REPORT ON BIRD SURVEY AT SIERRA DE LAS MINAS

MARCH 1992

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U.S. Fish & Wildlife Service
Patuxent Wildlife Research Center
Laurel, Maryland 20708, U.S.A.

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During the period 1-8 March 1992 we made a quantitative study of bird populations in the northwest portion of Sierra de las Minas near Chilascó. We greatly appreciated the assistance of Peace Corps volunteer Henry Louie, who worked with us at both study sites and also was our guide for a one-day hike on the Miranda Ranch trail toward Las Vegas on 8 March. The study sites were located at elevations of about 2100 and 2300 meters.

At each study site we erected 16 mist nets which we ran for 3 days. We banded all the netted birds, resident species as well as migrants, with numbered U.S. Fish & Wildlife Sevice bands. The totals for each of the two sites at Sierra de las Minas as well as those for the three forest sites at Monterrico (2 in mangroves and 1 in nearby dry, grazed upland) and three forest sites at Cerro San Gil are shown in **Tabla 1**.

We also conducted 5-minute point counts at 10 locations in each site; the species recorded on the Point counts are shown by an "X" in **Tabla 1**. We also measured the structure of the vegetation at 3 of these 10 locations (**Tabla 1**, p. 13-14). Other species observed incidentally to the banding and point counts are indicated with "x". We used the same methods we have used at more than 100 sites in Mexico, Belice, Costa Rica, Venezuela, and the Greater Antilles (see attached reprints), so the results can be compared with those in these other countries.

We also made brief visits to the Western Highlands and the Peten, but did not do quantitative sampling in these areas. **Tabla 2** summarizes, by major locality, all the species we observed during the 5-week trip. Note that of 309 species observed, only one species, *Mniotilta varia*, was found in all 5 geographic areas, and only 3 species were found in 4 of the 5 areas: *Cathartes aura*, *Wilsonia pusilla*, and *Quiscalus mexicanus*. This emphasizes the extraordinary diversity of habitats in Guatemala. Note also that of the 76 species identified at Sierra de las Minas, more than half (39) were not found anywhere else.

One of the interesting observations at Sierra de las Minas was that *Penelopina nigra*, which was very common at the banding sites and along the trail that led to those sites, was nearly absent from the more frequently used trail that led to Las Vegas.

TABLA 1. LAS AVES OBSERVADAS EN LOCALIDADES DE ESTUDIA EN GUATEMALA, 1 FEB. - 8 MAR. 1992

Numeros son totales de las aves anilladas en 3 dias, excepto ellos en paréntesis, que son contas durante un dia. X = observada en "point count." x = otros observaciones.
(Migrantes de America del Norte en descaro)

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Tinamus major	-	-	-	X	X	X	-	-	-	Great Tinamou
Crypturellus soui	-	-	-	-	X	-	-	-	-	Little Tinamou
Tachybaptus dominicus	x	-	x	-	-	-	-	-	-	Least Grebe
Pelecanus erythrorhynchos	-	x	x	-	-	-	-	-	-	**Am. White Pelican**
Pelecanus occidentalis	X	-	-	-	-	-	-	-	-	**Brown Pelican**
Phalacrocorax olivaceus	-	X	x	-	-	-	-	-	-	Neotropic Cormorant
Anhinga anhinga	-	x	x	-	-	-	-	-	-	Anhinga
Fregata magnificens	x	x	x	-	-	-	-	-	-	Magnificent Frigatebird
Tigrisoma mexicanum	-	x	-	-	-	-	-	-	-	Bare-throated Tiger-Heron
Ardea herodias	-	-	x	x	-	-	-	-	-	**Great Blue Heron**
Casmerodius albus	X	X	X	-	-	-	-	-	-	Great Egret
Egretta thula	-	X	X	-	-	-	-	-	-	Snowy Egret
Egretta caerulea	-	X	X	-	-	-	-	-	-	Little Blue Heron
Egretta tricolor	-	x	x	x	-	-	-	-	-	Tricolored Heron
Bubulcus ibis	-	x	-	-	-	-	-	-	-	Cattle Egret
Butorides striatus	X	X	1	-	-	-	-	-	-	Green-backed Heron
Nycticorax nycticorax	-	x	-	-	-	-	-	-	-	Black-crowned Night-Heron
Nycticorax violaceus	-	-	x	-	-	-	-	-	-	Yellow-crowned Night-Heron
Eudocimus albus	-	x	-	-	-	-	-	-	-	White Ibis
Ajaia ajaja	-	x	X	-	-	-	-	-	-	Roseate Spoonbill

	Pasto Matorral Monterrico	Manglar Pantano #1	Manglar Pantano #2	Bosque Maduro de Hoja Ancha Cerro San Gil 350m	Bosque Maduro de Hoja Ancha Cerro San Gil 750m	Bosque Maduro de Hoja Ancha Cerro San Gil 950m	Bosque y Borde Sierra de las Minas 2100m	Bosque y Borde Sierra de las Minas 2300m	Bosque y Borde Sierra de las Minas Misc.	
Mycteria americana	-	x	X	-	-	-	-	-	-	Wood Stork
Coragyps atratus	x	-	x	-	-	-	-	-	-	Black Vulture
Cathartes aura	x	X	X	-	-	-	-	-	(1)	Turkey Vulture
Sarcoramphus papa	-	-	-	-	-	x	-	-	-	King Vulture
Pandion haliaetus	-	x	-	-	-	-	-	-	-	**Osprey**
Elanoides forficatus	-	-	-	-	-	-	x	-	-	Am. Swallow-tailed Kite
Ictinia plumbea	-	x	-	-	-	-	-	-	-	Plumbeous Kite
Accipiter s. chionogaster	-	-	-	-	-	-	-	-	(1)	White-breasted Hawk
Accipiter cooperii	-	x	-	-	-	-	-	-	-	**Cooper's Hawk**
Leucopternis albicollis	-	-	-	x	-	-	-	-	-	White Hawk
Buteogallus anthracinus	-	X	x	-	-	-	-	-	-	Common Black-Hawk
Buteo magnirostris	2	x	1	-	-	-	-	-	-	Roadside Hawk
Buteo jamaicensis	-	-	-	-	-	-	-	-	(1)	Red-tailed Hawk
Herpetotheres cachinnans	x	-	-	-	-	-	-	x	-	Laughing Falcon
Falco sparverius	X	-	-	-	-	-	-	-	-	American Kestrel
Ortalis vetula	-	-	-	x	-	-	-	-	-	Plain Chachalaca
Ortalis leucogastra	X	-	-	-	-	-	-	-	-	White-bellied Chachalaca
Penelopina nigra	-	-	-	-	-	-	X	X	(3)	Highland Guan (Black Penelopina)
Penelope purpurascens	-	-	-	-	-	-	x	-	-	Crested Guan
Dendrortyx leucophrys	-	-	-	-	-	-	-	-	(2)	Buffy-crowned Wood-Partridge
Odontophorus guttatus	-	-	-	-	X	-	-	-	-	Spotted Wood-Quail
Porphyrula martinica	-	x	-	-	-	-	-	-	-	Purple Gallinule
Charadrius vociferus	x	-	-	-	-	-	-	-	-	Killdeer
Himantopus mexicanus	-	-	X	-	-	-	-	-	-	Black-necked Stilt
Jacana spinosa	-	x	-	-	-	-	-	-	-	Northern Jacana

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Tringa solitaria	X	-	-	-	-	-	-	-	-	**Solitary Sandpiper**
Actitis macularia	-	x	x	-	-	-	-	-	-	**Spotted Sandpiper**
Phalaropus fulicaria	x	-	-	-	-	-	-	-	-	**Red Phalarope**
Larus atricilla	X	x	-	-	-	-	-	-	-	**Laughing Gull**
Columba flavirostris	-	x	X	-	-	-	-	-	-	Red-billed Pigeon
Columba fasciata	-	-	-	-	-	-	X	x	(30)	Band-tailed Pigeon
Columba nigrirostra	-	-	-	X	X	x	-	-	-	Short-billed Pigeon
Columbina inca	20	1	X	-	-	-	-	-	-	Inca Dove
Columbina talpacoti	8	X	x	-	-	-	-	-	-	Ruddy Ground-Dove
Leptotila verreauxi	8	X	X	-	-	-	-	-	-	White-tipped Dove
Leptotila cassini (?)	-	-	-	-	X	x	-	-	-	Gray-chested (?) Dove
Geotrygon montana	-	-	-	7	x	X	-	-	-	Ruddy Quail-Dove
Aratinga nana	-	-	-	X	x	x	-	-	-	Olive-throated Parakeet
Aratinga canicularis	X	-	X	-	-	-	-	-	-	Orange-fronted Parakeet
Bolborhynchus lineola	-	-	-	-	-	-	x	-	-	Barred Parakeet
Pionopsitta haematotis	-	-	-	X	-	-	-	-	-	Brown-hooded Parrot
Amazona autumnalis	-	X	-	-	-	-	-	-	-	Red-lored Parrot
Amazona farinosa	-	-	-	X	x	x	-	-	-	Mealy Parrot
Piaya cayana	X	X	X	X	X	x	-	-	-	Squirrel Cuckoo
Crotophaga sulcirostris	12	1	x	-	-	-	-	-	-	Groove-billed Ani
Otus guatemalae	-	-	-	-	x	-	-	-	-	Vermiculated Screech-Owl
Glaucidium brasilianum	X	X	X	X	x	-	-	-	-	Ferruginous Pygmy-Owl
Chordeiles minor	-	x	-	-	-	-	-	-	-	Lesser Nighthawk
Nyctidromus albicollis	X	-	-	-	-	-	-	-	-	Common Pauraque
Caprimulgus vociferus	-	-	-	-	-	-	-	-	(5)	Whip-poor-will

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Streptoprogne zonaris	-	-	-	-	-	-	x	-	(25)	White-collared Swift
Chaetura vauxi	-	-	-	-	-	x	-	-	(25)	Vaux's Swift
Phaethornis superciliosus	-	-	-	18	5	3	-	-	-	Long-tailed Hermit
Phaethornis longuemareus	-	-	-	x	-	1	-	-	-	Little Hermit
Campylopterus hemileucurus	-	-	-	1	1	6	1	-	-	Violet Sabrewing
Colibri delphinae	-	-	-	-	-	3	-	-	-	Brown Violet-ear
Chlorostilbon canivetii	-	-	-	-	-	-	-	-	-	Fork-tailed Emerald
Thalurania colombica	-	-	-	13	6	5	-	-	-	Crowned Woodnymph
Hylocharis leucotis	-	-	-	-	-	-	-	-	(10)	White-eared Hummingbird
Amazilia candida	-	-	-	4	-	-	-	-	-	White-bellied Emerald
Amazilia cyanocephala	-	-	-	-	-	-	1	-	-	Azure-crowned Hummingbird
Amazilia rutila	1	x	-	-	-	-	-	-	-	Cinnamon Hummingbird
Eupherusa eximia	-	-	-	-	3	10	-	-	-	Stripe-tailed Hummingbird
Lampornis viridipallens	-	-	-	-	-	-	14	17	-	Green-throated Mountain-gem
Lampornis amethystinus	-	-	-	-	-	-	3	5	(10)	Amethyst-throated Hummingbird
Lamprolaima rhami	-	-	-	-	-	-	-	2	(1)	Garnet-throated Hummingbird
Eugenes fulgens	-	-	-	-	-	-	1	1	(3)	Magnificent Hummingbird
Atthis heloisa	-	-	-	-	-	-	X	-	(20)	Wine-throated Hummngbird
Trogon melanocephalus	-	-	-	X	-	-	-	-	-	Black-headed Trogon
Trogon violaceus	x	-	-	X	-	-	-	-	-	Violaceous Trogon
Trogon mexicanus	-	-	-	-	-	-	X	X	(10)	Mountain Trogon
Trogon massena	-	-	-	x	x	-	-	-	-	Slaty-tailed Trogon
Pharomachrus mocinno	-	-	-	-	-	-	X	X	(25)	Resplendent Quetzal
Hylomanes momotula	-	-	-	-	1	-	-	-	-	Tody Motmot
Aspatha gularis	-	-	-	-	-	-	X	-	-	Blue-throated Motmot

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Momotus momota	-	-	-	X	-	-	-	-	-	Blue-crowned Motmot
Electron carinatum	-	-	-	-	X	-	-	-	-	Keel-billed Motmot
Ceryle torquata	-	x	-	-	-	-	-	-	-	Ringed Kingfisher
Ceryle alcyon	X	1	X	-	-	-	-	-	-	**Belted Kingfisher**
Chloroceryle americana	x	x	x	-	-	-	-	-	-	Green Kingfisher
Chloroceryle aenea	x	1	x	-	-	-	-	-	-	American Pygmy Kingfisher
Malacoptila panamensis	-	-	-	1	-	-	-	-	-	White-whiskered Puffbird
Aulacoorhynchus prasinus	-	-	-	-	-	-	x	x	(2)	Emerald Toucanet
Pteroglossus torquatus	-	-	-	X	x	X	-	-	-	Collared Aracari
Rhamphastos sulfuratus	-	-	-	X	X	x	-	-	-	Keel-billed Toucan
Melanerpes pucherani	-	-	-	-	x	-	-	-	-	Black-cheeked Woodpecker
Melanerpes aurifrons	X	X	x	X	-	-	-	-	-	Golden-fronted Woodpecker
Sphyrapicus varius	-	-	-	-	-	-	-	x	-	**Yellow-bellied Sapsucker**
Picoides villosus	-	-	-	-	-	-	x	-	(2)	Hairy Woodpecker
Veniliornis fumigatus	-	3	-	-	1	-	-	-	-	Smoky-brown Woodpecker
Piculus rubiginosus	-	-	-	X	-	-	-	-	-	Golden-olive Woodpecker
Colaptes auratus cafer	-	-	-	-	-	-	x	X	(1)	**Red-shafted Flicker**
Celeus castaneus	-	-	-	x	-	-	-	-	-	Chestnut-colored Woodpkr
Dryocopus lineatus	-	x	-	x	-	-	-	-	-	Lineated Woodpecker
Campephilus guatemalensis	-	X	X	X	x	x	-	-	-	Pale-billed Woodpecker
Synallaxis erythrothorax	-	-	-	-	-	-	-	-	-	Rufous-breasted Spinetail
Anabacerthia variegaticeps	-	-	-	-	-	-	2	-	-	Spectacled Foliage-gleaner
Automolus ochrolaemus	-	-	-	-	5	3	-	-	-	Buff-throated Foliage-gleaner
Automolus rubiginosus	-	-	-	-	-	-	-	-	(2)	Ruddy Foliage-gleaner
Xenops minutus	-	-	-	1	-	-	-	-	-	Plain Xenops

	Pasto Matorral	Manglar Pantano Monterrico		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Sclerurus mexicanus	-	-	-	-	2	1	-	-	-	Tawny-throated Leaftosser
Sclerurus guatemalensis	-	-	-	1	3	-	-	-	-	Scaly-throated Leaftosser
Dendrocincla anabatina	-	-	-	3	-	1	-	-	-	Tawny-winged Woodcreeper
Dendrocincla homochroa	-	-	-	2	X	1	1	-	-	Ruddy Woodcreeper
Glyphorynchus spirurus	-	-	-	8	3	6	-	-	-	Wedge-billed Woodcreeper
Dendrocolaptes certhia	-	-	-	2	1	-	-	-	-	Barred Woodcreeper
Xiphorhynchus flavigaster	-	-	-	1	-	-	-	-	-	Ivory-billed Woodcreeper
Xiphorhynchus erythropygius	-	-	-	-	1	1	-	-	(1)	Spotted Woodcreeper
Lepidocolaptes souleyetii	1	3	3	-	-	-	-	-	-	Streak-headed Woodcreeper
Lepidocolaptes affinis	-	-	-	-	-	-	1	2	-	Spot-crowned Woodcreeper
Thamnophilus doliatus	-	-	-	-	-	-	-	-	(2)	Barred Antshrike
Dysithamnus mentalis	-	-	-	x	5	5	-	-	-	Plain Antvireo
Myrmotherula schisticolor	-	-	-	1	3	1	-	-	-	Slaty Antwren
Formicarius analis	-	-	-	X	1	X	-	-	-	Black-faced Antthrush
Zimmerius vilissimus	-	-	-	-	-	-	X	-	-	Paltry Tyrannulet
Camptostoma imberbe	X	-	-	-	-	-	-	-	-	No. Beardless Tyrannulet
Myiopagis viridicata	-	-	-	-	1	-	-	-	-	Greenish Elaenia
Elaenia franzii	-	-	-	-	-	-	-	-	(10)	Mountain Elaenia
Mionectes oleagineus	-	-	-	18	8	2	-	-	-	Ochre-bellied Flycatcher
Leptopogon amaurocephalus	-	-	-	2	-	-	-	-	-	Sepia-capped Flycatcher
Oncostoma cinereigulare	-	-	-	2	X	2	-	-	-	Northern Bentbill
Rhynchocyclus brevirostris	-	-	-	-	-	1	-	-	-	Eye-ringed Flatbill
Platyrinchus cancrominus	-	-	-	3	5	2	-	-	-	Stub-tailed Spadebill
Onychorhynchus coronatus	-	-	-	x	-	-	-	-	-	Royal Flycatcher
Myiobius sulphureipygius	-	-	-	1	2	1	-	-	-	Sulphur-rumped Flycatcher

	Pasto Matorral Monterrico	Manglar Pantano #1	Manglar Pantano #2	Bosque Maduro de Hoja Ancha Cerro San Gil 350m	Bosque Maduro de Hoja Ancha Cerro San Gil 750m	Bosque Maduro de Hoja Ancha Cerro San Gil 950m	Bosque y Borde Sierra de las Minas 2100m	Bosque y Borde Sierra de las Minas 2300m	Bosque y Borde Sierra de las Minas Misc.	
Mitrephanes phaeocercus	-	-	-	-	-	-	-	-	(10)	Tufted Flycatcher
Empidonax flaviventris	-	-	-	3	-	-	-	-	-	**Yellow-bellied Flycatcher**
Empidonax traillii	1	-	-	-	-	-	-	-	-	**Willow Flycatcher**
Empidonax minimus	3	-	-	-	-	-	-	-	-	**Least Flycatcher**
Empidonax flavescens	-	-	-	-	-	-	17	4	(3)	Yellowish Flycatcher
Attila spadiceus	-	-	X	1	2	x	-	-	-	Bright-rumped Attila
Rhytipterna holerythra	-	-	-	X	x	-	-	-	-	Rufous Mourner
Myiarchus tuberculifer	1	-	-	-	-	-	-	-	-	Dusky-capped Flycatcher
Myiarchus nuttingi	6	-	-	-	-	-	-	-	-	Nutting's Flycatcher
Myiarchus crinitus	1	-	-	-	-	-	-	-	-	**Great Crested Flycatcher**
Myiarchus tyrannulus	2	1	1	-	-	-	-	-	-	Brown-crested Flycatcher
Pitangus sulphuratus	7	x	x	-	-	-	-	-	-	Great Kiskadee
Megarynchus pitangua	X	-	X	X	-	-	-	-	-	Boat-billed Flycatcher
Myiozetetes similis	X	x	x	-	-	-	-	-	-	Social Flycatcher
Tyrannus melancholicus	1	x	X	-	-	-	-	-	-	Tropical Kingbird
Tyrannus forficatus	X	x	-	-	-	-	-	-	-	Scissor-tailed Flycatcher
Pachyramphus aglaiae	X	-	-	-	-	-	-	-	-	Rose-throated Becard
Tityra semifasciata	-	-	-	X	-	-	-	-	-	Masked Tityra
Lipaugus unirufus	-	-	-	X	X	-	-	-	-	Rufous Piha
Managus candei	-	-	-	2	-	-	-	-	-	White-collared Manakin
Pipra mentalis	-	-	-	15	10	1	-	-	-	Red-capped Manakin
Progne chalybea	-	x	-	-	-	x	-	-	-	Gray-breasted Martin
Tachycineta albilinea	X	x	-	-	-	-	-	-	-	Mangrove Swallow
Notiochelidon pileata	-	-	-	-	-	-	x	-	(100)	Black-capped Swallow
Hirundo pyrrhonota	X	-	-	-	-	-	-	-	-	**Cliff Swallow**

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Hirundo rustica	X	-	-	-	-	-	-	-	-	**Barn Swallow**
Calocitta formosa	X	x	-	-	-	-	-	-	-	White-throated Magpie-Jay
Cyanocorax yncas	-	-	-	X	X	-	-	-	-	Green Jay
Cyanocorax melanocyaneus	-	-	-	-	-	-	-	-	(5)	Bushy-crested Jay
Cyanolyca pumilo	-	-	-	-	-	-	x	-	-	Black-throated Jay
Aphelocoma unicolor	-	-	-	-	-	-	X	-	(4)	Unicolored Jay
Campylorhynchus rufinucha	4	4	1	-	-	-	-	-	-	Rufous-naped Wren
Thryothorus maculipectus	-	-	-	X	X	2	-	-	-	Spot-breasted Wren
Thryothorus pleurostictus	4	-	-	-	-	-	-	-	-	Banded Wren
Troglodytes aedon	-	-	-	-	-	-	-	-	(3)	House Wren
Troglodytes rufociliatus	-	X	X	-	-	-	X	x	(3)	Rufous-browed Wren
Henicorhina leucosticta	-	-	-	5	10	1	-	-	-	White-breasted Wood-Wren
Henicorhina leucophrys	-	-	-	-	-	1	5	8	(15)	Gray-breasted Wood-Wren
Microcerculus philomela	-	-	-	X	X	X	-	-	-	Nightingale Wren
Ramphocaenus melanurus	-	-	-	-	1	1	-	-	-	Long-billed Gnatwren
Polioptila caerulea	-	-	-	-	x	-	-	-	-	**Blue-gray Gnatcatcher**
Polioptila albiloris	X	-	-	-	-	-	-	-	-	White-lored Gnatcatcher
Sialia sialis	-	-	-	-	-	-	-	-	(4)	Eastern Bluebird
Myadestes occidentalis	-	-	-	-	-	-	X	1	(50)	Brown-backed Solitaire
Myadestes unicolor	-	-	-	2	X	-	6	4	(20)	Slate-colored Solitaire
Catharus frantzii	-	-	-	-	-	-	12	11	(20)	Ruddy-capped Nightingale-Thrush
Catharus mexicanus	-	-	-	x	-	2	-	-	-	Black-headed Nighting-Thrush
Catharus dryas	-	-	-	-	-	-	3	-	-	Spotted Nightingale-Thrush
Catharus ustulatus	1	-	-	-	-	-	-	-	-	Swainson's Thrush
Hylocichla mustelina	-	-	-	7	1	2	-	-	-	Wood Thrush

	Pasto Matorral Monterrico	Manglar Pantano		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Turdus infuscatus	-	-	-	-	-	-	7	x	(1)	Black Robin
Turdus plebejus	-	-	-	-	-	-	5	1	(4)	Mountain Robin
Turdus grayi	49	x	-	X	-	X	-	-	-	Clay-colored Robin
Dumetella carolinensis	X	-	-	1	-	-	-	-	-	**Gray Catbird**
Melanotis hypoleucus	-	-	-	-	-	-	-	-	(5)	Blue-and-white Mockingbird
Bombycilla cedrorum	-	-	-	-	-	x	-	-	-	**Cedar Waxwing**
Ptilogonys cinereus	-	-	-	-	-	-	x	x	-	Gray Silky-flycatcher
Vireo pallens	1	X	1	-	-	-	-	-	-	Mangrove Vireo
Vireo solitarius	-	-	-	-	-	-	1	-	-	**Solitary Vireo**
Vireo gilvus	-	-	-	-	-	-	-	-	(2)	**Warbling Vireo**
Hylophilus ochraceiceps	-	-	-	9	8	1	-	-	-	Tawny-crowned Greenlet
Hylophilus decurtatus	-	-	-	x	x	-	-	-	-	Lesser Greenlet
Vireolanius pulchellus	-	-	-	x	-	-	-	-	-	Green Shrike-Vireo
Cyclarhis gujanensis	-	-	-	-	-	-	-	-	(2)	Rufous-browed Peppershrike
Vermivora peregrina	6	-	-	-	-	-	-	-	-	Tennessee Warbler
Parula superciliosa	-	-	-	-	-	-	X	x	(1)	Crescent-chested Warbler
Dendroica petechia	8	5	2	-	-	-	-	-	-	Yellow Warbler
Dendroica pensylvanica	-	-	-	1	-	1	-	-	-	Chestnut-sided Warbler
Dendroica magnolia	1	X	1	X	X	3	-	-	-	Magnolia Warbler
Dendroica townsendi	-	-	-	-	-	-	x	-	-	Townsend's Warbler
Dendroica occidentalis	-	-	-	-	-	-	x	-	-	Hermit Warbler
Dendroica virens	-	-	-	X	-	1	x	x	(1)	Black-thr. Green Warbler
Mniotilta varia	3	1	1	1	-	1	-	-	(1)	Black-and-white Warbler
Setophaga ruticilla	2	5	3	X	x	2	-	-	-	American Redstart
Helmitheros vermivorus	-	-	1	-	-	-	-	-	-	Worm-eating Warbler

	Pasto Matorral	Manglar Pantano Monterrico		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Seiurus aurocapillus	4	3	1	-	3	4	-	-	-	Ovenbird
Seiurus noveboracensis	2	5	7	-	-	-	-	-	-	Northern Waterthrush
Seiurus motacilla	-	-	-	1	-	-	-	-	-	Louisiana Waterthrush
Oporornis formosus	-	-	-	5	2	-	-	-	-	Kentucky Warbler
Oporornis tolmiei	-	-	-	-	-	-	-	-	(2)	MacGillivray's Warbler
Wilsonia citrina	1	-	-	1	1	1	-	-	-	Hooded Warbler
Wilsonia pusilla	-	-	-	-	-	5	4	1	(20)	Wilson's Warbler
Myioborus pictus	-	-	-	-	-	-	2	-	(1)	Slate-throated Redstart
Basileuterus culicivorus	-	-	-	X	2	-	-	-	-	Golden-crowned Warbler
Basileuterus belli	-	-	-	-	-	-	15	14	(10)	Golden-browed Warbler
Icteria virens	5	1	-	-	-	1	-	-	-	Yellow-breasted Chat
Coereba flaveola	-	-	-	X	x	4	-	-	-	Bananaquit
Cyanerpes cyaneus	-	-	-	x	-	-	-	-	-	Red-legged Honeycreeper
Euphonia gouldi	-	-	-	17	4	6	-	-	-	Olive-backed Euphonia
Lanio aurantius	-	-	-	x	1	-	-	-	-	Black-throated Shrike-Tanager
Habia rubica	-	-	-	4	3	2	-	-	-	Red-crowned Ant-Tanager
Habia fuscicauda	-	-	-	1	-	-	-	-	-	Red-throated Ant-Tanager
Piranga rubra	-	-	-	x	1	X	-	-	-	Summer Tanager
Chlorospingus ophthalmicus	-	-	-	-	1	9	23	17	(25)	Common Bush-Tanager
Pheucticus ludovicianus	X	-	-	-	-	-	-	-	(3)	Rose-breasted Grosbeak
Cyanocompsa cyanoides	-	-	-	1	-	-	-	-	-	Blue-black Grosbeak
Passerina ciris	8	-	-	-	-	-	-	-	-	Painted Bunting
Spiza americana	X	-	x	-	-	-	-	-	-	Dickcissel
Atlapetes brunneinucha	-	-	-	-	-	-	2	5	(1)	Chestnut-capped Brush-Finch
Sporophila torqueola	7	2	-	-	-	-	-	-	-	White-collared Seedeater

	Pasto Matorral	Manglar Pantano Monterrico		Bosque Maduro de Hoja Ancha Cerro San Gil			Bosque y Borde Sierra de las Minas			
		#1	#2	350m	750m	950m	2100m	2300m	Misc.	
Diglossa baritula	-	-	-	-	-	-	3	x	(2)	Cinnamon-bellied Flowerpiercer
Aimophila ruficauda	1	-	-	-	-	-	-	-	-	Stripe-headed Sparrow
Zonotrichia capensis	-	-	-	-	-	-	-	-	(2)	Rufous-collared Sparrow
Dives dives	X	X	-	-	-	-	-	-	-	Melodious Blackbird
Quiscalus mexicanus	X	1	X	-	-	-	-	-	(10)	Great-tailed Grackle
Icterus pectoralis	2	x	-	-	-	-	-	-	-	Spot-breasted Oriole
Icterus gularis	4	-	1	-	-	-	-	-	-	Altamira Oriole
Icterus galbula galbula	5	-	x	X	-	-	-	-	-	**Baltimore (Northern) Oriole**
Icterus galbula bullockii	1	-	-	-	-	-	-	-	-	**Bullock's (Northern) Oriole**
Amblycercus holosericeus	-	X	X	-	-	-	-	-	-	Yellow-billed Cacique
Psarocolius montezuma	-	-	-	X	X	-	-	-	-	Montezuma Oropendola
Carduelis notata	-	-	-	-	-	-	-	-	(6)	Black-headed Siskin
Individuos anillados	193	38	25	166	107	106	130	92	0	
% migrantes de America del Norte	27	55	64	12	7	20	4	1	-	
Total de especies anilladas	36	16	14	37	34	40	23	14	0	
Total de especies identificadas	76	68	55	84	65	59	45	29	53	

Las Características de las Localidades de Investigación

Habitat	Pasto Matorral Monterrico #1	Pasto Matorral Monterrico #2	Manglar Pantano	Bosque Maduro de Hoja Ancha Cerro San Gil 350m	Bosque Maduro de Hoja Ancha Cerro San Gil 750m	Bosque Maduro de Hoja Ancha Cerro San Gil 950m	Bosque y Borde Sierra de las Minas 2100m	Bosque y Borde Sierra de las Minas 2300m	Misc.	
Altura de las arboles	11.42	12.41	13.27	24.85	30.64	18.95	24.19	25.91		Mean canopy height (m)
% cubierta del cielo	72%	80%	96%	93%	100%	100%	95%	95%		Mean canopy cover
% cubierta del suelo	17%	22%	10%	57%	35%	48%	75%	78%		Mean ground cover
Arboles (>8 cm)/hectárea	717	500	533	517	700	625	833	1033		Trees > 8 cm DBH / ha
Area al bajo (m^2/ha)	20	6	8	65	98	23	63	93		Basal area of live trees
Renuevos 3-8 cm/ha	1050	4033	4883	567	1350	2625	2633	1517		Saplings 3-8cm DBH / ha
Arboles muertas(>8 cm)/ha	0	33	50	83	0	0	117	50		Dead trees / ha
Perfil del follaje:										Vertical foliage profile
40.-45. m					10%					
35.-40. m					25%				5%	
30.-35. m				12%	25%				8%	
25.-30. m				32%	35%	20%	3%		28%	
20.-25. m				47%	35%	30%	10%		48%	
15.-20. m				47%	45%	32%	25%		48%	
10.-15. m	3%	2%		43%	55%	30%	38%		25%	
8.0-10. m	15%	30%	10%	42%	60%	48%	38%		18%	
6.0-8.0 m	37%	52%	63%	42%	25%	62%	48%		20%	
4.0-6.0 m	48%	50%	80%	28%	60%	50%	67%		28%	
3.0-4.0 m	13%	27%	23%	17%	5%	28%	42%		15%	
2.5-3.0 m	8%	3%	8%	5%	5%	15%	7%		3%	
2.0-2.5 m	10%	5%	3%	3%	5%	35%	13%		7%	
1.5-2.0 m	5%	5%	0	8%	0	8%	7%		2%	
1.0-1.5 m	3%	2%	2%	7%	15%	2%	25%		15%	
0.5-1.0 m	8%	10%	7%	23%	10%	15%	23%		33%	
0.0-0.5 m	7%	12%	2%	37%	15%	38%	45%		57%	

Habitat	Pasto Matorral Monterrico #1	Pasto Matorral Monterrico #2	Manglar Pantano	Bosque Maduro de Hoja Ancha Cerro San Gil 350m	Bosque Maduro de Hoja Ancha Cerro San Gil 750m	Bosque Maduro de Hoja Ancha Cerro San Gil 950m	Bosque y Borde Sierra de las Minas 2100m	Bosque y Borde Sierra de las Minas 2300m	Bosque y Borde Sierra de las Minas Misc.	
Densidad del follaje (%):										Foliage density (dens.bd.)
2.0-3.0 m	47%	45%	31%	42%	52%	81%	71%	57%		
1.0-2.0 m	45%	40%	14%	46%	38%	71%	81%	58%		
0.3-1.0 m	35%	33%	14%	63%	74%	83%	95%	88%		
0.0-0.3 m	34%	32%	17%	82%	78%	84%	98%	94%		
Latitud	13°56	13°57	13°57	15°41	15°41	15°40	15°06	15°05	15°07	North latitude
Longitud	90°29	90°28	90°28	88°39	88°41	88°42	90°03	90°03	90°04	West longitude
Elevación (metros)	3	0	0	350	750	950	2100	2300		Elevation (m)
Inclinación del suelo	4°	0°	0°	10°	10°	6°	5°	8°		Slope
Departamento	Santa Rosa			Izabal			El Progreso			Department

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Comparison of neotropical winter bird populations in isolated patches versus extensive forest

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ABSTRACT

Wintering birds were captured with mist nets at 12 pairs of forested sites in the New World tropics in 1984 and 1985 to compare populations in small isolated woodlands (generally 5-50 ha) with those in extensive forests (> 1,000 ha).

Net-hours of effort were similar in large and small sites, as were total birds captured and banded, but species composition was very different. Members of the Todidae, Dendrocolaptidae, Formicariidae and Thraupinae were significantly more common in extensive forest than in small isolated tracts, indicating that these birds are especially vulnerable to effects of forest fragmentation. However, in winter many species of North American migrants, even species that are restricted to extensive forest during the breeding season, were just as common in small forest fragments as in extensive forest.

A high percentage of the North American migrants banded in January 1984 (40 to 50 % for some species) were recaptured in 1985.

KEY-WORDS: *Forest fragmentation - Neotropics - Winter birds - Banding.*

RÉSUMÉ

Pour comparer les peuplements hivernaux d'oiseaux de forêts petites et isolées (inférieures à 5-50 ha) à ceux de vastes massifs forestiers (dépassant 10 000 ha) en zone néotropicale, des recensements furent effectués par capture au filet, sur un échantillon composé de 12 paires de forêts, pendant

les hivers 1984 et 1985. L'effort de capture fut le même (en heures-filet) dans toutes les forêts; obtient les mêmes nombres de captures dans les grandes et les petites forêts, mais des listes d'espè différentes. Des espèces de Todidae, Dendrocolaptidae, Formicariidae et Thraupinae furent sign cativement plus communes dans les grandes forêts que dans les boqueteaux isolés, montrant u vulnérabilité particulière à l'effet de fragmentation de l'habitat. Cependant, beaucoup d'espè de migrateurs venant d'Amérique du Nord se montrèrent aussi communes dans les petits fragme que dans les grands massifs forestiers (y compris les espèces confinées à la grande forêt en période reproduction). Beaucoup des migrateurs Nord-Américains bagués en janvier 1984 (40 à 50 % po certaines espèces) furent recapturés en 1985.

MOTS-CLÉS : *Fragmentation de la forêt - Néotropiques - Oiseaux en hiver - Baguage.*

In the summers of 1979-1983, the first three authors used the I. P. A. (Indic Ponctuel d'Abondance) technique (BLONDEL *et al.*, 1970) to compare breeding bi populations in 469 forest sites (0.01 to > 10,000 ha) in the eastern United Stat (ROBBINS *et al.*, in review). The main purpose was to estimate the forest area requi ments of the forest-interior specialists, species that are primarily neotropical migran We found strong correlations between both forest area and isolation and the abu dance of neotropical migrants. Comparisons of the vegetation structure of the si showed high similarity among the different areas represented, so we concluded th the differences noted in bird populations were related to the area and isolation the sites, not to the vegetation.

Census results for forest birds of the Patuxent Wildlife Research Center, t center of a 2,600 ha forest remnant on the coastal plain of Maryland, U. S. A supported the belief that 3,000 ha is a close estimate of the minimum area requir to retain the local avian community. Loss of surrounding woodland probably h been responsible for the loss of two breeding bird species at Patuxent; *Accipit cooperii* and *Buteo platypterus*, the latter a neotropical migrant, are the only woodlan species to have disappeared from the breeding avifauna since 1945. Smaller fores in the region have lost area-sensitive species in a predictable sequence.

There has been some controversy in the scientific literature between ecologis who stress the importance of large natural areas as faunal preserves (*e. g.* WHITCO *et al.*, 1981) and those who believe that, given a specified total area that can be devote to faunal preserves, it is better to divide it into two or more smaller tracts (*e. g.* SI BERLOFF & ABELE, 1976). Although more *total species* often can be accommodate by two smaller preserves than by a single one of equal total area, because of invasio of edge species (HIGGS & USHER, 1980), the conservation value in terms of *vulnerab species* that require protection is much greater for a single large tract. In our stud of breeding birds there was no species characteristic of small woods that was not al found in large ones; but many species, especially the neotropical migrants, we found only in large woods.

The North American Breeding Bird Survey (ROBBINS *et al.*, 1985) shows th continental populations of most forest birds are stable. In regions of rapid loss forest habitat, however, such as the Northern Piedmont region that extends fro Maryland north to southeastern New York, several species of neotropical migran have been showing statistically significant declines (ROBBINS, 1980). There has bee much speculation about whether such declines reflect forest fragmentation on th breeding grounds or the increasing rate of loss and fragmentation of primary fore in the tropics.

In some tropical countries, vast areas of forest are being cleared for grazing or mass production of crops. In other places the primary forest is being cleared in small patches, creating a patchwork of small subsistence farms, reverting forest, and, on the steeper slopes, remnants of the original forest. The question we set out to answer was whether the neotropical migrants that are obligate forest interior breeders are also dependent on undisturbed forest interior on their wintering grounds, or whether they can use forest fragments and edge habitats. We also wanted to determine if birds found in forest fragments were actually wintering there successfully or were simply vagrants searching for more favorable sites.

METHODS

In a cooperative study sponsored by the Office of International Affairs of the U. S. Fish and Wildlife Service, the authors, with the help of other government biologists and volunteers, established pairs of study sites in two or three habitats each in Puerto Rico, Republica Dominicana, Jamaica, Costa Rica, and Venezuela (table I) in January and February of 1984 and 1985. One member of each pair of sites was in undisturbed forest of 1,000 ha or more, generally a national park or forest preserve. The matching site was a small isolated tract of the same vegetation type, usually 5 to 50 ha in area, located within 5 to 10 km of extensive forest.

Bird populations at each site were sampled by mist netting and banding and by a series of 10 point counts of 5 minutes each at 200 m intervals. The mist netting gave a good representative sample of the relative abundance of species feeding within 2 m of the ground. The point counts supplemented the mist netting by providing information on birds of the upper layers of the forest. Because the mist netting provided the best samples for comparison, this report will be limited to the netting results. At most sites, 15 to 20 12-m, 4-shelf nets (36 mm mesh) were operated on three days from dawn to dusk except when interrupted by rain. Where logistically practical, nets were operated on alternate days at any one site in order to minimize disturbance and maximize the catch.

Each bird captured was banded, aged and sexed when possible, weighed, and examined for subcutaneous fat and for brood patch or cloacal protuberance; the wing chord was also measured. Instead of banding hummingbirds, the tip of one tail feather was clipped for individual recognition. Time of day and height in the net were also recorded for comparison with the point count data. Documentary photographs of many of the birds were taken to permit further study of plumage characters that are helpful in determining age and sex.

Two pairs of sites, one pair each in Puerto Rico and Jamaica, were visited in both winters to determine the extent to which banded birds returned to large and small woodlands.

RESULTS

Species composition and banding summary

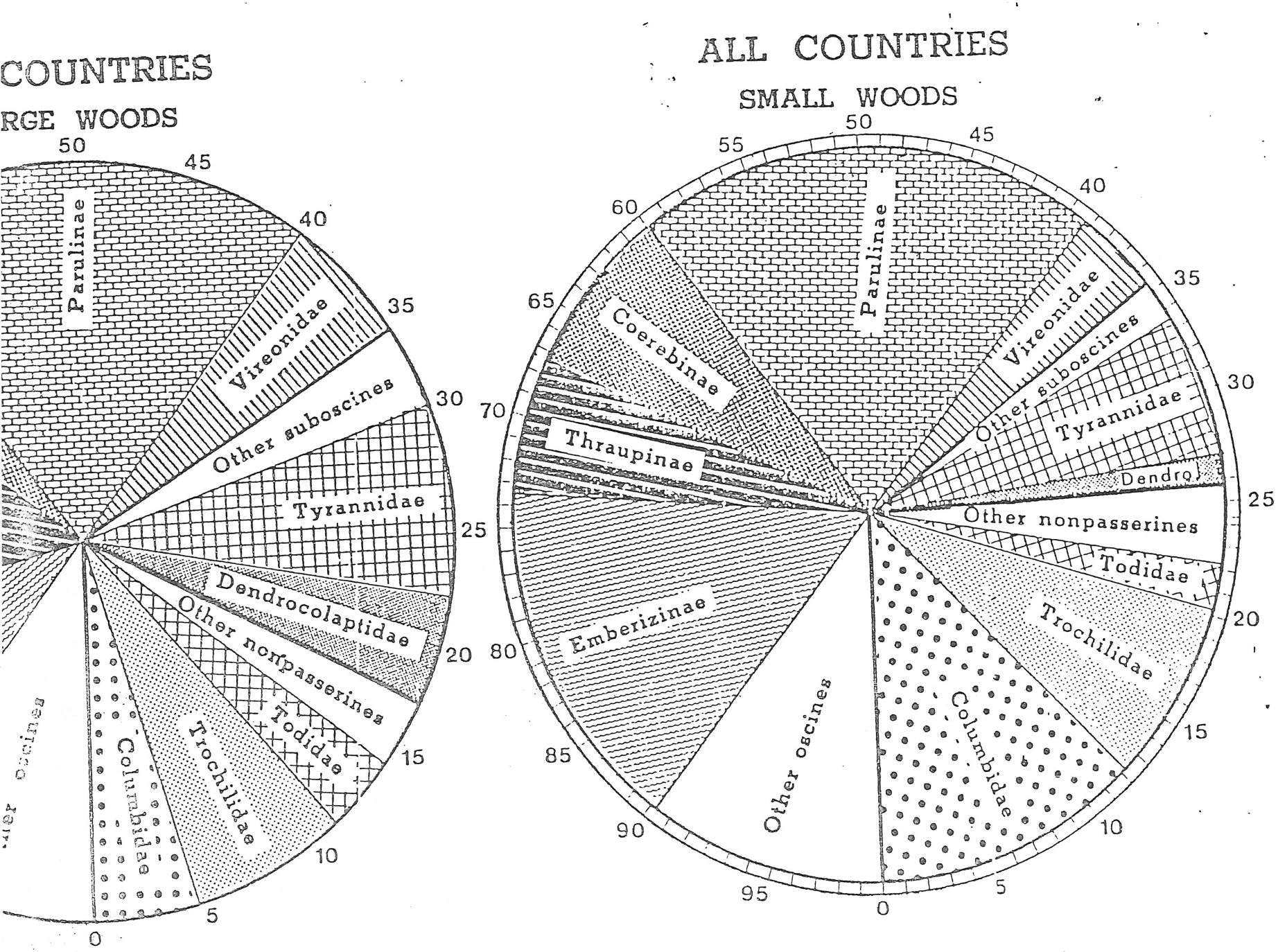
Nearly 3,400 birds were handled during the course of this study, with almost equal numbers in large and small forests (table I). Because of the broad geographic area and the large number of forest habitats sampled, the number of species captured was large (240) and few species were banded in sufficient numbers to show significant differences between large and small sites. Consequently the results are presented by families (table II). Species that breed in North America are included in the family total but are also summarized in a separate entry at the end of the table. Significant differences in abundance by families as determined by a chi-square test are indicated by asterisks.

In marked contrast to their distribution during the breeding season, most North American breeding species were not restricted to extensive forest on their wintering

grounds but, on average, were just as common in the small tracts as in the large areas. However, members of several important resident families and subfamilies were

TABLE I. — *Location of tropical study sites, mist-netting effort and capture summary.*

Country and Locality	Latitude-Longitude	Elevation (m)	Area (ha)	Year	Net-hours	Birds Banded	Birds per 100 Net-hours
Puerto Rico, USA							
Mangrove swamp							
Piñones	18°27'-65°58'	0	2,000	1984	479	140	29
San Juan	18°26'-66° 4'	0	10	1984	898	101	11
Mountain serpentine forest.							
Maricao large	18° 9'-66°59'	840	>10,000	1984	858	103	12
				1985	984	83	8
Maricao small	18°10'-67° 2'	480	40	1984	709	106	15
				1985	567	124	22
Dry coastal limestone forest							
Guánica Forest	17°59'-66°52'	200	5,500	1985	405	132	33
Punta Verraco	17°58'-66°48'	25	100	1985	353	129	37
Totals, large forest					2,726	458	17
Totals, small forest					2,527	460	18
República Dominicana							
Nature coastal limestone forest							
Parque Nac. del Este	18°20'-68°50'	5	>1,000	1984	332	128	39
La Botijuela	18°20'-68°50'	25	15	1984	283	113	40
Thorn scrub							
Parque Nac. del Este	18°20'-68°50'	5	>1,000	1984	636	126	20
Rio Chavón	18°20'-68°50'	50	5	1984	300	120	40
Totals, large forest					968	254	26
Totals, small forest					583	233	40
Jamaica							
Mid-level limestone							
Crown Lands	18°12'-77°38'	700	>10,000	1984	267	103	39
Marshall's Pen	18° 3'-77°31'	600	5	1984	626	184	29
Low-level limestone							
Windsor	18°22'-77°39'	400	>10,000	1985	461	112	24
Sherwood	18°24'-77°37'	300	25	1985	381	129	34
Arid limestone							
Round Hill	17°51'-77°21'	25	525	1984	350	107	31
				1985	333	152	46
Kemp's Hill	17°51'-77°17'	75	50	1984	517	125	24
				1985	574	158	28
Totals, large forest					1411	474	34
Totals, small forest					2098	596	28
Costa Rica							
Rain forest							
Tapanti	9°44'-83°47'	1500	>10,000	1984	325	101	31
Rio Macho	9°46'-83°51'	1400	10	1984	298	73	24
Rio Cataratitas	10° 1'-84° 3'	800	>10,000	1984	231	112	48
La Balsa	10° 1'-84° 3'	1160	25	1984	230	92	40
Totals, large forest					556	213	38



captures by families in large and small woods, based on totals for all countries combined. See table II for numbers
ts are based. Total area of charts is proportional to net-hours of banding effort in large versus small woods.

Recaptures of birds banded the previous year

In 1984, we banded 20 *Mniotilta varia* in Jamaica, 10 of them in extensive forest (Round Hill) and 10 in the matching isolated tract (Kemp's Hill). Ten of these 20 migrants were recaptured in the three days we spent in each tract in 1985: 6 of them in the large woods, 4 in the small woods. *Helmitheros vermivorus* were banded only in the small woods, but 4 of the 9 birds banded in 1984 were recaptured in 1985. Both of these species are dependent on extensive forest in eastern North America during the breeding season.

In Puerto Rico, we returned to a pair of tracts in Maricao Forest Reserve where there were 13 species (9 residents and 4 migrants) of which we had banded at least 4 individuals in 1984. At least one individual of each of these 13 species returned in 1985, and there was no significant difference (chi-square test) in return rate between the large and the small tract for either the resident species or the species that breed in North America.

DISCUSSION

The authors are much concerned over the effects of forest fragmentation on bird species that require forest interior habitats. In the deciduous forests of the eastern United States, the bird families that are most conspicuously affected are the forest-nesting neotropical migrants: wood warblers, vireos, tanagers and some of the thrushes and flycatchers. Our initial results from the tropical wintering grounds of these same birds suggest that many of them are not strictly bound to extensive forest during the northern winter, but use small, isolated woods and edge habitats in addition to the interior of extensive forest. This generalization does not apply to all species. *Hylocichla minima*, for example, was captured only in extensive forest (9 birds) and was not seen or heard in any isolated tract. *Seiurus motacilla* also was encountered only in extensive forests. On the other hand, many forest interior species of northern breeding grounds were found commonly in both large and small arid *Acacia* scrub habitats and in small, isolated, disturbed woodlands. *Seiurus aurocapillus* and *Parula americana*, for example, were captured in open scrubby habitats more typical of those used by *Dendroica discolor* and *D. palmarum*; and smaller numbers of other typical forest breeders were wintering with them.

We have not yet compared the weights of birds caught in isolated tracts versus extensive forests, but the high return rates of some North American breeding species indicate that at least some birds find that forest fragments provide suitable wintering habitat. It is well known that many species of birds that breed in North America return to wintering grounds in the tropics (SCHWARTZ, 1964; FAABORG & ARENDT, 1984), but we are not aware of any previous studies that have compared return rates in large versus small tropical woodlands.

Although many of the North American breeding birds may be wintering successfully in the small isolated woodlands, it is apparent from table II that fragmentation of tropical forests may be having a serious effect on many resident tropical species. More information is needed from other habitats and other geographic areas, but until it becomes available, the present paper should serve as a warning that massive losses, especially of resident tropical species, could occur unless provision is made for preservation of extensive forest tracts and for retaining wooded corridors to serve as connections between the main forest and small tracts that might otherwise become isolated.

FIG. 1. — Comparison of captures by families in large and small woods, based on totals for all countries combined. See table II for numbers on which these charts are based. Total area of charts is proportional to net-hours of banding effort in large versus small woods.

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COMPARISONS OF WINTER BIRD POPULATIONS IN EXTENSIVE NEOTROPICAL FOREST AND IN ISOLATED FRAGMENTS

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INTRODUCTION

This cooperative study of effects of forest fragmentation on birds spending the boreal winter in the neotropics was an outgrowth of work the first three authors had completed in the Middle Atlantic States during the summers of 1979-83 (Robbins 1980, Robbins et al. MS). We found, from examination of 469 study sites, that nearly all of the neotropical migrants that nest in temperate forests require extensive forest, and that the probability of encountering them at any random point within a forest decreases with contiguous area of the forest and with increasing isolation from adjacent forest. Notable exceptions are Coccyzus americanus, Contopus virens, and Myiarchus crinitus.

Because of claims that fragmentation of tropical forests, rather than habitat change on the breeding grounds, is the main cause of declining populations of neotropical migrants, we began this cooperative study. It was designed to compare bird use of small isolated tropical woodlands with use of similar-sized study sites located within extensive forest. The objective was to determine which avian species, residents as well as migrants, are able to use forest fragments and which ones are restricted to extensive undisturbed forest.

METHODS

Pairs of study sites were established in various wooded habitats in PuertoRico, República Dominicana, Jamaica, Mexico, Belize, Costa Rica, and no. Venezuela. This geographic spread ensured that most of the common neotropical species for which we had gathered information on the breeding grounds would be sampled during the northern winter.

About 15 mist nets (36 mm mesh) were operated from dawn to dusk for three days at each site. Where logistics permitted, nets were operated on alternate days. Nets were checked at half-hour intervals. Birds were carried in cloth bags to a central location for identification, banding, weighing, and measuring, and then were promptly released. Most hummingbirds were temporarily marked by clipping the end of one tail feather instead of using a numbered band.

Although mist nets are an efficient means of sampling birds that fly within 2 or 3 m of the ground, there are many canopy-dwelling species that are rarely captured in mist nets. Nets can be operated high above the ground, but only with considerable difficulty. Past experience by ourselves and other investigators (Rappole and Warner 1980) has shown that capture rates in the canopy are much lower than those in nets set near the ground. Therefore, in order to sample canopy species we needed to supplement the netting with another method. Unfortunately, no method is known that will give reliable estimates or even relative abundance of canopy species in tropical forest habitats (Hutto et al. 1986). The method we adopted is a modification of the Indices Ponctuels d'Abondance (IPA) or point count procedure (Blondel et al. 1970).

At each site, ten points at 100 m intervals along a transect through the netting area were marked with flagging tape. In extensive forest the points were located along a trail that passed through or was blazed through the netting area; in the small isolated woodlands, the points were along a trail that wound through the study site. In very small sites, some of the points were, of necessity, at or near the wood margin. Five-minute counts were made at each point on at least two mornings, with the same number of counts at both members of each pair of sites. Counts were made of all birds detected aurally or visually within 30 m, and separate counts were made of those beyond 30 m; only those birds detected within 30 m are included in the present analyses. This is similar to the method later proposed by Hutto et al. (1986), the differences being that he used 10-min counts, a 25 m radius, and a 200 m distance between points.

Total numbers of birds banded and mean number of individuals counted per transect were summed by species and families, and whenever sample size was ten or more the results from extensive sites were compared to those from small sites by chi-square analysis.

An effort was made to match the habitat (same dominant species and similar vegetative structure) and elevation in each pair of sites, to set up study sites of about the same size in both the small and extensive sites, and to distribute the banding effort evenly within each pair. Weather conditions (especially rain and inability to shield all nets from sun) prevented an exact match of net-hours between pairs of sites, but on average the effort in extensive sites was very similar to that in small sites.

At each study site a ninimum of two James-Shugart (1970) vegetation plots (0.02 ha each) were sampled at randomly selected point count locations. In addition to the standard measurements, we made four density board sightings (Noon 1981) at each of four intervals above ground (0.0-0.3 m, 0.3-1.0 m, 1.0-2.0 m, and 2.0-3.0 m), measured all saplings (3-8 mm DBH), and made a vertical profile of the vegetation (Schemske and Brokaw 1981). The vegetation summaries for the matching small and extensive sites were compared to be sure the pairs of sites were similar in vegetation structure.

Because census effort was identical in extensive and small sites we totaled each species across all extensive sites to compare with chi-square with comparable totals from small sites. Similar because net-hour totals were within 3% for large and small and three days of netting effort in each site had resulted in capture of most of the birds within the vertical range of the we used banding totals as the dependent variable for comparison of netting results. The netting comparisons must be interpreted with caution, however, because it was not possible to attain tical effort at all study sites.

The great majority of the species encountered were in numbers too small to permit differences between extensive and small sites to be detected, so the species totals were combined by family and reexamined by chi-square.

In order to determine whether marked birds were returning to remaining in) both extensive and small sites, we returned in subsequent winters to re-sample two pairs of sites in Puerto Rico, two pairs in Jamaica, and one pair in México.

RESULTS

Locations, habitats, elevations, areas, years of study, net-hours and total birds banded in extensive and small sites in January–February of 1984 and 1985 were summarized in Robbins et al. (1987). Additional sites studied in 1986 and 1987 are listed in Table 1. In addition to the new sites in Table 1, 400 net-hours were spent in previous extensive sites and 391 in previous small sites in Puerto Rico, and 975 in extensive sites and 943 in small sites in Jamaica. This, together with the 6478 net-hours in extensive sites and 6509 in small sites in 1984 and 1985, made a total of 10,704 net-hours in extensive sites and 10,358 in small sites during the four winters of the study.

In all, 5679 birds were captured, 2913 of them in the extensive sites, 2766 in the small sites. North American migrants (birds of 45 species) constituted 23% of the total; 645 were in the extensive sites, 666 in the small ones. Many species were captured in only small numbers, but for most of the species for which we banded ten or more individuals, one or more birds were recaptured the next w

TABLE 1
New sites studied in 1986 and 1987

Country and Locality	Latitude-Longitude		Elevation (m)	Area (ha)	Year	Net-hours	Bird Banded	Bird 100 m
Puerto Rico, USA								
Dry limestone								
Cambalache large	18°27'	66°36'	70	600	1987	463	38	
Cambalache small	1825'	66°36'	175	3	1987	300	37	
Jamaica								
Montane forest								
Hardwar Gap large	18°05'	76°43'	1200	>10,000	1986	373	90	
Hardwar Gap small	18°05'	76°43'	1200	3	1986	336	125	
México								
Lowland rain forest								
Los Tuxtlas large	18°35'	95°05'	160	>10,000	1986	722	83	
					1987	676	94	
Ruis Cortines all	18°37'	95°06'	60		1986	633	142	
					1987	843	126	

TABLE 1 (Cont.)
New sites studied in 1986 and 1987

Country and Locality	Latitude-Longitude	Elevation (m.)	Area (ha)	Year	Net- ours	Bird Banded	Birds per 100 net-hrs.
Chimalapa large	16°53' 94°43'	200	>10,000	1987	351	93	26.5
Chimalapa small	16°53' 94°43'	200	20	1987	271	118	43.5
Belize							
Gallery forest							
Banana Bank large	17°19' 88°47'	30	200	1987	526	269	51.1
Guanàcaste small	17°15' 88°47'	30	20	1987	444	123	27.7
Pine savanna							
Parrots Wood large	17°21' 88°33'	40	500	1987	416	79	19.0
Parrots Wood small	17°21' 88°33'	35	4	1987	531	115	21.7

TABLE 2
Species with significant diferences between extensive and small forests.
"X" indicates significantly more common ($p < 0.05$).

	Región [1]	Extensive forest Nets	Extensive forest Census	Small forest Nets	Small forest Census
Nonpasserines					
Zenaida aurita	W				X
Zenaida macroura	J				X
Columbina passerina	J			X	X
Leptotila verreauxi					X
Leptotila jamaicensis	J			X	X
Amazona autumnalis	M				X
Streptoprocne zonaris	C		X		
Tachornis phoenicobia	D		X		
Phaethornis guy	C			X	
Phaethornis augusti	V			X	
Anthracothorax dominicus	D			X	
Chlorostilbon maugaeus	P	X	X		
Amazilia candida	M	X			
Lampornis hemileucus	C	X			
Mellisuga minima	J		X		
Todus todus	J	X	X		
Momotus momota	C			X	X
Melanerpes striatus	D			X	
Melanerpes radiolatus	J		X		
Melanerpes aurifrons	M				X
Total Nonpasserines		4	6	7	8
Suboscines					
Dendrocincla fuliginosa	V	X			
Glyphorynchus spirurus	C	X			
Dysithamnus mentalis	V	X			
Elaenia martinica	P	X			
Leptopogon superciliaris	C	X			
Myiarchus tuberculifer	M				X
Myiarchus validus	J	X			
Tyrannus dominicensis	W				X
Tityra semifasciata	M				X
Total Suboscines		6	0	0	3
Oscines, Troglodytidae--Vireonidae					

TABLE 2 (Cont).
Species with significant diferences between extensive and small forests.
"X" indicates significantly more common ($p < 0.05$).

	Región [1]	Extensive forest Nets	Extensive forest Census	Small forest Nets	Small forest Census
Thryothorus maculipectus	C				X
Thryothorus modestus	C			X	
Myadestes melanops	C	X			
*Catharus minimus	D	X			
*Hylocichla mustelina	M				X
Turdus jamaicensis	J			X	
*Dumetella carolinensis	C				X
Vireo modestus	J	X			
Vireo latimeri	P	X	X		
Vireo osburni	J	X			
Vireo altiloquus	P			X	
Total	5	1		3	3
Troglodytidae-Vireonidae					
Oscines, Emberizidae					
*Parula americana	W				X
*Dendroica petechia	W	X	X		
*Dendroica magnolia	C				X
*Dendroica tigrina	J	X			
Dendroica caerulescens	J				X
Dendroica adelaidae	P	X			
*Seiurus noveboracensis	P	X			
*Oporornis formosus	M			X	
*Wilsonia pusilla	M			X	X
Basileuterus culicivorus	V		X		
Coereba flaveola	P			X	
Euphonia jamaica	J	X			
Eucometis penicillata	V	X			
Habia fuscicauda	M				X
Piranga rubra	M				X
Phaenicophilus palmarum	D	X			
Chlorospingus ophthalmicus	C	X	X		
Tiaris olivacea	J			X	
Tiaris bicolor	V&M				X

TABLE 2 (Cont).
Species with significant diferences between extensive and small forests.
"X" indicates significantly more common ($p < 0.05$).

	Región [1]	Extensive forest		Small forest	
		Nets	Census	Nets	Census
Loxigilla violacea	J	X			
Euneornis campestris	J			X	
Quiscalus niger	P	X			
Icterus leucopteryx	J	X			
Psarocolius wagleri	V				X
Total Emberizidae		11	3	5	8
Total species		26	10	15	22
North American migrants		3	0	2	6

1 C = Central America (Belize and Costa Rica), D = República Dominicana,, J = Jamaica, M = México, P = Puerto Rico, V = Venezuela, W = West Indies (more than one island)*North American migrant

TABLE 3
Number of species in each family that were significantly more common in either extensive woods or small isolated woods

Family	Extensive Forest		Small Forest	
	Nets	Census	Nets	Census
Columbidae	-	-	2	4
Psittacidae	-	-	-	1
Apodidae	-	2	-	-
Trochilidae	3	2	3	-
Todidae	1	1	-	-
Momotidae	-	-	1	1
Picidae	-	1	1	1
Dendrocolaptidae	2	-	-	-
Formicariidae	1	-	-	-
Tyrannidae	3	-	-	3
Troglodytidae	-	-	1	-
Turdinae	2	-	1	1
Mimidae	-	-	-	1
Vireonidae	3	1	1	-
Emberizidae				
Parulinae	4	2	2	4
Coerebinae	-	-	1	-
Thraupinae	4	1	-	2
Emberizinae	1	-	2	1
Icterinae	2	-	-	1
Total species	26	10	15	20

Species for which significant differences (p 0.05) were found between extensive and small sites are listed in Table 2. The geographical regions in which the differences were detected are indicated in the first column of the table.

Catharus minimus was the only North American migrant appeared to be restricted to extensive forest. All of the 10 captured (on the island of Hispaniola) were in extensive f On the other hand, many resident tropical species were f entirely or primarily in extensive forest; this was especiall of the suboscine families (Formicariidae, Dendrocolaptidae nariidae, Pipridae, and some of the Tyrannidae), and the To and Thraupinae.

Species for which no significant difference was found are of interest. Those species of which we banded 20 or mo dividuals and found no significant difference between exte and small sites (either by netting or by point counts) are a lows (North American migrants indicated with asteri Geotrygon montana, Trochilus polytmus, Amazilia tz Chalybura buffonii, Todus subulatus, Todus mexicanus, N noplex brunnescens, Dendrocincla anabatina, Sittasc griseicapillus, Mionectes olivaceus, Mionectes oleagi Platyrinchus mystaceus; Myiarchus barbirostris, Myiar stolidus, Myiarchus antillarum, Henicorhina leucophrys, Th assimilis, Turdus plumbeus, Mimus polyglottos, *Dend discolor, *Setophaga ruticilla, *Helmitheros vermiv *Seiurus aurocapillus, *Geothlypis trichas, *Wilsonia ci Basileuterus culicivorus, Spindalis zena, Habia ru Nesospingus speculiferus, Cyanocompsa cyanides, Loxip anoxanthus, Loxigilla portoricensis.

TABLE 4
Summary of banding and census totals by family

Family	Banding Totals		Census Totals	
	Extensive Sites	Small Sites	Extensive Sites	Small Sites
Ardeidae	1	0	7	7
Cathartidae	0	0	35	30
Falconidae	4	2	7	2
Columbidae	141	248***	59	173**
Psittacidae	3	1	147	208**
Cuculidae	22*	10	33	25
Apodidae	0	1	61***	5
Trochilidae	193	188	161	134
Trogonidae	2	2	4	3
Todidae	76**	44	106*	74
Momotidae	4	10	0	4
Galbulidae	7	4	5	1
Rhamphastidae	4	2	5	4
Picidae	20	35*	71	57
Furnariidae	32	22	3	5
Dendrocolaptidae	121***	59	4	1
Formicariidae	24**	13	4	3
Tyrannidae	250	198	111	135
Pipridae	31**	10	1	0
Hirundinidae	0	0	10	27**
Corvidae	1	0	16	21
Troglodytidae	35	37	33	63**
Cinclidae	0	0	2	0
Muscicapidae	212	238	29	73***
Sylviinae	(5)1	(2)	(1)	6
Turdinae	(207)	(236)	(28)	(67)**

TABLE 4.
Summary of banding and census totals by family

Family	Banding Totals Extensive Sites	Banding Totals Small Sites	Census Totals Extensive Sites	Census Totals Small Sites
Mimidae	66	67	57	50
Ptilogonatidae	1	0	0	0
Dulidae	0	3	0	0
Vireonidae	128*	93	127*	92
Emberizidae	1526	1469	779	1032***
Parulinae	(614)	(582)	(285)	(355)**
Icterinae	(42)***	(10)	(40)	(68)**
Coerebinae	(132)	(170)*	(155)	(274)***
Thraupinae	(337)***	(210)	(135)	(167)
Cardinalinae	(30)	(35)	(4)	(14)*
Emberizinae	(371)	(462)**	(160)	(154)
Total Birds	2913	2766	1888	2236***

1 Subfamily totals are in parentheses
* $p < 0.05$ (chi-square)
** $p < 0.01$
*** $p < 0.001$

Table 3 summarizes, by families, the significant differences in Table 2.

A summary of all birds netted and all birds detected within 30 m on the point counts is presented in Table 4, with the significance of the chi-square values included for each family.

DISCUSSION

The netting and point count data (Tables 2 and 3) yield different results. The netting data show that more species were captured in larger numbers in the extensive sites, whereas the point counts detected twice as many species as being more common in the small isolated forests. Both methods are biased by providing data on only a portion of the species present. Aerial feeders such as swifts, canopy species such as the large pigeons, parrots, and some of the icterinae, and some of the small hummingbirds were poorly sampled by netting. On the other hand, birds of the dense undergrowth that were not vocalizing were often missed on the point counts. To a degree, the two methods are complementary, but we realize that small, silent canopy-feeders are under sampled by both methods, especially in tall forests. Although the pairs of study sites were selected for similarity of age and structure of the vegetation, large feeding flocks of migrant warblers in the extensive mature forest tended to stay high in the canopy, whereas in isolated woodlands they often fed in the low vegetation near the edge of the forest.

By combining data from the two methods, 31 species were recorded as significantly more common in the extensive sites, and 33 species were more common in the small sites. Banding data showed three species of North American migants to be more common in extensive forest and two species more common in small forest. Point count data showed no migrants to be more common in extensive forest, but six species were detected more commonly in small forest, perhaps reflecting some of the bias mentioned in the previous paragraph. None of the 64 species in Table 2 showed opposing results by the two methods. When the species with no size preference and those with small samples were added to the family totals (Table 4), most of the patterns remained the same. The Columbidae, Hirundinidae, Troglodytidae, Turdinae, Parulinae, Coerebinae, Cardinalinae, and Emberizinae were more common in the small sites, while the Cuculidae, Apodidae, Todidae, Dendrocolaptidae, Formicariidae, Pipridae, Vireonidae, and Thraupinae were more common in the extensive sites. Two large families, the Trochilidae and Tyrannidae, showed no consistent family pattern because some species preferred small sites while other species were more commonly recorded in extensive forest. The diverse subfamily Icterinae registered conflicting preferences depending on the method used. Because of the small sample size for each species, the Cuculidae, Pipridae, Hirundinidae, and Cardinalinae did not show significant differences until all species in the family were combined.

In summary, the numbers of species and individuals depended more on the habitat than on the size of the forest. The banding totals revealed about 5% fewer birds in the small sites, while the point counts recorded 16% more birds in the small sites. The important consideration is the composition by species and families. Certain families, especially some of the suboscines (Dendrocolaptidae, Formicariidae), Todidae, Vireonidae, and Thraupinae, were much more common in the extensive forests, while the relative scarcity of these birds in the small forests was partially compensated for by greater abundance of edge species such as Coerebinae, and certain members of the Trochilidae, Troglodytidae, Turdinae, Parulinae, Icterinae, Cardinalinae, Emberizinae.

Of particular interest is the discovery that most species of North American migrants that are dependent on extensive forest on their breeding grounds are not restricted to extensive forest during the northern winter. On the other hand, many species and families of resident tropical birds will be severely impacted when extensive native forest is fragmented into small isolated patches.

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Comparison of Neotropical migrant landbird populations wintering in tropical forest, isolated forest fragments, and agricultural habitats

Abstract. Neotropical migrant bird populations were sampled at 76 sites in seven countries by using mist nets and point counts during a six-winter study. Populations in major agricultural habitats were compared with those in extensive forest and isolated forest fragments. Certain Neotropical migrants, such as the Northern Parula, American Redstart, and the Black-throated Blue, Magnolia, Black-and-white, and Hooded warblers, were present in arboreal agricultural habitats such as pine, cacao, citrus, and shade coffee plantations in relatively large numbers. Many north temperate zone shrub-nesting species, such as the Gray Catbird, White-eyed Vireo, Tennessee Warbler, Common Yellowthroat, and Indigo Bunting, also used agricultural habitats in winter, as did resident hummingbirds and migrant orioles. Ground-foraging migrants, such as thrushes and Kentucky Warblers, were rarely found in the agricultural habitats sampled. Although many Neotropical migrants use some croplands, this use might be severely limited by overgrazing by cattle, by intensive management (such as removal of ground cover in an orchard), or by heavy use of insecticides, herbicides, or fungicides.

Sinopsis. Se mostrearon poblaciones de aves terrestres neotropicales migratorias en 76 sitios de siete países usando redes de niebla y conteos puntuales durante un estudio de seis inviernos. Las poblaciones de habitats agrícolas principales se compararon con aquellas de bosques extensos y de fragmentos forestales aislados. Ciertas migratorias neotropicales, como *Parula americana, Setophaga ruticilla, Dendroica caerulescens, D. magnolia, Mniotilta varia* y *Wilsonia citrina,* estuvieron presentes en números relativamente grandes en habitats agrícolas arbóreos tales como plantaciones de pinos, cacao, cítricos y cafetales de sombrío. Muchas especies de la zona templada del norte anidantes en arbustos, como *Dumetella carolinensis, Vireo griseus, Vermi-*

vora peregrina, Geothlypis trichas y *Passerina cyanea,* igualmente usaron habitats agrícolas en invierno, como también lo hicieron los colibrís residentes y los *Icterus* migratorios. Migratorias que se alimentan en el piso, como los *Catharus* spp. y *Oporornis formosus,* se encontraron raramente en los habitats agrícolas mostreados. Aunque muchas migratorias neotropicales usan algunas tierras de cultivo, este uso podría estar seriamente limitado por el sobrepastoreo de ganado, el manejo intensivo (como por ejemplo la remoción de cobertura del suelo en una arboleda) o por el uso masivo de insecticidas, herbicidas o fungicidas.

In January 1984, the U.S. Fish and Wildlife Service (USFWS) began a cooperative study of use of tropical forest habitats by migratory songbirds during the northern winter. This study was prompted by concern that tropical deforestation was causing population declines in some species of northern songbirds that winter in the Neotropics. The Food and Agriculture Organization of the United Nations (1986) has reported the number of hectares of forested land in each nation in 1974–1976 and in 1984. In Mexico, for example, forested land declined 10.7% (from 51,150,000 to 45,700,000 ha); in Guatemala, 14.3% (4,933,000 to 4,230,000 ha); in Honduras, 16.3% (4,470,000 to 3,740,000 ha); in Nicaragua, 20.0% (5,050,000 to 4,040,000 ha); in Costa Rica, 29.1% (2,200,000 to 1,560,000 ha); but in Cuba an increase of 5.5% was reported (1,838,000 to 1,940,000 ha). The concern over tropical deforestation presented an opportunity to establish long-term cooperative studies in the tropics as a followup to month-long migratory bird workshops conducted for Latin American biologists under auspices of the USFWS Office of International Affairs. After four winters of comparing bird populations in isolated or fragmented tropical forests with those in nearby extensive undisturbed forest, the emphasis changed to evaluating the use of various agricultural habitats by wintering passerine migrants. With the rapid conversion of native tropical forest to cropland and pasture, it became increasingly important to know which species were able to use habitats to which forests were being converted. Little information had been available on use of agricultural habitats by either Neotropical migrants or resident species.

We conducted field work in Venezuela, Costa Rica, Belize, Mexico, Jamaica, Dominican Republic, and Puerto Rico. We placed the greatest emphasis on the Greater Antilles, Mexico, and Belize, because we found that the proportion of North American migrants was highest in these countries. Terborgh (1989: 77–78) presents a summary of the proportion of North American migrants at 76 sites in the Neotropics.

Focusing on those countries for which we have data on agricultural habitats, extensive forest, and forest fragments permits a three-way comparison. This allows us to assess habitat use in the original forest and the effects of forest fragmentation and of conversion to agriculture.

Methods

During midwinter (January and February) of 1984–1987, we used mist nets and point counts to sample bird populations in 16 pairs of tropical study sites in mature extensive forest (≥ 1,000 ha) and in small isolated patches (5–50 ha) of similar forest. Most sites were studied in only one or two winters, but one pair of sites in Jamaica was studied in three consecutive winters. During the winters of 1987–1989, we conducted similar counts at 32 sites in seven different agricultural habitats to learn which species could use various man-made habitats and which could not. We compare the habitat distributions of common migratory forest species based on the first year of netting and census results at these 64 sites. We also make some reference to data from 12 other sites, including early successional habitats, pastures, and crops such as cashew (*Anacardium occidentale*) and commercial banana (*Musa* sp.) that were used by very few birds.

SELECTION OF STUDY SITES. Finding extensive tracts of undisturbed tropical forest accessible from all-weather roads was seldom easy. The majority of extensive tracts that we used were in national parks or preserves. Small isolated tracts also were a challenge to locate. In some instances we could make a random selection. More frequently it was a matter of selecting the one candidate site that was the best match in terms of proximity (generally < 5 km), elevation (< 100 m difference), vegetation, and isolation from neighboring woodland. Other constraints were the size range of 5–50 ha, satisfactory shape (avoiding long, narrow tracts), uniformity, lack of present disturbance, accessibility, and ability to obtain landowner permission.

With early successional habitats, and with some of the agricultural habitats, it was possible to make a random selection from among candidate sites. Starting in 1989, candidate sites were selected from satellite imagery when available. Then, study sites were selected from the largest accessible uniform areas of habitat as identified on the imagery. These sites were then ground-truthed for uniformity, shape, size, proximity of edge, and disturbance.

NETTING OPERATIONS. Our chief method of determining bird use of different habitats was through the use of mist nets. Unbaited nets were erected at the same

ht in all habitats, and caught birds flying within 2 m
e ground. In most agricultural habitats, 16 nets
d be placed systematically in a grid. In national
s, preserves, and other places where cutting vegeta-
was not permitted and on very steep slopes, nets
to be placed along existing trails. We used 12-m, 4-
nets, with 36 mm (75%), and 30 mm (25%) mesh.
were generally operated for three days per site,
shortly before sunrise until about sunset, but were
d whenever heavy rain or high winds occurred. Fur-
more, nets that became exposed to full sunlight
closed temporarily when the safety of birds was in
tion. Net hours were recorded. Birds captured were
ed; aged and sexed, and wing chord, fat, weight,
of day, and net and shelf number recorded.
January and February, the number of new birds per
net hours declined rapidly with each day of netting.
t 73% of the birds captured in five days of netting
caught in the first two days, and 86% by the third
Therefore, we use the number of birds captured in
days as our netting standard for habitat compar-
rather than the number of birds per 100 net
s.

T COUNTS. At each site two (occasionally three) 5-
point counts were made at each of 10 flagged loca-
spaced at least 100 m apart throughout the net-
area. Separate counts were made of birds observed
in 30 m and beyond 30 m. Activity and estimated
ht above ground were recorded for each bird seen.
dents as well as migrants were counted. The
od is similar to that used by Hutto et al. (1986).

TATION SAMPLING. In forested sites, we modified the
od of James and Shugart (1970); our circles (three
ore randomly selected at each site) each had an
of 0.02 ha, instead of 0.04, because of the very
e foliage. We also took four density board readings
n 1981) and 20 vertical foliage sightings (Schemske
Brokaw 1981) in each circle. Where possible, a resi-
botanist identified the tree species. In arboreal
cultural habitats such as coffee and citrus planta-
s, we used rectangular vegetation plots, 20 × 20 m.
vegetation data for pairs of extensive forest and
st fragment sites were compared initially to assure
the sites were structurally comparable. More de-
d analyses are planned for relating habitat descrip-
s to satellite imagery.

ults

rior studies in the tropics, we banded 2,766 birds in
58 net hours in forest fragments, and 2,913 in
04 net hours in extensive forest (Robbins et al. 1987
in press). In the agricultural habitats summarized here, we banded 5,008 birds in 11,989 net hours.

In cropland habitats there were 14 Neotropical migrant species for which captures exceeded 40 individuals. To show the range of croplands used by these common migrants, their mean 3-day banding totals for the major agricultural habitats are shown in Table 1. Of 5,008 birds banded at the 32 sites summarized in Table 1, 1,250 (25%) were North American migrants.

Table 1 includes the major habitats for which at least three sites were sampled; the rice field was also included because of the large number of birds captured in that habitat. The first four columns of the table show West Indian habitats. Birds that winter primarily in the West Indies (e.g., Black-throated Blue Warbler) would be largely restricted to these columns, regardless of habitat requirements. Similarly, catbirds, orioles, and some of the warblers would be restricted to the Central American columns on the right. The citrus and cacao plantations stand out as supporting a wide variety of Neotropical migrants, as well as relatively high abundance.

A comparison of banding totals and point count totals for the species most commonly detected in agricultural habitats is presented in Table 2. Data represent the habitat and country in which the largest numbers were banded or counted. When the highest point count was from a different habitat, the second habitat is also listed. For most species the banding results yielded much larger counts than did the point counts (Table 2), so banding totals form the primary basis for comparison of habitat use. The point count totals tended to confirm the same habitats as being important, although not necessarily in the same sequence of relative abundance as suggested by the banding data. The chief values of the point counts were to reveal the presence of birds that were feeding above the 2-m height of nets, to detect large species such as raptors, jays, and toucans, that were not readily captured in nets, and to provide additional comparisons of relative abundance of common species. Except for the Blue-gray Gnatcatcher, which was slim enough to slip through the nets without being captured, the Gray Catbird and Northern Rough-winged Swallow were the only common passerines in agricultural habitats to be detected in larger numbers on point counts than by netting.

Agricultural habitats varied greatly in amount of bird use (Fig. 1). Even plantations of the same crop in the same geographic location varied greatly in bird species composition, probably as a function of age of crop, blooming or fruiting condition, time of season when birds were sampled, type and proximity of nearby habitats, and management practices, including type and density of ground cover, pruning regime, and use of chemicals. Much more work will be required to evaluate these various influences.

The percentage of migrants, as estimated from the

TABLE 1. Mean 3-day banding totals, rounded to nearest whole number, of Neotropical migrants by habitat (number of sites in parentheses)

Species	Puerto Rico		Jamaica		Belize					Costa Rica
	Shade (3)	Sun (3)	Coffee (3)	Citrus (3)	Citrus (5)	Cacao (4)	Mango (3)	Rice (1)	Pine (4)	Citrus (3)
Gray Catbird	–	–	–	–	7	4	+	1	8	–
Tennessee Warbler	–	–	+	–	6	10	–	–	–	3
Northern Parula	3	4	+	2	1	2	–	–	–	–
Magnolia Warbler	–	–	+	1	6	11	4	–	3	+
Black-thr. Blue Warbler	6	1	7	1	–	–	–	–	–	–
Black-and-white Warbler	4	2	2	3	12	12	5	–	3	1
American Redstart	2	+	2	2	8	9	2	–	5	+
Ovenbird	1	1	5	8	2	4	+	–	4	4
Northern Waterthrush	+	–	–	1	2	6	–	3	–	3
Common Yellowthroat	–	–	2	3	3	1	+	21	2	–
Hooded Warbler	–	–	–	–	1	3	1	–	5	+
Indigo Bunting	–	+	+	1	10	5	–	98	–	–
Orchard Oriole	–	–	–	–	7	3	–	2	–	–
Northern Oriole	–	–	–	–	6	4	–	–	–	1
Total banded	564	467	389	1014	787	1022	50	303	226	186
Total North American	55	27	93	97	316	300	41	127	146	48
% North American	10	6	24	10	40	29	82	42	65	26
Total net hours	1431	1461	1656	1542	1543	1609	1268	229	1944	1234
Migrant species	9	8	15	15	30	25	9	7	15	16
Total species	26	31	36	47	81	64	14	15	36	39

NOTE: + = present but < 0.5. Scientific names given in Table 2.

TABLE 2. Comparison of banding and point count totals in major agricultural habitats used by common migrants

Species	Mean number		Habitat	Country
	Banded[a]	Pt. count[b]		
Least Flycatcher *Empidonax minimus*	2	1	Citrus/Cacao	Belize
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	0	6	Grazed pasture	Belize
Blue-gray Gnatcatcher *Polioptila caerulea*	0	1	Cacao	Belize
Gray Catbird *Dumetella carolinensis*	8	11	Pine/Citrus	Belize
Tennessee Warbler *Vermivora peregrina*	10	1	Cacao/Citrus	Belize
Northern Parula *Parula americana*	4	1	Sun coffee/Cacao	Puerto Rico
Magnolia Warbler *Dendroica magnolia*	11	6	Cacao/Citrus	Belize
Black-throated Blue Warbler *D. caerulescens*	7	1	Coffee	Jamaica
Prairie Warbler *D. discolor*	5	+	Coffee	Jamaica
Black-and-white Warbler *Mniotilta varia*	12	3	Citrus/Cacao	Belize
American Redstart *Setophaga ruticilla*	9	6	Cacao/Pine	Belize
Worm-eating Warbler *Helmitheros vermivorus*	3	+	Cacao	Belize
Ovenbird *Seiurus aurocapillus*	8	+	Citrus	Jamaica
Northern Waterthrush *S. noveboracensis*	6	1	Cacao	Belize
Common Yellowthroat *Geothlypis trichas*	21	7	Rice/Citrus	Belize
Hooded Warbler *Wilsonia citrina*	5	1	Pine	Belize
Indigo Bunting *Passerina cyanea*	98	6	Rice/Grazed pasture	Belize
Orchard Oriole *Icterus spurius*	7	+	Citrus	Belize
Northern Oriole *I. galbula*	6	2	Citrus	Belize

a. Mean of the 3-day banding totals for the stated habitat and country.

b. Mean of the highest totals for 10 point count positions in the stated habitat and country.

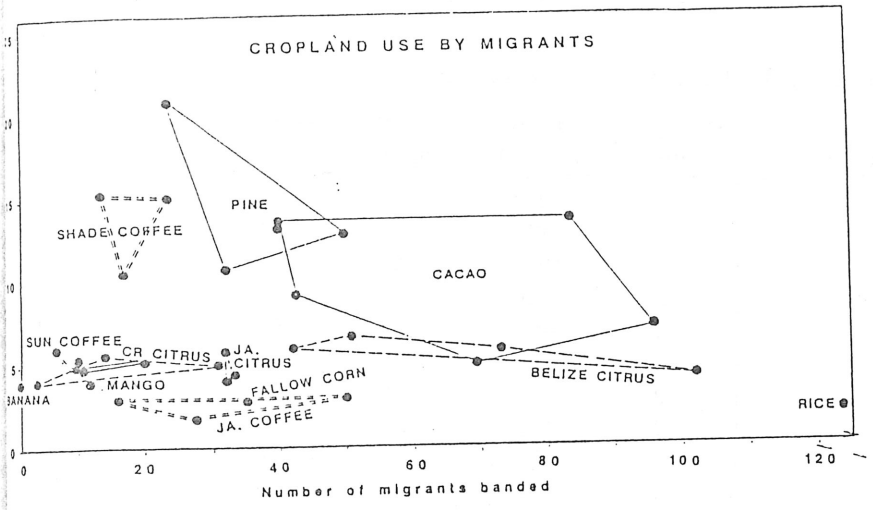


FIGURE 1. Number of migrant songbirds banded in three days of mist netting in agricultural habitats as a function of canopy height.

ding totals for each habitat, also varied within and ong habitats as well as among countries (Table 3). have assumed that relative vulnerability to capture migrants and residents remained constant among itats, but this may not have been true in fallow rice *yza sativa*). The number of individuals of migrant ds captured in fallow rice far exceeded that in any er habitat even though the number of migratory cies in rice was the second lowest of any habitat sam-d. The actual number of migrants present was much ger than the 127 birds banded. The banders caught many birds in the rice field that some nets were nev-set; furthermore, dozens of Indigo Buntings that me to roost at dusk were released unbanded so the ts could be closed before the arrival of bats.

The highest percentage of migrant individuals was in mango (*Mangifera indica*) plantations, but this was the poorest habitat in total number of birds captured. The two most productive agricultural habitats for Neotropical migrants, in both number of species and number of individuals (excluding fallow rice), were citrus (*Citrus* spp.) groves and cacao (*Theobroma cacao*) plantations. For comparison with the use of agricultural habitats by migrants (Table 3), the average use of native forest habitats, both in extensive forest and forest fragments, is summarized by country in Table 4. When individual species are not considered, but only percent of migrants in a population, use of forest fragments compared favorably with extensive forest. The percentage of migrants was especially high in Belize forests (52% and 55%), far

BLE 3. Mean number of birds captured, percent of migrants, and number of migrant species in agricultural habitats, anged by decreasing number of migrant species

bitat	Country	Mean birds captured		Percent migrants	Migrant species
		All species	Migrants		
trus	Belize	157	63	40	30
cao	Belize	256	75	29	25
rricane Coffee[a]	Jamaica	130	31	24	15
trus	Costa Rica	62	16	26	16
trus	Jamaica	338	32	10	15
nted pine	Belize	56	36	65	15
ngo	Belize	17	14	82	9
shew	Belize	30	10	33	9
ade Coffee	Puerto Rico	188	18	10	9
n Coffee	Puerto Rico	156	9	6	8
ce	Belize	303	127	42	7
llow corn	Belize	117	33	28	6

Former shade coffee whose shade trees were destroyed by hurricane.

TABLE 4. Percent of migrant birds in native forest habitats based on banding totals

Country and habitat	Number of sites	Total banded	Total migrants	Percent migrants
Venezuela E	2	311	4	1
Venezuela F	2	207	7	3
Costa Rica E	2	213	3	1
Costa Rica F	2	165	10	6
Belize E	2	348	182	52
Belize F	2	238	132	55
Mexico E	2	187	22	12
Mexico F	2	244	75	31
Jamaica E	4	458	75	16
Jamaica F	4	584	90	15
Dominican Republic E	2	254	62	24
Dominican Republic F	2	233	45	19
Puerto Rico E	4	414	135	33
Puerto Rico F	4	351	101	29

NOTE: E = Extensive forest; F = Forest fragment < 50 ha.

TABLE 5. Comparison of agricultural habitats with native extensive forest, by country, based on banding totals

Country	Native forest		Agricultural habitats	
	Total migrants	Percent migrants	Total migrants	Percent migrants
Costa Rica	3	1	48	26
Belize	243	42	930	39
Mexico	22	12	—	—
Jamaica	75	16	190	14
Dominican Republic	62	24	—	—
Puerto Rico	135	33	83	8
TOTAL	540	25.6	1251	16.8

exceeding the percentage found in any agricultural habitat sampled. As has been noted by other investigators (Rappole et al. 1983, Terborgh 1989), the percentage of Neotropical migrants in tropical forests was much lower in Venezuela and Costa Rica than in Belize, Mexico, and the Greater Antilles.

When percentage of migrants (total individuals) is computed for each country for all native forest habitats and all agricultural habitats studied (Table 5), the percentage of migrants using agricultural habitats in Belize compares favorably with the percentage using native forest. A further comparison, summarizing the number of migrant and resident species (rather than individuals) netted in each habitat is presented in Appendix 1. The number of species with which migrants must compete for resources in just the lower two meters of some wintering habitats is truly impressive, reaching 70 or more species.

In Puerto Rico the percentage of migrants in agricultural habitats was low because coffee was the only agricultural habitat sampled there. The total numbers of migrants in Table 4 cannot be compared between native forest and agricultural habitats because the number of sites differed. Also, because Table 4 includes only matched extensive forest sites and fragments, the total number of migrants there was fewer than the number in Table 5. The total number of Neotropical migrants captured in the 32 agricultural sites was 1,250, as compared with 537 found in 16 extensive forest sites.

Habitat use by six species of north temperate zone

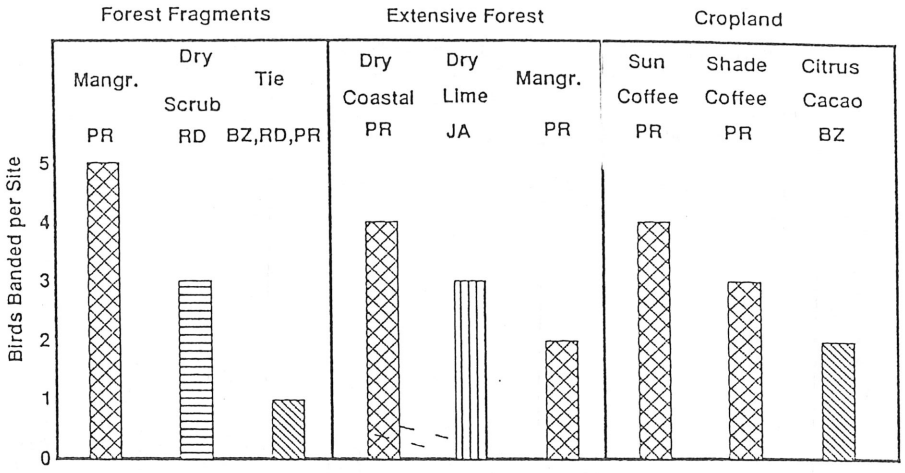


FIGURE 2. Relative abundance of the Northern Parula, *Parula americana*, a habitat generalist, in the winter habitats in which it was captured in largest numbers. Here and in the figures to follow, extensive mature forest habitats are shown at the center of each graph, in decreasing importance from left to right. When a habitat is listed as "Tie" in the last position at the right, two or more habitats in third place had the same small number of individuals. Forest data are available for all countries, but we have agricultural data for the same region only for Belize, Jamaica, and Puerto Rico. See Robbins et al. 1987 and in press for details of the forest habitats.

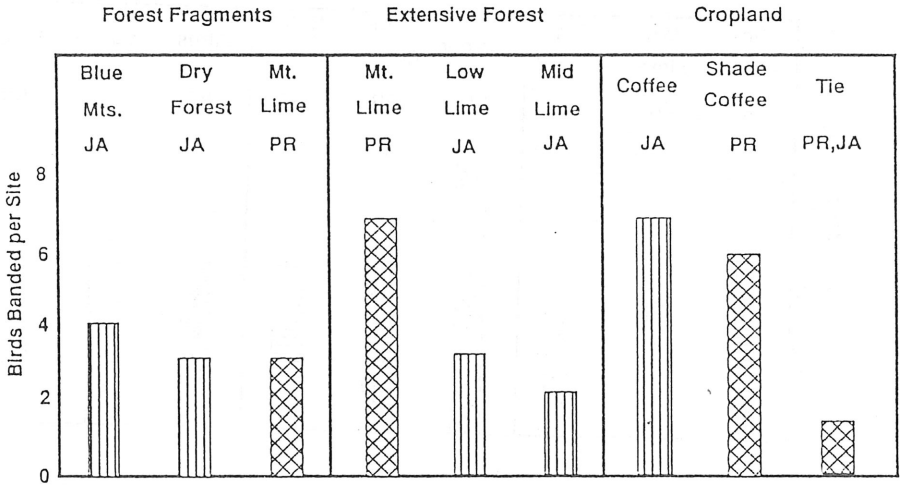


FIGURE 3. Relative abundance of the Black-throated Blue Warbler, *Dendroica caerulescens*, a habitat generalist, in the winter habitats in which the largest numbers were captured.

forest-breeding birds that winter in several agricultural habitats as well as extensive forest and forest fragments is summarized in Figures 2–7. We discuss each of these six species briefly, and then we discuss winter habitat use by some typical ground-feeding and brush-nesting species.

Data from the 64 sites were condensed as follows: (1) data from similar agricultural sites in the same country were combined into a single mean; (2) when a site was visited in multiple years only the data from the first year were used; and (3) within each category (extensive forest, isolated forest patches, and agricultural sites), only the three habitats in which a species was most common are included on the graphs.

SPECIES ACCOUNTS

The Northern Parula (Fig. 2) (see Table 2 for scientific names), which Raffaele (1989) calls the "most common wintering warbler" in Puerto Rico and the Virgin Islands, was as common in cropland as in native forest, and was the only warbler regularly captured in sun coffee plantations.

The Black-throated Blue Warbler (Fig. 3), a typical West Indian wintering species, was frequently captured in shade coffee plantations in Puerto Rico and in hurricane-damaged coffee plantations in Jamaica, but averaged no more than one bird per site in other agricultural habitats.

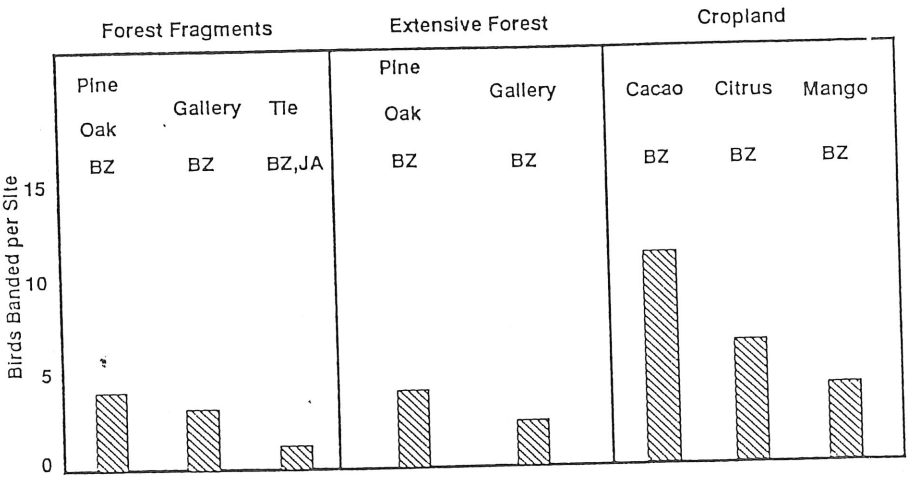


FIGURE 4. Relative abundance of the Magnolia Warbler, *Dendroica magnolia*, a habitat generalist, in the winter habitats in which the largest numbers were captured.

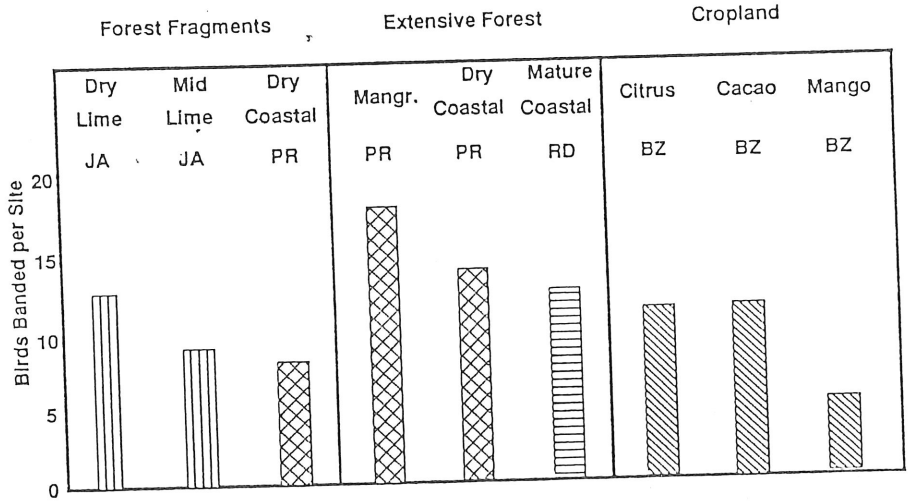


FIGURE 5. Relative abundance of the Black-and-white Warbler, *Mniotilta varia*, a habitat generalist, in the winter habitats in which the largest numbers were captured.

The Magnolia Warbler (Fig. 4) is an example of a species that apparently has adapted to orchard habitats (cacao, citrus, and mango). It was found in all arboreal agricultural habitats we sampled within its winter range.

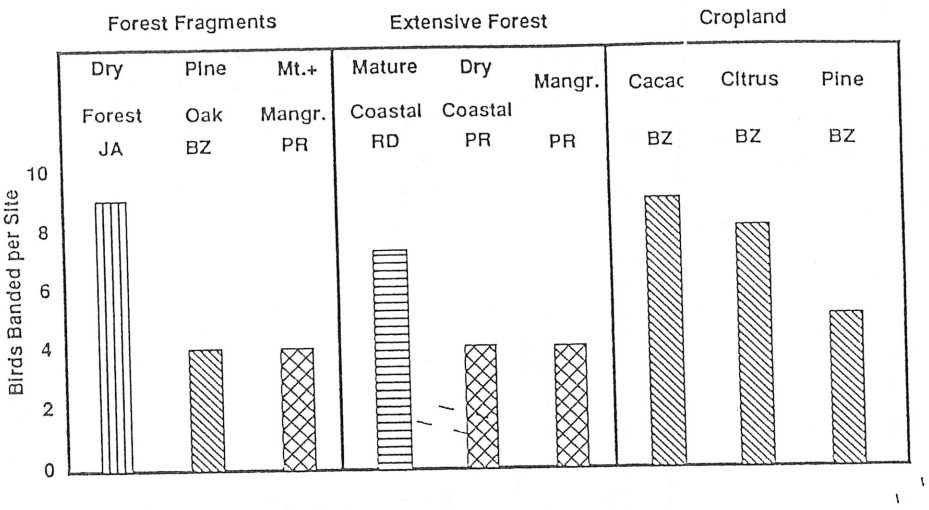
The Black-and-white Warbler (Fig. 5) is a widely distributed species that was encountered in almost all of our study sites. It was not only widespread geographically, but in most agricultural habitats it was among the three most common species captured, and was the most common migrant encountered during the study.

The American Redstart (Fig. 6) is an example of a warbler that is widely distributed geographically and uses a wide variety of agricultural habitats. In addition to the cacao, citrus, and pine plantations shown here, smaller numbers were found in mango and in both shade and sun coffee plots.

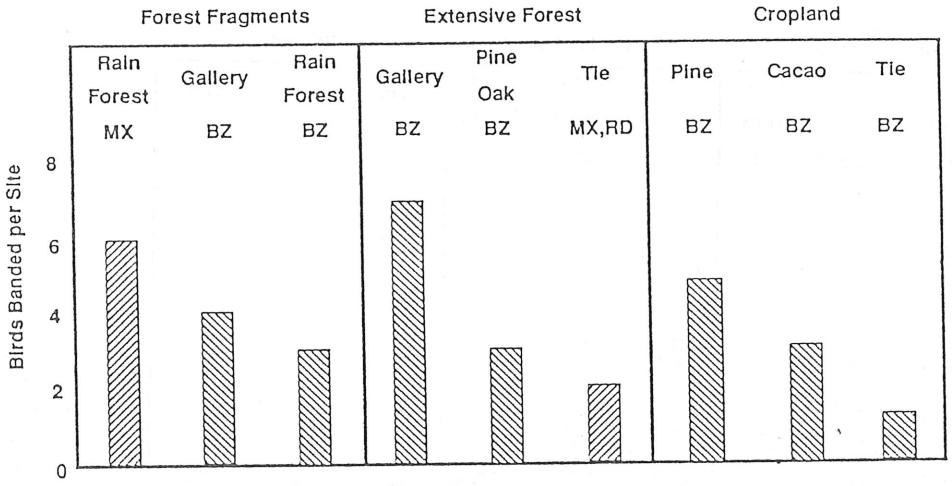
The Hooded Warbler (Fig. 7), on the other hand, was more restricted both geographically and ecologically. It was found regularly in pine plantations, and in cacao, but was scarce or absent in other agricultural habitats.

Species that feed on the forest floor, such as the Ovenbird and especially waterthrushes and thrushes, appear to be less adaptable to habitat change, based on our results. The Ovenbird, a very common and widespread species, was found in small numbers in many agricultural habitats. The Northern Waterthrush (Fig. 8) is a mangrove and floodplain specialist and was rarely found in cropland, not even the extensive rice field.

The Wood Thrush (*Hylocichla mustelina*, Fig. 9) is a



RE 6. Relative abundance of the rica Redstart, *Setophaga ruticilla*, a at generalist, in the winter habi- n which the largest numbers were red.



E 7. Relative abundance of looded Warbler, *Wilsonia citri-* habitat generalist, in the win- abitats in which the largest ers were captured.

re forest specialist that was almost never recorded gricultural habitats. The Gray-cheeked Thrush *arus minimus*) was never encountered in winter any- e except in extensive forest.

e Kentucky Warbler (*Oporornis formosus*, Fig. 10) is er ground forager that requires forest. Some were l in early successional habitats, but only an occa- l bird was captured in pine woods or agricultural ats.

ub-nesting species of the north temperate zone d to be common in one forest habitat, but much r in a variety of other habitats, including agricul- habitats. The Gray Catbird (Fig. 11), for example, d a strong preference for gallery forest in the s, but also used arboreal cropland (pine, citrus, cacao). The White-eyed Vireo (*Vireo griseus*, Fig. 12) required a dense understory, and was fairly common in pine-oak savanna; however, no more than one individual was found in any cropland habitat. The Prairie Warbler (Fig. 13) was encountered most commonly in dry limestone forest in Jamaica, but averaged only two or three individuals in other habitats, including agricultural habitats. The Common Yellowthroat (not figured) was, by far, most common in the rice plantation, with citrus plots the second most common habitat choice.

Nectar feeders, especially migratory orioles and resident hummingbirds, were common or abundant in citrus and cacao plantations, far exceeding their abundance in forested habitats. And finally, the Indigo Bunting was a rice-field specialist in our study. Its num-

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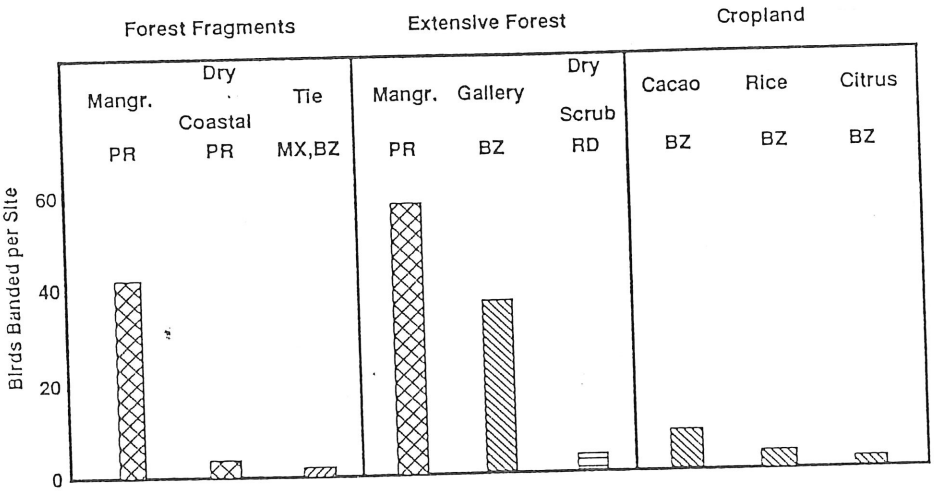

FIGURE 8. Relative abundance of the Northern Waterthrush, *Seiurus noveboracensis*, a ground feeder, in the winter habitats in which the largest numbers were captured.

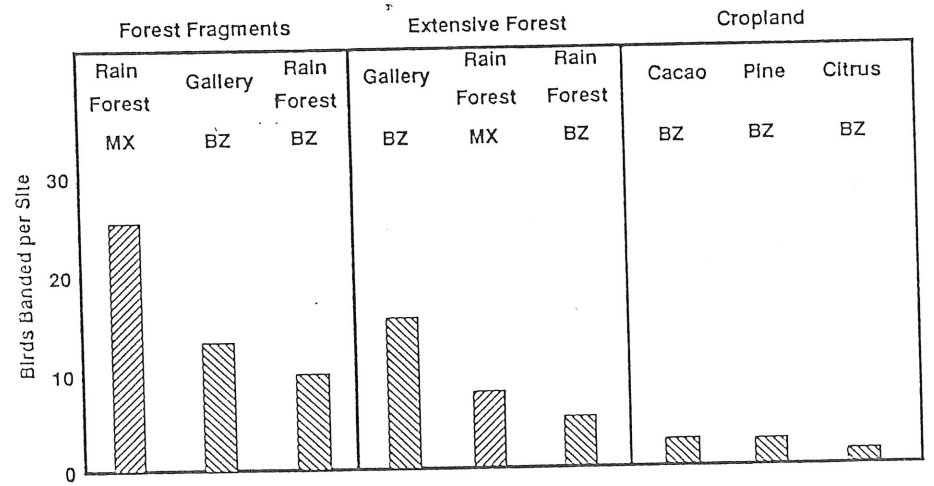

FIGURE 9. Relative abundance of the Wood Thrush, *Hylocichla mustelina*, a ground feeder, in the winter habitats in which the largest numbers were captured.

bers in a fallow rice field (98 banded) far exceeded the abundance of any other migratory species found in any habitat. Crease (1989) reported netting 682 Indigo Buntings in February-March 1989 at the Big Falls Rice Farm in Belize, but commented: "The numbers at BFF are unquestionably down now that rice production has ceased and so much of the farm is overgrown. It seems likely that only 50% of the total of ca. 2000 birds estimated to be using the area in 1986 (Triggs 1987) now find sufficient food to sustain them there throughout the northern winter."

We did not conduct netting in pasture habitats, so direct comparisons with other habitats cannot be made. Point counts in pastures, however, confirmed our general observations that closely cropped pastures contained very few birds. On the other hand, hedgerows adjacent to pastures or along roadsides often were used by migrants. Many migrants were seen in banana plants growing in small patches or scattered throughout other habitats; but when a large commercial banana plantation was examined, no arthropods could be found in the litter, and no birds were seen. Clearly more work needs to be done to evaluate bird use of these habitats.

Our results indicate that some Neotropical migrant species appear to be restricted to forested habitats in the tropics, whereas other species are present in early successional and agricultural habitats as well as in forests. They also show that some agricultural habitats

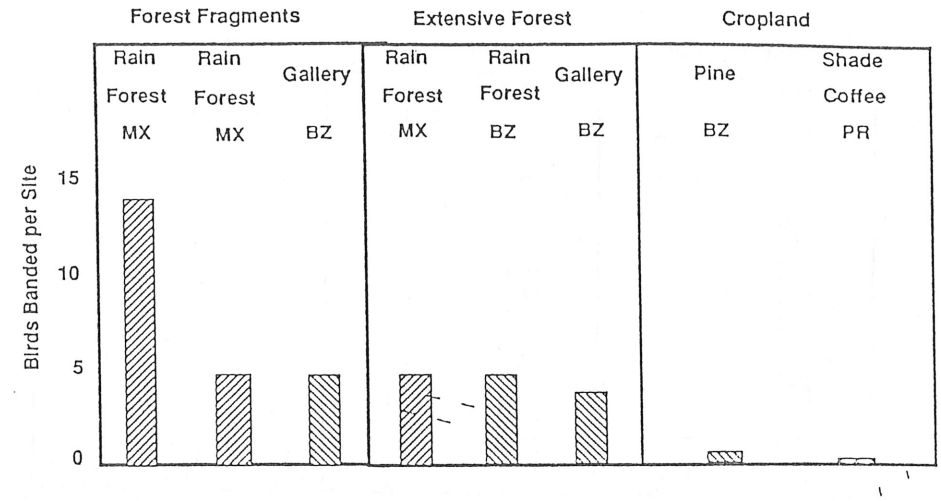

FIGURE 10. Relative abundance of the Kentucky Warbler, *Oporornis formosus*, a ground feeder, in the winter habitats in which the largest numbers were captured.

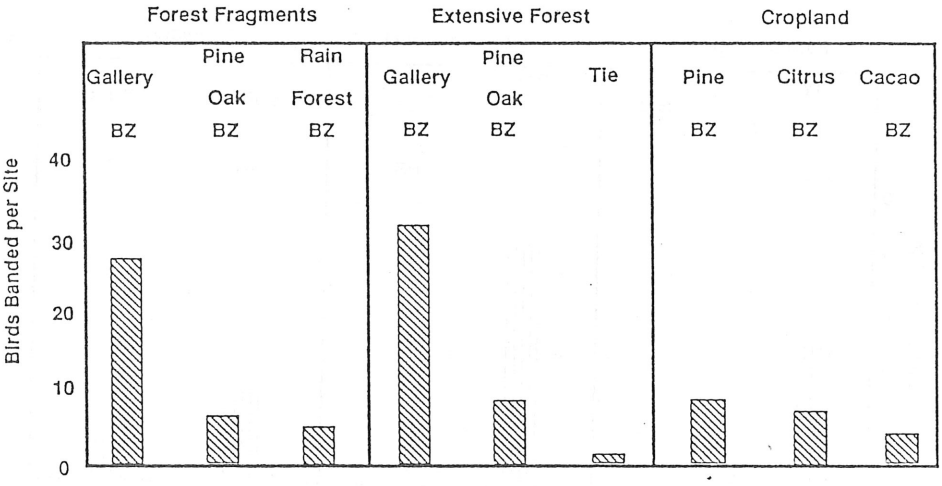

FIGURE 11. Relative abundance of the Gray Catbird, *Dumetella carolinensis*, a brush nester, in the winter habitats in which the largest numbers were captured.

contain a wide variety of migrant species, but that others support very few birds.

Discussion

This study was originally designed to assess the occurrence of Neotropical migrants in extensive and fragmented native tropical forests. When we found that many species of migrants were also using some of the agricultural habitats during the mid-winter season, we began sampling bird populations in major agricultural habitats also, while continuing to sample in nearby woodlands.

It became apparent early in the study that many Neotropical migrant species were using isolated forest fragments during the northern winter, and that their density in these fragments was comparable with that in extensive forest. Furthermore, in isolated forest fragments, as well as in extensive forest, we found a high return rate (up to 50%) for banded migrants in successive years, indicating that birds were surviving and returning to established territories (Robbins et al. 1987). On the other hand, some species of migrants (especially thrushes and Louisiana Waterthrushes, *Seiurus motacilla*) and many resident species (especially suboscines) were not found in isolated forest patches.

When bird populations in agricultural habitats are compared with those in woodland from which the crop-

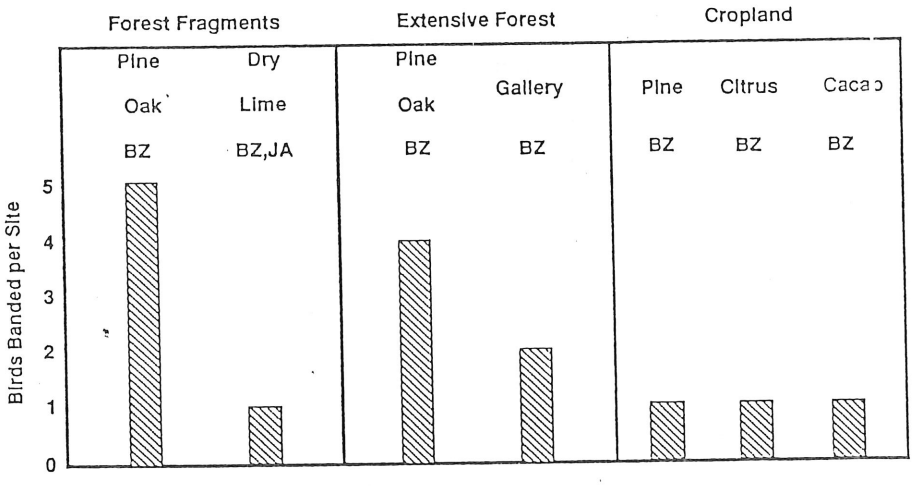

FIGURE 12. Relative abundance of the White-eyed Vireo, *Vireo griseus*, a brush nester, in the winter habitats in which the largest numbers were captured.

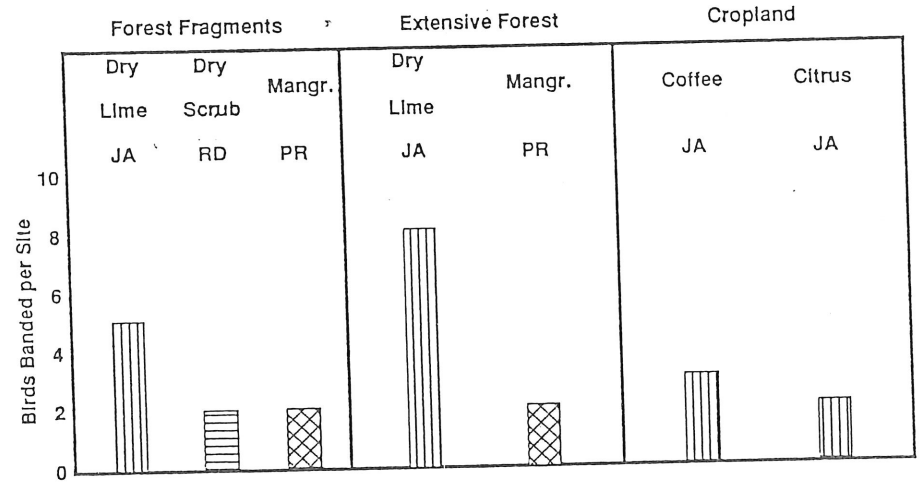

FIGURE 13. Relative abundance of the Prairie Warbler, *Dendroica discolor*, a brush nester, in the winter habitats in which the largest numbers were captured.

land was carved, the differences are more striking, as would be expected. The number of species captured in rice and fallow corn fields was very small, even though the total number of individuals was fairly high (Table 3). With shrub and tree crops, the bird species composition and density varied greatly depending on the crop. In general, a high avian diversity was associated with a high plant diversity; the outstanding exception was mature citrus groves, which supported a high avian diversity and density.

It is important to consider that 2-m-high mist nets come much closer to sampling the whole bird population in agricultural habitats than in mature forest with a high canopy. Direct comparisons can be made between extensive forest and isolated forest fragments because each pair of sites was selected for comparability, but point counts confirmed that few canopy-feeding forest species were captured in the nets. Therefore, although use of agricultural habitats might be compared among structurally similar crop habitats, netting efficiency is much higher in low-stature habitats than in high-canopy forest.

Cacao (under a canopy of *Erythrina*) and shade coffee plantations came closest to matching bird populations of native broadleaf forest, but ground-feeding birds such as thrushes and the Kentucky Warbler were scarce or absent in these agricultural habitats. Pine plantations were used by many species, a high percentage of which

ere migrants, but avian densities there were always w.

Mature citrus groves were especially attractive to eotropical migrants (Tables 1–3), and avian densities re high, except in Costa Rica which is too far south to ve a high density of migrants. The number of resi- nt species found in citrus groves was low, suggesting at citrus might not provide desirable nesting habitat r many tropical species.

So far, only one agricultural study site (a cacao plan- tion) has been sampled in two winters, so we do not t know how regularly migrants are using these agri- ltural habitats throughout the winter, or returning in bsequent years. Neither do we know whether these bitats fulfill all the needs of these birds during the nter season, or whether some of the birds spend part their time in neighboring habitats. Furthermore, we ve not been able to evaluate effects of fungicides, her- ides, and other chemicals that are used in croplands.

Thus, this rather optimistic report on the occurrence many migrant species in a variety of agricultural bitats in the tropics must be tempered until we have re information on the extent to which various crop- d habitats fulfill the requirements of birds using m. These habitats cannot serve as a haven for either grants or resident species if toxic pesticides threaten birds' condition directly, or indirectly through their d supply.

If we are to prevent the further loss of birds, we must only conserve forest habitats, but we must also find ys to assure that agricultural habitats provide safe d productive alternatives for migratory birds. Other ommendations would be to encourage the retention corridors of native vegetation, especially along ams, and to promote intercropping rather than ex- sive monocultures.

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APPENDIX 1. Numbers of migrant and resident species netted in study sites, by habitat

Country and habitat	Year	Number of migrant species	Number of resident species
Puerto Rico, USA			
Mangrove swamp (2 sites)	1984	9	12
Mt. serpentine forest (2)	1984	7	16
Dry coastal limestone (2)	1985	11	20
Haystack hills (2)	1987	2	10
Sun coffee (3)	1988	8	24
Shade coffee (3)	1988	9	17
Dominican Republic			
Mature coastal limestone (2)	1984	6	18
Thorn scrub (2)	1984	11	22
Jamaica			
Montane forest (2)	1986	7	21
Mid-level limestone (2)	1984	6	30
Low-level limestone (2)	1985	7	28
Arid limestone (2)	1984	9	19
Hurricane-damaged coffee (3)	1989	16	20
Citrus (3)	1989	15	32
Mexico			
Veracruz rain forest (3)	1987	17	47
Oaxaca rain forest[a] (2)	1987	16	35
Belize			
Gallery forest (2)	1987	17	47
Pine-oak savanna (2)	1987	16	35
Mature rain forest (1)	1989	3	25
Second-growth broadleaf (3)	1989	15	46
Caribbean pine (4)	1989	15	21
Citrus (3)	1988 & 1989	24	36
Fallow rice[a] (1)	1989	7	8
Fallow corn[a] (1)	1989	6	16
Mango (3)	1989	7	8
Cacao (4)	1987 & 1988	28	42
Costa Rica			
Mature rain forest (4)	1984	7	64
Citrus (3)	1989	16	23
Venezuela			
Mid-level semideciduous (2)	1985	2	27
Low-level semideciduous (2)	1985	3	31

a. Substandard netting effort in this habitat