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AN INTEGRATED COMMUNITY-BASED HARPY EAGLE AND AVIAN CONSERVATION PROGRAM FOR THE MAYA MOUNTAINS MASSIF, BELIZE

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Abstract. Historically, research and monitoring of flora and fauna in the protected areas of the Maya Mountains Massif (MMM) of Belize have been conducted primarily by foreign scientists. This is particularly true in areas such as the Bladen Nature Reserve (BNR) where its strict category of protection prevents even tourism as a means of alternative livelihoods for locals. Past studies have had little to no direct benefits (economic or educational) to buffer zone villages that border the BNR. What benefits that have been received are short-term in nature, and have had a strong negative impact on the local population's appreciation of the protected areas themselves. Locals perceive the parks as a benefit only for non-Belizeans. Our goal is to build capacity for avian conservation in the Maya Mountains by enhancing the links between protected areas and their surrounding communities. To achieve this goal, our project begins with a community-based alternative livelihood strengthening program for the development of a core group of avian technicians from buffer zone villages, and provides the tools for the acquisition of science based skills related to their work as parabiologists. After two years, we have trained five avian technicians who have identified 282 bird species, monitor rare Harpy Eagles (*Harpia harpyja*), conduct point counts, and have participated in the banding of nearly 1500 neotropical migrant and resident birds. In addition, our technicians act as ambassadors of conservation through our environmental education program. We present program results from our first two years, and provide recommendations for initiating similar programs.

Key Words: alternative livelihoods, avian monitoring, Belize, Bladen Nature Reserve, conservation, Harpia harpyja, Harpy Eagle, Maya Mountains.

UN PROGRAMA DE CONSERVACIÓN INTEGRADO AVIAR Y PARA EL ÁGUILA ARPÍA, CON BASE COMUNITARIA, EN EL MACIZO DE LAS MONTAÑAS MAYAS, BELICE

Resumen. Históricamente, la investigación y el monitoreo de la flora y fauna en las áreas protegidas del Macizo de las Montañas Mayas (MMM) de Belice, ha sido principalmente llevado a cabo por científicos extranjeros. El hecho es particularmente real en áreas tales como la Reserva Natural Bladen (BNR), donde su estricta categoría de protección, impide incluso el turismo como medio de subsistencia alternativo para la población local. Estudios anteriores han tenido poco o ningún beneficio directo (económico o educacional) sobre las aldeas situadas en las zonas de amortiguamiento fronterizas con el BNR. Los beneficios recibidos son de carácter breve y han tenido un fuerte impacto negativo en la forma que la población local valora las áreas protegidas en sí mismas. Los habitantes locales perciben que los parques sólo son de beneficio para los no Beliceños. Nuestro objetivo es crear la capacidad de conservación aviar en las Montañas Mayas mediante la adición de vínculos entre las áreas protegidas y sus comunidades vecinas. Para lograr este fin, nuestro proyecto comienza con un programa con base comunitaria de fortalecimiento a la subsistencia alternativa, mediante el cual se crea un grupo medular de técnicos aviares residentes en las aldeas de las zonas de amortiguamiento, a quienes se les proporcionan herramientas para la adquisición de habilidades de base científica, relacionadas con su trabajo como parabiólogos. En dos años hemos entrenado a cinco técnicos aviares, quienes han identificado a 282 especies de aves, monitoreado raras Águilas Arpía (*Harpia harpyja*), conducido conteos en puntos y participado en el anillado de

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casi 1500 aves neotropicales migrantes y residentes. Además, nuestros técnicos actúan como embajadores de conservación mediante nuestro programa de educación ambiental. Presentamos además resultados del programa de nuestros dos primeros años y ofrecemos recomendaciones para iniciar programas similares.

INTRODUCTION

A variety of research and monitoring has been conducted in the protected areas of the Maya Mountains Massif (MMM) of Belize. However, the majority of these studies have been conducted by foreign scientists, with little or no direct benefits (either monetarily or educationally) to members of local, buffer zone communities (exception for the Cockscomb Basin Wildlife Sanctuary - Jaguar Reserve). By excluding local people from participating in meaningful ways, locals perceive science and the protected areas as only benefiting educated non-Belizeans. These same stakeholders may be disenfranchised from the park or reserve that once was part of their daily lives, but is currently off limits due to management protection policy (Naughton-Traves and Salafsky 2004). The result is a disconnect between conservation science and local society.

Instead, any conservation and protection program associated with a park or reserve should involve local stakeholders as part of its core strategy (Belize examples: Cockscomb Basin Wildlife Sanctuary–Jaguar Reserve and the Community Baboon Reserve—for native Black Howler Monkeys). This is not always possible as with the case of the Bladen Nature Reserve (BNR), where its category of strict protection prevents even eco-tourism as a means of alternative livelihoods for locals.

One model for increasing local involvement is to train and incorporate "parataxonomists" into research and monitoring projects. The "parataxonomist", a term first coined by Janzen (1991 and 1993) refers to any person who lacks a formal, higher-level education, but who is trained to carryout biological field research, typically insect inventories. More recently, parataxonomists have an expanded role, including species monitoring rather than just inventory, as applied in Guyana, Gabon, and Papua New Guinea (Basset et al. 2004). The term, "parabiologists", rather than just parataxonomists, better describes the role of these highly trained local people (Sheil and Lawrence 2004).

In December 2005, we sighted the first confirmed record of a Harpy Eagle (see Appendix for scientific names) in the BNR of the Maya Mountains, and only the sixth in the entire country since 1980 (Vargas et al. 2006). The Harpy was confirmed as a juvenile which indicated a potentially active nest in the area where Harpy Eagles were considered to be locally extinct. The sighting is noteworthy for the species (Belize country status: Critically Endangered, IUCN Designation: Near Threatened). However, from a broader, scientific standpoint, potential Harpy Eagle nest sites in the BNR suggest that the region is productive enough, large enough, and diverse enough to support a variety of top predators (Touchton et al. 2002).

Questions such as what ecosystems contribute the most to this productivity and diversity, and how these ecosystems are related at the local and regional scales remain unanswered. One way to examine these research-based questions is to initiate monitoring programs to collect baseline data, vital to both research and conservation (Latta et al. 2005). Therefore, we initiated the Integrated Community-Based Harpy Eagle and Avian Conservation Program for the Maya Mountains Massif.

Our goal is to build capacity for avian conservation in the Maya Mountains by enhancing the links between protected areas and their surrounding communities. To achieve this goal, our project began with a community-based alternative livelihood strengthening program for the development of a core group of avian technicians from buffer zone villages. Project objectives include:

(1) To build capacity by providing a community-based alternative livelihood strengthening program and provide the tools for the acquisition of science based skills related to work as parabiologists,

(2) To survey and monitor Harpy Eagles in the BNR,

(3) To survey and monitor neotropical migratory and resident birds in the BNR, providing baseline data and contributing to regional-scale bird conservation and sound management, and,

(4) To enhance environmental awareness of the Maya Mountains Massif and its biodiversity through our environmental education program.

From these objectives, we predict that we will make long-term changes in how monitoring and research is carried out in the BNR, and anticipate that through our avian monitoring, capacity building, and environmental outreach efforts, we will improve the relationship between local communities and reserves in the Maya Mountains as well as gain new knowledge for the Reserve.

As for our avian monitoring effort, we were interested in studying the avian community associated with riparian habitat because this habitat was the location of our original Harpy Eagle sighting. We hypothesized that undisturbed habitat of this type should support a species rich avian community, including a wide variety of bird species and top predators such as the Harpy. However, we were most interested in the composition of species at this site and at similar sites rather than simply the number of species. Because vegetation disturbance in a lowland tropical forest can bring about changes in the bird community, including increasing the number of "weedy" species (Rotenberg 2007), we hypothesized that Harpy Eagle would be absent from such a habitat, and that the bird community at a disturbed site would not be similar to more pristine areas. Past studies found these pristine forested areas in the BNR to have higher measures of alpha-diversity for tree species compared with similar forests in Central America, potentially indicating that the forest harbors high diversity of other taxa as well (Brewer and Webb 2002).

METHODS

Capacity Building: The Community-based Alternative Livelihood Strengthening Program

We created new linkages between local communities and the BNR by providing alternative economic opportunities that can co-exist with sustainable management goals. To achieve this, we initiated an avian training program for local participants consisting of training parabiologists (avian field technicians), who carried out the bird monitoring program and represent the future of a sustainable monitoring and research program in the BNR.

Training consisted of bird identification, both by sight and sound, as well as training in the avian monitoring techniques of point counts and mist net mark-recapture-release. Because sampling vegetation is also important to any bird study, parabiologists were also trained to take a variety of quantitative measurements to characterize habitat. In addition, parabiologists were trained in the use of maps, compass, and Global Positioning System (GPS).

Study Area

The study area is located in the Bladen Nature Reserve, Toledo District, Belize (Fig. 1). The BNR is the core conservation area within the Maya Mountains and measures 40 336 ha (99 673 acres). The BNR has the highest level of protection afforded to any protected area in Belize, with only scientific research and education programs allowed within its boundaries. The BNR has been highlighted as one of the most pristine, biodiversity-rich areas within Belize lying within the Mesoamerican hotspot for biodiversity (Olivet and Asquith 2004), at the convergence point of the nearctic bioregions of North America, the neotropical bioregions of South America, and the Greater Antillean bioregion of the Caribbean. At its most sheltered points, west of the karst hills, it has protection from many of the destructive storms that hit the Caribbean coastline. This results in a forest that has a little-disturbed structure, with tall trees of impressive stature and intact ecological systems.

The large number of ecosystems encompassed by the Nature Reserve adds to its value as a conservation area, as it protects species diversity across perhaps the greatest elevational range of any protected area in Belize. In terms of importance for connectivity, the BNR is a crucial link within the natural Maya Mountain corridor, with Cockscomb Basin Wildlife Sanctuary to the northeast, and with the Columbia River Forest Reserve to the southwest. Chiquibul National Park and Forest Reserve lie to the northwest, connecting to the protected areas system in Guatemala. With the rapid clearing of forested areas throughout Central America, the BNR is part of the last remaining large, relatively intact block of forest within the Selva Maya region (Meerman and Wilson 2005), stretching from Belize to Guatemala and Mexico.

Bird Surveys

We established three monitoring sites in 2007 and added a fourth in 2008. All sites were spaced at least 2–5 km apart from one another along the Bladen River in the Bladen River watershed. Site selection was determined from our original 2005 Harpy Eagle sighting, with one site located at this location. We matched this location with three other sites for replication that were assessed as high probability sites for supporting Harpy Eagles based on vegetation type and characteristics (S. Brewer and A. Muela, pers. comm.). Another site was established that was highly disturbed in comparison (Blue Pool). Each site included an area (about 25 ha) necessary for the placement of 12, 12 m x 3 m mist nets in three groups of four nets, separated by 100 m, and six point count locations, each of which were at least 250 m apart. Sites were named for their locations: Blue Pool, Calera, Cabrada de Oro (Oro), and Richardson.

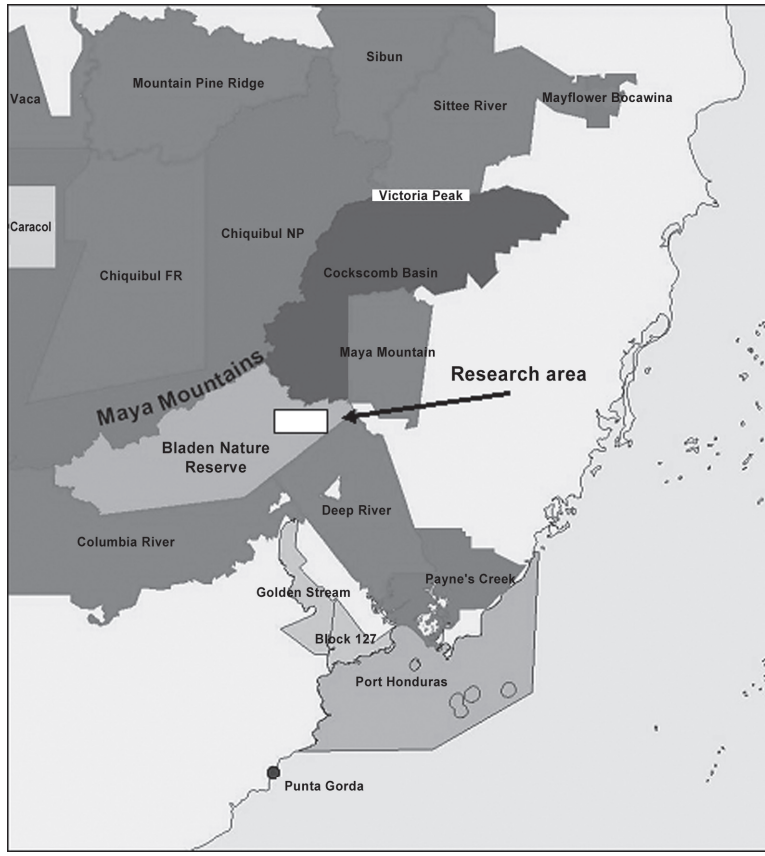

FIGURE 1. Map of study site within the Bladen Nature Reserve and the surrounding protected areas that make up the Maya Mountains Massif.

Mist net capture of birds began approximately 30 min after sunrise and continued until 30 min before sunset for two consecutive days per month (Ralph et al. 1993). For point counts, we sampled birds using a 25-m radius, 10-min point count, immediately followed by a 10-min area search (Hutto et al. 1986). We recorded species, detected by sight or sound, for birds actively using the habitat (i.e., not flyovers). Sampling began approximately 30 min after sunrise and was completed by 10:30 simultaneously on the same two mist net capture days per month.

Surveys were conducted January-May 2007 (Year 1 and pilot year) and December-May 2008 (Year 2). In addition to the bird community monitoring techniques described above, in Year 2 we established three raptor observation sites on top of canyon ridges in close proximity to our monitoring locations. Observations were made with a spotting scope, two-days per month at each of these locations from approximately 30 min after sunrise until dark, with sightings and behaviors recorded for all raptors.

Statistical Analysis

To determine if bird community patterns varied over the four riparian habitats, we measured species richness and species composition. We calculated richness as the mean number of bird species detected per point in each habitat, and used an ANOVA followed by Tukey's multiple comparison to test for differences between specific habitats.

Next, we used detrended correspondence analysis (DCA) based on bird species presence or absence in the point count data and banding datasets to calculate species composition at each site (Hill and Gauch 1980). Because this was only our second year (and only the first beyond our pilot year), we employed DCA to examine our data for early trends within the scope of our 5-yr monitoring efforts. DCA can yield a more biologically relevant analysis by accounting for the identity of each particular species in a sample and not just the sum of species found in each habitat as do species richness/diversity indices.

DCA is an ordination technique that simultaneously quantifies the association among a set of points (in this case our sites) by their similarities in species composition, and the association among species by the similarities of their distribution among those points. In other words, the resulting ordination yields a graph of points where proximity to each other denotes similarity in bird species composition.

Past studies from the region have also examined bird data using DCA, finding important patterns in the avian community (Deppe and Rotenberry 2005). For the ordination data matrix, we used bird species presence detected at each site's point count points as well as the banding data for the four sites (n = 28). We included the banding data because the set of bird species detected by point counts is not the same as that captured in mist nets. We calculated mean DCA point count scores to compare differences in species composition among our sites and tested these scores with ANOVA followed by Tukey's multiple comparison test.

Statistical analyses were completed with SPSS 15.0 statistical package (SPSS Inc. 2006) except for the DCA which was conducted with PCORD statistical software (McCune and Mefford 1999). The alpha level for each test was P = 0.05 unless otherwise noted, and all results are reported as mean ± 1 SE.

The Environmental Education Program

We developed an environmental education outreach program targeted for buffer zone communities adjacent to the Maya Mountains and the BNR. Our objective was to begin with primary/elementary level children by bringing our message of environmental conservation to schools. In particular, we addressed the importance of setting aside unspoiled lands as reserves for the benefit of species preservation (i.e., Harpy Eagles) and environmental services.

The program was developed in Year 1 and initiated in Year 2. Our school visit program consisted of three stations, with the stations spread outside in the school grounds. Classes were divided into three groups, each visiting a station and then rotating to the next. The stations focused on: 1) bird identification and point count surveys, 2) mist net capture and bird banding, and, 3) Harpy Eagle life history and ecology. At all three stations, we emphasized the importance of habitat conservation and the importance of the BNR for birds, all wildlife, forests, and people. Our main message was to convey the importance of the preservation of natural areas as they provide many life sustaining services for everyone, including fresh air, water, medicinal plants, enjoyment, and spiritual value. The program was conducted by our avian technician team and Belize Foundation for Research and Environmental Education (BFREE) staff.

RESULTS

The Bird Community

We identified 271 bird species during Year 1 of the project and an additional 11 species in Year 2. 183 bird species were identified during point count and/or mist net monitoring, and the remainder was identified by casual observation. Species included both neotropical migratory and resident species, some of which were previously undocumented in the reserve (Appendix). The 282 bird species identified during the project includes five species designated as "near threatened" on the IUCN Red List of Threatened Species for Belize and the Maya Mountains. These species are: Harpy Eagle, Solitary Eagle, Great Curassow, Cerulean Warbler, and Painted Bunting. Another species, Keel-billed Motmot is listed as "vulnerable."

We captured a total of 453 birds in Year 1 and 1033 birds in Year 2. Of the total for Year 2, 70% were newly captured and 30% were recaptures. Our capture rates for the four sites were similar as measured in birds caught per 100 mist net-hours, where a net-hour equals one net open for one hour. We found capture rates from a low of 18.5 birds/100 net-hours at Richardson and 23.9 at Oro, to 24.5 at Blue Pool and 26.7 at Calera, a difference of 33% from lowest to highest.

Many of our recaptures were the most common species found at each site. For example, examining species captured at least ten or more times per site shows that these species made up approximately half (49.6%) of all our captures in Year 2 (Table 1). Two neotropical migrants were also commonly captured and recaptured. These were Wood Thrush and Kentucky Warbler at 5.03% and 3.3% respectively of the total captured. These two species also made up 15.8% and 7.9%, respectively, of the total recaptured at our Richardson site.

For Year 1, mean bird species richness per point did not vary significantly among our three sites (F = 3.60, df = 2 and 15, P < 0.059). The Blue Pool site had the highest mean species richness (n = 36) and differed from the Oro site (n = 15.2), but not from our Richardson Creek site (n = 27).

In Year 2, our detrended correspondence analysis (DCA) showed a similar, but more informative relationship for bird species composition among our four sites (Fig. 2). First, the DCA1 axis shows a distinct separation between

TABLE 1. Species captured ten or more times per site during mist net mark–recapture. These species made up approximately half (49.6%) of all our captures in Year 2. Scientific names are given in the appendix.

Species	Percent of Total Captures
Ochre-bellied Flycatcher	11.5%
Long-billed Hermit	8.6%
Wedge-billed Woodcreeper	7.2%
Red-capped Manakin	7.1%
Wood Thrush	4.2%
Sulphur-rumped Flycatcher	4.1%
White-breasted Wood-Wren	2.8%
Thrush-like Schiffornis	2.1%
Tawny-winged Woodcreeper	2.0%
Total	49.6%

data sets representing the difference in bird species composition as detected by our two collection methods—banding and point counts. The DCA2 axis represents the differences among the bird communities at our four sites, with the point count data showing a highly significant difference (DCA2: $F = 15.72$, df = 3 and 24, $P < 0.001$). Post hoc comparisons showed the disturbed Blue Pool site differing from all other sites, while the three remaining sites were very similar to one another. Examination of the DCA2 axis also shows the banding data to be more similar to the point count data collected at Oro, Calera, and Richardson. However, at Blue Pool these data sets were somewhat different. For example, the disturbed site, Blue Pool lacked 14 species common to the other three sites. In addition, the non-disturbed sites of Oro and Calera were most similar to each other in composition, but different from the Richardson site which was missing nine species common to these two sites.

We confirmed five additional sightings of Harpy Eagles since our initial sighting in December 2005. All birds were identified as adults and our sightings were concentrated at two of our monitoring sites. The most recent sighting was a pair of birds at our Oro monitoring site.

Alternative Livelihood Strengthening Program

In Year 1, we selected two members of the Trio Village buffer zone community to be avian technicians. Neither had pervious birding experience. We also hired a Belizean (but not from a local community) with bird identification experience to conduct point count monitoring. Hands-on training for our team was conducted by the coauthors and partners and consisted of the following: 1) A two-week intensive training session on birding basics, bird identification techniques, individual species' songs and calls, and basic field methods; 2) A five-day workshop at BFREE on mist netting protocols, banding techniques, setting up permanent mist netting lanes, running a banding station, point count survey transects, and use of a RECON handheld advanced GPS; 3) Hands-on bird identification training for point counts in the field for five months with lead avian technician for point counts; 4) Hands-on mist net and banding training for two months with experienced bander; and, 5) Two-day

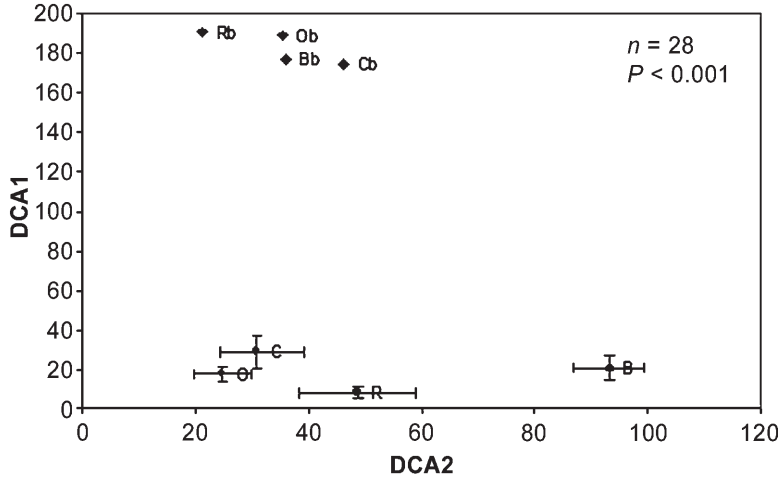

FIGURE 2. DCA of point counts (B, C, O, R) and banding sites (Bb, Cb, Ob, Rb) ($n = 28$) showing clear differences along DCA1 axis in species captured by mist nets vs. species detected on point count surveys. DCA2 axis shows differences in point count detections (mean DCA point scores ±SE), with our disturbed site (B), significantly different from the three undisturbed sites.

training session on Harpy Eagles at BFREE including information on life history traits and behavioral characteristics.

For Year 2, two of our three avian technicians returned to the project, and we added three new technicians for a total of five. This gave us technicians representing the buffer zone communities of Medina Bank, Indian Creek, Bladen Village, and Trio Village. The technician from Bladen Village is the first individual from this village hired to work with any local conservation NGO.

During Year 2, BFREE technicians were able to receive additional training and experience. These included: 1) Two of our original three technicians from Year 1 successfully passed a pre/post-field season science based course for in-country birder certification; 2) A 4-day, hands-on field course on bird banding and mist netting, with emphasis on handling and banding techniques; 3) A hands-on bird identification training for point counts and banding in the field for five months; and 4) Aerial over-flights for monitoring Harpy Eagles and to monitor for illegal activities.

Other capacity building activities included: 1) Coauthor Rotenberg and technician Mutrie co-presented at the Fourth International Partners in Flight (PIF) Conference held in McAllen Texas, February 13–16, 2008; 2) Technician Mutrie was invited to serve as the Belize Country PIF Program Coordinator, and now holds this position; 2) Technicians Mutrie and Garcia presented a poster on this project at the 2nd Natural Resource Management symposium held at the University of Belize, 11–12 June 2008; and 3) The technicians conducted a one-day seminar for a class of 15 university students visiting Belize from the U.S., providing instruction on mist netting, banding, and point count survey techniques as well as a lecture on the importance of monitoring in reserves such as the BNR.

The Environmental Education Program

Our environmental education program was well received during village visits to three buffer zone communities including Bladen Village, Medina Bank, and Trio Village. Our outreach program reached a total of 225 children during village school visits and visits by children to the BFREE field station in Year 2. Visits were conducted by our avian technicians in collaboration with the environmental education officer under an education program for the Maya Mountains administered by the Friends of Conservation and Development. Information about our bird project, the BNR and the Maya Mountains was presented in a series of educational stations as mentioned above (see Methods). At first, we found that many students and teachers knew very little about the BNR other than its protected status, and were rather shy about expressing themselves and participating. However, students had the chance to use binoculars, look through a spotting scope and/or identify birds in a field guide for the first time. This generated much more curiosity and by the end of the program both students and teachers alike were asking questions about the research, BFREE and the BNR.

The hands-on aspects of the program played a key role in gaining and maintaining student interest, all of whom are more accustomed to formal, in-class teaching styles. Leadership in the program by the avian technicians also provided important role models for the students, allowing the technicians to exhibit their skills and introducing the students to the concept of alternative job opportunities. Seeing people from their own villages developing new skills and involved in important research sets an example for Belizean youth.

A heightened interest in our project and field station by the village communities initiated several visits by students to our BFREE research site. Students were introduced to the field station, including activities for the students to learn and participate in hands-on activities such as river ecology, bird banding, a jungle walk and a scavenger hunt. They also learned about organic gardens, shade grown cacao, and alternative energy sources that are central to BFREE station. The genuine excitement and curiosity that students and teachers expressed at the end of the programs led us to believe that we were successful in developing a heightened awareness for the importance of conservation in these buffer communities.

DISCUSSION

Through our integrated program, we were able to train five avian field technicians (parabiologists) from buffer zone communities of the BNR, and at the same time, quantify vital, baseline data in the Reserve. To our knowledge, no past study has examined the avian community of the BNR to this extent (Brokaw and Lloyd-Evans 1987, Iremonger and Sayre 1994), and at the same time, brought about a successful alternative livelihood strengthening program. Though a new paradigm for the co-management of parks and protected areas that brings benefits to local communities exists (Lane 2001), ours is the only program operating in a strictly protected park in Belize.

The Bird Community

Our bird data show comparable results with past studies completed in the region, and have extended the number of known bird species for the BNR beyond the original expeditions and surveys (Brokaw and Lloyd-Evans 1987, Iremonger and Sayre 1994) that provided lists of species that eventually helped the BNR receive its protective status. In addition, our capture rates are similar to rates found in Secondary broadleaf and Karst hill broadleaf forests in Central Belize with 21.9 and 25.5 birds captured/100 net hours. However, riparian data from this region show higher capture rates than ours at 32.3 birds/100 net-hours. This may be due to differences in habitat types found from north to south along a longitudinal gradient within Belize and the region. Still, the percent captures for common migratory species were comparable. For example, our Wood Thrush capture rates were nearly equal (5.9%), while our Kentucky Warbler capture rates were twice the rate (1.6%) in Central Belize (Piaskowski et al. 2005). In addition, we have information on over-winter site fidelity for these migratory species in our area. Wood Thrush and Kentucky Warbler were recaptured on average 9.5% and 5.6% respectively at our non-disturbed sites, and both were common during our point count surveys. We highlight these migrants as both species are listed on the Partners in Flight watch list for Species of Continental Importance (Rich et al. 2004). With continued monitoring, we hope to fill in gaps in our knowledgebase for these two species wintering in Belize and plan to enhance our study by monitoring the fall migration as well as the over-winter and spring migration periods.

Also through our bird monitoring efforts, we have detected habitat heterogeneity in an area that is seemingly uniform. First of all, our use of both mist net captures and point count observations enabled us to examine these parameters for comparison. Past studies in the region have shown the utility of using both mist net capture and point counts for avian monitoring because certain species will only be included in one census type or the other (Rappole et al. 1998). The DCA analysis of our datasets clearly supports this claim. Next, both our species composition and species richness data show differences among our sites compared to the disturbed site (Blue Pool). Though the disturbed site had the highest species richness, its composition lacked 14 species common to the other three sites. Since 2000, four major disturbances (one high intensity flood, two low-to-moderate floods, and Hurricane Iris) occurred in the BNR that would have greatly disturbed this site (Klinger 2006), and the variation we detected in our bird data confirms this. Many of the additional species that contributed to this site's higher species richness were weedy generalists, common to disturbed sites. Though large-scale disturbances such as these can affect wide areas within the landscape matrix, variation in the severity of those effects can and did occur in the Maya Mountains (Klinger 2006). Past studies have found decreased bird diversity in response to disturbance at intermediate (1–25 ha) scales; and over larger spatial scales, disturbance tends to create mosaics of disturbance intensities over the landscape resulting in greater species diversity (Hill and Hamer 2004). Though preliminary, our data suggest that disturbance among our sites was not equivalent, and that the relationship between species diversity and species turn-over may be a good indicator of changes in species community composition including a habitat's ability to sustain a top predator such as the Harpy Eagle.

Finally, we also validated our hypothesis concerning where we might encounter Harpy Eagles. Harpy Eagle sightings were located only at undisturbed sites. These preliminary sightings suggest that the pristine condition of large forested areas in the BNR supports Harpy Eagles because it is relatively undisturbed (compared to other nearby reserves) and far from human perturbations. However, Harpy Eagles in Belize (released individuals in the north) can be found living in disturbed habitat near villages and cattle pastures with remnant trees as these areas can provide easily caught prey (C. Hatten and S. Matola, pers. comm.). Therefore, our sightings in an area where Harpies were thought to be extinct may be the result of the high level of protective status give to the BNR that has preserved Harpy Eagles from hunting pressures. Further monitoring is needed to better evaluate the role of management and the preservation of top predators like the Harpy.

Alternative Livelihood Strengthening and Environmental Outreach Programs

We could not be more satisfied with the accomplishments of our avian technician team and the success of our alternative livelihood strengthening and environmental outreach components. Team members became knowledgeable with the many benefits of protected areas within the Maya Mountains. In particular, they learned the rules and regulations pertaining to the BNR, and the importance of preserving the integrity of this undisturbed and biologically diverse area. By word of mouth from our

avian technicians and/or from our environmental outreach, buffer zone community members began to recognize that the Reserve had worth to them not just to foreign scientists. Villagers realized that the Reserve was providing economic benefits and valuable opportunities for community members, and many preconceived notions about the Reserve and our field station (BFREE) were discarded. Though we do not yet have a mechanism to assess these attitudes quantitatively (i.e., questionnaire), the qualitative feedback that we and our avian technician team received has been positive. For example, before project implementation, many buffer community members were simply unaware of BFREE's existence or the BNR, its boundaries, and the benefits of keeping parks and reserves intact. So far, this project has provided a framework in which community members from five local villages became aware of the Reserve in a new light, and how we are working to conserve the biodiversity and cultural heritage of the BNR, while providing for alternative livelihood strengthening and economic benefits to locals.

The Future—Serving as a Model and Contribution to Conservation and Management

Our work completed over the past two years has provided many lessons, challenges, and opportunities for such a large scale initiative, and our plan is to place our avian project within a larger framework for conservation monitoring in the Maya Mountains. We believe that our integrated science-based program will serve as a model for future efforts in the Maya Mountains. Already, our efforts have been recognized by governmental agencies and non-governmental organizations specifically for our integrative approach, and our monitoring, which will provide the first long-term dataset for avian assessment and management for the park. In particular, we are working with a group of stakeholders to develop a Research, Inventory, and Monitoring Program for the MMM. Our vision is to see parabiologists trained to work along side scientists studying a variety of taxa, from plants and insects to mollusks, mammals, and more, where each study contains similar components—science, livelihood strengthening, training, and environmental education outreach—all with the participation of local communities within the reserve system of the Maya Mountains. Conservation programs that include local people in the management of a protected area tend to be successful while others that do not fail. We can recommend this strategy to others who may also find themselves in a similar situation where a protected area is off-limits to visitation, ecotourism, etc. Nothing substitutes for first-hand participation with a program such as this, which can transform "ordinary" people into conservation advocates. For example, though we have identified several hundred bird species, we believe that the BNR supports many more, and may include additional rare species besides Harpy Eagles. Already, we have observed Solitary Eagle and Cerulean Warbler, both new species for the reserve in 2008, and listed as "near threatened" for Belize and the Maya Mountains. Both species were initially sighted by our Belizean technicians, whom we believe are far from ordinary.

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APPENDIX. All bird species observed during the study. Those detected by banding or point counts are noted. Species with IUCN status near threatened are also noted.

Genus	Species	Common Name	Banding	Point Count	IUCN
Tinamus	*Major*	Great Tinamou		x	
Crypturellus	*Soui*	Little Tinamou		x	
Crypturellus	*boucardi*	Slaty-breasted Tinamou		x	
Anhinga	*anhinga*	Anhinga			
Tigrisoma	*mexicanum*	Bare-throated Tiger-Heron			
Ardea	*herodias*	Great Blue Heron			
Ardea	*Alba*	Great Egret			
Egretta	*thula*	Snowy Egret			
Egretta	*caerulea*	Little Blue Heron			
Bubulcus	*ibis*	Cattle Egret			
Butorides	*virescens*	Green Heron			
Agamia	*agami*	Agami Heron			
Nyctanassa	*violacea*	Yellow-crowned Night-Heron			
Cochlearius	*cochlearius*	Boat-billed Heron			
Mycteria	*americana*	Wood Stork			
Coragyps	*atratus*	Black Vulture			
Cathartes	*aura*	Turkey Vulture			
Sarcoramphus	*papa*	King Vulture			
Cairina	*moschata*	Muscovy Duck			
Anas	*discors*	Blue-winged Teal			
Pandion	*haliaetus*	Osprey			
Chondrohierax	*uncinatus*	Hook-billed Kite			
Elanoides	*forficatus*	Swallow-tailed Kite			
Harpagus	*bidentatus*	Double-toothed Kite			
Ictinia	*plumbea*	Plumbeous Kite			
Geranospiza	*caerulescens*	Crane Hawk			
Leucopternis	*albicollis*	White Hawk		x	
Asturina	*nitida*	Gray Hawk		x	
Accipiter	*striatus*	Sharp-shinned Hawk			
Buteogallus	*anthracinus*	Common Black-Hawk			
Buteogallus	*urubitinga*	Great Black-Hawk		x	
Harpyhaliaetus	*solitarius*	Solitary Eagle			x
Buteo	*magnirostris*	Roadside Hawk	x		
Harpia	*harpyja*	Harpy Eagle			x
Spizastur	*melanoleucus*	Black-and-white Hawk-Eagle			
Spizaetus	*tyrannus*	Black Hawk-Eagle			
Spizaetus	*ornatus*	Ornate Hawk-Eagle		x	
Micrastur	*ruficollis*	Barred Forest-Falcon	x	x	
Micrastur	*semitorquatus*	Collared Forest-Falcon			
Herpetotheres	*cachinnans*	Laughing Falcon		x	
Falco	*femoralis*	Aplomado Falcon			
Falco	*rufigularis*	Bat Falcon		x	
Ortalis	*vetula*	Plain Chachalaca		x	
Penelope	*purpurascens*	Crested Guan		x	
Crax	*rubra*	Great Curassow		x	x
Odontophorus	*guttatus*	Spotted Wood-Quail			
Dactylortyx	*thoracicus*	Singing Quail		x	
Laterallus	*ruber*	Ruddy Crake			
Aramides	*cajanea*	Gray-necked Wood-Rail			
Heliornis	*fulica*	Sungrebe			
Aramus	*guarauna*	Limpkin			
Jacana	*spinosa*	Northern Jacana			
Tringa	*solitaria*	Solitary Sandpiper			
Actitis	*macularia*	Spotted Sandpiper			
Patagioenas	*cayennensis*	Pale-vented Pigeon		x	
Patagioenas	*nigrirostris*	Short-billed Pigeon		x	
Patagioenas	*speciosa*	Scaled Pigeon		x	
Columbina	*talpacoti*	Ruddy Ground-Dove		x	
Claravis	*pretiosa*	Blue Ground-Dove		x	
Leptotila	*verreauxi*	White-tipped Dove	x	x	
Leptotila	*rufaxilla*	Gray-fronted Dove	x	x	
Leptotila	*cassini*	Gray-chested Dove	x	x	

APPENDIX. CONTINUED.

Genus	Species	Common Name	Banding	Point Count	IUCN
Geotrygon	*montana*	Ruddy Quail-Dove	x	x	
Aratinga	*nana*	Olive-throated Parakeet		x	
Ara	*macao*	Scarlet Macaw			
Pionopsitta	*haematotis*	Brown-hooded Parrot		x	
Pionus	*senilis*	White-crowned Parrot		x	
Amazona	*albifrons*	White-fronted Parrot		x	
Amazona	*autumnalis*	Red-lored Parrot		x	
Amazona	*farinosa*	Mealy Parrot		x	
Amazona	*oratrix*	Yellow-headed Parrot			
Coccyzus	*americanus*	Yellow-billed Cuckoo			
Piaya	*cayana*	Squirrel Cuckoo		x	
Otus	*guatemalae*	Vermiculated Screech-Owl			
Glaucidium	*griseiceps*	Central American Pygmy-Owl		x	
Ciccaba	*virgata*	Mottled Owl			
Chordeiles	*acutipennis*	Lesser Nighthawk			
Chordeiles	*minor*	Common Nighthawk			
Nyctidromus	*albicollis*	Common Pauraque		x	
Nyctibius	*jamaicensis*	Northern Potoo			
Streptoprocne	*zonaris*	White-collared Swift		x	
Chaetura	*vauxi*	Vaux's Swift		x	
Phaethornis	*longirostris*	Long-billed Hermit	x	x	
Phaethornis	*striigularis*	Stripe-throated Hermit		x	
Threnetes	*ruckeri*	Band-tailed Barbthroat	x		
Phaeochroa	*cuvierii*	Scaly-breasted Hummingbird			
Campylopterus	*curvipennis*	Wedge-tailed Sabrewing	x	x	
Campylopterus	*hemileucurus*	Violet Sabrewing	x		
Florisuga	*mellivora*	White-necked Jacobin	x	x	
Anthracothorax	*prevostii*	Green-breasted Mango			
Chlorostilbon	*canivetii*	Canivet's Emerald			
Thalurania	*colombica*	Violet-crowned Woodnymph	x		
Amazilia	*candida*	White-bellied Emerald	x	x	
Amazilia	*tzacatl*	Rufous-tailed Hummingbird	x	x	
Heliothryx	*barroti*	Purple-crowned Fairy		x	
Archilochus	*colubris*	Ruby-throated Hummingbird			
Trogon	*melanocephalus*	Black-headed Trogon	x	x	
Trogon	*citreolus*	Citreoline Trogon			
Trogon	*violaceus*	Violaceous Trogon		x	
Trogon	*collaris*	Collared Trogon		x	
Trogon	*massena*	Slaty-tailed Trogon	x	x	
Momotus	*momota*	Blue-crowned Motmot	x	x	
Electron	*carinatum*	Keel-billed Motmot		x	
Hylomanes	*momotula*	Tody Motmot	x	x	
Ceryle	*torquata*	Ringed Kingfisher			
Ceryle	*alcyon*	Belted Kingfisher			
Chloroceryle	*amazona*	Amazon Kingfisher	x	x	
Chloroceryle	*americana*	Green Kingfisher			
Chloroceryle	*aenea*	American Pygmy Kingfisher	x		
Notharchus	*macrorhynchos*	White-necked Puffbird		x	
Malacoptila	*panamensis*	White-whiskered Puffbird	x	x	
Galbula	*ruficauda*	Rufous-tailed Jacamar	x	x	
Aulacorhynchus	*prasinus*	Emerald Toucanet			
Pteroglossus	*torquatus*	Collared Aracari	x	x	
Ramphastos	*sulfuratus*	Keel-billed Toucan		x	
Melanerpes	*pucherani*	Black-cheeked Woodpecker		x	
Melanerpes	*aurifrons*	Golden-fronted Woodpecker		x	
Picoides	*scalaris*	Ladder-backed Woodpecker			
Veniliornis	*fumigatus*	Smoky-brown Woodpecker	x	x	
Piculus	*rubiginosus*	Golden-olive Woodpecker		x	
Celeus	*castaneus*	Chestnut-colored Woodpecker		x	
Dryocopus	*lineatus*	Lineated Woodpecker	x	x	
Campephilus	*guatemalensis*	Pale-billed Woodpecker	x	x	
Synallaxis	*erythrothorax*	Rufous-breasted Spinetail	x	x	
Automolus	*ochrolaemus*	Buff-throated Foliage-gleaner	x	x	
Anabacerthia	*variegaticeps*	Scaly-throated Foliage-gleaner		x	
Xenops	*minutus*	Plain Xenops	x		
Sclerurus	*guatemalensis*	Scaly-throated Leaftosser	x		
Dendrocincla	*anabatina*	Tawny-winged Woodcreeper	x	x	
Dendrocincla	*homochroa*	Ruddy Woodcreeper	x	x	

APPENDIX. CONTINUED.

Genus	Species	Common Name	Banding	Point Count	IUCN
Sittasomus	*griseicapillus*	Olivaceous Woodcreeper	x	x	
Glyphorynchus	*spirurus*	Wedge-billed Woodcreeper	x	x	
Dendrocolaptes	*sanctithomae*	Northern Barred-Woodcreeper	x	x	
Xiphorhynchus	*flavigaster*	Ivory-billed Woodcreeper	x	x	
Lepidocolaptes	*souleyetii*	Streak-headed Woodcreeper	x	x	
Taraba	*major*	Great Antshrike			
Thamnophilus	*doliatus*	Barred Antshrike		x	
Dysithamnus	*mentalis*	Plain Antvireo			
Microrhopias	*quixensis*	Dot-winged Antwren		x	
Cercomacra	*tyrannina*	Dusky Antbird	x	x	
Formicarius	*analis*	Black-faced Antthrush	x	x	
Ornithion	*semiflavum*	Yellow-bellied Tyrannulet		x	
Camptostoma	*imberbe*	Northern Beardless-Tyrannulet		x	
Myiopagis	*viridicata*	Greenish Elaenia	x	x	
Elaenia	*flavogaster*	Yellow-bellied Elaenia			
Mionectes	*oleagineus*	Ochre-bellied Flycatcher	x	x	
Leptopogon	*amaurocephalus*	Sepia-capped Flycatcher	x	x	
Zimmerius	*vilissimus*	Paltry Tyrannulet			
Oncostoma	*cinereigulare*	Northern Bentbill	x	x	
Poecilotriccus	*sylvia*	Slate-headed Tody-Flycatcher			
Todirostrum	*cinereum*	Common Tody-Flycatcher	x		
Rhynchocyclus	*brevirostris*	Eye-ringed Flatbill	x	x	
Tolmomyias	*sulphurescens*	Yellow-olive Flycatcher	x	x	
Platyrinchus	*cancrominus*	Stub-tailed Spadebill	x	x	
Onychorhynchus	*coronatus*	Royal Flycatcher	x	x	
Terenotriccus	*erythrurus*	Ruddy-tailed Flycatcher	x	x	
Myiobius	*sulphureipygius*	Sulphur-rumped Flycatcher	x	x	
Contopus	*virens*	Eastern Wood-Pewee		x	
Contopus	*cinereus*	Tropical Pewee		x	
Empidonax	*flaviventris*	Yellow-bellied Flycatcher	x	x	
Empidonax	*minimus*	Least Flycatcher		x	
Empidonax	*virescens*	Acadian Flycatcher	x		
Sayornis	*nigricans*	Black Phoebe			
Attila	*spadiceus*	Bright-rumped Attila	x	x	
Rhytipterna	*holerythra*	Rufous Mourner	x	x	
Myiarchus	*tuberculifer*	Dusky-capped Flycatcher	x	x	
Myiarchus	*crinitus*	Great Crested Flycatcher		x	
Myiarchus	*tyrannulus*	Brown-crested Flycatcher		x	
Pitangus	*sulphuratus*	Great Kiskadee			
Megarynchus	*pitangua*	Boat-billed Flycatcher		x	
Myiozetetes	*similis*	Social Flycatcher	x	x	
Myiodynastes	*maculatus*	Streaked Flycatcher		x	
Myiodynastes	*luteiventris*	Sulphur-bellied Flycatcher		x	
Legatus	*leucophaius*	Piratic Flycatcher		x	
Tyrannus	*melancholicus*	Tropical Kingbird			
Tyrannus	*couchii*	Couch's Kingbird			
Tyrannus	*tyrannus*	Eastern Kingbird			
Schiffornis	*turdinus*	Thrush-like Schiffornis	x	x	
Lipaugus	*unirufus*	Rufous Piha		x	
Pachyramphus	*cinnamomeus*	Cinnamon Becard		x	
Pachyramphus	*polychopterus*	White-winged Becard			
Pachyramphus	*major*	Gray-collared Becard			
Pachyramphus	*aglaiae*	Rose-throated Becard		x	
Cotinga	*amabilis*	Lovely Cotinga			
Tityra	*semifasciata*	Masked Tityra	x	x	
Tityra	*inquisitor*	Black-crowned Tityra		x	
Manacus	*candei*	White-collared Manakin	x	x	
Pipra	*mentalis*	Red-capped Manakin	x	x	
Vireo	*griseus*	White-eyed Vireo		x	
Vireo	*pallens*	Mangrove Vireo			
Vireo	*flavifrons*	Yellow-throated Vireo			
Vireo	*olivaceus*	Red-eyed Vireo			
Vireo	*flavoviridis*	Yellow-green Vireo	x	x	
Hylophilus	*ochraceiceps*	Tawny-crowned Greenlet	x	x	

APPENDIX. CONTINUED.

Genus	Species	Common Name	Banding	Point Count	IUCN
Hylophilus	*decurtatus*	Lesser Greenlet		x	
Vireolanius	*pulchellus*	Green Shrike-Vireo		x	
Cyanocorax	*morio*	Brown Jay		x	
Progne	*chalybea*	Gray-breasted Martin			
Stelgidopteryx	*ridgwayi*	Ridgway's Rough-winged Swallow	x		
Stelgidopteryx	*serripennis*	Northern Rough-winged Swallow		x	
Tachycineta	*albilinea*	Mangrove Swallow			
Thryothorus	*maculipectus*	Spot-breasted Wren	x	x	
Troglodytes	*aedon*	House Wren	x		
Henicorhina	*leucosticta*	White-breasted Wood-Wren	x	x	
Microcerculus	*philomela*	Nightingale Wren	x	x	
Ramphocaenus	*melanurus*	Long-billed Gnatwren		x	
Polioptila	*caerulea*	Blue-gray Gnatcatcher			
Polioptila	*plumbea*	Tropical Gnatcatcher		x	
Catharus	*minimus*	Gray-cheeked Thrush	x		
Catharus	*ustulatus*	Swainson's Thrush	x		
Hylocichla	*mustelina*	Wood Thrush	x	x	
Turdus	*grayi*	Clay-colored Robin	x	x	
Dumetella	*carolinensis*	Gray Catbird	x	x	
Mimus	*gilvus*	Tropical Mockingbird			
Dendroica	*petechia*	Yellow Warbler			
Dendroica	*pensylvanica*	Chestnut-sided Warbler	x	x	
Dendroica	*magnolia*	Magnolia Warbler	x	x	
Dendroica	*cerulea*	Cerulean Warbler			x
Dendroica	*caerulescens*	Black-throated Blue Warbler			
Dendroica	*coronata*	Yellow-rumped Warbler	x		
Dendroica	*graciae*	Grace's Warbler		x	
Dendroica	*virens*	Black-throated Green Warbler		x	
Dendroica	*dominica*	Yellow-throated Warbler			
Mniotilta	*varia*	Black-and-white Warbler	x	x	
Setophaga	*ruticilla*	American Redstart	x	x	
Protonotaria	*citrea*	Prothonotary Warbler			
Helmitheros	*vermivorus*	Worm-eating Warbler	x	x	
Limnothlypis	*swainsonii*	Swainson's Warbler			
Seiurus	*aurocapillus*	Ovenbird	x		
Seiurus	*noveboracensis*	Northern Waterthrush	x		
Seiurus	*motacilla*	Louisiana Waterthrush	x	x	
Oporornis	*formosus*	Kentucky Warbler	x	x	
Oporornis	*philadelphia*	Mourning Warbler			
Geothlypis	*trichas*	Common Yellowthroat	x		
Wilsonia	*citrina*	Hooded Warbler	x	x	
Wilsonia	*pusilla*	Wilson's Warbler	x	x	
Icteria	*virens*	Yellow-breasted Chat	x		
Eucometis	*penicillata*	Gray-headed Tanager	x	x	
Lanio	*aurantius*	Black-throated Shrike-Tanager	x	x	
Habia	*rubica*	Red-crowned Ant-Tanager	x	x	
Habia	*fuscicauda*	Red-throated Ant-Tanager	x	x	
Piranga	*roseogularis*	Rose-throated Tanager			
Piranga	*flava*	Hepatic Tanager			
Piranga	*rubra*	Summer Tanager	x	x	
Piranga	*olivacea*	Scarlet Tanager			
Piranga	*leucoptera*	White-winged Tanager			
Ramphocelus	*sanguinolentus*	Crimson-collared Tanager	x	x	
Ramphocelus	*passerinii*	Passerini's Tanager			
Thraupis	*episcopus*	Blue-gray Tanager		x	
Thraupis	*abbas*	Yellow-winged Tanager		x	
Euphonia	*affinis*	Scrub Euphonia		x	
Euphonia	*hirundinacea*	Yellow-throated Euphonia	x	x	
Euphonia	*gouldi*	Olive-backed Euphonia	x	x	
Tangara	*larvata*	Golden-hooded Tanager			
Chlorophanes	*spiza*	Green Honeycreeper			

APPENDIX. CONTINUED.

Genus	Species	Common Name	Banding	Point Count	IUCN
Cyanerpes	*cyaneus*	Red-legged Honeycreeper		x	
Sporophila	*americana*	Variable Seedeater	x		
Sporophila	*torqueola*	White-collared Seedeater	x		
Oryzoborus	*funereus*	Thick-billed Seed-Finch	x		
Arremon	*aurantiirostris*	Orange-billed Sparrow	x	x	
Arremonops	*chloronotus*	Green-backed Sparrow	x		
Saltator	*coerulescens*	Grayish Saltator		x	
Saltator	*maximus*	Buff-throated Saltator	x	x	
Saltator	*atriceps*	Black-headed Saltator		x	
Caryothraustes	*poliogaster*	Black-faced Grosbeak		x	
Pheucticus	*ludovicianus*	Rose-breasted Grosbeak			
Cyanocompsa	*cyanoides*	Blue-black Grosbeak	x	x	
Cyanocompsa	*parellina*	Blue Bunting			
Passerina	*caerulea*	Blue Grosbeak	x		
Passerina	*cyanea*	Indigo Bunting	x	x	
Passerina	*ciris*	Painted Bunting	x		x
Dives	*dives*	Melodious Blackbird	x	x	
Quiscalus	*mexicanus*	Great-tailed Grackle			
Molothrus	*oryzivorus*	Giant Cowbird			
Icterus	*prosthemelas*	Black-cowled Oriole		x	
Icterus	*spurius*	Orchard Oriole			
Icterus	*mesomelas*	Yellow-tailed Oriole			
Icterus	*graduacauda*	Audubon's Oriole			
Icterus	*galbula*	Baltimore Oriole			
Amblycercus	*holosericeus*	Yellow-billed Cacique		x	
Psarocolius	*wagleri*	Chestnut-headed Oropendola		x	
Psarocolius	*montezuma*	Montezuma Oropendola		x	