

2020-2021 MoSI Report

May 2021

"Improving Natural Resources Management in Belize through Bird Monitoring"

A collaborative effort of the University of Belize Environmental Research Institute (UB ERI), Black Rock Lodge (BRL), Belize Audubon Society (BAS), Toledo Institute for Development and Environment (TIDE), Corozal Sustainability Future Initiative (CSFI), Foundation for Wildlife Conservation (FWC), the Belize Forest Department (FD) and Institute for Bird Populations (IBP)

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Photos of some colorful/cool birds that we catch at the different stations



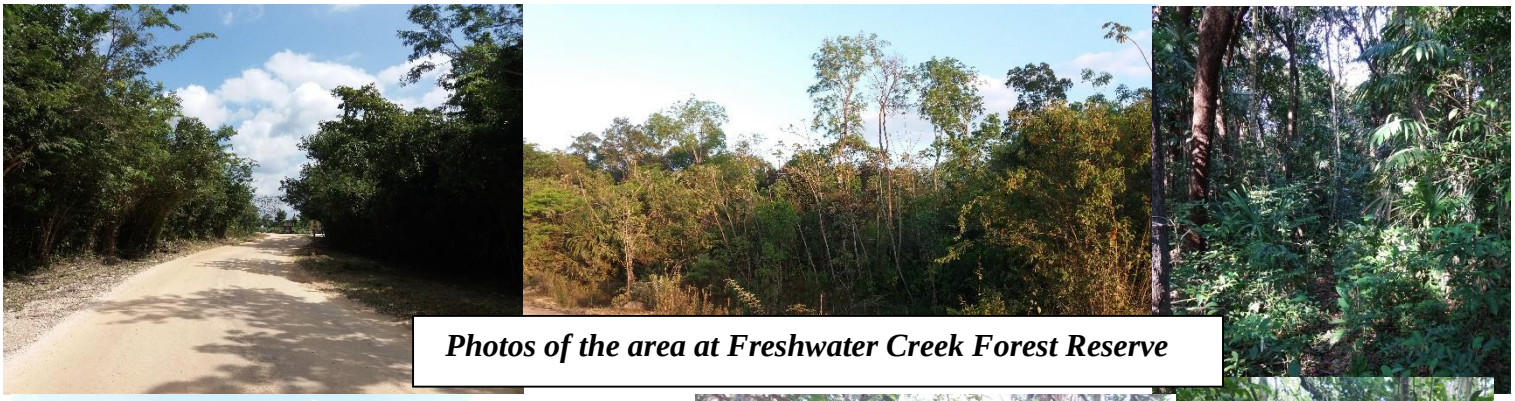
From top left to bottom right: Black-and-white Warbler, Swainson's Warbler, Yellow-breasted Chat, White-collared Manakin, Ruddy Quail-Dove, Blue Bunting

Photos of all assistants at each station



Top left to bottom right: Emmanuel Saqui (BAS), Kayla Hartwell, Reynold Cal, Stevan Reneau (FWC), Gliselle Marin, Abidas Ash (UB ERI) Fernando Obando, Isaias Morataya (BRL), Mario Xi, Owen Williams, Augustin Pop, Reymudo Chen and Liberato Pop (TIDE)

Photos of habitat at each station



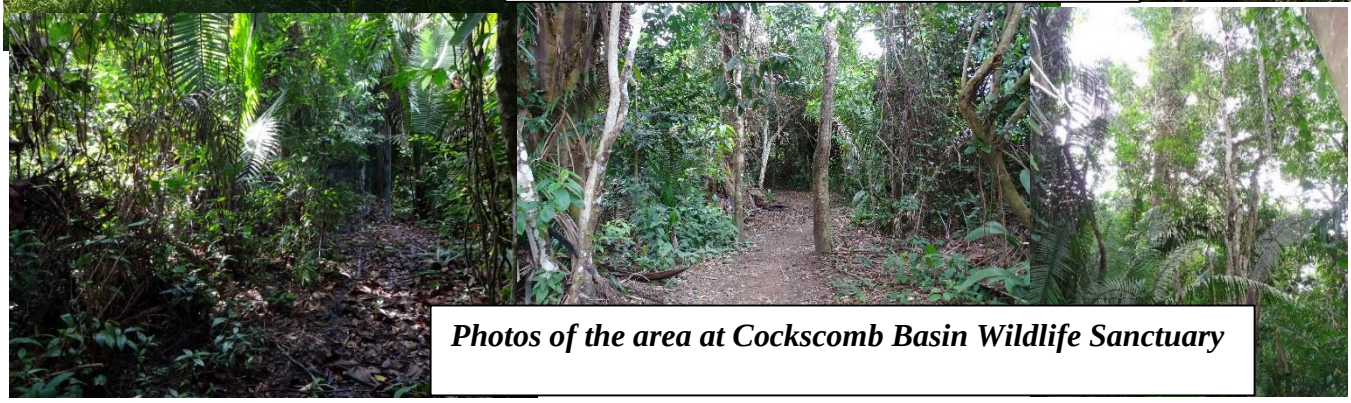
Photos of the area at Freshwater Creek Forest Reserve



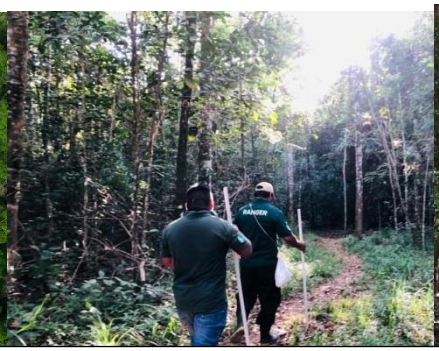
Photos of the area at Runaway Creek Nature Reserve



Photos of the area at Black Rock Lodge



Photos of the area at Cockscomb Basin Wildlife Sanctuary


Photos of the area at TIDE Private Protected Lands

1. Introduction:

Belize's diverse ecosystem types provide a home to many resident birds and the country's ideal location in the Mesoamerican continent makes it an instrumental flyway for migratory birds (Burke *et al*., 2009). Russell (1964) recognized a total of 465 species of birds in Belize (then British Honduras); 128 of those 465 species were winter visitants and transients. Jones (2003) noted 574 bird species reliably recorded for the country, 50 percent of which can be classified as truly tropical and 40 percent as migratory, i.e. present during winter or passing through Belize during spring and fall. To date, 594 species of birds have been recorded in Belize through the online bird checklist platform eBird (accessed May 2021).

Certain bird groups or species are considered sensitive and easily affected by disturbances, and as such can be used as indicators of overall ecosystem health, especially habitat quality (Canaday, 1997). The trends in their population can be indicative of changes to the ecosystem and potentially ecosystem services that relate to habitat quality, including watershed protection and biodiversity. Despite the potential for understanding ecosystem changes, a necessary step in adaptive management of natural resources, in Belize there has been limited bird monitoring that is consistent, continuous and standardized for comparability across sites.

In 2017, the UB ERI worked on a project, "Improving Natural Resources Management in Belize through Mobilization of Biodiversity Data" through the Biodiversity Information Development (BID) Programme of the Global Biodiversity Information Facility (GBIF). The objective of the project was to identify and compile large un-systematized datasets from various bird monitoring studies that were conducted by various partners and stakeholders in Belize and make these datasets accessible to the public through existing eBird and GBIF platforms. The UB ERI learned that these datasets used various bird monitoring techniques that produced un-systematized datasets. The data were not collected in accordance to any standard set of protocols or the protocols used were unclear. Also, a significant number of records in these datasets were of birds that were either unlikely to have been present during the seasons that the data was collected or out of their geographic range. Others were in inappropriate habitat where they are not expected to be and others were of species that do not occur in Belize but have similar common names to those in Belize. This suggests that at least some of the observers conducting the surveys were beginners and lacked the experience necessary to recognize the birds either by sight or sound and properly record the birds. Furthermore, the original data was probably handwritten in the field and was transcribed by people other than the observer who had little knowledge of the birds that occur in Belize and their common names which resulted in additional errors. Due to the high number of identification and transcription errors, many of the datasets were not validated on eBird.

Therefore, to resolve this problem the Cornell Lab of Ornithology and NABCI-MEXICO (organization that facilitates and promotes conservation of North American birds) have developed a program, Latin America Program for Wild Birds (PROALAS), which proposes a standardized protocol for monitoring birds in the Latin American region. This program allows data comparison at a regional level and can also be used at a more local scale. PROALAS also uses the eBird platform to compile, sort and validate the information collected in the field. This allows the generation of results after the first year of monitoring through data analysis using occupancy models to estimate the probability of the presence or absence of species at a site.

The project *Improving Natural Resources Management in Belize through Bird Monitoring* started as a collaborative effort amongst the University of Belize Environmental Research Institute (UB ERI), Black Rock Lodge (BRL), Belize Audubon Society (BAS), Belize Forest Department (FD) and Institute of Bird Populations (IBP) in 2016; Corozal Sustainable Future Initiative (CSFI) joined in 2017, Foundation for Wildlife Conservation (FWC), the managers of the Runaway Creek Nature Reserve (RCNR) joined the partner network in 2018 and the Toledo Institute for Development and Environment (TIDE), the managers of TIDE Private Protected Lands (TPPL) joined in 2020. The project has now gathered data using standardized Monitoreo de Sobrevivencia Invernal (MoSI) and point count methodologies to help determine a baseline of songbird community composition and distribution for the area at Black Rock Lodge (BRL) abutting the Elijio Panti National Park; to build upon three years of intensive research work at the Cockscomb Basin Wildlife Sanctuary (CBWS) by other researchers; and to initiate bird monitoring in the protected areas co-managed by CSFI, mainly Freshwater Creek Forest Reserve (FCFR), by FWC, mainly Runaway Creek Nature Reserve (RCNR) and by TIDE, mainly TIDE Private Protected Lands (TPPL). The primary goals of the project remain to establish a methodology and least amount of monitoring required to capture meaningful data on changes in bird community composition and distribution at these sites, to inform the implementation of bird monitoring in the framework of the National Biodiversity Monitoring Program (NBMP), and to involve the larger birding and tourism community in Belize in citizen science and efforts to conserve birds and their habitat in Belize.

2. Justification:

Belize is a small, developing country with high biodiversity that benefits all its productive sectors, particularly tourism, the largest contributor to Gross Domestic Product (GDP). Several decades ago, the country had the incredible foresight to establish an unparalleled national protected area (PA) system in the country, consisting of 103 PAs comprising approximately 35 percent of land and 28 percent of national territory. However, today, a 40

percent poverty rate, one of the fastest population growth rates in the region (2.62% annually (SIB, 2016)), and a public debt burden representing 68 percent of GDP are contributing to exacerbated habitat conversion and degradation mostly from unsustainable agriculture and extraction activities. As a response to the increasing need for communities to economically benefit from biodiversity, the 2015 National PAs System Act allows for changes in current PA designation to allow increased use. Therefore, more than ever, solid data on changes in biodiversity over time and the ability of PAs to maintain ecological function, thereby continuing to provide essential ecosystem services to Belizeans, including water regulation and resilience to climate change impacts, is necessary.

This requires a measurable and continuous national effort accompanied by a system to properly manage data at scale for sound decision-making as outlined in the NBMP. This project represents a collaboration with multiple partners, monitoring birds as indicators of ecosystem integrity, as a first step to determine the requirements and resources needed to roll out a national bird monitoring program under the NBMP. The NBMP was developed in June 2016 in collaboration with multiple stakeholders across Belize who collectively identified the bird abundance as a priority indicator. The NBMP was a response to the 2005 Protected Areas System Plan and moving forward provides a tool to measure progress in the implementation of Belize's National Biodiversity Strategy and Action Plan under the Convention on Biological Diversity. A feasibility study is being conducted to look at those priority indicators that stakeholders are already monitoring and what resources and capacity are lacking.

Apart from the value of the data gathered through the research, the project has a capacity building and outreach component that is complementary to the long-term sustainability of bird monitoring in Belize and the application of bird monitoring data in decision-making. We aim to achieve this complementarity through training and involvement of bird tour guides, rangers and other stakeholders in bird monitoring. These capacity building efforts are aimed, over the long-term, at securing buy-in for biodiversity conservation amongst those who directly depend on biodiversity for their livelihoods. We were looking at the National Bird Working Group as a platform for a national banding scheme. However, it is now the recently established National Biodiversity Office that is most likely to assist with the advancement of this as it has a special mandate to oversee monitoring for the protected areas system.

3. Objectives:

The main objectives for this 2020-2021 season were to complete the five years of data collection at Black Rock station, to continue monitoring at the three existing MoSI stations in northern, central and southern Belize and to provide technical support to the team at the

Toledo Institute for Development and Environment (TIDE) who started as a trial season. The overall main project output continues to be the following: a database with at least five years of data per site that would have enough recaptures to allow occupancy and other analyses to inform population trends.

4. Methodology:

The project follows the MoSI standardized protocol for gathering bird data. Bird banding of both migrants and residents is done under the framework of the MoSI system as fully outlined in the MoSI Manual (DeSante *et al.*, 2009). The MoSI manual was developed to study a total of 25 target species and 16 potential targets. Out of the 41 species (target and potential species) we have captured 20 species in Belize (Table 1) over the years. These species were selected based on three criteria: one, based on the Monitoring Avian Productivity and Survivorship (MAPS) data that shows that these species can be captured with ground-level mist-nets in high numbers; two, they are considered priority species in one or more bird conservation regions and three, they provide an adequate representation of declining and non-declining species in the Americas. Birds were captured by opening 16, 36-38 mm mesh nets of 3 m in height. The mist-nets are placed in areas that are likely to catch birds, contained some edge habitat and accessible to the banding station. The nets were operated at each site from December 2020 through March 2021. Full MoSI stations were again operated for BRL, CBWS, FCFR and RCNR. The TIDE (TPPL) station was operated as a trial for the 2020-2021 winter season. This season in November 2020, all stations were affected by heavy rains and flooding which made it impossible to operate and access all the other stations. As a result, BRL1 was the only station that operated in November for about two hours total and CBS2, RCR2, FWC1 and TPPL were operated from December to March. All stations were affected by rain in January and FWC1 was affected tremendously by high temperatures in January and February. Nets had to be opened late or closed early that we were only able to complete the minimum of 12 hours which is required by the MoSI protocol over three consecutive days. On the other hand, nets were opened for six hours daily over three consecutive days that had adequate weather conditions resulting in 18 hours of net effort.

Table 1: List of target and potential target species captured at the MoSI sites in Belize

Species	**Scientific Names**
Least Flycatcher	*Empidonax minimus*
White-eyed Vireo	*Vireo griseus*
Swainson's Thrush	*Catharus ustulatus*
Wood Thrush	*Hylocichla mustelina*

Gray Catbird	*Dumetella carolinensis*
Magnolia Warbler	*Setophaga magnolia*
American Redstart	*Setophaga ruticilla*
Prothonotary Warbler	*Protonotaria citrea*
Worm-eating Warbler	*Helmitheros vermivorum*
Ovenbird	*Seiurus aurocapilla*
Northern Waterthrush	*Parkesia noveboracensis*
Hooded Warbler	*Setophaga citrina*
Wilson's Warbler	*Cardellina pusilla*
Indigo Bunting	*Passerina cyanea*
Painted Bunting	*Passerina ciris*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Chestnut-sided Warbler	*Setophaga pensylvanica*
Black-and-white Warbler	*Mniotilta varia*
Common Yellowthroat	*Geothlypis trichas*
Yellow-breasted Chat	*Icteria virens*

Captured birds were safely extracted during 30-minute net checks and were taken to a banding table where data on species, age, sex, weight, fat, wing chord length and moult status was recorded. Data are transcribed in separate folders and each have three categories under which birds are recorded; 1.) New captures are birds that don not have a band and to which a band is applied; 2.) Recaptures are birds that have a band but are caught again; and 3.) Unbanded birds are birds that were not banded because they escaped, were released, or for which band size was not in stock. We recorded three types of recaptures- repeats, returns and recoveries. Repeats refer to subsequent captures on the same day of birds banded/recaptured at the same station earlier in the season; returns are the first captures in a given season at a given station of birds banded/recaptured at the same station in a previous season; and recoveries are the first captures of birds banded at a different station or on a different permit. A bird is counted once as an individual even though it might have been caught multiple times.

Migratory birds were banded with metal rings provided by the Institute of Bird Populations (IBP) and resident birds were banded with metal rings used by the UB ERI from a long-term collaboration with ProAves in Colombia and bands custom made by the National Bands & Tag Co, Newport Kentucky, U.S.A.

The biggest risk associated with bird banding is harm to the birds from net entanglement, predation in the net or stress from being held too long. The bander and assistants followed the banders code of ethics that places the safety of the bird above everything else; the team

ensured that no bird stayed in a net for longer than 30 minutes before being extracted, that no bird remained in a bag longer than 1 hour, that small delicate birds were processed first, ensuring that banding operations were done under appropriate weather conditions and that taking priority measures, over data collection, to ensure that birds were not harmed. In order to minimize these risks, the project has over the years counted on the experience of several lead and assistant bird banders (see Table 1). This past season, Abidas Ash (UB ERI) led the banding efforts assisted by Gliselle Marin (UB ERI), Emmanuel Saqui (BAS), Stevan Reneau (FWC), who were assisting with operations and processing birds, and Isaias Morataya (BRL), Fernando Obando (BRL), Reynold Cal (FWC), Kayla Hartwell (FWC) and Gilroy Welch (FWC) who assisted with extraction. Salustino Peck (BAS) was a trainee at the CBS2 station where he assisted with mist-net set up, recording of data and learned how to properly extract and hold birds. The team at TPPL station included Liberato Pop as bander and Mario Xi, Owen Williams, Reymundo Chen and Augustin Pop as assistants.

Table 2 is showing a list of all lead and assistant banders and volunteers that have been involved in the program thus far. It also lists the organizations, experiences, qualifications of each individual and years of involvement.

Table 2: List of all Lead and Assistant Banders and Volunteers Involved over the years

	Names	Organization	Experiences & Qualifications	Years of participation
Lead Banders	Lauren DiBacarri	Affiliated with Manomet Bird Observatory,	She had several years of experience working as a lead bander at the Manomet station. She also banded birds in North and Central America.	2016-2017
	Blaine Carnes	Affiliated with the Institute of Bird Populations	He had about a decade of banding experience when he volunteered with us in 2017-2019. He has done banding in North America, and Central America.	2017-2019
	Abidas Ash	University of Belize Environmental Research Institute	She has about six years of banding experience. She is currently the lead bander at the four MoSI stations in Belize. She has also	2016- present

			hosted several training sessions and bird banding demonstrations. In addition, she is a NABC certified trainer.	
Volunteers	Mary Alice Koeneke	Volunteer from Pennsylvania	She has several years working in the environmental field. She also volunteers at a few banding stations near her. In addition, she conducts 50-point count surveys as part of the Breeding Bird Survey Program. She has volunteered twice during the MoSI season and has supported us tremendously with equipment, bird books and bird bags.	2017-2019
	Mark LaBarr	Audubon Vermont	He has been working in bird banding for more than 30 years where he operates a MAPS station in Vermont and also work in the Bahamas on seabirds. He was able to volunteer with us for two weeks in November 2019.	2018-2019
	Daniel Arndt	Birder/ Environmentalist	He assisted for two weeks in March 2020 at two stations while on his birding trip in Belize. He is an avid	2018-2019

			birder and has some experience with bird banding. He has done some banding during the NABC course in 2017.	
Assistant Banders	Eluterio Pop	Belize Audubon Society	He worked with the BAS for several years and assisted with the banding station at Cockscomb Basin Wildlife Sanctuary (CBWS) for three years. He is also a North American Banding Council (NABC) certified assistant extractor.	2016-2019
	Emmanuel Saqui	Belize Audubon Society	He is currently the assistant bander at CBWS. He assisted last season and has improved on his extraction skills and now is assisting with banding at the station. He has also attended a few trainings on banding.	2018-present
	Diego Cruz	Black Rock Lodge (BRL)	He assisted for four years with the operation of the BRL banding station. He was great at extraction and improved his banding skills. He is also a NABC certified assistant bander.	2016-2019
	Isaias Morataya	Black Rock Lodge	He has been assisting with the operation of	2016-2021

			BRL station for the past five years. His skills with extraction are great and he is also a NABC certified assistant bander	
	Fernando Obando	Black Rock Lodge	He started assisting for the 2019-2020 season. He developed skills in extraction and mist-net set up.	2019-2021
	Reynold Cal	Foundation for Wildlife Conservation	He has several years of experience in banding. He worked as part of the Birds Without Borders and assisted with several bird banding research in Belize. He is currently assisting with the station at Runaway Creek Nature Reserve.	2018-present
	Stevan Reneau	Foundation for Wildlife Conservation	He has also worked with Birds Without Borders and have several years of experience in bird bandling. He is also assisting at the Runaway Creek Nature Reserve station.	2018-present
	Kayla Hartwell	Foundation for Wildlife Conservation	She has attended an intensive bird banding training which allowed her to gain skills in mist-net set up and extraction. She currently assists with the Runaway Creek Nature Reserve station.	2018-present

	Gilroy Welch	Foundation for Wildlife Conservation	He started training in the 2019-2020 MoSI season where he learnt how to set up mist nets and extract birds. He has now become a part of the team to assist with operations at the Runaway Creek Nature Reserve station.	2019-present
	Luis Pena	Corozal Sustainable Future Initiative	He assisted with mist net setup and take down, extraction and banding for two years.	2017-2019
	Eduany Munoz	Corozal Sustainable Future Initiative	He also assisted for two years with setting up and taking down mist nets and extraction.	2017-2019
	Gliselle Marin	University of Belize Environmental Research Institute	She had some experience with bird extraction from some trip in Central America. She assisted Abidas during the 2019-2020 season where she refreshed her extraction skills and started improving in her banding skills. Now she has been assisting Abidas with operating the Freshwater Creek Forest Reserve station.	2019-present
	Salustino Peck	Belize Audubon Society	This season was his first time assisting at the CBWS station. He is fairly good with bird identification, learnt	2020-present

			quickly about data recording and practiced the proper bird holds and did a few supervised extractions.	
	Liberato Pop	Toledo Institute for Development and Environment	He has several years of experience working at a banding station as an assistant bander. He is now working on becoming a bander	2020-present
	Owen Williams	Toledo Institute for Development and Environment	He just started to assist in the 2020-2021 MoSI season with extraction. He knows how to set up and take down mist-nets.	2020-present
	Reymundo Chen	Toledo Institute for Development and Environment	He just started to assist in the 2020-2021 MoSI season with extraction. He knows how to set up and take down mist-nets.	2020-present
	Mario Xi	Toledo Institute for Development and Environment	He just started to assist in the 2020-2021 MoSI season with extraction. He knows how to set up and take down mist-nets.	2020-present
	Augustin Pop	Toledo Institute for Development and Environment	He just started to assist in the 2020-2021 MoSI season with extraction. He knows how to set up and take down mist-nets.	2020-present

5. Study Sites

There are five MoSI stations across Belize. One is in the north (Freshwater Creek Forest Reserve-FCFR), one in the central (Runaway Creek Nature Reserve-RCNR), one in the west (Black Rock Lodge-BRL) and two in the south (Cockscomb Basin Wildlife Sanctuary-CBWS and TIDE Private Protected Lands-TPPL) as shown in Figure 1. Although, this season at TPPL was a trial the site will be a permanent station. The habitats are all different as well. At FCFR it is dry forest habitat and surrounded by overgrown agricultural areas and a main road (Figure 2). At RCNR it is broadleaf forest on karst hills and a large seasonal wetland (Figure 3). At BRL it is mostly riparian forest, forest edge and open areas (Figure 4). At CBWS it is broadleaf forest and forest edge (Figure 5). At TPPL it is mostly broadleaf forest buffered by the Rio Grande river and the ranger's station (Figure 6).

Figure 1: MoSI stations in Belize.

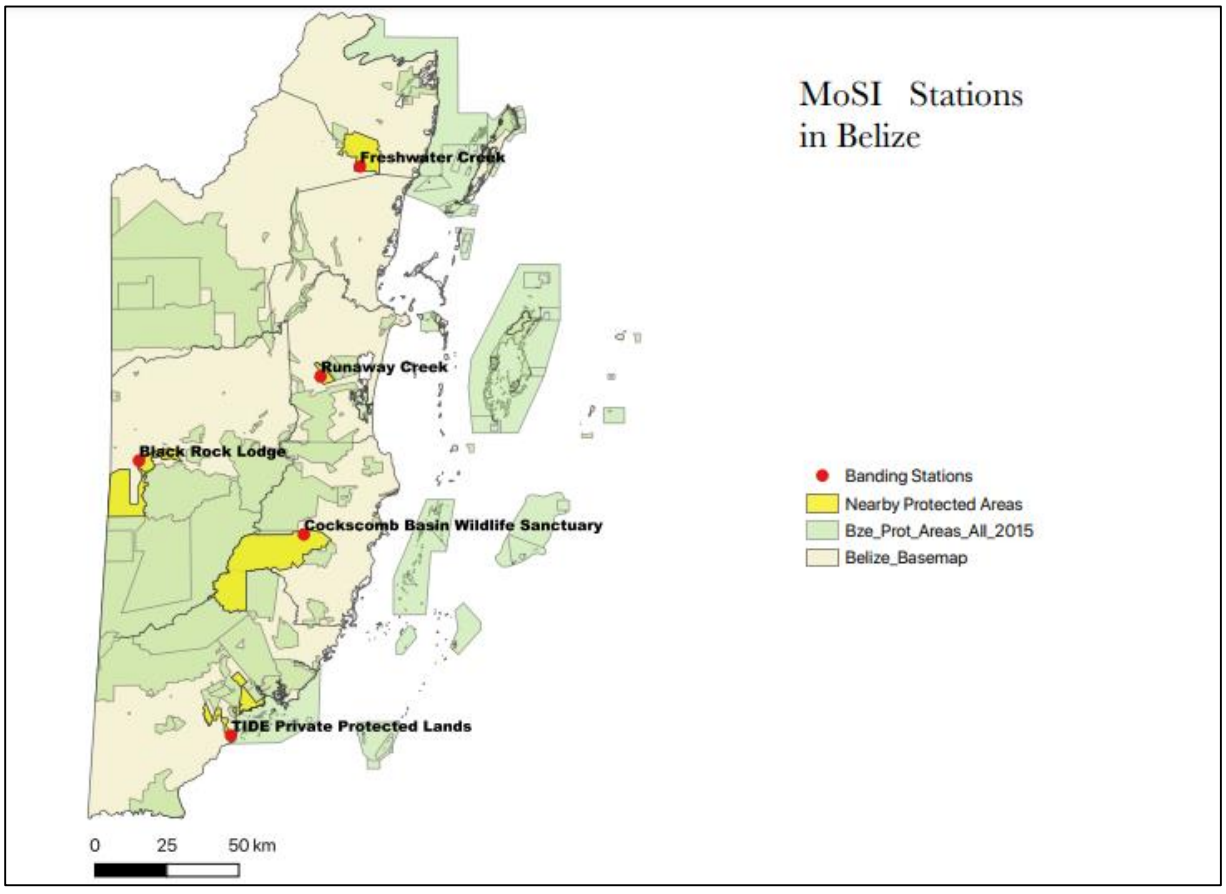


Figure 2: Aerial view of where the nets are at Freshwater Creek Forest Reserve is located.



Figure 3: Aerial view of where the station (area in red) at Runaway Creek Nature Reserve is located.



Figure 4: Aerial view of the Black Rock Lodge MoSI station.



Figure 5: Aerial view of Cockscomb Basin Wildlife Sanctuary MoSI station.



Figure 6: Aerial view of the area (area in red) where the TPPL MoSI station is located

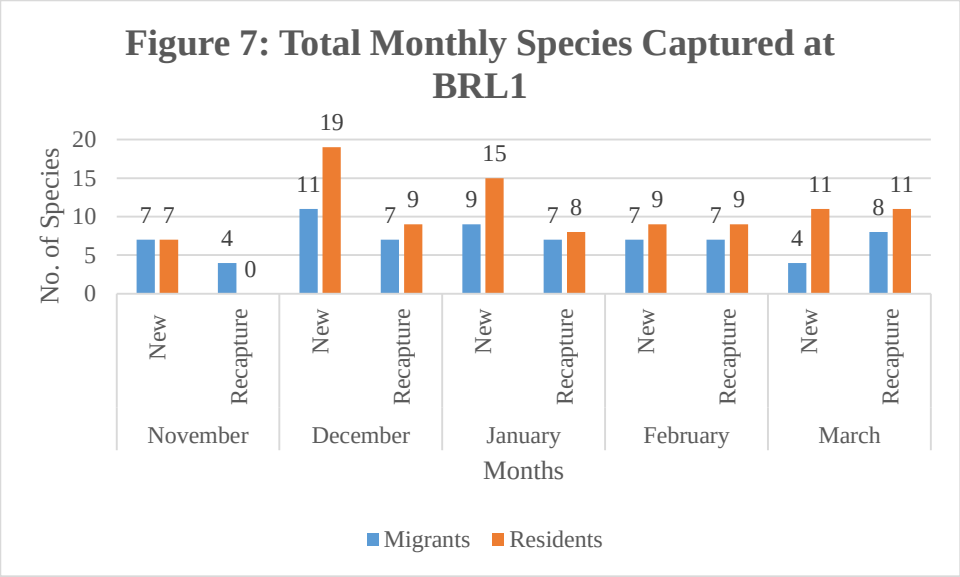


6. Summary of data gathered to date

Results from banding data for 2020-2021

The 2020-2021 banding season represented the sixth season of MoSI for BRL (fifth season done collaboratively with the UB ERI; their first season was in collaboration with Dr. Jamie Rotenberg of University of North Carolina- Wilmington). CBWS has completed five seasons (the first season was tested at a different area to determine if we could get the appropriate capture rate and it did not meet the requirements so CBS2 was established and has been operating as a full MoSI station for four seasons). The CSFI site has completed four seasons (the first season was tested at a different site, but it was not appropriate so an area at FCFR was tested and FWC1 was established and has been operating for three seasons as a full MoSI station). The RCNR site has completed three seasons (the first season was tested at a different area, but it was not appropriate so RCR2 was established and has been operating as a full MoSI station for two seasons). The 2020-2021 season was TPPL first season which was tested and will be established as a permanent station.

The total birds captured in 2020-2021 was 334 at BRL1, 386 at CBS2, 155 at FWC1, 203 at RCR2 and 161 at TPPL. CBS2 had the highest number of birds captured than all other sites. Figure 7 shows the total species captures of newly banded individuals and recaptures per month at BRL1. As shown in this figure, there were more species captures of both residents and migrants in the month of December at BRL1. A few net hours were completed in November since the site was affected by heavy rainfall and flooding. A fluctuation of the species captures for both residents and migrants occurred through the rest of the season with the lowest capture in the month of February.



As for CBS2, Figure 8 shows that there were higher numbers of newly banded resident and migrant species in December and January. Then in February and March the newly banded resident and migrant species fluctuated. The number of recaptured resident and migrant species increased each month.

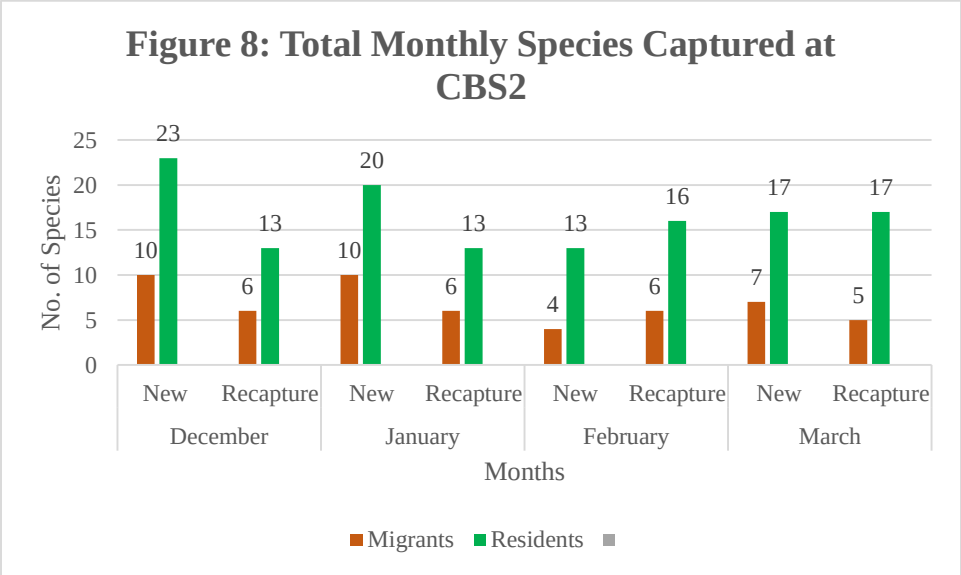


Figure 9 shows that at FWC1 there was a higher number of banded residents throughout the season and for migrant species in December. There was a higher number of recaptured resident and migrant species in December and decreased through March.

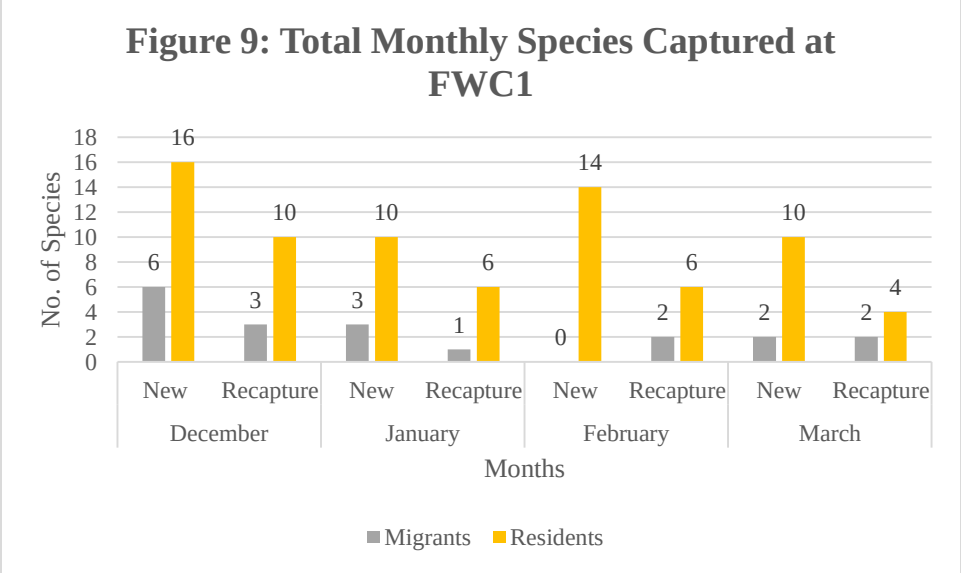


Figure 10 shows the monthly captures of newly banded and recaptured species at RCR2. There was a higher capture of newly banded resident species in December and decreased each month and the newly banded migrant species fluctuated throughout the season. The recaptured migrant species was highest in December and decreased each month. The recapture resident species was highest in January and decreased during the remainder of the season.

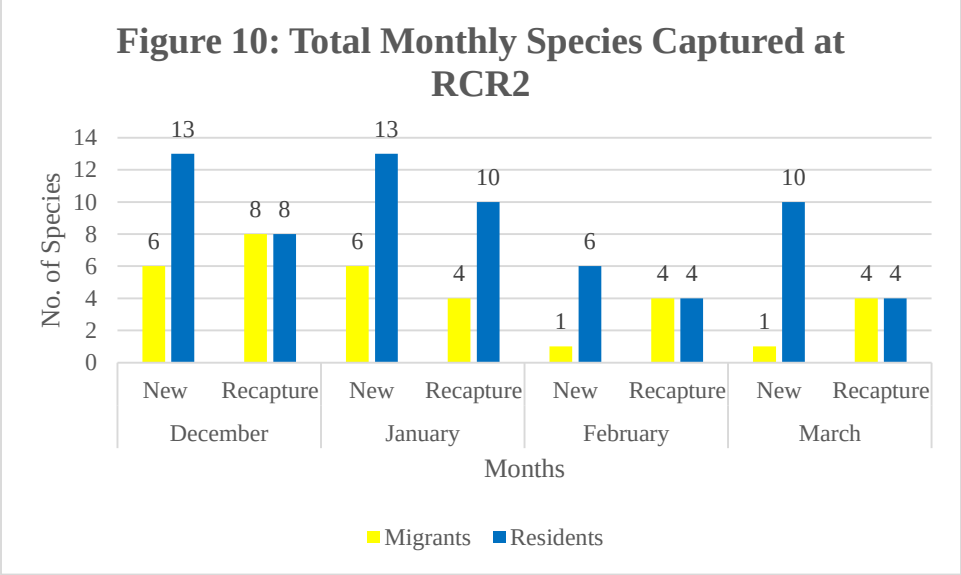


Figure 11 shows the monthly captures of newly banded and recaptured species at TPPL. There was higher capture of newly banded resident species in December and in February and the higher capture of newly migrant species was in February. The recaptures were repeats from the 2020-2021 season.

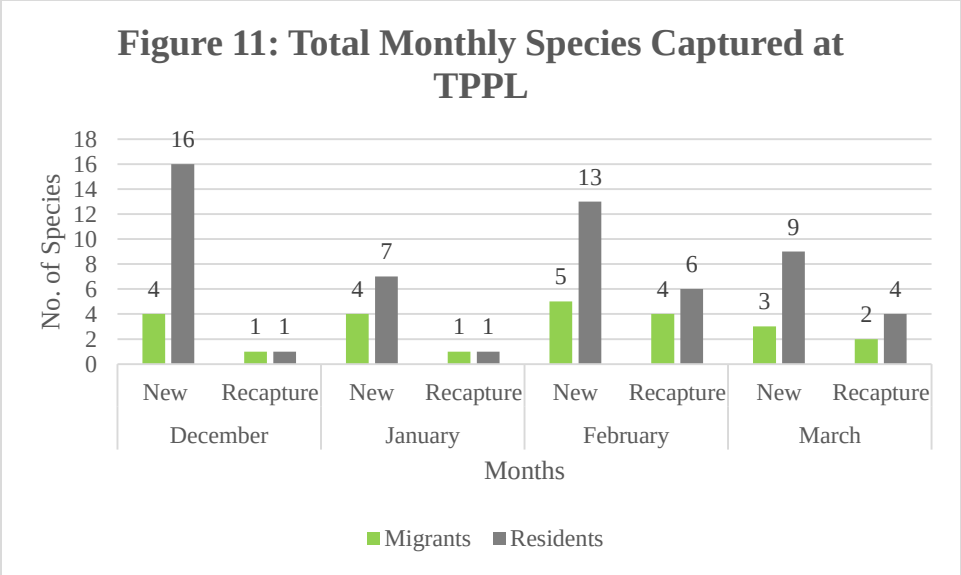


Figure 12 shows the total banded resident and migrant individuals for each site. CBS2 had the highest number of banded resident and migrant individuals. FWC1 had the least number of banded resident and migrant individuals. TPPL operated with 15 mist nets for three months and they had higher number of resident and migrant individuals than RCR2 and FWC1.

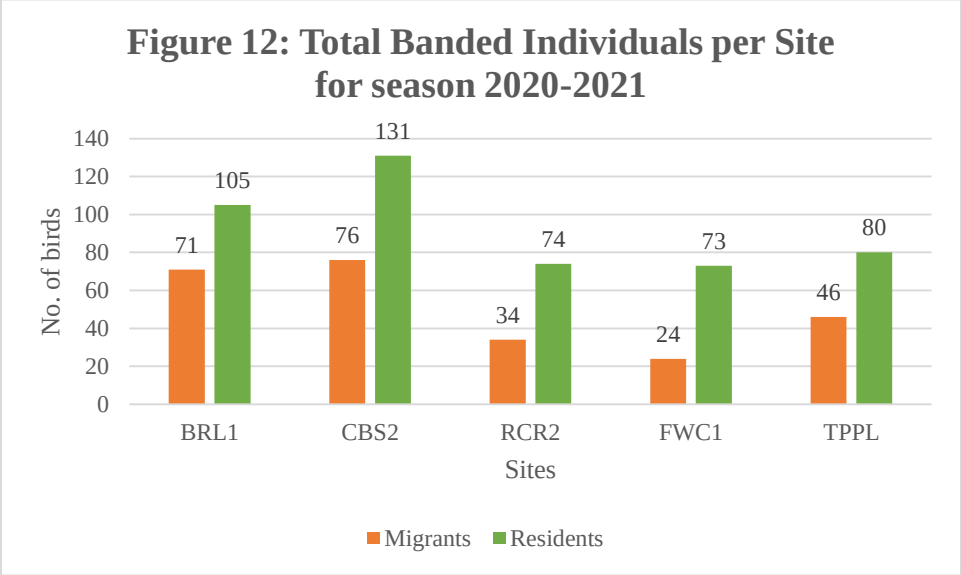


Figure 13 shows the list of species captured at each site for season 2020-2021 The total migrant species captured using mist-nets were higher at BRL1 and the resident species captured were higher at CBS2. There was much more resident species captured at RCR2, FWC1 and TPPL than migrant species.

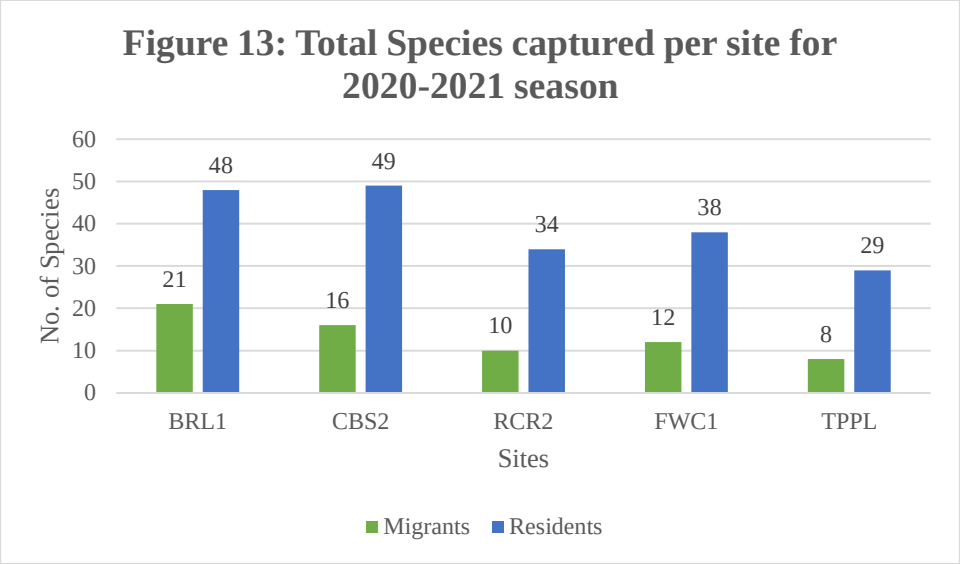


Table 3 shows that there were five (5) species of migrants and eleven (11) species of residents caught across the five sites (BRL1, CBS2, FWC1, RCR2, TPPL) during banding. Table 4 shows the different resident and migrant species that were only caught at each respective site. It also shows that there were more residents that were unique to their locality and the species (red text) that had not been caught in previous seasons or at any of the sites.

Table 3: Similar Species at all Locations

Category	Number of Species	Species Name
Migrants	5	WOTH, GRCA, KEWA, WEWA, OVEN
Residents	11	GREL, IBIW, NOBE, OBFL, RCMA, RTAT, RUWO, TWWO, WBWO, WBWW, WCOM

Table 4: Dissimilar Species per site

BRL1		CBS2		FWC1	RCR2		TPPL
Migrant (5)	Resident (12)	Migrant (1)	Resident (12)	Resident (1)	Migrant (1)	Resident (1)	Resident (2)
BTGN	AMKI	SWTH	BTFG	GBMA	SWWA	BBEH	BCAN
INBU	BAAN		BTSA				STLE
LEFL	BGRA		CCTA				
PABU	CARW		DCFL				
YTVI	ERFL		DUAN				
	GCDO		DWAN				
	LESG		LEMO				
	RTBE		RCAT				
	SBRH		SCFL				
	SHTF		TBSF				

	TRKI		VISA				
	WNJA		YWTA				

Figure 14 shows the total percentage of the target species that are caught at each of the sites. Out of a total of 20 target species that are more likely to be captured in Belize, 17 species were captured during this season. BRL1 had the highest number of captures (16 species) followed by CBS2 that had 13 species, RCR2 had 8 species, TPPL had 7 species and FWC1 had 6 species.

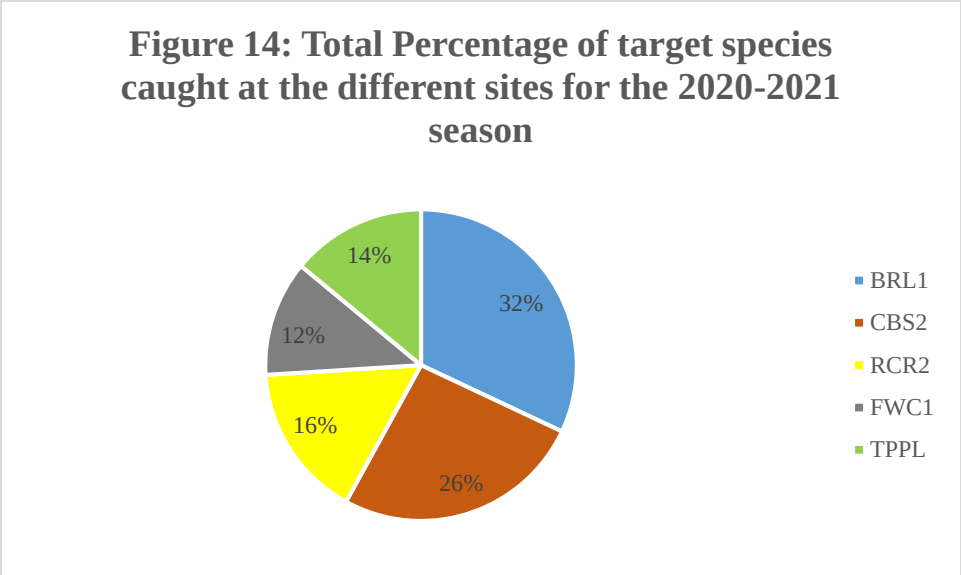
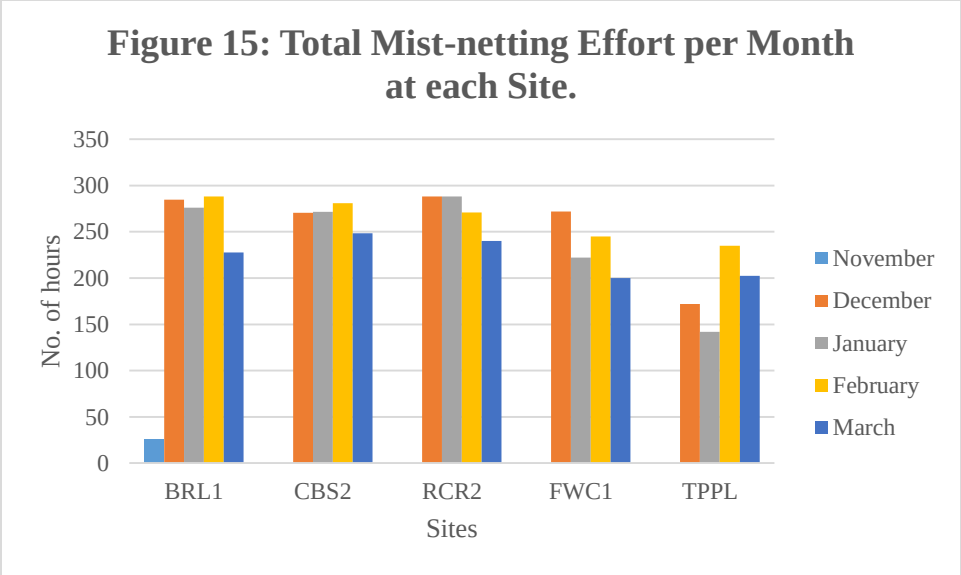


Figure 15 illustrates the total mist-netting effort per month for each site. In November, only BRL1 was opened for a few hours. The field effort had to be cancelled due to heavy rainfall and flooding. In March, fewer hours were completed due to high temperatures. CBS2, RCR2 and FWC1 had less hours completed in March. In December, only eight (8) mist nets were operated then in January to March, 15 mist nets were operated. The least number of hours was completed in January at TPPL.



Results for banding data across five seasons for four sites

Figure 16 shows the total number of newly banded migrant individuals captured at BRL1, CBS2, FWC1 and RCR2 across five seasons. BRL1 and CBS2 had the highest number of newly banded migrant individuals in season 2017-2018. The least number of newly banded migrant individuals captured was in season 2019-2020 at FWC1 and RCR2.

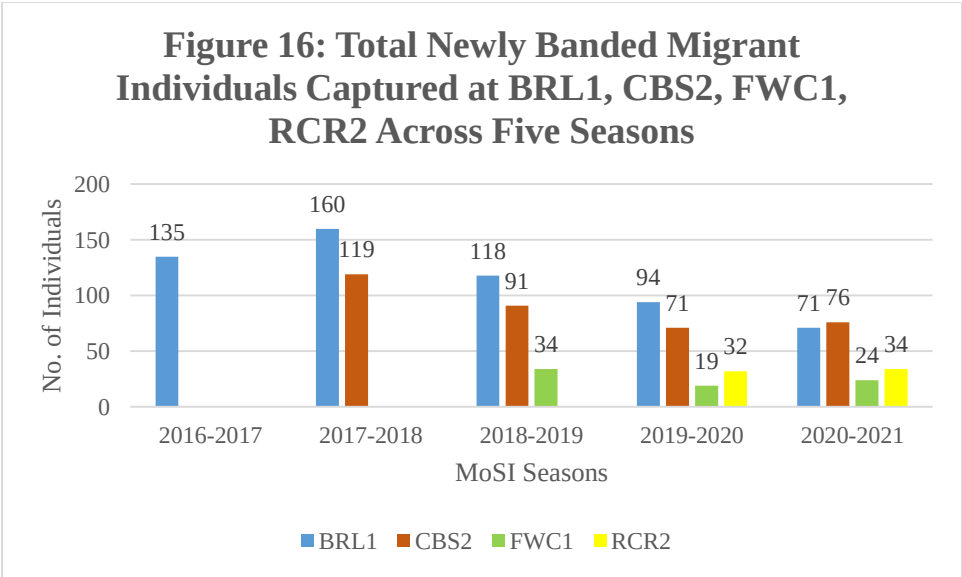


Figure 17 shows the total number of newly banded resident individuals captured at BRL1, CBS2, FWC1 and RCR2 across five seasons. The highest number of newly banded resident individuals was in season 2018-2019 for BRL1, in season 2017-2018 for CBS2, in season 2019-2020 for FWC1 and in season 2019-2020 for RCR2. The least number of newly banded resident individuals captured was in 2020-2021 for the four sites.

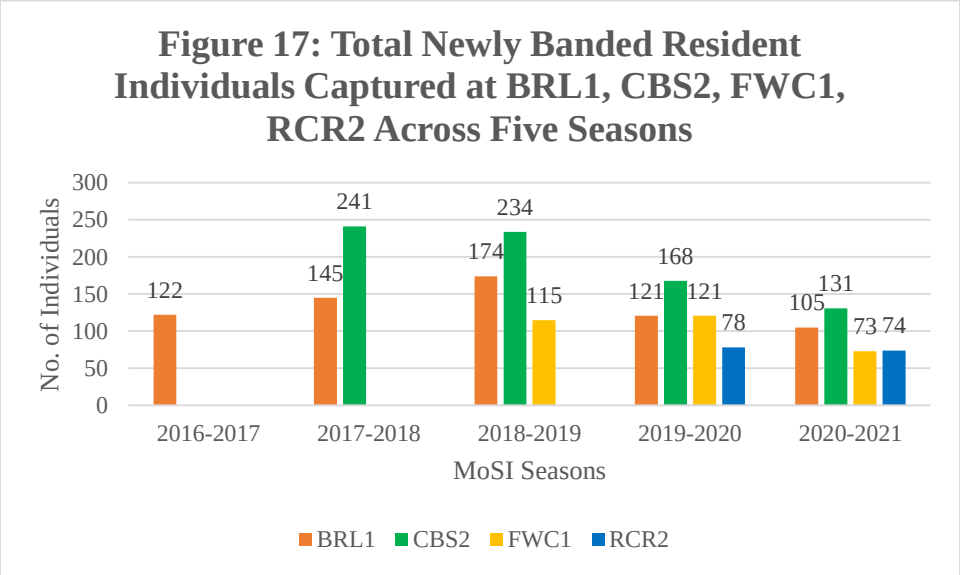


Figure 18 shows the total number of migrant species captured at BRL1, CBS2, FWC1 and RCR2 across five seasons. The highest number of migrant species was captured in season 2016-2017 for BRL1, for CBS2, and FWC1 it was in season 2018-2019 and for RCR2 it was in season 2019-2020. The least number of migrant species captured for BRL1 was in season 2017-2018, for CBS2 it was in seasons 2019-2020 and 2020-2021, for FWC1 it was in season 2019-2020 and for RCR2 it was in season 2020-2021.

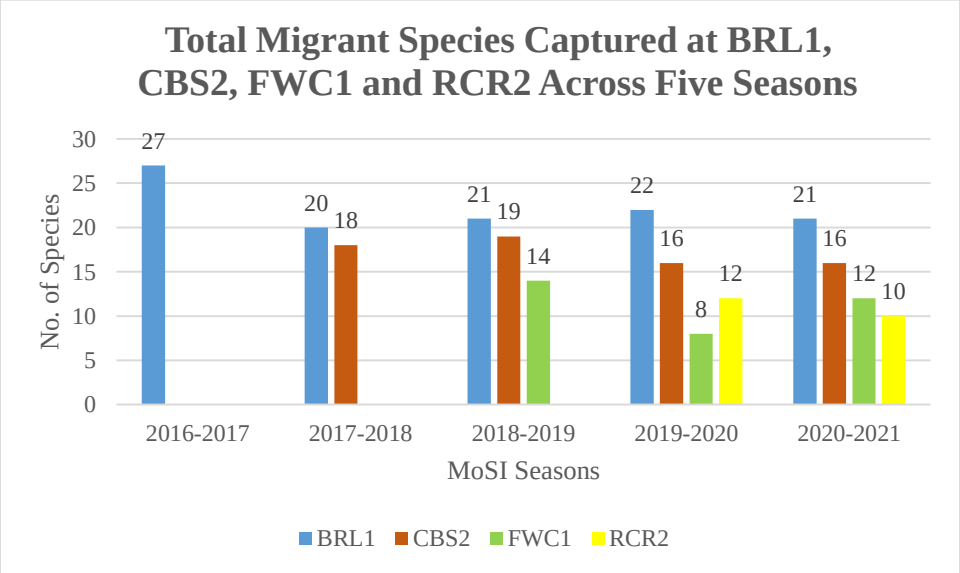
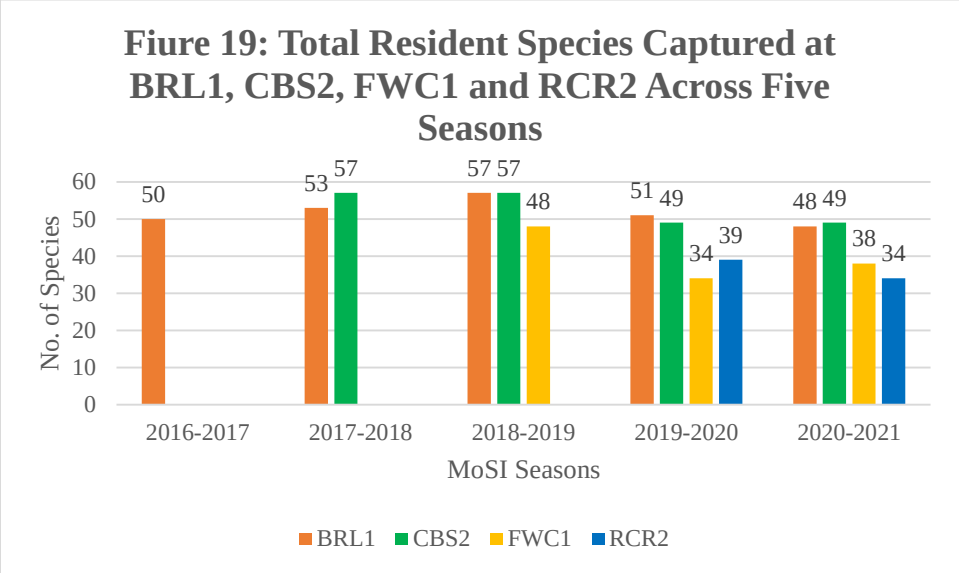


Figure 19 shows the total number of resident species captured at BRL1, CBS2, FWC1 and RCR2 across five seasons. The highest number of resident species captured at BRL1 was in season 2018-2019, for CBS2 it was in seasons 2017-2018 and 2018-2019, for FWC1 it was in season 2018-2019 and for RCR2 was in season 2019-2020. The least number of resident species captured for BRL1 was in season 2020-2021, for CBS2 it was in seasons 2019-2020 and 2020-2021, for FWC1 it was in season 2019-2020 and for RCR2 it was in season 2020-2021.



Recapture data for three sites for 2020-2021 season

Apart from new captures, there were also numerous recaptures. This is all recaptured data, so repeats are individuals that are recently banded in the same season and recaptured during the season and returns are individuals that were banded in previous seasons and are recaptured during the current season and station. Table 5 highlights the out of season recaptures (birds recaptured as returns from previous seasons) from the total recaptures in 2020-2021 at BRL1. A total of 33 migrant individuals and 44 resident individuals were recaptured. Out of the 33 migrant recaptures, two were from the 2015-2016 season, when the BRL1 station was run as a half station in collaboration with BFREE and Dr. Jamie Rotenberg of University of North Carolina Wilmington; two were from the 2016-2017 season when the BRL1 station was run as a full station as part of the current project; three were from the 2018-2019 season; and four were from 2019-2020 season. The repeats were 22 migrant individuals. Out of the 44 resident individuals recaptured, three were returns from the 2015-2016 season, one was a return from the 2016-2017 season, seven were from 2017-2018 season, four were from the 2018-2019 season, and eleven from the 2019-2020 season. There were also 18 resident repeats.

Table 5: BRL1 Season 2020-2021 Recaptures Highlighting Out of Season Recaptures						
	Returns					Repeats
	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Migrant	2	2		3	4	22
Resident	3	1	7	4	11	18

Table 6 highlights the out of season recaptures from the total recaptures in 2020-2021 at CBS2. A total of 41 migrant individuals and 76 resident individuals were recaptured. Out of the 38 migrant recaptures, five were from the 2016-2017 season at CBS2. However, another station, CBS1 was established in December 2016 and operated until January 2017 since the site was not ideal for capturing migrants. Recaptures during the 2020-2021 season from CBS2 were two from 2017-2018, five from 2018-2019 and two from 2019-2020. The repeats were 25 migrant individuals caught during the MoSI season and five were from a training in October 2020 that was held at CBS2 and the birds were banded using the resident bands. Out of the 76 resident individuals recaptured, 13 were returns from the 2016-2017 season, eight were returns from the 2017-2018 season, 17 were from the 2018-2019 season and 13 from the 2019-2020 season. The repeats were 18 resident individuals. There were seven from the training in October 2020.

Table 6: CBS2 Season 2020-2021 Recaptures Highlighting Out of Season Recaptures						
	Returns				Repeats	
	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	Trainings
Migrant	2	2	5	2	25	5
Resident	13	8	17	13	18	7

Table 7 highlights the out of season recaptures from the total recaptures in 2020-2021 at FWC1. A total of seven migrant individuals and 31 resident individuals were recaptured. Out of the seven migrant recaptures, one was from the 2018-2019 and 2019-2020 seasons. The repeats were five migrant individuals. Out of the 31 resident individuals recaptured, seven were returns from the 2017-2018 season at FWC1. However, for the 2017-2018 season, FWC1 was operated for two months (February and March 2018) since the site was in its testing phase. Recaptures during the 2020-2021 season were nine from the 2018-2019, and four from the 2019-2020 season. There were 11 repeats.

Table 7: FWC1 Season 2020-2021 Recaptures Highlighting Out of Season Recaptures				
	Returns			Repeats
	2017-2018	2018-2019	2019-2020	2020-2021
Migrant		1	1	5
Resident	7	9	4	11

7. Discussion

Long-term bird monitoring is an ongoing initiative to assist in evaluating ecosystem health in protected areas. As previously stated in section six (6), the five MoSI sites have been in operation for six seasons (BRL1, 2015-2020); five seasons (CBS2, 2016-2020); four seasons (FWC1 2017-2020); three seasons (RCR2, 2018-2020) and first season (TPPL, 2020-2021).

For this season 2020-2021, at BRL1, CBS2, FWC1, RCR2 and TPPL, there were higher numbers of new bird captures in December with capture rates fluctuating over the 4-month season (Figure 7, Figure 8, Figure 9, Figure 10, Figure 11). The November pulse was attempted at BRL1 but had to be cancelled due to heavy rainfall and flooding. The cancellation resulted in the cancellation of the pulse of the other four sites per the protocol. High numbers in December at the five sites operated during that month may have been due to the fact that nets were opened for the first time during this month, so birds weren't yet aware of the location of nets. Temperature may have also influenced changes in capture rates as the season progressed. During the month of December to January for all stations, the temperature was between 18^0C to 26^0C. However, in February, temperature would increase to 28^0C-31^0C closing time and in March, it was at 19-21^0C during opening time but started to increase to about 28-30^0C by 9:30 a.m. Therefore, most of the sites had to be closed around 10:00-10:30 a.m. Figure 7-11 shows that the low capture rate was between February and March. In addition to temperature, the cloud cover was 100% when opening, with fog or mist, and decreased to 70-80% when closing in December and January. However, in February and March there was no precipitation and cloud cover would decrease to 10% when closing. Due to the changes in weather conditions the total mist netting effort for each site differed (Figure 15). The MoSI protocol requires a minimum of 12 hours of mist-netting effort over three days or 18 hours. The total mist-netting effort was lower in March at BRL1, CBS2 and RCR2 which may be due to high temperatures and nets being closed early since they were in direct sunlight. The mist-netting effort was lower at FWC1 due to strong winds affecting the nets in January and high temperatures in March. The mist-netting effort was lower at TPPL due to only operating eight mist-nets and being affected by rain in December. In January, eight nets were operated on day one and 15 nets were opened on the other two days. In March, the mist-netting effort was lower due to high temperatures. In October-November 2020, La Niña appears to have peaked as a moderate strength event (WMO, 2021) which caused all the rain and affected operation in November and December.

The total banded individuals for season 2020-2021 was highest for residents and migrants at CBS2 (Figure 12). The newly banded migrants captured were higher in December at CBS2 and the most common species caught that month was GRCA and the number of species was also higher as shown in Figure 8. The high number of newly banded individuals could have been due to the heavy rains in November which made them stay in the area and that the birds were not aware of where the net lanes were located. November is at the end of the fall migration season

and in 2020 Belize was affected by Hurricane Eta and Iota which caused heavy rainfall and flooding across the country. Impacts to individuals along a migration route can either be direct (when individuals encounter active storms) or indirect (where storms impact habitat structure, resource distribution or interacting species along active migratory flyways) (Leslie Ries *et al*., 2018). This could have been the reason why migrants stayed in the area during the two hurricanes. Also, decline in soil moisture correlated with decline in arthropod abundance (McKinnon Emily *et al.*, 2015). This means that during the wet season (November-January) higher capture rate of species that feed on insects is expected and it decreases in the dry season (February-March). The high numbers of newly banded residents captured in December for CBS2 could have been due to young birds inhabiting forest edges and not knowing where the net lanes are located. This month also reported a higher number of captures of Ochre-bellied Flycatcher, White-collared Manakin and Red-capped Manakin. Throughout the rest of the season those three species were captured in higher numbers which could have been caused due to abundance in fruits and insects especially after the rains. Also, a lekking area for Manakins is beside the banding station which allowed us to catch a lot of Manakins.

Apart from total capture rate, the species diversity at each site is ideal in knowing what species are occupying the different habitats. The BRL1 site had an area with a huge patch of grass and a few tall shade trees and a flat terrain because of its close proximity to the river. However, it also includes secondary growth forest with a steep terrain and some human disturbance. The CBS2 site was also beside a camping area and had some human disturbance. The FWC1 site was in a small patch of forest edges and had human disturbance. RCR2 was along a hill that is secondary growth forest and is surrounded by a seasonal wetland and the savannah. The TPPL site was in a secondary forest type with small streams running through the site. Therefore, the difference in species diversity could probably be due to the difference in habitat among the four sites. There were more resident species than migrant species that were common at all sites (Table 3) and then there were those that were unique to each site (Table 4). The common migrants and resident species are considered generalists that can utilize a wide variety of habitat types. There were more resident species caught which could probably indicate that they are more tolerant of multiple habitats. BRL1 had more unique migrants and CBS2 and BRL1 had more unique resident species caught than the others, meaning that its resident species diversity as measured by number of species was also higher than the other sites. This may be due to the more complex habitat structure of the sites; other studies have linked an increase in habitat structure with more diversity of the bird community (Finch, Deborah M, 1991). There were two species at BRL1 and one at TPPL that have never been caught before at any of the stations and/or the previous seasons. In addition, MoSI has 41 target and/or potential target species that they study and in Belize we can capture 20 of these species. BRL1 and CBS2 had the highest number of species caught followed by RCR2, TPPL and FWC1 (Figure 12). At least 17 out of the 20 species were captured among the five sites. This shows that we are collecting information that contributes to determining population trends for the different species.

Apart from looking at season 2020-2021 data, we looked at the data for four sites across the five seasons so far. We have five years of data from a full MoSI station at BRL1, three years of data from a full MoSI station at CBS2, two years of data from a full MoSI station at FWC1 and two years of data from a full MoSI station at RCR2 which allowed comparison of the total new banded individuals of both migrants and residents and the total species captured across the seasons. There were higher numbers of newly banded migrants in season 2017-2018 for BRL1 and CBS2 compared to FWC1 which was in season 2018-2019 and 2019-2020 for RCR2 (Figure 16). In season 2017-2018, there were higher numbers of Wood Thrushes and Gray Catbirds caught compared to the other seasons for BRL1. In season 2017-2018, a Wood Thrush was a foreign recapture from a three-year study at CBWS. The individual was banded in January 2016 at CBWS and recaptured at BRL1 in February 2017. This recovery (bird banded at another station) shows that the protected areas between CBWS and BRL are important as a migration route for some birds. For CBS2, it was the first season of operating a full MoSI station, so birds were not aware of where net lanes were and most of the captures consisted of Wood Thrushes and Gray Catbirds. According to the National Centers for Environmental Information, in 2017 it was the sixth warmest year on record occurring since 2010 (NOAA, 2018) and in early 2018 was the coolest year in the Caribbean region (NOAA, 2019). This could probably be the reason why there were higher captures in 2017-2018 season. As for FWC1 and RCR2, the highest number of newly banded migrants was in season 2018-2019 and 2019-2020 since it was the first season for the operation of a full MoSI station at either site. Wood Thrushes and Gray Catbirds were caught mostly along with a few other warbler species even though the number of individuals captured was between two to four individuals per species. As for residents, there was a higher number of newly banded residents in season 2018-2019 for BRL1, CBS2, FWC1 and in 2019-2020 was highest for RCR2 (Figure 17). Overall, more resident individuals were banded across the four sites and for each season there are fluctuations in the number of banded individuals at each site. These fluctuations could have been influenced by arrival and departure of migrants and season shift and behaviors of individual species (Blake John, Rouges Mercedes, 1997). According to Poulin, B. and Lefebvre, G. (1996), the diet of migrants shows little overlap with that of the resident species, even though they use similar foraging substrate. The lower diet overlap could be due to the fact that resident birds coexist year-round while the migrants spend only a few months in the area. Resident species may also feed on a wide variety of arthropods or specialize on a specific taxon compared to migrant species.

The number of migrant species captured at BRL1 was higher in season 2016-2017, at CBS2 and FWC1 it was higher in season 2018-2019, and at RCR2 it was highest in season 2019-2020 (Figure 18). The migrant species was much higher in season 2016-2017 at BRL1 and could have been caused by the expansion to a full MoSI station. For FWC1 and RCR2 sites it could also be attributed to the stations operating as full MoSI stations. The increase of resident species was higher in season 2018-2019 for BRL1, for two seasons (2017-2018 and 2018-2019) it remained

the same and it was the highest amongst the other sites for CBS2; for FWC1 it was in season 2018-2019 and for RCR2 it was in season 2019-2020 (Figure 19). The steady increase over the three seasons for resident species could have been due to habitat recovery after the flood in 2016 at BRL1 and as shown in Figure 19 there was also a higher number of banded resident individuals which would probably mean that birds are returning to the area affected by the flood or disturbances. For CBS2, the number of newly banded resident individuals and resident species was also higher in season 2018-2019 which could have been caused by the restoration of habitat after the hurricane in 2016. Natural disturbances play a fundamental role in creating habitat and landscape heterogeneity that benefits various taxa (Brawn J.D, Robinson S.K, Thompson F.R III, 2001). In 2016 hurricane Earl affected the country with heavy rainfall and strong winds that affected the area at BRL1 and CBS2. The recovery of bird populations from hurricane effects is partially dependent on the extent and degree of vegetation damage as well as the rate of recovery (Wiley J.W, Wunderle Jr J.M; 1993). The area in which four mist-nets were set up was affected by the fire in 2019 at RCR2; however, the impacts of fire on avifauna remains unknown since the habitat structure undergo strong changes (Moreira *et al*., 2003). Structural changes of habitat attributes due to severity of fire events also produced variations in guild compositions (Albanesi Sebastian, *et al*., 2014). In 2019-2020 season the species caught in higher number were woodcreepers and tanagers. There is not sufficient data to conclude what might have caused the changes in migrant or resident captures but with more data collected over time we should be able determine the trends.

In terms of migrant recaptures, the 2020-2021 season at BRL1, there was a total of 11 return recaptures of migrant birds and 26 resident returns (Table 5). At CBS2 there were 11 migrant returns, 51 resident returns (Table 6). Long-distance migrants are territorial in their wintering grounds (Sherry, Thomas; Holmes, Richard, 1996) therefore they defend their area and return to the same site in subsequent years. As for FWC1, there was a total of two return recaptures of migrant birds and 20 resident returns (Table 7). In season 2017-2018 the site was sampled for two months as we were trying to find the ideal location then the full season and full MoSI station was operated in season 2018-2019. Since BRL1 and CBS2 have higher capture rate the returns are also high as well. MoSI also focuses on migrants to determine survival and population trends so getting returns is important. A factor that may increase a bird's survival probability and future reproductive success is returning to the same non-breeding area annually, which provides the advantages of increased familiarity with local resources, territorial dominance, and predator avoidance (Latta and Faaborg, 2001). Over time recapture data can be used to determine site fidelity of specific individuals, survivorship, assessing habitat quality and age and sex ratio.

8. In depth Summary for BRL1 and CBS2



Some of the most common species caught at each site. From to top left to bottom right: Yellow-bellied Flycatcher, White-eyed Vireo, Wood Thrush, Kentucky Warbler, Gray Catbird & Northern Waterthrush.

8.1 In depth data summary from BRL site

Table 8 shows the total number of newly captured and recaptured individuals of seven species for five seasons. These seven species were selected because they had at least 10 or more captures each season. However, individuals recaptured can be captured more than once but the recaptures listed are individuals. The table shows that Wood Thrushes and Gray Catbirds were captured in higher numbers than the other species in each season. In season 2020-2021, the number of newly banded and recaptured WOTH and GRCA were lower and the highest number was in season 2017-2018.

Table 8: BRL1 Newly Banded and Recaptures per Season

	2016-2017			2017-2018			2018-2019			2019-2020			2020-2021		
Species	**New**	**Recapture**	**TOTAL**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**
WOTH	34	16	**50**	57	23	**80**	21	17	**38**	22	16	**38**	18	14	**32**
GRCA	32	7	**39**	39	10	**49**	24	4	**28**	20	3	**23**	14	5	**19**
WEVI	9	4	**13**	7	5	**12**	4	6	**10**	8	3	**11**	4	4	**8**
NOWA	4	6	**10**	4	4	**8**	3	8	**11**	1	4	**5**	2	8	**10**
OVEN	7	2	**9**	5	5	**10**	13	10	**23**	11	11	**22**	3	4	**7**
KEWA	4	2	**6**	6	7	**13**	7	9	**16**	7	5	**12**	2	1	**3**
MAWA	7	4	**11**	9	4	**13**	7	3	**10**	3	1	**4**	5	2	**7**

Table 9 shows the total number of repeats and returned individuals in each season. This table shows that most of the recaptures were repeats but almost every season there are individuals that are from previous seasons.

Table 9: Total Number of Recapture Repeat and Return Individuals per Season

	2016-2017		2017-2018		2018-2019		2019-2020		2020-2021	
Species	**Repeats**	**Returns**	**Repeats**	**Returns**	**Repeats**	**Returns**	**Repeats**	**Returns**	**Repeats**	**Returns**
WOTH	13	3	19	4	11	6	10	6	4	0
GRCA	5	2	5	5	2	2	1	2	2	0
WEVI	4	0	2	3	2	3	3	0	0	3
NOWA	3	3	4	3	2	2	1	3	1	2
OVEN	1	1	2	3	6	4	5	4	0	2
KEWA	2	0	4	3	5	4	5	0	1	0
MAWA	3	1	2	2	2	1	0	1	1	1

Table 10 shows a list of all recaptured individuals to date for BRL1 and the seasons that they were recaptured in. The list is sorted by species in alphabetical order and includes the data from the first season 2015-2016. The table contains the following data for each banded bird: band number, species (common name code), sex, net number where captured, and seasons in which they were caught. For each season, the number of recaptures is also provided. Thus far, there is one individual that has returned for five consecutive years to the same site (highlighted in yellow) and four individuals returning for four years (highlighted in green).

Table 10: List of Recaptured Migrant Individuals for each Season at BRL1

Band #	**Species**	**Sex**	**Net Numbers**	**Seasons**					
				2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
253003444	AMRE	M	2,4	1	1				
253003434	BAWW	F	4,5,6,13	2	1	1		1	
253003436	BAWW	M	3,7,11	1	1	1			
266007807	BAWW	F	1,14		1		1		
266007854	BAWW	F	3,4,6			2	1	2	
253003432	BWWA	M	3,5,12	2	1				
251068596	COYE	M	5,8	1	1				
253003418	COYE	M	3,5,7	2	1				
266007822	COYE	M	1,3,5		1	2	1		
266007856	COYE	M	1			1		1	
253003433	CSWA	F	3,5	1	1				
256156349	GRCA	U	2,3,4	2	1				
256156350	GRCA	U	3,15	1			1		
256156362	GRCA	U	3,5,7,12,13	1	3	2			
233128915	GRCA	U	3,4,5		1	1		1	
233128935	GRCA	U	5,16		1	2			
270111177	GRCA	U	2,3			1		1	
D0469	GRCA	U	4,5			2	1		
266007814	HOWA	M	5,12,15		1		1		
266007890	HOWA	F	5,6,7,9,12				3	1	3

231101417	KEWA	F	6,7,12		5	3			
231101404	KEWA	F	7,8,9		2	3	1		
231101421	KEWA	F	3,4,5		1	1	2		
231101474	KEWA	M	4,10,11			4	3		
231101475	KEWA	M	12			1	1		
277070058	LEFL	U	6,8		1	1			
231101468	LOWA	U	3,8,12,13			3	1		
253003417	MAWA	U	6,11	3		1			
253003419	MAWA	F	1,5,8,9	2	1	1			
277070096	MAWA	F	7,12			1	1		
283036949	MAWA	M	9,12,14				1	1	1
251068572	NOWA	U	3,5,6,8	2		5		1	
251068575	NOWA	U	1,4	3	1				
251068576	NOWA	U	1,3,4	2		1			
251068584	NOWA	U	1,3,7	3		1			
251068590	NOWA	U	4	1	1				
251068593	NOWA	U	3,5,6	1	5				
231101402	NOWA	U	1,4,5,12		1		1	1	2
231101465	NOWA	U	3,6,8			5	3		
231101529	NOWA	U	3,4,5				3	2	
251068574	OVEN	U	4,8,9	1			2		
252136036	OVEN	U	3,12	1	1				
231101418	OVEN	U	3,4,5		1	4			
231101407	OVEN	U	10,11		1	1			
231101410	OVEN	U	6,12		1		1	1	
231101434	OVEN	U	3,4		1	1			
231101466	OVEN	U	7,8			3	1		
231101502	OVEN	U	8			2	1		

231101517	OVEN	U	4			1	1	1	
231101524	OVEN	U	3,4,5,6				4	1	
231101563	OVEN	U	6,7,8,10				2	4	
125176716	SUTA	M	5, 8	1				1	1
253003329	WEVI	U	2,3,4	1		3	2		
266007808	WEVI	U	6,7,9,10		4	1			
277070053	WEVI	U	2,5,14		1	3			
266007840	WEVI	U	5,6,7,14			4	2		
266007871	WEVI	U	9			1	1		
256156345	WOTH	U	7,14	1	2				
256156335	WOTH	U	2,3,16	2	2				
256156337	WOTH	U	4,7,12	3	2	2	1		
256156377	WOTH	U	1,12,13	1			2		
233128905	WOTH	U	2,12,15		1		1		
233128936	WOTH	U	6,7,8,15		4	3	1		
270111128	WOTH	U	3,7		1	1	2		
270111170	WOTH	U	6,13			2	1	3	
270111188	WOTH	U	8,9,16			2	2		
273162065	WOTH	U	1,7,8,9,12				3	4	
273162071	WOTH	U	1,3,7,14,15				3	2	
BZ1A079	WOTH	U	2,4,5,7			1	1	2	
BZ1A006	WOTH	U	6,7,12			4	1		
D0472	WOTH	U	8,11			1	1	1	
D0488	WOTH	U	3,15			1		1	
234115208	YBCH	M	1,3,4,5,6,7,14,15			8	5	1	
253003330	YBFL	U	1,2,3,4,11	1	1	1	1	2	
253003327	YBFL	U	4,8	1	2	1	2		
277070056	YBFL	U	13		1	1			

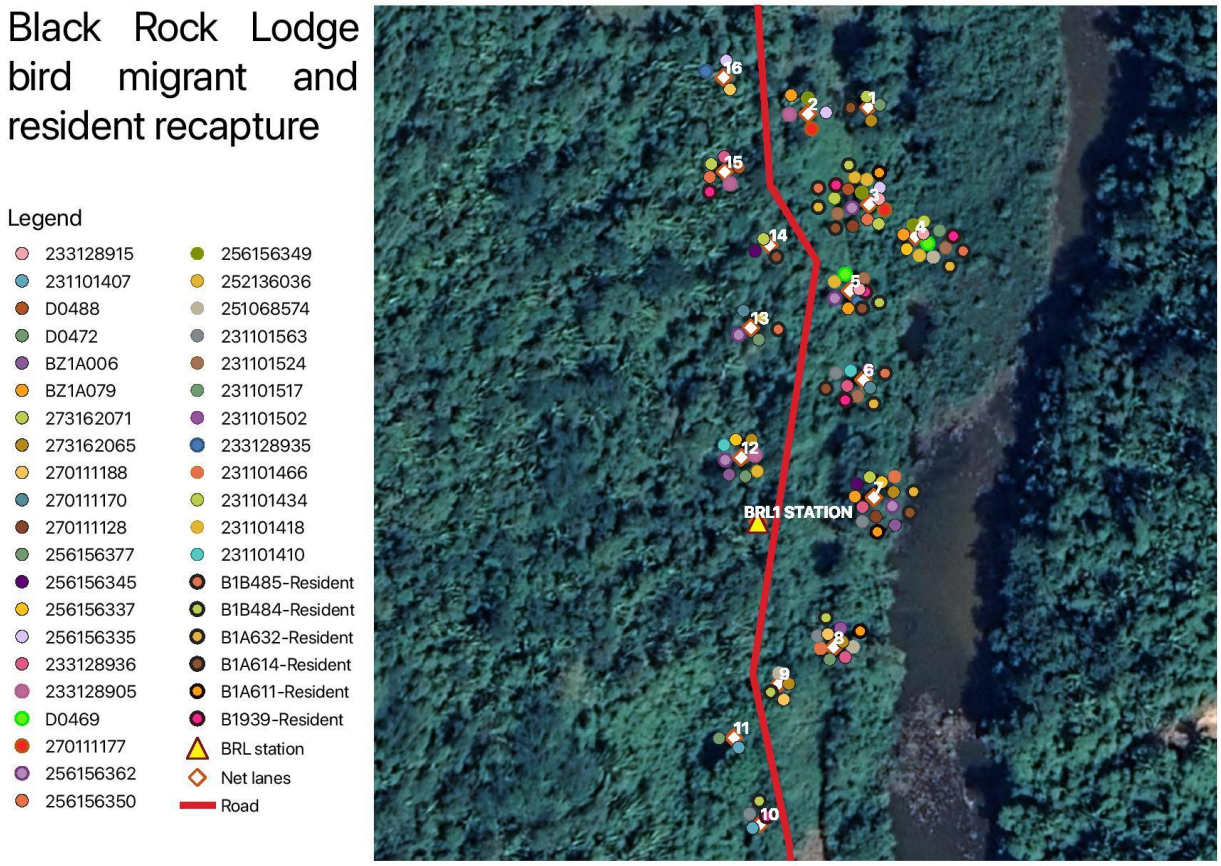
277070056	YBFL	U	13		1	1			

Table 11 shows the total number of newly banded and recaptured individuals and species captured at BRL1 across six years. Out of 571 individuals that have been banded, 340 individuals have been recaptured. A total of 30 species have been captured and 25 species have been recaptured.

Table 11: Total Newly Banded and Recaptured Individuals and Species captured at BRL1 across six years

	New	**Recapture**
Total Individuals	571	340
Total Species	30	25

Figure 21 illustrates the mapping of nets in which 33 migrant individuals of three species (WOTH, GRCA, and OVEN) and nine resident individuals of three species (SBSW, GBSP and BGRO) were caught in over the years. All this data is derived from Table 10. The resident individuals were selected since they were caught each year and the migrant individuals were those species that were caught the most. In the first year that a migrant individual is captured it moves between nets but in the general area. Once an individual identifies its territory it returns to that area the following years. As shown in the map, the hotspot for most captures of migrant individuals is in nets 3, 4, 5, 6 and 7. These nets are all along the river.



8.2 In depth data summary for CBS2

Table 12 shows the total number of newly captured and recaptured individuals of six species over five banding seasons. These six species were selected because they had at least 10 or more captures each season. However, individuals recaptured can be captured more than once but the recaptures listed are individuals. The table shows that Wood Thrushes, Gray Catbirds and Ovenbirds were captured in higher numbers than the other species in each season. In season 2019-2020, the number of newly banded and recaptured WOTH and GRCA were lower, and the highest number was in season 2017-2018.

Table 12: CBS2 Newly Banded and Recapture per Season

	2016-2017			2017-2018			2018-2019			2019-2020			2020-2021		
Species	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**	**New**	**Recapture**	**Total**
WOTH	16	8	24	29	18	47	23	16	39	9	13	22	15	15	30
GRCA	40	2	42	47	25	72	40	11	51	24	11	35	34	11	45
OVEN	8	8	16	6	15	21	2	13	15	10	6	16	4	8	12
WEWA							5	5	10						
HOWA										8	13	21	2	10	12
KEWA													3	8	11

Table 13 shows the total number of repeats and returned individuals in each season. This table shows that most of the recaptures were repeats but almost every season there are individuals that are from previous seasons. In seasons 2018-2019 and 2019-2020 some individuals were recaptured but were initially banded during a training before the season started.

Table 13: Total Number of Recapture Repeat and Return Individuals per season

	2016-2017		2017-2018		2018-2019			2019-2020			2020-2021	
Species	**Returns**	**Repeats**	**Returns**	**Repeats**	**Returns**	**Training**	**Repeats**	**Returns**	**Repeats**	**Training**	**Returns**	**Repeats**
WOTH		7		2	6		3	6	4		1	4
GRCA		3	3	3	5		4	4	5		2	
OVEN		10	5	5		3	4	1	4	1	2	3
WEWA					1	2						
HOWA									4	1	3	1
KEWA											2	1

Table 14 shows a list of all recaptured individuals so far for CBS2 and the seasons that they were recaptured in. The list is sorted by species in alphabetical order. The table contains the following data for each banded bird: band number, species (common name code), sex, net number where captured, and seasons in which they were caught. For each season, the number of recaptures is also provided. Thus far, most of the individuals have been recaptured in at least two seasons.

Table 14: List of Recaptured Migrant Individuals for Each Season at CBS2

Band #	Species	Sex	Net #	Seasons				
				2016-17	2017-18	2018-19	2019-20	2020-21
266007864	BAWW	M	5,7		1	1		
266007859	COYE	M	8		1		1	
284046013	COYE	M	8			1	1	
233128945	GRCA	U	2,3	1	1			
270111129	GRCA	U	2	1	1			
270111135	GRCA	U	4,11,13,14,15	1	3	2		
270111147	GRCA	U	11,14,16		1	1	2	
BZ1A022	GRCA	U	10		1		2	
BZ1A023	GRCA	U	10,12		1			1
BZ1A030	GRCA	U	12		1	1		
BZ1A094	GRCA	U	6,8		1	1		
273162019	GRCA	U	12			1		1
273162053	GRCA	U	5,12			1		2
273162081	GRCA	U	8,11			1		1
BZ1A393	GRCA	U	1,15				1	1
266007830	HOWA	M	3,15	1	1			
232181323	HOWA	M	3,5,6			2	2	
A28393	HOWA	M	13			1	1	
232181328	HOWA	M	1,3,9,14				5	1
231101428	KEWA	M	12,13	1	1		2	
A28389	KEWA	F	3,5,8,13			3	1	
B28692	KEWA	F	12,13,15			3	1	
232181327	KEWA	F	7,10,11				1	3
277070071	MAWA	M	7,10		1	1		
231101425	OVEN	U	8,14,15	2		2		
231101430	OVEN	U	8,10	1	1			
231101431	OVEN	U	2,16	1	2			
231101438	OVEN	U	6	1	2			
B28695	OVEN	U	1,2,7,15			4	1	
232181349	OVEN	U	1,3				1	1
234115205	SUTA	M	6	1		1		

231101460	WEWA	U	1,6,7		2	3		
270111117	WOTH	U	6	1			1	
270111141	WOTH	U	7,10	1			2	
233128946	WOTH	U	11	1			1	
233128939	WOTH	U	4,6	3		1		
270111149	WOTH	U	12		1	1	1	
BZ1A128	WOTH	U	1,2		1	1		
BZ1A087	WOTH	U	13		1		1	
D0449	WOTH	U	1,14,15		1			
D0450	WOTH	U	1,2		1	2		
273162090	WOTH	U	10			1		1
273162047	WOTH	U	6,15			1	1	
BZ1A444	WOTH	U	6,11,12,13				1	4
BZ1A452	WOTH	U	2,13				1	1
233128943	YBCH	M	8,10	1	1			
234115209	YBCH	M	4,10		1	1		
234115207	YBCH	M	7,15		1	2	1	
273162022	YBCH	F	8,9		1	1		
283036939	YBFL	U	2,8			1		1
283036940	YBFL	U	8			1	1	

9. Discussion

Since BRL1 has six years of data with five years as a full MoSI station we looked at summarizing the data, specifically at migrant recaptured data. There were seven migrant species that were caught in high numbers over the four seasons (Table 8). The species with the highest capture rate were Wood Thrush and Gray Catbird followed by White-eyed Vireo, Northern Waterthrush, Ovenbird, Kentucky Warbler and Magnolia Warbler. Many Neotropical migratory species inhabit both mature and early successional forest. Previous studies in Belize have shown to capture Wood Thrush, Ovenbird and Kentucky Warbler in abundance (Piaskowski *et. al*., 2005) and Gray Catbird and Magnolia Warbler have also been caught in abundance (Montes and Bayly, 2010). The newly banded individuals varied from season to season for each species, but the recaptured individuals increased each season. It shows that birds are returning each season and some individuals are recaptured each season. We looked at the recaptured data further to see if there were more repeats or returns (Table 9). The data presented in the table shows that more individuals were repeat captures from the same banding season than returns banded in other seasons. Most of the repeats are young birds that are displaced by older birds and are floating around to find a space (Brown, David and Long, Jennifer, 2007) and this results in repeat recaptures. However, between 20%-50% of the recaptures were returns. We also looked closely at those individuals returning each season and listed them in Table 10. In addition, Table 11 looked at a summary of all newly banded individuals and species captured at BRL1 across six years. A total of 571 individuals were captured and 340 of them were recaptured. Although 340 individuals have been recaptured there are only 77 of them that have been recaptured for at least two or more seasons. Thus far, 77 individuals of 18 species have returned for at least two seasons. One Yellow-bellied Flycatcher has returned to BRL1 since it was banded in 2015-2016 for five consecutive seasons. There are also four individuals (BAWW, NOWA, WOTH and YBFL) that have returned for at least four seasons. These individuals could provide data on survival, territory size and preferences. Wood Thrush is heavily studied because they are rapidly declining in North America (2.2%/year over the last 10 years) (Sauer *et al*., 2012). A few studies on winter territorial (Winker, Rappole, Ramos, 1990) and age-specific reproduction and survival (Brown and Roth, 2009) are some examples of studies from recaptured data. These types of information would provide meaningful data on population trends and distributions and allow managers to properly administer and conserve habitats these species require in Belize. We would further analyse the recapture data using occupancy models to determine survivorship and habitat association with species diversity. This analysis would be done separately with assistance of Dr. Viviana Ruiz-Guiterrez of the Cornell Lab of Ornithology.

A map was developed to show where 33 migrant individuals of three species (WOTH, GRCA, and OVEN) and nine resident individuals of three species (SBSW, GBSP and BGRO) were captured (Figure 21). It shows in which net or nets they were caught in. All of this information

was derived from Table 10. The hotspots were the nets that are near the farm and close to the river. The area is open and riparian forest edge and consists of grass, shrubs, and some tall trees with over hanging vegetation. It could be that these nets were best for catching migrant birds since they were on the forest edge. Studies have shown that many Neotropical migratory species occupy a wide variety of habitats, both natural and disturbed (Johnson *et al*., 2006) and appear to be resilient to habitat change than residents who have clear habitat preferences (Wallace *et al*., 1996). Also, studies show that the proportions of migrants were lower in undisturbed forest than in modified habitats (Montes and Bayly, 2010) which is represented in Figure 21. This could mean that migrant species are better able to adapt to changes in habitats and take advantage of the space available. On the other hand, these disturbances create microhabitats and provide resources that could increase species richness.

The CBS2 site has five years of data with four years as a full MoSI station. There were six species that had 10 or more captures per season. Some seasons had some species that were not captured in high numbers but the species with the high numbers for each season are WOTH, GRCA and OVEN (Table 12). The 2017-2018 season had the highest capture of those three species. Similar trend is shown at BRL1 in which season 2017-2018 had the highest number of captures. This could be because of the cooler weather conditions during that season (NOAA, 2019). As mentioned previously, these species have shown to have higher capture rate as indicated in Montes and Bayly, 2010 and Piaskowski *et. al*. 2005. Looking closely at those recaptured species, they had higher number of repeats than returns (Table 13). Those individuals that were recaptured in two or more seasons were listed in Table 14. A total of 51 individuals of 12 species were listed and most of them were recaptured within two seasons. This is interesting because most individuals are caught at least in two seasons unlike the recaptures at BRL1 where individuals are recaptured in more than two seasons. A possible explanation could be due to habitat type difference between these two sites, BRL1 is mostly semi-open shrublands, open overgrown pasture and forest edges and CBS2 has some closed forest areas and shrublands (Meerman and Sabido, 2001). According to studies based on general mist-netting activities report low return rate than studies on color-banded birds and intensive resighting show higher values of returns especially when studying site fidelity (Koronkiewicz, T, *et a*l., 2006). This could be another explanation as to why we have lower recaptures at CBS2.

10. Conclusions and Recommendation

The project continues to gather data on the songbird community and distribution for the established and new MoSI stations and although the data is not yet enough for all the stations to make conclusions or reveal clear patterns (more recaptures are needed), the experience of working as a banding network is helping to constantly improve the program. The data entered has been cross-checked and reviewed at the end of the season for errors and consistency. The migrant data will be submitted to IBP in June 2021 and the resident data is available upon request for partners to access. We continued collecting pictures for the reference library that can

help in ageing and sexing resident birds. The results have shown changes (increase and decrease of captures, total number of species etc.) over the five seasons of operation. There has also been returns on birds banded from previous seasons and birds banded by a different program which shows that birds are surviving, supports site fidelity and that their habitat is very important for them. Based on the recaptured data, YBFL, BAWW, NOWA, WOTH are returning to the sites. This means they are surviving the rigor of long-distance migration twice a year, potential habitat changes on both ends of the migration, weather and finding their way back to the same area at these banding sites which makes these locations in Belize valuable to maintain and conserve. This information assists in better management of protected areas as birds depend on these areas for shelter, food, and protection. Overtime, more in-depth analysis can be done to better understand what indication birds are providing towards the health of our ecosystems for the other stations. For the BRL1 data we will be analysing it further and hope to produce one paper at the end of this year.

The project was another success due to the help and collaboration of committed partners and individuals. The UB ERI coordinated and supervised the operations and staff; BRL, BAS, CSFI, FWC and TIDE also supervised and assigned field staff and provided logistical support such as food, accommodation and assisted with transportation when needed. The Forest Department also showed support by granting permission for the work; IBP provided bands and responded to technical queries regarding MoSI. Over the past five seasons we have had some major improvements:

2017-2018

- Improvement on data collection- more accurate data has been collected for both residents and migrant birds while at the same time building the processing skills of the assistant banders.
- Data quality and database management- the entering and cross-checking process has been done more efficiently and better organization is in place for the database.
- Reducing the cost of expense; expenses were distributed among all partners, with each contributing towards accommodation, meals, and field support.
- The UB ERI, with the support of FD and BAS worked on a project funded by the Biodiversity Information for Development (BID) initiative to mobilize unpublished bird data into the Global Biodiversity Information Facility platform. This project collaborated with many local institutions including FWC, TIDE, Ya'axche Conservation Trust and others to obtain unpublished data and also in capacity building activities on publishing data on eBird and data analysis using occupancy models in collaboration with the Cornell Lab of Ornithology. The project allowed partners to participate in data mobilization workshops on the use of eBird and data analysis of data. In addition, data sharing agreements were developed, and a national data standard protocol was developed for biodiversity data management. This initiative has been excellent to move us a step ahead in the goal of adopting a robust

bird monitoring program (PROALAS) for Belize that will produce results to help assess bird population trends and more importantly the effectiveness of management interventions. This has allowed us to work with partners to roll out PROALAS and provide training. In addition, we are a GBIF data publisher that would allow us to publish biodiversity data in the future.

2018-2019

- Standardized ageing of resident birds using the Cycle Based System- there was limited resources available before for ageing the resident species but last year a new book was issued that helps ornithologists to better understand the biology of resident birds. Also, Blaine Carnes, our volunteer in 2018-2019, was quite knowledgeable with the system so he helped Abidas Ash, our Avian Biologist, to understand how the system works.
- Ivanna and Abidas applied for an equipment grant through IDEA WILD and the grant was received. The equipment received are four Identification Guide to North American Birds, Part 1, 2 5-hole banding pliers, 2 small standard wing ruler, 1 Medium standard wing ruler, 10 thread, 4 repair kit (mist-nets), Banding pliers (sizes OA-1A & 2-3), leg gauge, and Ohaus compact scale.
- Abidas asked for some equipment from IBP and we received them. The equipment includes scales, banding pliers, band openers. We also got some equipment, books and bird bags donated by Mary Alice Koeneke. She came to Belize for six weeks in November to December to help with operations of the four stations.
- Blaine Carnes and Abidas Ash published a scientific note on "A suspended Prebasic Molt in a White-eyed Vireo" to Western Birds

2019-2020

- With all the equipment received there was enough for each station to have a set of banding equipment. The mist-nets were the only equipment that was shared among the stations with the exception of RCR2 that had all their own equipment.
- Over the four years of working as a collaborative network at least 20 people have received training in bird banding and some of the people are now working as part of the program.
- Currently, one assistant, Isaias Morataya from BRL is the only one with an assistant certification. Emmanuel Saqui (BAS), Stevan Reneau, Reynold Cal (FWC) and Gliselle Marin (UB ERI) all assisted with extraction and worked on processing birds. They are encouraged to get certified as well. Kayla Hartwell (FWC) continued to assist with extraction and record keeping. This season Fernando Obando (BRL) and Gilroy Welch (FWC) were trainees during the MoSI season and they were able to safely extract birds from the net on their own. Leonardo Gonzales and Jorge Pena

(CSFI) were able to join for a few sessions during the MoSI period to start learning about extraction. They still need to practice a lot and hope they would be able to be the assistants for the FCFR site.

- Abidas assisted Emmanuel in applying for IBP's fellowship which he successfully received but due to the COVID-19 pandemic the program was cancelled.
- With the support from a grant from the North American Bander Council (NABC) and additional financial support from the UB ERI and BAS, Abidas was able to attend the NABC training and become a certified trainer.

2020-2021

- A new MoSI station was established at TIDE Private Protected Lands (TPPL) and this station was led by Liberato and his team of four assistants.
- Mary Alice Koeneke donated additional net bags and bird bags, as well as pencils.
- We received a total of 10 used mist-nets (some need repairing) from IBP, Powdermill Nature Reserve-Avian Research Center and Elizabeth Seller, former bander at the Banshee Reeks Nature Preserve, Virginia. Also, six new mist-nets were donated by Blaine Carnes and Mary Alice Koeneke.
- The MoSI stations were operated by Belizeans and COVID protocols were followed.
- Abidas assisted as one of the trainers with the NABC Certification Session held at Toucan Ridge Ecology and Education Society. Emmanuel Saqui from BAS, Liberato Pop, Reymundo Chen, Owen Williams and Mario Xi from TIDE attended the workshop and certification sessions. Two received Assistant Bander and two received Assistant Extractor certifications

We are striving for a minimum of five years' data for each station. Each year, new partners are joining and our effort to collect data for at least five forested areas across Belize appears possible to achieve. In addition, Bull Run have also expressed interest. It seems they are interested in managing and operating a MoSI station and they discussed about getting their team trained.

Moving forward into the next season we need to:

- replace mist-nets especially those that cannot be used again and repair those with holes and purchase more banding equipment so that there can at least be a set of equipment for each station;
- deliver more training in processing for assistants so they can start building their knowledge and be able to start taking the lead in the operation;
- deliver training and involve citizen science participation for people in the tourism sector;
- seek funding source to cover salary for biologist and to cover field expense such as fuel, equipment, and food;
- adopt the PROALAS protocol for a better point count monitoring system;

To meet our goals of five years or more per station we need to take advantage of opportunities that may arise. These include:

- continue getting volunteer bird banders to assist in the operation of the sites;
- continue finding training opportunities outside the country that assistants can part-take in which can help to improve their skills;
- applying for grants that provide any kind of assistance such as equipment, training,
- assistants applying for NABC certification grants.

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12. Annex

Species Codes and Common Names

AMKI	Amazon Kingfisher
BAAN	Barred Antshrike
BCAN	Black-crowned Antshrike
BBEH	Buff-bellied Hummingbird
BGRA	Blue-black Grassquit
BTFG	Buff-throated Foliage-Gleaner
BTGN	Black-throated Green Warbler
BWWA	Blue-winged Warbler
CCTA	Crimson-collared Tanager
DCFL	Dusky-capped Flycatcher
DUAN	Dusky Antbird
DWAN	Dot-winged Antwren
ERFL	Eye-ringed Flatbill
GBMA	Green-breasted Mango
GREL	Greenish Eleania
GCDO	Gray-chested Dove
GRCA	Gray Catbird
HOWA	Hooded Warbler
IBIW	Ivory-billed Woodcreeper
INBU	Indigo Bunting
KEWA	Kentucky Warbler
LEFL	Least Flycatcher
LEMO	Lesson's Motmot
LESG	Lesser Greenlet
NOBE	Northern Bentbill
OBFL	Ochre-bellied Flycatcher
OVEN	Ovenbird
PABU	Painted Bunting
RCMA	Red-capped Manakin
RCAT	Red-crowned Tanager
RTBE	Rose-throated Becard
RTAT	Red-throated Ant-Tanager
RUWO	Ruddy Woodcreeper
SBRH	Scaly-breasted Hummingbird
SHTF	Slate-headed Tody-Flycatcher
SCFL	Sepia-capped Flycatcher
STLE	Scaly-throated Leaftosser
SWTH	Swainson's Thrush
SWWA	Swainson's Warbler
TBSF	Thick-billed Seed Finch
TRKI	Tropical Kingbird
TWWO	Tawny-winged Woodcreeper

WBWO	Wedge-billed Woodcreeper	WOTH	Wood Thrush
WBWW	White-breasted Wood-Wren	VISA	Violet Sabrewing
WEWA	Worm-eating Warbler	YTVI	Yellow-throated Vireo
WEVI	White-eyed Vireo	YWTA	Yellow-winged Tanager
WCOM	White-collared Manakin		