks. This while the habitat appears perfect for these species. Even other larger birds such as Keel-billed Toucans and Mealy Parrots showed depressed numbers. Both species are considered fair game and judging by the amount of parrot feathers found near villages and human presence even preferred game. The only large bird still widespread throughout the project area is the Great Tinamou. Possibly due to its secretive habits, it is a more difficult prey for hunters. Clearly the current hunting pressure throughout the project area including the project area is not sustainable.

Figure 16. Ornate Hawk Eagle photographed along the Temash near Crique Sarco (Sept 12, 2003)

Species noted during the REA that are of conservation concern include the Wood Stork, the Muscovy Duck and the Ornate Hawk Eagle (see picture of specimen photographed at Crique Sarco).

Table 9. Bird diversity among different sites

Birds	*Barranco forest 1*	*Barranc forest 2*	*Midway Quarry*	*Midway high forest new layout*	*Temash "Hill" Forest*	*Temash Manicaria*	*CrSar River Scrub*	*CrSar High Swamp Forest*	*Conejo swmp forest*	*Conejo high forest*	*Sunday Wood low forest*	*Mayfl lowland 1*	*Mayfl lowland 2*
N_0 *= Number of species*	40	42	38	38	30	17	38	37	41	46	54	40	42
H' = Shannon's div. index	3.65	3.64	3.55	3.56	3.29	2.69	3.5	3.54	3.59	3.67	3.87	3.56	3.59
Evenness E_5	5.24	2.13	2.28	2.3	1.77	1.8	1.76	2.77	1.62	1.35	1.75	1.42	1.54
Rarefraction at sample size of 10 birds	9	9	9	9	9	9	9	10	9	9	9	9	9
Rarefraction at sample size of 20 birds	16	18	18	18	16	NA	17	18	16	17	18	17	17
Rarefraction at sample size of 30 birds	24	25	25	25	22	NA	24	26	22	23	25	23	23
Rarefraction at sample size of 40 birds	30	32	32	30	27	NA	30	32	27	29	32	27	29
H' index for tree vegetation at same site	2.11	2.08	2.83	2.96	2.98	2.1	NA	2.91	2.29	3.19	NA	NA	2.21

7.3 BIRD DIVERSITY

As indicated above, biodiversity indices were calculated for bird-counts at the vegetation transects. For this the same methodologies as in the vegetation transects were used (see that chapter). For sake of comparison, the data for two lowland forest sites at Mayflower National Park are included in the table.

The comparison between sites (table 9) shows a surprising similarity in biodiversity between sites. Most sites even have a bird diversity index (not species composition) very similar to any of the two Mayflower sites. Only clear exception is the *Manicaria* forest along the Temash River. This clearly has the lowest biodiversity, which initially does not seem surprising since this site also had one of the lowest tree diversity indices. Having noticed this, it also becomes obvious that high tree diversity does not always translate in high bird diversity and vice versa. Some of the "richer" bird sites such as "Barranco forest transect #2" had a very low tree diversity while one of the lower bird diversity sites "Midway High Forest New Agricultural Layout" had a very high tree diversity index.

It is clear that high diversity in one group of organisms does not always translate in high diversity for any other group of organisms. In some cases this is clearly explained as those organisms not having the same habitat requirements. In one extreme example it would be obvious to everyone that a lake will have a high fish diversity but has a very low tree diversity. In other cases the differences can be explained as resulting from incompatible methodology. In the case of birds, there is a clear seasonal factor. In the period just before reproduction birds are more active and easier identified by sound than at other times of the year. Migration also has a profound impact on the diversity of birds in a given area. Trees on the other hand just stand there and can be measured and identified at any time of the year.

8 MAMMALS

Mammals were assessed on an opportunistic basis during all fieldwork. In addition, interviews were held with users (including some hunters) of the area to assess the presence of the more conspicuous species. Much work still remains to be done, and no more than a total of 24 mammal species were documented with confidence (see list in appendix).

The focus of the survey was very much on the larger species. The smaller mammals, especially the rodents were not monitored. Establishing meaningful lists for small mammals requires intensive trapping efforts using multiple trap types and baits. Arboreal small mammals are notoriously difficult to sample and no proven time-efficient methods have been developed as yet.

Interesting is the claim by some informants that Cacaomistles *Bassariscus sumichrasti* occur in the area. This is a rare species throughout most of Belize and the only place where it appears to be common is in certain areas along the Maya Mountains. (Meerman et al. 2003)

Manatees and Bottle-nose Dolphins patrol the coastline and Manatees enter the rivers. Unfortunately, Manatees are still heavily hunted (mostly so by people from Guatemala it is claimed by the local informants).

In general, very few mammals or mammal signs were noted. This may partly be attributed to the inundated nature of much of the terrain which would make life difficult for most terrestrial species. Of much greater influence though is the extreme hunting pressure. The only larger mammal that the Q'eqchi' claim not to hunt is the Black Howler Monkey *Alouatta pigra* and this is usually the only larger mammal that is abundantly present through most of the area.

Noteworthy in this aspect is the apparent disappearance of the Warree or White-lipped Peccary *Tayassu pecari* throughout much of the area. Only the residents of Crique Sarco claim that Warree's still can be found in the area. Residents of Barranco claim the same but people in Midway, Conejo Creek and Sunday Wood state that Warrees have disappeared from their area, making the Barranco claim somewhat questionable.

Large cats such as the Jaguar *Panthera onca* still have a presence in the area and each community has stories about when the last one was shot near their village. Jaguars are perceived to be a menace since they eat pigs and dogs. This problem is partly a result of the habit of the villagers to have their pigs roam free in and around the village, including the forest. Occasionally there are stories of Jaguars entering the village and stealing dogs or pigs that are penned in. Given the reluctance of Jaguars to come out in the open, this must be seen as an indication that the Jaguars are unable to get enough food in the wild. This would indicate a severe depletion of the wild prey basis.

In general the amount of Mammals encountered and reported was rather low. Much of the terrain is difficult for many terrestrial mammals but most importantly it has to be concluded that the hunting pressure is too high and clearly not sustainable.

9 ASSOCIATIONS BETWEEN ANIMAL SPECIES AND ECOSYSTEMS

This study focused strongly on ecosystems. With vegetation being the basis for ecosystems and biodiversity, the floristic biodiversity can be assumed to be a proxy for overall ecosystem biodiversity. Having done this, the next step is to see which animal species are linked to a certain ecosystem.

One interesting link exists in the ecosystem that is found along the Temash River just below Crique Sarco. This habitat is probably natural although it is probably affected by occasional agriculture (Mata hambre) by people from Crique Sarco. The vegetation is not very impressive and is dominated by broadleaved shrubs, vines and grasses.

One important species occurring in this habitat is the Bribri (*Inga vera*), which has

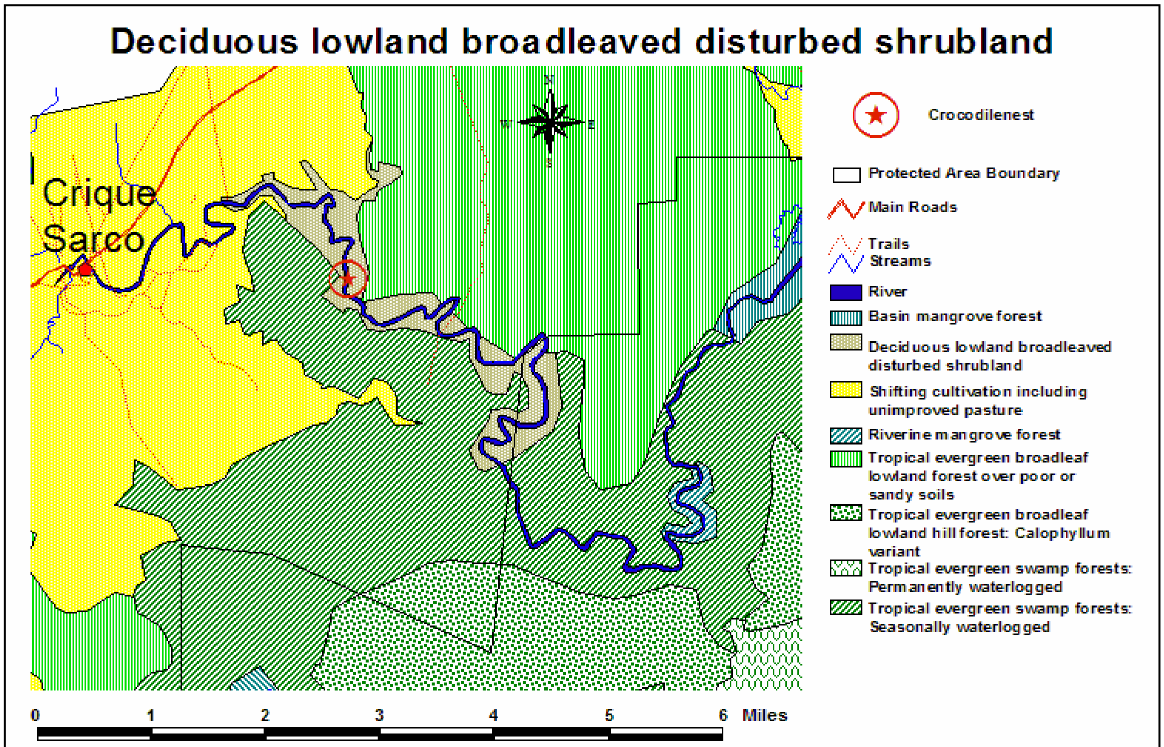


Figure 17. Location of the deciduous lowland broadleaved disturbed shrubland in the project area.

been dealt with in an intermezzo earlier in this document. The Bribri is a critical food resource for much of the Temash's aquatic life including fish and the endangered Hickatee (*Dermatemys mawii*). The banks of this riverside ecosystem are a mix of alluvial deposits and decaying plant matter, an ideal substrate for nesting Crocodiles (*Crocodylus moreletii*), Hickatees and Green Iguana's (*Iguana iguana*). Most of this ecosystem lies outside the protected area, but is one of the more productive ecosystems found in the entire project area.

The "Tropical Evergreen Lowland Peat Shrubland with Sphagnum" ecosystem, the newly discovered ecosystem, is obviously very interesting, since it is unique in all of Central America. Unfortunately we could conduct very little research in this ecosystem. It seems though that the place is poor in wildlife. The plant biodiversity is low and this often translates in low animal diversity. Also the habitat is very "extreme", even when not inundated, it must be difficult to cross for most larger mammal species. An interesting find was the unidentified stick insect (Phasmidae) that was very common here.

Another invertebrate that appears quite special is the "Brown Morpho" (*Morpho theseus*). This species was unusually common in high forest habitats. And there appears to be a link with high forest of the type: "Tropical evergreen broadleaf lowland forest over poor or sandy soils". The species (and/or the larval foodplant) is probably intolerant of disturbance since it was never seen over extensive areas of secondary growth.

Another interesting ecosystem is the "Tropical evergreen broadleaf lowland forest over steep calcareous hills" that is found at the quarry site near Midway. The soil conditions here are so different from the rest of the project area that nearly half of the plants found there were not found elsewhere. The same is no doubt true for some animal species. The Blue-crowned Motmot, normally a common species throughout Belize was not found in the project area but in this ecosystem

Unfortunately, mammal observations were too rare to be able to draw any conclusions about special relationships to certain ecosystems. For many of the terrestrial mammals, the "high ground" or "upland" ecosystems, are probably of crucial importance. With much of the project area, and certainly much of the actual protected area, being inundated for part of the year, it is vitally important for terrestrial mammals to be able to retreat to dry land.

As so often, anywhere in the world, when the protected area was designed, wildlife movements were not taken into consideration. The map in figure 18 shows which areas are of critical importance for the local wildlife, and much of these are outside the protected area. Realizing this, it is hardly surprising that a species as the Warree or White-lipped Peccary has already become locally extinct in much of the project area.

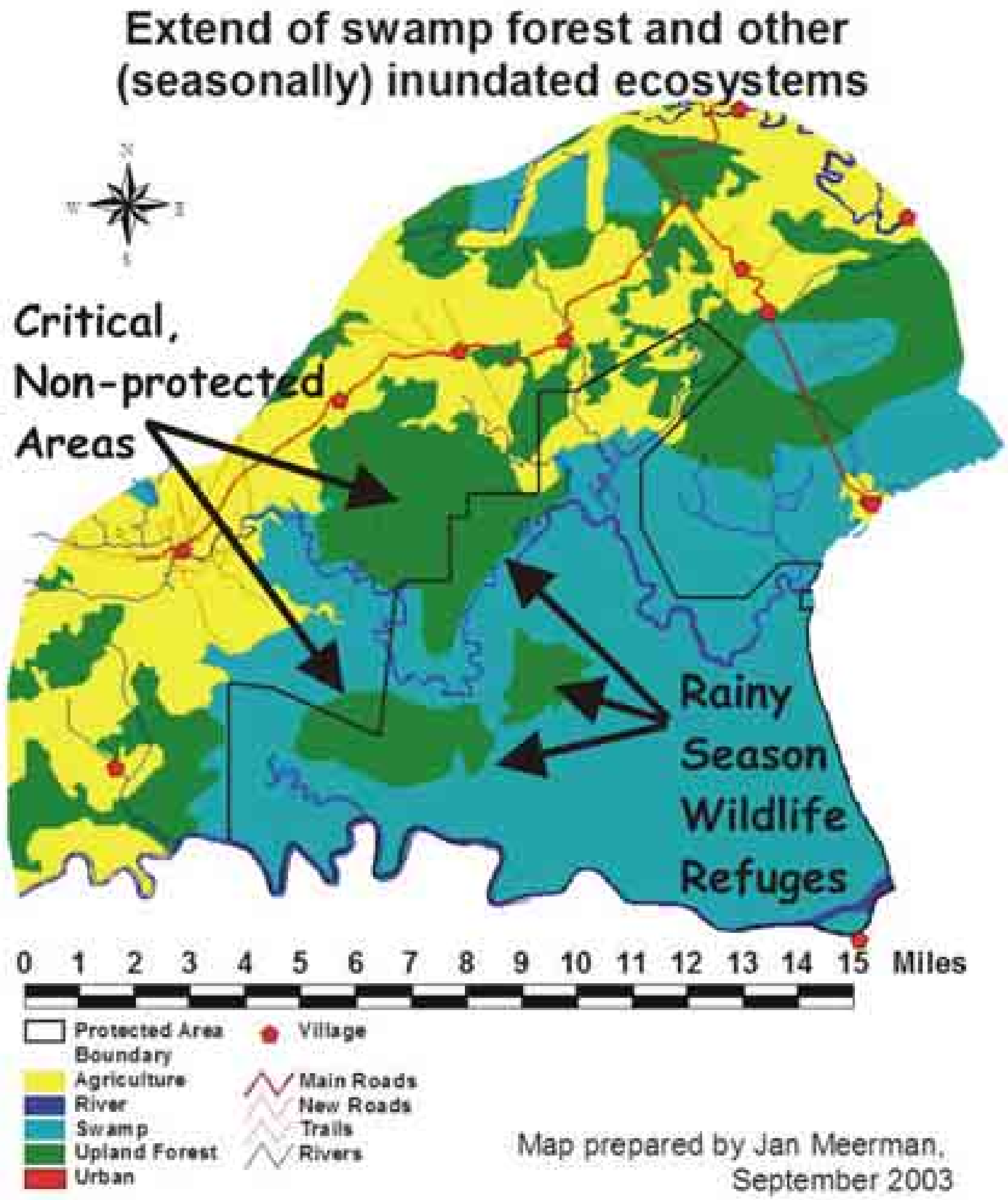


Figure 18. Seasonally inundated ecosystems

The following table 10 gives an indication of known ranges of some animal species occurring in the project area:

Table 10. Home ranges of some mammal species

Home ranges	***Jaguar***	***Puma***	***White-lipped Peccary (herd)***	***Tapir***
Kilometers	28 - 40 km^2	200-800 km^2	200 km^2	1.25 km riverlength
Hectares	2,800 - 4,000 ha	20,000 - 80,000 ha	20,000 ha	
Acres	7,000-10,000 ac	50,000-200,000	50,000 ac	
Miles	11-15 sq mile	77-310 sq ml	77 sq ml	0.83 ml
Country	Belize	USA	Peru	Macal River, Belize
Notes	Females use smaller ranges within male range	One or more females may be included in male home range.		Figure reflects optimal riverine habitat.
Source	Rabinowitz and Nottingham 1986.	Reid, 1997	Reid, 1997	Fragoso 1991

How difficult it is to provide these species with enough protected area is indicated by the following table 11, indicating the size of some well known protected areas in Belize:

Table 11. Size of some protected areas in Belize

Sarstoon Temash National Park	41,000 ac
Cockscomb Basin Wildlife Sanctuary	86,929 ac
Bladen Nature Reserve	99,678 ac
Mountain Pine Ridge Forest Reserve	126,825 ac
Rio Bravo Conservation Management Area	230,875 ac

It is clear that some mammal species need large ranges if they are to maintain viable populations. It is also clear that even most of our larger protected areas do not provide for this. For this reason biological corridors are of great importance.

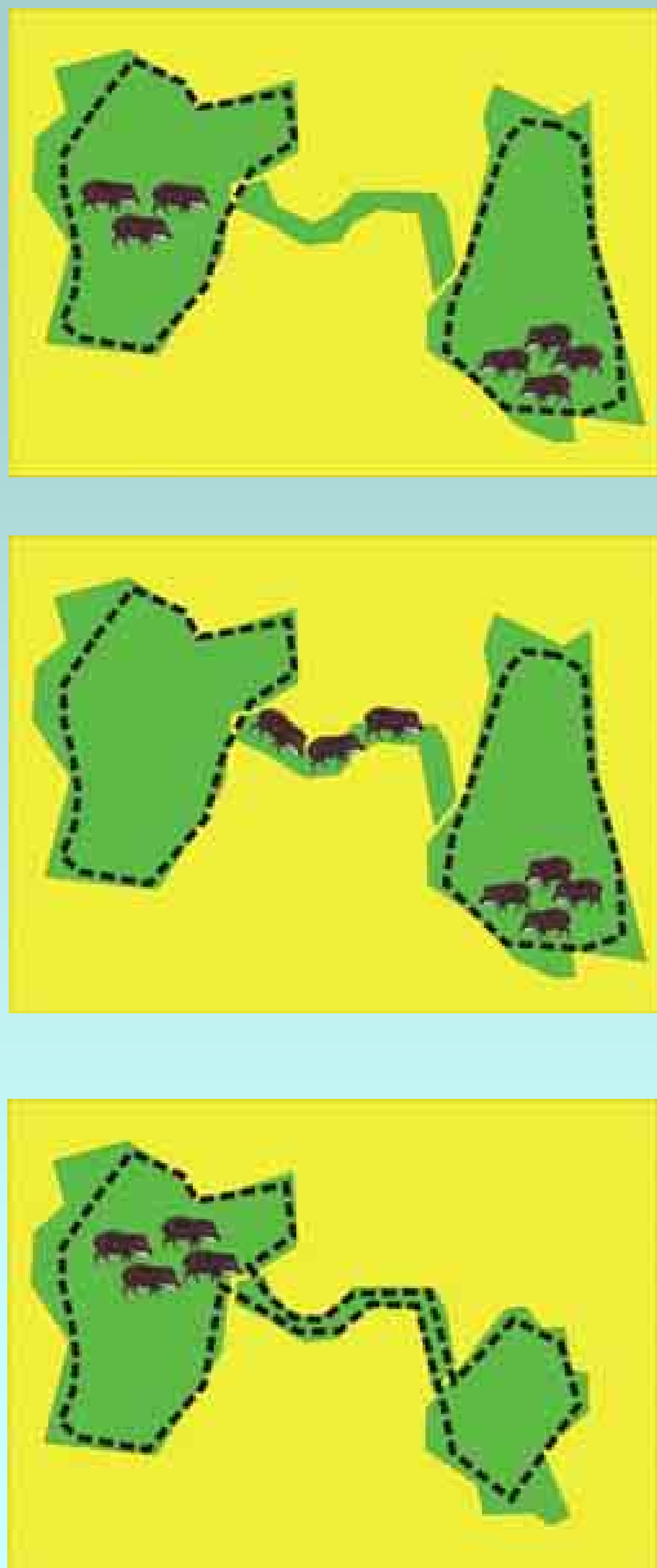
10 BIOLOGICAL CORRIDOR

Protected areas constitute the principal tool for biodiversity conservation. This approach – designating areas with particularly important characteristics or biological richness and placing them under management regimes that maintain those qualities – does, however, have shortcomings if employed as the sole conservation technique. Biological corridors have been proposed as a means of overcoming those problems.

The central issue is the fragmentation and eventual elimination of natural habitats, and their replacement by landscapes modified by man. This process is the most important cause of species loss in the current global extinction wave. Where natural habitat is already broken up, protected areas are perforce established in the residual natural areas and are thus isolated from each other and often small in extent. Where natural habitat is still extensive, as in Belize, the areas themselves are scattered but retain habitat connections beyond their boundaries. In Belize, the fragmentation process is, however, only at an earlier stage. On-going trends in demographic growth, economic development, and land use change all indicate that the end-result in the foreseeable future will be the same – a scatter of protected areas of various sizes, isolated from each other, and themselves coming under increasing pressure.

The problems lie in the ecological dynamics of smaller, fragmented, isolated habitat patches as against extensive, continuous, tracts. These have now been well-studied, using island biogeographical theory supported by field observations and experimentation. The basic phenomenon is that a given area can, in isolation, support a much less diverse biological community than the same area embedded within a larger extent of the same habitat. When isolated, the number of species therefore falls, rapidly at first but sustained for a long period of time, to a new, more impoverished, level. The degree to which this "relaxation" occurs is dependent on such factors as the area of the relict patch, the proximity of other similar patches, and the ability of individual species within the original community to traverse the intervening, now less hospitable, terrain. The actual dynamics are many and varied, and act in different ways with different species according to their ecology and population biology, but four major processes – often acting in combination – can be identified and illustrate the issue.

Many populations of animals and plants are patchily distributed, and may simply not occur in remnant habitat fragments. There is an element of chance in this process, but the likelihood of loss increases as the area of habitat is reduced. The logical end-point is reached when no further habitat remains and all dependent species are eliminated. Species with specialised requirements are likely to be affected first. A rare species such Orange-breasted Falcon *Falco deiroleucus* that appears to need cliffs in extensive forest would, for instance, be lost if it happened that no such combination was included in the protected area system. Species that combine specialist requirements with limited dispersal capability are even more at risk.



Intermezzo 8. Potential functioning of a corridor.

Three hypothetical forests (green), each surrounded by open habitat (yellow: agriculture or open savanna). Two of these forests are large enough to have a herd of White-lipped Peccaries, a species notorious for it's intolerance to habitat fragmentation (Top figure, normal home ranges of each herd indicated by a dotted line). The narrow line of forest between the two large forests in itself does not provide a suitable habitat (too small, not enough food) to have its own resident herd of peccaries.

This narrow forest fragment, however, does provide the peccaries with enough cover to allow safe passage from one forest to the next (middle figure). Now, the narrow forest, which in itself may be unsuitable habitat for long term survival, acts as a biological corridor for the two peccary populations, thus enabling genetic exchange and even re-colonisation should the species become extinct in one of the two forests.

A similar situation exists when only one of the three forests is big enough to house a herd of collared peccaries. In this case the forest corridor (bottom figure) allows the herd to include the medium sized forest fragment in its home range.

Even before this end point is reached, populations may fall below the minimum level (often reckoned at c. 1000 individuals) for long-term viability. In-breeding effects reduce vigour, and small, isolated, scattered populations become vulnerable to random events (e.g. fires, hurricanes, epidemics) or pressures (e.g. hunting) from which they could previously recover. Reduction in population density can even break up breeding strategies. Naturally wide-ranging but thinly distributed species, often top-predators, are likely to show these effects first. Again, the effect becomes more pronounced as the area is reduced. Notice for example the limited space in the current study area for a healthy Jaguar population.

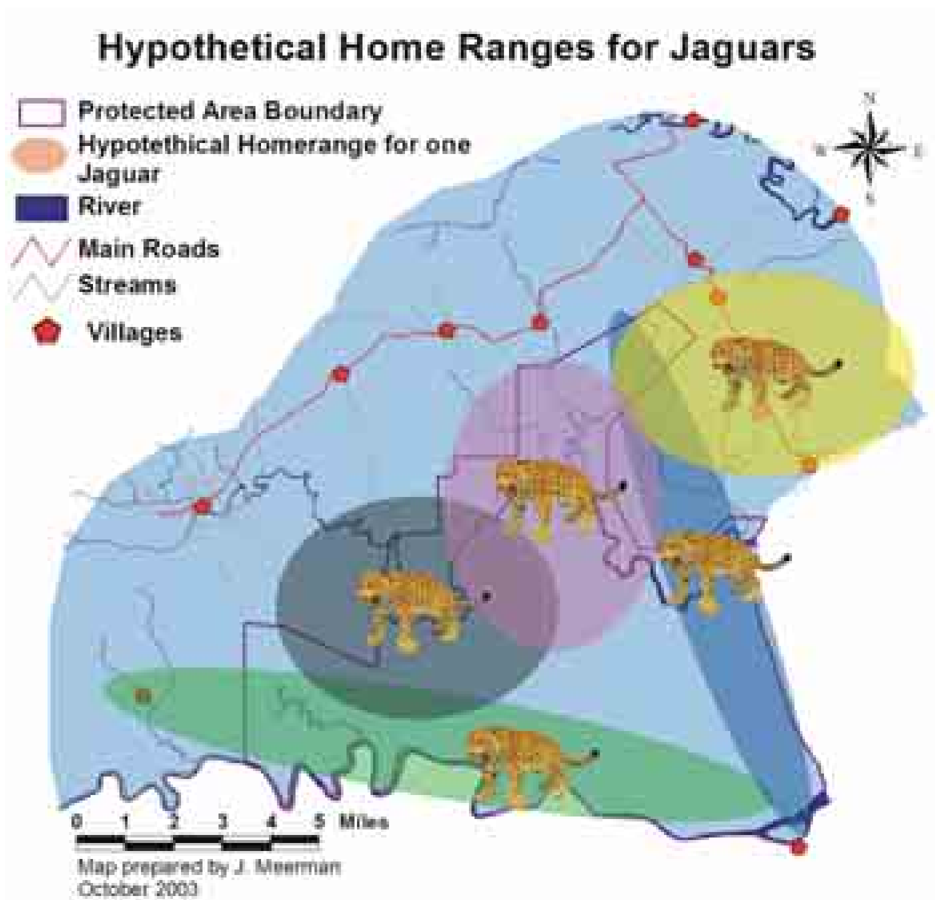


Figure 19. Hypothetical ranges of Jaguars in the project area

While the general habitat remains, critical elements of that habitat required by particular species at particular times may be lost. These requirements are often seasonal – food and water being obvious examples – and may only be needed for a short but critical period. Species engaging in regular movements, including long-distance migrants, where staging points on the migration routes are used briefly but are nonetheless essential, are cases in point. A similar process takes place where the habitat is changed in a way that renders it unsuitable – e.g. edge effects allowing penetration of competitors or causing micro-climatic changes. In both cases, the habitat may appear to have been conserved, but no longer provides all the characteristics essential for survival of certain members of the community. A good example of the latter is the White-lipped Peccary. These highly social animals need vast ranges to survive as a group

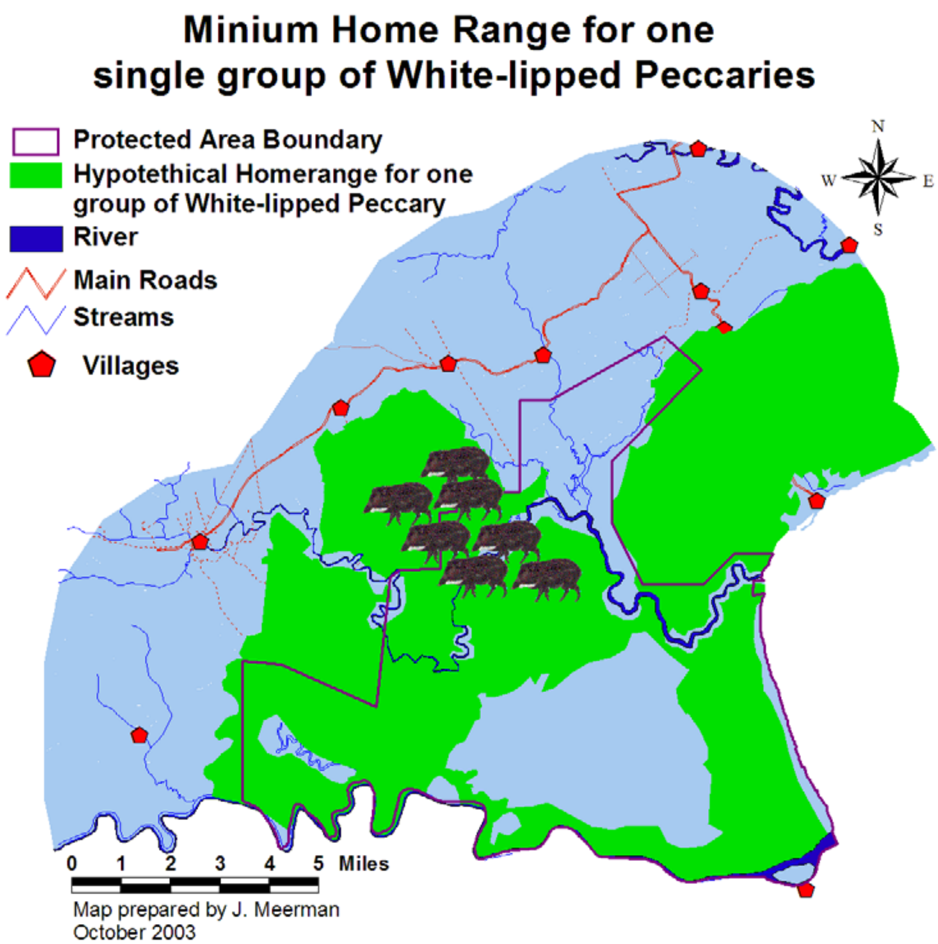


Figure 20. Minimum home range for one single herd of White-lipped Peccaries

Although the number of species occupying a given area may be more or less constant, the actual species composition is not. There is always a degree of species turnover on a given site, with some species being lost and replaced by others that have immigrated into the area. Some populations may come and go in this way while others, especially those in marginal habitat, are only maintained by regular replenishment from a neighbouring source population. This is a physical version of the genetic interchange mentioned above, and is broken up by fragmentation and isolation. The local extinction then occurs without the corresponding replacement and local biodiversity is diminished.

The effects are compounded by reduced resilience in the natural system. Loss of certain community members results in an extinction cascade, as the species dependent upon them are also lost. Furthermore, the system also loses its ability to adapt to climate change, whether it occurs in medium to long-term cycles or uni-directionally. In the past, the adaptation has taken the form of major shifts in geographical range, often into "refugia" where populations can persist before expanding again as conditions ameliorate. A good example of a medium-term response - and present species distributions are in large part explicable in terms of population movements during glacial periods. In both cases, however, the process assumes continuity of natural habitat through which the populations can move while a barrier to that movement results in extinction. Man-modified habitat now represents just such a barrier, created on an enormous scale and so likely to disrupt this natural adaptation process fundamentally. The potential for a yet greater extinction rate is much enhanced, even inevitable, by the combination of these man-made barriers and the triggering of significant climate change through anthropogenic greenhouse gas emission.

Protected area establishment, then, is a conservation strategy with definite limitations. These limitations may be reduced by protection of more and larger areas, especially when carefully selected, but cannot be removed entirely. Furthermore, the extent required stretches the limits of practicality. Current targets such as the 10-12% protected area coverage used by the World Conservation Union are indeed only targets where actual figures are very much lower. It has been reckoned that 25-75% protection of each ecosystem is a minimum requirement to conserve fully the biodiversity of the USA. Although the Belizean protected area system is one of the most comprehensive in the world (over 30% of national area, with full representation of all natural habitats to some degree), even this is almost certainly inadequate to ensure survival of all species in the country. The key issue is connectivity between the protected areas, and the response is to broaden the strategy by keeping protected areas as the core conservation sites but to promote actions in the wider landscape that link them up. These linkages are the biological corridors. Broad connecting stretches of natural habitat is the ideal, but corridors can operate at any scale and in any way that allows some form of interchange through the landscape and between core sites. Under these conditions, even a partial linkage is better than none. The concept is encapsulated in the definition used by the US Circuit Court of Appeals in 1990 - " avenues along which wide-ranging species can travel, plants can propagate, genetic interchange can occur, population can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas."

Unfortunately, the Sarstoon Temash National Park is very isolated from the remainder of the National Protected Areas. Also the existing link over non-protected lands is tenuous. The best link is with the east towards the Ya'axche Protection Area (Golden Stream, see map in figure 21), but the forested land in between is under high pressure and likely to lose its corridor functionality in the next decade or two.

Consequently the position of Sarstoon Temash National Park in the National Corridor system is weak. This is regrettable not only for the long term survival of its own wildlife but also because of the importance of the park as a cross-boundary protected area.

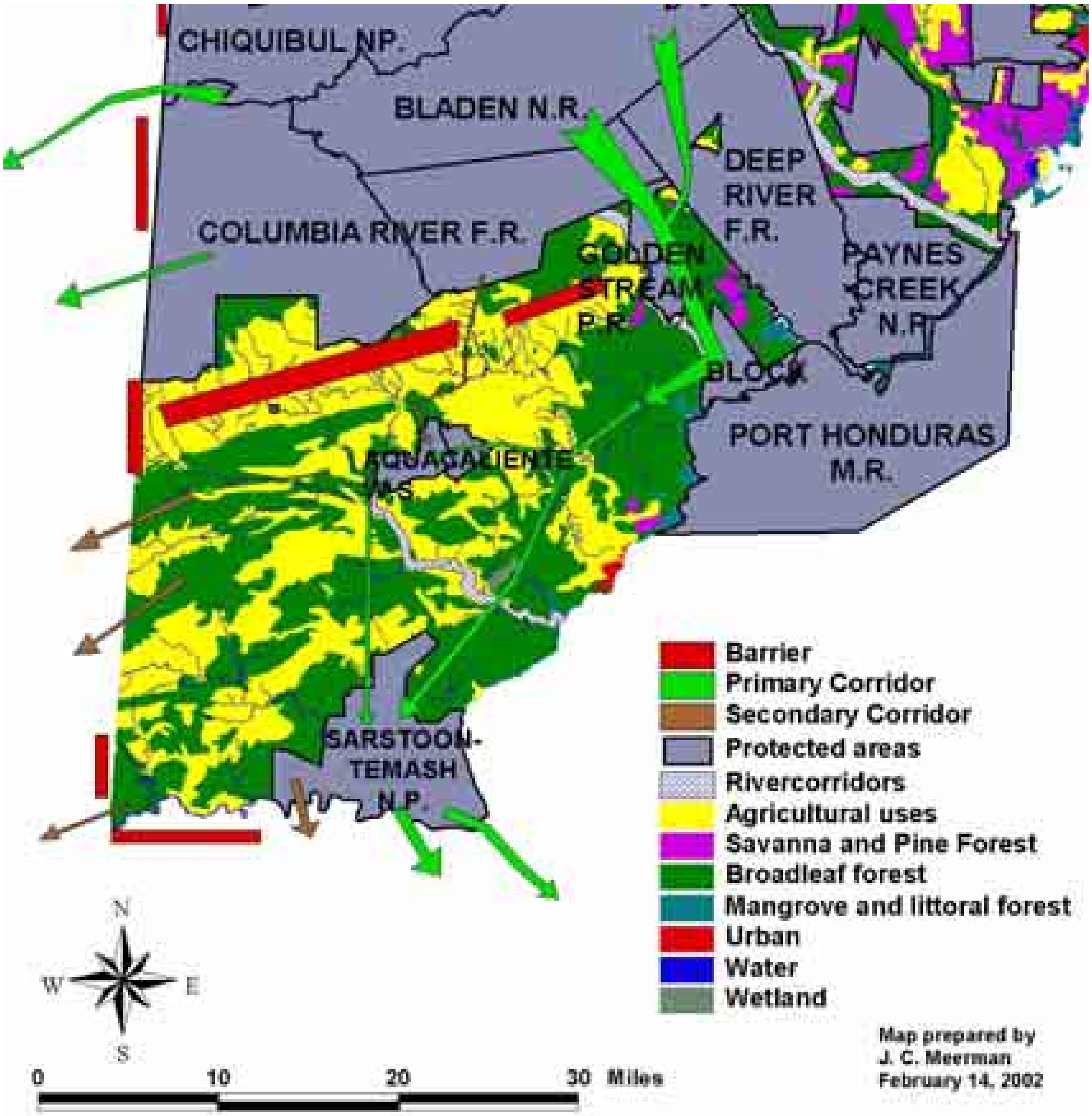


Figure 21. STNP within the Belizean Biological Corridor

One of the main management requirements for SATIIM is therefore to maintain and strengthen the biological corridor from Sartsoon Temash National Park to the Ya'axche Protection Area.

11 THREATS

11.1 HUNTING.

Hunting is part of the lifestyle in all of the communities in the project area. No one sees any harm in it. Often economic necessity is given as an excuse for hunting. Certainly, with a population whose economy is largely based on subsistence, game meat can be an important source of protein for the family. However, there are several arguments against this, economics is one of them. The gun is expensive even though the expense is not recurring. But cartridges are also expensive and this expense is recurring. As far as we are aware, we don't know of any study of how many shells it takes on average to take one prey, but every shell spent adds to the price of the meat. So to some extend, hunting can be seen as a luxury occupation. This idea is strengthened by the observation that many villagers commonly shoot medium sized birds as game (Parrots, Toucans), the economics of this makes this type of meat then at least equal to, or probably substantially more expensive than chicken. It appears that hunting is more culturally engrained than a real economic necessity.

An additional problem with hunting is "carrying capacity". Hunting is sustainable when the number of hunters is low, and when the hunters migrate to fresh hunting grounds on a frequent basis. In the project area, we are dealing with a fairly large (and probably rapidly increasing), sedentary population. Wildlife has no chances here. The ecological peculiarities of the project area with much of it inundated for a large portion of the year, forces wildlife to concentrate in certain areas where they are easily killed.

All the evidence throughout the project area, low mammal counts, species disappearing from the list of available prey species (White-lipped Peccary), Jaguars entering villages etc., all point to a gradually disappearing wildlife base. And the conclusion must be that hunting in its current levels is not sustainable and will inevitably lead to local extinction of many of the more desirable species.

Even if it would be possible to enforce a hunting ban within the actual protected area boundaries this would make very little differences, since much of the wildlife depends on the "high ground" ecosystems outside the protected area.

Seeing that the wildlife resources (and other natural resources, see the following chapters) are not being used sustainably, the question may rise, why is it that the indigenous people here have apparently abandoned their values of the forest?

Indigenous people such as the Garifuna and Q'eqchi of the Toledo district can only live in "harmony" with nature if their numbers are low and they have the freedom to move to fresh "hunting grounds". The Q'eqchi of today still have that tendency as shown by the fresh settlements of Tushville and Tamagash. People are no different than any other predator, when game (or for that matter, other resources including soil fertility) in an area gets depleted it is time to move on, and the abandoned area gets the opportunity to recover. Today, with a burgeoning population that doubles every 18-19 years, and nowhere left to go; people are forced to stay where they are and, without management techniques in place, slowly but inevitably deplete their environment.

Seen in this way, the indigenous people of Toledo have abandoned their "values" of the forest as the result of socioeconomic changes, both in their own culture and in the world around them. There is no way back but to develop and implement new values, if the natural resources of the Sarstoon Temash Area are to be preserved.

11.2 FISHING

For fishing much of the same story is true. Human pressures are high, while the carrying capacity appears to be low. The fish population depends largely on energy input from outside the protected area (see section on fishes), so strictly enforcing fishing regulations inside the park will not be sufficient to restore a healthy fish population. Particularly protection of the riverside forest upstream with it Bribri (Inga) vegetation is important.

11.3 LOGGING

Logging occurs in the reserve but principally this takes place from the Guatemalan side (see “incursions” below). There are currently logging licenses operational in the high forest near Sunday Wood and Conejo Creek. The timber is sawn on the spot and exported to Orange Walk. This logging takes place in areas that ultimately are expected to fall for agricultural expansion. Nevertheless, there are no indications that the current logging practices are any where near “sustainable”. Essentially any Emeri (Yemeri) tree of significant size goes down. Some people in the community are reaping some short term benefits from this trade but in the long run this represents a depletion of local resources that could have benefited the community for decades to come.

11.4 EXTRACTION OF NON-TIMBER FOREST PRODUCTS

In some places we found evidence of extraction of non-timber forest products. Near Conejo Creek, Bayleaf or Sha'n (*Sabal mauritiiformis*) was being collected on a large scale (again for clients outside the area). Normally Bayleaf is being collected only from young sub-canopy palms (guanu) and the tall, mature palms (botan) are being left alone. Botan provides a substandard leaf and is avoided as thatch by the people that know what they are doing. Near Conejo, Bayleaf was being collected indiscriminately, cutting every single tree to get to the leaves at the top. In the process, destroying future crops by removing seed-producers. At the same time cheating the buyer of the leaves by providing him with useless material. The bayleaf harvesting here was a clear case of greed.

Another non-timber product that we noticed as being harvested was “Xate” (*Chamaeodorea ernesti-augusti*). The leaves of this little palm are valued in floral arrangements and there exist a big export market in Guatemala. Xate is rare in the project area but was found on the karst hill near Midway. The Xate there all showed signs of collecting. The leaves were probably collected for Guatemalan traders.

11.5 INCURSIONS

One of the most important active threats is incursions from Guatemala. The Belizean side of the Sarstoon River is for all facts and purposes a no-mans land where

Figure 22. Logging "road" through swamp forest near Crique Sarco.

people from Sarstoon Village and further away in Guatemala have a free hand. This is immediately obvious when assessing the Belizean shore of the Sarstoon. At any random landing, there is evidence of logging (mostly for Santa Maria - Lech – *Calophyllum brasiliense*) and (towards the east) extraction of Comfra leaves (*Mannicaria saccifera*). Many places are so heavily used that it looks as if a hurricane has passed. This impact is probably not go very deep inland given the difficulty of the terrain, but people are willing to go through tremendous effort to obtain more valuable booty. We discovered a trail all the way from Crique Sarco to Black Creek and from there to the Sarstoon River. The obvious purpose of this trail was extraction of Mahogany (*Swietenia macrophylla*). Much of this trail led through swamp forest and the loggers went into extremes to get the sawn lumber out. To get through the swamp, the loggers felled trees all along the trail and thus provide the (sure footed) intruders with a way out with their sawn boards on their backs.

There are rumors about Guatemalans farming on the Belizean side of the Sarstoon. This may be the case further west, but the satellite images show no evidence of this within the protected area. The soils here are unsuitable for agriculture anyhow.

11.6 FIRE.

Another threat to the area is fire. Fire as a threat to biodiversity and the status of the vegetation, is not well understood. The frequency, magnitude and effects that wildfires have had on biodiversity in Belize have not been documented. However, the dimensions of areas destroyed during these fires strongly imply major destruction of flora and fauna" (Rosado in: Jacobs & Castaneda, 1998).

Fires in broadleaf forests are often ignored and bear no resemblance to the massive blazes that can be seen in burning needle-leaf forests. The fire is usually low, and slowly creeping through the leaf litter. Often it is possible to walk close up to it and even through it without too much danger. There is usually little "media value" in such fires. Only in areas with Cohune (*Attalea cohune*), the effects can be more dramatic. The abundant leaf litter under these palms explodes into flames, often igniting the crown and spraying sparks over great distances. But even in the case of these slow, low fires, the damage can be profound. Trees, especially young trees may appear unharmed but still die over time. The mortality either being the result of direct damage or indirect damage such as increased pathogen access through the fire damaged bark.

Tree mortality as the result of such slow fires may continue for several years after the actual fire (pers. obs.). Each fire, which leaves more dead or dying trees behind makes the forest even more prone to fire damage.

Natural fire in broad-leaved forest is a relatively rare phenomenon. It is argued that in Central America most species of trees have evolved in the absence of fire and thus developed little tolerance for it (Budowski, 1966, Hopkins, 1983). Actual documentation of lowland broadleaf forest fires started by lightning is rare (Middleton et al., 1997). Consequently, fire in tropical lowland forests has traditionally been considered as human induced.

Fires are most devastating on hills where an upward draft creates extremely hot fires towards the top of the hill. Fire affected hills; therefore, show the greatest damage towards the summit. Repeated hill fires result in "bald" hills with no woody vegetation but a cover of grasses or "Tigerbush" (the ferns *Dicranopteris* and *Pteridium caudatum*). The influence of fire is clearly greatest where there is drought stress and highly inflammable vegetation is present.

More than anything, slash and burn agriculture has to be seen as the main culprit for fires in lowland broadleaf forests. In general the subsistence farmer has little consideration for the well being of the forest and most farmers do not take escaped "milpa" fires seriously.

Belize has experienced massive fires in broad-leaved forest after hurricanes, which cause large amounts of debris. Initially, these fires are usually started by farmers and may be accidental escapes from farm clearings. The debris caused by the hurricane is such that access and movement for firefighters is very difficult. Consequently, these fires are difficult to suppress unless they can be reached at a very early stage. Fire in broad-leaved forest may stimulate the regeneration of mahogany and cedar but more usually there is complete destruction of forest and replacement by persistent bracken, which is itself a fire hazard.

Most of the project area appears too wet for large fires. However, climate change, un-seasonal droughts, hurricanes etc. may alter this and fires are a distinct possibility even in the project area. The karst hills near Midway are particularly at risk and have already sustained severe fire damage due to past agricultural activities. On top of this, most of the soils on which the communities farm are very poor and severe and repeated fires here can easily lead to savanna formation, which in its turn leads to further soil deterioration, biodiversity degradation and rendering the area useless for further agriculture activities.

12 TOURISTIC POTENTIAL

The eco-tourist (distinguishing the strict eco-tourist here from the "cultural" tourist) potential of the project area is limited. Much of the project area is inundated during part of the year and even in the dry season very hard to access. The rivers are scenic but devoid of the abundant birdlife that characterizes many of Belize's other rivers. High hunting pressure has made most wildlife scarce and what is left is very shy and rarely visible. There may be some potential for sports fishing in the mouth of the river, but this may also be compromised by the noted over-fishing of the area.

13 NEXT STEPS

With this REA, some baseline data have been established that will enable management of the protected area and guide further research. But clearly much work remains to be done. Although a large amount of flora and fauna data have been gathered, certain groups warrant further research. One of these groups would be the invertebrates since these are important elements in the food chain and very often good environmental indicators. Within the invertebrates, Lepidoptera (butterflies and moths) are natural candidates since they are relatively easy to identify and well documented for Belize (Meerman, 1999).

The real next step will be a management plan based on all the available data collected during this and other studies. Within such a management plan, zoning is one of the first items that comes to mind. The previous chapters have shown that the current park boundaries do not really guarantee the ecological functioning of the park. For most wildlife, the park is really too small and some key ecosystems are not or insufficiently present within the park boundaries. Reducing the National Park or turning the park into a large multiple use zone is not a viable option with the exception of the northern most lobe that includes actively farmed areas. This lobe also includes the karst hill which is of ecological importance. The following is proposed:

Develop a management plan for the "northern lobe" that allows current traditional use but enforces some form of sustainable use and a protection for the intact parts of the karst hills (those areas that are not being used by Ministry of Works as quarry).

Create a multiple use zone involving all that area above the Temash River from the coast to the western shores of the Temash Lagoon.

Expand the park with a small area in the west (see map 23 following page) in order to include critical habitats such as "Tropical evergreen broadleaf lowland hill forest: *Calophyllum* variant" and a small piece of the "Deciduous broad-leaved lowland disturbed shrubland". These are absolute minimum requirements for maintaining the ecological functioning of the Protected Area.

Manage the remainder of the park as a strict protection zone.

Set up a voluntary community management of the "Deciduous broad-leaved lowland disturbed shrubland" that will remain outside the park and focus on Hickatee, Crocodile and Iguana conservation.

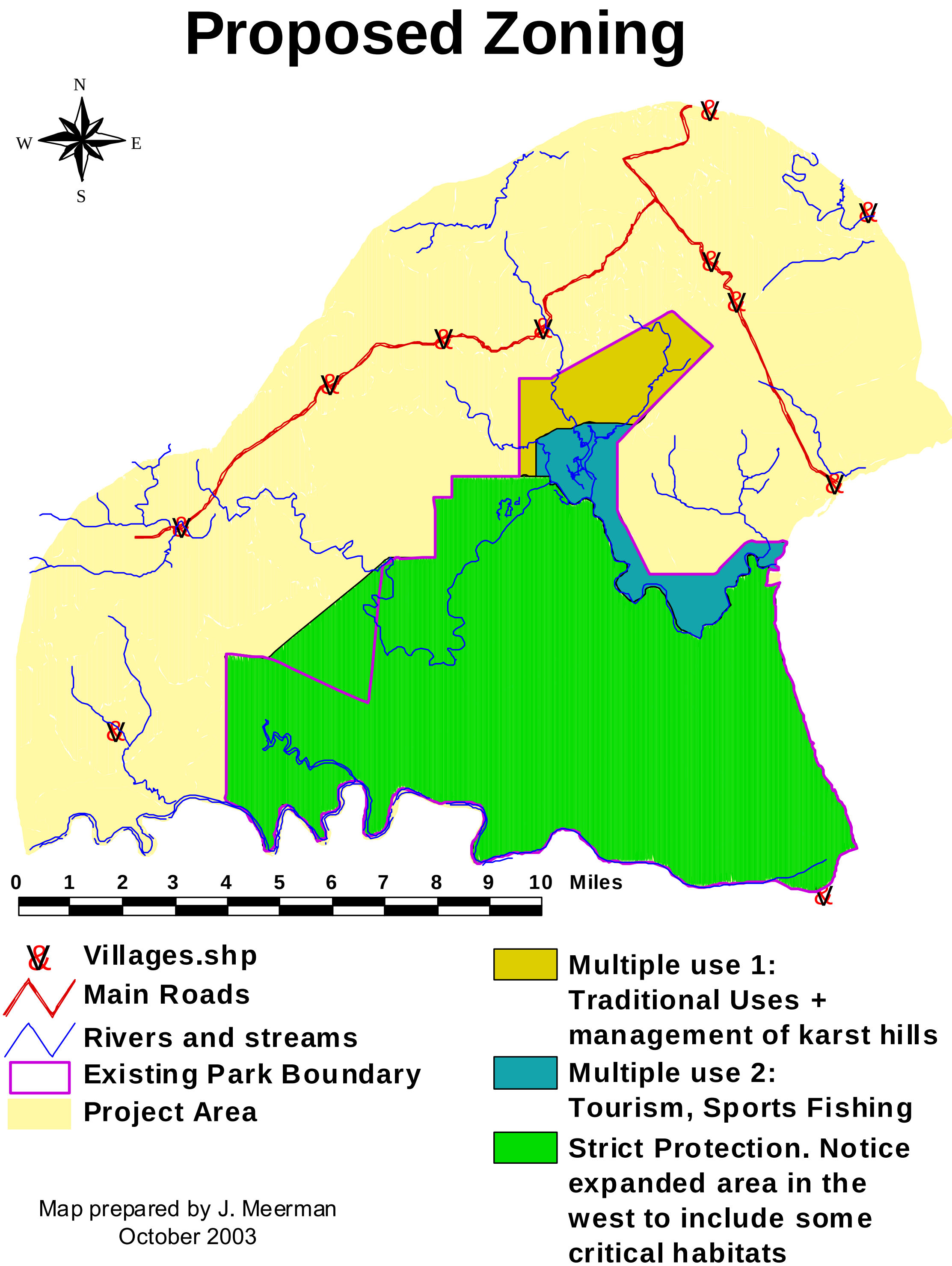


Figure 23. Proposed zoning

Creating of a "bufferzone" around the park is ideal but only possible with cooperation of the abutting land users. Essentially these users have to agree to manage their land in a sustainable way. Involving these land users in the management of the park or at least encouraging them to become members of the organization is in important step in this process.

Since the aquatic ecosystems of the Park are so dependent on outside forces, constant monitoring of the entire Sarstoon and Temash Watershed is important. Alliances are to be made to have an impact on the proper management of these watersheds.

Critical is the issue of strengthening the biological corridor function. Not only the cross boundary corridor, but specifically the link between the Sarstoon Temash National Park and the Ya'ache Conservation Area (with Lu Ha or Aguacaliente more or less in-between).

As outlined earlier, fire resulting from poorly executed agricultural practices forms a potential threat to the Karst Hill in the Sartsoon Temash National Park and its ecological functioning. Management should constantly monitor agricultural development in the around the park. Annual aerial overflights are ideal for this. In some years the services from the volunteer organization "Lighthawk" can be used for this purpose. Knowing pace of development around the park and proactive thinking can prevent a lot of trouble. Trained volunteers should be present in the area at least during the high risk periods (late dry season) and have access to simple firefighting tools.

Meanwhile, there is an important aspect of management that needs to be carried out immediately. This is monitoring. This document contains some information and there exist a manual for monitoring of Northern Belize Biological Corridor (Meerman et al., 2000). Also, the Belize Audubon Society is currently attempting a permanent monitoring for many of the sites under their management. Possibly, there are things to be learned from their experience and possibly their methodology could be adapted.

Monitoring can come in different forms and intensities. The management plan could recommend more scientific monitoring. Important would be climate monitoring. Installation of an automatically operated weather station on a secure site would in the long run provide interesting data and trends. Manually collecting rainfall data is the least, but manual collection is difficult without a permanent on-site presence or supervision.

The village volunteers can carry out one level of monitoring even under the current situations. This is keeping tab of everything of interest. Things of interest can be noteworthy wildlife (Jaguar tracks, Currasow observation etc.), but also special events (flooding, fire, hunting camp found, etc.). Over the years, valuable date will be accumulated in this way and the data may thus give an indication of wildlife presence en thereby effectiveness of conservation management. These data can be recorded in a regular hardcover notebook. Important is that the data are transferred from the book to a computerized file on a regular base. Also data from a visitor's book (where they can list observations) can be entered in the computer database in the same way. Frequent back-ups are essential. See the following chapter for a more in-depth discussion.

14 MONITORING SETUP AND SCHEDULE

Monitoring is an essential yet much neglected component of a successful integrated conservation and development program. With effective monitoring, it should be possible to track an individual project such as the conservation of the Sarstoon Temash National Park or the Biological Corridors Project. Feedback may be provided that will guide the long-term course of the project, and blend conservation and development information for optimization of both.

There exist a "manual for monitoring developed for the Northern Biological Corridor (Meerman et al, 2000). It is best to refer to this document since it contains much information, methods and standardized techniques but some of the conclusions of this report should be introduced here:

Short- and long-term effects and conditions are only discernible with an effective, flexible system of examination and evaluation of selected parameters that will indicate functionality of the natural system and the adjacent communities.

Monitoring the physical parameters should be monitored on the landscape level (forest cover) by means of bi-annual review of most recent aerial and LANDSAT data.

The easiest monitoring method, in the absence of time and qualified observers, is a simple logbook in which wildlife observations are recorded.

Stations need to be selected by combined knowledge of local people in Corridor segments and lead NGO.

Stations need to be located in the immediate vicinity of communities active in the Biological Corridor.

Basic climate data, at least daily rainfall, should be recorded at convenient locations near each station.

Once a station is set, it is best to maintain as long as possible.

Training sessions must be well-planned (via meetings with NGO/CBO partners) and include the following elements at a minimum: Project overview; review of Corridor sections; review of each protocol and the equipment needed to perform it (including care and calibration); species identification (visual, audio, trace): vegetation, fish, birds; mammals [others]; reporting methodologies. An assessment regarding all aspects of fieldwork must be passed for field supervisors; local personnel participating only in species detection must proficiency in identification and recording methodologies.

Techniques, sampling regimes and stations must maintain flexibility to adapt to changes over time.

It is best to begin with a smaller number of key stations during the learning phase, then expand stations as expertise develops. Too ambitious a program at the outset may lead to discouragement and reduce participation in the program.

Hand-held meters, tape reels, calipers, binoculars, field guides, GPS and all other equipment must be carefully selected to be tough and durable under field conditions, purchased in advance along with all accessories and calibration standards.

Collaboration with the National Biodiversity Office and work within Plan framework for Forest Department, Department of the Environment, medicinal plants and other applicable institutions is recommended.

Not withstanding all the techniques discussed in the document, my advice is to keep it simple. A simple logbook for wildlife observations will serve the purpose in most cases. The logbook can have a pre-designed lay-out. This layout again should be very simple. An example of such a layout is presented in table 12.

Table 12. Layout for general monitoring data sheet

Species	Type of Record	Date	Location	Time	Observer	Together with
Jaguar	1 Seen at milpa	13 Dec 2004	Milpa along creek	10 am	Rojelio Coc	Benjamin Tush
Antelope	1 Hunted	14 Dec 2004	Milpa along creek	8 pm	Benjamin Tush	
Mountain Cow	Tracks of 1	14 Dec 2004	Along creek where little bridge crosses	9 pm	Benjamin Tush	
Harpy Eagle	2 Flying over	15 Dec 2004	Village (name)	1.30 pm	Fredo Cal	Rojelio Coc, Benjamin Tush, Nasario Bol.
Hickatee	7 Caught for eating	15 Dec 2004	Creek (name) 1 mile south of village (name)	Evening	Nasario Bol	

This logbook can be maintained by an interested person in each community, but should contain data from as many people as possible. A farmer mentions some unusual observation, a hunter returns with his prey, fishermen bring home their catch. All of these are data worth recording. Over time, this logbook will come to contain valuable data. When species once hunted disappear from the logbook it will indicate local extinction. Species becoming more common may indicate habitat change etc. etc.

During our field work we noticed that most volunteers were fascinated by birding but lacked the species knowledge. This noticed interest should be exploited and birds should be made priorities for monitoring purposes. Some training will be required. Interested youths should receive intensive training from experienced birders.

Tools for this continued monitoring should be simple and consist of the actual logbook, writing materials and possibly some essential tools such as binoculars and (bird) identification books.

Crucial is a good management of the data. SATIIM should act as the repository of the data. Data should be taken in from all communities on a monthly basis. This frequency provides a means of monitoring the intensity and quality of the data collection. Also it prevents too many data getting lost in case of a disaster such as the disappearance of a logbook. Data analysis should take base on a yearly basis and be shared with the communities.

15 SUMMARY

The Sarstoon Temash National Park (STNP) was created in 1994 (SI 42 of 1994 and amended in SI 22 of 2000). With approximately 41,000 acres it is one of the largest National Parks in the country. The current REA indicates that the true importance of the Sarstoon Temash National Park lies in the fact that it covers a number of ecosystems that are extremely rare in Belize or even unique within all of Central America!

The ecosystem: "Tropical Evergreen Lowland Peat Shrubland with *Sphagnum*". Was discovered and described during this Rapid Ecological Assessment.

The biodiversity of the Sarstoon Temash National Park is average or slightly above average compared to other lowland sites in Belize. The species composition in the park reflects the nature of the park as a very wet, seasonally inundated forest. There are several species that appear to be rare or absent elsewhere in Belize. The showiest of these is the Comfra palm (*Manicaria saccifera*). We have designated this species to be the "flag-ship" species of the Park.

Despite its pristine image, the National Park is severely impacted by unsustainable hunting and fishing practices to an extent that some species are on the brink of (local) extinction. Furthermore the park is threatened by incursions from the Guatemala side that express themselves mostly in unsustainable logging, hunting and fishing practices.

The current protected area boundary does not consider existing land use patterns (pre-existing agriculture in the "Northern Lobe"), nor does it consider its biological functioning (some critical ecosystems insufficiently incorporated). This may be difficult to change on short notice but this report lists some recommendation for possible zoning and park boundary corrections.

Consolidation and strengthening of existing biological corridors outside the park is of prime importance and should be high on the list of priorities for a management plan.

The current Rapid Ecological Assessment has validated the Sartsoon Temash National park as a unique and irreplaceable component of Belize's national protected area system!

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