RAPID ECOLOGICAL ASSESSMENT
MAYFLOWER BOCAWINA NATIONAL PARK

Volume I

J.C. Meerman

B. Holland, A. Howe, H. L. Jones, B. W. Miller

This report was prepared for:
Friends of Mayflower under a grant provided by PACT & UNDP/GEF.

July 31, 2003

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Appendices

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1. Introduction

The Mayflower Bocawina National Park is located in the Stann Creek district and has as its original attraction the Mayflower Archaeological Site. The recent declaration of the National Park with emphasis on community co-management has widened the scope from Archaeology to environmental protection. To acquire data for this co-management, a Rapid Environmental Assessment (REA) has been called for and on September 2, 2002, "Friends of Mayflower" awarded the contract for the REA to Jan Meerman and team. The National Park was declared in SI 139 of 2001. The description incorporates areas previously covered under the Sittee River and Commerce Bight Forest Reserves.

Objectives for the Rapid Ecological Assessment

A Scope of Work drafted on May 8, 2002, stated the following objectives of the REA:

- To produce biophysical information necessary for development of management plans and environmental impact assessments.
- To produce data, reports, maps, lists, classifications, descriptions, and threats identification for management, educational, inventory and funding purposes.
- Generate baseline data for monitoring activities in the Park.
- Contribute to the National inventory.
- Identify species that are in danger of becoming extinct.
- Develop preliminary data sets for future use in inventories that are more detailed and in ecological characteristics.
- Characterize natural communities, provide descriptions listing key species and assess their importance for conservation.
- Associate animal communities with the vegetation types they inhabit.

Methodology

The biodiversity component of the REA focused on a few groups of organisms. These were: flora, birds, reptiles, amphibians and mammals. Most of the fieldwork within the project addressed these groups although each group had different approaches and requirements. A five person multidisciplinary team was organized to deal with these various aspects. In brief, the approach to each biodiversity grouping was as follows:

Flora

Based on satellite imagery, an attempt was made to assess the various vegetation types / ecosystems present within the park boundaries. Once established, the main ecosystems were visited and a species assessment made. In the most important ecosystems, standardized transects were established in order to assess species composition and

vegetation structure. To facilitate the identification of the maximum number of species, multiple visits were made (wet season / dry season).

Birds

Birds were assessed during walk-over surveys. Identification was by both visual and vocal characteristics. The bird inventory was linked to the vegetation / ecosystem types identified during the floristic survey.

Amphibians and Reptiles

Amphibians proved difficult to assess within the given timeframe. 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.

Mammals

Mammals were assessed on an opportunistic basis by all of the teams. Interviews were held with known bushmen / hunters in the area to assess the presence of game species. Bats received special attention. For this purpose, some "harp" traps and mist nets were utilized. Additionally multiple acoustic monitoring on several unattended monitoring sites were also carried out. This provided the most complete survey possible for all family of bats.

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. For example, the consultant is the principal author of the recent ecosystem map of Belize and co-author of the Central-American Ecosystems map. On other fields consultant is the Belize contact person for MAYAMON anuran monitoring project. The office of the principal consultant has in-house GIS capacity. Specific fields of expertise: Flora, Reptiles, Amphibians and Butterflies.

Lee Jones, Punta Gorda, Toledo District.
Ornithologist. Specializes in the vocal identification of birds. Author of the new and comprehensive illustrated fieldguide "Birds of Belize" (In press).

Peter Herrera, Belize City, Belize.
Tourguide. Although not officially part of the team. Mr. Herrerra provided valuable extra bird data and made spot counts on all of the vegetation transects.

Bruce Miller, Gallon Jug, Orange Walk District.
Biodiversity specialist. Manager of the Belize Biodiversity Information System. Specific fields of expertise: Birds, Mammals, Bats.

Augustin Howe, San Antonio, Cayo District
Former Forest Planning and Management Project Employee. Tree Identification Specialist.

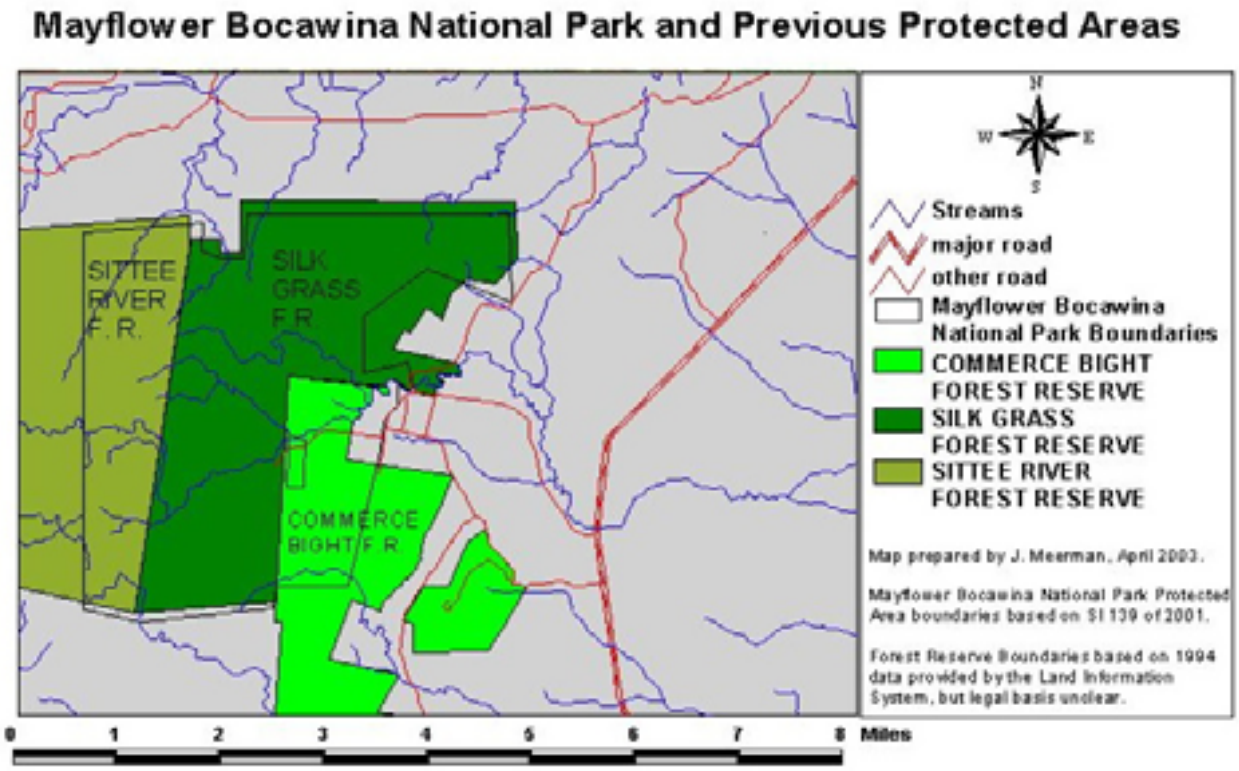
Brian Holland, Punta Gorda, Toledo District.
Geologist. Director of Belize Minerals Ltd.

Apart from relying on the team experts, this project utilized local expertise and knowledge. Particularly important were the contacts with the wardens of the park: Ramon Guzman and Genovivo Peck. Apart from guiding and general assistance, they also performed the hunter interviews. The latter was a difficult task since hunters proved very hesitant in providing any type of information. Of importance were also the contacts with the owners of Mamanoots lodge Kevin and Nanette Denny.

2. Historical Overview

The Mayflower Bocawina National Park is not a completely new protected area. The new National Park essentially consolidates the ruins of the Commerce Bight and Silk Grass Forest Reserves. In order to be able to include the Three Sister and Bocawina Falls in the new protected area, a section of the Sittee River Forest Reserve was annexed as well.

With the creation of the 7,107 acre Mayflower Bocawina National Park in 2001 (SI 139 of 2001), the Silk Grass Forest Reserve has effectively ceased to exist. Whether the outlying remnant of the Commerce Bight Forest Reserve still have protected area status is unclear. Neither forest reserve has officially been revoked.



Both the Silk Grass Forest Reserve and the Commerce Bight Forest Reserve, have troubled pasts. The Silk Grass Forest Reserve was Belize's first protected area, designated as a Forest Reserve in October 1922 (Notice 624) with the intend to protect and develop mahogany silviculture (FD 1926, para. 21). The original area was 6720 acres. It was reduced to 6525 acres in August 1982 (SI 60). Excisions have since been made without due recourse to appropriate de- reservation procedures. The Commerce Bight Forest Reserve was established in October 1944 (SR & O 56), at 10,176 acres (FD 1944) with the aim to protect the area for the management and exploitation of Pine. This reserve has been slightly expanded and then repeatedly reduced in size. The re-designation in June 1977 (SI 46) gives a boundary enclosing an estimated 10910 acres, after which excisions from the reserve started. In August 1982, it was split into Commerce Bight A and B (2437 and 6864 acres) (SI 59). These were reduced in April 1989 to 1302 and 6609 acres (SI 41) then to a total of 5451 acres.

Both reserves formed part of the Grants Works/Silk Grass/ Commerce Bight/Melinda complex in which considerable silvicultural activities took place from the 1920s. Both pine and mahogany plantations were established, with varying degrees of success, silvicultural experiments were carried out, and widespread fire control was implemented. Extraction was carried out under a series of small licenses, before a coordinated attempt at management was made by FD. To this end, the first working plan was drawn up by Wolffsohn (1954) for the period 1954-1959, running from Melinda Forest Station. It appears that due to financial cut backs in 1959, the scale of FD's silvicultural activities in these reserves was greatly reduced. In addition, systematic activities were halted in the wake of Hurricane Hattie (1961), which badly damaged the reserve's forest.

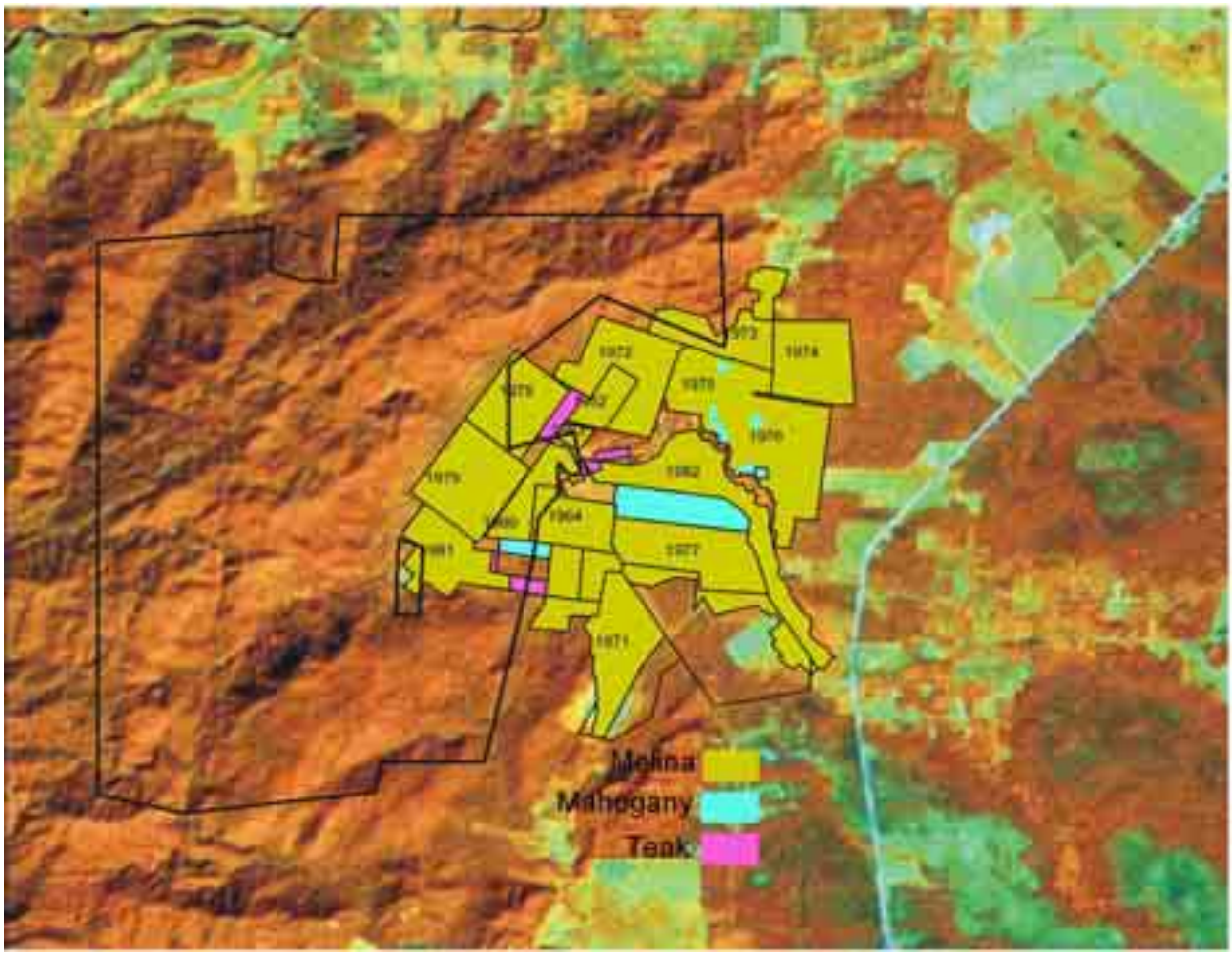


Figure 2. Past silvicultural plantations in the Mayflower area superimposed on 1999 Landsat TM image. Black line indicates the current protected area boundary. With yearly blocks marked with the year of plantation. Most blocks were planted with Gmelina. Information based on various maps (mostly undated), found in Melinda Forest Station.

Gmelina: *Gmelina arborea* (Verbenaceae) (Adapted from Lamprecht, 1989)

Gmelina is native to moist forests in a large disjunct area on the Indian subcontinent, in southern China, Southeast Asia and the Philippines. It is found at elevations up to 1,200 m above sea level. Plantation growing of Gmelina is practiced throughout the tropics.

On favorable sites Gmelina can attain a height of up to 30 m and a DBH of 60-80 cm at age 20. Without intensive pruning it has a tendency to develop heavy branches and a forked, crooked and tapered stem. The bark of young trees is brownish gray-green and smooth. At about age 5-8 it starts taking on a gray color, becomes cracked, and peels off in irregular patches. The leaves are simple and broadly oval with a denticulate margin. The species is drought deciduous. The flowers are reddish-brown; the calyx base and the "lip" are vividly yellow in color. The fruits grow to a length of approximately 1"; the flesh of the fruits is sweet; each fruit usually contains 2-3 seeds or pits surrounded by a hard shell.

Gmelina arborea *leaves*

Gmelina arborea flowers

Gmelina thrives in climates with absolute maximum temperatures of 37 to 48°C and absolute minimums of -1 to +16°C. The total annual rainfall in its native range varies between 760 mm and 4,600 mm or more. Optimum conditions exist in areas with 3-5 dry months and monthly temperatures between 18°C (coldest month) and 35°C (warmest month), and annual rainfall of between 1,750 and 2,300 mm. In plantations it only attains the required high annual volume increments of 20-25 $m^3.ha^{-1}$ in fresh, well-drained and fertile soils.

Gmelina is a highly light-demanding species, and regenerates naturally only in the open and on the edge of forests. It is thus an ideal choice for large-scale afforestation and plantations. Natural regeneration under a closed forest canopy is minimal as was confirmed from within the Mayflower Bocawina National Park. In its natural range Gmelina is affected by various pests and diseases. In Belize these natural pests do not occur, but leaf-cutter ants cause increment losses. Gmelina is fire-resistant.

Gmelina produces an excellent timber. It is yellowish and shiny, the sapwood being somewhat lighter in color and remaining very narrow. Its specific gravity varies between 0.49 and 0.53 g/cm3. The wood is soft and does not warp or check, is easy to work, turn, peel and slice, and can be readily stained. It is insect-resistant and durable, especially under water. Its calorific value is low, however, for which reason there is very little demand for it as fuelwood.

Gmelina arborea *timber*

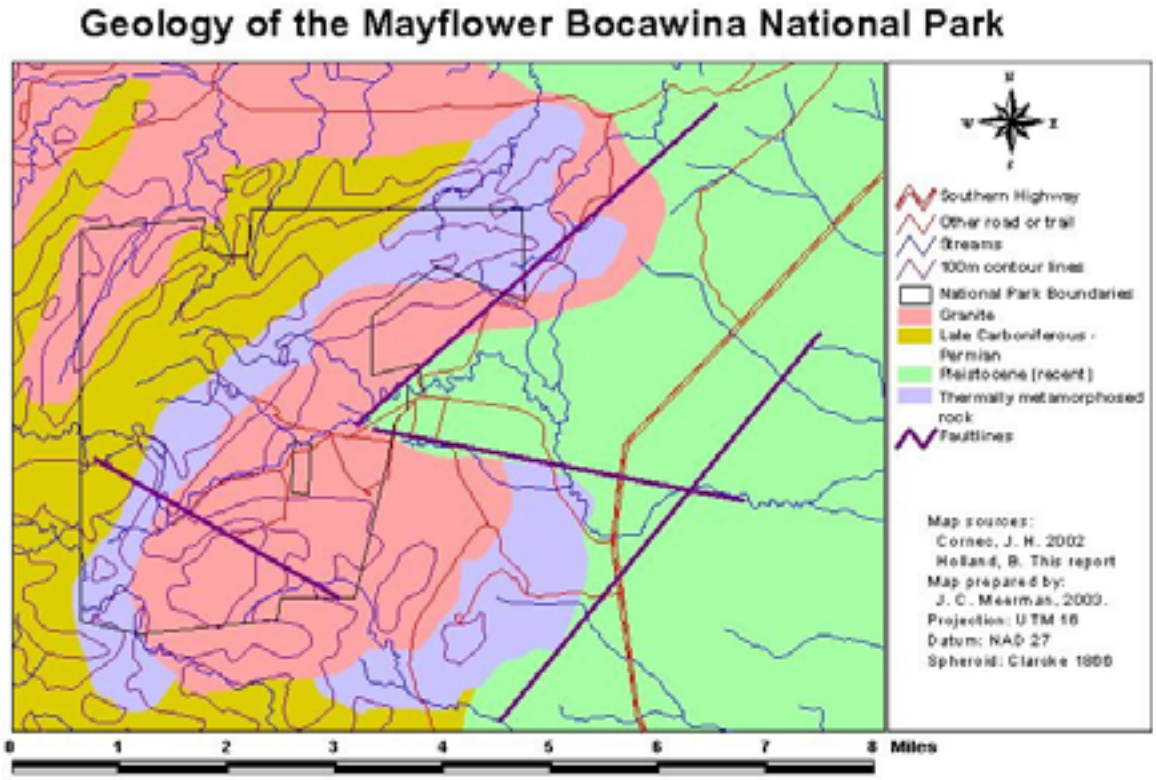
A new plantation scheme was initiated after Hurricane Hattie and provided for planting yearly blocks, mostly with Gmelina but also some Mahogany and Teak (5 plots), and on an even smaller scale *Eucalyptus citridora, Eucalyptus deglupta*, *Pinus patula*, Salmwood (*Cordia alliodora* – 2 plots), Balsa and possibly others (Forest Ranger Garcia, pers. comm.). Plantings were carried out at least until 1982. But after that the reserve went downhill. More and more parcels were given out for agriculture as well as for other purposes (the Mamanoots property was carved out of the Commerce Bight Forest Reserve in the early 90's). An investigation by McGill (1994) found that especially the Commerce Bight Forest Reserve was severely invaded, Most of the cleared land was converted to agriculture.

3. GEOLOGY OF THE MAYFLOWER NATIONAL PARK

Brian Holland, Punta Gorda.

Geological setting

Mayflower National Park (MNP) is situated on the border of the northeastern part of the Maya Mountains the eastern coastal plain of Belize. As with much of Belize, the geology of the MNP is only cursorily known. There are only two published studies that describe the geology of this general area - Dixon (1956) and Bateson and Hall (1977). Both publications present geological maps that include MNP. Geological data from these maps have subsequently been merged and updated by Cornec (2002) See the map below.



Land forms in the MNP

The topography of MNP is clearly related to both tectonic activity (faulting and folding of bedrock) and the composition of the rocks that form the Maya Mountains.
Approaching MNP from the east by road from the Southern Highway one drives across the relatively flat, coastal plain, which is of fairly recent Pleistocene origin. The plain is composed of unconsolidated clay, sand and gravel. These are sediments derived from the erosion of rocks composing the Maya Mountains and are easily examined in ditches excavated along the nearby Southern Highway.
Entering the park area the Maya Mountains abruptly arise from the coastal plain along major faults (see map). One fault trends NE-SW and the upper reaches of the Silk Grass Creek flow along this fault (referred to here informally as the “Silk Grass Creek Fault”)

in a northeasterly direction until it enters the coastal plain just outside the park where the creek turns and flows in a southeasterly direction. This NE-SW fault is part of a system of faults that define the eastern margin of the entire Maya Mountains.

Figure 4. The Bocawina Falls are situated on top of and E -W. fault line.

Another fault, trending E-W and intersecting the NE-SW fault, can be seen just to the south of the entrance road. Again, the Maya Mountains rise abruptly from a flat plain along this fault. This fault apparently stops where it intersects the "Silk Grass Creek Fault". Another E – W trending fault demarcates the Bocawina falls.

Age of faulting

Faulting is believed to have begun approximately 65 million years ago in the early Tertiary resulting in uplift of the Maya Mountains. The faults along the eastern and northern margins of the Maya Mountains are regarded as still active and tremors are felt regularly in Belize (James and Ginsburg, 1979). This tectonic activity is related to the movement of the Caribbean plate moving away from Belize which lies on the North American plate.

Topographic features

Another dominant topographic feature of MNP is Monday Morning Ridge which rises to an elevation of 400 meters above sea level at Antelope Hill (the coastal plain in the park is at an elevation of only 40 meters). The ridge extends from the northeast part of the park southwestwards to Bocawina Falls. It forms the prominent high feature seen from the east. To the west of Monday Morning Ridge the terrain falls steeply into a valley (80 meters above sea level) drained by north flowing False Creek, a tributary of North Stann Creek. The ridges and valleys in MNP were formed through folding of late Paleozoic (Carboniferous and Permian – 345-225 million years ago) strata caused by the intrusion of the Hummingbird-Mullins River Granite in the Triassic (225-192 million years ago). Prior to uplift of the Maya Mountains which began in the late Cretaceous - early Tertiary (approximately 65 million years ago), the area was covered by a thick deposit of Cretaceous limestones. These limestones have been largely eroded after uplift but some limestone deposits have been preserved and can be seen in nearby Stann Creek valley where the Ministry of Works has quarried limestone for road building material.

Rock types in MNP

The Hummingbird-Mullins River Granite is a light colored (leucocratic) rock with white quartz and muscovite (mica) and feldspar. Apart from outcrops in Silk Grass Creek in the MNP, the granite is also well exposed in Canada Hill Quarry a few kilometers to the north of the park. The intrusion of the molten granite thermally metamorphosed the surrounding Carboniferous and Permian sedimentary rocks, turning black shales into slates and sandstones into quartzites. Away from the contact to the granites the degree of this thermal alteration fades in direct proportion to distance.

Granite forms the Bocawina Falls in the south of the park. Here, a NW-SE trending group of parallel faults (down faulted to the north) has created a series of granite terraces over which Silk Grass Creek flows as waterfalls. The fault terraces have vertical drops of 5 to 10 meters. At the base of the falls one can see abundant large boulders of the light colored granite. The granite is cut by numerous thin quartz veins and also includes rare xenoliths (exotic fragments) of an older, dark rock, possibly a dolerite.

The older, Carboniferous and Permian black slates and lighter colored quartzites are poorly exposed and deeply weathered. The weathering of these sedimentary rocks and the oxidation of iron minerals in the granite has formed the deep red gravelly soils seen throughout the park along trails. In creek beds one can find abundant cobbles and boulders of grey and brown quartzite and black slate, sometimes with cm sized chiastolite crystals.

***Theobroma bicolor*. (Sterculiaceae)**

Branches with fruit

An usual tree species encountered at Mayflower Bocawina National Park is *Theobroma bicolor*. This is a species, similar to cacao, cultivated from southern Mexico to Bolivia and Brazil. It is a tree to 12 m high and thus much more tree-like than its better-known relative Cacao *Theobroma cacao.* Whether this species is really native of the Mayflower area or an artifact of past cultivation by the ancient Maya, is as yet undecided.
The tree produces ellipsoid fruits of 6-8 x 4-5", that weigh 1-6 lbs. The fruit is gray or greenish before maturity, yellow or yellowish brown at maturity. The aril is cream to yellow and each fruit contains 40 seeds on average.

Peter Herrera with Theobroma bicolor *tree*

The beans are used to make a drink and are traditionally mixed with Achiote (*Bixa orellana* L.) and sugar to make a sweet dessert. The seeds are consumed roasted, boiled, in pastry, and to prepare a poor quality chocolate. The beans are sometimes used to adulterate true cacao produce. Also the aril is eaten fresh or used to prepare juice or ice creams.
The fruit of the wild growing plants is small and the seeds exceedingly bitter, hence the cultivated cocoa is preferred. The seeds are prepared in two ways, fermented and unfermented. In the former the seeds are placed in heaps in holes in the earth, in boxes or barrels, covered with leaves. In the course of four or five days they begin to "sweat" or undergo a mild form of fermentation. During this time the seeds must be stirred about occasionally. At the close of the sweating process most of the bitterness is gone and they have lost about one-half in weight. Afterwards the seeds are rapidly dried in the sun or in ovens. The fully dried seeds have a rich brown color.

Fruit of Theobroma bicolor

4. Vegetation/Ecosystems

Introduction

Vegetation is relatively easy to monitor. Although the state of the vegetation cover is never stable, they are 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.

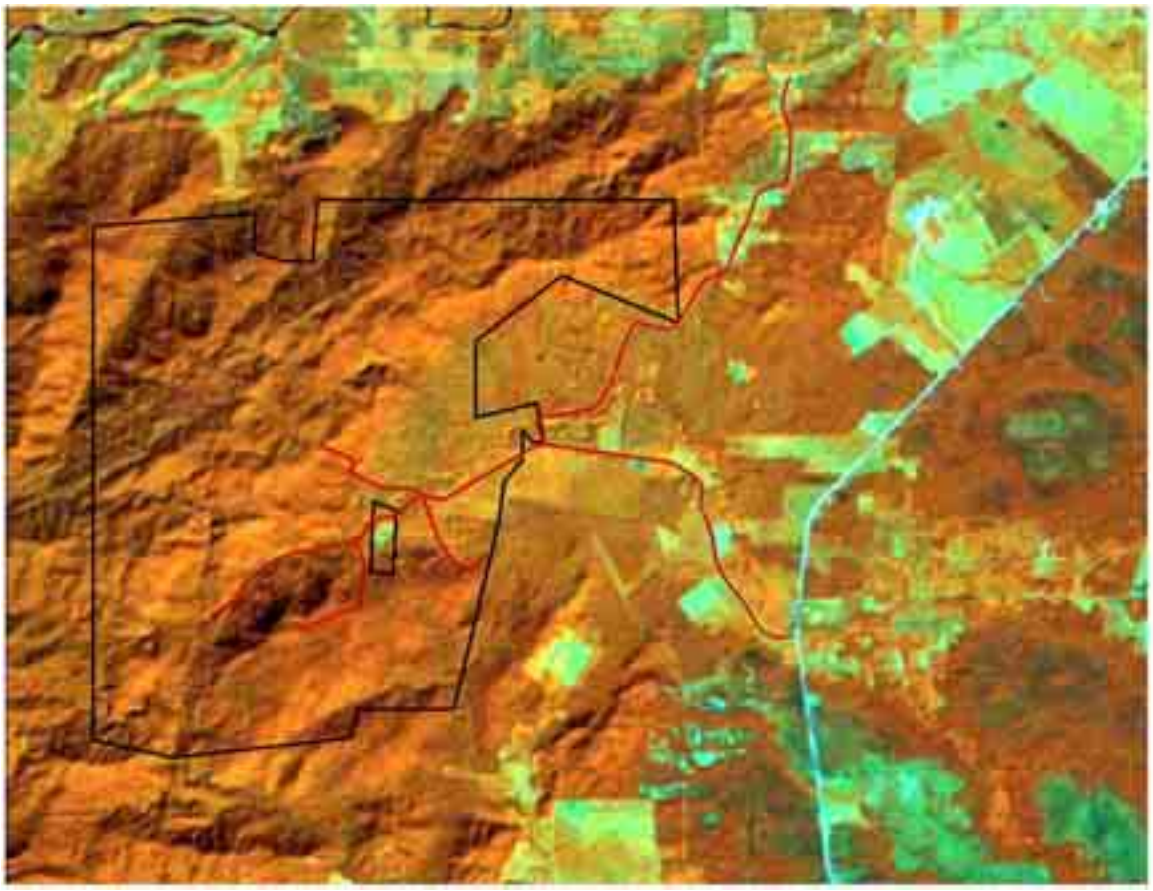


Figure 5. Landsat Satellite image (November 29, 1999) of project area with park boundary and roads/trails indicated. The image is in false color. Reddish brown colors indicate closed vegetation. Aqua blue is an indicator for open terrain with sparse or no vegetation.

The youngest Landsat image available without cloud-cover over the project area was taken at November 29, 1999 (see previous page). The image data were ordered (Michigan State University) on September 2, 2002 and received on September 23rd. Subsequent geo-referencing of the data was not completed until October 14, 2002. The geo-referenced data were translated in to a geo-tiff file. This geo-tiff file was later reduced to just show the project area and immediate surroundings.Given that vegetation cover is one of the main determining factors for ecological factors it can be assumed that vegetation cover is a proxy for ecosystem identification.

Methodology

Based on the 1999 Landsat satellite imagery, an attempt was made to assess the various vegetation types / ecosystems present within the protected area boundaries. At first glance, there appear to be 2 main ecoystems within the protected area (see ecosystemsmap): “Hill forest” and “Lowland forest”

Based on this, locations were selected for vegetation transects as a means to assess species composition and vegetation structure. Two transects were set out in the lowland forest. But within the hill forest, a distinction was made between the more exposed ridges and slopes. This assuming that there would be a difference between the two sub-ecosystems and subsequently, two transects were planned on slopes and two on ridges.

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 (and in this study, straight) 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).

An attempt was made to have two transects in each of the main habitats (lowland, slope, ridge). With the data thus obtained, several biodiversity indices were calculated (Ludwig and Reynolds, 1988) for each transect: these indices included

a) The number of species (N0),
b) The number of abundant species (N1),
c) The number of very abundant species (N2), d) the Shannon's diversity index (H') in which a higher figure indicates a higher diversity,
d) The level of evenness (E5), which looks at the number of individuals per species and in which a high evenness (=1) indicates a high diversity and un-even communities receive a figure < 1. and finally
e) The rarefraction at sample size of 20 - 30 trees which is the number of species had the sample size been 30. All these biodiversity data are useful when comparing different sites. In conjunction with these biodiversity indices, the dominant tree species (> 10% of total) were noted.

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

a) The average stem dbh,
b) The number of multi-stemmed trees,
c) The number of dead trees and

d) 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).

A cluster analysis was used to visualize similarity between transects based on species composition and species abundance. The methodology uses was a single linkage dendrogram based on the "nearest neighbor, pi-square measure count" method (Software: SPSS 10.1). To anchor the dendrogram and to provide some means of comparison, the results of a Limestone forest transect in the Cayo district (Maya Ranch, 1998) was included in the calculation.

Palo de Hombre: *Quassia amara* (Simaroubaceae) (Adapted from Taylor, 2002)

"Palo de Hombre" is a small tree, growing only 2–6 m in height with red hummingbird pollinated flowers and fruit that turn red as it matures. It is indigenous to South and Central America.

In the Mayflower Bocawina National Park it is a common and conspicuous species as park wardens traditionally leaves the trees when maintaining the ground at the archaeological sites.

Throughout the American tropics, Quassia is a reputed folk remedy for debility, dyspepsia, fever, hepatosis, hyperglycemia, malaria, snakebite, and spasms of the back. It is also used as an insecticidal, anthelmintic, and aperitive.

Quassia bark contains many active constituents and phytochemicals, including indole alkaloids, triterpenes, and bitter principles reported to be 50 times more bitter than quinine. While amargo contains many of the same types of quassinoids as quinine bark, it also contains another chemical called *quassin*. The large amount of quassin in the bark and wood gives amargo a high bitterness rating. The bark also contains the phytochemicals *quassimarin* and *simalikalactone D*. Quassimarin has demonstrated antileukemic and antitumorous properties in various studies, while simalikalactone D has been documented to have antimalarial, antiviral, antitumor, and cytotoxic activities. Other quassinoids have demonstrated amebicidal actions *in vivo* and *in vitro*.

Several early clinical studies performed on Quassia verified its traditional use as a natural insecticide—documenting it to be an effective treatment for head lice infestation in humans. Since Quassia has long been used for malaria in South America, researchers studied this pharmacological effect as well. One study (in which a leaf extract was employed) showed strong *in vivo* antimalarial activity in mice.

Quassia has been reported to adversely effect fertility in males. The effects reported include reduction in the weight of the testis, epididymis and seminal vesicle, and an increase in that of the anterior pituitary gland. These changes seemed to be restored eight weeks after the withdrawal from extract treatments. The compound implicated in the antifertility characteristic of quassia is considered to be quassin.

Quassia appears to be safe when used as a topically, and there are no reported side-effects when consumed internally. High doses of Quassia are emetic in humans, and therefore excessive consumption is self-limiting. Acute toxicity studies of aqueous extract found that oral doses of up to 1,000mg/kg in mice was not associated with any toxic symptoms.

Results

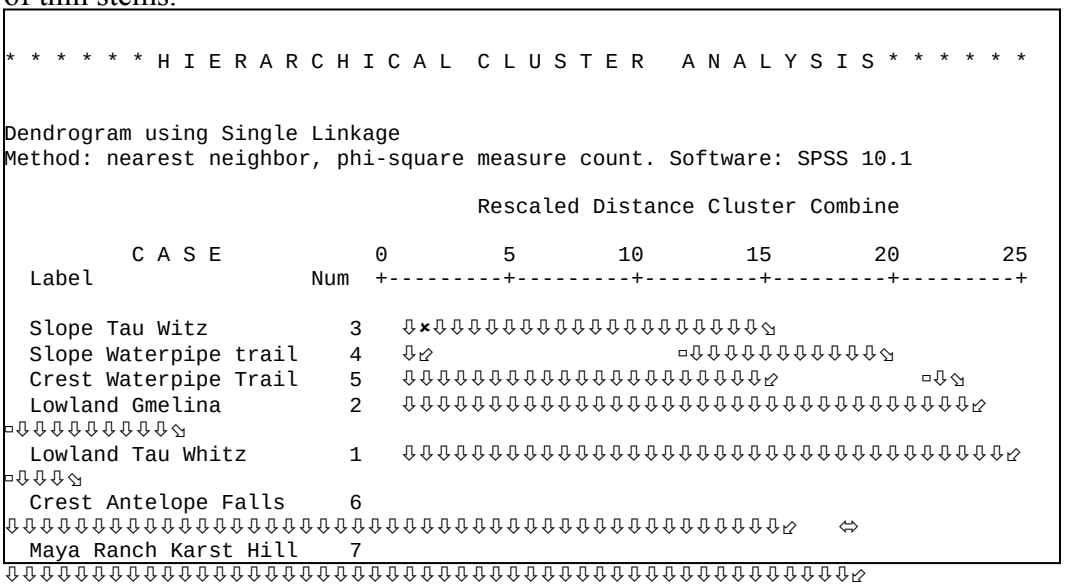
A total of 228 plant species were identified at least up to genus name. This number includes the species identified on the transects but also includes some species that were noted elsewhere in the park. Clearly, this number is not exhaustive, many more plants (especially herbs remain to be recorded. 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.

Some interesting plant species that were found include the Medicinal tree *Quassia amara*, the Cacao *Theobroma bicolor,* an as yet unidentified *Heliconia* and the invasive wild banana *Musa balbisiana* (See intermezzo's for descriptions of these three species.

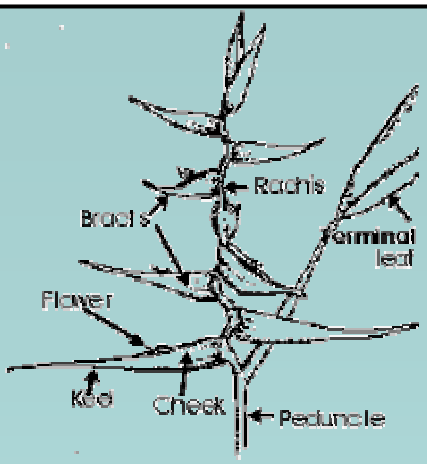
The analysis and resulting dendrogram indicate that both slope transects (Tau Witz Slope and Waterpipe trail slope are very similar in species composition and species abundance. The forest on the Waterpipe Trail Crest transect, is also very similar to these. All three have a similar, high biodiversity (expressed in H', E5 and rarefraction).

The Forests on both lowland transects are quite different. Not only different from the above three transects but also when compared with each other. This is not surprising since the lowland has been heavily disturbed and the "Gmelina lowland" transect is essentially a silvicultural plantation. Both the lowland transects have a very low floristic biodiversity.

Most different from these all is the transect of the "Antelope falls crest". This transect also has a high biodiversity but differs strongly in species composition and physical structure. For example, the average dbh on the "Antelope falls crest" was only 15 cm (29 cm on the "Waterpipe trail slope"). The number of stems was as high as 232 (66 on the "Tau Whitz lowland") and the space per living tree was only 10.5 m² on the "Antelope falls crest" (22.9 m² on the "Tau Whitz slope"). In short, the "translation" of these figures mean that the forest on "Antelope falls crest" transect is characterized by a high density of thin stems.



Heliconia species (Heliconiaceae)



Heliconia species are a very conspicuous component of the more disturbed areas of the Mayflower Bocawina National Park. The lowland, moist and disturbed conditions create an ideal habitat for this group and as a consequence, the diversity here is unusually high by Belizean standards.

Heliconias are medium to large herbs related to banana's. The inflorescence is often large and attractive and many Heliconia's are grown for use in flower arrangements. The inflorescence is almost always terminal on erect, leafy shoots. It has either an erect or pendent orientation (erect in the diagram to the right), with respect to the leafy shoot from which it emerges. The inflorescence is made up of the peduncle and modified leaflike structures known as bracts (or spathes), the rachis connecting adjacent bracts. Within each bract there is a coil of inconspicuous flowers. The fruits also develop within the bracts. The bracts are often filled with water and form a distinctive aquatic micro-ecosystem.

Heliconia bourgaeana

Large species with erect inflorescence. The color of the bracts varies from mottled red to pure yellow. The yellow variety is know as var. "Maya Gold". Distributed in hilly terrain in the Cayo, Stann Creek and Toledo districts.

Heliconia collinsiana

Large plant (3 m - 10 ft) with pendant reddish pink inflorescence. Unmistakable because of the white, waxy undercoating of the leaves. Growing under disturbed conditions in hilly terrain of the Stann Creek and Toledo districts.

Heliconia latispatha

The most common *Heliconia* in Belize. Found in all districts (except Corozal?) in lowland under open, disturbed and moist conditions. The erect inflorescence is orange.

Heliconia vaginalis mathiasiae

Relatively small species (< 2m - 7 ft). Usually found inside forests on slightly acidic soils. Not capable of surviving open, heavily disturbed conditions. Found in Belize, Cayo, Stann Creek and Toledo districts.

Heliconia unidentified species

Discovered during this REA of the Mayflower Bocawina National Park. This species keys out to *H. tortuosa*, but is still quite different from this species. Most notably, the inflorescence is larger and the whole plant is very tall (3 1/2 m - 12 ft). All in all this is a much more elegant plant. The inflorescence is orange-red. The sepals, ovaries and pedicels are all yellow. Young shoots have white waxy coating.

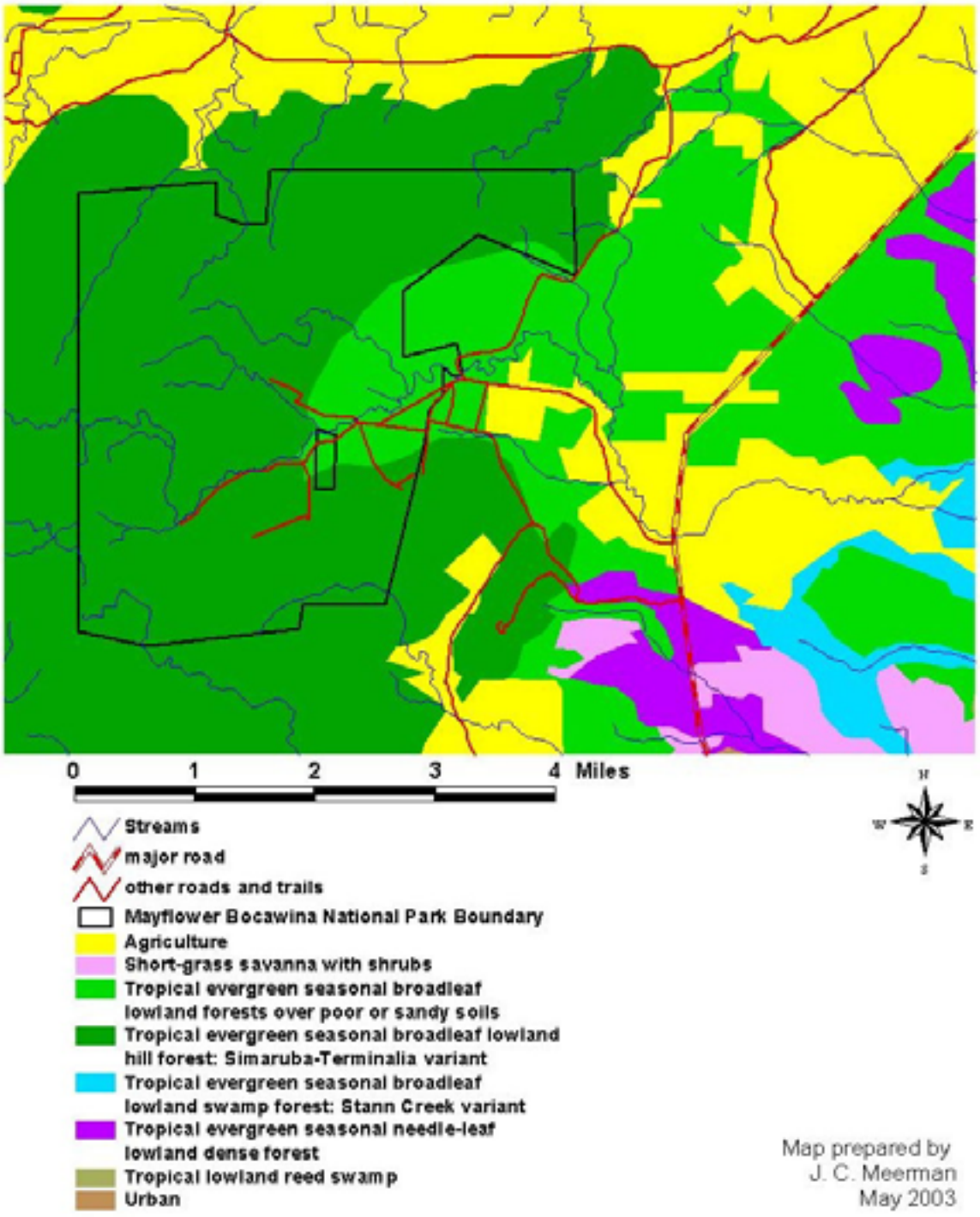
	Mayflower Lowland *Gmelina*	*Mayflower Lowland TauWitz*	*Mayflower Slope TauWitz*	*Mayflower Slope waterpipe*	*Mayflower Crest waterpipe*	*Mayflower Crest Antelope*	*Cayo district Maya Ranch Karst Hill*
N_0 = Number of species	12	12	17	23	25	19	20
N_1 = Abundant species	4	9	13	16	20	15	14
N_2 = Very 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
Number of multi-stemmed trees	8	4	0	0	2	0	5
Number of dead trees	4	8	5	3	2	5	2
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
Canopy height	20 m. Broken canopy	5-25 m. Broken canopy, understory very dense	20-25 m	25 m	18 m. Broken canopy	10-15 m. Canopy very open	
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*
Cumulative dbh	Total DBH = 1366 cm	Total DBH = 1000 cm	Total DBH = 826 cm	Total DBH = 1800 cm	Total DBH = 955 cm	Total DBH = 1280 cm	Total DB = 992 cm

The outcomes of these calculations are somewhat similar to the results reported by Brewer et al (in prep.). Brewer and his team found that slope and ridge forests had the highest diversity and also found that the stature of the forests became shorter from the valley to the ridges, with fewer large trees. His explanation is that this was of reasons of increased edaphic drought enhanced by greater drainage and thinner soils at higher elevations, less access to groundwater, and greater exposure to desiccating winds. Others Bellingham 1991, Brokaw & Grear 1991, Everham & Brokaw 1995) also have listed exposure to hurricanes as a major reason for the lesser stature of ridge forests, but observations of Brewer (pers. comm.) after Hurricane Iris in 2001 actually indicate a greater resistance of ridge forests to hurricane damage as was previously reported by Scatena and Lugo, 1995).

Interesting is that only one of the "crest" transect showed this great difference. The other "crest" transect actually being very similar to both slope transects. When revisiting the original satellite image, the difference between crest and slope vegetation cover is not immediately obvious. Clearly the "crest" vegetation cover noticed above the Antelope falls does not repeat itself on every crest, and also the extend of this vegetation cover appears to limited to be mapable.

As a result we have to assume that at leas on a scale of approximately1:50.000, there are indeed only two main ecosystems: (Modified) Lowland forest and Hill forest. With their distribution as in the ecosystems map on the following page.

Mayflower Bocawina National Park Ecosystems



Musa balbisiana (Musaceae)

Musa balbisiana *in the Mayflower Bocawina National Park*

Musa Balbisiana was not originally reported in Balick et al (2000) and was finally identified during this Rapid Ecological Assessment of the Mayflower Bocawina National Park. In the more disturbed lowland parts of MBNP, *M. balbisiana* was very common. Just outside the park in abandoned farmland, this banana has reached pest proportions and locally out-competes anything else.

M. balbisiana - this seedy-fruited, species from southern Asia has been used as a parent in several cultivars, due to its disease resistance, drought tolerance, and general hardiness to environmental factors. It is a diploid, symbolized BB. Its natural range does not overlap that of *M. acuminata*, but human migration in this region allowed these two species to hybridize in nature many years ago. This gave rise to 3 additional genotypes, AB, AAB, and ABB, being 1/2, 1/3, and 2/3 balbisiana, respectively. Hybrids (AB, AAB, ABB) are sometimes given the name *Musa* x *paradisiaca* L. (syn.s *Musa* x *sapientum* L., *M. acuminata* x *M. balbisiana* Colla).

In the field (at least Belize), *M. balbisiana* is easily recognized by the leaves that grow in a more upright position compared to cultivated bananas. Other characteristics are as follows: The fruit bunch is pendent, very compact, the crowded fruits having little room (except in the basal hand) and reflex geotropically. Consequently the fruits, for the most part are standing out from the rachis.

Musa balbisiana *bunch*

The individual fruit is about 4" long and 1¾" in diameter. The pale yellow fruit is also distinctly angulate at maturity. The pulp is whitish; the seeds are black, irregularly globose, scarcely depressed, minutely warty, 5 - 6 mm. across and 4 - 5 mm. high.

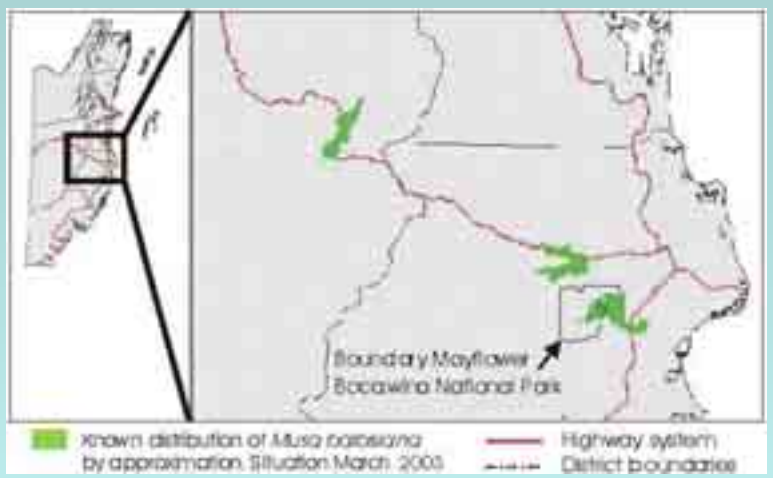
Fruit of Musa balbisiana *cut open to show the seeds*

In contrast to the polymorphic *Musa acuminata* with numerous subspecies identified, *Musa balbisiana* is a remarkably uniform species with only one variety reported.

Locally, the fruits of *Musa balbisiana* are used to produce a beverage. Ripe fruits are strained to remove the seeds. *Musa balbisiana* is the true Japanese Fiber Banana grown in the Ryukyu Islands of Japan from which the cloth basho is woven.

***Musa balbisiana* (Musaceae) – continued**

Further surveys indicated that *M. balbisiana* also occurred along the Hummingbird Highway. Subsequently these locations were mapped using GPS coordinates and entered in a GIS system. In total two centers of distribution were located in the Stann Creek district and one in the Cayo district. It is quite possible that not all locations have been identified and that the distribution of the species is wider than the map suggests. Reports that this species also occurs in the Toledo district have, so far, not been confirmed.



Where the species occurs it is found in lowland areas that are headily disturbed as a result of agricultural activities. Typically the highest densities are found along streams. At such locations the density can be very high and very few other plant species can be found. In areas regenerating back to forest such as in the Mayflower Bocawina National Park, the species persists for a long time, but seems to disappear as soon as the canopy cover of the new forest closes.

The presence of M. balbisiana in Belize is without question the result of introduction by man. Possibly plants were introduced as experimental material for the improvement of existing banana stocks. The current distribution pattern of the species, suggest a more natural distribution, probably birds and/or bats.

The fruits are filled with seeds (see picture in the previous page), and germination experiments I carried out using fresh seed, revealed a seed-viability of approximately 95%. This high viability, and the fact that banana's are readily eaten by a large number of frugivorous bats and birds, would seem to guarantee a rapid spread of the species.

The fact that the species is still restricted to a limited area is probably the result of the ecological requirements of the species. The species, like all bananas needs fairly fertile soils and abundant moisture. Also, it is incapable of surviving and reproducing under a closed forest canopy. The current locations with the species are essentially locked up between areas with an intact forest cover and areas with poor (savanna) soils. However, as deforestation progresses, the species is likely to expand further throughout Belize.

5. Invertebrates

Invertebrates were not a focus of the REA. But some interesting observations were made. The most noticeable invertebrates in the Mayflower Bocawina National Park are the biting insects. Most notable are "botlass flies" (Simulidae), these small black flies reproduce in flowing water (Silk Grass Creek!), and are a real nuisance. Fortunately, they are not known to transmit any diseases (at least not in Belize).

Other notable biting insects are various mosquito species (Diptera: Culicinae) that can be a nuisance at night but also during day when under canopy cover. A very annoying insect is a "Deer fly" (Diptera: Tabanidae), that can be particularly common in the forest in the early part of the year. This particular species has an unusually long proboscis, with which it is able to penetrate several layers of clothing.

Figure 7. Citheracanthus meermani

Several spider (Arachnidae) species were found. Very distinctive is the Golden Orb Spider *Nephila clavipes* with its massive, golden yellow orb web.

Mayflower Bocawina National Park is home to at least 2 tarantula spiders. The common species with the red abdomen is *Brachypelma vagans.* It is often found in open, disturbed areas at low elevation.The only recently described *Citheracanthus meermani* appears less common and is found more in the hills.

More attractive insects are the butterf lies. During the entire period of the REA, relatively few butterfly species were noted. These include:

Adelpha cytherea. October 28, 2002.
Aeria eurimeda March 6, 2003.
Anartia fatima. Common butterfly in open areas. Seen every visit.
Caligo memnon (Owl Butterfly), Seen virtually every visit.
Caligo uranus Seen only on October 28, 2002.
Eueides aliphera March 6, 2003
Eueides Isabella March 6, 2003
Eurema daira March 6, 2003
Heliconius charitonia. October 28, 2002
Heliconius errato. October 28, 2002
Leucochimona nivalis March 6, 2003
Mechanitis polymnia Feb 25, 2003 Eggs on *Solanum torvum*
Morpho peleides. Frequent. March 6, 2003
Siproeta superba: Uncommon species: 9-Oct 2002, near Bocawina falls

Fig. 8. Anartia fatima

Other notable insects include the “peanut bug” *Fulgora laternaria* several of which were seen on October 9, 2002 on Zanthoxylum trees near the main Mayflower archaeological site. Care should be taken to preserve these trees since the peanut bugs seem to depend on them and they are certainly a tourist attraction.

***Fulgora laternaria* (Homoptera: Fulgoridae)**

This most unusual insect reaches up to 10 cm (4") in length. Apart from its size, the most astonishing feature is the inflated head. This hollow ornament (see the real, small eye just behind it) has the appearance of a lizard's head including eyes, nostrils and grinning teeth! Hence the name "alligator bug". Another common name is "lantern bug". This because of the widely held (but false) belief that the hollow "head" contains a light. "Peanutbug" is a more appropriate common name due to the shape of the ornament. Little or nothing is known about the biology of this oddity. In Costa Rica the species is believed to be linked to the tree *Hymenaea coubaril* (Leguminosae). This tree is quite rare in Belize and I have found specimens of *Fulgoria* most commonly on trunks of “Prickly Yellow” (*Zanthoxylum*: Rutaceae) trees.

During the mid-rainy season, this species can rather reliably be observed on the *Zanthoxylum* trees near the main Mayflower Archaeological Site. During the REA they were seen on October 9, 2002.

6. Fishes

The fish fauna of Mayflower National Park was not a focus of the REA. Nevertheless, some observations were made and these observations were augmented with data provided in the book of Greenfield and Thomerson (1997)
Small, fast flowing streams such as the Silk Grass Creek are notoriously poor in species composition. Highest diversity will be found at the lower reaches (especially when approaching the sea), while the waterfalls upstream pose severe barriers for most species. One or two species (notably *Astyanax*) however, have made it at least to the Bocawina Falls.

Species list

Characidae

Astyanax aeneus or Central Tetra. This is the most common and visible species at the Reserve. The red tail fin is diagnostic. At the picnic spot, there are large schools of this species hanging around, ready to devour any table scrap thrown in the river by a tourist. (Visual record March 20, 2003)

Pimelodidae

Some catfish were seen at night in a deep pool of the Silk Grass Creek (Visual March 20, 2003). Based on the fairly large size, it can be assumed that the species observed here was *Rhamdia guatemalensis*. The much smaller (up to 6") *Rhamdia laticauda* is listed for the Silk Grass Creek in Greenfield and Thomerson (1997).

Poeciliidae

The shallow and fast flowing character of the Silk Grass Creek is not beneficial for a high fish diversity. One family however, seems to do well in this type of water. A total of 5 Poeiciliidae (livebearers) was recorded for the stream:
Heterandria bimaculata Visual March 20, 2003
Belenox belizanus Visual March 20, 2003
Gambusia luma Visual March 20, 2003
Poecilia mexicana Listed for the Silk Grass Creek in Greenfield and Thomerson (1997)
Xiphophorus helleri Listed for the Silk Grass Creek in Greenfield and Thomerson (1997)

Cichlidae

Several individuals of a cichlid species were seen on March 20, 2003. No positive identification was made but Greenfield and Thomerson (1997) list *Cichlasoma spilurum* for the Silk Grass Creek. One or two more cichlids may be expected in the Silk Grass Creek.

7. 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. At that time they are very vocal and easily located. Since the survey started after this event, it became very difficult to find amphibians.

Only five species were identified with certainty:

The small tree-frog *Scinax staufferi,* the toads *Bufo marinus* and *Bufo valiceps* the rainfrog *Leptodactylus melanonotus* and the real frog *Rana vaillanti*. The latter was seen in the Silk Grass Creek. These five species are common throughout most of Belize. The habitat is suitable for many more species, but a survey at exactly the right moment would be required.

Literature search (Lee, 1996) revealed older records from the general area ("Silk Grass Creek" and "Bocawina") of the following species:

Salamanders:

Bolitoglossa mexicana
Oedipina elongata

Frogs and toads:

Eleutherodactylus chac
Eleutherodactylus rugulosus
Smilisca baudinii

Surprising was the apparent absence of the tiny glass frog *Hyalinobatrachium fleischmanni.* This species can be common along fast flowing streams and has a very distinctive call. Normally the species continues calling even after the main reproductive season has ended. Several nocturnal surveys along the creek failed to locate this species.

Another species that received some special attention was the worm salamander *Gymnophis syntrema.* This species is supposedly very rare in Belize but because of it's fossorial lifestyle probably overlooked. Comments by Mr. Peck made me believe this species could be present within the park but extensive digging near the steam did not reveal a single worm salamander. Still, a species to be on the lookout for.

Fig. 10. Gymnophis syntrema

8. 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:

1 Crocodile species
16 Lizard species
7 Snake species
2 Turtle species

Fig 11. Norops lemurinus

Several of the lizards were found during night surveys while they were resting on branching or leaves. Examples of that include the various anoles (*Norops lemurinus*) and the juvenile of the "Old Man Lizard" (*Corytophanes hernandezii*). The latter is a rarely encountered species. These lizards are "sit and wait" predators and don't attract attention by their movements. As a consequence they are often overlooked.

Fig 12. Corytophanes hernandezii

Most of the reptiles encountered are common and unthreatened in Belize. The reported presence of the Crocodile *Crocodylus moreletii* was surprising. Small, fast flowing creeks such as the Silk Grass Creek are not an optimal habitat for this species. Deliberate introduction of the specimen reported is certainly an option but on the other hand crocodiles are sometimes found in similar creeks in the Orange Walk district. So its occurrence may well be natural.

The introduced gecko *Hemidactylus frenatus* proved to be extremely common on the buildings of Mamanoots Lodge. This species is strongly tied to human presence and is not expected to build up high population densities outside the built up areas.

Green Iguanas (*Iguana iguana*) were seen along the Silk Grass Creek and a dead female was found as a roadkill on the access road. On the access road, outside the reserve, a Spiny-tailed Iguana (*Ctenosaura similis*) was seen. This species may be expected on the cleared Maya sites within the reserve.

An uncommon species that was recorded in the literature (Lee, 1996) was the arboreal lizard *Celestus rozellae.* Very few specimens have been reported in Belize.

The venomous snake; *Bothrops asper* (Tommygoff, Yellow-Jaw, Fer de Lance) was reported by the park wardens. The presence of this species is not surprising and it can be expected that it is quite common in the area.

9. Birds

(Lee Jones, Punta Gorda)

INTRODUCTION

As part of this rapid ecological assessment of the newly designated Mayflower-Bocawina National Park, avian surveys were conducted by H. Lee Jones on the site on 5–6 November 2002 and 6–9 March 2003. The results of these surveys are presented in this report, along with complete species lists for the two visits and raw transect data from the second visit. Peter Herrera conducted additional avian surveys on 24–26 February 2003. Although officially not part of the REA team, Mr. Herrera used the same vegetation transects to do his bird counts and he was kind enough to share his data with us. In order to facilitate comparison between the data collected by the two ornithologists, an analysis of Herrera's surveys is presented, and the results of the two survey efforts are compared and contrasted. The raw data of the surveys are presented in the appendix. The Mamanoots bird list was also taken into account even though it contains a few doubtful species. Altogether a total of 197 bird species was recorded.

METHODS

In November, general site walkover surveys were conducted, and the species and numbers of all birds encountered were recorded or estimated each day (Appendix A). In March, in additional to site walkover surveys, surveys were conducted along established transects in three localities: the hill behind (south of) Mama Noots resort (two transects) known as Water Pipe Trail, the Tau Witz trail south of the Mayflower ceremonial site (two transects), and along the ridge above and east of Antelope Falls (one transect). A sixth transect has been established at the eastern boundary of the national park in an old *Gmelina* forest plantation. Bird surveys were not conducted at this locality.

All 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. Transect dates and times, and the weather conditions at the time of survey are presented in Table 1; raw transect data are presented in Tables 2–6; and a compilation of transect results is presented in Table 7 (All in appendix 1).

Each established transect was 200 meters long and as straight as the terrain would allow. 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.

RESULTS

Seventy bird species were recorded from five transects over a three-day period. Except for the second-growth forest along the lower Tau Witz trail (Transect 4), the number of birds recorded on each transect ranged from 23 to 31 (Appendix 1, Table 7), indicative of roughly the same avian diversity, in as much as this can be postulated from a single survey. Forty-one species, however, were recorded along Transect 4, one-third more than the next highest transect count.

An additional 104 species were recorded away from the transects on the two visits in November 2002 and March 2003. Many of these were species of different habitats, primarily aerial species, and species more likely to be encountered later in the day (many hawks, for example); however, many others are likely to be present within the transect boundaries and would likely be recorded with the completion of more transect surveys.

The most commonly encountered species on the transects was the Lesser Greenlet (*Hylophilus decurtatus*), with an average of 5.4 per transect. The next most common species was the Red-capped Manakin (*Pipra mentalis*) with 3.4 per transect, followed by the Spot-breasted Wren (*Thryothorus maculipectus*) with 2.6, the Plain Chachalaca (*Ortalis vetula*) with 2.2, and the Short-billed Pigeon (*Columba nigrirostris*), Gray-fronted Dove (*Leptotila rufaxilla*), Blue-crowned Motmot (*Momotus momota*), and Brown Jay (*Cyanocorax morio*), all with 2.0 per transect. These are all common species of the tropical lowland broadleaf forest, forest-edge, and high second-growth forest, with the Blue-crowned Motmot and Red-capped Manakin more typical of forest interior and the Plain Chachalaca and Brown Jay being more typical of forest edge and second-growth. These preferences are reflected by the fact that Red-capped Manakin was found in all four mature forest interior plots but not in the second-growth plot (Transect 4). By way of contrast, eight of the ten Plain Chachalacas recorded were in Transect 4 and the other two were heard from nearby Transect 3.

Species of conservation concern (Jones and Vallely 2001) recorded on the transects were Crested Guan (*Penelope purpurascens*) and Keel-billed Motmot (*Electron carinatum*). A relatively low number of North American migrants was recorded: six species, compared with 63 resident species and one dry season breeding visitor.

DISCUSSION

It is not surprising that the highest species diversity was recorded on the one transect that is in recovering forest. While many of the more common and widespread species may be found within second-growth woodland and the forest edge, most rarer species are restricted to mature broadleaf forest, for example, the two species of conservation concern, Crested Guan and Keel-billed Motmot. Second-growth forest supports a higher diversity of species because it attracts birds from more open habitats as well as many from more mature forest, and still others from ecotonal or transitional habitats.

The low number of North American migrants, however, was a surprising find. Perhaps, more transect surveys would yield more of the expected species such as the many wood-warblers not recorded, including Chestnut-sided Warbler (*Dendroica pensylvanica*), Black-throated Green Warbler (*Dendroica virens*), Black-and-white Warbler (*Mniotilta varia*), American Redstart (*Setophaga ruticilla*), Worm-eating Warbler (*Helmitheros*

vermivorus), and Ovenbird (*Seiurus atricapilla*), all of which should be relatively common in winter in the broadleaf forest interior.
The overall avifaunal diversity for the national park appears to be high compared with comparable areas in Belize. The presence of Keel-billed Motmot is especially encouraging, as this species is dependent on virtually undisturbed foothill primary broadleaf forest, and as such has become one of the rarest bird species in all of Central America, as these forest areas continue to be extensively logged.

Keel-billed Motmot (Electron carinatum)

Keel-billed Motmot (Picture by Carolyn Miller)

The Keel-billed Motmot, has always been considered the rarest of all motmots. Found locally in humid lowland and montane forest on the Caribbean slopes of Northern Meso-America, it has been considered very rare throughout its range. The status of this species in Belize was obscure until the early 1990s when intensive studies were carried out in the Maya site of Caracol (Miller & Miller, 1996).

Current knowledge indicates that the species probably occurs throughout the Maya Mountains (Meerman & Williams, 1995) but only in low densities and usually in very difficult to reach locations. The preferred habitat appears to consist of steep gullies and cliffs in very dense, vine covered hill forest.

Keel-billed Motmots can be conspicuous and thus can appear deceptively numerous. From January through March they are readily detected as the males are in their territories and loudly vocalizing. The most frequently heard are the far carrying and territorial calls which can be described as a drawn out Kawaa...kawaa (Miller & Miller, 1996). Often the species is one of the earliest birds to vocalize during a morning chorus.

The presence of Crested Guan, Great Curassow, and Ocellated Turkey in the park is very encouraging. Especially considering the high hunting pressure. Successful curtailment of hunting in the park in the coming years would likely result in a significant increase in these three species. Recent observations of Ocellated Turkeys in the park by both Mama Noots staff and visitors suggest that a remnant population is present in the area.
The Ocellated Turkey and Keel-billed Motmot are of special interest to bird watchers. These two species are hard to find outside of Belize, and until now, there was no known area in Belize where this motmot species could be seen within an easy walk of a parking place or tourist lodge. Mayflower Bocawina National Park is ideally situated for tourists wishing to see the Keel-billed Motmot; and if the Ocellated Turkey population expands

once hunting pressure eases, Mayflower Bocawina National Park would also be an excellent destination for those wishing to enjoy this rare and elusive Yucatan endemic.

AVIAN SURVEYS CONDUCTED BY PETER HERRERA

On 24–26 February 2003, Tourguide Peter Herrera conducted avian surveys on all six transects (Jones did not survey the *Gmelina* transect). The methods employed in both Herrera's and Jones' surveys were very similar; however, only Jones compiled totals for all birds encountered. Herrera made only one entry per station for each species (i.e., if three Spot-breasted Wrens were recorded at Station 2, Transect 3, a "1" was entered rather than a "3" for that species at that station). Jones conducted all transect surveys in the morning between 05:45 and 08:15 (Appendix 1, Table 1); whereas Herrera conducted surveys in the afternoon as well.

Species names used by Herrera have been adjusted in the text below and in Appendix 1, Table 8 to conform with those used by Jones, per AOU (1998, 2000, 2002).

For the most part, Herrera's surveys appear to be thorough and accurate; however, on the upper Tau Witz transect (Transect 3), Herrera recorded Ferruginous Pygmy-Owl (*Glaucidium brasilianum*). On this same transect, Jones recorded a probable Central American Pygmy-Owl (*G. griseiceps*). The former is not known from this area but could occur. Herrera *may* have confused the two species. On this same forested transect, Herrera recorded a Least Flycatcher (*Empidonax minimus*). Yellow-bellied Flycatcher (*E. flaviventris*) is much more likely in this habitat. Of the two *Empidonax* likely to be encountered in Belize in winter, *flaviventris* is found almost exclusively in forests and *minimus* is found in open and disturbed habitats; thus, it is more likely that he had *flaviventris*, not *minimus*. His Slaty-breasted Tinamou (*Crypturellus boucardi*) recorded on the *Gmelina* transect may also be suspect (possibly the similar-sounding White-tipped Dove [*Leptotila verreauxi*]), as this Tinamou is found exclusively in relatively undisturbed primary forest.

A few species appear to have been missed by Herrera: Gray-chested Dove (*Leptotila cassini*), Tawny-crowned Greenlet (*Hylophilus ochraceiceps*), Green Shrike-Vireo (*Vireolanius pulchellus*), and possibly Kentucky Warbler (*Oporornis formosus*). All of these species were recorded frequently by Jones on the transects one month later. On the other hand, Jones missed, for example, Stripe-throated Hermit (*Phaethornis striigularis*), White-bellied Emerald (*Amazilia candida*), Yellow-olive Flycatcher (*Tolmomyias sulphurescens*), and Dusky-capped Flycatcher (*Myiarchus tuberculifer*), all relatively common species recorded frequently by Herrera. The failure of both Herrera and Jones to record several common species is testament to the fact that brief, one-time-only surveys will not detect all of the relatively common species (but should detect all of the most common species).

One species recorded by Jones, but not Herrera, Piratic Flycatcher (*Legatus leucophaius*), is seasonal and would not have been present in early February.

Appendix 1, Table 8 presents a species-by-species comparison of the surveys conducted by Jones and those conducted by Herrera for all but the *Gmelina* transect which Jones did not include in his surveys. While there are many more similarities than differences shown in this table, it is almost impossible to make detailed comparisons of two people's data. Both Jones and Herrera are likely to have overlooked some species recorded by the other. As most of the species recorded on a forested transect are heard rather than seen, and as

most people have rather widely differing experiences and expertise with bird vocalizations, this makes such a comparison even more difficult. Also, slight differences in methodologies employed, as well as differing times of day the surveys were conducted add to the difficulty in making detailed comparisons.

Herrera legitimately recorded a number of species that Jones did not, and vice versa. The total number of species recorded by both Jones and Herrera, was approximately 92. Of these, Jones recorded 76% and Herrera recorded 71%. Undoubtedly, both Herrera and Jones failed to detect a number of rarer and transient species not present (or at least not vocalizing) on the transects at the time of survey; thus, the total number of species likely to be present, would be much greater than 92.

Some similarities between the surveys appear to be real, and are not surprising. Both Herrera and Jones recorded more species in the disturbed woodland of the lower Tau Witz trail (Transect 4) than on the other four transects that were surveyed by both parties. The reasons for this higher diversity in disturbed habitats are discussed above.

In examining which species were most frequently recorded, Herrera's data and Jones' data vary considerably (Appendix 1, Table 9), but even factoring in differences in degree of observer recognition of the vocalizations of the common species, the apparent discrepancies are more likely to be a reflection of the relatively small component of the resident avifauna present or vocalizing at any given time. All of the most common species recorded by Herrera and Jones are undoubtedly present in moderate numbers, but only the two or three most common and conspicuous species are likely to be recorded during every hour of survey time (each transect takes an hour to survey).

Only two species, the Lesser Greenlet and the White-breasted Wood-Wren, were recorded on four or more transects by both Herrera and Jones. In looking at number of birds recorded per station (out of 25 stations in all), only two species in common were recorded at eight or more stations: Lesser Greenlet and Spot-breasted Wren, and these are certainly among the most common species in the area. But Red-throated Ant-Tanager, another very common species, was recorded by Herrera at 12 stations (his highest recording rate), yet by Jones at only four stations. Conversely, Jones recorded Gray-fronted Dove, Violaceous Trogon, Slaty-tailed Trogon, and Red-capped Manakin at nine stations and Herrera had these four species at only 3, 4, 5, and 4 stations, respectively, again illustrating the importance of conducting multiple surveys (i.e., a much larger sample size) in obtaining results that reflect an accurate estimate of avian diversity and abundance in the Mayflower-Bocawina National Park.

10. MAMMALS

Mammals were assessed on an opportunistic basis by all of the teams. In addition, interviews were held with users (including some hunters) of the area to assess the presence of the more conspicuous species. The park wardens were particularly helpful in this aspect. Although much work remains to be done, a total of 50 mammal species were documented with confidence (see list in appendix).

The only mammal group that was assessed in a systematic way were the bats. This species-rich group was assessed by Bruce Miller, Associate Conservation Zoologist of the Wildlife Conservation Society. Miller identified 23 bat species in the park. To achieve this result, Miller used a number of "harp" traps, mist nets and multiple acoustic monitoring devices to survey this group. This combination of methodologies provides the most complete survey possible for all bat families. Mist netting alone ignores 7 families for the most part and is biased to one group only (Phyllostomids). The reports dealing with the bats of Mayflower Bocawina are attached in its original format as an appendix to this main report.

Figure 24. Putting up a harp trap

Figure 15. Receiver section of an acoustic trap

In Belize, 71 bat species are known from eight families. Most previous sampling in the neotropics used only mistnets. Such ground-level nets sample less than 10% of the airspace under a typical forest canopy and are biased towards species of leaf-nosed bats (Phyllostomidae). Other species, representing the remaining seven families, are seldom captured in such mistnets. Consequently, the distributions and status of the species comprising the other seven families in Belize have been poorly understood. In addition to assisting Friends of Mayflower with a biodiversity inventory of this national park, this survey was also part of an on going NEOBAT atlas project where bat species distributions are being mapped for an assessment of their conservation status.

Because most surveys for bats in Belize have focused on mist-netting, Miller concentrated on the other methods now available. He employed double-frame harp traps and acoustic survey techniques to sample those species of interest. Acoustic techniques used the Anabat system that has proven to be an effective means of identifying free flying bats. Because of several years of study carried out by Miller and others, nearly 91% of

the 32 known non-phyllostomid bat species of Belize' are now identifiable by vocal signatures. Research was carried out in two phases. December 10 – 11 (2002) and March 20 – 21 (2003). For the full details of the research please consult the full reports in the appendix.

The December 2002 bat survey was quite productive although some expected species remained undetected. The March 2003 bat survey was much less productive. The diversity was altogether lower and no new species could be added.

The unseasonably hot and extremely dry weather in March 2003 no doubt influenced the activity of these aerial insectivorous bats. Overall impressions are that within the areas of the Mayflower-Bocawina National Park surveyed, the bat species were habitat generalists found across Belize. A notable species was the Ghost-faced bat (*Mormoops megalophylla*) recorded at Mayflower Creek during the December survey and again during this survey. This is a species of conservation concern and is an obligate cave roosting species. It does not tolerate disturbance in roost caves. This species is at risk in Belize and is threatened in Mexico, due to tourism visitation to caves that serve as roosts. Because this species was detected early in the evenings, one can assume that they are roosting within 5-10 miles of where they were recorded (the foot bridge at Mayflower Creek). This observation is particularly interesting since the granitic bedrock of the general area is not conducive to cave formation. The nearest limestone area is much more than 10 miles away from Mayflower.

As for the other mammal species, 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.

Much information was obtained from reading tracks, but this worked only during the wet months. In March this method was no longer successful. The owners of Mamanoots lodge, Kevin and Nannette Denny, who live permanently inside the reserve, had much anecdotal information. Important were the discussions held with the two wardens Ramon Guzman and Jenovivo Peck. The two wardens were also instrumental in sending out feelers with the resident hunters.

Based on this information, it appears that Mayflower Bocawina National Park has a fairly typical mammal species composition, with species found in most forest habitats in Belize. Yucatan Black Howler Monkeys are infrequently heard throughout the area but don't seem to reach high densities. The habitat appears suitable for the Central American Spider Monkey but this species appears to be even more rare. One Spider Monkey was allegedly shot (for food) in October 2002.

Notable species also include the large cats, of which the Jaguar gets fairly frequently seen by the residents of Mamanoots resort, and of which tracks are common. The presence of this top predator indicates that there is still a healthy prey-base.

Hunting remains a problem, even now that the area has a protected status. Hunters come from Silk Grass, Dangriga, Sittee River, Hopkins and the Stann Creek Valley. There is a perception that hunting has increased since the Forest Department abandoned the forest reserves. The presence of Forest Department staff appeared to act as a deterrent to hunters. Since the termination of active management, the area is essentially a free for all. The park wardens are only present during daytime, while hunting is carried out mainly at

night. Even then, the wardens do not have a mandate to act against hunters. The most effective deterrent appears to come from the owners of the Mamanoots lodge. They at least attempt to curb hunting and there physical presence should at least deter some hunters. Another problem is the expansion of the trail system in the park, giving easy access deep into the park. The survey lines are part of the same problem. Using the survey-lines even the remotest parts of the park and beyond can be reached. Short forays onto the survey-lines always turned up shotgun shells. The survey-lines are probably the single largest problem in combating hunting.

11. Associations between animal species and habitat

Two main habitats/ecosystems can be recognized within the park:

1) Hill forest
2) Lowland forest

A number of smaller ecosystems exist such a stream habitat and the different "upland crest habitat" discussed in chapter 4. However, these habitats were insufficiently researched and cover only small areas. Interaction between the surrounding habitats may therefore overshadow habitat specific interactions.

The analysis carried out in this study indicates that both slope transects are very similar in species composition and species abundance. The forest on one of the crest transect, is also very similar to these. All three have a similar, high biodiversity. The Forests on both lowland transects however, are quite different. Not only different from the above three transects but also when compared with each other. This is not surprising since the lowland has been heavily disturbed and the "Gmelina lowland" transect is essentially a silvicultural plantation. Both the lowland transects have a very low floristic biodiversity. The bird fauna reflects these differences. Of the most commonly encountered birds, the Red-capped Manakin and Blue-crowned Motmot were most commonly encountered in the hill/crest transects, while Plain Chachalaca and Brown Jay were encountered most in the lowland, second growth transects.

Highest bird species diversity was recorded on the one transect that is in recovering forest. While many of the more common and widespread species may be found within second-growth woodland and the forest edge, most rarer species are restricted to mature broadleaf forest, for example, the two species of conservation concern, Crested Guan and Keel-billed Motmot. Second-growth forest supports a higher diversity of species because it attracts birds from more open habitats as well as many from more mature forest, and still others from ecotonal or transitional habitats.

As for the mammals, it appears that Mayflower Bocawina National Park has a fairly typical mammal species composition, with species found in most forest habitats in Belize. Yucatan Black Howler Monkeys are infrequently heard throughout the area but don't seem to reach high densities. This species is more commonly found in lowland (especially riverine) forests. The hill habitat of Mayflower Bocawina appears more suitable for the Central American Spider Monkey which is usually found in hilly terrain. But for some reason, this species appears to be even more rare in the park than the Howler Monkey.

With bats the same applies, a fairly "normal" species composition with the overall impressions are that within the areas of the Mayflower-Bocawina National Park surveyed, the bat species were habitat generalists found across Belize.

12. Threaths

Hunting.

One of the principal and direct threats to the wildlife of the reserve remains hunting. Hunting continues even now that the area has a protected status. Hunters come from Silk Grass, Dangriga, Sittee River, Hopkins and the Stann Creek Valley. There is a perception that hunting has increased since the Forest Department abandoned the forest reserves. The presence of Forest Department staff appeared to act as a deterrent to hunters. Results of interviews indicate that wildlife densities have steadily decreased over the past two decades. Currently the area is essentially a free for all. The park wardens are only present during daytime, while hunting is carried out mainly at night. Even then, the wardens do not have a mandate to act against hunters. The most effective deterrent appears to come from the owners of the Mamanoots lodge. They at least attempt to curb hunting and there physical presence should at least deter some hunters. Another problem is the expansion of the trail system in the park, giving easy access deep into the park. The survey lines are part of the same problem. Using the survey-lines even the remotest parts of the park and beyond can be reached. Short forays onto the survey-lines always turned up shotgun shells. The survey-lines are probably the single largest problem in combating hunting. Combating hunting is a difficult task. Training wardens with constable authority is one option, but this will be active only when patrols will take place at night. Coordination with Mamanoots on this issue is also essential.
With respect to the survey-lines, these should be maintained wherever there is a threat of incursions. This applies essentially to the eastern survey lines. The northern and southern survey lines have a much lower priority for keeping clear. Under no circumstance should the western survey line be re-opened. The boundary has been established and that should be enough.

Fire.

Another threat to the area is fire. The whole area has been classified as “high fire risk” (Meerman & Sabido, 2001). And the hill-forests in the area have been proven to be very susceptible to 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.

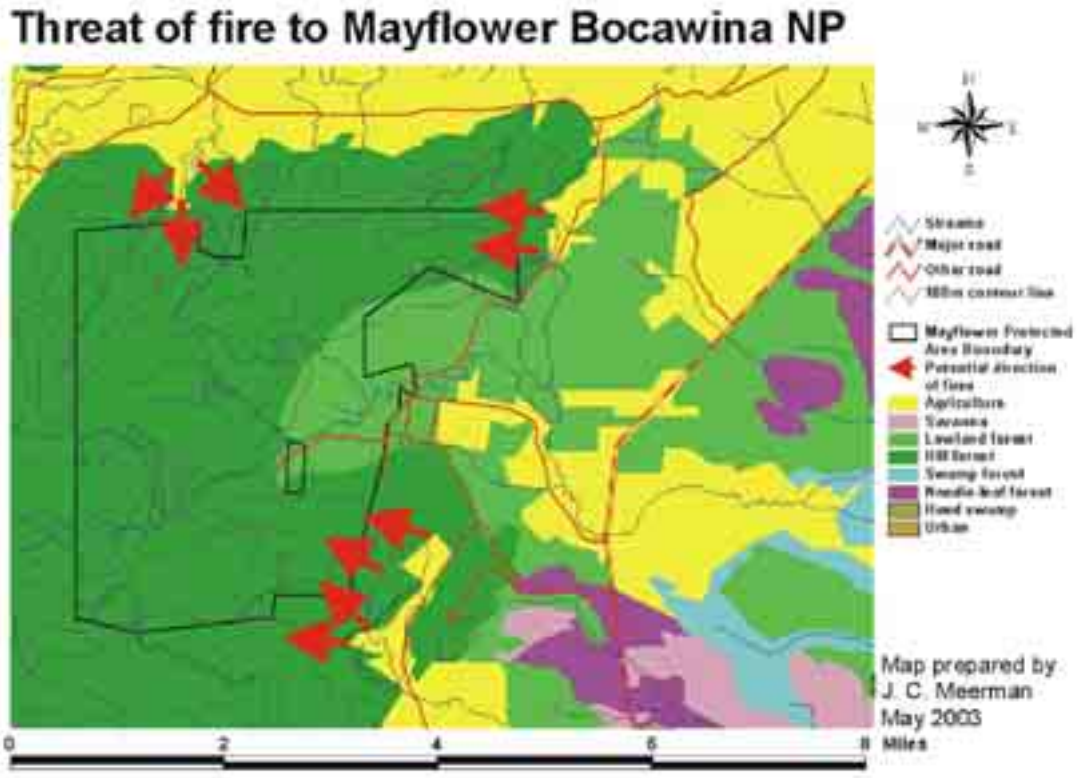
Figure 36. Fire in the hills just north of Mayflower Bocawina NP, May 9, 2003.

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. Observations in the field show that burned hill tops are virtually always connected with agricultural clearings in at the foot of the same hill. The only noteworthy exceptions seem to be some fire damaged areas well away from any activity on a hillcrest of the Maya Mountains. Lightning strike is the most plausible explanation for these burned areas although agriculture is present at the feet of some of these same hills and fire-creep below the canopy remains a distinct possibility.



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 (Johnson & Chaffey 1973).
Fighting fires is only possible when there is a staff trained in fire combat, This staff has to be present in the area at least during the high risk periods (late dry season) and have access to simple firefighting tools. Access to the site is also essential. For this reason alone it is recommended to keep the eastern survey line open and accessible.

Tourism

One last important threat to the area is tourism. Mayflower Bocawina National Park is a favorite spot and with increased visitation, negative effects of tourism (trash etc.) may become visible. Currently the actions of the tourist (and tour operators) that visit the park appears to be quite responsible and tourism is more a blessing than a threat. Constant involvement of the tourism industry in the management of the park is essential in order to keep it this way.

13. Touristic potential

The feature for which Mayflower Bocawina National Park is known, is the Maya site. The main components of the site are called; Mayflower, Maintzunun and Tau Witz. Several smaller sites exist in the surrounding forest.

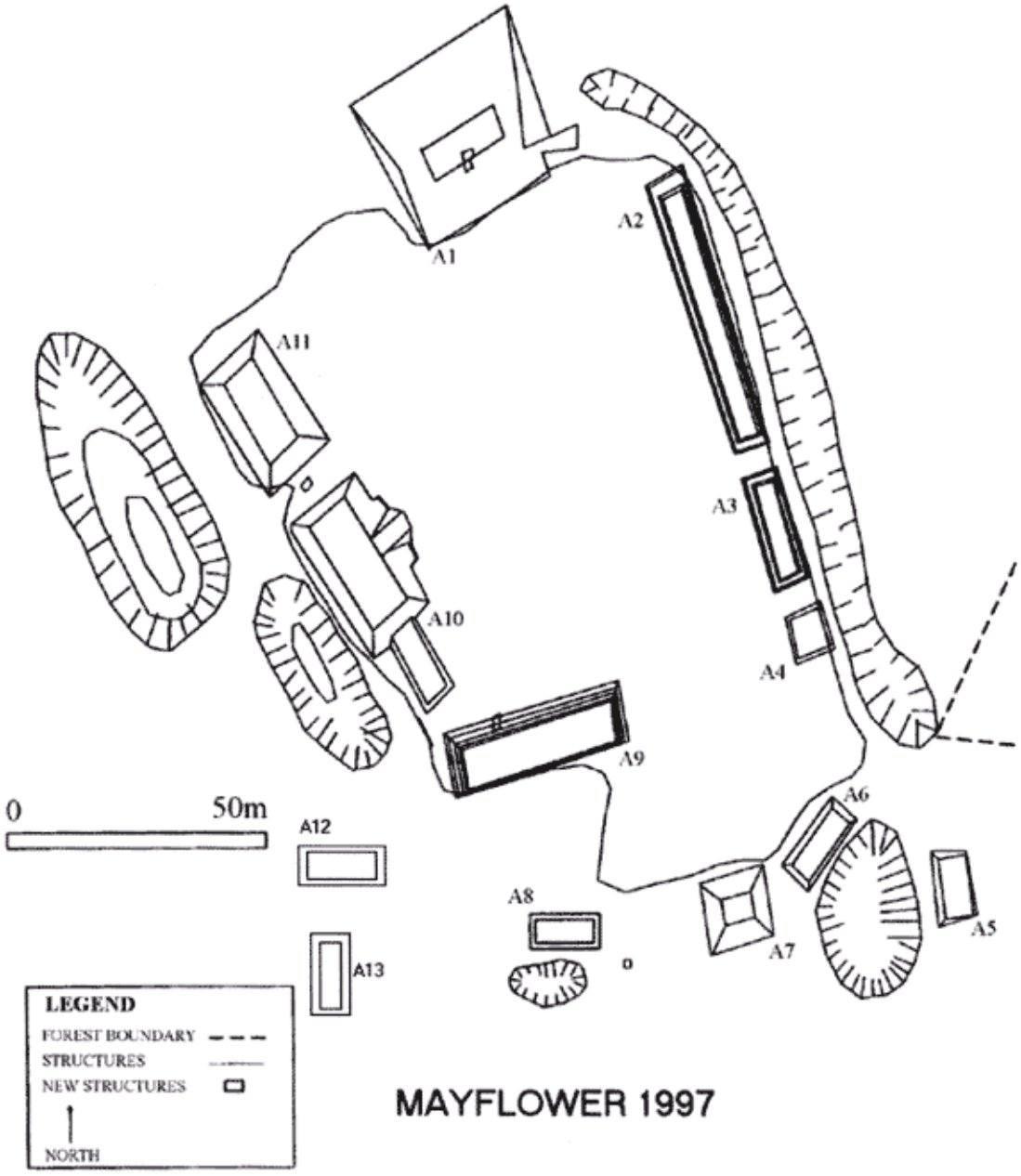


Figure 13. Updated Map of Mayflower with new Structures (A12 & A13) noted.

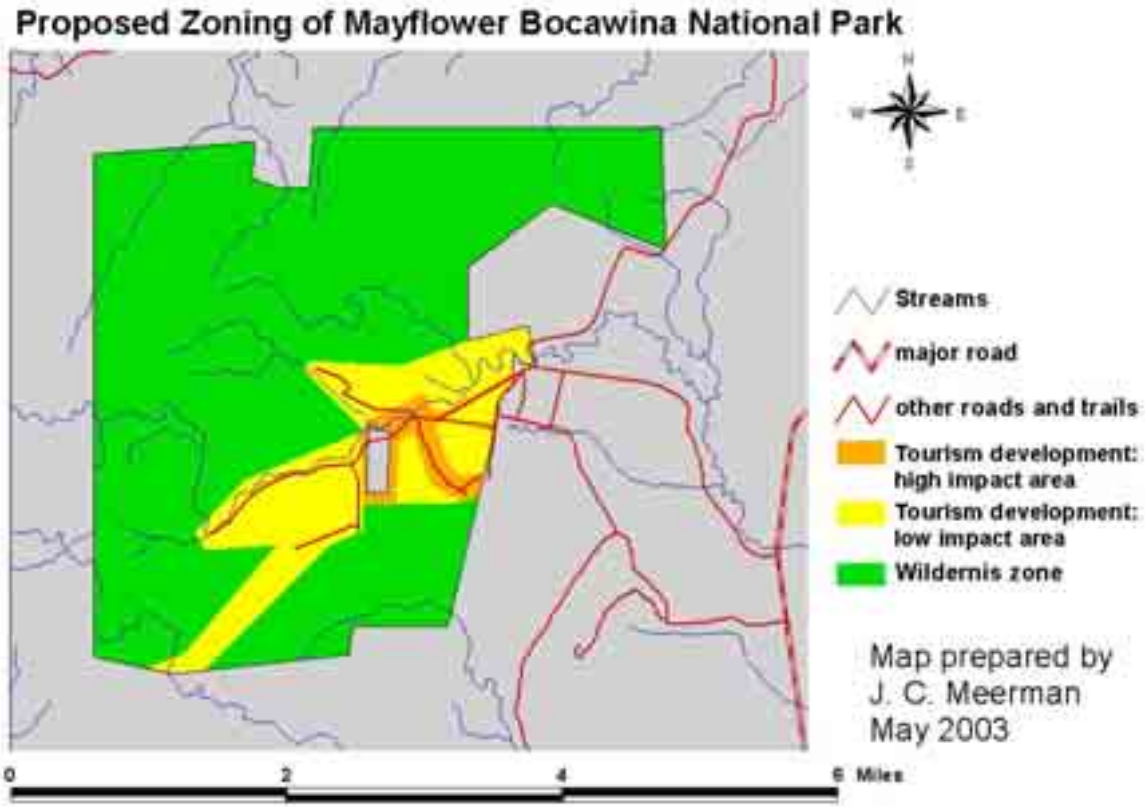
Fig 18. Archeologist (Jef Stomper) drawing of the Mayflower Archaeological Site

Because of this readily accessible Maya site (one of the few in the Stann Creek district), Mayflower has become a popular tourist attraction. Several tour operators and lodges offer trips to Mayflower.
A quick web search revealed a large number of operations that list Mayflower Bocawina on their website:
Kanantik Resort
Second Nature Divers
Hopkins Inn
Beaches and Dreams
Ecological Tours and Services
Kingfisher Adventures
Toucan Sittee
Jaguar Reef
Worldwide escapes
Pal's Guesthouse, Dangriga
Magnum Belize
Kevin Modera Guide Services. Placencia
Manatee Lodge, Gales Point
Mama Noots Lodge.
Loco Gringo Belize
Beaches and Dreams Inn.

Which such a large amount of attention, it is clear that Mayflower Bocawina is getting a lot of attention from the tourism industry. For the tourism industry Mayflower Bocawina is important because, apart from the Cockscomb Wildlife Sanctuary, there are very few other inland tourist destinations.
Apart from the Archaeological features, Mayflower Bocawina has other features of interest. These include principally the waterfalls. Although not spectacular by international standards, they do provide a scenic background for both jungle and archaeological trips.
Specifically of interest is the ecological value of the park from a tourism point of view. Most forest ecosystems are difficult to access. Now is the lowland portion of the Mayflower forest far from pristine, but less disturbed and actually quite attractive forest is still very accessible in the park. A disadvantage is that most pristine forest in the park is on steep slopes and the current trails are not very "comfortable" (too steep).
High hunting pressure has made most wildlife very shy and rarely visible, although tracks (even from Jaguar) are generally easy to find. Birding brings more ready rewards and the presence of a bird species such as the Keel-billed Motmot is most certainly an asset. This species is so unique that it can be used in a marketing strategy aimed at specialized birding groups.
Concluding: The Mayflower Bocawina National Park has an above average tourism potential.

14. 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. The real next step will be a management plan. The preparation of this management plan should involve the tourism industry, tour operators, lodges etc.
In general the management plan should give some thoughts to zoning issues. This zoning could be flexible, and based on new discoveries, developments etc. But for the current situation I propose three zoning categories (see map below):



a) Wildernis zone: An area in which the only allowable activities are research, patrols and maintenance (such as maintenance of survey lines). Construction of trails should be avoided here.

b) High impact tourism development: An area essentially following current developments where permitted activities include Archaeological excavations, Tourist structures, Trails, Camping. Development of these infrastructures should avoid direct impacts on the banks of the Silk Grass Creek, a 66ft bufferzone is to be maintained.

c) Low impact tourism development. Trails only. No structures (other than bridges and other trail improvements). Trails should not follow the creek(s) for extended lengths. Occasional points of contact are OK but in general the 66 ft bufferzone should be maintained. The current situation is largely correct in this aspect. Note

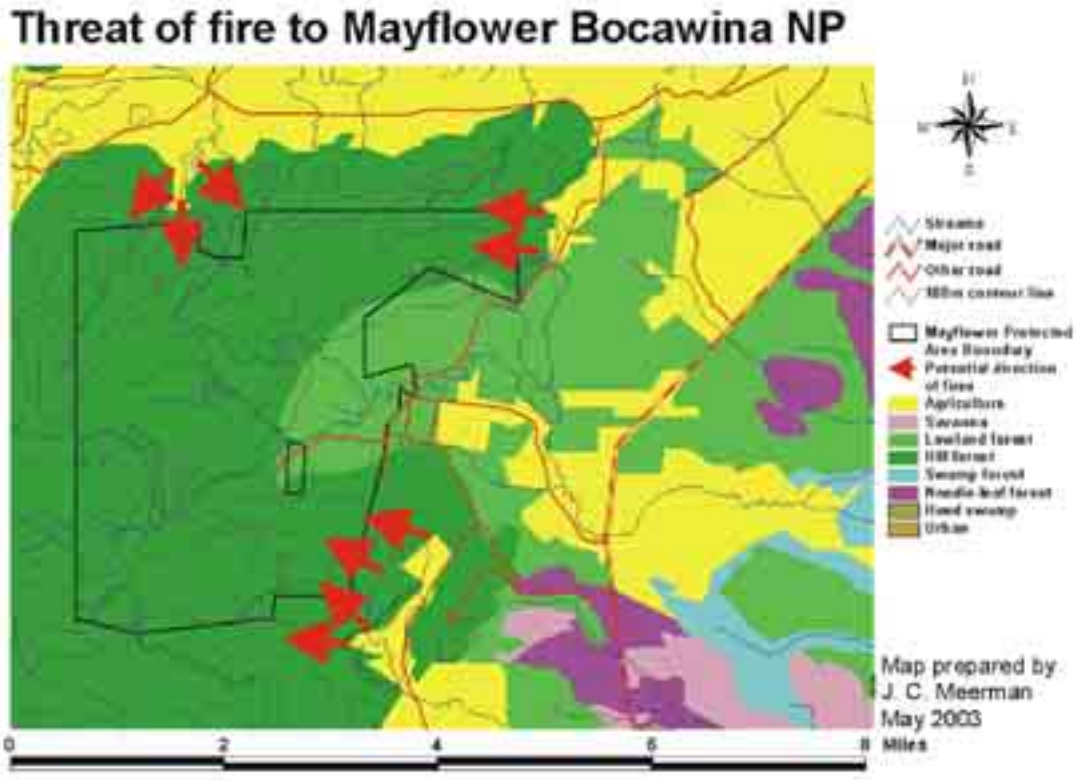
that the zonation here can be flexible, correction/improvement of existing trails can shift the zoning as outlined in the map.

Furthermore, the management plan should incorporate the following thoughts:

- With aspect to research, the possibilities are clearly infinite. For direct management purposes though, there is at least one clear priority. The presence of the Keel-billed Motmot is highly interesting and of interest for the future Touristic development of the park. However, the exploitation of this resource has to be carried out with the greatest care. Over visitation of nesting sites for example, could lead to abandonment of the nests and decline of the population. For this purpose, it should be attempted to establish the population density of this bird and locate the sites with easiest access to the birds with minimum disturbance.
- For this same reason the development of trails should be planned carefully, trails should not lead to the actual nest burrows for example.
- On the further matter of trails, the priorities are to develop the trails to the existing attractions (ruins, waterfalls). One problem of the current trail system is that they can be very steep. Apart from the obvious physical access problems, there is a risk of erosion. It should be noted that heavily compacted trails are more prone to erosion than forest soil, even on steep slopes. Whenever possible, trails should have an easier incline. In other words, approach the target from an angle and not following a straight line.
- Another attraction of the reserve that has not been properly developed is “high forest” Some high forest is accessed on the trails to Antelope Falls, and the trail to the “new” waterfall. However, these trails are steep and do not invite the traveler to enjoy the forest there. Again, if alternative routes can be found that are more accessible, this would improve the enjoyment of this resource. A straight line between A and B is not always the best solution.

Watershed management is in integral part of conservation. The Mayflower Bocawina National Park covers parts of four Watersheds. 1) To the north lies the North Stann Creek, This is a fairly large watershed but the portion of this covered by Mayflower Bocawina National Park is minute. 2) In the Southwest section lies a small portion of the of the Freshwater Creek River watershed. This watershed is of some importance since it supplies Hopkins village with drinking water. It drains into the Freshwater Creek Lagoon. 3) In the Southeast lies a small portion of the Back Ridge Creek watershed. It ultimately drains into the Commerce Bight Lagoon. This is the creek that runs through Silk Grass village. 4) The central portion of

Mayflower Bocawina National Park makes up the headwaters of the Silk Gras Creek watershed. No communities are directly served by this watershed, but there is increasing agriculture in the watershed also depending on a healthy water supply. Protecting this and other watersheds is easily achieved by maintaining forest cover, not only directly around the streams but specifically on the hillslopes. Fire prevention should also be part of the watershed management.



As outlined earlier, fire resulting from poorly executed agricultural practices forms a potential threat to the Mayflower Bocawina 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 staff has to be present in the area at least during the high risk periods (late dry season) and have access to simple firefighting tools. Access to the sites is also essential. For this reason alone it is recommended to keep the eastern survey line open and accessible.

Creating of a "bufferzone" around the park is ideal but only possible with cooperation of the abutting landowners. Essentially these landowners have to agree to manage their land in a sustainable way (no clearing of steep slopes, agricultural fire management). Involving these landowners in the management of the park or at least encouraging them to become members of the organization is in important step in this process.

A management plan should also consider the future of the Gmelina stands within the reserve (See the historical overview in chapter 2). Essentially Gmelina is an alien species and alien species are generally considered undesirable within protected areas. One of the options would be to harvest the existing stands of Gmelina (and earn some revenue) and allow natural forest to regenerate. On the other hand, the species does not appear to be overly invasive. There is abundant seed production but natural regeneration is minimal. If left to it's own devises, the species will probably disappear over the next century and its place reclaimed by naturally occurring species.

Meanwhile, there is an important aspect of management that needs to be carried out immediately. This is monitoring. 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 a 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. Potentially, an agreement with the Lodge Mamanoots can be worked out in this aspect.

The wardens 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!

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