Habitat Associations of Neotropical Migrants in Belize, Central America, during the Non-breeding Season

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ABSTRACT

We studied the use of six habitats in central Belize by Neotropical migratory birds during the non-breeding seasons (December–March) of 1999–2003. Birds were captured and banded in karst hill broadleaf forest, a transition zone from a karst hill forest to an adjacent seasonal wetland, riverine forest, pine savanna, scrub-shrub, and secondary broadleaf forest. The riverine forest and transition zone were undisturbed and the other four habitats studied were disturbed. We examined habitat associations for 13 species in which 20 or more individuals were banded and found that the majority of species (10, or 76.9%) showed non-random use of the habitats

studied. Only the Magnolia Warbler, Black-and-white Warbler and Ovenbird showed random distribution across the six habitat types. We used niche breadth calculations to determine the tendency of each species to use the six habitat types studied and found that none of the species was a habitat specialist, eight were moderate habitat generalists, and five were generalists. Although some species showed clear preferences, migrants of different species utilized all of the habitats studied. This study emphasizes that it is important to work toward conserving many different habitat types in the tropics to ensure that different species of Neotropical migrants have adequate non-breeding habitat.

Introduction

Neotropical migratory birds include those species that have a large portion of their breeding population in the United States and Canada and spend the non-breeding season (North American winter) south of the Tropic of Cancer (Speicher and Greenberg 1991). Since 1950, deforestation has changed the landscape in Central and South America (Terborgh 1980, Hartshorn 1992). In the U.S., many forests and grasslands have been converted to cropland and pasture and the remaining eastern forests have been logged and are now less than 60 years old (Terborgh 1992). The decline of the populations of some species of Neotropical migratory birds was documented by Robbins et al. (1989) and Terborgh (1989). As a result of the deforestation described above, numerous investigations have been conducted in the tropics during the non-breeding season to determine the habitats that are utilized by Neotropical migrants during this time period and to determine if they are affected by the changes in these habitats.

Several studies focusing on Neotropical migrants have been conducted in Belize during the non-breeding season. Nickell (1968) banded birds for five years in second-growth and edge habitats, including the edges of citrus groves, and found that migrants readily utilized these habitats. Studies of the use of disturbed and undisturbed habitats by migrants during the non-breeding season were conducted by Lloyd-Evans (1984), Petit et al. (1992) and Kricher and Davis (1992). All found that migrants used both disturbed and undisturbed habitats. Lynch (1989) studied migrant use of a number of different habitats in the Yucatan Peninsula, including Belize, and found that the main habitat for many migrants was tropical forest. However, he found that some species of migrants were most frequently found in pastures, agricultural fields, and brushy second growth. Robbins et al. (1992) studied habitat use by migrants in Mexico, Central and South America, and the Greater Antilles, conducting research in Belize as part of this study. They found that migrants used isolated forest fragments as well as extensive forest and some agricultural habitats; however, some species of migrants were restricted to forested habitats. Mills and Rogers (1992) studied migrant use of citrus plantations during the non-breeding season in Belize and found high proportions of migrants in these habitats.

During the past ten years, the central region of Belize has been exposed to increased developmental pressures

that have resulted in significant natural habitats being converted or lost to large residential areas, citrus farms, fish farms, gravel mines, pastures, and logging (Boles 1999, Piaskowski et al. 2005a). Because of these developmental pressures and to compare our results to those of previous studies, we designed a study to examine the use of six different habitats commonly found in central Belize by migratory and resident birds. We included both disturbed and undisturbed habitats in the study. The purpose of the research was to determine the habitat associations of Neotropical migratory and resident bird species during the non-breeding season from 1999–2003. In this paper we present the results of the 1999–2003 research on the habitat associations of Neotropical migrants during the non-breeding season in Belize.

Methods

Study sites

The research was conducted on privately owned lands in six different habitats at three study sites in central Belize. The Runaway Creek Nature Preserve (RCNP) is a 2,500 ha preserve owned and managed by the Foundation for Wildlife Conservation, Inc., of Milwaukee, Wisconsin. It is located in the Belize District (17°18′05.1″N, 88°27′31.8″W) at 16 meters above sea level (m a.s.l.). The Tropical Education Center (TEC) site consisted of the Tropical Education Center of the Belize Zoo and adjacent privately owned lands. It is located in the Belize District (17°21′26.9″N, 88°32′26″W) ten km west of the RCNP site at 46 m a.s.l. and encompassed an area of approximately 438 ha. The 180 ha Chaa Creek study site (CHAA) consisted of the Chaa Creek Nature Reserve and adjacent privately owned lands. It is located in the Cayo District (17°06′15.9″N, 89°04′53.2″W) at 80 m a.s.l.

We conducted vegetation measurements in each of the six habitats at mist net locations based on the methods of Mueller-Dombois and Ellenberg (1974), Ralph et al. (1993), Howe et al. (1997), Mallory (1997) and Martin et al. (1997). We classified each habitat as disturbed or undisturbed based on visual observations of the site and on discussions with landowners regarding whether the vegetation was altered within the past ten years. We also considered the amount of human disturbance present in the study area. Except for the transition zone and secondary broadleaf forest, the remaining habitats studied were fairly uniform and nets were distributed in areas representative of that habitat. The following are descriptions of the vegetation present in each of the six habitats studied.

Karst hill broadleaf forest—The study area was located at the RCNP study site and consisted of broadleaf forest at the base of a forested karst hill. Mean canopy cover was 76.4%. Maximum tree height was 21.8 m. The dominant tree species were the black poisonwood (*Metopium browneii*), logwood (*Haematoxylum campechianum*) and give-and-take palm (*Chrysophila stauracantha*), with a few nargusta (*Terminalia amazonia*). Herb cover was <25% and consisted mainly of vines. Graminoid cover, mainly cutting grass (*Scleria bracteata*), was <25%. Leaf litter was >75%. The site was bordered on the north and south by broadleaf for-

est, on the east by forested karst hills and on the west by open pine savanna and seasonal wetland. The karst hill broadleaf forest was categorized as disturbed due to the presence of a trail cleared by hunters and their sporadic use of this trail. However, no logging or major alteration of the forest canopy was evident in this habitat.

Transition zone from a karst hill broadleaf forest to an adjacent seasonal wetland (Transition zone)—The study area was located at the RCNP study site and consisted of a transition zone from a broadleaf karst hill forest to an adjacent seasonal wetland. Nets were set in the wetland edge and at the edge of the broadleaf forest at the base of a forested karst hill. Canopy cover ranged from 6.3% in the wetland edge to 35.0% in the forest edge. Maximum tree height was 11.9 m in the forest edge and 7.4 m in the wetland edge. The dominant tree species in both the wetland and forest edge were logwood and calabash (*Crescentia cujete*), with a few mayflower (*Tabebuia rosea*) and *Pouteria* sp. in the forest edge. A few herbs, mainly vines, were present in the forest edge. Graminoid cover ranged from 5–25% in the forest edge to >75% in the wetland edge. Leaf litter was 5–25% in the wetland edge and >75% in the forest edge. The study site was bordered by forested karst hills to the north and west, by wetland on the east, and by open pine savanna on the south. The transition zone was classified as undisturbed, as there was no recent alteration of the vegetation or evidence of human disturbance in this habitat.

Riverine forest—The study area was located at the RCNP study site and consisted of riverine forest with an area dominated by spiny bamboo (*Guadua longifolia*) near the river edge. The spiny bamboo transitioned into forested areas dominated by cohune (*Atelea cohune*) and coccoloba (*Coccoloba schiedeana*), with scattered large, emergent quamwood (*Schizolobium parahybum*) trees. A few large fig (*Ficus* sp.) trees were also present along the riverbank bordering the study area, and two large fig trees (approximately 80 cm dbh) were present within the study area. A small forest gap of approximately 20 × 20 m was present near the center of the study area. A dense cover of wild cane (*Tripsacum andersonii*) bordered the eastern edge of the study area. Mean canopy cover was 88%. Maximum tree height was 45 m. Herb cover varied from few, with small cover, to 75%. The most common herbs were ferns, *Dieffenbachia* sp., *Heliconia* sp., vines and lianas. In the forest gap and in areas where the vegetation was dominated by spiny bamboo, a dense concentration of thorny vines and lianas such as haul-me-back (*Mimosa* sp.) and tear coat (*Byttneria aculeata*) were also present. Graminoid cover varied from solitary, with small cover, to 50% cover. Leaf litter with cover of >75% was present in all areas sampled. Moss cover ranged from little to <25%. The riverine forest was classified as undisturbed, as there was no recent alteration of the vegetation or evidence of human disturbance in this habitat.

Pine savanna—The study area was located at the RCNP study site and consisted of open pine savanna with areas of shrubland with pine and pine-oak forest. Canopy cover in the shrubland with pine and pine-oak forest was 80.2%. Maximum tree height was 13.9 m. Dominant trees included live oak (*Quercus oleoides)* and Caribbean pine (*Pinus caribaea)* with a few craboo *(Byr-*

sonima crassifolia), schippea palm *(Schippea concolor)* and yaha *(Curatella americana)*. Herb cover was < 25% and graminoid cover was >75%. The savanna was dry during the dry season, but temporary ponds, wetlands, and flowing water were prevalent during the rainy season. The pine savanna was classified as disturbed due to a fire that had burned the site approximately five years prior to the start of the study and occasional human disturbance by hunters.

Scrub-shrub (Also termed savanna-scrub, in Belize, this habitat is referred to as "Broken ridge.")—The study area was located at the TEC study site and consisted of scrub-shrub habitat that was interspersed with a few buildings. The canopy cover ranged from 10.2% in the more open areas to 85.4% in the more densely forested areas. Maximum tree height was 18.7 m. The dominant tree species were Caribbean pine and live oak with a few craboo, white maya (*Miconia argentea*) and wild spice (*Myrica cerifera*). Herb cover ranged from <5% to 50–75%. The most common herbs were dodder (*Cuscuta* sp.), *Philodendron* sp. and ferns. Graminoid cover was 50 to >75% and wild cane and cutting grass (*Scleria bracteata*) were the dominant species. Leaf litter ranged from 50-75% to >75%. A 1.5-acre freshwater pond was present on the southeast edge of the site. The site was bordered to the north by a seasonal stream and scrub-swamp forest. The scrub-shrub habitat was classified as disturbed as the vegetation was altered by roads and the maintenance of paths and a nature trail. It also had human disturbance; e.g., a number of buildings were scattered throughout the study area that were used regularly by students and tourists, and they often walked the paths and trails.

Secondary broadleaf forest—The study area was located at the CHAA study site and consisted of secondary broadleaf forest in which the majority of the trees had not been cleared for approximately 45 years. The forest was bordered by a pasture on the south and west. Between the pasture and the forest, an area of dense shrubs and small trees was present that had been cut less than 10 years earlier. Nets were set mainly in the broadleaf forest, but a few nets also were set in the area containing dense shrubs and trees. Mean canopy cover was 89.9%. Maximum tree height was 13.5 m. Dominant tree species included grande betty (*Cupania belizensis*), red gumbolimbo (*Bursera simaruba*), and cortes (*Tabebuia chrysantha*), with moderate fiddlewood (*Vitex gaumeri*), prickly yellow (*Zanthoxylum kellermanii*), and cohune. Herb cover was <25% and consisted of vines. Graminoid cover was <5%. Leaf litter with cover of 50 to >75% was present in all areas sampled. The secondary broadleaf forest was classified as disturbed because of the recent clearing of one part of the study area described above and alteration of the vegetation by the regular extraction of medicinal plants. Human disturbance was also present, as a horse trail passed the northern edge of the study area and was used frequently by tourists and guides.

Avifaunal Sampling

Since the study took place during the non-breeding season and territorial singing is infrequent during this time period (Lynch 1995), we utilized

a sampling technique modified from the Long Point Bird Observatory migration monitoring protocol (McCracken et al. 1993). The bird species were sampled using mist-netting, a standardized census, and casual observations. The mist-nets used in this study were nylon, 12 m × 2.6 m, of 30 mm mesh with 4 shelves. Ten to 15 ground-level nets were operated at each study area. In addition, we operated one to two nets elevated to five to seven meters (Albanese and Piaskowski 1999) in the riverine forest, pine savanna and scrub-shrub study areas. We also operated one 30 mm mesh mist-net measuring 6 m × 5.2 m to sample stratum starting approximately 21 m above ground level during one year in the karst hill broadleaf forest and two years in the riverine forest.

Monitoring was conducted for 1.5 to 3 consecutive days at each study area each month. From 1999–2001 monitoring was conducted only in February and March. From December 2001 through March 2003, monitoring was expanded and conducted from December through March. In 1999, nets were operated for six hours on most days and for up to 11 hours on a few days. From 2000–2003 nets were operated for up to 11 hours the first day of banding and then for six hours the second and third days, weather permitting. Monitoring was conducted in the scrub-shrub and secondary broadleaf forest in 1999 and, with the exception of the secondary broadleaf forest which was not studied in 2000, in all six habitats from 2000–2002. In the 2002–2003 field season monitoring was conducted only in the transition zone, riverine forest, and secondary broadleaf forest.

We standardized mist-netting capture results using mist-net hours. Mist-net hours were calculated by summing the number of hours each 12 m net was operated (one mist- net hour = one 12 m mist-net open for one hour). The total mist-net hours for each site are listed in Table 1. All North American migrants captured, except hummingbirds, were banded using a United States Bird Banding Laboratory (United States Geological Survey, Biological Resources Division) aluminum leg band. All resident birds captured, except hummingbirds, were banded with a uniquely numbered aluminum leg band. Breeding condition was determined by the presence of a brood patch (BP) or cloacal protuberance (CP), as described in Burton and DeSante (1998). Aging and sexing of North American migrants was based on Pyle (1997). Aging and sexing of residents was based on Stiles and Skutch (1989), Howell and Webb (1995) and Pyle (1997). Hummingbirds were examined before being released but were not included in the capture analyses.

To sample birds not captured in mist-nets, we also inventoried birds by visual and auditory observations using a standardized census and casual observations based on the methods of McCracken et al. (1993). The information on bird species documented by visual and auditory observations is not included in this report.

Data Analysis

We analyzed habitat associations based on the methods described in Petit et al. (1992). We performed analyses on those species for which we

Table 1. Summary of mist-netting data for the six habitats studied in Belize.

Habitat	Total mist-net hours	Total birds banded	Total birds per 100 mist-net hours	Number of migrants banded (% of total birds banded)	Number of migrants per 100 mist-net hours	Number of residents banded (% of total birds banded)	Number of residents per 100 mist-net hours
Karst hill broadleaf forest	975.28	249	25.5	79 (31.7)	8.1	170 (68.3)	17.4
Transition zone	1542.31	408	26.5	169 (41.4)	11.0	239 (58.6)	15.5
Riverine forest	3172.11	1022	32.2	446 (43.6)	14.1	576 (56.4)	18.2
Pine savanna	512.06	128	25.0	65 (50.8)	12.7	63 (49.2)	12.3
Scrub-shrub	2086.10	676	32.4	306 (45.3)	14.7	370 (54.7)	17.7
Secondary broadleaf forest	2191.48	480	21.9	179 (37.3)	8.2	301 (62.7)	13.7

had captured more than 20 individuals. Sampling effort (mist-net hours) was unequal in the six different habitats studied; therefore, we could not calculate expected mist-net captures for a given species by dividing the number of individuals captured in each habitat by the total number of captures in all habitats. Instead, we standardized expected captures based on the number of mist-net hours (h_i) spent sampling each habitat *i*. The formula used was: $E(c_i) = C \bullet h_i / H_T$, where $H_T = \Sigma h_i$. To determine if each species' habitat associations were different from the expected uniform distribution across the six habitat types, we used the goodness of fit G-test (Sokal and Rohlf 1981).

To determine the niche breadth of the species studied, we used the method of Levins (1968) as described in Petit et al. (1992). Niche breadth (B) was calculated as follows: $B = 1/\Sigma p_i^2$, where p_i is the proportion of captures of a species in habitat *i*. In this study, B values could range from 1, if a species was found in only one habitat, to 6 if a species was found in all habitats. We categorized species as habitat specialists if $B \leq 2$, as moderate habitat generalists if $B > 2$ but ≤ 4, and as habitat generalists if $B > 4$.

To determine if there was a difference in a given species' use of disturbed and undisturbed habitats, we used the χ^2 goodness of fit test (Sokal and Rohlf 1981). We standardized captures for each species by calculating the birds per 100 mist-net hours in each habitat. We then pooled birds per 100 mist-net hours for the four disturbed sites and the two undisturbed sites and calculated the χ^2 for these two variables.

Results

From February 1999 through March 2003, 1,244 Neotropical migrants of 35 species, and 1,719 residents of 110 species, were banded in the six Belize habitats studied. Table 1 summarizes the mist-netting data for each of the

six habitats studied. The proportion of migrants banded ranged from 31.7% of the total in the karst hill broadleaf forest to 50.8% in the pine savanna. Conversely, the proportion of residents banded was highest in the karst hill broadleaf forest (68.3%) and lowest in the pine savanna (49.2%).

To analyze habitat associations, we considered only those species for which we had banded 20 or more individuals. We were able to determine habitat associations for 13 species of Neotropical migrants and 23 species of resident birds. Data on the residents will be presented in a later report. The species of Neotropical migrants and number of individuals banded in each habitat is shown in Table 2. Table 2 also shows the goodness of fit G-test value and p-value that were used to determine whether a species departed significantly from random distribution across all six habitats. The majority of species (10, or 76.9%) showed nonrandom use of the habitats studied. Only the Magnolia Warbler, Black-and-white Warbler, and Ovenbird showed random distribution across the six habitats studied. Habitat disturbance did not affect use by the 13 species of migrants studied, as no significant difference in the use of disturbed versus undisturbed habitats was found for any of the 13 species studied (χ^2 ranged from 0.026–1.914, d.f. = 1, $p > .05$).

We used niche breadth calculations to determine the tendency of each species to use the six habitat types studied (Lynch 1992). Based on these calculations, none of the species studied was a habitat specialist, eight were moderate habitat generalists, and five were habitat generalists (Table 3).

Discussion

Mist-nets operated at ground level sample avifauna that moves within two to three meters of the ground (Remsen and Good 1996) and, as a result, our banding data are biased toward those species that move and forage within this area of the habitat. To sample other strata, we devised an elevated net system that samples areas within five to seven meters of the ground (Albanese and Piaskowski 1999) and operated one to two elevated nets in the riverine forest, pine savanna and scrub-shrub study areas. In addition, we operated one 30 mm mesh net measuring 6 m × 5.2 m to sample stratum starting approximately 21 m above ground level during one year in the karst hill broadleaf forest and two years in the riverine forest. Due to staffing changes after 2001, we were not able to operate the canopy net in the 2001–2002 and 2002–2003 field seasons. We operated the majority of our nets at ground level and may have missed capturing individuals foraging in the canopy. However, for nine of the 13 species studied here, fewer than 5% of individuals banded were captured in elevated or canopy nets. For the following four species, more than 5% of the individuals banded were captured in the elevated or canopy nets: White-eyed Vireo, 6.3%; Magnolia Warbler, 9.6%; Black-and-white Warbler, 10.4%; and American Redstart, 11.7%.

In the habitats we studied, Neotropical migrants comprised from 31.7% to 50.8% of the birds banded. The percentage of migrants found in our study is similar to a number of other banding studies conducted in Belize. In four Belize habitats Lloyd-Evans (1984) found that migrants comprised

Table 2. Number of each species banded in the six habitats studied in Belize and whether distribution across habitats departed from the expected random distribution.

Species	Total number banded	Karst hill broadleaf forest	Transition zone	Riverine forest	Pine savanna	Scrub-shrub	Secondary broadleaf forest	G-test value	p-value[c]
White-eyed Vireo *Vireo griseus*	32	5[a] (15.6)[b]	9 (28.1)	0	0	17 (53.1)	1 (3.1)	46.4099	< .001**
Wood Thrush *Hylocichla mustelina*	174	14 (8.0)	17 (9.8)	67 (38.5)	1 (0.6)	14 (8.0)	61 (35.1)	47.6253	< .001**
Gray Catbird *Dumetella carolinensis*	289	5 (1.7)	31 (10.7)	157 (54.3)	8 (2.8)	74 (25.6)	14 (4.8)	134.4113	< .001**
Magnolia Warbler *Dendroica magnolia*	115	9 (7.8)	21 (18.3)	36 (31.3)	4 (3.5)	30 (26.1)	15 (13.0)	7.7004	> .05[NS]
Black-and-white Warbler *Mniotilta varia*	48	4 (8.3)	9 (18.8)	9 (18.8)	2 (4.2)	15 (31.3)	9 (18.8)	5.7797	> .05[NS]
American Redstart *Setophaga ruticilla*	60	7 (11.7)	7 (11.7)	12 (20.0)	10 (16.7)	21 (35.0)	3 (5.0)	29.6184	< .001**
Worm-eating Warbler *Helmitheros vermivorum*	36	5 (13.9)	2 (5.6)	19 (52.8)	0	2 (5.6)	8 (22.2)	17.0987	< .01*
Ovenbird *Seiurus aurocapilla*	94	7 (7.4)	7 (7.4)	26 (27.7)	3 (3.2)	30 (31.9)	21 (22.3)	11.1894	> .05[NS]
Northern Waterthrush *Seiurus noveboracensis*	54	4 (7.4)	21 (38.9)	9 (16.7)	0	19 (35.2)	1 (1.9)	45.0367	< .001**
Kentucky Warbler *Oporornis formosus*	48	8 (16.7)	5 (10.4)	14 (29.2)	0	0	21 (43.8)	35.8290	< .001**
Common Yellowthroat *Geothlypis trichas*	89	0	18 (20.2)	22 (24.7)	21 (23.6)	28 (31.5)	0	94.2915	< .001**
Hooded Warbler *Wilsonia citrina*	81	6 (7.4)	9 (11.1)	26 (32.1)	0	21 (25.9)	19 (23.5)	10.7092	< .01*
Yellow-breasted Chat *Icteria virens*	56	3 (5.4)	8 (14.3)	16 (28.6)	9 (16.1)	20 (35.7)	0	39.1710	< .001**

[a]Number of birds of this species banded in this habitat.
[b]Percent of total birds of this species banded in this habitat.
[c]Statistical significance based on the G-test value with five degrees of freedom: **very highly significant,*highly significant, [NS]not significant. Statistical significance indicates that the species departed from the expected random distribution across the six habitat types.

Table 3. Niche breadth scores and habitat use categories for the Neotropical migrants studied in Belize.

Species	Total number banded	Niche breadth (B)	Category[a]
White-eyed Vireo *Vireo griseus*	32	2.59	Moderate generalist
Wood Thrush *Hylocichla mustelina*	174	3.40	Moderate generalist
Gray Catbird *Dumetella carolinensis*	289	2.66	Moderate generalist
Magnolia Warbler *Dendroica magnolia*	115	4.47	Generalist
Black-and-white Warbler *Mniotilta varia*	48	4.72	Generalist
American Redstart *Setophaga ruticilla*	60	4.55	Generalist
Worm-eating Warbler *Helmitheros vermivorus*	36	2.83	Moderate generalist
Ovenbird *Seiurus aurocapilla*	94	4.16	Generalist
Northern Waterthrush *Seiurus noveboracensis*	54	3.24	Moderate generalist
Kentucky Warbler *Oporornis formosus*	48	3.17	Moderate generalist
Common Yellowthroat *Geothlypis trichas*	89	3.90	Moderate generalist
Hooded Warbler *Wilsonia citrina*	81	4.11	Generalist
Yellow-breasted Chat *Icteria virens*	56	3.87	Moderate generalist

[a]We categorized species as follows:
B ≤ 2 habitat specialist
B >2 but ≤ 4 moderate habitat generalist
B > 4 habitat generalist

22% to 43% of the total birds banded. Kricher and Davis (1992) found that 30.1% of the total individuals mist-netted at three sites in Belize was migrants. Petit et al. (1992) found that migrants represented 28.1% to 57.7% of birds mist-netted in five habitats in Belize. Robbins et al. (1992) found that migrants represented 39% of the birds banded in native forest and 42% of birds banded in seven agricultural habitats combined (including citrus) during their work in Belize. Our results contrast with two other studies conducted in Belize in which migrants comprised a higher percentage of the birds banded. Nickell (1968) found that migrants ranged from 57.5% to 74% of the birds banded. Mills and Rogers (1992) found that migrants made up 50% to 69.1% of total birds banded in orange groves and 80.6% of those in a grapefruit orchard. The differences of the percentages of migrants in these two studies are likely due to the different habitats sampled and their focus on citrus groves.

It was of value to examine the habitat associations with the two methods utilized here, as it made it possible to view each species use of the six habitats in both ways. Based on the G-test and p-values shown in Table 2, the majority of species studied (10, or 76.9%) were not randomly distributed across the six habitat types studied, indicating that species do select habitats during the non-breeding season. Only the Magnolia Warbler, Black-and-white Warbler, and Ovenbird showed random distribution across the six habitats studied, and these species also were categorized as generalists by niche breadth calculations. Using the niche breadth calculations (Table 3), we were not able to categorize any of the 13 species studied as habitat specialists. The majority of species studied, (8, or 61.5%), were moderate habitat generalists. Five species used

more than four habitats and therefore were categorized as habitat generalists. As described above, three generalists also showed random distribution across the six habitats, but two species, the American Redstart and Hooded Warbler (Table 2), were categorized as generalists by niche breadth calculations, yet were not randomly distributed across the six habitat types as determined by the G-test value (Table 1).

Examining the percentage of individuals banded in each habitat provided information on habitat preferences for some species and indicated that the majority of individuals of some species do select habitats (Table 2). For three species, the White-eyed Vireo, Gray Catbird, and Worm-eating Warbler, the majority of individuals (>50%) was banded in one habitat type, although individuals of these species also were captured in other habitats. However, this predominant use of one habitat was not sufficient to categorize them as habitat specialists through niche breadth calculations, although all had niche breadth values less than three. For the Wood Thrush, Northern Waterthrush, and Kentucky Warbler, more than 70% of the individuals was banded in two habitats, but these species were categorized as moderate generalists by niche breadth calculations. The remaining seven species, the Magnolia Warbler, Black-and-white Warbler, American Redstart, Ovenbird, Common Yellowthroat, Hooded Warbler and Yellow-breasted Chat, were captured in four to six of the habitats studied and the niche breadth of these species ranges from 3.87 for the Yellow-breasted Chat to 4.72 for the Black-and-white Warbler.

We found that the 13 species of migrants we studied utilized both disturbed and undisturbed habitats. Previous studies (summarized in Petit et al. 1993) have shown that the number of migratory species was highest in disturbed habitats. However, it is important to note that all types of disturbance may not be beneficial for migrants. Saab and Petit (1992) found that actively grazed pastures in Belize had 50% lower species richness of both residents and migrants than abandoned pastures. Faaborg (2002) emphasized that human habitat alterations have taken place over the past 500 years in the tropics and that some migratory species may have benefited by these changes and others negatively impacted. He also states that we also need to consider resident species when planning for habitat preservation, as they are more vulnerable to disturbance and fragmentation than many species of migrants. Studying the habitat associations of both migrants and residents as we did in this study (although only the migrant data are presented here), will provide information on the habitats important to both, and allow for conservation planning for the tropical bird communities found in each habitat.

Conservation implications

The habitat associations shown in Table 2 and the non-random use of habitats by the majority of species studied reiterates that migrants cannot be viewed as a group when planning for non-breeding habitat conservation. The habitat associations of each species during the non-breeding season must be examined as we did here and also throughout their non-breeding range, as some species have shown

regional differences in habitat use (Petit et al. 1993, Faaborg 2002).

Of the 13 species of Neotropical migrants studied, six are listed as species of continental importance by Partners in Flight (Rich et al. 2004). The White-eyed Vireo, Magnolia Warbler, and Hooded Warbler are listed as Stewardship species and the Wood Thrush, Worm-eating Warbler, and Kentucky Warbler are listed as both Watch List and Stewardship species. Watch List species have "multiple reasons for conservation concern across their entire ranges," while Stewardship species "have a proportionately high percentage of their world population in a single Avifaunal Biome during either the breeding or wintering season" (Rich et al. 2004). With the exception of pine savanna, in which only two of the six species were banded, most of these species of continental importance were found in four to five of the other habitats studied (Table 2), indicating the importance of these habitats to these species during the non-breeding season.

Although Belize has retained more of its natural vegetation than other Central American countries, the development pressures described above will undoubtedly continue. To conserve habitats important to Neotropical migrants during the non-breeding season, it is necessary to share the results of research such as this with local governments, non-government organizations (NGOs), conservation and education groups, and local citizens. In this way, habitats important to Neotropical migrants during the non-breeding season can be considered in land management and development plans and preserved wherever possible. Since the start of the Birds Without Borders—*Aves Sin Fronteras* (BWB-ASF) project in Belize, we have shared results of our research with the private landowners who have allowed us to use their land as study sites, with government, NGOs, and other groups in Belize through research reports and educational outreach presentations so that the information is available to those who have a role in conservation and development planning. This also enhances the awareness of the importance of birds and their role in ecosystems.

We have emphasized that conservation of undisturbed habitats such as the riverine forest and transition zone studied here should be accorded high priority in management plans, as once they are altered, considerable time is required for regeneration. To stress the importance of conservation of riverine forests, we summarized the results of four years of avifaunal research conducted on the Sibun River in central Belize (Piaskowski et al. 2005b). This information is being condensed so that it can be printed in conservation newsletters in Belize and thus reach the general public. Pine savanna and scrub-shrub are commonly viewed as wastelands in Belize and the need for the conservation of these habitats, as well as the other habitats we studied, for the benefit of both migratory and resident birds, will be emphasized in a future publication. This publication will be a manual for private and public landowners based on our research results emphasizing the importance of birds and providing landowners with information on how to conserve migratory and resident birds by conserving habitats and plants utilized by birds. It will highlight the key role of landowners in aiding in the survival of both resident and migratory

birds and that landowners working together can save large amounts of habitat. By reaching a wide audience with this information, we hope it will be possible to conserve the habitats reported in this paper that are important to migratory birds during the non-breeding season and also to resident birds year-round.

An important component of the research was to train the Belize staff working on the Birds Without Borders—*Aves Sin Fronteras* project in the ornithological research techniques utilized, so that in the future they could design and conduct their own research as well as utilize the expertise gained to implement local conservation strategies. This goal was met and the field research from 2001–2003 was conducted mainly by the BWB-ASF Belize staff. It will be important for them to continue this research as habitats in central Belize continue to change. In addition, the relationship between the BWB-ASF Belize staff and Belizean landowners will be maintained so that both public and private landowners can be informed about the research results and use this information to conserve bird habitat.

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For more information about the Birds Without Borders—*Aves Sin Fronteras* project and our research results, visit http://www.zoosociety.org/Conservation/BWB-ASF/. For more information on the Runaway Creek Nature Preserve in Belize visit http://www.zoosociety.org/Conservation/SaveAnAcre.php

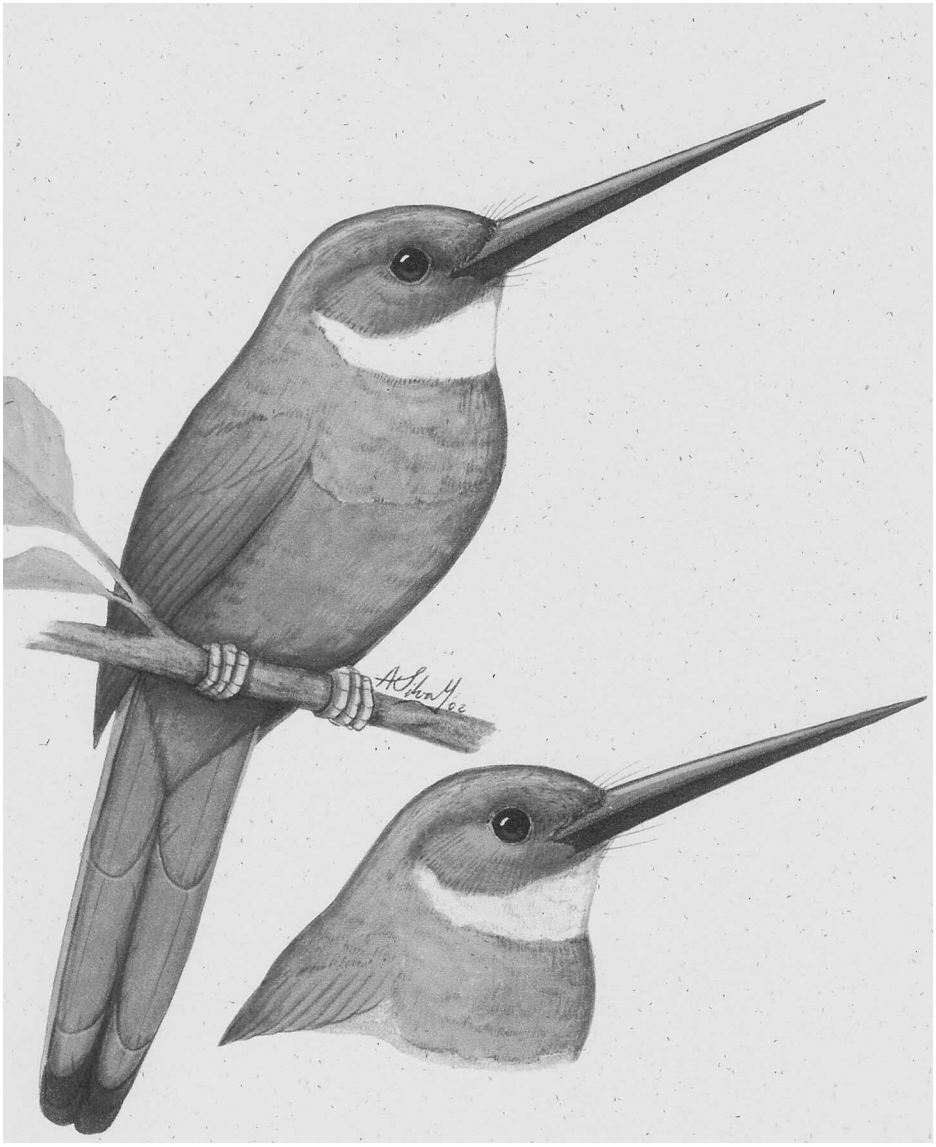
ACTION IDEAS:

1. To encourage protection of different habitats, when you travel, ask to see birds in various habitats. (For example, pine savannas are viewed as wastelands in Belize, but are very important to many bird species.)
2. Tourism: Promote the Neotropics as birdwatching destinations so that more tourists travel there for bird watching. This will provide jobs for local tour guides and encourage others to become guides.
   - Many tour guides are hungry for knowledge. In addition to giving them a tip, find out what resources they can use (books, subscriptions, etc.) and send these to them upon your return home. (Resources like these are often more readily available here than in many Neotropical countries.)
   - Take part in activities that support local conservation organizations. Sponsored hikes, bird counts and other excursions may need pledges, publicity or resources you can provide.
3. Capacity building:
   - Donate funds to assist local conservation groups and conservation projects, to help manage protected areas, and to support groups involved in bird and conservation education.
   - Provide educational resources (new or used field guides, bird books, maps, posters, cassettes, CD's and videos) to conservation groups, environmental and bird clubs, and conservation-based educational facilities. In Belize, these types of resources are not readily available.
   - Donate a reliable used truck to conservation education programs.
4. Training: Provide short-term training scholarships in Park/Protected Areas Management to conservation organizations in the Neotropics. The knowledge will be utilized to better manage bird habitats in the Neotropics.
5. Increase awareness of the value of a diverse bird population in the Neotropics by letting businesses know that you are there because of the birds.
6. Patronize businesses (hotels, restaurants, shops, etc.) owned by local citizens. Many of the large resorts are foreign-owned. Local people work there providing services, but don't share in the profits.
7. Be willing to share your knowledge of and enthusiasm for birds. If you are willing to do so and have time during a visit to the Neotropics, give an informal presentation to a local school or environmental group about migrants on their breeding grounds or another topic about which you are knowledgeable. As in the US, many people in the Neotropics don't realize why birds are important.
8. Avoid activities and products that are exploitative of wildlife and speak out about these to businesses and other tourists who might not be aware of the issue. Boycott businesses that exploit or do not show respect for wildlife and encourage others to do so.

The Birds Without Borders—Aves Sin Fronteras[SM] *project of the Zoological Society of Milwaukee and Foundation for Wildlife Conservation, Inc. began in 1996 with four major goals: 1.) research on both migratory and resident bird species in Wisconsin, USA, and Belize, Central America, 2.) application of the research results to conservation by compiling the data into recommendations for landowners on how land can be managed to benefit birds, 3.) educating children and adults about birds and 4.) training of Belizeans to conduct the research with the end result being autonomy of Belizeans in designing and conducting their own research as well as implementing local conservation strategies.*

Victoria Piaskowski has been the International Coordinator since the start of the

project. Mario Teul is the Belize National Coordinator and has been with the project since it started in Belize in 1997. Kari M. Williams has been the Project Assistant since 2000. Reynold N. Cal is the Runaway Creek Nature Preserve Manager and has been with the project since 2001.



Rufous-tailed Jacamar