State of the Protected Areas Report 2020

An assessment of Bladen Nature Reserve, Golden Stream Corridor Preserve and Maya Mountain North Forest Reserve

YA'AXCHÉ CONSERVATION TRUST

March 2021

Harmony between nature and human development for the benefit of both

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Acronyms

ASPT-CR	Average Score Per Taxon- Costa Rica
BNR	Bladen Nature Reserve
BRIM	Biodiversity, Research, Inventory and Monitoring
BSR	Biodiversity Synthesis Report
CCAD	Central American Commission for Environment and Development
CRFR	Columbia River Forest Reserve
EC	Electrical Conductivity
FD	Forest Department
GSCP	Golden Stream Corridor Preserve
IUCN	International Union for Conservation of Nature
MGL	Maya Golden Landscape
MMM	Maya Mountain Massif
MMNFR	Maya Mountain North Forest Reserve
NPAS	National Protected Areas System
NTFPs	Non-timber Forest Products
NTU	Nephelometric Turbidity Unit
PAM	Protected Areas Management
PA(s)	Protected Area(s)
PAP	Protected Areas Program
PPA	Private Protected Area
SPAR	State of the Protected Area Report
SVAP	Stream Visual Assessment Protocol
TFCG	Trio Farmers Cacao Growers Limited
Ya'axché	Ya'axché Conservation Trust

Preamble

Ya'axché's programs have been undergoing rapid growth over the last 5 years with extensive development in capacity and strategic direction. Its current program structure is now far from its humble beginnings but always staying true to its roots and its vision for conservation and livelihoods in the Toledo District, and more specifically, the Maya Golden Landscape (MGL). Within the last 13 years, Ya'axché has been able to add two protected areas to its Protected Areas Program, a major achievement in its relentless effort to accomplish its vision of harmony between nature and human development for the benefit of both.

As part of its drive for evidence-based decision making and adaptive management approach, Ya'axché first introduced biodiversity research and monitoring in 2009 as a pilot with its first assessment of biodiversity across the MGL published in 2010—the first Biodiversity Synthesis Report. The main objective of this report was to provide Ya'axché and the general public with a snapshot of the status of biodiversity across the landscape, which included a mosaic of protected area and community farm lands as study sites. Results of data analysis were then used to target priority areas for conservation action and/or education and awareness campaigns. This report had a 9-year run with its last issue published in 2019.

During the same time period, a number of changes took place within the Protected Areas Program (PAP) including the addition of more study sites and additional alignment with national priorities in research and monitoring. The research and monitoring program slowly transitioned to the Science Program within the wider PAP having its own structure and program targets. Human resources gaps were filled and the efficiency and effectiveness of management activities increased significantly. However, the only measure of efficiency and effectiveness in management of the PAs remained the Biodiversity Synthesis Report (BSR) with no publicly available information on other aspects of Protected Areas Management (PAM), such as enforcement and compliance activities. This gap is now addressed through the development of this first State of the Protected Areas Report (SPAR).

In an effort to accommodate the growing need for management effectiveness assessments of its protected areas program, Ya'axché took the decision to incorporate a SPAR to its annual reporting and integrate the analysis of Biodiversity Research, Inventory and Monitoring (BRIM) as a tool to assess for status of both PAs and the biodiversity within them. Notwithstanding the integration of the BSR into this report, research and monitoring activities outside the PAs will continue to be assessed and will subsequently be presented as a Farmscape Report at a later time. Note that information presented in this report in some cases may cover multiple years to serve as a reference point for subsequent reports.

Executive Summary

Ya'axché manages the Golden Stream Corridor Preserve (GSCP) and co-manages the Bladen Nature Reserve (BNR) and the Maya Mountain North Forest Reserve (MMNFR) along with the Government of Belize. For the last 22 years, Ya'axché has been actively involved in Protected Areas Management (PAM) and has grown to become one of the leading organizations in Belize promoting sustainable livelihoods, as well as conservation of natural resources. With the growth of the organization came the need for adequate assessments of management effectiveness, particularly within the Protected Areas Program (PAP). This report is the first of its kind at the organization and is intended to provide a summary of the status of multiple target areas relevant to the management, monitoring and conservation of resources within the Protected Areas (PAs).

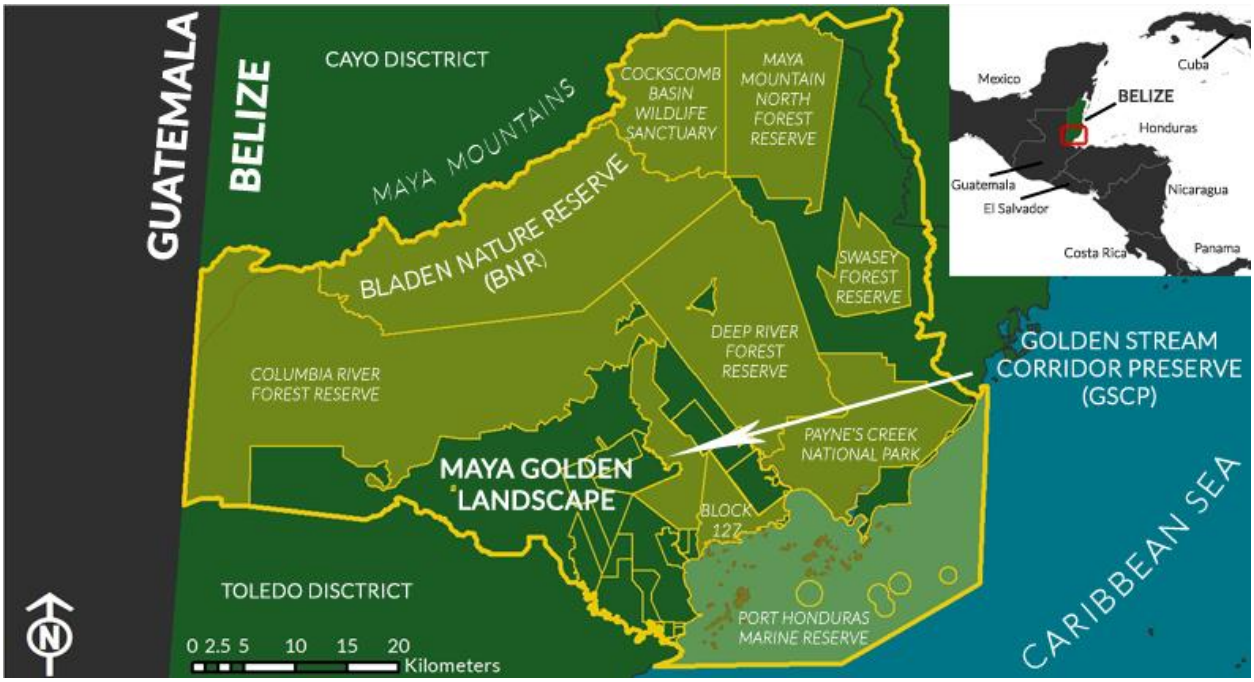
Seven (7) Priority Target Areas (PTAs) have been selected for this report. These target areas are not absolute and may include other targets of interest in future iterations of this report. For this report we include: (i) Habitat Indicators, (ii) Rare, Threatened, Socio-Economic, and Culturally Important Species, (iii) Broad Ecosystems and Land Use Change, (iv) Ecosystem Services, (v) Sustainable Natural Resource Use, (vi) Enforcement and Compliance, and (vii) Biodiversity Knowledge for Adequate Management. All seven PTAs were chosen based on its ability to indicate changes in conditions over time and whether there was data available and/or baselines in the process of being established. A combination of data analysis and expert opinion guided the assessment of condition thereafter.

Based on the assessments, Habitat Indicator Species are stable and in good condition across all three PAs. While there is limited data on Rare, Threatened, Socio-Economic, and Culturally Important Species, the available data suggests that these species remain in good condition across all three protected areas. Broad Ecosystems and Land Use Change show negligible changes for GSCP and BNR with moderate concern in a deteriorating trend for the MMNFR. Sustainable Natural Resource Use is stable within moderate concern for the GSCP and is of moderate concern with a deteriorating trend in MMNFR. Enforcement and Compliance is stable and in good condition for GSCP with moderate concern for BNR but with stable conditions and moderate concern with a deteriorating trend for the MMNFR. Over the last 5

years, there has been a significant increase in baseline data collected and more in-depth Biodiversity Knowledge for Adequate Management, which for this report we consider in good condition with an improving trend.

The overall assessment of the PAs can be summed as follows: The Bladen Nature Reserve remains the most stable protected area with the vast majority of its forest cover intact and its biodiversity in good condition. The Golden Stream Corridor Preserve also remains stable with some concern over activities related to unauthorized extraction. The majority of its land area is currently forested and its biodiversity is in good condition. The Maya Mountain North Forest Reserve is the most unstable protected area of the three. Most infraction and activities affecting condition are concentrated in a small portion of the reserve which warrants moderate concern due to the deteriorating conditions. It still retains most of its land area under forest cover despite the concerns.

Introduction



Map 1. Protected Areas within the Maya Golden Landscape in the Toledo District.

Ya'axché's Protected Areas Management (PAM) efforts are focused in the conceptual area of scope referred to as the Maya Golden Landscape (MGL) in the Toledo District, Belize. The MGL is a mosaic landscape comprised of protected areas, private lands, indigenous communal lands and agriculture lands. Ya'axché currently manages and co-manages three Protected Areas (PAs) with three distinct protected area designations under Belize's National Protected Areas System (NPAS). These three protected areas include the Golden Stream Corridor Preserve (GSCP), Bladen Nature Reserve (BNR) and the Maya Mountain North Forest Reserve (MMNFR) (Map 1).

The Golden Stream Corridor Preserve is a Privately Protected Area (PPA) in the Toledo District established in 1998 through the efforts of Ya'axché which at the time was comprised of a consortium of local community members and conservation experts both national and international. The PA encompasses 15,000 acres of lowland broadleaf forests that connect the foothills of the Maya Mountains to the coastal lowlands of Toledo. Ya'axché is fully responsible for all management activities within this PA.

The Bladen Nature Reserve is Belize's largest nature reserve with this designation providing the highest level of protection for any PA under the NPAS Act. The PA spans approximately

100,000 acres in the core zone of the Maya Mountain Massif (MMM). The remoteness of the PA provides an excellent shield from most anthropogenic impacts that other protected areas are affected by. Ya'axché holds co-management of this reserve along with the Government of Belize with major responsibility for daily operational activities.

The Maya Mountain North Forest Reserve is an extractive reserve in the Toledo District with a long history of management absence up until 2015 when Ya'axché took on co-management of the reserve. It currently has no major extractive activities other than an agroforestry concession regulated by the Belize Forest Department (FD) and managed by Ya'axché on behalf of a community group from the Trio Village. The PA encompasses 36,000 acres, most of which is rugged terrain that remains forested landscape on the eastern flank of the MMM.

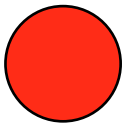
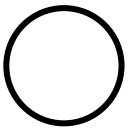
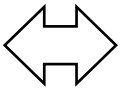
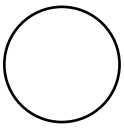
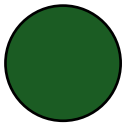
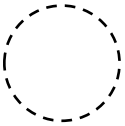
The purpose of this report is to assess the overall condition of all three PAs under Ya'axché's management and to communicate protected area conditions to management partners, donors, stakeholders and the general public. The report also highlights priority areas under Ya'axché's Biodiversity, Research, Inventory and Monitoring (BRIM) strategy as well as the individual PAM plans. It also provides recommendations for future work particularly in the areas of concern as assessed through the process of developing this report.

With this issue of the State of the Protected Areas Report (SPAR), information spanning up to 11 years may form part of the assessment of condition and status. This is more prevalent with biodiversity data which has a consistent data set dating back to 2010. In other cases, such as land use change, and enforcement and compliance, the assessment of status is based on data collected exclusively for the year 2020. The intention is to have this report function as a reference point for future iterations of the SPAR. In synthesis, information briefs within the report may at times contain multi-year analysis of data with the assessment year for comparison.

The SPAR is summarized in table format for seven target areas based on a synthesis of research and monitoring activities, management activities and effectiveness evaluations, and internal expertise. An Information Brief providing details of specific target areas with relevance to one or more of the three PAs under Ya'axché's management mandate can be found at the end of each section assessment when data is available for publication.

Summary of State of the Protected Areas

In order to standardize the evaluation of condition and trend across target areas, we use the following evaluation key in the table below. The colors represent the condition status of the target area whether that be significant concern, moderate concern or good condition. Arrows represent the trend in condition such as improving, stable or deteriorating. The confidence of the assessment is represented by bold solid circle for high confidence, solid line if medium confidence or dotted circle if low confidence in the assessment. If the organization is still gathering baseline data on a particular target or if data is in the form of a one-time inventory, the trend arrows are omitted. If a target area is not yet measured or is not applicable to the protected area, the condition is assessed as "Unknown" and "NA", respectively.

Resource Condition		Trend in Condition		Confidence in Assessment	
	Warrants Significant Concern		Condition is Improving		High
	Warrants Moderate Concern		Condition is Stable		Medium
	Resource is in Good Condition		Condition is Deteriorating		Low

Summary of Condition and Trends of Priority Targets

Priority Targets	Condition Status/Trend			Rationale
	GSCP	BNR	MMNFR	
I. Habitat Indicator Species				Ya'axché monitors indicator species on 12 transects distributed across a disturbance gradient within the MGL. On the 1-km long transects, point counts for 30 indicator birds and signs of 19 indicator mammals are recorded. The select birds and mammals belong to indicator groups that serve to reflect changes in habitat or underlying ecological conditions. BSRs with analyses for individual monitoring years can be found on Ya'axché's website.

Priority Targets	Condition Status/Trend			Rationale
	GSCP	BNR	MMNFR	
				Transect data from GSCP and BNR since 2010 and from MMNFR since 2016 were analyzed for this report. Overall, trends in the index of abundance for habitat indicators in each PA allude to stable environmental conditions over time.
II. Rare, Threatened, Socio-Economic, and Culturally Important Species				The terrestrial ecosystems across GSCP, BNR, and MMNFR support at least 24 threatened mammals, including Yucatan spider monkeys (*Ateles geoffroyi yucatanensis*), and white-lipped peccaries (*Tayassu pecari*) and keel-billed motmots (*Electron carinatum*). Seven mammal and seven bird species of conservation concern are monitored on biodiversity transects. Threatened birds are consistently low across all three reserves, with significant declines in the yellow-headed parrot (*Amazona oratrix*) in BNR since 2012. Trends vary for individual threatened mammal species in each reserve with the majority having stable indices of abundance over time. Across the three reserves, 23 rare, threatened, and/or culturally important plants have been subject to studies to improve knowledge of their distribution, population size, age structure, and phenology in order to inform better management practices at the local and national level. Eight threatened tree species are currently being propagated at Ya'axché's Golden Stream nursery for out-planting into the MMNFR. The mature forest of BNR supports at least 53 species of bats, while 34 species have been documented in the secondary forest of GSCP.
III. Broad Ecosystems and Land Use Change				Ecosystems within the PAs are fairly intact for all protected areas. In the case of GSCP most ecosystems are stable and areas are still recovering from historical heavy land use types like cattle farming and from damages sustained from Hurricane Iris in 2001. The BNR is the most stable of all with all ecosystems intact and negligible changes brought about by natural occurrences, such as flood damage along the

Priority Targets	Condition Status/Trend			Rationale
	GSCP	BNR	MMNFR	
				banks of the Bladen Branch. The MMNFR contains 6 broad ecosystems with the lowland broad-leaved wet forest ecosystem under the most pressure for agriculture purposes. However, the area currently under pressure is small relative to the size of the PA. All other ecosystems within the MMNFR are shielded by rugged terrain and difficulty accessing these. Note: All three PAs have retained a large portion of their land mass under forest cover.
				The GSCP under regular monitoring and patrols has been able to deter any major clearings within its boundaries. There are small areas that are being monitored due to farm boundaries now being shared with that of the reserves. While intentional clearing within the reserve along the boundary line is unlikely, the risk of fires from these farms is high particularly during the dry months of the year. 2020 saw no incidents of fire escaping into the reserve.
				The BNR has most of its natural vegetation intact. Apart from negligible changes in forest cover along the banks of the Bladen Branch River, the reserve remains untouched as far as clearings go. In MMNFR, just north of the agroforestry concession is an area under illegal cultivation which has degraded the forest conditions resulting in unsustainable use of an estimated 300 acres of land within the reserve. This area continues to be active and attracts more incursions and clearings contributing to the deteriorating trend in forest cover in the area.
				In MMNFR, just north of the agroforestry concession is an area under illegal cultivation which has degraded the forest conditions resulting in unsustainable use of an estimated 300 acres of land within the reserve. This area continues to be active and attracts more incursions and clearings contributing to the deteriorating trend in forest cover in the area.

IV. Ecosystem Services				In 2016-2017, a freshwater bio-assessment was conducted within four watersheds in the MGL (Bol, 2018). The study was done to develop baseline data and potential station sites for continuous monitoring in order to assess long-term trends of the stream condition. All sites ranked either as "good" or "excellent" based on integrated scores for stream physical, biological, and chemical parameters (using SVAP and ASPT-CR scoring criteria).
V. Sustainable Natural Resource Use		NA		Resource use in the GSCP is restricted to sustainable extraction zones established for NTFPs. Extraction of cohune leaves within two extractions zones is seasonal and monitored by the ranger team. The BNR, by virtue of its designation, cannot allow the use of resources within the reserve. As such, sustainable natural resource use is not applicable to this PA. The MMNFR is by designation an extractive reserve. Since 2015, Ya'axché along with the Trio Farmers Cacao Growers (TFCG) have been developing an agroforestry concession for the production of shade-grown cacao. This development has seen the conversion of 936 acres of forested land into productive shade-grown cacao. A small number of permits were issued out by FD for the extraction of timber species for personal use. Permits remain at a low number.
VI. Enforcement and Compliance				The GSCP is relatively stable and in good conditions in relation to enforcement and compliance of rules and regulations. Base of operations is ideally located with most patrol routes accessible within minutes. The BNR is stable but with some concern in relation to activities, such as hunting, which is on the rise in areas where patrols are infrequent due to remoteness and ruggedness of the terrain. These patrols require additional support from the relevant regulatory departments, but coordination for such patrols

				was inconsistent in 2020, in part, due to COVID-19. Patrols in the MMNFR keep encountering evidence of infractions on a regular basis. Illegal activities such as hunting, fishing and logging are on the rise despite an increase in patrols in the affected areas. Conditions may be deteriorating in the near future.
VII. Biodiversity Knowledge for Adequate Management				In the last five years, Ya'axché has ramped up its efforts on research, inventory and monitoring. Its research and monitoring program has grown significantly with a dedicated team for data collection and technical staff for the analysis of data and reporting. As the program continues to grow, the knowledge of the biodiversity within the PAs continues to increase as well. Species lists for mammals and birds exist for all reserves and are currently being updated. The creation of native bee lists has been initiated. Threatened and socio-economically important species lists will be revised in the process. Plant and bat species lists are established and in use in the management of BNR and GSCP, but that information is still lacking for MMNFR. In all reserves, recent information on invasive species in particular is lacking. Ecosystem maps exist at a scale of 1:100,000 for all three reserves (Meerman, 2005), and Ya'axché is exploring the use of drones for ecotype mapping as of 2021 to improve the resolution of its maps. Results from a cohune palm leaf regeneration study in GSCP are being used in the management of the extraction zones in that reserve. Certain rare, threatened, data deficient, and/or timber trees that are lacking management plans at the national level are being studied in GSCP, BNR, and MMNFR to determine life cycle and population dynamic information.

I. Habitat Indicator Species

Habitat Indicator Species		Overall Condition			GSCP	BNR	MMNFR
Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale		
		GSCP	BNR	MMNFR			
Migratory Birds	Index of Abundance				Eight bird species monitored on the biodiversity transects are generalist migrant species without specific habitat requirements in Belize. Declines in the abundance of these birds could indicate deteriorating conditions of their migration routes among other stressors.		
					GSCP. There are no long-term trends in the index of abundance for migratory birds indicating conditions have been stable since 2010. However, the index of abundance is lower in 2020 than the average over the last 3 years and since monitoring began in 2010.		
					BNR. There is a significant decline in the index of abundance for migration route health indicators in BNR since 2010. This is a reflection of the significant decline in that indicator group from the forested transect. The negative trend is not observed in the savanna transect of BNR.		
					MMNFR. There are no significant trends for migratory bird index of abundance since monitoring began. The abundance in 2020 is comparable to the average over the last 3 years and since 2016.		
Forest Birds	Index of Abundance				Eleven bird species are monitored as forest health indicators, as they are only found in primary forests or undisturbed secondary forest.		
					GSCP. There is no linear trend over 10 years of monitoring. 2020 is comparable to the average over the last		

Habitat Indicator Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					3 years and since monitoring began in 2010.
					BNR. The index of abundance is stable with no linear trend since 2010. Forest bird index of abundance in 2020 is comparable to the average over the last 3 years.
					MMNFR. There is no linear trend over time. However, in 2020, the index of abundance for forest indicators was higher than the average since monitoring began in 2016.
Savanna Birds	Index of Abundance				Three of the monitored bird species are linked to pine savanna ecosystems and are considered indicators of the health of that habitat.
					GSCP. There is no linear trend in savanna birds over 10 years, though the index of abundance in 2020 is higher than the average over the last 3 years and since monitoring began in 2010.
					BNR. Though the index of abundance for savanna birds in 2020 is lower than the average over the last 3 years and the average since monitoring began in 2010, there is no significant decline over time.
					MMNFR. There is no linear trend for abundances over time. However, 2020 is comparable to the average over the last 3 years and since monitoring began in 2016.
Wetland Birds	Index of Abundance				Three bird species are monitored as wetland indicators because of their link to healthy riparian or littoral habitat.

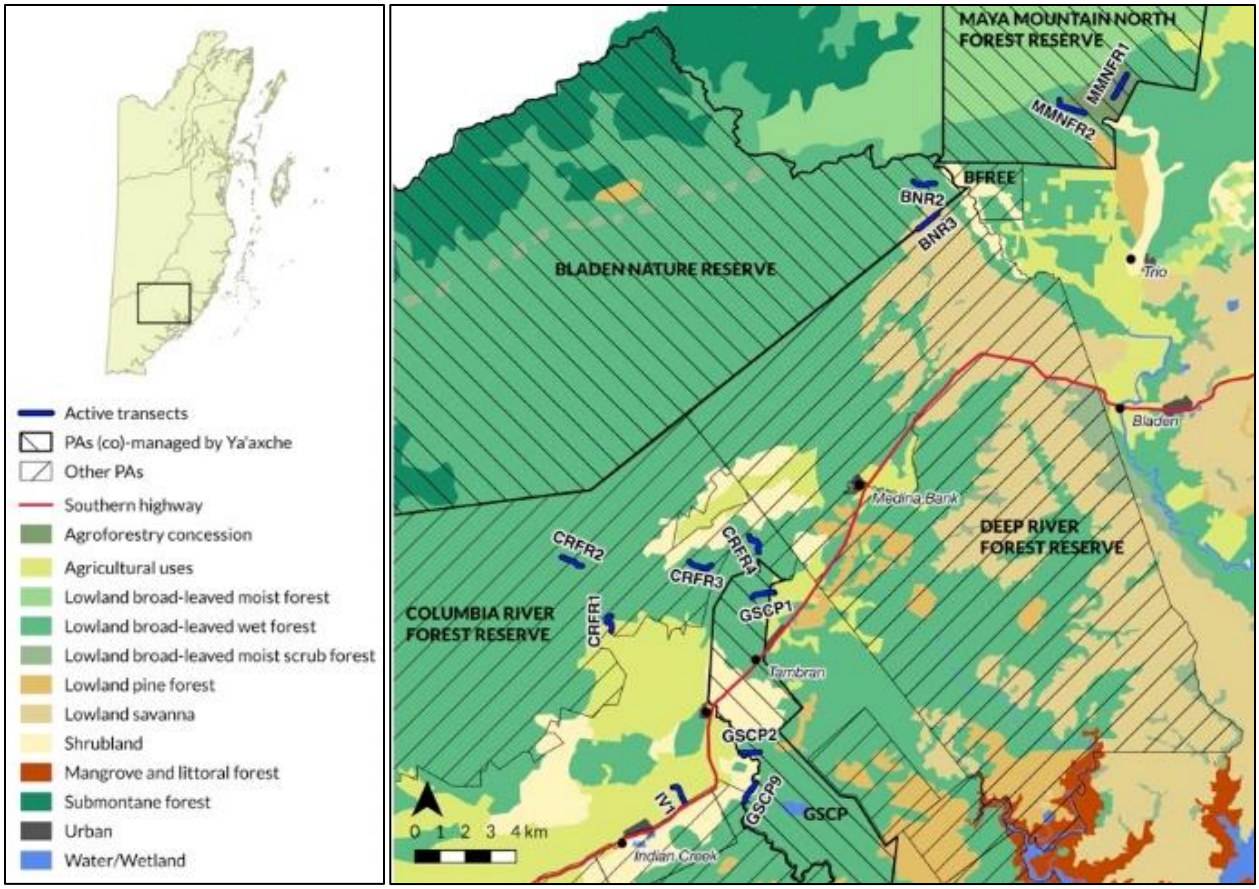
Habitat Indicator Species		Overall Condition			GSCP	BNR	MMNFR
Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale		
		GSCP	BNR	MMNFR			
					GSCP. There is no linear trend for wetland birds over 10 years, though the index of abundance in 2020 is much higher than the average over the last 3 years and since monitoring began in 2010.		
					BNR. The index of abundance in 2020 is comparable to the average over the last 3 years and since monitoring began in 2010.		
					MMNFR. There is no linear trend over the last 10 years. The index of abundance for wetland birds was higher in 2020 than the average over the last 3 years and since monitoring began in 2016.		
Disturbed Forest Birds	Index of Abundance				Three bird species are monitored as disturbance indicators. These species are known to tolerate and even thrive in fallow lands, forest gaps, and human impacted landscapes. Of the three, the bronzed cowbird and dickcissel have never been recorded on any transect since 2010. The results shared are for the plain chachalaca only.		
					GSCP. There is a significant decline in disturbance indicators since 2010. Zero were recorded in GSCP in 2020.		
					BNR. There is no linear trend in disturbed forest indicator birds for BNR overall. 2020 is comparable to the average over the last 3 years and last 10 years. When examining individual transects, the savanna transect shows a significant decline in disturbance indicator species over time but this is not seen in the forested transect.		

Habitat Indicator Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					MMNFR. There is no linear trend over time. Zero disturbance indicators were recorded in 2020, which is comparable to the average over the last 3 years and since monitoring began in 2016.
Game Birds	Index of Abundance				Three commonly hunted game bird species are monitored as indicators of hunting presence and sustainable use. GSCP. There is no linear trend in game bird index of abundance since 2010. Game bird index of abundance has remained very low since monitoring began in 2010. In 2020, no game indicators were recorded, but this index is comparable to the average over the last 10 years. BNR. The index of abundance is stable with no linear trend since 2010. Game bird index of abundance in 2020 is comparable to the average over the last 3 years. MMNFR. There is no linear trend over time. However, zero indicator game birds were recorded on the transects in 2020, which is lower than the average over the last 3 years and the average since monitoring began in 2016. Despite no game bird indicators observed on the transects in 2020, camera surveys in the same area and year did confirm the presence of great curassow and great tinamou.
Wetland Mammals	Index of Abundance				Two mammal species are monitored as indicators of riparian forest health. Between the two, the neotropical river otter is rarely recorded on the transects while the Baird's tapir is consistently recorded.

Habitat Indicator Species		Overall Condition			GSCP	BNR	MMNFR
Indicators of Condition	**Specific Measures**	**Condition Status/ Trend**			**Rationale**		
		GSCP	BNR	MMNFR			
					GSCP. There are no linear trends since 2010, indicating stable populations over time.		
					BNR. There is a significant increase in index of abundance for wetland indicator species (mostly driven by significant increase in tapir abundances in the savanna transect over time).		
					MMNFR. There are no linear trends for MMNFR as a whole or for the individual transects.		
Forest Mammals	Index of Abundance				Seven mammal species are monitored as forest health indicators, since they prefer primary forest or undisturbed secondary forest habitat.		
					GSCP. There are no linear trends in forest mammals, indicating populations are stable. However, transects in the adjacent Columbia River Forest Reserve (CRFR) show significant declines in forest mammal index of abundance since 2010.		
					BNR. There are no linear trends for the forested transect, and the abundance in 2020 is comparable to averages over the last 3 years and 10 years. However, there is a significant decline since 2010 in howler monkeys and jaguars for savanna transect.		
					MMNFR. There are no linear trends, though there is an abrupt decline in the index of abundance between 2016 and the following year, which stabilized through 2020. This might be a reflection of increased human activity in the cacao concession where the transects are located. Both the cacao		

Habitat Indicator Species		Overall Condition			GSCP	BNR	MMNFR
Indicators of Condition	**Specific Measures**	**Condition Status/ Trend**			**Rationale**		
		GSCP	BNR	MMNFR			
					and forested transects in MMNFR share this pattern.		
Disturbed Forest Mammals	Index of Abundance				Only one mammal, the jaguarundi, is monitored as a disturbance indicator that can tolerate human-modified landscapes and regenerating forests. Detection of jaguarundis has been rare in BNR and GSCP over the last 10 years and in MMNFR over the last 4 years. Zero observations were made on transects in 2020.		
Game Mammals	Index of Abundance				GSCP. There are no linear trends, though transects in the CRFR adjacent to GSCP show significant declines in game mammal index of abundance since 2010. BNR. There are no linear trends. The index of abundance is stable in forested and savanna transects in 2020 compared to averages over the last 3 years and last 10 years. MMNFR. There are no linear trends, though there is a steep decline in index of abundance between 2016 and the following year, which stabilized through 2020. This might be due to an increase in activity in the cacao concession where the transects are located. When examining individual transects in MMNFR, the cacao transect reflects the steep decline between 2016 and 2017. The forested transect reflects a decline from 2019 to 2020.		



Map 2. Transect locations and ecotypes.

Information Brief: Indicator Species and Biodiversity Transects

Ya'axché began monitoring biodiversity in 2006 with the establishment of bird and mammal transects. Over the years, the monitoring program has grown to encompass new target taxa and methodology, but transects have remained at the core of the program. As of 2020, 12 transects exist across the MGL. These are point-count and sign transects, all 1km in length, with stopping points every 200m to observe and listen. Birds are detected using sight and sound cues, while mammals are detected using direct sightings, tracks and an array of different signs such as scat, smell, sounds and scratch marks.

Transect locations

Diverse habitats and a range of disturbance levels were chosen for transect locations to ensure that our monitoring program is representative of the land cover found across the landscape. Two transects are located in BNR, four in CRFR, three in GSCP, one in Indian Creek Village, and two in MMNFR. The location and ecotype of the transects is depicted in Map 2. Details of each of the transects can be found in Table 1.

Indicator species

Thirty-one (31) bird and 19 mammal species make up the target species list, which is classified into six indicator groups based on

Transect	Year Est.	Disturbance
BNR2	2010	Minimal
BNR3	2012	Minimal
CRFR1	2010	Minimal; 0-20% hurricane damage (2001); proximity of agriculture
CRFR2	2010	Minimal; 0-20% hurricane damage (2001)
CRFR3	2010	Minimal; 0-20% hurricane damage (2001)
CRFR4	2010	Minimal; 0-20% hurricane damage (2001)
GSCP1	2010	60-75% hurricane damage (2001); proximity of village and agriculture
GSCP2	2010	60-75% hurricane damage (2001); proximity of agriculture
GSCP9	2012	60-75% hurricane damage (2001); proximity of agriculture
IV1	2012	60-75% hurricane damage (2001); proximity of highway and agricultural clearings
MMNFR 1	2016	Up to 40% thinning of overstory with cacao crop planted underneath
MMNFR 2	2016	Minimal

Table 1. Description of transect disturbance levels and the year that consistent and consecutive monitoring was established. Any data recorded on the transects prior to the year listed below were not included in this report.

habitat preferences and ecology (Tables 2 & 3).

Species lists and indicator group assignment were based national and IUCN Red List conservation priorities, expert knowledge, ecological preferences as given in "Field Guide to the Mammals of Central America and Southern Mexico" (Reid, 2009) and "Birds of Belize" (Jones & Gardner, 2003), and validated by the local knowledge of Ya'axché's field ranger team.

Indicator groups are taken into account when analyzing bird and mammal data and are used to facilitate making conclusions from the monitoring results. For example, an increase of "Disturbed forest indicators" could indicate habitat degradation, whereas decreased "Game species" richness could indicate a high level of hunting pressure and/or habitat degradation.

Table 2. Target mammal indicator species (n=19).

Common Name	Class	IUCN Status
Agouti	G	LC
Baird's Tapir*	W	EN
Brown Brocket Deer	NA	VU
Collared Peccary	G	LC
Jaguar	F	NT ▼
Jaguarundi*	D	LC ▼
Margay*	F	NT
Naked-tailed Armadillo	NA	DD
Neotropical River Otter*	W	NT ▼
Nine-banded Armadillo	G	LC
Ocelot	F	LC
Paca	G	LC
Puma*	F	LC ▼
Red Brocket Deer	F	DD
White-lipped Peccary*	G	VU
White-nosed Coati	NA	LC
White-tailed Deer	G	LC
Yucatan Black Howler Monkey*	F	EN
Yucatan Spider Monkey*	F	EN

Table 3. Target bird indicator species (n=31).

Common Name	Migra-tory	Class	IUCN Status
American Redstart	Y	M	LC ↓
Black and White Warbler	Y	M	LC ↓
Blue-gray Gnatcatcher	Y	P	LC
Bronzed Cowbird	N	D	LC
Brown-hooded Parrot	N	F	LC
Cerulean Warbler	Y	F	NT ↓
Chestnut-sided Warbler	Y	M	LC ↓
Common Yellowthroat	Y	M	LC
Crested Guan	N	G	LC ↓
Dickcissel	Y	D	LC
Golden-winged Warbler*	Y	F	NT ↓
Grace's Warbler	N	P	LC ↓
Great Curassow*	N	G	VU
Great Tinamou*	N	G	NT ↓
Hooded warbler	Y	M	LC
Keel-billed Motmot*	N	F	VU ↓
Keel-billed Toucan	N	F	LC ↓
Kentucky Warbler	Y	F	LC ↓
Little Tinamou	N	F	LC ↓
Louisiana Waterthrush	Y	W	LC
Magnolia Warbler	Y	M	LC
Mealy Parrot*	N	F	NT ↓
Northern Waterthrush	Y	W	LC
Painted Bunting	Y	M	LC
Plain Chachalaca	N	D	LC
Prothonotary Warbler	Y	W	LC ↓
Slaty-breasted Tinamou	N	F	LC ↓
Swainson's Warbler	Y	F	LC
Wood Thrush	Y	M	LC ↓
Worm-eating Warbler	Y	F	LC
Yellow-headed Parrot	N	P	EN ↓

*Assessed as part of the threatened bird or mammal indicator for the target "Rare, Threatened, Socio-Economic, & Culturally Important Species."

KEY: M = migration route health, P = pine savannah health, D = disturbed forest, F = forest health, G = game (hunting pressure), W = wetland health, NA = not assigned. LC = least concern, NT = near threatened, VU = vulnerable, EN = endangered, DD = data deficient.

Arrow indicates trend in global populations.

Three mammal species are monitored but are not assigned to an indicator class and were not analyzed for this report.

Analysis

The number of indicator species recorded on the transects was standardized across years and reserves through the creation of an index of abundance for each indicator group and for each species of conservation concern.

The index of abundance gives an indication of the status of an animal population, based on the numbers of animals seen per unit of time or distance, in a particular area over several years. In this case, the indices were calculated as the number of individuals observed per 1000m.

Data from all GSCP transects were analyzed and reported together for a comprehensive score for that reserve. For each BNR and MMNFR, data from transects were analyzed and reported together and also separately because the transects in those reserves have habitat and/or land use types that are distinct from each other.

Indices of abundance over time were plotted and analyzed for trends using ordinary least squares regression techniques in PAST (Hammer et al. 2001).

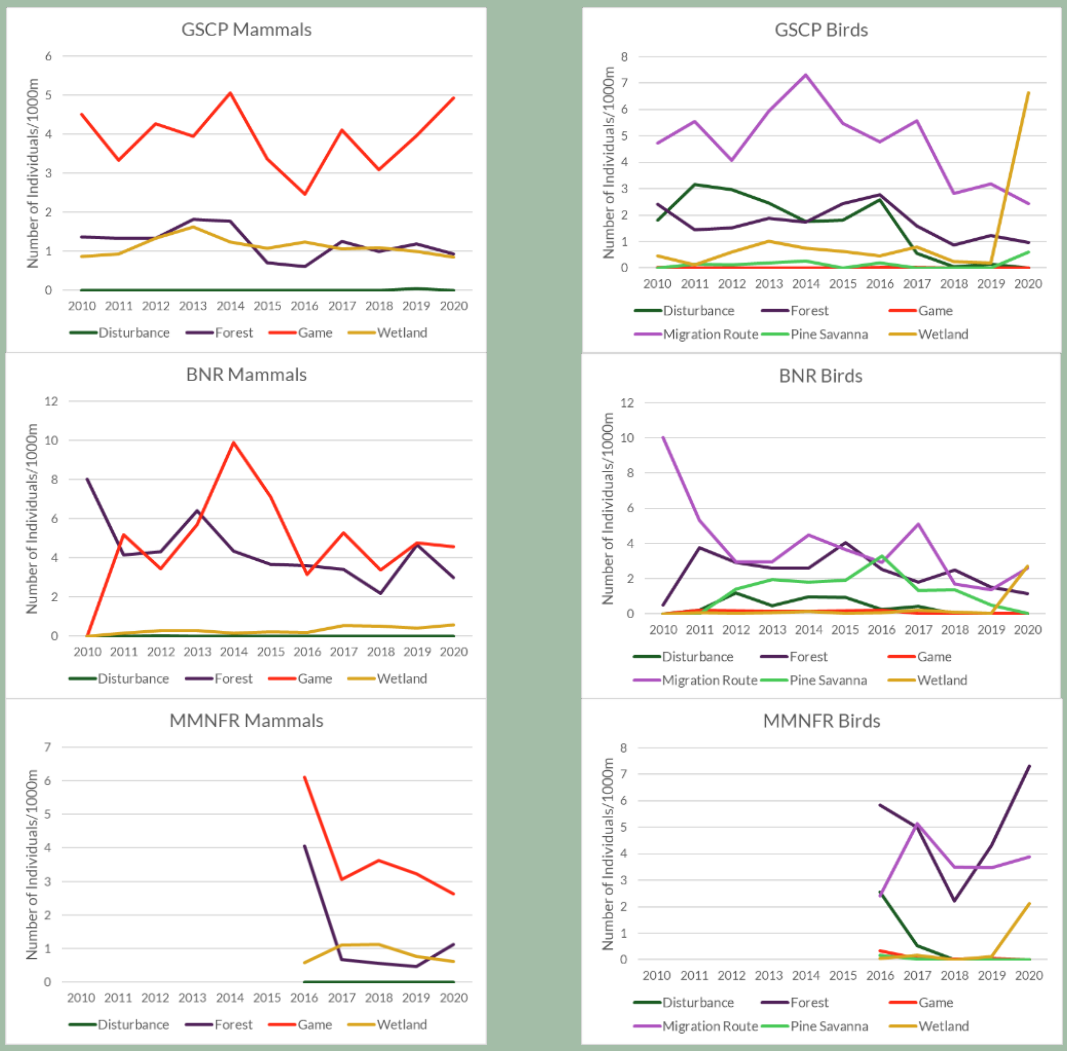
Methods

The core data collected in transects since 2010 were the number of species observed and the number of individuals observed per species. Birds were monitored twice daily: early morning and late afternoon. Large mammal monitoring was done simultaneously with bird monitoring but

signs and sightings were only recorded once during the day to avoid double counting. A more detailed description of the methodology used on the transects can be found in Ya'axché's BRIM strategy document (Wicks, 2009). The number of transect visits per year averages 34.1 in BNR, 34.1 in GSCP, and 33 in MMNFR.

Indicator group trends

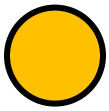
Indices of abundance for each indicator group can be found below. Significant negative trends are reported for BNR forest health mammals (y=-0.3487x + 6.3972; R^2=0.4154; p<0.05) due to significant negative trends in howler monkeys (y=-0.2281x + 2.5125; R^2=0.6334; p<0.05) and jaguars (y=-0.0995x + 1.1387; R^2=0.6212; p<0.05) in the savanna transect. BNR migration route health birds (y=-0.5656x + 7.1582; R^2=0.481; p<0.05) and GSCP disturbance birds (y=-0.298x + 3.3365; R^2=0.6123; p<0.01) also declined. Significant positive trends are seen in BNR wetland mammals (y=0.0438x + 0.0355; R^2=0.6201; p<0.01). No other linear trends are reported.



Graphs 1-6. Trend in the number of individuals recorded per transect per year for both mammal and bird indicator species.

II. Rare, Threatened, Socio-Economic, & Culturally Important Species

Rare, Threatened, Socio-Economic, and Culturally Important Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Threatened Birds	Index of Abundance				Seven bird species monitored along the biodiversity transects are considered to be of conservation concern because they have either a threatened IUCN Red List status or a near-threatened status with decreasing global populations. These species include the cerulean warbler, golden-winged warbler, keel-billed motmot, great curassow, great tinamou, mealy parrot, and yellow-headed parrot. Of these, the cerulean warbler has never been recorded on the transects. There have been no significant long-term trends for the great curassow, keel-billed motmot, great tinamou, or mealy parrot, but the 2020 index of abundances for these species are lower than the averages over the last 3 years and since monitoring began. Great curassow index of abundance is highest in the forested BNR and MMNFR transects. The species has rarely been recorded in the savanna transect of BNR and is also rarely recorded in GSCP (not since 2012). It has never been recorded in the cacao transect of MMNFR. All reserves saw a decline in great tinamous in 2017, and the species was not recorded on any transect in 2020. Keel-billed motmots have not been recorded on a transect in any reserve

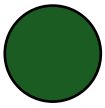
Rare, Threatened, Socio-Economic, and Culturally Important Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					since 2018 and have never been recorded in GSCP nor the nearby village transect. There has been a significant decline in index of abundance for yellow-headed parrot in the BNR savanna since monitoring began there in 2012. The parrot has never been recorded on the forested transect in BNR, which is expected for the pine savanna-dependent species. The parrot has not been recorded in GSCP or MMNFR since 2016 and index of abundance is lower in those reserves than in BNR since monitoring began. The golden-winged warbler is rarely recorded in the MGL transects. It has been observed only occasionally in GSCP and MMNFR. It was not observed in 2020.
Threatened Mammals	Index of Abundance				Of the mammals monitored along the biodiversity transects, seven species are of conservation concern: Yucatan black howler monkeys, jaguars, jaguarundis, pumas, tapirs, white-lipped peccaries, and Yucatan spider monkeys. The brown brocket deer was not assessed. **GSCP.** Transect data show a significant increase in index of abundance for pumas since 2010. Spider monkeys and white-lipped peccaries are rarely seen and were recorded 0 times in 2020 which is not unusual for this reserve. **BNR.** The puma index of abundance has increased significantly in the

Rare, Threatened, Socio-Economic, and Culturally Important Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					forested transect since 2010. Similarly, tapir index of abundance has significantly increased in the BNR savanna. However, the index of abundance for howler monkeys has significantly decreased in the savanna over time. This is likely due to a change in the data collection methods for the savanna transect. There's also a significant decrease in jaguars in the savanna transect that stabilized in the last 4 years.
					MMNFR. There's a significant increase for pumas in the forested transect. Jaguars have not been observed in the MMNFR cacao transect since 2016, though they have been observed in the MMNFR forested transect. All other species of conservation concern are either stable or have no trend.
Bats	Number of species, Relative Abundance			NA	During a 2016 survey, 53 bat species were recorded through mist and harp netting and acoustic monitoring in BNR (Foxley & Gartzia, 2014). 34 species were recorded in GSCP. Both are likely underestimates of true species richness. Trapping results show a difference between bat assemblages in the mature forest of BNR and that of GSCP and between BNR and the agroforests and orange orchards outside of the reserves. BNR has the highest species diversity, including a high number of rare species. It is dominated by *Artibeus jamaicensis*, which has been linked to continuous mature forest habitat. GSCP has the

Rare, Threatened, Socio-Economic, and Culturally Important Species	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					lowest overall species richness in the study, which may be due to the structure of the secondary forest which is recovering from Hurricane Iris damages in 2001. The species assemblage in GSCP is composed of bats more common in disturbed and open areas.
Rare and Endangered Trees	Abundance & Age Structure				GSCP. The broken ridge ecosystem type found in GSCP forms the ideal conditions for the growth Honduran rosewood (*Dalbergia stevensonii*). The reserve is considered one of the last remaining strongholds for the species due to deforestation elsewhere within its range. Populations have been monitored consistently since 2013 to track growth rates and phenology, which are critical for the creation of biologically-relevant timber management plans at the national level. Propagation trials have been ongoing in Ya'axché's nursery since 2017 to learn best practices and growing conditions for the species.
					BNR. A total of 227 tree species from 65 plant families have been recorded from the roughly 5000 trees within 4 permanent sample plots in the BNR. Out of these, 72 species (32%) have distributions restricted to northern Mesoamerica. The BNR landscape, composed of limestone ridges, creates niche conditions that promote the evolution of species specialized to unusually high drainage, pH, and calcium levels compared to what is found in soils

Rare, Threatened, Socio-Economic, and Culturally Important Species	Overall Condition	GSCP	BNR	MMNFR

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					from more common substrata across the Neotropics. Notable rare, restricted, and/or ecologically important species include *Bartholomaea sessiliflora*, *Beilschmiedia hondurensis*, *Chiangiodendron mexicanum*, and *Guettarda davidseorum*. The rough terrain of the BNR landscape also contributes to the protection of trees from illegal extraction.
					MMNFR. The surveys for threatened timber species in 2020 revealed previously unknown populations of *Zanthoxylum* species (Dorgay, 2020). Due to a history of legal and illegal logging in the reserve, the age structure for the several of the populations is skewed toward younger trees. These populations are now the target of conservation action through improved zonation in the reserve, increased patrols, and out-planting and monitoring of saplings over the next few years

Information Brief: Big Cats of the PAs

For the two years in a row since 2019, we have recorded five of the five big cats of Belize in the MMNFR cacao concession. For our monitoring, sixteen camera traps were evenly distributed across the 936 acres concession area to monitor and document the wildlife in this cultivated section of the reserve.

Jaguars

In 2020, we recorded two independent jaguar sightings. One was a new jaguar and the other a recurring female from 2019. The new Jaguar (Photo 1) appeared pregnant, and was recorded in the dry season, while the recurring female was recorded in the wet. In addition, one male jaguar recorded in 2019 was not captured in 2020. No record does not mean it was not present in the reserve.

Up to 2020, three unique jaguars have been identified in the concession.

Photo 1. New jaguar detected in the MMNFR cacao agroforestry concession in 2020.

Pumas

There was an increase in independent puma sightings in 2020 with five records, compared to one in 2019. This increased presence could be associated with a lower presence of jaguars in the concession, nine independent sightings in 2019 compared to two in 2020. Harmsen et al. (2009) found evidence of temporal avoidance between jaguars and pumas in Cockscomb Basin Wildlife Sanctuary, with the physically smaller puma likely avoiding the jaguar. Both species used the same habitat and schedules but avoided coincident times. A similar occurrence could be at play in the MMNFR agroforestry concession, with the puma occupying the concession in times when the

Photo 2-5. Puma detected in the MMNFR cacao agroforestry concession in 2020.

jaguar is out. Further investigation needs to be done into this. The species was recorded in the dry and wet season in the concession.

Ocelot, Margay, Jaguarundi

In 2019, we recorded 33 independent Ocelot sightings in the MMNFR cacao concession, and uniquely identified at least 9 individuals. Several of these individuals were recaptured in 2020 and detected in other areas of the concession indicating movement of the species for feeding or mating.

Margay

Margays are a naturally elusive species adapted to the arboreal environment. In 2019, we recorded 20 independent sighting of the species across the concession. We recorded similar results in 2020. Most of the images were captured in the night, representative of the species' nocturnal habit.

Jaguarundi

The jaguarundi by nature is another elusive species. This small wildcat was recorded seven times across the concession in 2019, similar results were recorded in 2020.

Prey

Notably, no white-lipped peccary was recorded in 2020. In the 2019 dry season a herd of more than thirty-five individuals was recorded. Several factors could influence their non-detection in 2020, either hunting pressures or dispersal to better feeding grounds. Another species of peccary, the collared peccary, had good detection rates within the concession and was recorded for both seasons in 2019 and 2020. Other important prey such as red-brocket deer, Lowland paca, and nine-banded armadillo were also detected in good numbers across the concession.

III. Broad Ecosystems and Land Use Change

Broad Ecosystems & Land Use Change	Overall Condition	GSCP	BNR	MMNFR
		⇔	⇔	⇓

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Extent of Broadleaf Forest	Percent cover	⇔	⇔	⇓	The GSCP has for the most part benefitted from a stable relationship with the neighboring communities over the last two decades. As such, no incursions within the reserve have led to any major clearings within the boundaries of the reserve. GSCP retains an estimated 97% of its forest cover within 15,000 acres.

Broad Ecosystems & Land Use Change	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					The BNR enjoys widespread protections via its location at the center of the Maya Mountains block of protected areas. Restricted and patrolled access to the reserve ensures little opportunity for any forest areas to be cleared. The BNR retains 99.8% of its forest cover within an estimated 100,000 acres of reserve.
					The MMNFR retains most of its forest cover; however, 2020 saw a spike in clearings in an area that was under recovery for the last 5 years. The larger expanse of the reserve is still well intact due to remoteness and rugged terrain making access for clearings nearly impossible. The MMNFR excluding the concession area retains 98.9% forest cover within an estimated 35,000 acres. The concession area retains 71% of forest cover from within the 936 acres under development.
Extent of Deforestation	Percent cover				Based on our annual assessment through remote sensing and GIS work, the following figures suggest the conditions are good and stable for both GSCP and BNR and warranting moderate concern for MMNFR. For the year 2020, approximately 1% of forested area was under some form of clearing or non-forest use within the MMNFR. This encompasses an estimated 328 acres most of which is for agriculture.

Broad Ecosystems & Land Use Change	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Extent, Increase, and Impact of Agricultural Lands	Area of land cleared or under unsustainable development	NA	NA		This indicator does not apply to both GSCP and BNR since there are no known areas within the reserve that are of concern and agricultural lands in the buffer areas have remained stable for years. Within the MMNFR, there is an area of illegal land clearings that continues to degrade the lowland areas around Governor's creek in the vicinity of the eastern boundary line. An estimated 328 acres, give or take, is currently under unregulated and illegal cultivation. 2020 saw a spike in additional areas cleared to the existing areas under illegal cultivation. This trend continues to grow and warrants concern for future management of the area to avoid further incursions.

Information Brief: Land Use Change in the Protected Areas

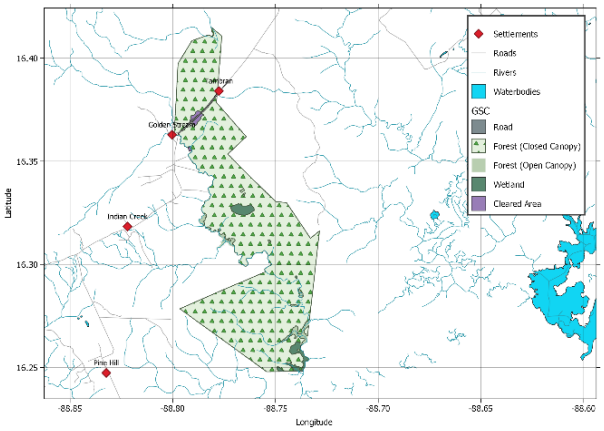
Golden Stream Corridor Preserve (GSCP)

The GSCP has remained steady and stable in its recovery from Hurricane Iris which heavily disturbed the forests of the PA in 2001. Nineteen years later, the forests in the GSCP are healthy and providing valuable habitat for wildlife and ecosystem services to the buffer communities. Due to its accessibility for the field staff, the PA is patrolled regularly and has resulted in deterring any incursions for land clearing within its boundaries. Up to the end of 2020, GSCP retained 97% of its land mass under natural forested vegetation. The remaining 3% of the land mass includes road access, wetlands and open spaces near and around the Golden Stream Field Station.

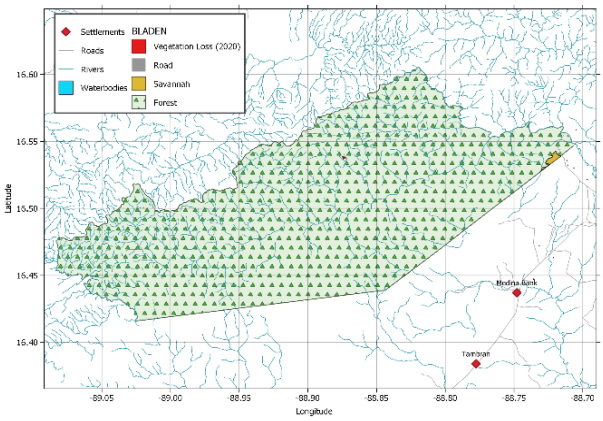
Bladen Nature Reserve (BNR)

The BNR retains is forest cover as intact as nature allows it. As of the end of 2020, the BNR had 99.8% of its land mass under natural forest cover. The remaining 0.2% comprises of a tiny area of savannah ecosystem and some areas of natural change along the banks of the Bladen Branch River. Due to its protected area designation, limited

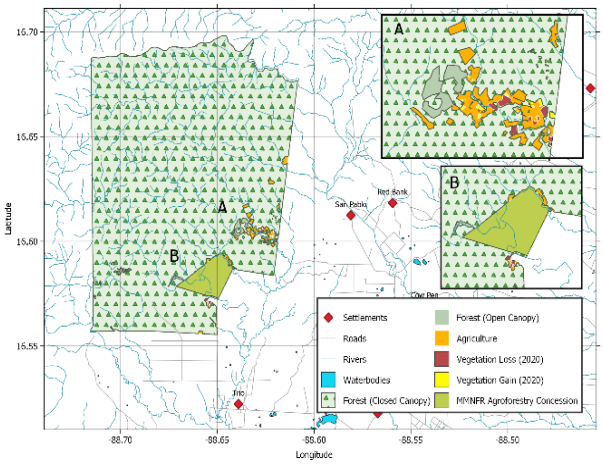
access, and overall ruggedness, the BNR remains as untouched as possible.



Map 3. Land Use Map of GSCP.



Map 4. Land Use Map of BNR.



Map 5. Land Use Map for the MMNFR.

Maya Mountain North Forest Reserve (MMNFR)

The MMNFR is currently the most active of the PAs in terms of a variety of permissible activities. Ya'axché has been co-managing the reserve since 2015 and has seen several changes occur within and outside the boundaries of the PA. As an extractive reserve by designation, the reserve had an active logging concession in 2015, which was cancelled in 2016 due to lack of proper management practices. By the end of 2015, Ya'axché had finalized the documentation of and started the implementation of Belize's first agroforestry concession within a forest reserve.

This was a turning point for land use changes to occur for the next 5 years in a sustainable manner through the effort of a community-based group in Trio Village. While this concession is an attempt to combat illegal incursions into the reserve, it has not halted the incursions and there is an area of concern where an estimated 283 acres of forest has been converted into farm land within the reserve.

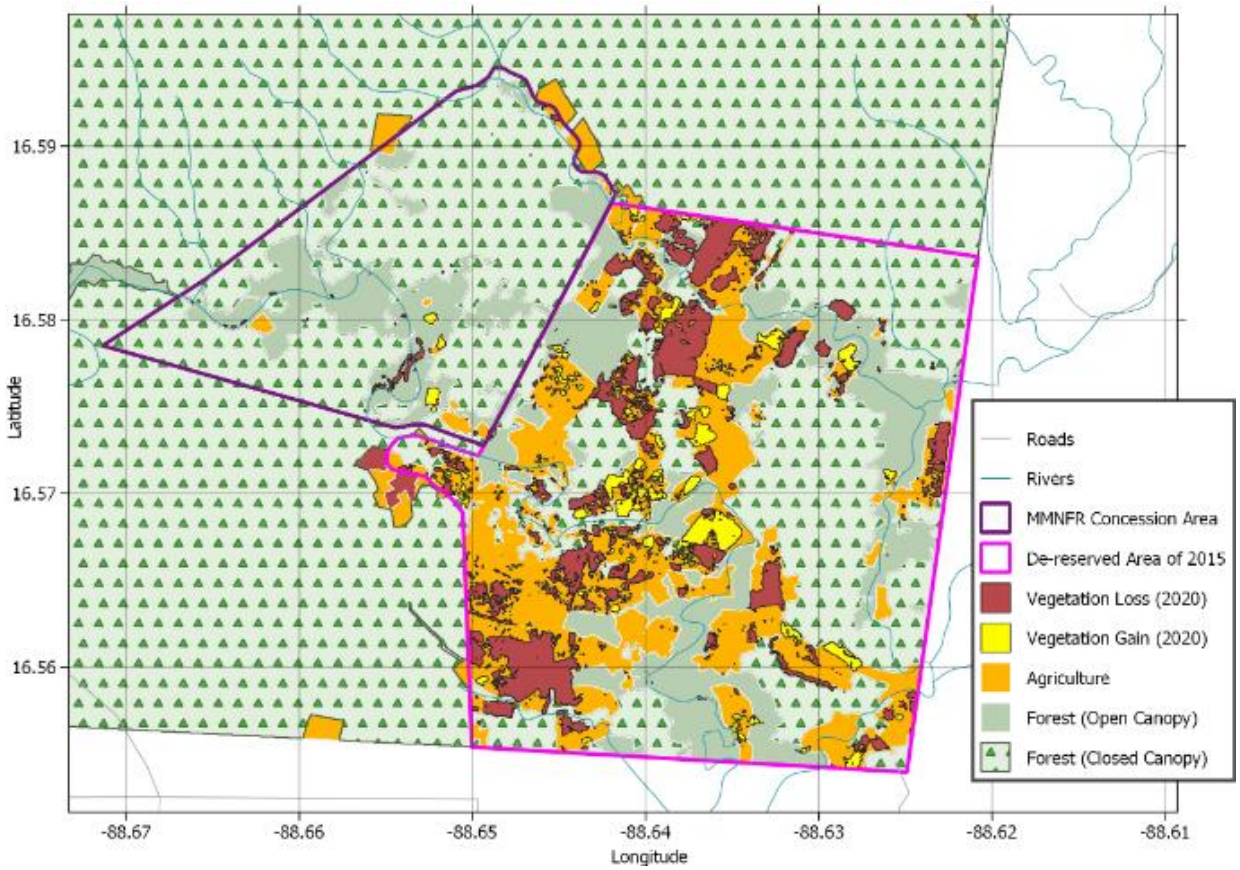
The land mass—excluding the agroforestry concession (35,064 acres)—retains a total of 98.96% of its forest cover. Approximately 0.9% represents the areas cleared and under illegal cultivation. In general, the areas under pressure are lowland broad-leaved forests where access roads are present. The remainder of the PA is shielded for the most part due to the rugged terrain and distance from the nearest communities.

Land use change in and around the agroforestry concession

The agroforestry concession was developed under a management plan that ensured adequate guidance and oversight of the conversion of forested areas into productive agroforestry land. The concession implements the production of shade-grown cacao. As such much of the concession should retain a large percentage of canopy cover.

Within the concession, a total of 455 acres was initially planned for development, including 350 acres for cacao production and 105 acres for annual crops production which would require the clearing of land of up to 3 acres per farmer. This meant that approximately 49% of the 936 acres of concession would eventually be under cultivation with the remaining 51% of the concession under natural forest cover to serve as conservation zones.

This concession provided an opportunity to study and monitor the development and its impacts on the forested landscape. In the last 5 years since the start of development, a total of 75 acres have been converted to cacao plantations under shade. At this phase in development, most cacao trees are of mature age and vegetative cover in high percentages are present. The concession retains approximately 97% vegetation cover inclusive of the cacao producing area. On the other hand, the adjacent de-reserved land has seen rapid degradation when compared to the concession.



Map 6. Land Use Map for the Agroforestry Concession in MMNFR.

IV. Ecosystem Services

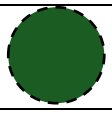
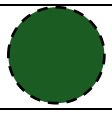
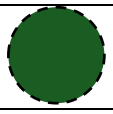
Ecosystem Services	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Freshwater Quality	Macro-invertebrate assemblages				Macroinvertebrates were collected from diverse riparian habitats and identified to family level. Macroinvertebrate assemblages were scored by assigning a sensitivity value from 1-10 to each family collected at the streams. The very pollutant tolerant families are assigned a value of 1, while a very sensitive intolerant families are assigned a value of 10. The sum of these is divided by the number of scoring taxa collected from each sample to obtain the Average Score Per Taxon- Costa Rica (ASPT-CR) index value. Higher ASPT scores indicate the stream to be of higher ecological status, while lower scores indicate a stream of degraded ecological status. An ASPT value greater than six [> 6] indicates high ecological status of the stream. All sites scored between 4-6 indicating waters with regular quality and medium contamination, which is rated as "good" on the scale.
	Dissolved oxygen				GSCP. Dissolved oxygen at one of two sites sampled in the Golden Stream watershed was 3.25 mg/L, below the 5 mg/L Mexico standard for aquatic life in warm surface waters. BNR and MMNFR. Dissolved oxygen in waterways were within the ideal range.

Ecosystem Services	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
	Turbidity				Turbidity for all sites in all three reserves ranged from 0.1-10.2 NTU, which are within Mexico (<10NTU) and Costa Rica (<25NTU) standards for water quality.
	Electrical conductivity				Salinization of freshwater resources, both from natural and man-made sources, is a growing water quality challenge. Salinity can negatively impact sectoral water use, health, biodiversity, and ecosystem services. Electrical Conductivity (EC) is a commonly measured parameter to assess salinity. The EC values for each tributary vary based on the substrate material and season. Calcareous sites on GSCP and BNR have higher values, while siliceous sites in MMNFR are expectedly lower in comparison. Conductivity in rivers generally ranges from 50-1500 µS/cm with ideal values below 500 µS/cm (Conductivity, 2012). GSCP. Electrical conductivity of the sites in the Golden Stream watershed ranges from 337-428.3 µS/cm in both seasons. BNR. Sites on the Bladen Branch of Monkey River range from 266-245 µS/cm in both seasons. This is significantly higher than the electrical conductivity at either of the sites in MMNFR that are part of the same watershed.

Ecosystem Services	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					MMNFR. Electrical conductivity is 107.4-122.4 µS/cm for the sites on the Trio River Branch of Monkey River during both seasons. Electrical conductivity is significantly lower for sites on the Governor's Creek Branch of Monkey River at 31.9 – 69.8 µS/cm during both seasons.
	Temperature				GSCP. The water temperature for sampled sites in the Golden Stream watershed ranges from 23°C - 26°C in both wet and dry seasons.
					BNR & MMNFR. The water temperature of the sites on the Monkey River watershed for the wet season ranges from 23°C – 26°C and slightly increases in the dry season from 27°C - 32°C.
	pH				The pH for all sites sampled was neutral within range of 7-8.7.
	Stream physical condition				The Stream Visual Assessment Protocol (SVAP) is a qualitative scoring criteria of the different physical attributes of a stream, including channel condition, riparian zone, shade (canopy), bank stability, hydrologic alteration, pools, water appearance, nutrient enrichment, sedimentation, insect/invertebrate habitat, in-stream fish cover, barriers to fish movement, fishing pressure, presence of garbage and manure presence. The scores of each attribute are average to result in an overall site score. The rating system of SVAP scores is as follows: 6.1-7.4 rates fair, 7.5-8.9

Ecosystem Services	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					rates good and >9.0 is excellent physical condition of the stream. In 2016, all sites in all three reserves scored either in either the "good" or "excellent" range for stream physical condition.

Information Brief: Freshwater Quality Monitoring Locations

Freshwater sampling sites in the MGL (Map 7) represent areas that are important for a combination of reasons: detecting natural variation and land use change impact, serving surveillance purposes, and/or creating opportunities for community engagement in watershed stewardship.

Natural variation

Five forested sites (GS5, DR2, MR14, MR30, and MR39) are located within protected areas and upstream of villages, where minimal human impact (e.g., fishing) occurs. These sites serve as reference conditions within the watersheds of the MGL. Two sites (GS5 and DR2) are within the calcareous tributaries and three sites (MR14, MR30, and MR39) are within siliceous tributaries.

MMNFR agroforestry concession

Two sites (MR30, MR28) are on the Trio Branch River in the Monkey River watershed for the main purpose of assessing the impacts of the agroforestry concession in the MMNFR on the stream water quality. The agroforestry concession grants local farmers from Trio Village access and usage to roughly 400 acres of the reserve. Of the two sites, MR30 is a selected natural forested site, and MR28 site is located below the agroforestry concession that has a road passing through the river for use during the dry season.

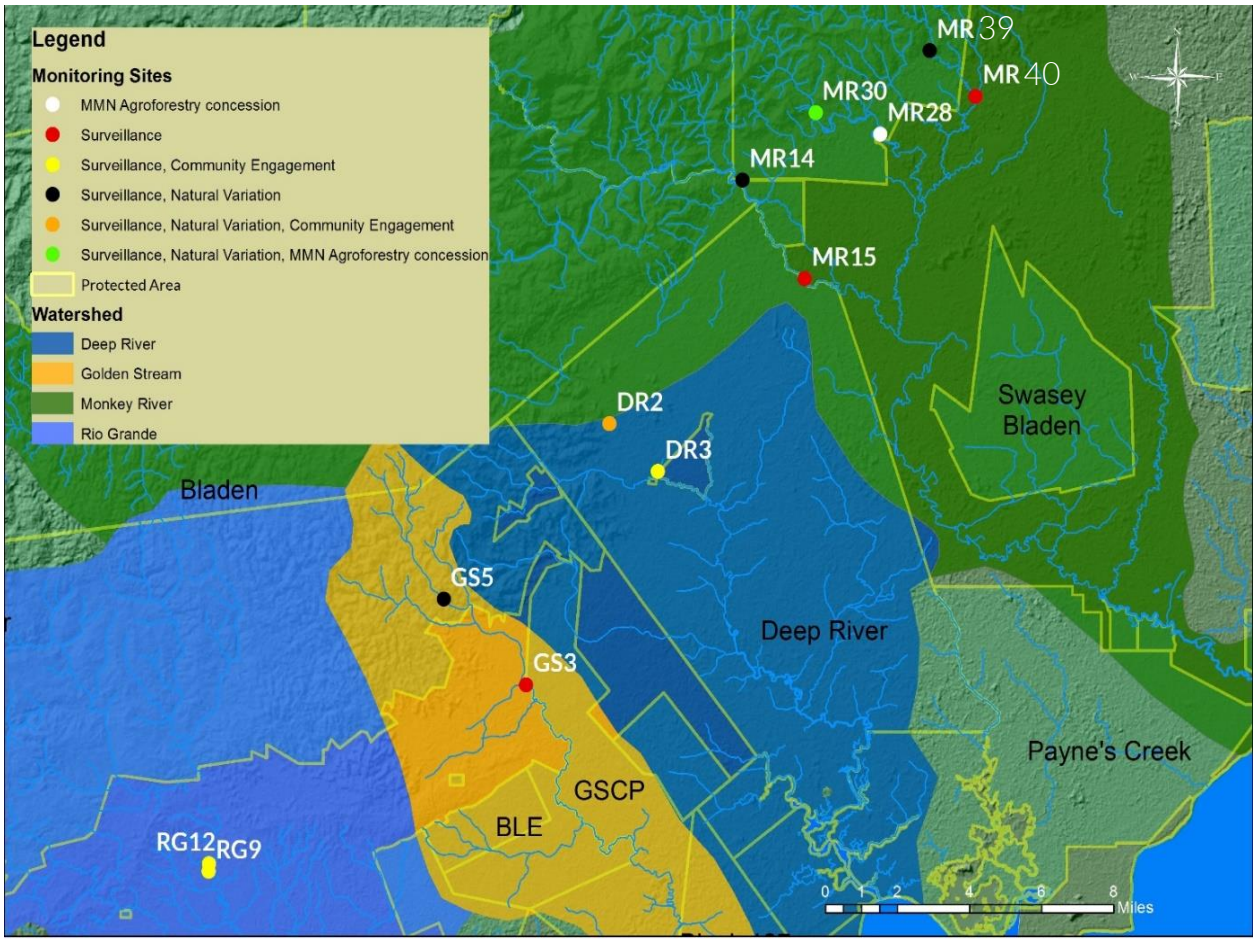
Community engagement

Four sites (RG 9, RG 12, DR 3, and DR 2) on the Rio Grande and Deep River watershed are located near the rural communities of San Miguel and Medina Bank. The communities depend on the rivers daily for domestic use that includes washing laundry, bathing, fishing, and agriculture. In both communities, there are local watershed groups who are keen to learn and develop their knowledge about macroinvertebrate-based bio-assessment and to create awareness and stewardship of rivers in their community.

Surveillance

Eleven sites (RG12, RG9, GS5, GS3, DR2, DR3, MR14, MR15, MR30, MR 39, MR 40) were selected to monitor changes or trends

in the metrics and macroinvertebrate assemblages that can provide an evaluation of the condition of the stream water quality over time.



Map 7. Locations of the freshwater quality sampling sites within the MGL.

V. Sustainable Natural Resource Use

Sustainable Natural Resource Use	Overall Condition	GSCP 	BNR NA	MMNFR 

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Knowledge	Up-to-date documentation for resource use is available in communities eligible to harvest resources in the reserve		NA		GSCP has seen little change in this regard. One internal study on cohune regeneration has provided a better understanding for harvesting of leaves. However, there hasn't been an opportunity to share with the community and gather feedback for an updated extraction plan. Funding has stalled this initiative. This section does not apply to BNR. There has been a considerable effort to increase the information on resources status from MMNFR. Of most notable interest in 2020 was the start of soil health monitoring within the current areas under legal development for the agroforestry concession. Baseline data collection for shade levels within plots will continue to provide the necessary data for improved management.
Opportunity for Subsistence Activities	Subsistence users are engaged in subsistence management	NA	NA		MMNFR is the only PA with an active concession for cash crops and subsistence farming. The TFCG are developing a small area of the agroforestry concession where annual crops can be produced. The farmers in partnership with Ya'axché are signatories to a Conservation Agreement and follow a management plan for the concession. This plan and

Sustainable Natural Resource Use	Overall Condition	GSCP 	BNR NA	MMNFR 

Indicators of Condition	Specific Measures	Condition Status/ Trend GSCP	BNR	MMNFR	Rationale
					conservation agreement was renewed in 2020.
	Proportion of permits that are approved for subsistence use		NA	NA	The GSCP extraction zones have benefited buffer communities who request extraction of construction material for traditional home building. All materials are NTFPs which were identified in consultation with the communities. This extraction process is guided by an outdated sustainable extraction plan. The 2020 plans for an update of the extraction plan were placed on hold due to the COVID-19 pandemic.
Extent of Legal vs. Illegal Natural Resource Use	Incidence				Overall, extraction in the reserve has been under permits for NTFPs; however, GSCP recorded a couple instances of illegally harvested timber, mainly mahogany (*swietenia macrophylla*). This trend was not present the year before.
					The BNR remains stable. No extraction is allowed and so the few instances of extraction are related to the target below where hunting of game species is the most prevalent infraction. Incidents remained low in 2020.

Sustainable Natural Resource Use	Overall Condition	GSCP 	BNR NA	MMNFR 

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					The most concern is within MMNFR where 2020 saw a spike in cases of illegal activities. The two main activities were illegal logging and illegal hunting within the reserve. A few instances of fishing were also documented. Even when logging was permitted by FD, the extraction processes itself was in breach of the regulations by means of cutting the wrong species, cutting in the wrong location and cutting more than what was stated in the permit. In one instance, all harvested products were confiscated after the infractions were reported to FD. This trend seems to be pervasive within the accessible areas surrounding the agroforestry concession and in areas where illegal land clearing is occurring. If not addressed, conditions will continue to deteriorate.

Information Brief: The Agroforestry Concession in MMNFR

In early 2012, a group from the village of Trio approached Ya'axché with a unique request. They wanted assistance in acquiring legal access to arable land within the Maya Mountain North Forest Reserve (MMNFR). The request, although unique and unconventional, was not a farfetched one as current legislation allows for such developments to occur within forest reserves with the proper permitting procedures in place, but it had never been done before. At least not in recent times that Ya'axché was aware of.

After thorough analysis of the situation in the reserve Ya'axché decided to start lobbying for a concession to be granted to the group. In tandem with this request, Ya'axché tabled its proposal for co-management of the reserve and so dialogue was initiated with the Government of Belize through the Belize Forest Department which led to the approval of an agroforestry concession in 2014

followed by a co-management agreement in 2015.

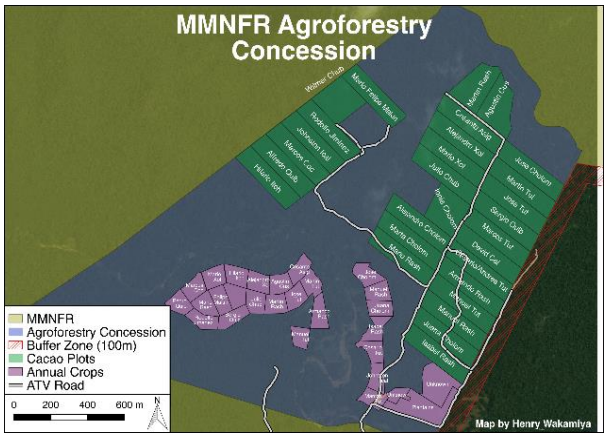
By the end of 2016, all logging operations had ceased due to unforeseen challenges between the only logging concessionaire and the Forest Department. The only remaining concession was then the Agroforestry Concession which was well within its second year of development. The group now named the Trio Farmers Cacao Growers (TFCG), were in the process of establishing up to 350 acres of cacao plantation under shade.

Borrowing concepts from Taungya systems, the cacao plantations would be the main crop, and instead of having to plant trees around it, the forest only needed to be thinned to allow for enough sunlight to penetrate to the forest floor allowing for the cacao to grow. The process of thinning and canopy cover was and continues to be monitored by Ya'axché and enforced by FD.

The agroforestry concession spans 936 acres of which only 350 acres is to be developed into shade-grown cacao plantations and 105 acres dedicated to annual crop. The annual crop section would eventually be phased out when cacao production reaches its peak and the farmers do not need to rely on it for their livelihoods. The remaining 481 acres of concession area will remain unmodified and will serve as conservation areas to function as corridors for wildlife to persist in the area.

In order to maintain ecological integrity within the concession development, strict monitoring of thinning and canopy cover percentage was established. At the stage of planting, the forest canopy was to be reduced to allow for 60% shade on the forest floor. At 5 years, the canopy can then be further thinned to allow 40% shade on the forest floor. The final thinning will occur at the 10-year mark when the canopy will be thinned to a final 30% shade on the forest floor. At this point the cacao plantations should be at its peak production with balanced sunlight and shade.

As of 2020, TFCG had established 270 acres of cacao out of the total 350 available for cacao cultivation. Within the annual crops section only an approximate 12 acres was under cultivation out of a total of 105 acres



Map 8. The blocks of agroforestry and annual crops in relation to the conservation area within the concession.

Photo 6. Farmers in the agroforestry concession harvesting cacao.

available. Of the 270 acres of cacao, 160 acres are at a productive stage and the farmers collectively managed to harvest 32,000 pounds of wet cacao beans in 2020 alone. It is anticipated that production will increase every year onwards until it reaches peak production in about another five years.

With the efforts to minimize impacts on the surrounding forests, the concession as of 2020 resembles a natural forest with cacao as the understory and wild tree species left as canopy trees. In an effort to document the impacts the development of the concession has on native wildlife, camera-trap surveys were established in 2019 and 2020 with continued long-term monitoring for the foreseeable future.

The camera surveys within the agroforestry concession have returned invaluable information for future development. Preliminary analysis of the camera-trap data suggests that wildlife is using the converted landscape much in the same manner they are using the surrounding forest. More data is required to make adequate comparisons, but these findings are promising. Important flagship species such as white-lipped peccaries, jaguars and tapirs are frequently captured on camera, although seldomly seen in person. With continued monitoring of the concession development, it is expected that the wildlife will persist in the area for the long term and the farmers will continue to reap the benefits of a sustainable and environmentally-sound model of farming.

Photo 7. Cacao as the understory and wild tree species as canopy within a well-managed cacao plot.

Photo 8. Jaguar captured on camera within the concession in MMNFR.

Photo 9. White-lipped peccaries captured on camera within the MMNFR.

VI. Enforcement & Compliance

Enforcement & Compliance	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Effectiveness of Patrols	Number of patrols				The number of patrols within GSCP has remained the highest of all the PAs during 2020. The location of the field station and proximity to patrol routes allows for ease of access and wide coverage of the priority areas for patrols.
					The BNR is a large area with most patrols focusing on the accessible areas close to the boundary lines. It has the second highest number of patrols, but is also the largest protected area by land mass covering approximately 100,000 acres of forest. While the area is large, the activities within the reserve are minimal so the effort is proportionate to the activities occurring in the PA.
					The MMNFR has the lowest number of patrols making management of activities less effective than the other two PAs. However, there was a small increase in patrol effort which led to the discovery of more illegal activities as well as a couple of incidents where people were encountered, warned and escorted out of the reserve. While patrol numbers are low, there has been an effort to increase the number of patrols in 2020.
Protected Area Rules and regulations infractions	Number of infractions				The GSCP had 7 infractions most relating to illegal harvesting of NTFPs.
					The BNR recorded only 1 major incident of hunting and fishing in the reserve.

Enforcement & Compliance	Overall Condition	GSCP	BNR	MMNFR

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					The MMNFR is the PA with the most recorded infractions. There were 25 records of land clearing in the reserve, 19 cases of timber extraction and at least 21 instances of evidence of hunting.

Information Brief: Enforcement and Compliance Patrols - Incidents

Ya'axché's ranger team is comprised of one research and monitoring unit and two enforcement and compliance units. All teams collect information on illegal activities within the PAs, but the two enforcement and compliance units are the ones collecting the bulk of the information on infractions. The GSCP and BNR were the least affected by incursions and illegal activities during 2020. On the other hand, MMNFR recorded an increase in activities within the reserve.

Documenting illegal activities

The most common illegal activity within the MMNFR was logging. Although extraction of resources is permissible in a forest reserve, it must be done with a valid permit/license issued exclusively by the FD. The rangers are responsible for verifying locations prior to permit approval. However, on occasions this process does not occur and the permit is approved independent of our input and may on occasion cause confusion.

One such case resulted in logging occurring within the forest reserve when the

Photo 10-11. Illegally extracted lumber in MMNFR September 4, 2020.

extraction permit was approved for an area outside the reserve. The individual responsible for the extraction claimed to be unable to read and write and was operating based on what a forest officer suggested, which by all means suggests it was taken out of context. It is not the first instance that such logging activity occur within the reserve where a permit is presented but the location is misguided. Once the infraction was flagged and the FD informed, the lumber was confiscated and the permit revoked.

The other form of illegal extraction is the intentional and coordinated extraction of timber from the reserve with knowledge of being within reserve boundaries. One major incident occurred an impressive 2.3km into the reserve. The illegal loggers targeted mahogany which remains one of the species in high demand in Belize, locally.

The ranger patrols within the area affected were infrequent at the time due to limitations on movement attributed to COVID-19 regulations. However, targeted patrols based on intelligence received resulted in this find during a period when logging is not permitted and when people were not expected to be moving much.

The discovery of the roughly milled lumber within the reserve was reported immediately and a plan for its extraction and confiscation by rangers and FD staff was put together for the following week. During this waiting period, the team suspected that word got out about rangers in the area and so decided to conduct an unplanned patrol to the site a couple days later.

The team came upon a group of men extracting the lumber by use of horses. The men fled the scene leaving behind the lumber and horses. As a result, the planned extraction was expedited by the ranger team and within 48 hours all the lumber and horses were confiscated and reported to the FD. No one came forward to claim the horses and so the horses were sold off with the permission of the FD.

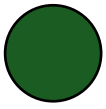
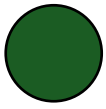
Photo 12-14. Illegally extracted lumber in MMNFR September 4, 2020.

VII.Knowledge of Biodiversity for Adequate Management

Knowledge of Biodiversity for Adequate Management	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
Baseline Data	Comprehensive species lists of key taxa				The update of mammal and bird lists and the creation of native bee lists in all reserves are in progress. Since 2009, plants and bats have been surveyed well in GSCP and BNR and species lists are in use in the management of those reserves. In MMNFR, which Ya'axché began managing more recently, plants and bats are understudied.
	Accurate ecosystem maps with descriptions				Ecosystem maps for all three reserves come from larger ecosystem maps for Belize that were produced as part of the Central American Ecosystems Map project (Worldbank/CCAD) in 2001 (Meerman and Sabido). The Belize maps were improved by Meerman using ground-truthed vegetation data in 2004 (Meerman, 2005). However, the resolution of the ecosystem maps could be improved for the MGL through the integration of on-the-ground survey data and drone classification of vegetation. Ya'axché is exploring the use of drones for ecotype mapping as of 2021. An aquatic ecosystem map for Belize is available, though the national aquatic ecosystems concept is a work in progress and

Knowledge of Biodiversity for Adequate Management	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					is pending validation with field data (Esselman et al. 2005).
	Accurate lists of threatened, socio-economically important and invasive species				Updated lists of threatened and socio-economically important species are in progress for the three PAs along with the establishment of accurate species lists. In all reserves, recent information on invasive species in particular is lacking. *Gmelina arborea* and tilapia are two invasive taxa identified as potential threats in Belize, though a lower population and lower rates of urbanization and encroachment into forests of the MGL compared to other areas make invasive species less of a threat here. Surveys in 2009 did not identify *Gmelina* in BNR or GSCP, but follow-up surveys should be done to confirm that it has remained absent and that other invasive species remain absent.
	Accurate understanding of NTFP harvest limits		NA		Cohune palm leaves are one of the most commonly used NTFPs by community members buffering the reserves. The leaves are harvested from the standing palm and used for thatch. GSCP has two sustainable use zones where cohune leaves can be extracted by villagers after they make a request and obtain a permit from Ya'axché. In 2018, Ya'axché conducted a study on cohune leaf regeneration rates under different harvest

Knowledge of Biodiversity for Adequate Management	Overall Condition	GSCP	BNR	MMNFR
				

Indicators of Condition	Specific Measures	Condition Status/ Trend			Rationale
		GSCP	BNR	MMNFR	
					intensities to identify the level of harvest (maximum number of leaves per tree) that is sustainable in GSCP, i.e., allows for continued reproduction and leaf regeneration of the species for long-term harvest. The resulting ideal harvest intensity was integrated into the management practice of the extraction zones.
					Cohune palms in the MMNFR can be expected to have similar regeneration rates and the same harvest strategy applied there.
	Accurate understanding of priority species life cycles and population dynamics				Priority species for life cycle and population dynamic studies in GSCP, BNR, and MMNFR are certain rare, threatened, data deficient, and/or timber trees that are lacking management plans at the national level. Since 2013, Ya'axché has gathered monthly phenology data on 7 tree species. Honduran rosewood (*Dalbergia stevensonii*) is also the subject of a stump regeneration study in MMNFR.

Information Brief: Native Bee Inventory for the MGL

A native bee inventory for the MGL has been in progress since 2019. Information gathered such as relative abundance and distribution of bees, habitat associations, and extinction risk will help to evaluate the extent of healthy, intact ecosystems with trophic integrity within and outside the PAs. Bees are collected using pan traps and aerial nets along transects in BNR, GSCP, CRFR, MMNFR, and in agroforestry farms in 5 of their surrounding communities.

To date, through pan trapping and netting, 15 species have been recorded in BNR, 6 in

MMNFR, and 7 in GSCP compared to 33 species across the entire MGL. Common species at all sites belong to the stingless bee genus *Trigona*. Species richness is expected to increase through the end of the survey at the end of the dry season of 2021. Results will be used to create a baseline for species richness and abundance in each reserve with which to compare trends from future bee monitoring.

Tetragona mayarum (Photo 6) has a limited global distribution and is found only in the Maya forests of Central America. It has been previously documented in Chiapas and Tabasco, Mexico; Itzabal, Guatemala; Cortes, Honduras, and Cayo, Belize. It has been recorded in GSCP and the agroforestry landscape outside of that reserve.

Socio-economic value

Beyond their immense value as pollination service providers, several bee species identified in the MGL so far also have socio-economic value as honey producers. Many species belonging to the stingless Meliponini tribe have been domesticated in the Americas. In fact, the Maya region of Mexico, including the Yucatán Peninsula and northern Guatemala and Belize, are thought to be places of intense stingless bee rearing activity in pre-Columbian days and is considered the birthplace of the practice (Kent 1984). In Guatemala, 16 species of stingless bees are semi-domesticated for honey production (Obiols and Vasquez 2012) including all the stingless bees so far known to the MGL—except for *Tetragona mayarum*, which is noted to have high pollen stores, but very little honey.

Photo 15. *T. mayarum* specimen from the MGL.

Photo 16. *Melipona beechei*, a honey producing stingless bee belonging to the tribe Meliponini.

Photo 17. *Megachile* species belonging to the leafcutter bee tribe Megachilini.

Environmental indicators

Bees as a taxon are often referred to as indicators of environmental damage and degradation. In addition, the ability of some individual species and genera to reflect and predict environmental changes has been investigated. In Brazil, *Scaptotrigona* species were shown to be effective indicators of neonicotinoid (a common family of agricultural pesticide) presence because of their generalist feeding habits (de Souza et al. 2015). *Megachile* species are known to be susceptible to chalkbrood disease, a fungal pathogen that also affects honeybees and is present from Mexico through Central America (Vandenberg, 1982). Therefore, large abundances of *Megachile* individuals could indicate a lack of disease that has the potential of spreading into managed honeybee hives.

Conclusions

For all three protected areas, one major important aspect of management is needed. Collaboration between Ya'axché and the Government of Belize needs to be strengthened by all means necessary. Having the enforcement support of the relevant department can make a difference in ensuring the management effectiveness is at the right level and that conditions within the protected areas are stable and improving. Over all, conditions remain good for all protected areas and with the adequate effort it can continue with this trend into the near future.

Golden Stream Corridor Preserve

The effort placed into the management of this reserve has kept the area as intact as possible with only minor infractions documented. The major consideration for management within this reserve relates to the monitoring of illegal logging in the vicinity of the accessible boundary lines. An increase in surveillance patrols can minimize attempts at continued logging targeting valuable timber species. It is recommended that an increased effort be placed on education and awareness campaigns targeting the buffer communities of Golden Stream and Tambran. There are ample opportunities to strengthen the sustainable use of resources for traditional use which active but in need of updates in policy and monitoring.

Bladen Nature Reserve

The BNR remains the most intact and undisturbed of the three protected areas under Ya'axché's mandate. The remoteness of this reserve provides an opportunity to ensure adequate management of the area. It is recommended that patrol effort is strategic with the use of technology and intelligence gathering to curb hunting pressures at the boundary areas. A continued and sustained education campaign should be developed to disseminate information on the importance of the BNR.

Maya Mountain North Forest Reserve

The MMNFR is the protected area with the highest level of concern among the three. Illegal logging and hunting and the added pressure of illegal land clearings demand that patrol effort be doubled at the very least in order to curb the levels of infractions seen in 2020. Extensive hotspot mapping is required to assess the areas requiring short-term, medium-term and long-term monitoring. The engagement of all stakeholders is important in order to ensure successful management of this reserve. A full management plan with the necessary consultation process will be a crucial first step in improving the conditions within the reserve. Early detection of illegal clearings can be achieved through the use of technology coupled with on the group intelligence gathering

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State of the Protected Areas Report 2020

An assessment of Bladen Nature Reserve, Golden Stream Corridor Preserve and Maya Mountain North Forest Reserve

March 2021

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