

NEARCTIC-NEOTROPICAL MIGRANT WOOD-WARBLER POPULATIONS IN ST. MARTIN, WEST INDIES

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Abstract: Standardized mist netting was used from 2002–2009 to survey Nearctic-Neotropical migrant wood-warbler populations in three common habitats on the island of St. Martin, West Indies. The primary goal of this study was to compare avian diversity and relative abundance in (a) secondary dry forest, (b) thorn scrub forest, and (c) mangrove scrub forest, including assessment of sex and age differences among these habitats, and a preliminary evaluation of annual return rates. A total of 18 species and 710 individuals were captured across all habitats. Data collected indicate a greater abundance and diversity of wood-warbler species on St. Martin than previously recorded, with four new species recorded for the island. The secondary dry forest was the most used habitat with the highest capture rate (9.32 birds captured per 100 mist net-hr) and diversity of species (14). There were no age or sex differences in passerine use of the three habitats. In general, wood-warbler populations had lower rates of annual return compared to similar studies in the West Indies.

Key words: habitat use, Lesser Antilles, Nearctic-Neotropical migrants, St. Martin, wood-warblers

Resumen: POBLACIONES MIGRANTES NEÁRTICAS-NEOTROPICALES DE PARÚLIDOS EN SAN MARTIN, CARIBE INSULAR. Un muestro estandarizado con redes de niebla fue utilizado del 2002–2009 para muestrear las poblaciones migrantes neárticas-neotropicales de parúlidos en tres hábitats comunes de la isla de San Martin, en el Caribe Insular. El objetivo principal de este estudio fue comparar la diversidad y la abundancia relativa en (a) un bosque seco secundario, (b) un matorral espinoso y (c) un manglar, incluyendo la estimación de diferencias entre sexos y edades entre estos hábitats y una evaluación preliminar de las tasas anuales de retorno. Se capturaron un total de 18 especies y 710 individuos en todos los tipos de hábitat. Los datos colectados indican una mayor abundancia y diversidad de parúlidos en San Martin que lo que había sido registrado previamente, con cuatro nuevas especies reportadas para la isla. El bosque seco secundario fue el hábitat más utilizado, con las más altas tasa de captura (9,32 individuos capturados por 100 h / red) y diversidad de especies (14). No existieron diferencias entre sexos y edades en el uso de los tres hábitats por parte de este grupo de aves. En general, las poblaciones de parúlidos tuvieron tasas de retorno anual menores al compararlas con estudios similares en el Caribe Insular.

Palabras clave: Antillas Menores, migrantes neárticos-neotropicales, parúlidos, San Martin, uso de hábitat

Résumé : POPULATIONS DE PARULINES MIGRATRICES NÉARCTIQUES-NÉOTROPICALES À SAINT-MARTIN, ANTILLES. Des captures normalisées au filet ont été réalisées de 2002 à 2009 pour étudier les populations de parulines migratrices néarctiques-néotropicales dans trois habitats communs sur l'île de Saint-Martin, Antilles. L'objectif principal de cette étude était de comparer la diversité et l'abondance relative de l'avifaune en (a) forêt sèche secondaire, (b) forêt d'arbustes épineux, et (c) forêt de mangrove, de comparer les sexes-ratios et les âges-ratios des peuplements de parulines de chacun de ces habitats, et de faire une évaluation préliminaire des taux de retour annuel. Au total, 710 individus appartenant à 18 espèces ont été capturés dans tous les habitats. Les données recueillies indiquent une abondance et une diversité des espèces de parulines sur Saint-Martin plus fortes que ce qui avait été précédemment observé, avec quatre espèces observées pour la première fois sur l'île. La forêt sèche secondaire était l'habitat le plus utilisé, présentant le taux de capture le plus élevé (9,32 oiseaux capturés par 100 filet/h) et la plus forte diversité spécifique (14). Les peuplements des trois habitats ne présentaient pas de différence d'âges-ratios ni de sexes-ratios. En général, les populations de parulines présentaient des taux de retour annuel plus faibles que ceux observés lors d'études similaires dans les Antilles.

Mots clés : migrants néarctiques-néotropicaux, Petites Antilles, Saint-Martin, utilisation de l'habitat

A Nearctic-Neotropical migrant wood-warbler is any species of warbler in the family Parulidae that breeds in North America and regularly migrates southward to the Neotropics during the non-breeding season (Hayes 1995). Significant declines in these populations over the last few decades have led to increased research into causes of these de-

clines on both breeding and non-breeding grounds (Wallace *et al.* 1996, Latta and Baltz 1997, Norris *et al.* 2004, Johnson *et al.* 2006, Norris and Marra 2007). With migrants spending up to seven months on their tropical wintering grounds and only two to three months in temperate breeding areas, Holmes *et al.* (1989), Wunderle (1995), Norris *et al.* (2004),

Keller and Yahner (2006), and others have suggested that events on the wintering grounds play a critical role in the annual cycle of these birds.

During the non-breeding season wood-warblers winter in a wide range of habitats and geographic locations including Mexico, Central America, South America, and the Caribbean islands, where loss of tropical forest has been severe and well documented (Brooks *et al.* 2002). Although wood-warblers may be more diverse in the types of habitats used in the wintering grounds, the geographical range of habitat is much smaller than in the breeding season. Therefore, loss of habitat in the wintering grounds may have a more intense effect on populations, making it more difficult to find food and avoid predators (Terborgh 1989).

In order to better understand and track changes in abundance and distributions due to events on the wintering grounds, the geographic range of research on wood-warbler in the Neotropics must expand, especially in the Caribbean. The majority of research in the Caribbean has focused on a few species of migrant wood-warblers in the Greater Antilles, mainly on the islands of Hispaniola, Puerto Rico, and Jamaica (Parrish and Sherry 1994, Wunderle 1995, Wunderle and Latta 2000, Latta and Faaborg 2001, Latta *et al.* 2003, Faaborg *et al.* 2007). Relatively few studies have taken place in the Lesser Antillean islands of the Caribbean, where long-term scientific research on overwintering wood-warblers is absent on many of the smaller islands.

Little is known of the basic ecology or habitat needs of wood-warblers wintering in St. Martin, a small island in the northern fringe of the Lesser Antilles. Many of St. Martin's habitats, especially secondary dry forest, are currently under threat due to development, and it is essential to identify and protect habitats used by wintering wood-warblers.

The goals of this paper, based on banding data collected from 2002–2009 in three habitats on St. Martin, are to (1) quantify wood-warbler diversity and relative abundance, (2) explore habitat distribution and segregation by sex and age for five common species, (3) explore habitat used by wood-warblers, and (4) expand the geographic range of knowledge for wintering Nearctic-Neotropical migrants in the Caribbean.

METHODS

Banding operations were conducted at three common habitat types on St. Martin: (a) secondary dry forest, (b) thorn scrub forest, and (c) mangrove

scrub forest. The secondary dry forest habitat patch sampled was 2.74 km² and located 350 m above sea level on Lotterie Farm, in northeast St. Martin. The patch was bordered on two sides by thorn scrub forest and two sides by road. The site was once a plantation but since has been reforested and left to regenerate for over 200 yr with a mix of native hardwoods, such as mahogany (*Swietenia mahagoni*) and cedar species, and horticultural species such as breadfruit trees (*Artocarpus communis*), cocoa (*Theobroma cacao*), mango (*Mangifera indica*), and royal palm (*Roystonea regia*). Thorn scrub is the most common vegetation type on St. Martin. The thorn scrub forest site sampled was 0.45 km², on Lotterie Farm, located 300 m above sea level. The site was dominated by acacia (*Acacia turtuosa*) and bordered on one side by dry forest and on three sides by road. The mangrove scrub forest was located at sea level in Etang Aux Poissons, a lagoon that is completely fringed in mangroves. The side of the lagoon where banding occurred was located in a patch of mangroves 1.22 km², consisting primarily of red mangroves (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), buttonwood (*Conocarpus erectus*), and sea grape (*Coccoloba uvifera*)

All nets used were 12 m long, 30 mm mesh, 4-tier, tethered, nylon mist nets. Captured birds were banded with uniquely numbered United States Fish and Wildlife Service bands, and identified to species, age, and sex by plumage characteristics following Pyle (1997). All mist nets were placed in areas where avian traffic was predicted to be high to assure high capture and recapture rates within sites. Net locations were constant among years. The sampling effort consisted of three 15-day netting cycles conducted over 3 months, starting in January and ending in March; during each cycle, sampling occurred at each site for five consecutive days. A total of 12,589.25 net hours were accumulated from 2002–2009: 6728.8 net hours in the secondary dry forest, 2042.0 net hours in the thorn scrub forest, and 3818.5 net hours in the mangrove scrub forest (see Appendix 1 for more details of sampling effort). Although all bird species were captured and banded during these sampling periods, this analysis is restricted only to wood-warblers.

Relative abundances for each species of migrant wood-warbler captured were calculated as the number of individuals captured per 100 net-hr within each habitat (excluding recaptures). Annual return rates were expressed as the percentage of captured and banded individuals that was recaptured in the

Table 1. Capture rates (number of individuals captured per 100 mist net-hr) for all Nearctic-Neotropical migrant wood-warblers in three common habitats on St. Martin during 2002–2009. Numbers in parenthesis represent total number of individuals captured. *H* and *P* values for among habitat comparisons are based on Kruskal-Wallis tests; an asterisk (*) indicates statistically significant differences among habitats.

Species	Secondary Dry Forest	Thorn Scrub Forest	Mangrove	<i>H</i>	<i>P</i>
			Scrub Forest		
Ovenbird (<i>Seiurus aurocapilla</i>)	0.21 (14)	0.24 (9)	–	2.26	0.13
Worm-eating Warbler (<i>Helmitheros vermivorus</i>)	0.03 (2)	–	–	–	–
Louisiana Waterthrush (<i>Parkesia motacilla</i>)	0.02 (1)	–	–	–	–
Northern Waterthrush (<i>Parkesia novaboracensis</i>)	–	0.05 (2)	1.08 (22)	5.67	0.02*
Blue-winged Warbler (<i>Vermivora cyanoptera</i>)	0.02 (1)	–	–	–	–
Black-and-white Warbler (<i>Mniotilta varia</i>)	1.89 (128)	0.05 (2)	–	11.27	< 0.01*
Prothonotary Warbler (<i>Protonotaria citrea</i>)	–	0.03 (1)	0.15 (3)	0.07	0.80
Kentucky Warbler (<i>Geothlypis formosa</i>)	0.13 (9)	–	–	–	–
Hooded Warbler (<i>Setophaga citrina</i>)	0.50 (34)	0.13 (5)	–	8.30	0.02*
American Redstart (<i>Setophaga ruticilla</i>)	4.14 (281)	0.11 (4)	–	12.30	< 0.01*
Cape May Warbler (<i>Setophaga tigrina</i>)	–	–	0.05 (1)	–	–
Northern Parula (<i>Setophaga americana</i>)	1.31 (89)	0.60 (23)	–	10.20	0.01*
Magnolia Warbler (<i>Setophaga magnolia</i>)	0.04 (3)	–	–	–	–
Chestnut-sided Warbler (<i>Setophaga pensylvanica</i>)	0.06 (4)	–	–	–	–
Black-throated Blue Warbler (<i>Setophaga caerulescens</i>)	0.71 (48)	–	–	–	–
Prairie Warbler (<i>Setophaga discolor</i>)	0.02 (1)	0.34 (9)	0.39 (8)	11.85	< 0.01*
Black-throated Green Warbler (<i>Setophaga virens</i>)	0.02 (1)	–	–	–	–

same habitat during a subsequent year (within year recaptures were excluded).

Due to limitations in sample sizes and sexual dimorphism, analysis of sex and age differences was restricted to five species of commonly captured wood-warblers: Black-and-white Warbler (*Mniotilta varia*), Hooded Warbler (*Setophaga citrina*), American Redstart (*Setophaga ruticilla*), Northern Parula (*Setophaga americana*), and Black-throated Blue Warbler (*Setophaga caerulescens*). Birds were sexed as male, female, or unknown, and aged as either hatch-year (HY), second-year (SY), after-second-year (ASY), after-hatch-year (AHY), or unknown following criteria presented by Pyle (1997).

Tests for statistical differences ($\alpha = 0.05$) were performed using the statistical program JMP IN version 4.04 (SAS Institute 2001). The Kruskal-Wallis test was used to compare the abundance of individuals captured in mist nets among habitats and the Fisher's exact test was used to compare sex and age ratios among habitats.

RESULTS

A total of 710 individuals from 18 species of Nearctic-Neotropical migrant wood-warbler were captured and banded from 2002–2009 across all habi-

tats (Table 1). Capture rates were higher in the secondary dry forest (9.32 birds captured per 100 mist-net-hr) than in mangrove scrub forest (1.67 birds captured per 100 mist net-hr) or thorn scrub forest (1.57 birds captured per 100 mist net-hr). Of the 18 species, 77.8% (14) were found in the secondary forest, 50.0% (nine) were found in the thorn scrub forest, and 22.2% (four) were found in the mangrove scrub forest.

The data collected suggest a high level of habitat specialization on St. Martin. Of the 18 species detected, 55.6% (10) were captured in only one habitat (Table 1). More species were captured solely in the secondary forest (eight) than in the thorn scrub forest (one), or mangrove scrub forest (one). Beyond those species identified as occurring in only one habitat, seven species occurred in two habitats and only one species occurred across all three habitats. Within-species tests revealed a significant difference in abundance of net captures for six species; four species were most abundant in secondary dry forest, and the remaining two species were most abundant in mangrove scrub forest (Table 1).

We determined the sex and age in five species with adequate sample sizes for analysis. No significant differences between habitats for either sex or age ratios were found (all Fisher's exact test *P*-

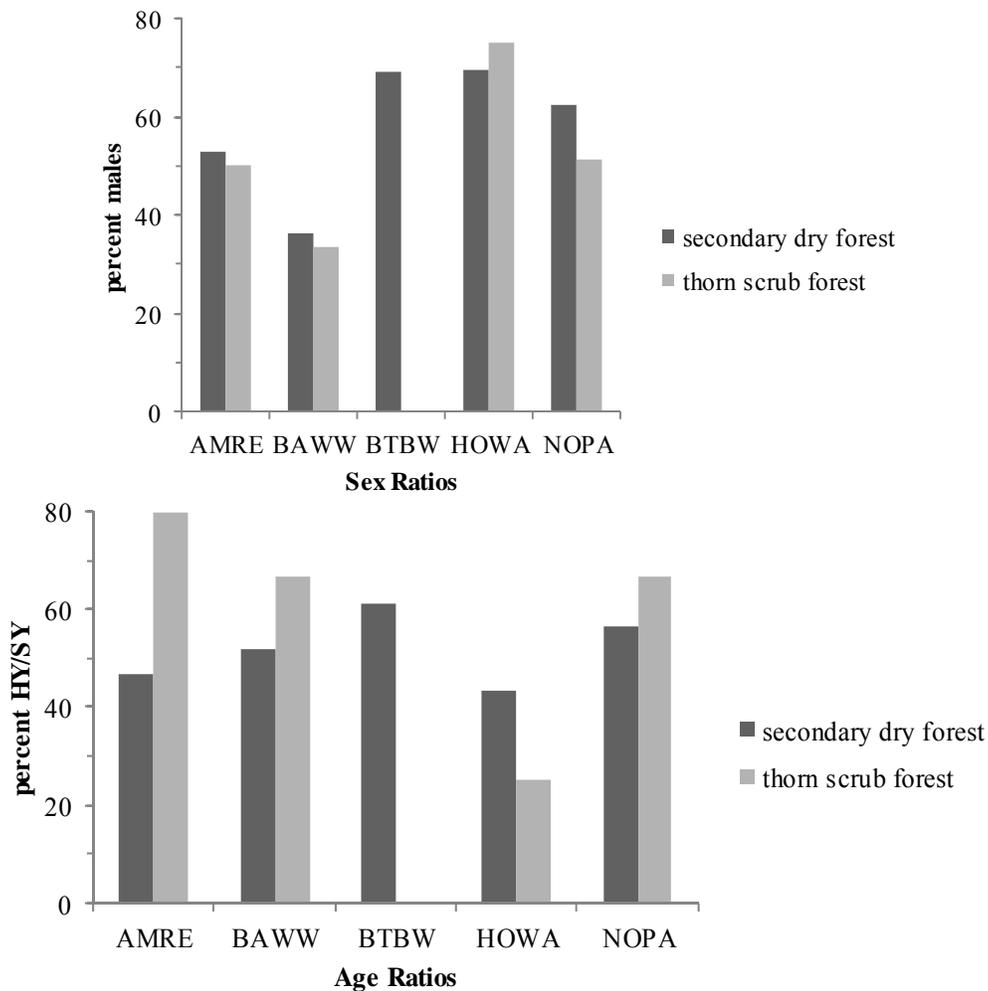


Fig. 1. Sex and age ratios (% of total capture) for five commonly occurring migrant wood-warblers in three common habitats on St. Martin from 2002–2009. AMRE = American Redstart, BAWW = Black-and-white Warbler, BTBW= Black-throated Blue Warbler, HOWA= Hooded Warbler, NOPA= Northern Parula.

values > 0.05) (Fig. 1).

Five species were recaptured in the same habitat in subsequent years following initial banding (Table 2). Of these species the Northern Waterthrush (*Parkesia noveboracensis*) was recaptured only within the mangrove scrub forest and the Prairie Warbler (*Setophaga discolor*) was recaptured only within the thorn scrub forest. The Black-and-white Warbler, American Redstart, and Northern Parula were recaptured in both the secondary forest and thorn scrub forest.

DISCUSSION

ABUNDANCE

Data collected on St. Martin has indicated a great-

er abundance and diversity of Nearctic-Neotropical migrant wood-warbler species than was previously recorded (Raffaele *et al.* 1998), with four new species records for the island: Blue-winged Warbler (*Vermivora cyanoptera*), Kentucky Warbler (*Geothlypis formosa*), and Chestnut-sided Warbler (*Setophaga pensylvanica*). We also recorded four second island records: Worm-eating Warbler (*Helmitheros vermivorum*), Louisiana Waterthrush (*Parkesia motacilla*), Prothonotary Warbler (*Protonotaria citrea*), and Magnolia Warbler (*Setophaga magnolia*).

The regular occurrence and abundance of American Redstart, Black-and-white Warbler, Black-throated Blue Warbler, Hooded Warbler, Northern Parula, Northern Waterthrush, Ovenbird (*Seiurus aurocapilla*), and Prairie Warbler is especially sur-

Table 2. Average yearly return rate for five Nearctic-Neotropical migrant wood-warblers in three common habitats on St. Martin during 2004–2008, expressed as the percentage of captured and banded individuals that was recaptured in the same habitat during a subsequent year (within year recaptures were excluded). Numbers in parenthesis represent the total number of individuals captured at each site.

Species	Secondary Dry Forest	Thorn Scrub Forest	Mangrove Scrub Forest
Northern Waterthrush	– (0)	– (2)	9.10 (22)
Black-and-white Warbler	24.22 (128)	50.00 (2)	– (0)
American Redstart	28.11 (281)	25.00 (4)	– (0)
Northern Parula	19.10 (89)	4.35 (23)	– (0)
Prairie Warbler	– (8)	7.69 (13)	– (8)

prising on St. Martin considering these species are documented as rare or vagrant in the Lesser Antillean region of the Caribbean (Voous 1983, Bond 1987, Evans 1990, Raffaele *et al.* 1998). For several of these species, capture rates exceed reported abundances from comparable mist netting studies in the Dominican Republic and Bahamas, including: American Redstart, Black-throated Blue Warbler, Northern Waterthrush, and Hooded Warbler (Murphy *et al.* 1998, Latta *et al.* 2003).

American Redstart capture rates, ranging from 0.11–4.14 individuals per 100 mist net-hr on St. Martin, were higher than those reported in both the Dominican Republic (0.04–0.28; Latta *et al.* 2003) and Bahamas (0.6–3.6; Murphy *et al.* 1998). Black-throated Blue Warblers were captured at a higher rate (0.71 individuals per 100 mist net-hr) in the secondary forest of St. Martin than in the Dominican Republic (0.34–0.50; Latta *et al.* 2003), but at a lower rate than in the Bahamas (2.50; Murphy *et al.* 1998). Northern Waterthrush capture rates, ranging from 0.05–1.08 individuals per 100 mist net-hr on St. Martin, were higher than in the Dominican Republic (0.28; Latta *et al.* 2003) but much lower than in the Bahamas (6.6; Murphy *et al.* 1998). Hooded Warblers winter primarily in the Yucatan peninsula of Mexico (Howell and Webb 1995). Smaller numbers of wintering individuals are found in the Greater Antillean islands of Cuba, Puerto Rico, and the Virgin Island, and on the Lesser Antillean islands of Guadeloupe and Martinique, but rarely on other islands in the Lesser Antilles (Arendt 1992). Comparable mist netting studies in the Dominican Republic and Bahamas produced zero Hooded Warbler captures. On St. Martin, Hooded Warbler captures ranged from 0.13–0.50 individuals per 100 mist net hours, which may be one of the larger population densities reported in the Caribbean (Wunderle and

Waide 1993, Latta *et al.* 2003).

HABITAT USE AND SEGREGATION

Habitat use by migrant wood-warbler species wintering in the Caribbean is diverse and has been found to vary between islands. Mangrove scrub forest on St. Martin provided critical habitat for the Northern Waterthrush but it did not support a high diversity or abundance of other species, unlike many other parts of the Caribbean (Arendt 1992, Lefebvre *et al.* 1992, Wunderle and Waide 1993, Parrish and Sherry 1994, Wallace *et al.* 1996, Latta *et al.* 2003). The thorn scrub forest was marginal for wood-warblers on St. Martin, supporting a high diversity of species but with low abundances. The secondary dry forest was the most critical habitat for Nearctic-Neotropical migrant wood-warbler species on St. Martin, supporting the highest abundance and diversity of species. Of all the wood-warbler species captured, 66.7% (12) were found only in the secondary dry forest or had significantly higher abundances in this habitat type. Additionally, the total capture rates were nearly nine times higher in the secondary dry forest than in any other habitat sampled. Annual return rates in the secondary dry forest (American Redstart, 28%; Black-and-white Warbler, 24%; and Northern Parula, 19%) were lower than those reported in comparable studies (Holmes and Sherry 1992, Wunderle and Latta 2000). Return rates were more similar to shaded coffee plantations in the Dominican Republic (American Redstart, 34%; Black-and-white Warbler, 40%; Black-throated Blue Warbler, 31%; Wunderle and Latta 2000) than those in natural forested habitats in Jamaica (American Redstart, 51%; Black-throated Blue Warbler, 46%; Holmes and Sherry 1992).

No segregation between habitats by sex or age was detected in St. Martin, contrary to many wood-

warblers populations studied in the Greater Antilles such as the American Redstart and Black-throated Blue Warbler. In Jamaica older, dominant, male American Redstart actively defend territories in relatively tall and moist forests whereas non-territorial females and younger birds are more confined to drier scrubby areas and disturbed habitats, including mangroves (Parrish and Sherry 1994). In Puerto Rico, male Black-throated Blue Warblers were similarly more common in relatively tall, mature forest with few fruiting understory plants, whereas females were more common in shrubby secondary forests with an abundance of fruiting plants (Wunderle 1995).

HABITAT CONSERVATION

New information on both the distribution and conservation requirements of migrants is being discovered as researchers move away from the familiar Greater Antillean regions of the Caribbean and into smaller, lesser known islands to the south such as St. Martin. This information can help raise awareness with government officials on the role each island plays in conserving populations of migrant birds, and help better manage rapidly disappearing habitats that are important for these species. Given the unexpectedly large number of migrant wood-warblers on St. Martin, habitat protection on the island may help sustain populations of these species and complement other protection efforts in the Caribbean region. The secondary dry forest is the most critical habitat for Nearctic-Neotropical migrant wood-warblers on the island and should be a conservation priority.

LITERATURE CITED

- ARENDR, W. J. 1992. Status of North American migrant landbirds in the Caribbean region: a summary. Pp. 143–171 *in* Ecology and conservation of Neotropical migrant landbirds. (J. M. Hagan III and D. W. Johnston, eds.). Smithsonian Institution Press, Washington, DC.
- BOND, J. 1987. Twenty-seventh supplement to the Check-list of birds of the West Indies (1956). Academy of Natural Sciences of Philadelphia, Philadelphia.
- BROOKS, T. M., R. A. MITTERMEIER, C. G. MITTERMEIER, G. A. B. DA FONSECA, A. B. RYLANDS, W. R. KONSTANT, P. FLICK, J. PILGRIM, S. OLDFIELD, G. MAGIN, AND C. HILTON-TAYLOR. 2002. Habitat loss and extinctions in the hotspots of biodiversity. *Conservation Biology* 16:909–923.
- EVANS, P. G. H. 1990. Birds of the eastern Caribbean. MacMillan Press Ltd, London.
- FAABORG, J., K. M. DUGGER, AND W. J. ARENDR. 2007. Long-term variation in the winter resident bird community of Guánica Forest, Puerto Rico: lessons for measuring and monitoring species richness. *Journal of Field Ornithology* 78:270–278.
- HAYES, F. E. 1995. Definitions for migrant birds: what is a Neotropical migrant? *Auk* 112:521–523.
- HOLMES, R. T., AND T. W. SHERRY. 1992. Site fidelity of migratory warblers in temperate breeding and Neotropical wintering areas: implications for population dynamics, habitat selection, and conservation. Pp. 563–575 *in* Ecology and conservation of Neotropical migrant landbirds (J. M. Hagan III and D.W. Johnston, eds.). Smithsonian Institution Press, Washington, DC.
- HOLMES, R. T., T. W. SHERRY, AND L. REITSMA. 1989. Population structure, territoriality and overwinter survival of two migrant warbler species in Jamaica. *Condor* 91:545–561.
- HOWELL, S. N. G., AND S. WEBB. 1995. A guide to the birds of Mexico and northern Central America. Oxford University Press, Oxford.
- JOHNSON, M. D., T. W. SHERRY, R. T. HOLMES, AND P. P. MARRA. 2006. Assessing habitat quality for a migratory songbird wintering in natural and agricultural habitats. *Conservation Biology* 20:1433–1444.
- KELLER, G. S., AND R. H. YAHNER. 2006. Declines of migratory songbirds: evidence for wintering-ground causes. *Northeastern Naturalist* 13:83–92.
- LATTA, S. C., AND M. E. BALTZ. 1997. Population limitation in Neotropical migratory birds: comments on Rappole and McDonald (1994). *Auk* 114:754–762.
- LATTA, S. C., AND J. FAABORG. 2001. Winter site fidelity of Prairie Warblers in the Dominican Republic. *Condor* 103:455–468.
- LATTA, S. C., C. C. RIMMER, AND K. P. MCFARLAND. 2003. Winter bird communities in four habitats along an elevational gradient on Hispaniola. *Condor* 105:179–197.
- LEFEBVRE, G., B. POULIN, AND R. MCNEIL. 1992. Abundance, feeding behavior, and body condition of Nearctic warblers wintering in Venezuelan mangroves. *Wilson Bulletin* 104:400–412.
- MURPHY, M. T., CORNELL K. L., AND MURPHY K. L. 1998. Winter bird communities on San Salvador, Bahamas. *Journal of Field Ornithology* 69:402–414.
- NORRIS, D. R., AND P. P. MARRA. 2007. Seasonal

interactions, habitat quality, and population dynamics in migratory birds. *Condor* 109:535–547.

NORRIS, D. R., P. P. MARRA, T. K. KYSER, T. W. SHERRY, AND L. M. RATCLIFFE. 2004. Tropical winter habitat limits reproductive success on the temperate breeding grounds in a migratory bird. *Proceedings of the Royal Society of London: Biological Sciences* 271:59–64.

PARRISH, J. D., AND T. W. SHERRY. 1994. Sexual habitat segregation by American Redstarts wintering in Jamaica: importance of resource seasonality. *Auk* 111:38–49.

PYLE, P. 1997. Identification guide to North American Birds. Slate Creek Press, Bolinas, CA.

RAFFAELE, H., J. WILEY, O. GARRIDO, A. KEITH, AND J. RAFFAELE. 1998. A guide to the birds of the West Indies. Princeton University Press, Princeton, NJ.

SAS Institute, Inc. 2001. JMPIN, V4.0.4. SAS Institute Inc., Cary, NC.

TERBORGH, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, NJ.

WALLACE, G. E., H. G. ALONSO, M. K. MC-NICHOLL, D. R. BATISTA, R. O. PRIETO, A. L. SOSA, B. S ORIA, AND E. A. H. WALLACE. 1996. Winter surveys of forest-dwelling Neotropical migrant and resident birds in three regions of Cuba. *Condor* 98:745–768.

WUNDERLE, J. M., JR. 1995. Population characteristics of Black-throated Blue Warblers wintering in three sites on Puerto Rico. *Auk* 112:931–946.

WUNDERLE, J. M., JR., AND S. C. LATTA. 2000. Winter site fidelity of Nearctic migrant birds in isolated shade coffee plantations of different sizes in the Dominican Republic. *Auk* 117:596–614.

WUNDERLE, J. M., JR., AND R. B. WAIDE. 1993. Distribution of overwintering Nearctic migrants in the Bahamas and Greater Antilles. *Condor* 95:

904–933.

VOOUS, K. H. 1983. Birds of the Netherlands Antilles. De Walburg Press, Curaçao.

Appendix 1. Sampling effort in St. Martin during 2002–2009.

Year	Nets	Net-hr	Dates
Secondary dry forest			
2002	10	480	11–14 Feb, 4–7 Mar
2003	11	954	5–9, 31 Jan, 1–4 Feb, 1–5 Mar
2004	16	1246	3–8 Jan, 8–11 Feb, 10–14 Mar
2005	16	992	2–6, 19–22 Jan
2006	17	1678.5	1–5, 18, 22 Jan, 2–5 Feb
2007	17	1234.75	2–6 Jan, 1–6 Feb, 1–5 Mar
2008	7	101.5	2–4 Jan, 6–8 Feb
2009	4	42	26–27 Feb, 1 Mar
Thorn scrub forest			
2003	10	900	10–14 Jan, 9–13 Feb, 1–5 Mar
2005	15	382.5	9–13 Jan
2006	17	1236	7–11, 23–27 Jan, 6–8 Feb
2007	17	1300	9–13 Jan, 7–11 Feb, 7–11 Mar
Mangrove scrub forest			
2003	10	750	15–19 Jan, 16–20 Feb, 7–11 Mar
2004	15	712	10–14 Jan, 5–9 Mar
2007	10	340	12–14 Jan, 13–15 Feb, 13–15 Mar
2008	10	240	6–8 Jan, 9–10 Feb