J. Field Ornithol., 69(3):402–414

WINTER BIRD COMMUNITIES ON SAN SALVADOR, BAHAMAS

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Abstract.—We used mist nets to quantify the abundance and habitat use of birds in three habitats on San Salvador, Bahamas, during the winters of 1994, 1996, and 1997. Thirty species were captured, of which 28 (12 permanent and 16 winter residents) were regular community members. Permanent residents composed 40% of species in all habitats, and parulid warblers (13 species) dominated the winter-resident community. The number of migrant species was virtually identical to that of other Bahama islands that are larger and/or closer to the North American continent. Disturbed habitat yielded the most species (24) and highest capture rate (103 birds/100 net h), followed by mangrove (17 species and 51 birds/100 net h) and thickets (14 species and 60 birds/100 net h). Capture rates of migrants were relatively constant across years (30–38 birds/100 net h), with the possible exception of declines in White-eyed Vireos (*Vireo griseus*). Annual variation in capture rates of permanent resident was high (30–64 birds/100 net h) due to a decline of Bananaquits (*Coerba flaveola*) in 1997. Bananaquits also showed a significant decline in body condition in 1997. We attribute both phenomena to the impact of Hurricane Lilly on Bananaquit food supplies. Six species exhibited narrow habitat preferences (three in mangroves, three in disturbed), whereas three others were habitat generalists. Mangroves were the primary or secondary habitat for six species, whereas ten species used the disturbed area either exclusively or as a secondary site. Thickets were the preferred habitat of only one species (Thick-billed Vireo; *V. crassirostris*). Lightly disturbed areas and mangroves serve as important habitats for nearctic migrants and permanent residents on San Salvador.

COMUNIDADES DE AVES INVERNALES EN SAN SALVADOR, BAHAMAS

Sinopsis.—Utilizamos redes de captura para cuantificar la abundancia y el uso de habitats de aves residiendo en tres habitats en San Salvador, Bahamas, durante los inviernos del 1994, 1996 y 1997. Se capturaron 30 especies, de las cuales 28 (12 permanentes y 16 residentes invernales) eran miembros regulares de la comunidad. Los residentes permanentes fueron un 40% de las especies en todos los habitats, y la subfamilla Parulinae dominó la comunidad residente invernal. El número de especies migratorias fué virtualmente identica a la de otras islas en las Bahamas que son mucho más largas y/o están mucho más del continente de Norte América. El hábitat alterado produjo más especies (24) y la mayor tasa de captura (103 aves/100 horas-red), seguidos por manglares (17 especies y 51 aves/100 horas-red) y matorrales (14 especies y 60 aves/100 horas-red). Las tasas de captura de migratorios fueron relativamente constantes a través de los años (30–38 aves/horas-red), con la posible excepción de reducción en captura de *Vireo griseus*. La variación anual en las tasas de captura de residentes permanentes fué alta (30–64 aves/100 horas-red) debido a una reducción en *Coereba flaveola* en 1997. Esta especie también mostró una reducción significativa en su condición corporal en 1997. Atribuímos ambos fenómenos al impacto del Huracán Lilly en los recursos alimenticios de *Coereba flaveola*. Varias especies mostraron estrechas preferencias de habitat (tres tanto en manglares y en áreas alteradas), mientras otras tres eran generalistas de habitats. Los manglares fueron el habitat primario o secundario para tres especies, mientras que diez especies utilizaron el área alterada de forma exclusiva o como lugar secundario. Los matorrales fueron el habitat preferido de tan solo una especie (*Vireo crassirostris*). Las áreas ligeramente alteradas y los manglares sirven como habitats importantes para migrantes nearticos y para residentes permanentes de San Salvador.

Studies of Caribbean birds have helped to increase our understanding of island biogeography (Ricklefs and Cox 1972, Terborgh and Faaborg

1973), the relationship between climate and population dynamics in tropical birds (Faaborg et al. 1984, Wunderle et al. 1992), and how ecological communities are organized (Emlen 1980, Lack and Lack 1972). The latter work has been possible because the annual influx of nearctic migrants into relatively simple Caribbean communities (compared to continental tropical regions) has allowed ornithologists to measure resident and migrant responses to seasonal changes in food availability and the intensity of competition (e.g., Emlen 1980). Important research has also begun to examine the nature of the interactions between age/sex classes of birds on their wintering grounds to provide a clearer picture of how migrant populations are regulated (Parrish and Sherry 1994, Sherry and Holmes 1996, Wunderle 1995).

Studies of Caribbean birds are also important because a number of the species that overwinter within the region, including two of three species whose winter ranges are almost exclusively limited to the Bahamas and Greater Antilles (Prairie Warbler [*Dendroica discolor*] and Cape May Warbler [*D. tigrina*]), are presently declining (Sauer and Droege 1992). To better understand the nature and extent of the declines of permanent and winter resident birds in the Caribbean, it is essential that long-term field studies of distributions, habitat use, and abundance be conducted. To this end, we have begun a banding program on San Salvador, Bahamas, to document the winter bird communities, to describe patterns of habitat use, and to monitor populations trends. Here we report results from our first three years, and describe the population responses of migrants and residents to Hurricane Lilly, which struck the island in October 1996.

STUDY AREA

Our research was conducted at the Bahamian Field Station (BFS) on San Salvador, Bahamas during January of 1994 (5–26 January), 1996 (8–28 January), and 1997 (8–28 January). San Salvador is one of the easternmost islands in the Bahama chain (24°07′N, 74°28′W). The BFS is located at the northeast corner of the roughly rectangularly shaped island (19.5 km × 8 km). Most of the annual total of 1000–1500 mm of rain falls during the wet season (May–October), but hurricanes and winter storms can produce substantial rainfall during other months; there is little freshwater available.

San Salvador's natural plant communities have been heavily disturbed by humans over the past 200 years, but for at least the last several decades most human activity has been restricted to the coasts. Jimbay (*Leucaena leucocephala*) is abundant along road sides, the coast, and all disturbed areas. The interior has many saline or hypersaline lakes (Godfrey et al. 1994) that are surrounded by mainly red (*Rhizophora mangle*) and white (*Languncularia racemosa*) mangroves. Forests in the interior are recovering from past failed attempts at agriculture and are generally stunted (Eshbaugh and Wilson 1995). Early successional communities at the shrub/tree stage are dominated by haulback (*Mimosa bahamensis*), red calliandra (*Calliandra haematomma*) and poison wood (*Metopium toxiferum*). As communities age, the latter species become mixed with Bahama maiden bush (*Savia bahamensis*), five fingers (*Tabebuia bahamensis*), pigeon plum (*Coccoloba diversifolia*), black torch (*Erithalis fruiticosa*), gumbo limbo (*Bursera simaruba*) and lignum vitae (*Guaiacum sanctum*) (Smith 1993).

METHODS

We conducted our work in the human-disturbed habitats at the southern end of the BFS's grounds and in natural habitats that extended beyond the compound's border. The disturbed environment was heavily vegetated, but included a large concrete catchment basin (3.25 ha) that collected rainwater for human use. The basin was built in the mid-1950s and is surrounded by jimbay trees. Other sites in the disturbed area also contained jimbay, along with poison wood, scattered almond trees (*Prunus dulcis*) and Australian pine (*Casuarina equisetifolia*). Nearly half of the disturbed area was covered by shrubs, including horsebush (*Gundlachia corymbosa*), bay cedar (*Suriana maritima*), and hardhead (*Phyllanthus epiphyllanthus*).

The dry forest (hereafter "thicket") and mangrove communities were located to the west and east of the Reckley Hill Pond trail, respectively. The trail began in the disturbed area and connected to saline inland lakes (Godfrey et al. 1994). Where we worked, the trial was 3–10 m above sea level and formed a border between the mangrove and thicket. Forest height was 3–4 m (maximum of 5 m), and vegetation was continuous from the ground to the canopy in both habitats. Red mangrove was the dominant species at Reckley Pond, but Bahama swamp-bush (*Pavonia bahamensis*), a bird-pollinated associate of mangroves (Rathcke et al. 1995), was also common. The thicket was 30–35-yr old (D. Suchy, BFS Director). The disturbed, mangrove, and thicket fall into the Forest Edge, Wetland, and Dry Forest categories of Arendt (1992).

In 1994 we cut net lanes through vegetation in all three habitats (two in mangrove, three in thicket and five in disturbed areas). We reused eight of the ten original sites in later years but made several changes in 1996. One thicket net site was changed to a nearby location because the original site was lost to subsistence agriculture. We also added a third mangrove and a sixth disturbed net site and repositioned one net in the disturbed area. Net sites in the mangrove and thicket were paired and spaced at intervals of roughly 100 m along the trail. The mangrove nets cut through the ring of trees surrounding the pond. The thicket nets were set away from, but perpendicular to the trail. Most of our nets were 12 m × 2.6 m (30-mm mesh; four shelves), but we also used a few 6-m and 9-m nets. To control for net-size variation, we report results by giving capture rates per 12 m of net.

Over 90% of our netting activity took place between 0730 and 1130 h EST. We usually operated six nets in either the disturbed area or the two natural habitats. We measured body mass (Pesola scale), wing chord (15-

cm ruler), and length of tarsometatarsus and bill (with dial calipers). Individuals were sexed and aged when possible (Pyle et al. 1987). Birds were banded with U.S. Fish and Wildlife Service bands (1997 only) and then released at the site of capture.

We used STATISTIX (Siegel 1994) to summarize capture records and compare capture rates by habitat and year for each species and ecological category (i.e., resident and migrant). Capture rates were compared among habitats and years using contingency table analysis and *G*-tests. We also computed annual capture rates by species, and then compared mean capture rates of migrants and residents using analysis of variance. Similarity in species composition of the three communities was measured using Morisita's index (C_m; Cox 1996); values range from 0 (no similarity) to 1 (identical communities). Habitat use was assessed using capture records and direct observations. Habitat specialists were netted in a single habitat, while generalists were captured in all three. We also compared body mass and condition (mass divided by wing chord) among habitats for species with adequate samples. We tested for homogeneity of variances among groups and used parametric statistics when variances were homoscedastic. Additional specific statistical tests are described below.

RESULTS

We captured 454 individuals and 30 species in 568 net h. In addition to the 28 species listed in Table 1, we captured an American Kestrel (*Falco sparverius*; disturbed zone) and Green Heron (*Butorides virescens*; mangrove) in both 1996 and 1997. Excluding the kestrel and heron, 12 of the species were residents and 16 were migrants. Bananquits (see Table 1 for scientific names) made up 56% of the resident captures (145/258). The migrants were not dominated by a single species, but 13 of 16 species and 79.8% of captures (n = 188) were parulids.

The failure to account for recaptures during the first two years might confound the estimates of each species' relative abundance. To examine this problem, we used the 1997 data on banded birds to compare total capture rate for each species to the number of banded individuals. The total number of captures for each species was positively correlated with the number of banded individuals (r_s = 0.980, n = 24 species, $P < 0.001$). This correlation persisted when species with fewer than five captures were excluded (r_s = 0.912, n = 13 species, $P < 0.001$). In further analyses we use the total number of captures as an estimate of the relative number of individuals of each species.

Community characteristics.—More species (Table 1) and individuals (Table 2) were captured in the disturbed habitat than in mangrove or thicket, but in all habitats the percentage of species that was resident was near 40% when species with single captures were excluded (Table 1). The number of specialist species (captured in one habitat) was highest in the disturbed community and lowest in the thicket (Table 1). Our measure of community similarity indicated that the mangrove and thicket communities were the least (C_m = 0.531), and the thicket and disturbed site

TABLE 1. A comparison of capture rates of permanent resident (R) and winter resident (= migrant; M) birds in mist nets placed in three habitats on San Salvador, Bahamas during 1994, 1996 and 1997. Migratory status obtained from Sordahl (1995).

Species	Capture Rate (birds/100 net h)		
	Mangrove	Thicket	Disturbed
Common Ground-Dove (*Columbina passerina*; R)			6.8
Mangrove Cuckoo (*Coccyzus minor*; R)	0.7		0.4
Smooth-billed Ani (*Crotophaga ani*; R)			0.7
Bahama Woodstar (*Calliphlox evelynae*; R)		0.6	0.4
West Indian Woodpecker (*Melanerpes superciliaris*; R)	0.7		
Thick-billed Vireo (*Vireo crassirostris*; R)	2.9	9.8	2.2
White-eyed Vireo (*V. griseus*; M)		1.3	2.5
Gray Catbird (*Dumetella carolinensis*; M)	2.2	0.6	0.7
Northern Mockingbird (*Mimus polyglottos*; R)			1.1
Bahama Mockingbird (*M. gundlachii*; R)	1.4		0.4
Pearly-eyed Thrasher (*Margarops fuscatus*; R)	3.6		2.9
Northern Parula (*Parula americana*; M)			0.7
Yellow Warbler (*Dendroica petechia*; R)	5.8	2.0	7.2
Cape May Warbler (*D. tigrina*; M)		1.3	5.4
Black-throated Blue Warbler (*D. caerulescens*; M)			2.5
Yellow-rumped Warbler (*D. coronota*; M)	4.0	1.3	
Yellow-throated Warbler (*D. dominica*; M)			0.4
Prairie Warbler (*D. discolor*; M)	3.6	4.6	7.2
Palm Warbler (*D. palmarum*; M)		3.3	6.8
Black-and-white Warbler (*Mniotlia varia*; M)	3.6		0.4
American Redstart (*Setophaga ruticilla*; M)	3.6	0.6	3.2
Worm-eating Warbler (*Helmitheros vermivorus*; M)	2.9		
Ovenbird (*Seiurus aurocapillus*; M)	1.4	2.0	3.6
Northern Waterthrush (*S. noveboracensis*; M)	6.6		
Common Yellowthroat (*Geothlypis trichas*; M)	0.7	0.6	3.6
Bananaquit (*Coereba flaveola*; R)	7.3	30.1	31.9
Indigo Bunting (*Passerina cyanea*; M)			8.2
Black-faced Grassquit (*Tiaris bicolor*; R)	0.7	2.0	4.3
Total species[a]	17 (13)	14 (10)	24 (19)
Resident species[a]	8 (5)	5 (4)	11 (8)
Migrant species[a]	9 (8)	9 (6)	13 (11)
Exclusive species[a]	3 (2)	0	7 (6)

[a] Number in parentheses excludes species captured only once in that habitat.

TABLE 2. Net hours and capture rates for resident and migrant birds from three habitats on San Salvador during mid-January 1994, 1996, and 1997.

Capture rate (birds/100 net h)	Mangrove				Thicket				Disturbed			
	1994	1996	1997	Mean	1994	1996	1997	Mean	1994	1996	1997	Mean
All species	67	28	58	51	84	41	55	60	130	185	62	103
All residents	36	20	19	23	73	29	33	44	65	117	33	58
Bananaquits	18	5	3	7	62	22	13	30	48	87	5	32
Migrants	31	8	39	28	9	12	22.5	16	65	68	29	45
Net Hours	33	40	64	—	45	41	67	—	60	60	159	—

TABLE 3. Annual variation in capture rates of selected species and ecological groups on San Salvador between 1994 and 1997. Data combined across habitats.

	1994	1996	1997
Residents	61.6	63.8	30.0
Bananaquits	45.6	44.7	6.6
Thick-billed Vireos	2.2	5.0	5.2
Residents (no Bananaquits)	15.9	19.1	23.4
Migrants	38.4	34.8	29.7
White-eyed Vireo	3.6	2.8	0.0
Indigo Bunting	4.3	2.1	4.8
Common parulids[a]	3.1 (1.73)	3.7 (3.06)	2.5 (1.81)
Uncommon parulids[b]	0.6 (0.58)	1.1 (1.45)	0.3 (0.39)

[a] Mean (SD) of species with ten or more captures: Cape May Warbler, Prairie Warbler, American Redstart, Ovenbird, Northern Waterthrush, Common Yellowthroat (ANOVA among years; $F_{2,15} = 0.40$, $P = 0.69$).

[b] Mean (SD) of species with fewer than ten captures: Northern Parula, Black-throated Blue Warbler, Yellow-throated Warbler, Black-and-white Warbler and Worm-eating Warbler (ANOVA among years; $F_{2,12} = 0.64$, $P = 0.55$).

($C_m = 0.847$) were the most, similar ($C_m = 0.656$ for the mangrove and disturbed sites). However, much of the similarity between the thicket and disturbed plot arose from the many Bananaquits captured at both sites (Table 1). Reanalysis after excluding Bananaquits resulted in C_m values that were lower and similar ($C_m = 0.489$, 0.533, and 0.505 for mangrove versus thicket, thicket versus disturbed, and mangrove versus disturbed, respectively).

Averaged over the 3-yr period, the mangrove and thicket yielded between 50 and 60 birds per 100 net h compared to just over 100 at the disturbed site (Table 2). The 3-yr totals indicate that migrant and resident capture rates were about equal in the mangrove and disturbed sites, but resident species were captured nearly three times more often than migrants in the thicket (Table 2; 2 × 3 contingency table, $G = 9.639$, df = 2, $P < 0.01$). Excluding Bananaquits, annual comparisons showed that migrants were more likely to be captured in disturbed sites in both 1994 ($G = 12.440$, $P < 0.005$) and 1996 ($G = 9.262$, $P < 0.01$), and that in 1997 migrants tended to be captured more often in the mangroves ($G = 5.394$, $P = 0.07$). The latter pattern was also evident in 1994 (Table 2). On the other hand, residents and migrants were equally likely to be captured in the thicket in all three years.

Annual variation in capture rate.—Total capture rate varied more among habitats in 1994 and 1996 than in 1997 (Table 2). Resident capture rates were high in the thicket in 1994, and in the disturbed community in 1994 and 1996, due entirely to high Bananquit capture rates (Table 2). The number of Bananaquit captures dropped in all habitats in 1997 (Table 3), but capture rates of other residents did not (e.g., Thick-billed Vireos) or even increased (Table 3). The capture of migrants in the disturbed community dropped sharply in 1997 (Table 2). However,

TABLE 4. Comparisons of mean (standard deviation in parentheses) body mass and condition (mass/wing chord) between high capture rate (= High) and low capture rate (= Low) habitats for species captured frequently in two or more habitats.

	Body mass (g)			Body condition (g/mm)		
	High	Low	t (P)[a]	High	Low	t (P)[a]
Thick-billed Vireo	14.0 (0.72)	13.6 (0.68)	1.43 (0.16)	0.23 (0.01)	0.22 (0.01)	1.71 (0.10)
Yellow Warbler	9.3 (1.04)	9.6 (0.92)	0.32 (0.76)	0.16 (0.02)	0.16 (0.02)	0.38 (0.71)
Prairie Warbler	6.9 (0.87)	6.7 (0.22)	0.57 (0.57)	0.13 (0.02)	0.12 (0.01)	0.93 (0.36)
Ovenbird	19.6 (1.16)	18.8 (1.73)	1.03 (0.32)	0.26 (0.02)	0.26 (0.03)	0.85 (0.41)
Bananaquit	11.3 (1.18)	12.2 (1.61)	1.96 (0.07)	0.18 (0.02)	0.20 (0.02)	2.31 (0.02)

[a] Results of t-test comparing body mass and condition between high and low capture habitats. Sample sizes for high and low capture habitats, respectively, for each species are: Thick-billed Vireo (15 and 8), Yellow Warbler (24 and 4), Prairie Warbler (24 and 4), Ovenbird (10 and 5) and Bananaquit (81 and 13).

capture rates of the 13 migrants failed to show significant variation among years ($F_{2,45}$ = 0.28, P = 0.76), regardless of whether they were common or uncommon species (Table 3). The White-eyed Vireo was the only species to show a linear decline in captures over time (Table 3).

Habitat use.—Northern Waterthrushes and Worm-eating Warblers were only captured in mangroves whereas Common Ground-Doves, Indigo Buntings, and Black-throated Blue Warblers were only captured in the disturbed habitat. Common Yellowthroats were captured mainly at disturbed sites, but Black-and-white Warblers depended heavily on mangroves (Table 1). Thick-billed Vireos were captured in all habitats, but were 3–4 times more likely to be captured in the thicket than elsewhere. Most of the remaining species were captured frequently in two or even three habitats (Table 1). In general, 7–8 species were restricted to mainly one habitat, 3–4 were generalists (i.e., used all habitats frequently), and seven were captured often in two habitats. Six species had mangroves as either a primary or secondary habitat whereas ten relied on disturbed sites as their primary or secondary habitat (Table 1). The Thick-billed Vireo was the only species that appeared to prefer the thicket.

Habitat and body condition.—We tested for differences in body mass and condition among habitats for species with adequate sample sizes. Thick-billed Vireos from high capture habitats (=thickets) tended to be heavier and in better condition than birds from other habitats, but the differences were not statistically significant (Table 4). Differences in body mass and condition between individuals caught in high and low capture habitats for three parulids were also not significant (Table 4). All three species were captured in all habitats and used at least two habitats fairly equally (Table 1). We limited our analysis of Bananaquits to 1994 and 1996 because not only were Bananaquit capture rates very low in 1997 (Table 3), but body mass and condition were lower in 1997 than in 1994 and 1996 (Table 5). Bananaquits also exhibited an apparent habitat shift

TABLE 5. Bananaquit body mass and condition (mass/wing chord) during January of 1994, 1996 and 1997.

	1994	1996	1997	
	x̄ (SD, *n*)	x̄ (SD, *n*)	x̄ (SD, *n*)	*F* (*P*)[a]
Body mass (g)	11.2 (1.20, 48)	11.5 (1.35, 46)	10.8 (0.94, 18)	2.54 (0.08)
Body condition (g/mm)	0.18 (0.017, 47)	0.19 (0.021, 41)	0.17 (0.014, 18)	3.36 (0.04)

[a] Results of analysis of variance on body mass and condition across years.

between 1994 and 1996 (see also Wunderle et al. 1992). In both years, mangroves had the lowest and disturbed habitats the highest capture rates. In the thicket, capture rates were high in 1994 but low in 1996 (Table 2). We combined habitats on the basis of similarity in capture rates and compared the high capture rate habitats (thicket and disturbed in 1994 and disturbed in 1996) to the low capture rate habitats (mangrove in 1994 and mangrove and thicket in 1996). Bananaquit body mass tended to be, and body condition was significantly higher in the low capture rate habitats than in the high capture rate habitats (Table 4).

DISCUSSION

Like most West Indian islands (Faaborg and Terborgh 1980, Terborgh and Faaborg 1980), San Salvador supports relatively few permanent residents (Miller 1978). The community is dominated by small, migrant, gleaning insectivores, most of which belong to the family Parulidae. Based on our captures, 57% of species and 41% of individuals were migrants (61% if Bananaquits are excluded). The percentage of winter-resident species and individuals on San Salvador is greater than or equal to other islands in the Greater and Lesser Antilles (Terborgh and Faaborg 1980) and is high even for the Bahamas. San Salvador supports essentially the same community of nearctic migrants as Andros, New Providence, and Great Inagua, despite the fact that San Salvador has only 2% of the total land area of the other three islands (7708 km^2), is xeric (xeric habitats support fewer migrants in the Caribbean, Askins et al. 1992, Terborgh and Faaborg 1980, Wunderle and Waide 1993), and is the most isolated of the islands in the Bahamas. Indeed, species richness declines with distance from Florida in the Bahamas and Greater Antilles, especially when analyses are conducted within habitat types (Wunderle and Waide 1993).

Our characterization of San Salvador's avian community was based on mist net captures, which may lead to large errors in the estimated relative abundance of species and even age/sex classes within species due to several biases (Remsen and Good 1996). For example, abundance may be incorrectly estimated if (a) mist nets do not sample the entire vertical range of vegetation and avian activity, (b) if the ability to evade capture varies among species, or if species differ in (c) spacing patterns (e.g., territorial versus flocking behavior) and (d) frequency of flights (Remsen and Good 1996). Although we realize that our study suffered from some of these problems, we believe that with only a few exceptions, our capture rates did in fact accurately reflect the relative abundance of most species. The most serious flaw of using mist nets is probably the failure to capture birds that remain above the maximum height of the nets (Fitzgerald et al. 1989). However, because the forests within our study area rarely exceeded four meters in maximum height (and often only 3 m), we were able to net at nearly all vegetational levels. The few species that we only infrequently captured because they remained above the nets included Bahama Mockingbird, Yellow-throated Warbler, and Smooth-billed Ani. Anis were also infrequently captured because they were often able to struggle free of the net. Likewise, the abundance of Bahama Woodstars was underestimated because they virtually always moved through the nets. Species that are highly mobile and/or social are also far more likely to be captured than are species that either fly infrequently or are territorial (Remsen and Parker 1983). However, given that our 1997 data showed that the total number of captures of each species was strongly correlated with the number of marked individuals, we do not believe that differences in spacing or movement patterns greatly influenced our result.

On the other hand, we frequently captured a number of species that Sordahl (1995) listed as uncommon (American Redstart, Black-and-white Warbler, Indigo Bunting, Northern Waterthrush) or rare (Black-throated Blue Warbler, Common Yellowthroat, Worm-eating Warbler, Yellow-rumped Warbler). These discrepancies may have arisen as a result of either recent eastward range expansions by some species in the Caribbean (Arendt 1992), or more likely, the failure of observers to note the presence of secretive species. We also captured 12 of the 16 resident landbirds: the four missing species were uncommon to rare pigeons and doves (Sordahl 1995).

Annual variation in capture rate.—The most dramatic event to occur over the 4-yr period covered by our study was the Bananaquit population crash in 1997. Capture rate dropped seven-fold, and body mass and condition were lower in 1997 than in the previous two years. Bananaquits eat nectar and insects (Terborgh and Faaborg 1980), and we suspect that the population crash and the poor condition of the remaining birds were related to the destruction of nectar resources when Hurricane Lilly passed over San Salvador on 21 Oct. 1996. Lilly stripped vegetation from virtually all of the plants in the study area and from much of the island (D. Suchy, pers. comm.). We traveled widely over the island throughout January 1997, and few Bananaquits were seen anywhere. The only other nectarivore on the island, the Bahama Woodstar, was captured once in both 1994 and 1996, but not in 1997. We also saw fewer woodstars in 1997 than in previous years, and it seems that this hummingbird also experienced a population decline. Nectarivores and frugivores are generally thought to be more affected by severe weather than are insectivores (Faaborg and Terborgh 1980, Wunderle et al. 1992). The low capture rate and poor body condition of Bananaquits, and the failure of other permanent and winter residents to show significantly lower capture rates (Table 3) all suggest that only nectarivores suffered a catastrophic loss of food supplies after Hurricane Lilly. The only other species to exhibit a decline was the White-eyed Vireo (we saw only one individual in 1997 and captured none). In the Yucatan, Greenberg (1992) found frugivory to be more common in White-eyed Vireos than in all other migrants. Although White-eyed Vireos are declining throughout their breeding range (Sauer and Droege 1992), they may have also suffered from depressed food supplies following Hurricane Lilly.

Habitat use and preference.—Northern Waterthrushes were mangrove specialists on San Salvador as they are throughout their winter range (Lefebvre and Poulin 1996, Terborgh and Faaborg 1980, Wunderle and Waide 1993). Black-and-white Warblers and American Redstarts also used mangroves heavily (see also Arendt 1992, Lynch 1989, Sherry and Holmes 1996, Wunderle and Waide 1993), but our finding that Worm-eating Warblers were netted only in mangroves was unexpected because this species usually winters in wet or montane forests (Arendt 1992, Wunderle and Waide 1993). The restriction of Worm-eating Warblers to mangroves possibly arose from their dead leaf foraging habits (Greenberg 1987) and the high concentration of dead leaves in the mangrove habitat.

For species captured in two or more habitats, frequency of capture can be a misleading indicator of habitat preference for at least two reasons. First, differences in foliage height profile among habitats will usually influence captures rates (Fitzgerald et al. 1989), and secondly, territorial behavior by dominant individuals can displace large numbers of "floaters" to suboptimal habitats (Wunderle 1995). Although the former bias was not a major factor in our study (because vegetation showed similar height distributions in the three habitats), we cannot exclude the possibility that territorial behavior influenced habitat distributions. In such cases, other criteria are needed to establish preference (e.g., residence time, body condition, or variation in age/sex class distributions; Lopez and Greenberg 1990, Marra et al. 1993, Rappole et al. 1989, Wunderle 1995). Based on frequency of capture, Thick-billed Vireos seemed to prefer the thicket. Body condition tended to be higher in the thicket than elsewhere, but the difference was not statistically significant. Ovenbirds, Prairie Warblers and Yellow Warblers were captured in all habitats nearly equally often and exhibited no tendency for body mass or condition to vary among habitats, suggesting that they were indeed habitat generalists. On the other hand, mangrove nets yielded far fewer Bananaquits than nets placed elsewhere, yet their body condition in the mangroves (and nearby thicket in 1996) indicated that these birds were very well fed. Unbeknownst to us during the study, a major nectar source (Bahama Swamp-bush; Rathcke et al. 1995) was common at our mangrove site and along the border with the thicket. Based on the distribution of nectar supplies, Bananquit captures, and body mass and condition, we suspect that dominant Bananaquits defended nectar sources in and near the mangroves and excluded most conspecifics to the disturbed habitat.

Migrants and disturbed habitats.—It is difficult, possibly impossible, to generalize about the importance of disturbed sites as overwintering areas for nearctic migrants. Askins et al. (1992) and Greenberg (1992) noted heavier use of native habitats, but in other studies migrants were reported to use disturbed areas more than undisturbed forest (Kricher and Davis 1992, Lynch 1992, Petit et al. 1992, and Wunderle and Waide 1993). We found that winter residents used the disturbed site more than other habitats. Typical forest species may use disturbed areas (albeit at lower densities than moist forest; Greenberg 1992, Lynch 1992), but generally only when such sites are found near large, relatively undisturbed forest patches. Another factor that may explain the high abundance of migrants in the disturbed area on San Salvador is the fact that dry scrub habitats (our thicket) generally support few migrants (Wunderle and Waide 1993). The presence of freshwater in the catchment basin at our disturbed site may have also attracted birds. Equally important, we found that migrants tended to use mangrove in excess of the thicket in two of three years. Wunderle and Waide (1993) noted the same pattern, and speculated that this was because most nearctic migrants in the Caribbean breed in forest habitats in eastern North America and prefer the greater cover provided by mangroves. Mangroves and disturbed zones with abundant vegetation thus appear to be important habitats for nearctic migrants on San Salvador (see also Lefebvre and Poulin 1996, Lynch 1989 for studies in mangroves elsewhere).

ACKNOWLEDGMENTS

We are indebted to Dr. Daniel Suchy and his wife Nicole for their logistical support during our three visits to the Bahamian Field Station. We would also like to thank Vince and Sandy Vogelai, the rest of the BFS staff, and Dr. Douglas Hamilton for their friendship and generosity.

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Received 21 Feb. 1997; accepted 21 Jul. 1997.