ECOLOGICAL IMPACTS OF SILVICULTURAL TRIALS IN THE RIO BRAVO CONSERVATION AND MANAGEMENT AREA, BELIZE

Pre-treatment and proposed post-treatment studies

Porgramme for Belize
2 South Park Street
Belize City, Belize

In 1994 the Forest Planning and Management Project (FPMP) established silvicultural trial plots in the Hill Bank section of the Rio Bravo Conservation and Management Area, Belize. The goal of the trials is to evaluate the impact on tree growth and recruitment of a more intensive tree harvest than is normal in traditional selective felling in Belize. Another concern is the impact of this harvest on habitat structure and biological diversity. Thus, before the harvest took place, in early 1995, Programme for Belize and Manomet Observatory measured forest structure and canopy openness on the plots and surveyed birds and butterflies.

Birds are a good index of forest disturbance because they are sensitive mainly to habitat structure, for example the number of foliage layers in a forest. Butterflies, on the other hand, are sensitive to plant species composition. Both structure and plant species composition are likely to be altered by tree harvest. Thus Birds and butterflies together can indicate impact on forest fauna.

This document summarizes results of the pre-harvest studies in the silvicultural plots and describes post-harvest work proposed for 1996.

STUDY AREA AND PLOTS

The Hill Bank study area (c. 17°35' N, 88°44' W) is near the southwestern tip of the New River Lagoon, in the Rio Bravo Conservation and Management Area (RBCMA) near Hill Bank, southeastern Orange Walk District, Belize. The area is in the ***subtropical moist*** life zone and receives about 1500 mm of rain a year. A dry season extends from January to early May, although the amount of rainfall in the dry and wet seasons may vary greatly from year to year. The soils are shallow to moderately deep clays and are

underlain by porous limestone. Year-round surface water is rare. The topography is relatively flat, punctuated with low (5-10 m) hills. The upland forest in the area averages 21 m in height, with emergent trees to 30 m. A few species are deciduous in the dry season.

Since the early 1800s, mahogany (*Swietenia macrophylla*) and Spanish cedar (*Cedrela mexicana*) have been selectively logged at low intensities throughout northwestern Belize. Stands that were logged 10 or more years ago have an intact canopy. This has reduced mahogany and Spanish cedar abundance, but does not appear to have altered the forest significantly. Although there is no clear record of hurricane damage within the last 50 years, hurricanes have undoubtedly had a significant effect on the ecology of this forest.

Two 18-ha (600 x 300m, partly gridded at 20 m intervals) silvicultural plots were established, one each at Punta Gorda (PG) and Marimba (MA). PG is about 5 km northeast of Hill Bank. The soils at PG are rocky and shallow in places and on a 0-5% slope. Several mahogany were removed from this plot about ten years ago. MA is 4 km southwest of Hill Bank. The soils at MA are moderately deep, and some poorly drained areas support a short swamp forest. A few trees may have been logged from this plot about ten years ago.

The FPMP marked, mapped, and identified trees throughout the 18 ha of each plot. Larger and smaller diameter classes were enumerated in interior hectare plots; only larger trees were enumerated in exterior hectares. In the experimental harvest, six trees were removed from each hectare in one nine-ha half of each 18-ha plot .

METHODS

Forest structure. The FPMP placed stakes at 20 m intervals around the perimeter and throughout much of the interior of each 18 ha study plot, forming a partially installed 20 x 20 m grid system for much of each plot. In areas within the plots not staked by the FPMP we temporarily located the unmarked 20 m points, using a compass to determine orientation of gridlines and a "hip chain" to determine distance to. At every other point (i.e., half the points in the plot, as opposed to all points in the FPMP plots in Chiquibul), staked by the FPMP or temporarily located by us, we measured:

a) *canopy height* - height of the uppermost vegetation directly above the grid point, measured with a rangefinder;
b) *canopy openness* - the amount of canopy cover in the area above a point, measured with a spherical densiometer, a concave mirror held horizontal to the ground, reflecting the canopy above in a fish-eye view, and engraved with gridlines that allow the viewer to quantify the amount of open space visible in the reflection. Openness at a given point is taken here as the average of two readings made by a viewer standing at the point and making readings

Birds: Netting. Twelve mist-nets were deployed in each study site as shown in Figure 2. The mist-nets were 12 x 2.6 m, 4-panels, and constructed of black nylon (AFO ATX 36 mm extended mesh). One half of each study site was netted for two consecutive days, followed by two days netting in the other half, within the period 11 February - March 1995. Nets were opened, weather permitting, between 06:15 - 06:30 and closed 17:00 - 18:00. The number of hours the nets were opened was recorded each day, providing a standardized measure of effort. Thus nets were open for nearly all daylight hours for a two-day period on each half plot, maximizing captures and recaptures in this intensive period, but minimizing bias due to net-shyness which might be expected to rise, the longer nets were maintained in the same locations.

Nets were checked every hour and birds brought back to a central banding table for processing. All birds were banded with a uniquely numbered aluminum band on the right tarsus, and additional individual combinations of plastic color-bands placed on those species that were common, had small territories and were thus likely candidates for resighting for behavioral observations. Data collected on each capture or recapture included: natural wing chord (mm), weight to the nearest 0.5 g, fat class, degree of skull ossification, presence of brood patch or cloacal protuberance, age and sex, capture panel, location and time. Birds were returned to the capture location to avoid displacement or territorial conflicts.

Birds: censuses (point counts). At each of the silvicultural plots 12 census point counts, each spaced 100 m apart, were set up in each of the plots (Fig. 1). An observer experienced with Belizean bird calls and field marks was assisted by 1-2 data recorders. Each point was censused for 10 minutes, starting at least one minute after arrival so birds could acclimate to observer disturbance in reaching the point. We used the fixed radius method: birds seen or heard within a 50 m radius of the census point were recorded as either <25 m from the point, or 25-50 m from the point. The time of each observation was recorded. Each study plot was censused on 3 consecutive days, between 06:00 and 09:00. The origin and the order of visits to points changed each day so that each point was visited once in the first hour, once in the second hour, and once in the third hour of a morning sample period. Plots were censused between 21 February and 1 March 1995.

Butterflies. Butterflies were sampled by trapping and by censusing in circular plots in both halves of the trial plots (Fig. 3). Three plots were located in the zone of selective logging, three were adjacent to the zone of selective logging, and three were 200 m away (Fig. 3). The butterfly report has been delayed, pending species identifications from the Smithsonian Institution. A provisional list is given in Appendix A.

RESULTS AND DISCUSSION

Forest structure. Canopy height was greater at MA (mean = 16.5 m, sd = 3.5, n = 64) than at PG (mean = 14.4 m, sd = 3.3, n = 112) (ANOVA: $F = 16.73$, $df = 175$, $P<0.001$. Canopy openness was greater at MA (mean = 7.7%, sd = 3.0, n = 64) than at PG (mean = 7.0%, sd = 1.7, n = 112)(ANOVA: $F = 5.2$, $df = 175$, $P = 0.024$). Although the canopy is taller at MA, it can still be more broken, if it is an older forest in which larger trees have

started die, producing more large gaps. The MA site is also on swampy soil, in which trees may be unstable.

Bird communities: mist-netting. As with the bird census data we made two comparisons of bird communities using mist-netting data. First, we compared sites (MA versus PG) to determine if both sites had similar frequencies of individuals within each species, taxonomic family, foraging guild, and migratory status. Particular species occurred with the same frequency ($\chi^2 = 43.6$, df = 37, p = 0.21) at both sites, as did guilds ($\chi^2 = 4.94$, df = 4, P = 0.29). However, different taxonomic families did not occur at the same frequency at both sites (Fig. 4a; $\chi^2 = 23.3$, df = 11, p = 0.02). There were more individuals in the family Troglodytidae (wrens) at PG than MA and more individuals in the family Muscipidae (thrushes) at MA than PG. Likewise, more migrants occurred more frequently at MA than PG (Fig. 4b; $\chi^2 = 5.15$, df = 1, p = 0.02). These differences in part can be attributed to the fact that Wood Thrushes, a migrant and member of the family Muscipidae, occurred much more frequently at MA (n = 31) than PG (n = 9). The mist-net data confirm the census data: the greatest difference between these two sites was in the frequency of occurrence of some species, especially the Wood Thrush.

In the second comparison, we compared to-be-logged treatment halves of the plots (areas logged after the bird survey work) with the unlogged plot halves within each site to determine if any differences occurred before logging, to verify if the unlogged half was similar enough to the to-be-logged half to be a valid control. We did not find any differences in the frequency of species between to-be-logged and unlogged halves at MA ($\chi^2 = 42.9$, df = 33, p = 0.11) or PG ($\chi^2 = 27.0$, df = 30, p = 0.62). There were no differences between logged and unlogged halves in the frequency of individuals in different families in MA ($\chi^2 = 18.9$, df = 11, p = 0.06) or PG ($\chi^2 = 10.4$, df = 9, p = 0.32). There were no differences between logged and unlogged halves in the frequency of individuals in different guilds at MA ($\chi^2 = 6.84$, df = 4, p = 0.15) and PG ($\chi^2 = 3.27$, df = 4, p = 0.51). There not differences between logged and unlogged in the frequency of migrants or residents in halves in MA ($\chi^2 = 0.1.53$, df = 1, p = 0.22) or PG ($\chi^2 = 0.02$, df = 1, p = 0.88). We also found that the number of species and individuals caught at each net was the same for logged and unlogged halves. As with the census data, mist-netting data suggest that there were no differences in the bird communities between logged and unlogged halves before logging.

Birds communities : census data. We made two kinds of comparisons with the census data. First, we compared sites (MA versus PG) to determine if both sites had similar frequencies of individuals within each species, taxonomic family, foraging guild, and migratory status. Some species occurred at different frequencies at MA and PG ($\chi^2 = 165.3$, df = 105, p = 0.001). Red-billed Pigeon, Dot-winged Antwren, Scaled Pigeon, Gray Catbird, Wood Thrush, and Tawny-crowned Greenlet were much more common in MA than PG. Yellow-bellied Tyrannulet, Red-legged Honey , Creeper, Brown-hooded Parrot, Spot-breasted Wren, and Black-headed Trogon were much more common in PG than MA. However, both sites had the same frequency of individuals in different guilds ($\chi^2 = 3.89$, df = 6, p = 0.69) and in different families ($\chi^2 = 28.9$, df = 22, p = 0.15).

Migrants occurred more frequently than residents at MA compared to PG (Fig. 4c; $\chi^2 = 3.40$, df = 1, p = 0.07), probably because Wood Thrushes were more frequently detected at MA (n = 25) than PG (n = 11). Thus the census data suggest that the greatest difference between these two sites was in the frequency of occurrence of some species, especially the Wood Thrush.

In the second comparison, we compared logged (areas logged after the bird survey work) and unlogged plots within each site to determine if any differences occurred before logging, and thus to verify if the unlogged portion was similar enough to the logged portion to be a valid control. The frequencies of different species were similar for logged and unlogged plots at MA ($\chi^2 = 92.6$, df = 88, p = 0.35) and PG ($\chi^2 = 94.3$, df = 80, p = 0.13). The frequencies of different no families were similar between logged and unlogged in MA ($\chi^2 = 16.4$, df = 19, p = 0.63) and PG ($\chi^2 = 28.3$, df = 19, p = 0.08). The frequencies of different guilds was similar between logged and unlogged in MA ($\chi^2 = 8.42$, df = 6, P = 0.21) and PG ($\chi^2 = 18.2$, df = 6, $p<0.01$). Likewise, the frequencies of migrants were similar in logged and unlogged plots in MA ($\chi^2 = 0.13$, df = 1, p = 0.72) and PG ($\chi^2 = 0.10$, df = 1, p = 0.75). We also found that the total number of species and individuals detected at each net were the same for logged and unlogged plots. The census data suggest that there were no differences in the bird communities between logged and unlogged plot halves before logging.

Summary of Bird Results. The ten most common species caught in mist-nets (from most to least common) were Wood Thrush, Ruddy Woodcreeper, White-breasted Wood-wren, Red-throated Ant-Tanager, Kentucky Warbler, Stub-tailed Spadebill, Red-capped Manakin, Olivaceous Woodcreeper, Tawny-crowned Greenlet, Gray Catbird, Ochre-bellied Flycatcher, and Thrush-like Manakin (the last three species tied for tenth rank). Species in the family Emberizidae (sparrows and allies, warblers, tanagers, and orioles), Dendrocolaptidae (woodcreepers), and Tyrannidae made up over 60% of the individuals captured (Fig. 5a). Individuals in the insect, fruit-eating, and small insect-eating foraging guilds made up over 80% of the individuals captured (Fig. 5b). Migrants comprised just over 30% of the individuals captured (Fig. 5c).

The ten most common species detected on point counts (from most to least common) were White-breasted Wood-wren, Lesser Greenlet, Gray Catbird, Northern Bentbill, Magnolia Warbler, Wood Thrush, Red-legged Honeycreeper, Black-faced Ant-thrush, Kentucky Warbler, and White-bellied Emerald. Species in the family Emberizidae (sparrows and allies, warblers, tanagers, and orioles), Tyrannidae (flycatchers), and Vireonidae (vireos and greenlets) comprised over 60% of the individuals detected (Fig. 6a). Individuals in the insects and fruits-eating, and in the small insect-eating foraging guilds made up over 70% of the individuals detected (Fig. 6b). About 25% of the individuals detected were migrants(Fig. 6c).

CONCLUSIONS

The results suggest that MA and PG differ in their vegetation structure and bird communities. The mist-netting data suggested that the sites had different frequencies in

the number of individuals of different species and of different families. Mist-netting and point count data both suggest that Marimba had more migrants than Punt Gorda.

By contrast, comparisons between plot halves within each 18 ha plot suggest that the halves are similar and are therefore suitable for treatment-control comparisons. Numbers of individual species, individuals in different families, foraging guilds, and migratory status guilds occurred with similar frequency between logged and unlogged plots in Marimba and in Punta Gorda. Species richness and total numbers of individuals of all species were also the same between logged and unlogged plots in Marimba and in Punta Gorda.

PROPOSED RESEARCH FOR 1996

In 1996 we propose to repeat the studies we made in 1995 (except mist-netting, see below), to include field work on forest structure and on bird and butterfly communities. Results from the 1995 field season provide a picture of forest structure and bird and butterfly communities before the harvest in the silvicultural trial plots. The harvest took place shortly afterwards. Results from 1996 will give us the first view of forest structure and birds and butterflies after harvest. Comparing 1995 and 1996 results will suggest how the harvest has affected the habitat and fauna within. Since we have studied both treatment and control halves of the silvicultural plots we will also be able to make that contemporaneous comparison as an indicator of the effect of the treatments. Also, by comparing the same control halves in 1995 and 1996 we will be able to detect any changes over that period that are not due to harvest. Although the butterfly data are not worked up yet, we expect to analyze and develop it eventually.

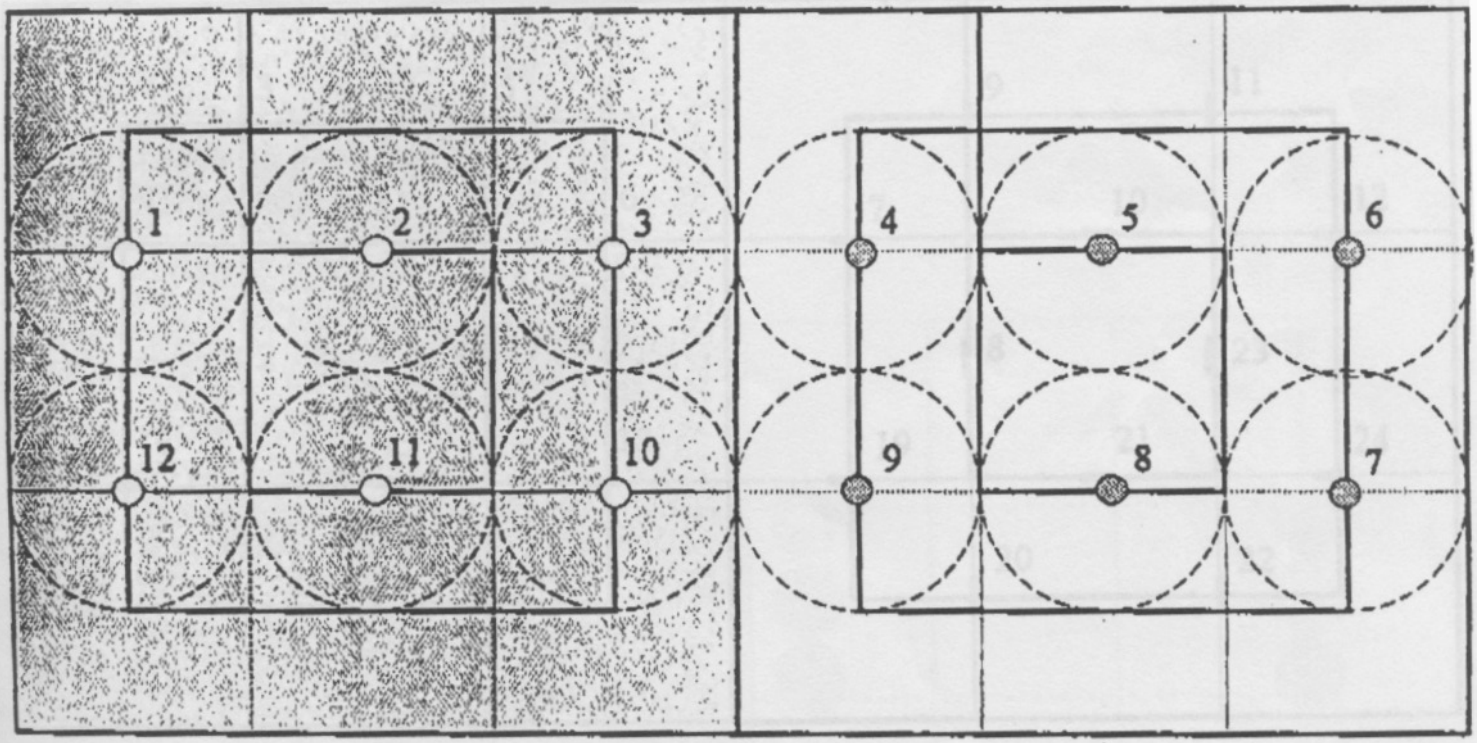
The studies will be repeated in exact detail, except that there will be no mist-netting. Mist-netting requires expertise and is labor intensive, and it is too late to raise the money and assemble people for that job. Although censusing and mist-netting are complementary methods, detecting somewhat different parts of the bird community, censusing is the superior method, as it provides a more nearly complete picture of the bird community and requires fewer people. Censusing does, however, require a highly skilled observer, one who can instantly recognize the calls, notes, and songs of scores of bird species.

Consistent with the 1995 field work, the proposed bird work will about one week, in the latter half of February 1996. The butterfly censusing will also require about one week, while the butterfly trapping will be carried out over about six weeks, requiring visitis to traps every several days during that period.

Personnel required for the field work are bird and butterfly census specialists and one field assistant for each of those specialists durig the time required for the study.

Fig. 1. Distribution of bird point counts in 18 ha plot for the thinning study. Each numbered circles indicates the location of a 50 m-radius point count. The main access trails are solid lines. The shaded half will serve as a control and will not be logged.

BELIZE FOREST DEPARTMENT
SILVICULTURAL RESEARCH TRIAL
REPICATE LAYOUT

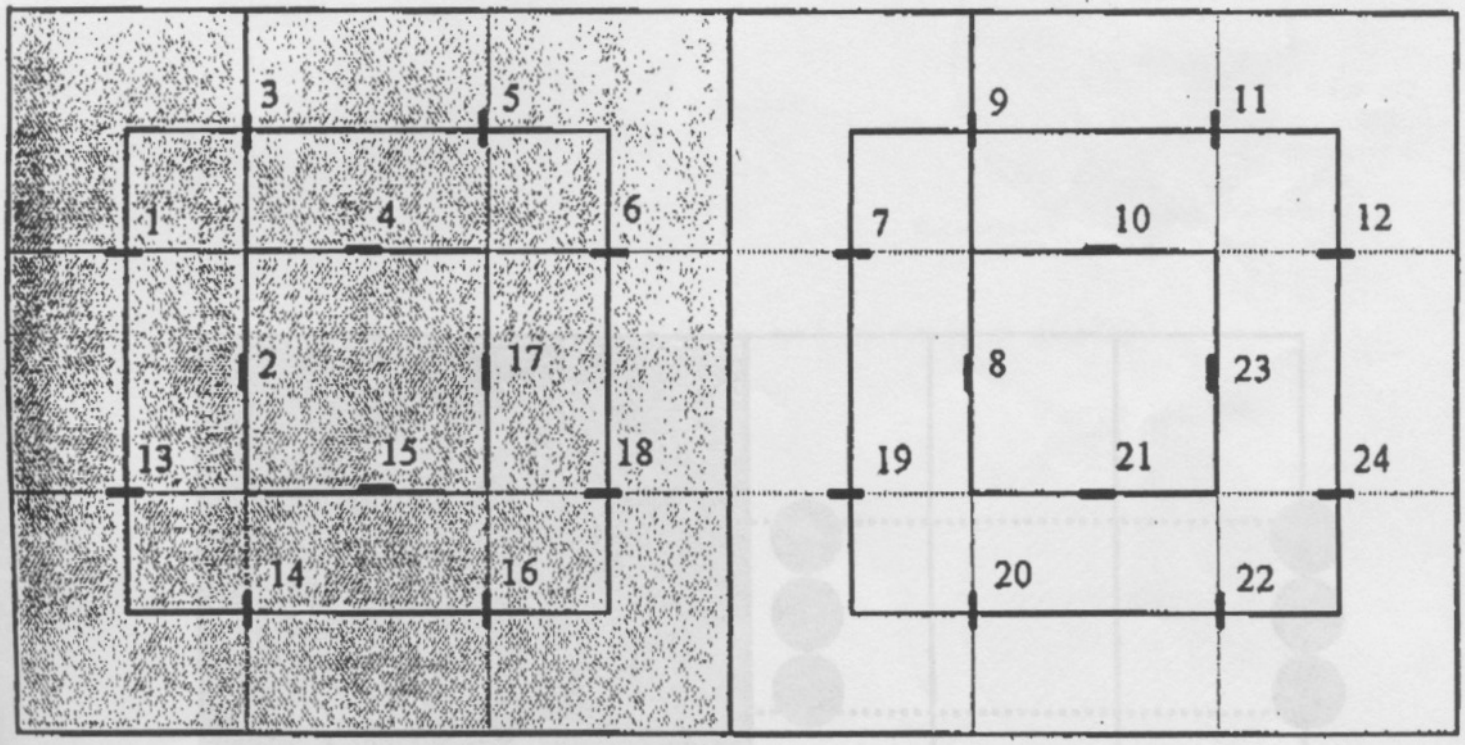


UNLOGGED LOGGED

Census point 100 M

Fig. 2. Distribution of bird mist-nets in a 18 ha plot for the thinning study. Each numbered line represents the location of single mist-net. The main access trails are solid lines. The shaded half will serve as a control and will not be logged.

BELIZE FOREST DEPARTMENT
SILVICULTURAL RESEARCH TRIAL
REPICATE LAYOUT



UNLOGGED LOGGED

Mist-net 100 M

Fig 3. Distribution of butterfly survey points in a 18 ha plot for the thinning study. The filled circles indicate the location of butterfly survey points. The shaded half will not be treated and will serve as a control. The un-shaded half will be logged. Each point will be the location of a 20m radius point count and a butterfly trap. Each butterfly survey point will be surveyed with a 20 m-radius point count and a butterfly trap.

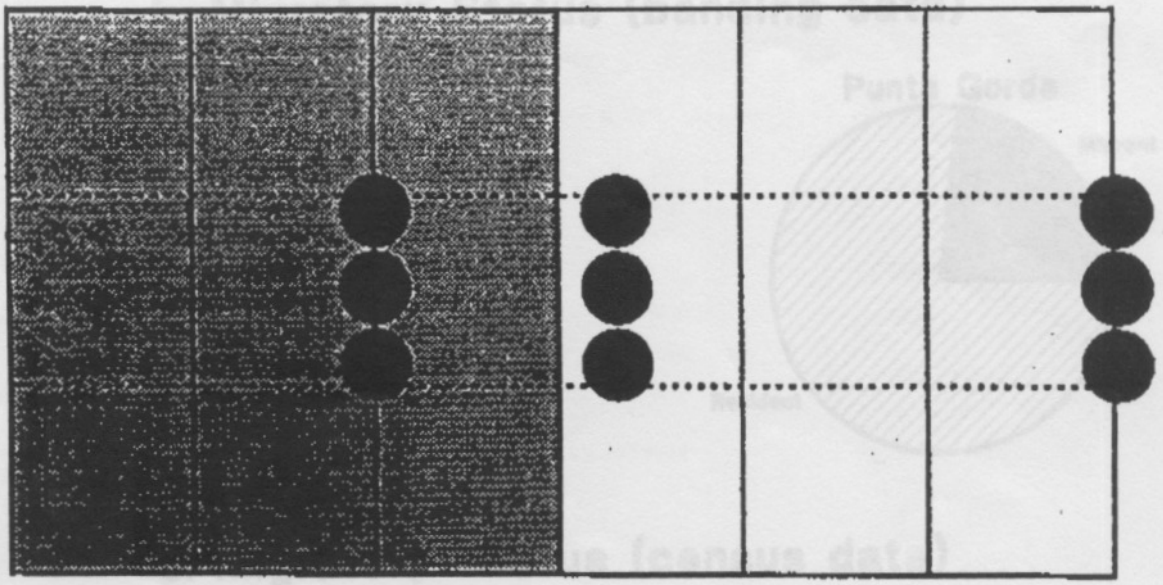
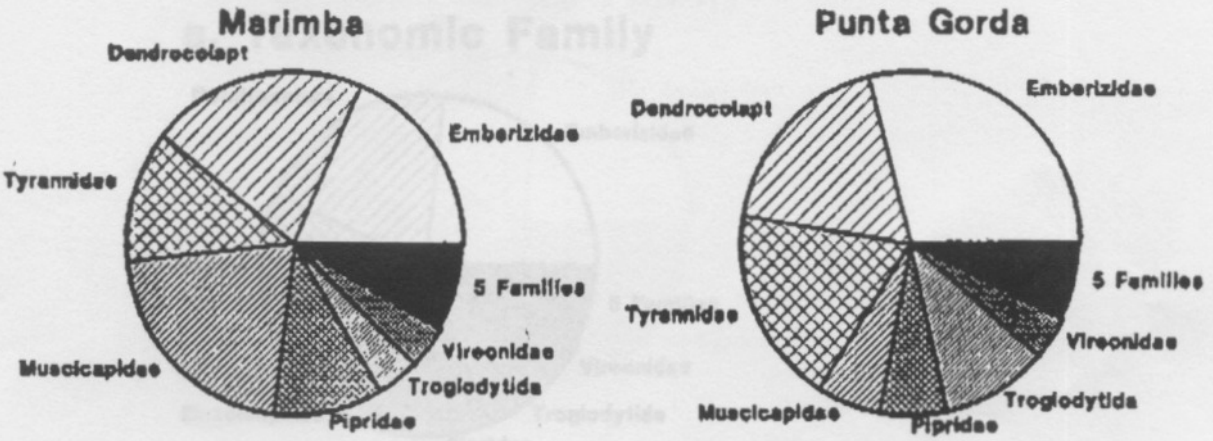
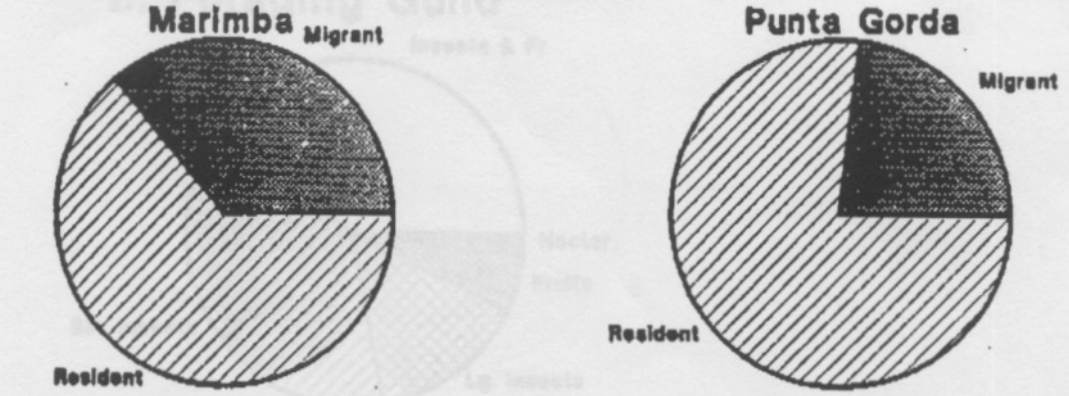


Fig. 4. Frequency of individuals of different (a.) taxonomic families (based on banding data), (b.) migratory status guilds (based on netting data), and (c.) migratory status guilds (based on netting data) at Marimba and Punta Gorda sites.

a. Taxonomic Family (banding data)



b. Migratory Status (banding data)



c. Migratory Status (census data)

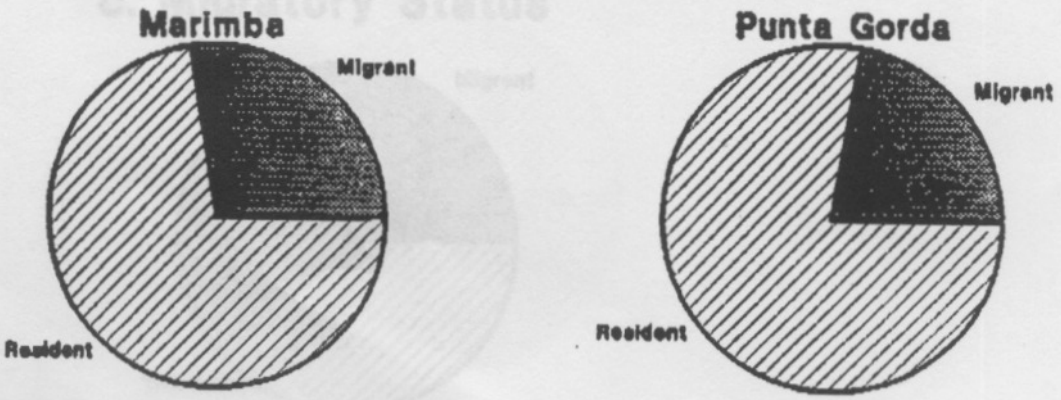
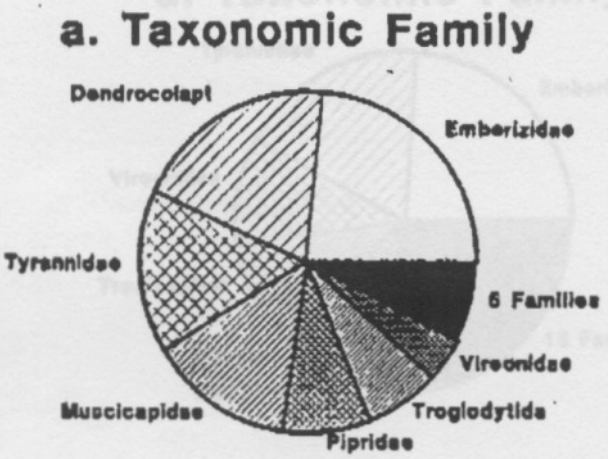
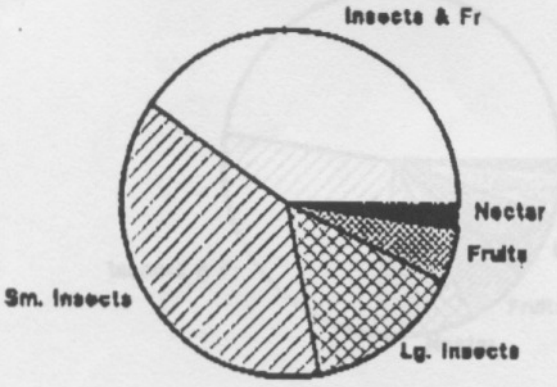


Fig. 5. Frequency of individuals of different (a.) taxonomic families, (b.) foraging guilds, and (c.) migratory status guilds based on mist-netting data combined from Marimba and Punta Gorda.





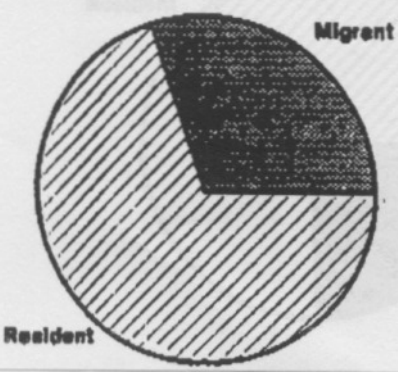
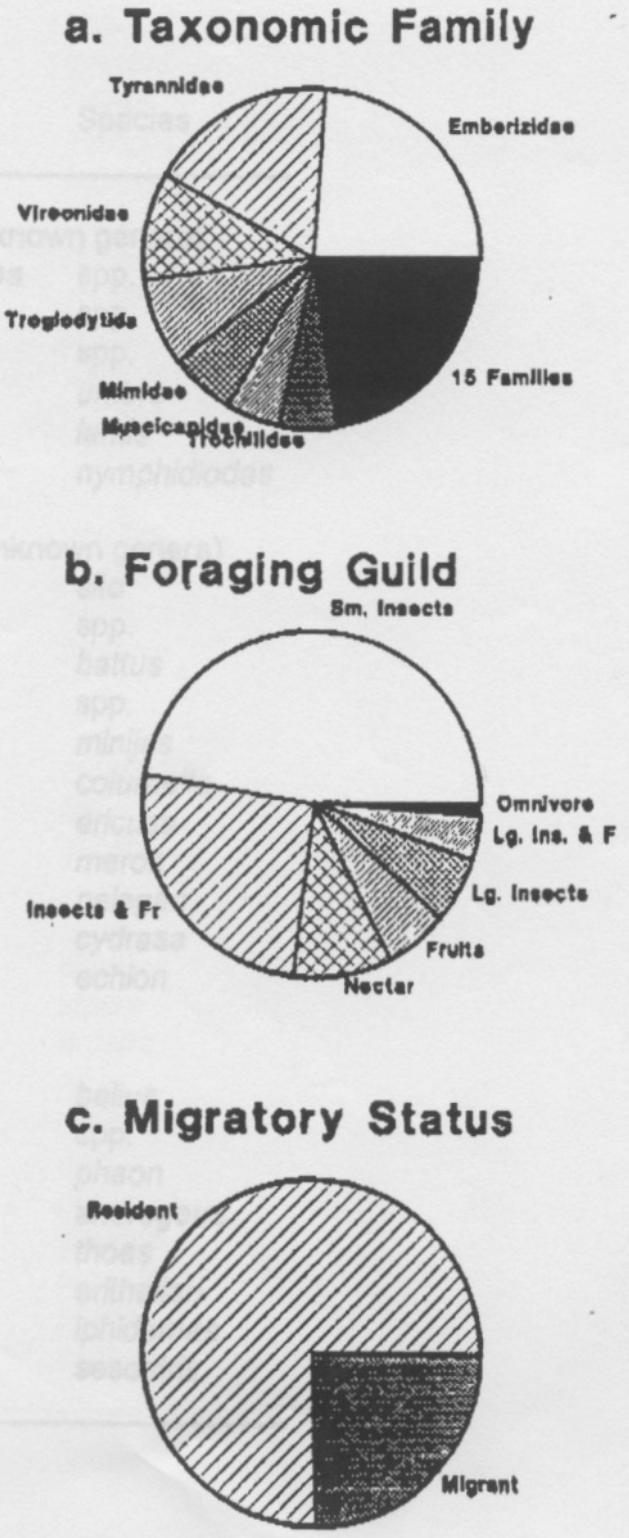


Fig. 6 Frequency of individuals of different (a.) taxonomic families, (b.) foraging guilds, and (c.) migratory status guilds based on point count data combined from Marimba and Punta Gorda.



Appendix A. Preliminary list of butterflies found near Hill Bank, Orange Walk District, Belize

This is a preliminary list of butterfly species from the Hill Bank area in Orange Walk District, Belize. Identification are provisional and need to be verified by consulting other lepidopterists and museum collections. Nomenclature follows DeVries (1987) and Scott (1986)

Family Genera	Species
Rioinidae (+ two unknown genera)	
Argyrogramma	spp.
Diopthaima	spp.
Emesis	spp.
Napaea	*umbra*
Nymphidium	*lamis*
Nymula	*nymphidiodes*
Lycaenidae (+ six unknown genera)	
Arawacus	*sito*
Calycopis	spp.
Cycnus	*battus*
Darno	spp.
Eumaeus	*minijas*
Strymon	*colurnella*
Thecla	*ericusa*
Thecla	*meron*
Thereus	*paiegan*
Tmolus	*cydrasa*
T.	*echion*
Papilionidae	
Battus	*belius*
Eurytides	spp.
Eurytides	*phaon*
Papilio	*androgeus*
P.	*thoas*
Parides	*erithalian*
P.	*iphidamas*
P.	*sesostris*

(continued)

Family	Genera	Species
Nymphalidae		
	Adelpha	*spp.*
	A.	*iphiclus*
	Anartia	*fatima*
	A.	*jatrophae*
	Biblis	*hyperia*
	Callicore	*texta*
	Colobura	*dirce*
	Dynamine	*mylitta*
	Matpesia	*chiron*
	M.	*petreus*
	Temanis	*lacthoe*
Heliconiinae		
	Agravlis	*vanillae*
	Dryadula	*phaetusa*
	Eueides	*aliphera*
	Euptoieta	*hegesia*
Ithomiinae		
	Aeria	*eurimedia*
	Greta	*oto*
	Mechanitis	*polymnia*
Peridea		
	Anteas	*chlorine*
	Aphrissa	*statira*
	Appias	*drusilla*
	Eurema	*alba*
	E.	*daria*
	E.	*nisa*
	E.	*proterpia*
	Phoebius	*argante*
	P.	*argante*
	P.	*philea*
	P.	*sennae*

(continued)

Family	Genera	Species
Satyrinae		
	Cissia	spp.
	C.	spp.
	C.	spp.
	C.	*confusa*
	C.	*heiane*
	C.	*hermes*
	C.	*metalevca*
	Taygetis	spp.
	T.	*andromeda*
	T.	*mermeria*
Brassolinae		
	Apsiphones	spp.
	A.	*quiteria*
	Eryhanis	*aesacus*

BIODIUERSITY BUDGET

BIODIVERSITY RESEARCH COSTS

		US $	
Salaries			
	Bird work (8 wk @ $281/wk)	2248	
	Butterfly work (10 wk @ $281/wk)	2810	
	total	5058	
Finges			
	Bird work (12% of salary)	270	
	Butterfly work (12% of salary)	337	
	total	607	
Other			
	Return airfare (Boston-Belize, 2 @ $700)	1400	(this might be somewhat less)
	Supplies	300	
	total	1700	
Grand Total		7365	

Assumes:

one day off per week
room and board on site
some field assistance from local trainees
transport (trips to different study sites for each worker each day)

NON-SALARY $5,680.00 U.S.

MAB Budget

Budget

Salary:	
Brokaw	$2,680
Travel:	
Brokaw (1 trip)	480
Per diem:	
Brokaw ($50/day for 24 days)	1,200
Clearing gaps in Belize	1,600
Growing seedlings in Belize	800
Field assistants while researchers are in-country	
Belize ($15/day per person)	1,600
TOTAL	8,360

NON-SALARY
U.S. $5,680.00