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Diversity of Neotropical migratory landbird species assemblages in forest fragments and man-made vegetation in Los Tuxtlas, Mexico

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Abstract. We investigated the presence of Neotropical migratory landbirds in a 90-km^2 landscape in the region of Los Tuxtlas, Veracruz, Mexico. Using the fixed-radius count point procedure, migratory landbirds were surveyed in 21 forest fragments and in four replicates of shaded (coffee, cacao and mixed) and unshaded (citrus and allspice) plantations, live fences, non-arboreal crops (corn and jalapeño chili pepper) and pastures. The surveys resulted in the count of 4732 birds representing 72 species. While forest fragments accounted for 65% of the total species count, 73% of the birds were counted in the arboreal man-made habitats. Pastures contributed to 10% of the species and to 1% of the individuals counted. Live fences were particularly rich in individuals, accounting for 28% of the birds counted. Rarefaction analysis showed that forest fragments were the sites richest in species, followed by shaded and unshaded plantations and by live fences. Pastures were the habitats poorest in species, followed by non-arboreal crops. Species richness of Neotropical migratory landbirds was associated to vertical and horizontal diversity of vegetation in the habitats investigated. Shaded and unshaded plantations as well as live fences were more similar to forest fragments in species assemblages than non-arboreal crops and pastures. We discuss the conservation value of arboreal agricultural habitat and of live fences in conjunction with forest fragments as temporary habitats for Neotropical migratory landbirds that stop over or winter in Los Tuxtlas.

Introduction

Migratory birds that breed in northern latitudes and winter in the tropics are an important component of avian diversity in tropical regions. For example, at Los Tuxtlas in southern Veracruz, Mexico, Neotropical migratory birds that breed in Canada and the USA contribute to about 30% of avian diversity in this region (ca. 550 species; Winker 1997) and thus constitute an important component of the local biological richness (Rappole and Ramos 1995; Estrada et al. 1997). Through their foraging activities in their wintering and stop-over habitats, Neotropical migratory (NM from here on) landbirds contribute to the cycling of animal and plant matter in the ecosystem and may also act as seed and pollen dispersal agents for a broad spectrum of plants in the forest, thus contributing to the natural process of forest regeneration (Coates-Estrada and

Estrada 1988; Loiselle and Blake 1993; Rappole 1995). It may be assumed that because of their dispersal abilities NM landbirds may be less vulnerable than other animals (e.g. carnivores, primates) to extensive deforestation and fragmentation of their stop-over and wintering habitats in the tropics. However, evidence to the contrary suggests important declines in numbers of these birds (Rappole 1995; Robbins et al. 1995).

In spite of their importance in the biodiversity and ecology of tropical rain forests, information on NM landbird responses to human-induced changes in the native vegetation of their stop-over and wintering landscapes is still scanty and only available for a few localities in Mesoamerica and the Caribbean (Rappole 1995; Wilson and Sader 1995). To contribute information in this direction, from 1996 to 1998, we investigated NM landbird species presence and relative abundances in forest fragments and in five agricultural habitats found in a human modified landscape in Los Tuxtlas, Mexico.

Methods

The study was conducted in a ca. 90 km^2 rugged landscape about 10 km long from north to south with a minimum and maximum width of about 3.5 and 12 km, respectively, with its eastern side bordering the Gulf of Mexico and located in the northeastern section of the region of Los Tuxtlas (95°00′W, 18°25′N) in southern Veracruz, Mexico (see Figure 1 in Estrada et al. 2000). Mean annual rainfall is 4900 mm with a drier season (mean = 111.7 SD ± 1.7 mm per month) from March to May and a wetter season (mean = 486.25 SD ± 87.0 mm per month) from June to February. Mean annual temperature is 27 °C. The elevational gradient in the landscape ranges from sea level to about 500 m above sea level.

The landscape originally occupied by lowland rain forest was gradually converted to pasture lands between the 1960s and 1970s, but because of difficult topography and because local inhabitants need to preserve water supplies for their own consumption and for their cattle, several forest fragments still remain in the area. The total area accumulated by these fragments ($N = 50$) was estimated at 25 km^2 or about 28% of the surface of the landscape under consideration; the rest consists of pasturelands divided among owners by live fences (live posts of *Bursera simaruba* – Burseraceae and *Gliricidia sepium* – Leguminosae). Interdigitated in some of the open spaces are occasional citrus, allspice, coffee, cacao and mixed (coffee and cacao) plantations (coffee, cacao and mixed plantations are grown under the shade of rain forest trees) with areas ranging from 5 to 10 ha. These perennial islands of man-made vegetation contribute to about 2% of the area of the landscape under investigation. Cultivation of non-arboreal crops such as corn and jalapeño chili pepper in small sections of the pasturelands is also a common seasonal practice among landowners.

Study sites

Forest fragments

Twenty-one of the 50 forest fragments present in the landscape under investigation were randomly selected to study the presence of NM landbirds. These sites ranged in elevation from sea level to about 200 m, in area from 5 to ca. 150 ha (median = 18, average = 35 ha ± 39; range 5–150), and in years since isolation (isolation = complete separation of forest from major forested land mass) from 5 to 35 years. Average isolating distance (straight line distance to the nearest vegetation patch, forest or man-made) of these fragments was 127 m (range 20–800 m). The total accumulated area of these sites was approximately 730 ha or 7.3 km^2.

Man-made habitats

NM landbirds were sampled in shaded arboreal plantations (coffee, cacao, mixed = coffee and cacao), unshaded arboreal plantations (citrus, allspice), live fences, non-arboreal seasonal cash crops (corn and jalapeo pepper) and in pastures. Four replicates of each agricultural habitat were investigated and these ranged in size from 5–10 ha. The arboreal habitats ranged in age from 12 to 15 years and the non-arboreal crops had been planted during one of the study years. All habitats were fruit productive and were isolated from other similar habitats and from forest fragments. Distance from these man-made habitats to the nearest forest fragment, regardless of size, ranged from 200 to 2000 m; distance to the nearest plantation ranged from 200 to 1000 m. Elevation at these sites ranged from sea level to 300 m. The live fence sites were about 2 km long each and located across the pasture land and in the vicinity of the forest and agricultural habitats studied and each of these sites was 2–3 km away from the others. The total accumulated area of these man-made sites was approximately 140 ha or 1.4 km^2. The four pasture habitats (grasses about 15–30 cm in height) in which NM landbirds were sampled were about 15 ha in size each and totally devoid of forest vegetation and of other arboreal vegetation introduced by man, and at least 2 km apart from each other, but within a 5 km radius of the forest sites we studied.

Bird counts

We conducted visual counts of birds in the habitat investigated using the fixed-radius census points method (Hutto et al. 1986) and following the guidelines for monitoring populations of landbirds in Mexico (Geupel and Warkentin 1995). In this procedure, all perching individuals detected by sight within a 25 m radius of the point-count center were recorded. Each count lasted 10 min and at least

30 min elapsed between counts at each point. Point counts were set up at 150 m intervals at each site for a total of nine points. We conducted all bird counts between 06:30 and 11:00 A.M. and avoided sampling on heavily overcast and rainy days. Each site was sampled once in each trimester of the year for a total of four samples. Our records excluded those species detected flying across the landscape and well above canopy level. Birds counted were identified to species and taxonomic level following the American Ornithologist's Union (1983).

Measures of the vegetation at the study sites

We recorded all trees >10 cm in dbh and at least 1.5 m in height in six 10×10 m plots at each site. We located the plots randomly within the area where we sampled the birds; the plots were at least 30–40 m from each other. Vegetation plots in the live fence sites were 2×10 m. We measured vertical foliage density at four randomly selected spots within each of the six plots by scoring vegetation intercepts along a vertical pole at the following intervals: 0–0.5, >0.5–1, >1–2, >2–3, >3–5, >5–8 (Schemske and Brokaw 1981). We expressed intercepts at each height interval as the proportion of total intercepts recorded per site in each habitat and foliage vertical diversity was calculated using Shannon's information index (H′) (Ludwig and Reynolds 1988). We used the same index to express horizontal plant diversity per habitat.

Data analysis

We compared bird and species counts across vegetation types using totals, percentages and mean number of bird and species per count in each habitat (Hutto et al. 1986). We describe results of bird counts for shaded (cacao, coffee and mixed crops) and not shaded (citrus and allspice) plantations and for arboreal (cacao, coffee, mixed, citrus and allspice) and non-arboreal (corn and jalapeño chili pepper) man-made vegetation as well as for live fences and pastures. Rarefaction analysis was used to compare species richness among habitats investigated when numbers of birds counted differed among sites (Ludwig and Reynolds 1988). Sorensen's index of similarity was used to compare similarity in species assemblages among habitats and the *t*-test was used when contrasting detection rates (mean number of species/birds per point count) of NM landbirds among habitats (Fitch 1992). Means and standard deviations ($\pm$SD) are given throughout the paper. Since we were interested in making a general assessment of the diversity of NM land bird species present in forest and in agricultural habitats in the landscapes investigated, we did not make a distinction between transient and wintering NM landbirds in our data. We are aware that transient or wintering NM landbirds may have different needs depending on whether or not they are resting for the day or refueling and that it is possible that an unknown number of individuals of species known to

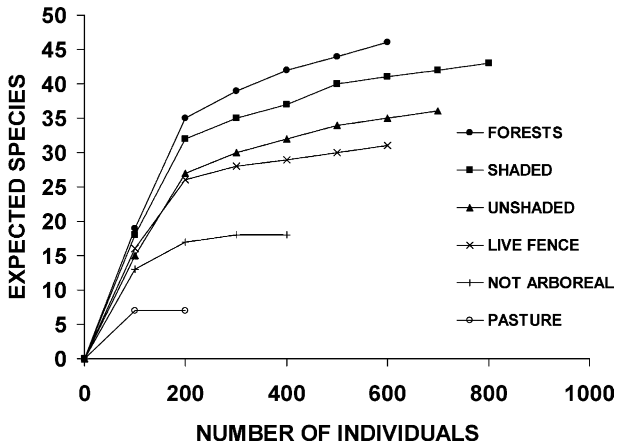

Figure 1. Rarefaction curves for the habitats investigated. Shaded – shaded plantations such as cacao, coffee and mixed (cacao and coffee); unshaded – citrus and allspice plantations; non-arboreal – corn and jalapeño chili pepper crops. Comparisons between sites made at $N = 200$, 400, 600. Note the high species richness of the forest fragments and of shaded plantations as well as the extremely low species richness of pasture habitats and non-arboreal habitats.

winter in Los Tuxtlas region, and that we recorded in our study, may have been in transit during the transient periods (August–October and March–May).

Results

Forest fragments

Counts in forest fragments totalled 653 NM landbirds representing 46 species. The number of species per site ranged from 7 to 23 and the number of individuals from 16 to 65. Mean number of species and the number individuals counted per point were 1.3 ± 0.5 and 3.5 ± 1.5, respectively (Table 1). The top ranking species in these habitats were the Hooded Warbler, Wood Thrush, Kentucky Warbler, American Redstart, Wilson's Warbler, and Summer Tanager which accounted for 50% of records (see Appendix A). Forest sites had from 20 to 60% of NM landbird species in common.

Shaded and unshaded arboreal plantations

At the shaded plantations (coffee, cacao and mixed) we counted 1288 NM landbirds representing 44 species. Mean number of species and individuals per count were 1.4 ± 0.4 and 10.7 ± 3.2, respectively (Table 1). Six species (Magnolia Warbler, Wilson's Warbler, Hooded Warbler, American Redstart, Wood Thrush, and White-eyed Vireo) accounted for 50% of the birds counted. These habitats had 12 species in common (see Appendix A). At the unshaded

Table 1. Neotropical migratory landbirds counted at the forest sites and man-made habitats investigated in the region of Los Tuxtlas, Mexico.

Habitat	Point			Mean no. of species	Individuals	Mean no. of individuals
	Sites	Counts	Species			
Forests	21	189	46	1.3 ± 0.5	653	3.5 ± 1.5
Shaded plantations	12	108	44	1.4 ± 0.4	1288	10.7 ± 3.2
Unshaded plantations	8	72	37	1.3 ± 0.3	867	12.0 ± 2.9
Live fences	4	36	31	1.9 ± 0.5	1317	27.8 ± 9.5
Non-arboreal	8	72	18	0.4 ± 0.3	545	6.7 ± 1.8
Pasture	4	36	7	0.2 ± 0.1	54	1.5 ± 0.2
Total			71		4724	

Mean number of species and individuals refer to the mean number of each per count point in each habitat studied.

plantations (citrus and allspice) bird counts resulted in 867 individuals of 37 species. Mean number of species and individuals per count were 1.3 ± 0.3 and 12.0 ± 2.9, respectively (Table 1). Four species (Magnolia Warbler, American Redstart, Hooded Warbler, and Yellow-rumped Warbler) accounted for 50% of the records. These habitats had 18 species in common (see Appendix A).

Arboreal and non-arboreal agricultural habitats

In the arboreal habitats (cacao, coffee, mixed, citrus and allspice) we counted 2155 NM landbirds representing 51 species. Mean number of species and individuals per count were 1.4 ± 0.4 and 11.3 ± 3.1, respectively (Table 1). Five species (Magnolia Warbler, Hooded Warbler, American Redstart, Wilson's Warbler, and White-eyed Vireo and Black-and-White Warbler) accounted for ca. 50% of the records. These habitats had 10 species in common (see Appendix A). In the non-arboreal habitats (jalapeño and corn) we counted 546 NM landbirds of 18 species, but the majority (83%) of species and individuals were counted at the corn fields (Table 1). Mean number of species and individuals per count were 0.4 ± 0.3 and 6.7 ± 1.8 respectively (Table 1). Species such as the Dickcissel, Indigo Bunting and the Scissor-tailed Flycatcher dominated the sample, accounting for about 50% of the records. These habitats only had two species in common (see Appendix A).

Live fences

In the live fences we counted 1317 NM landbirds representing 31 species. Mean number of species and individuals per count were 1.9 ± 0.5 and 27.8 ± 9.5, respectively (Table 1). Species such as Magnolia Warbler, White-eyed Vireo, and Wilson's Warbler, Yellow-rumped Warbler and the Blue-gray Gnatcatcher accounted for 50% of the records (see Appendix A).

Pastures

In the pastures bird counts yielded 54 individuals of seven species. Mean number of species and individuals per count point were 0.2 ± 0.1 and 1.5 ± 0.2, respectively (Table 1). The most common species were the Dickcissel and the Cliff Swallow, which accounted for 62% of the records. Three species were detected in pastures only. These were the Killdeer, Tree Swallow and the Peregrine Falcon (see Appendix A).

Forest fragments and man-made habitats

Taking all habitats investigated in the landscape, we counted 4732 neotropical migratory birds representing 72 species. Forest fragments accounted for 65% of the total species count, shaded plantations for 62%, unshaded plantations for 52%, live fences for 44%, non-arboreal crops for 25% and pastures for 10% (Table 1). Rarefaction analysis showed that at $N = 200$, 400 and 600, forest fragments were the richest sites followed by the shaded and unshaded plantations and live fences. Pastures were the habitats poorest in species, followed by non-arboreal crops (jalapeño and corn) (Figure 1).

There were no differences in detections rates of NM landbird species between forest sites and shaded ($p = 0.82$), unshaded ($p = 0.17$) and arboreal plantations ($p = 0.54$), but forest sites differed significantly from non-arboreal crops in this measure (Table 2). Significantly more NM landbirds were counted per count point in the other habitats than in the forests, except in pastures where the opposite was the case (Table 2). Shaded plantations did not differ from unshaded plantations in mean number of NM landbird species counted per count point, but significantly more species and more birds were counted in these habitats than in the non-arboreal crops (Table 2). Detection rates for species and individuals were significantly higher at the unshaded plantations than in the non-arboreal habitats. In all habitats, except non-arboreal crops, detection rates for NM landbirds were higher than in pastures (Table 2). At the live fences we counted significantly more NM landbirds than in any of the other habitats. Interestingly, significantly more species of NM landbirds were counted per count point in live fences than in non-arboreal plantations and pastures (Table 2).

The highest similaries, in species assemblages, as indicated by Sorensen's index, were found between the forests and shaded and unshaded plantations and between the latter two habitats. Live fences species assemblages were moderately similar to forests and to arboreal plantations (Table 3). Non-arboreal habitats had a low number of species in common with forests and arboreal habitats, including live fences. Pastures were the least similar compared to the other habitats (Table 3). In general, while 65% of the NM landbird species were present in more than one habitat, 35% were present in one habitat only. These latter species were found either in forest or in

Table 2. Results of *t*-test (probability shown in columns) comparing detection rates of Neotropical migratory landbird species and individuals between pairs of habitats investigated at Los Tuxtlas, Mexico.

Comparison	Species	Individuals
Forest–shaded	0.82	0.0001
Forest–unshaded	0.17	0.001
Forest–aboreal	0.54	0.002
Shaded–unshaded	0.80	0.04
Forest–live fence	0.31	0.01
Shaded–live fence	0.17	0.04
Unshaded–live fence	0.23	0.07
Arboreal–live fence	0.17	0.04
Forest–non-arboreal	0.002	0.03
Shaded–non-arboreal	0.001	0.04
Unshaded–non-arboreal	0.001	0.01
Live fence–non-arboreal	0.005	0.02
Forest–pasture	0.009	0.03
Shaded–pasture	0.05	0.008
Unshaded–pasture	0.006	0.001
Non-arboreal–pasture	0.05	0.008
Live fence–pasture	0.004	0.01
Forests	1.3	3.5
Shaded plantations	1.4	10.7
Unshaded plantations	1.3	12.0
Live fences	1.9	27.8
Non-arboreal crops	0.4	6.7
Pastures	0.2	1.5

Table 3. Values of Sorensen's index of similarity between habitats, at the species level, for Neotropical migratory landbirds in Los Tuxtlas, Mexico.

	Forests	Shaded	Unshaded	Live fences	Non-arboreal	Pastures
Forests		0.89	0.75	0.65	0.31	0.00
Shaded plantations			0.72	0.64	0.32	0.00
Unshaded plantations				0.68	0.36	0.00
Live fences					0.41	0.00
Non-arboreal crops						0.24

non-forest habitats only (see Appendix A). Seven NM landbird species (Magnolia Warbler, Hooded Warbler, Wilson's Warbler, American Redstart, White-eyed Vireo, Yellow-rumped Warbler, and Black-and-white Warbler) strongly dominated the total sample, contributing to 50% of the records (see Appendix A).

A positive association existed between the number of habitats occupied by a species and its abundance rank in the total sample ($r_s = 0.83$ $p < 0.01$, $N = 71$). Number of species and individuals recorded were not related to forest fragment's isolating distance or to isolating age ($p > 0.15$). In the case of the arboreal plantations, number of species and individuals recorded were inversely related to the site's isolating distance (species $r_s = -0.88$, $p < 0.001$, $N = 20$; individuals $r_s = -0.50$, $p < 0.001$, $N = 20$). An association existed between number of migratory birds and species counted in each habitat and foliage height diversity (H′) (species $r_s = 0.72$, $p = 0.009$; individuals $r_s = 0.56$, $p = 0.04$) and horizontal plant diversity (species $r_s = 0.76$, $p = 0.004$; individuals $r_s = 0.69$, $p = 0.01$).

Discussion

Our study is limited in that the presence of migrants in many of the forest and non-forest habitats investigated is not necessarily an indication of the quality or value of the habitat. Aspects such as body condition and site fidelity would, among others, have to be investigated (Rappole and Ramos 1995; Latta and Baltz 1997). Bearing this in mind, estimates of tropical forest conversion to pastures and other agroecosystems for the region of Los Tuxtlas indicate that only from 15 to 25% of the original forest cover (2500 km^2) remains today and that 82% of this cover is found in an extensive state of fragmentation (Dirzo and Garcia 1992; Estrada and Coates-Estrada 1996). This means important decrements and changes in the distribution of native habitat opportunities available to NM landbirds that stop over or winter in the region. Our results suggest that many NM landbird species seem to respond to such change by taking advantage of other habitats present in the anthropogenic landscape. For example, in our study 85% of NM landbirds recorded were counted outside forest fragments, 14% in forest fragments and 1% in pastures (similar results for other geographic regions have been reported by Yahner 1985; Villaseñor and Hutto 1995; Greenberg et al. 1997).

The forest fragments investigated were the most diverse habitats in NM landbird species, suggesting that the conservation of these remnants in tropical regions such as Los Tuxtlas should be a critical component of any conservation strategy aimed at preserving avian biodiversity. Even forest fragments representing different stages of succession of the original vegetation (i.e. second growth) might be particularly rich in NM landbirds, as shown by other studies in Mexico (Hutto 1992; Greenberg et al. 1995; Lynch and Whigham 1995; Rappole 1995) and in Central America (Karr 1976; Martin 1985; Blake and Loiselle 1992).

Our study, however, showed that a wide array of NM landbird species visited the agricultural habitats investigated, but that not all of these habitats seemed equal in the opportunities they may offer to these birds. For example, the complexity of the vegetation along vertical and horizontal dimensions in the shaded and unshaded arboreal plantations may explain the presence and co-occurrence of high numbers of NM landbird species and individuals in these habitats. Shaded agroecosystems such as coffee and cacao plantations have been pointed out to be an important resource for these birds in the Neotropics (Powers 1995; Greenberg et al. 1997; Wunderle 1999).

In contrast, the poorness of NM landbirds in non-arboreal agricultural habitats (e.g. corn) may be the result of greater exposure to high temperatures and low humidity, lack of perching structures as a result of the low height, sparse foliage and the non-woody nature of the cultivated plants and possibly a greater exposure to predators. Heavy use of pesticides and frequent visitation by people in these crops may also deter NM landbirds from visiting these habitats (Robbins et al. 1989). While species such as the Yellow-rumped Warbler, the Magnolia Warbler and Wilson's Warbler were observed foraging for insects among the stalks in the corn fields, we noted that these birds usually flew off into the cover of nearby forests or live fences. However, species such as the Scissor-tailed Flycatcher, Indigo Bunting, Dickissel and the Lark Sparrow were assiduous visitors at the corn and the jalapeño chili pepper fields. These habitats, however, are sporadic in time and space due to their seasonal appearance and once the crops are harvested the fields are returned to pastures.

Pastures, in comparison to all other habitats sampled, were the poorest man-made habitats for NM landbirds. Lack of sufficient food resources, the extreme climatic conditions and increased predation risks would make pastures inappropriate temporary habitats for many neotropical migratory bird species. For example, we witnessed several predation attempts and successes on small NM landbirds by resident raptors such as the Roadside Hawk (*Buteo magnirostris*) and the Laughing Falcon (*Herpetothere cachinnans*).

Our study suggests that the linear corridors formed by live fences in the landscape are important to NM landbirds. A significant number of neotropical migratory birds (44% of species and 28% of individuals detected in the total sample) were present in these habitats. The presence of thousands of meters of live fences in the landscape may be an opportunity seized by these birds that use them as stepping stones to reach other habitats (Villaseñor and Hutto 1995; Wankerting et al. 1995. In those live fences where vegetation has been allowed to regenerate under the live fence trees, the presence of pioneer plant species of the genera *Piper* (Piperaceae), *Solanum* (Solanaceae), *Cecropia* (Moraceae), *Miconia* (Melastomataceae), *Psycotria* (Rubiaceae), *Siparuna* (Mominaceae) and the occasional strangler figs (*Ficus* spp. Moraceae) may provide NM landbirds that use them with cover and food resources in the form of insects as well as fruit. These birds may participate in important ways in the dispersal and regeneration of these resources (Blake and Loiselle 1992; Coates-Estrada and Estrada 1986, 1988). For example, the flowers of *Gliricidia sepium* seem to attract the migratory Ruby-throated Hummingbird, while the fruits of *B. simaruba* are dispersed by species such as the White-eyed vireo, Yellow-throated Vireo and the Summer Tanager (Greenberg et al. 1995).

Our data indicated that only a small number of NM landbird species (Magnolia Warbler, Wilson's Warbler, Hooded Warbler, American Redstart, White-eyed vireo, Black-and-white Warbler, Summer Tanager, Kentucky Warbler, Northern Parula and Black-throated Green Warbler) were able to use the widest variety of the habitats sampled, suggesting that species vary in their behavioral plasticity. In this context, the diversity of habitats present in human-modified landscapes in the Neotropics may provide opportunities for NM landbird species that may be less flexible in terms of specific habitat requirements. Under these circumstances, a landscape perspective to preserve both resident and migratory birds may be necessary (Latta and Baltz 1997). Such a perspective needs to take into account the fact that conservation planning of isolated forest fragments is incomplete unless consideration is also given to the conservation value of man-made vegetation that, while being an integral part of the human-modified landscape and of the local subsistence economies, may also provide temporary habitat for the migratory components of avian biodiversity in Neotropical regions.

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Appendix A. Species of Neotropical migratory landbirds and individuals counted in the habitats investigated.

Common name	Species	F	SH	USH	LF	NARB	PAST	Total
Magnolia Warbler	*Dendroica magnolia*	33	133	176	197	25		564
Hooded Warbler	*Wilsonia citrina*	80	127	83	63			353
Wilson's Warbler	*Wilsonia pusilla*	41	131	45	126	20		363
American Redstart	*Setophaga ruticilla*	47	111	96	75	5		334
White-eyed Vireo	*Vireo griseus*	16	79	52	182	5		334
Yellow-rumped Warbler	*Dendroica coronata*	8	5	73	101	40		227
Black-and-white Warbler	*Mniotilta varia*	33	37	58	38			166
Wood Thrush	*Hylocichla mustelina*	73	91	1				165
Summer Tanager	*Piranga rubra*	36	40	34	55			165
Indigo Bunting	*Passerina cyanea*	12	12	12		105		141
Blue-gray Gnatcatcher	*Polioptila caerulea*	17	12	17	88			134
Kentucky Warbler	*Oporornis formosus*	53	58	4	4.2			119
Northern Parula	*Parula americana*	3	24	52	34			113
Yellow Warbler	*Dendroica petechia*	6	17	36	46	10		115
Least Flycatcher	*Empidonax minimus*	18	23	13	59			113
Dickcissel	*Spiza americana*					100	18	118
Black-throated Green Warbler	*Dendroica virens*	22	30	6	50			108
Scissor-tailed flycatcher	*Tyrannus forficatus*				13	85		98
Louisiana Waterthrush	*Seiurus motacilla*	12	67	3				82
Blue Grosbeak	*Guiraca caerulea*		49			25		74
Northern Oriole	*Icterus galbula*	6	26	14	21			67
Yellow-bellied Flycatcher	*Empidonax flaviventris*	8	38	3	13			62
Ovenbird	*Seiurus aurocapillus*	22	37	1				60
Gray Catbird	*Dumetella carolinensis*	10	24	5	17			56
Common Yellowthroat	*Geothlypis trichas*	5		4	23	15		47
Yellow-breasted Chat	*Icteria virens*	6	7	16	4	5		38
Lark Sparrow	*Chondestes grammacus*					35	6	41
Couch's Kingbird	*Tyrannus couchii*	8	13		17			38
Yellow-throated Vireo	*Vireo flavifrons*	4	7	4	21			36

Appendix A. *Continued.*

Common name	Species	F	SH	USH	LF	NARB	PAST	Total
Ruby-throated Hummingbird	*Archilochus colubris*			17	17			34
Black-headed Nightingale-Thrush	*Catharus ustulatus*	16	11	3				30
Nashville Warbler	*Vermivora ruficapilla*	2	3		8	15		28
Acadian Flycatcher	*Empidonax virescens*	5	7	1	13			26
White-winged Dove	*Zenaida asiatica*					25		25
Worm-eating Warbler	*Helmitheros vermivorus*	19	1					20
Lincoln's Sparrow	*Melospiza lincolnii*					20	4	24
Willow Flycatcher	*Empidonax traillii*	3	12					15
Cliff Swallow	*Hirundo rustica*						15	15
Tennessee Warbler	*Vermivora peregrina*				8			8
Great-crested Flycatcher	*Myiarchus crinitus*	2	4	5	4			15
Northern Waterthrush	*Seiurus noveboracensis*	2	10	4				16
Yellow-throated Warbler	*Dendroica dominica*			11				11
Red-eyed Vireo	*Vireo olivaceous*	3	7					10
Painted Bunting	*Passerina ciris*				13			13
Olive-sided Flycatcher	*Contopus borealis*		9					9
Rose-breasted Grosbeak	*Pheucticus melanocephalus*		9					9
Canada Warbler	*Wilsonia canadensis*	5	2		2			9
Yellow-billed Cuckoo	*Coccyzus americanus*	1		7				8
Bell's Vireo	*Vireo bellii*	1	2	4				7
Peregrine Falcon	*Falco peregrinus*						6	6
Solitary Vireo	*Vireo solitarius*	3	1	1				5
Palm Warbler	*Dendroica palmarum*			1		5		6
Black-throated Blue Warbler	*Dendroica caerulescens*	1	2	2				5
Cooper's Hawk	*Accipiter cooperii*					5		5
Mourning Warbler	*Oporornis philadelphia*		4					4
Tree swallow	*Tachycinata bicolor*						4	4
Varied Bunting	*Passerina versicolor*				4			4
MacGillivray's Warbler	*Oporornis tolmiei*	2	1					3

Appendix A. *Continued.*

Common name	Species	F	SH	USH	LF	NARB	PAST	Total
Rose-breasted Grosbeak	*Pheucticus ludovicianus*		3					3
Sharp-shinned Hawk	*Accipiter striatus*			2				2
Merlin	*Falco columbarius*	2						2
Ruby-crowned Kinglet	*Regulus calendula*				2			2
Chestnut-sided Warbler	*Dendroica pennsylvanica*	1	1					2
Veery	*Catharus fuscescens*	2						2
Red-tailed Hawk	*Buteo jamaicensis*	1						1
Gray-cheekd Thrush	*Catharus minimus*	1						1
Warbling Vireo	*Vireo gilvus*			1				1
Blue-winged Warbler	*Vermivora pinus*		1					1
Orange-crowned Warbler	*Vermivora celata*	1						1
Blackburnian Warbler	*Dendroica fusca*	1						1
Blackburnian Warbler	*Dendroica fusca*	1						1
Killdeer	*Charadrius vociferus*						1	1
Species		46	44	37	31	18	7	72
Individuals		653	1288	867	1317	545	54	4724

F, forest fragments; SH, shaded plantations; USH, unshaded plantations; LF, live fences; NARB, non-arboreal crops; PAST, pastures.

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