

Rapid Ecological Assessment Aguas Turbias National Park Orange Walk District, Belize



J. C. Meerman

P. Herrera,

A. Howe,

E. Bustamante.

December 2003

Report prepared for the Conservation Division of the Forest Department

INDEX

1. Introduction	1
1.1. Objectives for the Rapid Ecological Assessment	1
2. Methods used	2
2.1. Methodology	2
2.2. Data analysis	4
2.3. Team	5
3. Characterization of the ATNP	6
3.1. Geology	6
3.2. Topography	6
3.3. Hydrology	6
3.4. Climate	7
3.5. Biology	8
3.5.1. Ecosystems	8
3.5.2. Vegetation	15
3.5.3. Invertebrates	16
3.5.4. Fish	16
3.5.5. Amphibians	16
3.5.6. Reptiles	17
3.5.7. Birds	17
3.5.8. Mammals	19
3.5.9. Ecosystem Conditions	20
3.6. Other issues	21
4. Consultations with Stakeholders	22
5. SWOT analysis model and possible Management Alternatives Arrangements.	23
6. Literature	25

Appendices

- Appendix 1: Flora of the ATNP
- Appendix 2: Fauna of the ATNP
- Appendix 3: Vegetation Transect: Low Swamp Forest
- Appendix 4: Vegetation Transect High Swamp Forest
- Appendix 5: Vegetation Transect High Forest over Limestone
- Appendix 6: Bird Transects
- Appendix 7: Bird Checklist
- Appendix 8: Checklist of the Flora of the RBCMA

Cover Picture: ATNP as seen from the North. Straight line is eastern survey line

List of Figures

<i>Cover Picture: ATNP as seen from the North. Straight line is eastern survey line</i>	
<i>Figure 1. Location of ATNP in the region</i>	1
<i>Figure 2. March 7, 2001. Landsat tm image of the project area and surroundings.</i>	2
<i>Figure 3. Topography of the ATNP</i>	6
<i>Figure 4. Average Annual Rainfall in Nearby Stations</i>	7
<i>Figure 5. Rainfall Isohyets for Belize</i>	7
<i>Figure 6. Ecosystem map of ATNP and Surroundings.</i>	8
<i>Figure 7. Low Swamp Forest</i>	9
<i>Figure 8. High Swamp Forest</i>	9
<i>Figure 9. High Forest over Calcareous Soils</i>	10
<i>Figure 10. Vegetation/Bird Transects in the ATNP</i>	12
<i>Figure 11. Tillandsia fasciculata. Bromeliaceae. Aguas Turbias NP</i>	15
<i>Figure 12. Hyla ebraccata larva</i>	16

List of Tables

<i>Table 1. Descriptions of the Ecosystems found in the ATNP</i>	10
<i>Table 2. Tree Biodiversity Indices for Three Ecosystems in the ATNP</i>	13
<i>Table 3. Tree diversity indices for various lowland sites in Belize.</i>	14
<i>Table 4. Some typical "northern" plant species found in the ATNP</i>	15
<i>Table 5. Bird diversity indices for three ecosystems in the ATNP</i>	17
<i>Table 6. Bird diversity indices for some lowland forest sites in Belize</i>	18
<i>Table 7. Home ranges of some mammal species</i>	19
<i>Table 8. SWOT Matrix</i>	23

List of Acronyms

ATNP =	Aguas Turbias National Park
BDF =	Belize Defense Force
CBO =	Community Based Organization
CCAD =	Central American Commission for Environment and Development
cm =	Centimeter
dbh =	Diameter at Breast Height
FD =	Forest Department
GIS =	Global Information System
GOB =	Government of Belize
km =	Kilometer
m =	Meter
MAYAMON =	Maya Forest Anuran Monitoring
MBC =	Meso-American Biological Corridor
ml =	Mile
mm =	Milimeter
NGO =	Non Government Organization
NW =	North-West
PfB =	Programme for Belize
RBCMA =	Rio Bravo Conservation an Management Area
REA =	Rapid Ecological Assessment
SE =	South-East
SI =	Statutory Instrument
SWOT =	Strenghts, Weaknesses, Opportunities & Threats Analysis
tm =	Thematic Mapper

1. Introduction

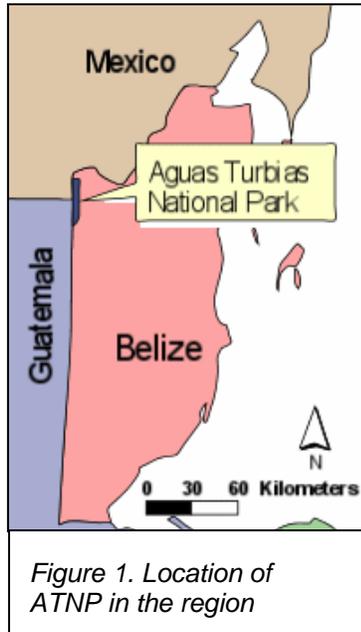


Figure 1. Location of ATNP in the region

Within the National Protected Areas System of Belize, only a few Protected Areas have management plans; Aguas Turbias National Park (ATNP) is one of those parks without a management plan. Declared in 1994 through SI #44/94 with an area of approximately 8800 acres, the ATNP is contiguous with the Rio Bravo Conservation and Management Area (RBCMA) in the south and was originally established as a “peace park” along the borders with Guatemala and Mexico. Due to its location it was expected to play an important role in the trans-boundary connectivity between Belize, Guatemala and Mexico in the Selva Maya Priority Area of the Mesoamerican Biological Corridor. Most recently, the ATNP has been selected under the Central American Commission for Environment and Development (CCAD) regional initiative to receive grant funding for the preparation of its management plan and on-the-ground management activities.

Management of the ATNP rests with the Forest Department (FD). The FD under its Protected Areas Program has seen it timely and necessary for a Rapid Ecological Assessment (REA) to be made in preparation for the Management Plan that is scheduled for completion in 2004. This partnership between the Meso-American Biological Corridor (MBC) and CCAD initiative is considered as a strategic approach to park management. The current REA will provide biological data to be used in the management plan and also makes recommendations for management options.

1.1. Objectives for the Rapid Ecological Assessment

The general objective of this REA was to develop a biological, geological and climate characterization of the Aguas Turbias National Park and other relevant information that will feed into the site’s Management Plan that will be developed during 2004 with funds from Spain known as the CCAD initiative. The specific objectives of this consultancy were the following:

- Review all existing literature on the ATNP;
- Carry out a baseline survey to provide information on the various flora and fauna (including geology, vegetation, ecosystems, invertebrates, fish, amphibians, reptiles, birds, mammals, etc) in the ATNP;

Carry out consultations with NGOs and CBOs to get their inputs or feedback on the characteristics of the ATNP and management options, using a Strengths, Weaknesses, Opportunities & Threats Analysis, on possible Management Alternatives Arrangements.

2. Methods used

2.1. Methodology

A literature search was conducted, but no publications pertaining to the ATNP were found. The National Protected Areas System Plan for Belize (Wilson et al. 1995) briefly discusses the ATNP. A paper on Karst in Belize makes mention of the park (Day, 1996), and there are a number of flora and fauna studies for the RBCMA that list biodiversity data for the area. These titles are listed in the literature list.

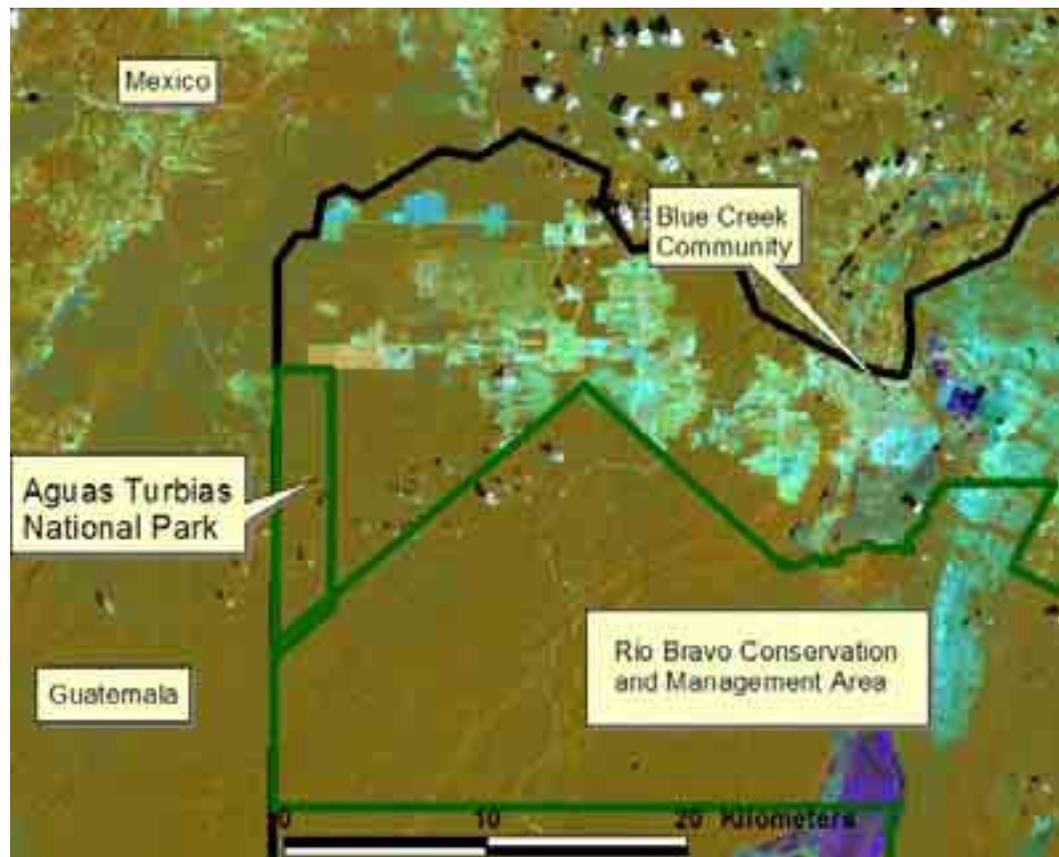


Figure 2. March 7, 2001. Landsat tm image of the project area and surroundings. This is a false color image in the bands 453. Orange Brown colors in this image represent vegetation, blue-green colors bare ground.

Based on satellite imagery, an attempt was made to assess the various vegetation types / ecosystems present in and around the park boundaries. The satellite images used included Landsat 7 tm images of 27 December 1989, 7 March, 2001 and 18 September 2002. The latter image was partly obscured by cloud cover but clear enough to identify land use changes.

Additional data were obtained through an overflight of the area, made on October 25, 2003. This overflight confirmed the location of trails and roads. As well that it, in conjunction with the satellite data, gave a good overview of the ecosystems found in the ATNP.

Based on the above it was concluded that from the point of data collection, access from the north was the most desirable option. The southern access would be through the RBCMA and conversations with Mr. Edilberto Romero from Pfb, indicated that road access from that area would be questionable during this time of year.

Also, and more importantly, the southern section of the ATNP appeared very similar to the RBCMA which has been well studied (see **some** titles in the literature section and appendix 8 for a plant species list for the RBCMA). The northern section of the ATNP on the other hand, is a mosaic of low swamp forests which have been much less studied than the high forests of the RBCMA. Taking into account the limited amount of time in which this study was to be completed, the northern section of the ATNP clearly had the highest priority.

A complication was formed by the fact that it had become obvious that fieldwork in the area, specifically the northern section of the ATNP would be problematic due to wet conditions. The overflight of October 25 had shown that several sections of the ATNP were actually inundated.

Initial fieldwork was carried out from October 22 through October 24. Although flora and fauna data were collected, these first days mostly served as general reconnaissance. More intensive research was carried out from November 17 through 21, 2003.

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

With the data thus obtained, several biodiversity indices were calculated for each transect. With the data thus obtained, several biodiversity indices were calculated (Ludwig and Reynolds, 1988). These data are important to calculate biodiversity in the area. With vegetation being the basis for ecosystems and biodiversity, the floristic biodiversity can be assumed to be a proxy for overall ecosystem biodiversity. These data also give some indication on the dynamics of the transect.

Faunal elements were sampled as follows:

Invertebrates

The limited timeframe for the REA did not allow for intensive invertebrate sampling. But some notes were made of the Lepidoptera of the area.

Fishes

Fishes were assessed by visually locating them. Should they have been present they could have been caught with nets or with baited traps. The fish fauna of Belize is well documented and identification poses no problems

Amphibians and Reptiles

Amphibians were 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. Most species are secretive and given the limited timeframe, the REA had to depend on opportunistic observations.

Birds

Birds were assessed through point-count transects. These transects were the same as the vegetation transects. In this way, the bird inventory will be linked to the vegetation / ecosystem types identified during the floristic survey. Additionally birds were assessed during walk-over surveys. Identification was both by visual and vocal characteristics. Preferably, bird surveys are conducted over a longer period of time, in order to cover the different seasons. The current bird survey took place only during the wet season, which was a shortcoming of the study but at least, during this time, many of the migrants were present.

Mammals

Mammals were assessed on an opportunistic basis. Some species were actually observed, but tracks served as important indicator for the presence of species.

2.2. Data analysis

The consultant and his team have much experience in gathering data following a standardized methodology. Using the vegetation transects as described and conducting bird point counts in these same transects allows us to calculate standard biodiversity indices (Ludwig and Reynolds, 1988). In the past the consultant collected comparable data in El Pilar Archeological Reserve, Maya Ranch Private Reserve and Runaway Creek Private Reserve. Recently the team carried out research using these techniques in protected areas such as [Mayflower National Park](#), [Sarstoon Temash National Park](#) and [Spanish Creek Wildlife Sanctuary](#). The experience and

data obtained in all these projects make it possible to objectively compare biodiversity between sites using scientific methodology. Similarly, the results obtained in this REA can be used to update the Belize Ecosystems Map.

Project initiation and progress have been posted on the consultant's webpage <http://biological-diversity.info/aguasturbias.htm>. The benefit of this is that activities and data are publicly accessible and can benefit a variety of users from tourist through scientists and students both abroad and in Belize.

2.3. Team

The REA team was composed as follows:

Jan Meerman, Seven Miles, Cayo District. Principal consultant. Biodiversity specialist (see attached résumé). 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.

Peter Herrera, Belize City, Belize District. Originally from Rancho Dolores, Belize district, Mr. Herrera is a successful tour guide but also received professional ornithological training from the Wisconsin based "Birds without Borders". Participated in several, previous Rapid Ecological Assessments.

Ernelio Bustamante, Saint Matthews Village, Cayo District. Mr. Bustamante is an enthusiastic ornithologist having received training from the Wisconsin based "Birds without Borders". His specialty is recognizing bird sounds.

Augustin Howe, San Antonio, Cayo District. Tree identification specialist. Extensive taxonomic knowledge. Trainee of the Forest Planning and Management Project. Proficient in setting out vegetation transects and collecting vegetation data. Collected herbarium material for various institutions such as the Missouri Botanical Gardens and Mary Selby Botanical Gardens. Participated in several previous Rapid Ecological Assessments.

3. Characterization of the ATNP

3.1. Geology

The entire ATNP is underlain by limestone deposited during the Paleocene-Eocene (early tertiary) era. This limestone bedrock can be very close to the surface, especially towards the southern portion of the Park, occasionally it even surfaces. In the north the limestone is overlain with more recent Pleistocene deposits which are probably fairly deep. The deposits themselves are derived from limestone and contain many small limestone fragments.

The limestone underground is clearly karstified. This conclusion is based on the fact that the northernmost creek on the topographical map was dry even after copious rain during the weeks preceding fieldwork. Also, the creek bed showed several deep holes, which were essentially, tiny sinkholes caused by the collapse of underground cavities or caves. Also Day (1996), reports ATNP as being mostly “karstic”.

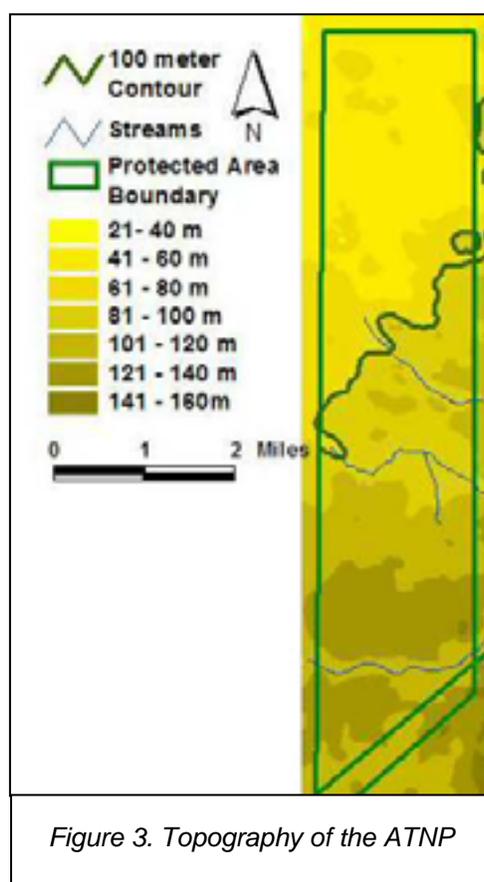


Figure 3. Topography of the ATNP

3.2. Topography

The entire area is relatively flat and becoming only slightly more undulating towards the south. In the NW corner, the lowest point is approximately 50 m above sea level while the highest point of 160 m is found in the SE corner of the ATNP. Over a distance of 11,800 m this translates to a rise of 120 m, or in other words an average slope of only 1%. However, this rise is not always this gradual. Especially the 100 m boundary is quite well marked in the landscape by a sudden rise of a few meters (possibly a fault line?).

3.3. Hydrology

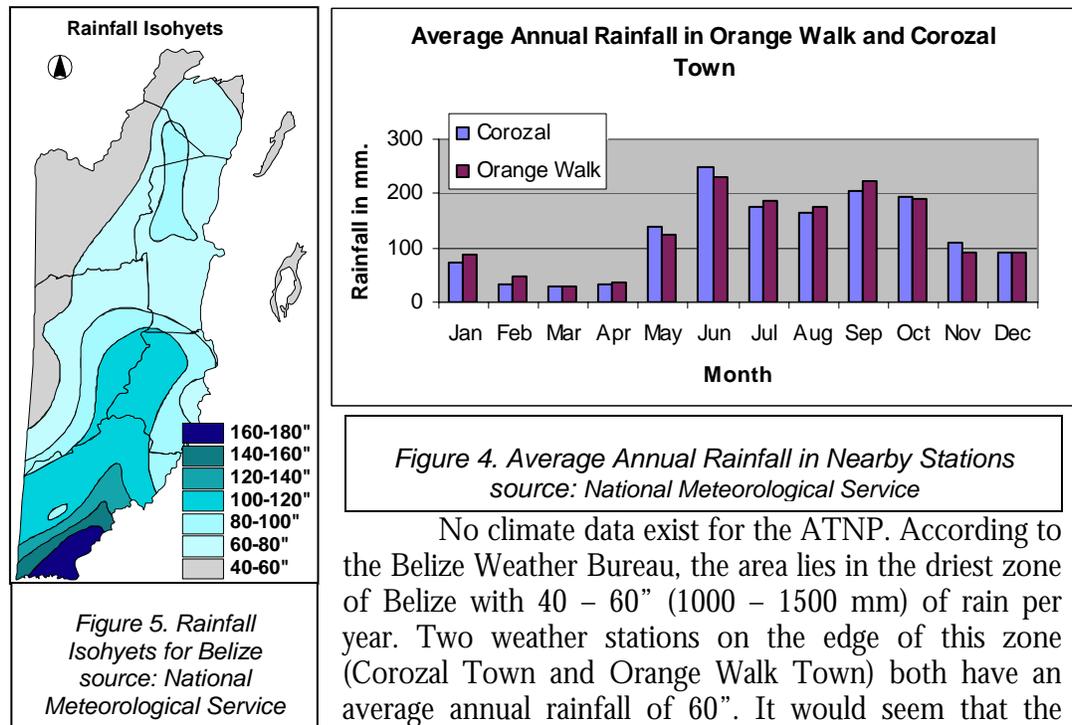
Drainage of the area is generally in a western or northwestern direction. Three creeks are shown on topographic maps but only the southernmost creek is likely to be more or less permanent during the rainy season. This creek has actually eroded a small valley.

Much of the drainage is either through sheet flow or through direct drainage into the porous bedrock. Due to the minimal slope, many areas are badly drained. The whole northern “Bajo” section was inundated during our fieldwork and this

situation is probably normal during much of the rainy season, but also the high forest has many low, swampy spots. A similar condition has been reported from the adjacent part of the RBCMA.

Most of the ATNP is expected to be water deficient during the dry season.

3.4. Climate



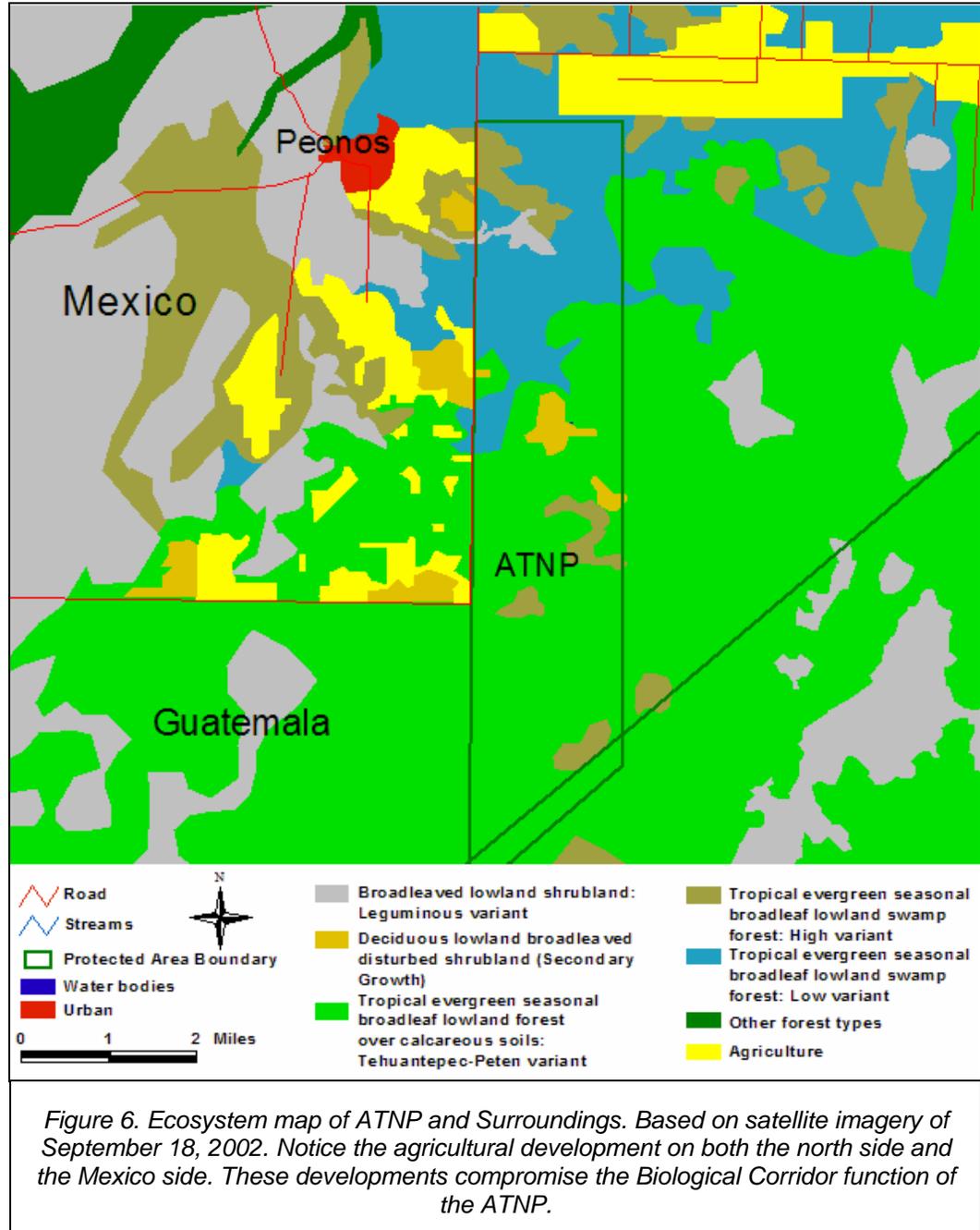
that, a fact that is corroborated by the vegetation which includes many drought tolerant species. However, the ATNP lies west of the Blue Creek escarpment and given the predominantly eastern airflow in Belize, this sudden change in topography may well have its effects on local climate. In other words, the climate may well be wetter or dryer than figure 5 assumes.

Based on the Corozal and Orange Walk data, there is a dry season from February through April with a moist season from May through January. Highest rainfall is normally in the months of June and September.

3.5. Biology

3.5.1. Ecosystems

Based on both satellite image studies and field work, the following ecosystems map has been prepared (figure 6). Because the ecosystems of the ATNP can not be seen isolated from the areas outside the park, the ecosystems map includes surrounding areas including Mexico and Guatemala.



The map immediately makes clear that the Northern and Western sides of the park are being influenced by agricultural development. In the north the agricultural development is mostly intensive cattle raising (Mennonite farmers) on improved pasture. In the west on the Mexican side it is mostly small scale slash and burn cultivation, with rapid expansion but also large areas of secondary growth.

The principal ecosystems in the ATNP are:

- Broad-leaved lowland shrubland: Leguminous variant. Locally called “Bajo”. Due to inundation, this ecosystem could not be sampled.

- Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant.: Dense forest of a very low stature on badly drained soils subject to inundation. Locally called “Bajo”. This ecosystem was sampled in one transect just west of the eastern survey line.



Figure 7. Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant.

- Tropical evergreen seasonal broadleaf lowland swamp forest: High variant: Higher “transitional” forest on wet but not typically inundated soils. This ecosystem was sampled in one transect just to the east of the eastern survey line (and thus just outside the ATNP). Due to inundation of access routes, similar habitats within the ATNP were inaccessible during the survey



Figure 8. Tropical evergreen seasonal broadleaf lowland swamp forest

- Tropical evergreen seasonal broadleaf lowland forest over calcareous soils: Tehuantepec-Peten Variant. Found throughout the southern section of the ATNP.
- Deciduous lowland broadleaf disturbed shrubland. This is essentially secondary growth found in areas of past agricultural activities. Given time, this ecosystem will revert to its original state.



Figure 9. Tropical evergreen seasonal broadleaf lowland forest over calcareous soils: Tehuantepec-Peten Variant

The classification of these ecosystems is based on the Belize Ecosystems Map by Meerman & Sabido (2001) and these ecosystems are described as follows:

Table 1. Descriptions of the Ecosystems found in the ATNP (From Meerman & Sabido, 2001).

<u>Broad-leaved lowland shrubland: Leguminous variant</u>
Geology and Soils: Soil is a pale gray brown leached layer overlying a gray layer with manganese concretions. A hog-wallow micro-relief occurs.
Hydrology: A "perched" water table develops seasonally.
Rainfall: Average rainfall mostly less than 2000 mm per year with a pronounced dry season from February through May.
Comments: This type undergoes extremes of wetting and drying in the course of the year and has a significant complement of deciduous species. The canopy is very level with few or no emergents and only 4-6 m. high. Usually found in association with the IA2g(1)(a) types (Tropical evergreen seasonal broadleaf lowland swamp forest).
Frequently encountered species include <i>Acoelorrhaphe wrightii</i> , <i>Ardisia</i> sp., <i>Bucida buceras</i> , <i>Byrsonima bucidaefolia</i> , <i>Caesalpinia gaumeri</i> , <i>Cameraria latifolia</i> , <i>Calophyllum brasiliense</i> , <i>Chrysobalanus icaco</i> , <i>Coccoloba reflexiflora</i> , <i>Croton</i> spp., <i>Erythroxylum guatemalense</i> , <i>Eugenia rhombea</i> , <i>Gliricidia sepium</i> , <i>Gymnopodium floribundum</i> , <i>Haematoxylon campechianum</i> , <i>Kruguidendron ferreum</i> , <i>Manilkara zapota</i> , <i>Margaritaria nobilis</i> , <i>Metopium brownei</i> , <i>Myrica cerifera</i> , <i>Ouratea</i> sp., <i>Pithecellobium albicans</i> , <i>Plumeria obtusa</i> , <i>Rapanea guianensis</i> , and <i>Swietenia macrophylla</i> . Epiphytes are abundant. This forest is known locally as "akalche" or "tintal".
Faunal notes: It appears that this is the preferential habitat for the rare and only recently discovered Gray Brocket Deer <i>Mazama pandora</i> .

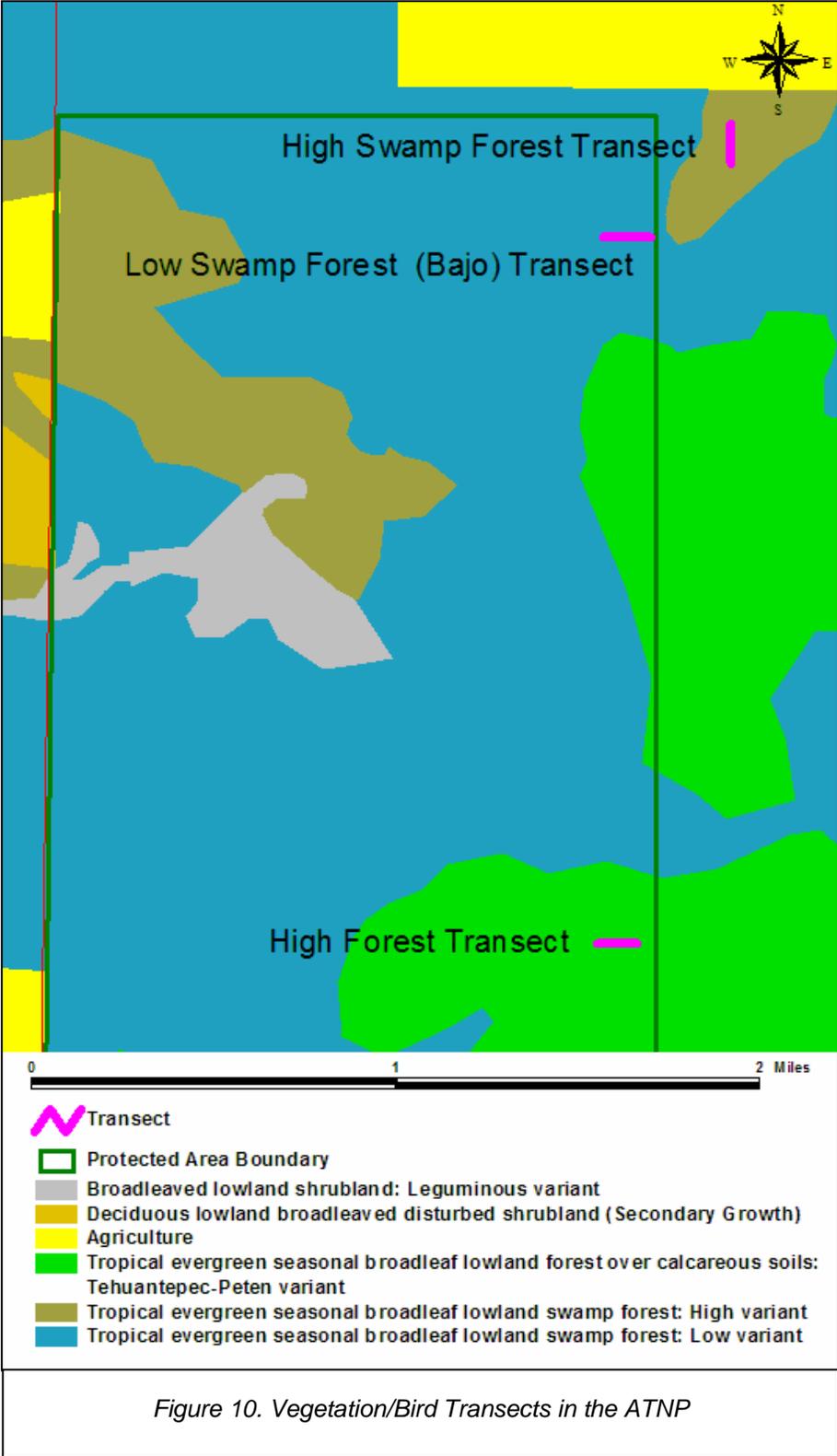
<u>Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant.</u>
Geology and Soils: Generally over calcareous rock. Some hog-wallow micro-relief exists as a result of repeated wetting and drying of the soil.
Hydrology: Ill drained, often waterlogged for part of the year.

Rainfall: Average rainfall less than 2000 mm per year with a pronounced dry season from February through May.
Comments: Swampy stands of low, thin stemmed trees and shrubs without emergents. Usually associated with 1A2g(1)(a)T and closely related to IIIA1bL. There is a distinctive deciduous element.
Frequently encountered trees include <i>Acacia</i> sp., <i>Acoelorrhaphe wrightii</i> (usually occurring in dense clumps), <i>Bucida buceras</i> , <i>Calliandra</i> sp., <i>Calypttranthes</i> sp., <i>Cameraria latifolia</i> , <i>Chrysobalanus icaco</i> , <i>Clidemia</i> sp., <i>Crescentia cujete</i> , <i>Erythroxylum guatemalense</i> , <i>Haematoxylon campechianum</i> , <i>Hampea trilobata</i> , <i>Helicteres guazumifolia</i> , <i>Hirtella racemosa</i> , <i>Hymenocallis littoralis</i> , <i>Licania hypoleuca</i> , <i>Miconia</i> spp., <i>Mimosa hemendieta</i> , <i>Mouriri exilis</i> , <i>Rinorea</i> sp., <i>Xylopia frutescens</i> and <i>Zygia</i> sp.

<u>Tropical evergreen seasonal broadleaf lowland swamp forest: High variant.</u>
Geology and Soils: Over calcareous rock.
Hydrology: Ill drained
Rainfall: Average rainfall less than 2000 mm per year with a pronounced dry season from February through May.
Comments: This forest type is low in stature with a broken canopy with a distinctive deciduous element. Where the canopy is open there is a distinctive herbaceous layer dominated by sedges sometimes including <i>Scleria bracteata</i> .
Frequently encountered trees include <i>Amyris elemifera</i> , <i>Bactris</i> spp., <i>Bucida buceras</i> , <i>Calophyllum brasiliense</i> , <i>Croton pyramidalis</i> , <i>Croton reflexiflora</i> , <i>Dracaena americana</i> , <i>Metopium brownei</i> , <i>Coccoloba reflexiflora</i> , <i>Coccoloba acapulcensis</i> , <i>Coccoloba cozumelensis</i> , <i>Manilkara zapota</i> , <i>Gliricidia sepium</i> , <i>Ouratea nitida</i> , <i>Sabal mauritiiformis</i> , <i>Simarouba glauca</i> , <i>Swietenia macrophylla</i> and <i>Zygia</i> sp. Thick woody vines are sometimes present. Includes some areas that are locally called "bajos". Logwood <i>Haematoxylon campechianum</i> , typically occurs in the wetter, more open sections.

<u>Tropical evergreen seasonal broadleaf lowland forest over calcareous soils: Tehuantepec-Peten Variant</u>
Geology and Soils: Soils are well drained gray or brown clays, variably stony over calcareous rock.
Hydrology: Mostly well drained.
Rainfall: Average rainfall less than 2000 mm per year with a pronounced dry season from February through May.
Comments: This variant is characterized by taller forest than the eastern variants. It is also found only west of the Booth river escarpment. The canopy attains 20-30 m.
Common trees are <i>Alseis yucatanensis</i> , <i>Ampelocera hottlei</i> , <i>Aspidosperma cruenta</i> , <i>Attalea cohune</i> , <i>Brosimum alicastrum</i> , <i>Bursera simaruba</i> , <i>Calophyllum brasiliense</i> , <i>Cedrela odorata</i> , <i>Clusia salvinii</i> , <i>Cupania belizensis</i> , <i>Crysophila stauracantha</i> , <i>Dendropanax arboreus</i> , <i>Drypetes laterifolia</i> , <i>Drypetes brownei</i> , <i>Ficus</i> spp., <i>Hirtella americana</i> , <i>Lonchocarpus castilloi</i> , <i>Manilkara zapota</i> , <i>Matayba oppositifolia</i> , <i>Metopium brownei</i> , <i>Passiflora mayarum</i> , <i>Pimenta dioica</i> , <i>Pouteria reticulata</i> , <i>Protium copal</i> , <i>Pseudobombax ellipticum</i> , <i>Pseudolmedia</i> sp., <i>Sabal mauritiiformis</i> , <i>Schizolobium parahybum</i> , <i>Spondias mombin</i> , <i>Stemmadenia donnell-smithii</i> , <i>Swietenia macrophylla</i> , <i>Talisia olivaeformis</i> , <i>Trichilia minutiflora</i> , <i>Trophis racemosa</i> and <i>Zuleania guidonia</i> . The understory has species such as <i>Adiantum pulverulatum</i> , <i>Malvaviscus arboreus</i> , <i>Piper jacquemontianum</i> , <i>Psychotria pubescens</i> , <i>Pteris longifolia</i> and <i>Tectaria heracleifolia</i> . A frequently found graminoid is <i>Ichnanthus lanceolatus</i> .

Three vegetation transects were established in order to be able to characterize and rank them for biodiversity. Their location is indicated in figure #:



Using the biodiversity formulas as discussed before (Ludwig and Reynolds, 1988), using tree species along the vegetation transects as an indicator, the following figures were found (table 2):

Table 2. Tree Biodiversity Indices for Three Ecosystems in the ATNP

	<i>Aguas Turbias Swamp Forest low variant (Bajo)</i>	<i>Aguas Turbias Swamp forest, high variant</i>	<i>Aguas Turbias High forest over Calcareous Soils</i>
<i>N₀ = Number of species</i>	14	23	20
<i>N₁ = Abundant species</i>	8	19	16
<i>N₂ = Very abundant species</i>	6	22	21
<i>H' = Shannon's div. index</i>	2.1	2.9	2.8
<i>Evenness E₅</i>	0.67	1.18	1.27
<i>Rarefraction at sample size of 20 trees</i>	9	14	13
<i>Rarefraction at sample size of 30 trees</i>	NA	18	17
<i>Living stems > 10 cm dbh (incl. vines)</i>	45	47	39
<i>Average stem dbh in cm</i>	18.9	19.9	21.4
<i>Number of trees (non vines)</i>	77	123	55
<i>Number of multi-stemmed trees</i>	3	0	0
<i>Number of dead trees</i>	1	1	0
<i>Space per living tree in m²</i>	17.8	17.0	20.5
Total species	38	63	28
Dominant tree species (> 10% of total, >10cm dbh)	<i>Pithecellobium sp*., Coccoloba sp. Small leaf.</i>	<i>Manilkara zapota, Eugenia sp.</i>	<i>Pouteria reticulata, Trichilia minutiflora</i>
Dominant woody species	<i>Pithecellobium sp*., Coccoloba sp. Small leaf.</i>	<i>Manilkara zapota.</i>	<i>Pouteria reticulata.</i>
Largest biomass	<i>Pithecellobium sp*.</i>	<i>Manilkara zapota</i>	<i>Pimenta dioica</i>

* Unfortunately, this dominant species could not be properly identified. The plant somewhat fits the description of *Pithecellobium lanceolatum*. But since no flowering or fruiting specimens could be found, the identification remains uncertain.

The low figures (H', E5, Rarefraction) indicate that the tree diversity is lowest in the low variant of the swamp forest (bajo). This is not surprising given the extreme circumstances in which this forest grows. Only a limited number of species are able to cope with the seasonally inundated conditions.

Normally, it is found that high "primary" forest has the highest tree diversity. In this case, the "swamp forest, high variant" had a surprisingly high tree biodiversity, comparable to that of the "high forest over calcareous soils". The overall tree density in the "swamp forest, high variant" was fairly low, indicative of a dense forest. The canopy however was broken, letting through abundant light and thus allowing a dense understory of herbs and shrubs (see the high number of total species encountered). The "high forest over calcareous soils" on the other hand, had a closed canopy resulting in poor understory development.

Interesting is a comparison with biodiversity indices found on other sites:

Table 3. Tree diversity indices for various lowland sites in Belize. Most diverse sites to the left, poor diversity sites on the right.

	Toledo: Conejo high forest	Toledo: Temash "dry hill" forest	Toledo: Crique Sarco swamp	Toledo: Midway nr. Limestone Quarry	Stann Creek Mayflower, Slope (waterpipe)	Cayo district: Maya Ranch, Karst Hill	Stann Creek: Mayflower Lowland (TauWitz)	Toledo: Comfrey swamp
<i>N</i> ₀ = Number of species	28	25	21	20	23	20	12	14
<i>N</i> ₁ = Abundant species	24	20	18	17	16	14	9	8
<i>N</i> ₂ = Very abundant species	41	22	28	24	15	15	9	6
<i>H'</i> = Shannon's div. index	3.19	2.98	2.91	2.83	2.8	2.74	2.21	2.1
Evenness <i>E</i> ₅	1.74	1.12	1.56	1.43	0.9	0.94	1	0.71
Rarefraction at sample size of 20 trees	16	10	14	14	12	13	9	9
Rarefraction at sample size of 30 trees	23	13	18	NA	16	16	11	11
Living stems > 10 cm dbh (incl. vines)	37	63	36	35	63	52	40	56
Average stem dbh in cm	22	17	27	30	29	19.08	24	14
Number of trees (non vines)	43	71	59	43	150	52	66	70
Space per living tree in m ²	21.6 m ²	12.7 m ²	22.2 m ²	22.9 m ²	12.7 m ²	15.4 m ²	20 m ²	14.3 m ²
Total species	40	39	43	38	67	40	56	29
Dominant tree species (> 10% of total, >10cm dbh)	<i>Guatteria</i> sp., <i>Laetia</i> sp.	None	<i>Spondias</i> sp.	<i>Attalea cohune</i>	<i>Attalea cohune</i> , <i>Pterocarpus</i> <i>rorhrii</i> , <i>Pouteria</i> <i>campechiana</i>	<i>Dendropanax</i> <i>arboreus</i>	<i>Inga</i> sp., <i>Trichospermum</i> <i>grewiiifolium</i> , <i>Guazuma</i> <i>ulmifolia</i>	<i>Mannicaria</i> <i>saccifera</i> , No.1
Dominant woody species	<i>Guatteria</i> sp., <i>Laetia</i> sp., <i>Sabal</i> <i>mauritiiformis</i>	None	<i>Attalea cohune</i> , <i>Dendropanax</i> <i>arborea</i>	<i>Attalea cohune</i> , <i>Guarea</i> sp.	<i>Attalea cohune</i> , <i>Pouteria</i> <i>campechiana</i> , <i>Protium</i> sp., <i>Pterocarpus</i> <i>rorhrii</i>	<i>Dendropanax</i> <i>arboreus</i>	<i>Attalea cohune</i> , <i>Casearia</i>	<i>Mannicaria</i> <i>saccifera</i> , No.1
Largest biomass	<i>Matayba</i> <i>opositifolia</i>	<i>Licania</i> <i>hypoleuca</i>	<i>Bursera</i> <i>simarouba</i>	<i>Attalea cohune</i>	<i>Attalea cohune</i> , <i>Manilkara</i> <i>zapota</i> , <i>Pterocarpus</i> <i>rorhrii</i>	<i>Dendropanax</i> <i>arboreus</i>	<i>Musa balbisiana</i> , <i>Inga</i> sp., <i>Trichospermum</i> <i>grewiiifolium</i>	<i>Calophyllum</i> <i>brasiliense</i>

Based on the data above, it shows that both high forest sites fall well within the range of “average” tree diversity for lowland forests in Belize. The low swamp forest site (bajo) has a tree diversity very similar to another swamp forest type; the Comfrey (*Manicaria saccifera*) swamp forest in Toledo.

On each vegetation transect, a bird point count was carried out. This enables to link bird diversity with ecosystem types. And it is interesting to notice that, at least for the sites listed, there appears to be a correlation between tree diversity and bird diversity (expressed as Shannon’s index H’). Sites with high tree diversity also have high bird diversity and vice versa. See chapter 3.5.7. for the bird data.

3.5.2. Vegetation

A total of 184 plant species was identified (appendix 1). Some of these showing a northern, Yucatan influence (table 4).

Family	Species name	Common name
Apocynaceae	<i>Plumeria obtusa</i>	<i>Nittechum</i>
Caesalpinoideae	<i>Caesalpina gaumeri</i>	Warree Wood, Kitamche
Euphorbiaceae	<i>Jatropha gaumeri</i>	Bubble Tree
Malpighiaceae	<i>Byrsonima bucidifolia</i>	Sac Pah
Orchidaceae	<i>Rhyncolaelia digbyana</i>	
Polygonaceae	<i>Gymnopodium floribundum</i>	Canelita
Polygonaceae	<i>Coccoloba acapulcensis</i>	
Theophrastaceae	<i>Jacquinia macrocarpa</i>	Knock-me-back, Xcansic

Table 4. Some typical "northern" plant species found in the ATN



Figure 11. *Tillandsia fasciculata*.
Bromeliaceae. Aguas Turbias
NP

Notable was the absence of the normally ubiquitous Cohune palm (*Attalea cohune*). Only in a small spot along near the tri-national border, some Cohunes were seen. Cohune appears associated with well drained soils. The impeded drainage of much of the ATNP is probably responsible for the absence of the species.

Both “Tropical evergreen seasonal broadleaf lowland swamp forest” variants were very rich in epiphyte diversity. Unfortunately only few flowering specimens (orchids and bromeliads) were found, so many species remain unidentified.

This richness in epiphytes in these two ecosystems is probably the most important feature of the ATNP.

3.5.3. Invertebrates

A total of 18 butterfly species (appendix 2) was recorded using opportunistic recording techniques. Most of these were seen along the trail in the low swamp forest. This does not necessarily signify that the greatest butterfly diversity is to be found in this ecosystem. Most likely the higher number was caused by the low canopy here which allowed the sun to reach the trail. In the high forest, the trail was mostly under canopy cover. With butterflies that prefer direct sunlight, this undoubtedly has influenced the frequency of observation. None of the species observed was in any way unusual or rare.

Two tarantula species were observed, the ubiquitous *Brachypelma vegans* and the lesser known *Crassicrus lamanai*. Both are common lowland species in Belize

3.5.4. Fish

Although much of the area was inundated during the fieldwork, no fishes were seen! Most likely, the whole area is devoid of water during the dry season. At least two of the creeks mapped for the area are merely ‘flood drains’ that contain water only during extended periods of rain. The southern most stream is expected to carry more water, but also that is expected to fall dry during the dry season.

Even the ‘aguada’ in the center of the Protected Area which is possibly the only permanent water source, appeared to contain no fish. The stock pond, not far from the aguada appears to be filled with water only during the rainy season (based on vegetation cover).

3.5.5. Amphibians

Very few amphibians were encountered during the field trips (Appendix 2). But one species confirmed was a very special one. The Tungara frog *Physalaemus pustulosus* is a small species of frog that is rarely recorded in Belize. The only known locations are all in Northern Belize. The species was found in small numbers in the ‘Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant’ ecosystem on the edge of the pasture in the extreme north of the park.



Figure 12. *Hyla ebraccata* larva

In the stock pond located in the pasture remnant in the center of the park, the larva of the tree frog *Hyla ebraccata* was collected.

3.5.6. Reptiles

Only four reptile species were identified (Appendix 2). Partly this may be the result of the inundated and cool conditions during the field trips. The Tropical Rattlesnake *Crotallus durissus* was confirmed from the pasture adjacent to the park. It is expected to be a component of the “Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant” ecosystem. The Tropical Rattlesnake tends to replace the generally more common Fer-de-Lance (Tommygoff) in open, seasonally dryer habitats. The Fer-de-Lance is expected to be present in the southern half of the park.

The observation of *Anolis uniformis* is interesting because Lee (1996) does not list this species for Northern Belize. The find is however, not unexpected since this is a common species in high forest elsewhere in Belize.

3.5.7. Birds

The bird transects were very successful in providing data. A total of 137 bird species was identified (Appendix 6 & 7). Species of note were the Yucatan Jay (Yucatan influence) and Gray-throated Chat (both scrub forest associates). Crested Guans were fairly common. Great Curassow and Ocellated Turkeys were seen but did not appear common. Whether the apparent scarcity of Ocellated Turkeys is a result of habitat conditions or hunting pressure is not clear at this stage. Based on the known habitat requirements of the species, it is expected that the habitat in the northern part of the park is not conducive to high Ocellated Turkey populations. Montezuma Oropendula nests were noted in Ceiba trees in the secondary growth area.

Birds	Swamp forest: low variant (bajo)	Swamp forest high variant	High forest over calcareous soils
<i>N₀</i> = Number of species	25	47	47
<i>H'</i> = Shannon's div. index	3.15	3.77	3.75
Evenness <i>E₅</i>	2.93	2.41	2.01
Rarefaction at sample size of 10 birds	9	10	9
Rarefaction at sample size of 20 birds	17	18	18
Rarefaction at sample size of 30 birds	Na	26	25
Rarefaction at sample size of 40 birds	Na	33	32
<i>H'</i> index for tree vegetation at same site	2.1	2.9	2.8

Table 5. Bird diversity indices for three ecosystems in the ATNP

Bird diversity varied among the three ecosystems sampled. Lowest numbers and diversity was found in the bajo forest site (table 5). The Swamp forest and High forest sites were very similar in numbers and diversity (table 5). The diversity of these two sites actually compare favorable with several other locations where data were collected in the same way (table 6).

Each table also lists the tree diversity (as Shannon's index H'), and it is interesting to notice that, at least for the sites listed, there appears to be a correlation between tree diversity and bird diversity. Sites with high tree diversity also have high bird diversity and vice versa.

Table 6. Bird diversity indices for some lowland forest sites in Belize

<i>Birds</i>	<i>Toledo: Conejo high forest</i>	<i>Toledo: Temash "dry hill" forest</i>	<i>Toledo Crique Sarco High Swamp Forest</i>	<i>Toledo: Midway nr. Quarry</i>	<i>Stann Creek: Mayflower lowland (Tau Witz)</i>	<i>Toledo: Temash Comfrey Swamp</i>
<i>N₀ = Number of species</i>	46	30	37	38	42	17
<i>H' = Shannon's div. index</i>	3.67	3.29	3.54	3.55	3.59	2.69
<i>Evenness E₅</i>	1.35	1.77	2.77	2.28	1.54	1.8
<i>Rarefraction at sample size of 10 birds</i>	9	9	10	9	9	9
<i>Rarefraction at sample size of 20 birds</i>	17	16	18	18	17	NA
<i>Rarefraction at sample size of 30 birds</i>	23	22	26	25	23	NA
<i>Rarefraction at sample size of 40 birds</i>	29	27	32	32	29	NA
<i>H' index for tree vegetation at same site</i>	3.19	2.98	2.91	2.83	2.21	2.1

3.5.8. Mammals

Only 9 mammal species were confirmed during the field visits. Both Collared and White-lipped Peccaries are present and were noted. Both were seen in the “Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant” but with higher forest near. Both Black Howler Monkeys and Spider Monkeys were common in the high forest. Tracks of a large cat (likely Puma) were found. White-tailed deer tracks are common in the “Tropical evergreen seasonal broadleaf lowland swamp forest: Low variant” ecosystem. This ecosystem does not appear to be beneficial for this species (dense vegetation), but it is likely that the deer use this habitat for shelter, but graze in the pasture areas north of the park.

Judging the lack of tracks, Tapir appeared absent, which seemed surprising given the fact that the swampy habitat appeared ideal for this species. Discussions with Bruce Miller (WCS) revealed that in the Gallon Jug area (south of the project area), the Tapir population collapsed about a decade ago. Previously Tapir were common, frequently seen and tracks easily found. Presently, even tracks are rare. Hunting pressure may appear to be a likely explanation of this collapse, but other, more desirable species (deer, peccary) are doing well in the same area. **More likely is** some epidemic disease that has devastated the Tapir population in North-Western Belize.

The ATNP is also rather small to independently sustain large populations of various of the larger mammal species. The following table (7) gives an indication of known ranges of some animal species occurring in the project area: 8800

Table 7. Home ranges of some mammal species

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

With the 8800 acres of the ATNP it is clear that wildlife in this park depends on the intact state of neighboring habitats.

3.5.9. Ecosystem Conditions

The area appears to be recovering from past logging activities. Few larger Mahoganies were found, but Mahogany seedlings were very common.

A 250 acre area of secondary growth is found in the center of the ATNP. This is the remnant of a previous farming operation. There is a stock pond (that probably dries out during the dry season) and there are still traces of fenced pasture.

Immediately south and east of this secondary growth area, the high forest appeared damaged by fairly recent wind throw. There were many downed trees and the area was a tangle of vines. The density of the vegetation actually prevented us from continuing any further south during our investigations. It seems likely that that this damage was caused during hurricane Keith that passed over the area in the year 2000.

The remnants of a house were found in the high forest. This house was built by the Forest Department in a failed attempt to establish a permanent presence in the area.

Hunting signs were found throughout. None of the cartridges found appeared very fresh and the hunting pressure may be infrequent. The highest concentration of cartridges was found near an "aguada" in the secondary growth area. This may indicate that hunting pressure is most severe during the dry season when wildlife is attracted to this aguada, which is probably the only permanent water source in this area.

Fresh machete marks of approximately 6 weeks old were found in the center region. This region also seemed to have been subject to Bayleaf (*Sabal mauritiiformis*) harvesting approximately 1.5 - 2 years previously.

Based on trash found, the BDF does occasionally enter the area for patrols. This observation was corroborated by Mr. Albert Reimer of Blue Creek who confirmed BDF sometimes crossing his property.

3.6. Other issues

The agricultural developments on the northern and western sides of the ATNP effectively cut the park off from any connections towards the north. The value of the ATNP for the MBC is therefore minimal.

The ATNP is probably rich in archaeological sites, at least in the southern half in the “Tropical evergreen seasonal broadleaf lowland forest over calcareous soils: Tehuantepec-Peten Variant.”. Pure by chance, 2 minor sites were discovered here. One of them being on a vegetation transect.

In a previous report it was mentioned that Mr. Albert Reimer’s pasture appeared to occupy 85 ha (212 acres) of the north-eastern section of the ATNP. This assumption was based on the delineation of the ATNP as presented on the protected areas map of Belize prepared by LIC. Study of the original SI #44/1994, revealed that this information was incorrect and that there is no conflict with ATNP boundaries. However, now there appears to be an overlap with the RBCMA. PFB is well aware of this situation and the LIC has been informed about the issue. Up to now, no new SI has been issued rectifying this situation.

All the land north and east of ATNP is privately owned. To the north, the land is occupied by Albert Reimer and largely in pasture, to the east the situation is less clear. The land appears to be owned by an expatriate interest in the name of “Patrick Colby”, the acreage of his holdings is unclear at this stage. The land does not appear to be on the market for the time being.

It was found that the entire border with Mexico has been bulldozed by the Mexicans, creating a road all along the border (this “road” also runs along the Mexico – Guatemala border). This road is accessible from the farm road that leads from Blue Creek to the western border. The last 2.6 km (1.7 ml) of that road to the boundary line is only accessible during the dry season. It was found that parts of this section were under water.

4. Consultations with Stakeholders

Several meetings were held with Mennonite farmers from the Blue Creek area (October – December 2004). Most important of these was Albert Reimer, the Blue Creek Farmer who owns and manages the property and pasture immediately north of the ATNP. Mr. Reimer explained about access and potential problems. According to Mr. Reimer, there is a severe security issue at the border. Just across the border lies the Mexican community of “Peonos”. People from this community frequently cross the border. They constitute not so much a personal safety problem as well a material safety issue. Anything left unguarded will disappear or be dismantled. The area is also a well known hotbed for drug transshipments.

Consultations were held with Edilberto Romero, Managing Director of Pfb (October, 21, 2003 and 16 December, 2003). and Wilber Sabido Technical Coordinator of Pfb (16&17 December 2003). The major concern that Pfb has about the ATNP is the level of human movements through it. This somewhat contradicts my own findings, but the current survey focused mainly on the northern section of the ATNP, while Pfb would out of practical reasons focus more on the southern section. The human movement reported deals both with cross-boundary movements of contraband (including drugs) and people.

Pfb indicated that for many years they have been interested in a co-management agreement with FD for ATNP. The rationale for this interest being that the ATNP is a natural extension of the RBCMA. A pre-requisite for such a co-management would be continued support from FD specifically in legal matters, in other words a guarantee from FD that perpetrators caught in the ATNP by Pfb staff, would be prosecuted by GOB/FD. Also, Pfb would like to see an arrangement where BDF would coordinate patrols with Pfb patrols.

Consultations were held with Chief Forest Officer, Oswaldo Sabido on December 15, 2003. Items discussed were past management experiences and management expectations. Past efforts to establish a permanent presence in the area were explained and the problems resulting from that (such as possessions belonging to the station being stolen).

5. SWOT analysis model and possible Management Alternatives Arrangements.

The National Protected Areas System Plan for Belize (Wilson et al. 1995) briefly discusses the ATNP. It is listed here as an area without critical habitats that complements the System but that is not essential to its integrity. The 1995 report furthermore recognizes that the Rio Bravo Conservation Management Area and the Aguas Turbias National Park form a single conservation management unit. The Aguas Turbias National Park is more important for its location, against the Mexican and Guatemalan borders and contiguous with the RBCMA, than for its intrinsic values.

The report continues with the the recommendation to re-designate the area as a Forest Reserve, allowing a management regime that combines protection with controlled extractive use. And furthermore notes that the southern part of ATNP (south of the monument) adjoins the Rio Azul National Park in Guatemala. It is recommended that this area at least be zoned as protection forest within a forest reserve framework so that the management regime is comparable across the frontier.

Based on the above considerations, but mostly based on own fieldwork and stakeholder consultations, a SWOT analysis was carried out. A SWOT Analysis is an effective way of analyzing a projects potential by identifying Strengths and Weaknesses, and to examine the Opportunities and Threats which may affect it. A SWOT matrix is presented in table 7.

Table 7. SWOT Matrix

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> • Low human pressure • Some ecosystems inaccessible • Good wildlife densities • Good epiphyte populations • Buffer zone for RBCMA • Ecological extension of RBCMA ecosystems and wildlife habitat • Buffer zone between Mexico, Guatemala and Belize • Existing roads now overgrown and impossible to pass. 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> • No management • No enforcement of wildlife laws • No unique ecosystems • No unique species • No tourist potential • Long and narrow (strong edge-effect) • Easy access from the Mexican side • Not essential to MBC • Very little harvestable timber left
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> • Provides some form of protection of both human properties and wildlife habitats from incursions from the Mexican side. • Neighboring RBCMA has management in place, ATNP could benefit from this. 	<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> • Agricultural encroachment north and west (fire risk?) • Unguarded border, uncontrolled movement of people • Hunting • Logging • Unfamiliarity with the area resulting in indifference

The matrix makes clear that there are many weaknesses and threats that affect the viability of the ATNP. However, there are some strengths and opportunities that present some justification for continuation of the protected area status. In order to maintain and safeguard the status of the ATNP, the following four points need to be considered:

Items to be addressed immediately:

- Install some form of interim management (Early 2004). Include PFB and BDF in this. At this stage the Mennonites of Blue Creek appear to have little interest in the area; they don't seem to be likely candidates for co-management. A low level of management seems to be the most appropriate. The area is not served by opening it up and creating roads and trails. Instead, management should consist of bi-annual over flights to check on agricultural incursions and infrequent foot-patrols. Any incursion or other problem should then be dealt with on a case by case basis.

Items to be handled now:

- Start negotiations with PFB about co- management (Early 2004).

Items that should be researched further:

- Level of incursions during the dry season (March – June, 2004). The current REA could not assess these issues and management conclusions are entirely based on a wet season experience.

Items that should be planned for the future:

- Dry season REA (March-June 2004). Mostly to be able to access ecosystems that were inaccessible during the wet season, and to obtain management information pertaining to the dry season.
- After dry season REA, prepare management plan (Mid 2004)
- Install formalized management (End 2004)

6. Literature

- Balick, M.J., M.H.Nee & D.E.Atha. 2000. Checklist of the Vascular Plants of Belize. New York Botanical Garden Press. 246 pp.
- Brokaw, N. V. L. & E. P. Mallory. 1993. Vegetation of the Rio Bravo Conservation and Management Area, Belize. *Manomet Bird Observatory, Manomet, Massachusetts*
- Brokaw, N. V. L. & E. P. Mallory. 1989. Natural history of the Rio Bravo Conservation and Management Area *Manomet Bird Observatory*
- Brokaw, N. V. L., E. P. Mallory & P. W. Alcorn. 1990, Trees of Rio Bravo. *Programme for Belize, Belize City*
- Budowski, G. 1966. Fire in tropical lowland areas. Proceedings of the annual tall timbers fire ecology conference. 5: 5-22.
- Cornec, J. H. 2002. Geological Map of Belize: Geology and Petroleum Department, Belmopan.
- Cornec, J. H., 1985. Note on the provisional geological map of Belize at the scale of 1:250.000. Belmopan, Belize, Petroleum office. 22. pp.
- Day, M. Conservation of Karst in Belize. *Journal of Cave and Karst Studies* 58(2):139-144.
- Dixon, C. G., 1955. Geology of Southern British Honduras with Notes on Adjacent Areas. Belize. Government Printers.
- Fragoso, J. M. V. 1991. The effects on hunting on Tapirs in Belize. Pp. 154-162, in *Neotropical wildlife use and conservation* (J. G. Robinson and K. H. Redford, eds.). Univ. Chicago Press, Chicago. 520 pp.
- Fragoso, J. M. & D. I. Rumiz, C. E. Hunter, G. Silva-Lopez, L. Grober and K. 1990, wildlife inventory of the Rio Bravo Conservation and Management Area. Part 1. Ungulates and Primates. *Program for studies in tropical conservation. University of Florida, Gainesville*
- Greenfield, D. W. & J. E. Thomerson. 1997. *Fishes of the Continental Waters of Belize*. University Press of Florida, Gainesville.
- Hopkins, B. 1983. Successional processes. In: F. Bourliere (ed.). Tropical Savannas. Pp. 605-616. Elsevier, New York.
- Howell, S. N. G., & S. Webb. 1995. A guide to the birds of Mexico and Northern Central America. *Oxford University Press, New York*
- Iremonger, S. & N. Brokaw. 1995. Vegetation classification for Belize. *In: Programme for Belize. 1995. Towards a National Protected Area Systems Plan for Belize. Synthesis Report. 114 pp + app.*
- Jacobs, N. D. & A. Castaneda. 1998. The Belize Biodiversity Strategy. Belmopan 2 vols.
- Jacobson, S. K. (editor), 1990. Wildlife survey of the Rio Bravo Conservation and Management Area, Belize. *Program for Studies in Tropical Conservation, University of Florida, Gainesville*
- Jones, H. L., and Vallely, A. C. 2001. Annotated Checklist of the Birds of Belize. Lynx Edicions, Barcelona.

- Lee, J. C. 1996. *The amphibians and reptiles of the Yucatan Peninsula*. Cornell University Press. 500 pp.
- Ludwig, John A. and James F. Reynolds. 1988. *Statistical ecology: a primer of methods and computing*. Wiley Press, New York, New York. 337 pp.
- Mallory, E. P. & N. V. L. Brokaw, 1993. Birds of the Rio Bravo Conservation and Management Area, Belize. *Manomet Bird Observatory, Manomet, Massachusetts*
- Mallory, E. P. & N. V. L. Brokaw, 1995. Ecological impacts of silvicultural trials in Chiquibul Forest Reserve and the Rio Bravo Conservation. *Manomet Observatory for Conservation Sciences*
- Meerman, J. C. & W. Sabido. (2001). Central American Ecosystems Mapping Project: Belize. 2 volumes. Programme for Belize.
- Meerman, J. C. 1999. Lepidoptera of Belize: 1) Butterflies, 2) Emperor moths and Hawk moths *Tropical Lepidoptera 10. Supplement 1*
- Meerman, J.C. & W. Sabido. 2001. Ecosystems Map of Central America: Belize. 2 vols + map. Programme for Belize.
- Meerman, J.C. (1999). Lepidoptera of Belize: 1). Butterflies, 2)Emperor-moths and Hawk Moths, Tropical Lepidoptera 10. Supplement 1.
- Meerman, J.C. 1996. Vegetative Key to the Passionflowers of Belize. Passiflora 6(3): 25-28.
- Meerman, J.C. 1997. Columbia River Forest Reserve (Compartment 33, subcompartment 2) Rapid Biodiversity Assessment. Report to the Forest Planning and Management Project, 14 pp.
- Middleton, B. A., E. Sanchez-Rojas, B. Suedmeyer and A. Michels. Fire in a tropical dry forest of Central America: A natural part of the disturbance regime? *Biotropica* 29(4): 515-517.
- Rabinowitz, A. R., Nottingham, B. G. Jr., 1986. Ecology and behavior of the Jaguar (*Panthera onca*) in Belize, Central America. *J. Zool., Lond. (A)*, 210:149-159.
- Reid, F. A. 1997. *A field guide to the mammals of Central American and Southeast Mexico*. Oxford University Press. 334 pp.
- Schipp, W. A. 1933-1934. Flora of British Honduras, price list of seeds and herbarium material. Privately Published., Stann Creek, British Honduras. 69 pages., Copy at NYBG.
- Shawe, K. 1997. Ecological Survey - Sampling Strategy and Method. Draft report to the Forest Planning and Management Project, Forest Department, Belmopan. 10 pp.
- Standley, P. C., J. A. Steyermark and L. O. Williams. 1946. Flora of Guatemala. *Fieldiana Bot. V. 24. part 1-13. 1946-1978*
- Wilson et al., 1995. National Protected Areas System Plan for Belize, Synthesis report. Prepared by Programme for Belize in collaboration with the IADB. NARMAP contract 001/94.
- Zisman, S. 1996. The directory of Belizean Protected Areas and Sites of Nature Conservation Interest. NARMAP.