AN EVALUATION OF THE VULNERABILITY OF CANADIAN MIGRATORY BIRDS TO CHANGES IN NEOTROPICAL FOREST HABITATS

A report to the Latin American Programme
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EXECUTIVE SUMMARY

1) Tropical forest is being destroyed so rapidly that there is widespread scientific concern about the global consequences. These include:

the loss of a high proportion (perhaps half) of the world's genetic diversity (sources of crops, medicines, timber and industrial raw materials);

the extinction of a similar proportion of the planet's species of flora and fauna;

global climatic change;

political, social and economic instability resulting from environmental damage in tropical countries.

2) Canada as a whole is as susceptible to these consequences - and as responsible for their causes - as any other developed nation. Of direct and particular concern to Conservation and Protection, and especially the Canadian Wildlife Service, is the imminent loss of winter habitat to 90 species of bird that breed in Canada and migrate to Latin American forests for the winter. About half of these species either winter widely in the U.S. as well as in the tropics, or are mainly American species extending into Canada only in extreme southern Ontario; the remaining 44 species breed widely in Canada and winter almost entirely in tropical forest.

3) Some of the species concerned are known to be of potential economic importance as controllers of forest-insect pests. All of them are highly valued by the Canadian public as a whole; most are songbirds, whose loss would constitute a second "Silent Spring" rivalling the spectacular declines in bird-life of the 1960s that were brought about by excessive use of pesticides.

4) Estimates of the rates of deforestation are compiled globally by the Food and Agriculture Organisation of the United Nations. FAO's deforestation estimates are not entirely appropriate for measuring habitat, but have been corrected as far as possible. The distribution and habitat use of North American migrant birds in the Neotropics (the tropical zone of the western hemisphere) have been compiled by the World Wildlife Fund - U.S. These two data sets are matched to provide estimates of the area of winter forest habitat available to Canadian migratory birds at two times: 1985, and the year 2000. The rate and direction of change between 1985 and 2000 is used as an index of the vulnerability of each species to loss of winter habitat by tropical deforestation. Because the FAO figures under-estimate deforestation - and especially the loss of secondary forest - this measure is a <u>conservative</u> index of vulnerability; species are certainly more vulnerable than this index suggests. By this measure:

5) **more than half of the species of bird which breed in Canadian forests and migrate to the tropics in winter are likely to lose more than 25% of their winter habitat by the year 2000**

and **twelve species are expected to lose half or more of their winter habitat.**

6) There is no routine monitoring of changes in forest habitats in the area most critical to Canadian migratory birds (Central America) partly because it lies between LANDSAT receiving stations. There is an urgent need to set up a scheme using satellite technology to monitor the loss of forest in Central and northern South America.

7) Existing schemes to monitor long-term population trends in migratory forest birds do not show consistent declines in species that migrate to the tropics. However all are flawed in their ability to detect such changes, and there is a need to review these schemes in relation to this problem.

8) Existing information on the population density and structure of migratory bird species in neotropical habitats is inadequate, and needs to be improved urgently if the effects of habitat loss on population sizes are to be evaluated.

9) Research called for in (7) and (8) will require co-operation between professional and volunteer ornithologists; between Canadian and U.S. wildlife biologists; and between Canadian and Latin American researchers and institutions. There is outstanding potential for co-operative projects focusing the activities of the many players involved on a single issue whose resolution will benefit all concerned.

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December 1986

Chapter 1 - INTRODUCTION

Half or more of the species of bird that breed in North America are long-distance migrants that spend two-thirds of the year in tropical South and Central America (Lovejoy 1983, Rappole et al. 1983), many of them in forest habitats. The rapid pace of destruction of tropical forests is becoming recognised as one of the major environmental issues of our time (Whitmore 1975, Myers 1979, 1980, 1984, IUCN 1980, Allen 1980, Ehrlich and Ehrlich 1981, Anon. 1985, Diamond and Lovejoy 1985, Lewin 1986, Murphy 1986). Most of the debate focuses on the global consequences - reduced bio-diversity, loss of genetic resources, and climatic change - of the loss of this biome as a whole. But there are also likely to be significant direct effects on populations of Canadian migratory birds in the very near future, arising out of the imminent serious reduction in the already very small amount of winter habitat available to them in Latin America (Myers (1980) estimated that 37% of Latin America's rain forest has already been lost). Discussing the impact of the loss of tropical forest on North American birds, Terborgh (1980) concluded that "we are . . . about to play observers in a massive experiment in which there will be dramatic alterations in the relative population sizes of numerous common species."

Ornithologists were first alerted to the implications of changes in winter habitat for migrants to the tropics by a catastrophic decline in the British breeding population of the Common Whitethroat Sylvia communis. This decline was attributed to massive habitat changes in the Sahel region of Africa caused by prolonged severe drought (Winstanley et al. 1974). Trends in the British breeding populations of Whitethroats and several other species between 1963 and

and Rappole et al. (1983) gave projections of "forest" area for Latin America that suggest very little will be left by the year 2 000 in most countries. The latter figures were taken from Myers (1980), who referred only to "tropical moist forest"; this is the category of forest which is declining fastest, as the FAO figures clearly show (see Chapter 6), but it is not necessarily the type of forest which is most important to nearctic migrants (see Chapter 4). In this report I attempt to increase significantly the precision of estimates of the possible impact of tropical deforestation on nearctic migrants, by assessing those changes species by species, habitat by habitat and country by country. This is achieved by correlating, as closely as possible, the most precise and up-to-date figures available from the two disciplines involved, i.e. ornithology and forestry.

Flycatcher, Philadelphia Vireo, Connecticut, Tennessee, Cape May, Blackpoll, Bay-breasted and Palm Warblers, Gray-cheeked Thrush);

(iii) survey schemes which monitor the populations of breeding birds successfully in the U.S., using largely volunteer observers, may need to be modified in relation to the much lower human population densities and greater geographical remoteness of most of Canada.

This study seeks to promote such a Canadian approach, by assessing the likely importance to birds breeding in Canada of the continued decline in tropical forest. I first define the species pool by examining range maps and selecting those species in which half or more of the winter range lies south of the southern border of the U.S., and which according to Rappole et al. occupy at least one woody habitat in winter. The countries and habitats occupied in winter are extracted from the appropriate tables in Rappole et al. I then match those habitats as closely as possible with the habitats classified in the United Nations report on tropical forest resources (FAO 1981, Lanly 1982). From these tables, the area of each type of woody habitat in each country is estimated; these figures are then used to assess, for each bird species, the proportion of its total winter habitat available to it in each country of its winter range. This quantitative description of the present concentration of suitable habitat in each neotropical country is presented as tables, and as single-species maps, which are an advance on simple range maps because they show which countries are most "important" (in terms of area of suitable habitat available) to each species.

Table 1. CANADIAN MIGRANTS TO LATIN AMERICAN FOREST.

(a) species breeding widely in Canada, and wintering almost entirely within the tropics.

Broad-winged Hawk	*Buteo platypterus*
Black-billed Cuckoo	*Coccyzus erythrophthalmus*
Chimney Swift	*Chaetura pelagica*
Vaux's Swift	*Chaetura vauxi*
Eastern Kingbird	*Tyrannus tyrannus*
Great-Crested Flycatcher	*Myiarchus crinitus*
Olive-sided Flycatcher	*Nuttallornis borealis*
Eastern Wood Pewee	*Contopus virens*
Western Wood Pewee	*Contopus sordidulus*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Traill's Flycatcher	*Empidonax traillii*
Least Flycatcher	*Empidonax minimus*
Hammond's Flycatcher	*Empidonax hammondii*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Western Tanager	*Piranga ludoviciana*
Scarlet Tanager	*Piranga olivacea*
Red-eyed Vireo	*Vireo olivaceus*
Philadelphia Vireo	*Vireo philadelphicus*
Warbling Vireo	*Vireo gilvus*
Golden-winged Warbler	*Vermivora chrysoptera*
Nashville Warbler	*Vermivora ruficapilla*
Orange-crowned Warbler	*Vermivora celata*
Tennessee Warbler	*Vermivora peregrina*
Northern Parula	*Parula americana*
Cape May Warbler	*Dendroica tigrina*
Yellow Warbler	*Dendroica petechia*
Black-throated Blue Warbler	*Dendroica caerulescens*
Magnolia Warbler	*Dendroica magnolia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Bay-breasted Warbler	*Dendroica castanea*
Blackpoll Warbler	*Dendroica striata*
Blackburnian Warbler	*Dendroica fusca*
Black-throated Green Warbler	*Dendroica virens*
Northern Waterthrush	*Seiurus novaboracensis*
Connecticut Warbler	*Oponornis agilis*
Mourning Warbler	*Oponornis philadelphia*
Wilson's Warbler	*Wilsonia pusilla*
Canada Warbler	*Wilsonia canadensis*
American Redstart	*Setophaga ruticilla*
Wood Thrush	*Hylocichla mustelina*
Veery	*Catharus fuscescens*
Gray-cheeked Thrush	*Catharus minimus*
Swainson's Thrush	*Catharus ustulatus*

made of each species' vulnerability to the likely future trends in winter habitat.

It is important to stress again that this report attempts to quantify changes in bird habitats, not their populations. If each species occurred at the same density in all of its winter habitats, and throughout its range, and if population size is limited by area of winter habitat, then these changes in area of habitat could be used as measures of changes in population size. But as Morse (1980) has pointed out, we do not know whether the populations of neotropical migrants are limited primarily on the breeding grounds or in the winter quarters, and it is likely that there is a dynamic equilibrium between the limiting factors operating in the two major centres of a population's range. Nor is enough known of the relative densities of any species in different habitats throughout its winter range, for any correction to be made at this stage for the differences in density which are a consequence of the habitat preferences which undoubtedly exist in any species. Further reasons for caution in extrapolating the projections, presented here for habitats, to projections of population size, are discussed in Chapter 7.

It is also important to emphasise that the measures of deforestation rates used in this report, deficient as they are in several respects, are the most precise and comprehensive that are available. In the ornithological literature on this topic to date, the concepts and measures of "deforestation" have been imprecise and extreme. For example, it has been stated that "forest in Central America will be reduced to 10% by the year 2 000" (Bertrand 1986);

and Rappole et al. (1983) gave projections of "forest" area for Latin America that suggest very little will be left by the year 2 000 in most countries. The latter figures were taken from Myers (1980), who referred only to "tropical moist forest"; this is the category of forest which is declining fastest, as the FAO figures clearly show (see Chapter 6), but it is not necessarily the type of forest which is most important to nearctic migrants (see Chapter 4). In this report I attempt to increase significantly the precision of estimates of the possible impact of tropical deforestation on nearctic migrants, by assessing those changes species by species, habitat by habitat and country by country. This is achieved by correlating, as closely as possible, the most precise and up-to-date figures available from the two disciplines involved, i.e. ornithology and forestry.

Chapter 2 - SPECIES AT RISK

Seventy-eight species of bird that breed in Canada and winter in tropical forest (in the broadest sense) are listed in Table 1. The 44 species which winter entirely (or almost entirely) within the tropics are identified separately (Table 1(a)) from the 22 species whose winter range includes parts of the southern U.S. (Table 1(b)).

Twelve other species breed in Canada and winter at least partly in Latin America, but reach the northern limit of their breeding range in extreme southern Ontario (Table 1(c)). Since the Canadian population represents only a very small part of these species' populations as a whole, and because their very limited distribution in Canada means that they are sampled inadequately by population surveys operating in Canada, these species are also omitted from further analysis in this report. (Golden-winged Warblers have a similar distribution in Canada to that of Blue-winged Warblers, but Golden-winged Warblers have a smaller overall range so that a higher proportion occurs within Canada; Golden-winged Warbler has therefore been retained for study but Blue-winged Warbler excluded).

A further 18 species winter partly in Latin America but mainly in the southern U.S.; these species are likely to be affected more by habitat changes in North America than by factors operating in the tropics so they have been omitted from further study.

Table 1. CANADIAN MIGRANTS TO LATIN AMERICAN FOREST.

(a) species breeding widely in Canada, and wintering almost entirely within the tropics.

Broad-winged Hawk	*Buteo platypterus*
Black-billed Cuckoo	*Coccyzus erythrophthalmus*
Chimney Swift	*Chaetura pelagica*
Vaux's Swift	*Chaetura vauxi*
Eastern Kingbird	*Tyrannus tyrannus*
Great-Crested Flycatcher	*Myiarchus crinitus*
Olive-sided Flycatcher	*Nuttallornis borealis*
Eastern Wood Pewee	*Contopus virens*
Western Wood Pewee	*Contopus sordidulus*
Yellow-bellied Flycatcher	*Empidonax flaviventris*
Traill's Flycatcher	*Empidonax traillii*
Least Flycatcher	*Empidonax minimus*
Hammond's Flycatcher	*Empidonax hammondii*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Western Tanager	*Piranga ludoviciana*
Scarlet Tanager	*Piranga olivacea*
Red-eyed Vireo	*Vireo olivaceus*
Philadelphia Vireo	*Vireo philadelphicus*
Warbling Vireo	*Vireo gilvus*
Golden-winged Warbler	*Vermivora chrysoptera*
Nashville Warbler	*Vermivora ruficapilla*
Orange-crowned Warbler	*Vermivora celata*
Tennessee Warbler	*Vermivora peregrina*
Northern Parula	*Parula americana*
Cape May Warbler	*Dendroica tigrina*
Yellow Warbler	*Dendroica petechia*
Black-throated Blue Warbler	*Dendroica caerulescens*
Magnolia Warbler	*Dendroica magnolia*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Bay-breasted Warbler	*Dendroica castanea*
Blackpoll Warbler	*Dendroica striata*
Blackburnian Warbler	*Dendroica fusca*
Black-throated Green Warbler	*Dendroica virens*
Northern Waterthrush	*Seiurus novaboracensis*
Connecticut Warbler	*Oponornis agilis*
Mourning Warbler	*Oponornis philadelphia*
Wilson's Warbler	*Wilsonia pusilla*
Canada Warbler	*Wilsonia canadensis*
American Redstart	*Setophaga ruticilla*
Wood Thrush	*Hylocichla mustelina*
Veery	*Catharus fuscescens*
Gray-cheeked Thrush	*Catharus minimus*
Swainson's Thrush	*Catharus ustulatus*

Table 1 (contd.)

(b) species with a substantial part (but less than half) of their wintering range in the southern United States.

Turkey Vulture	Cathartes aura
Yellow-bellied Sapsucker	Sphyrapicus varius
Whip-poor-will	Caprimulgus vociferus
Ruby-throated Hummingbird	Archilochus colubris
Black-chinned Hummingbird	Archilochus alexandri
Rufous Hummingbird	Selasphorus rufus
Calliope Hummingbird	Stellula calliope
Western Flycatcher	Empidonax difficilis
Dusky Flycatcher	Empidonax oberholseri
Northern Oriole	Icterus galbula
Lincoln's Sparrow	Melospiza lincolnii
Violet-green Swallow	Tachycineta thalassina
Rough-winged Swallow	Stelgidopteryx ruficollis
Solitary Vireo	Vireo solitarius
Black-and-White Warbler	Mniotilta varia
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Townsend's Warbler	Dendroica townsendi
Palm Warbler	Dendroica palmarum
Ovenbird	Seiurus aurocapillus
Common Yellowthroat	Geothlypis trichas
Gray Catbird	Dumetella carolinensis

(c) species whose Canadian distribution is confined to extreme southern Ontario (and so not covered in this report).

Canada

Yellow-billed Cuckoo	Coccyzus americanus
Acadian Flycatcher	Empidonax virescens
Yellow-throated Vireo	Vireo flavifrons
White-eyed Vireo	Vireo griseus
Prothonotary Warbler	Protonotaria citrea
Blue-winged Warbler	Vermivora pinus
Cerulean Warbler	Dendroica cerulea
Prairie Warbler	Dendroica discolor
Louisiana Waterthrush	Seiurus motacilla
Yellow-breasted Chat	Icteria virens
Hooded Warbler	Wilsonia citrina
Blue-gray Gnatcatcher	Polioptila caerulea

Table 2 summarises the basic information relevant to this study for the 66 species selected. Breeding habitats in Canada are taken from Erskine (1977) and Godfrey (1966). Wintering habitats are from Rappole et al. (1983), except for primary forest, which that study does not distinguish; species using primary forest are taken from Table 2 of Terborgh (1980), subtracting those species which Rappole et. al. (1983) show as also occurring in scrub, which are presumably the species referred to in the caption to Terborgh's Table 2 as "having broad habitat tolerances."

"Winter distribution type" in Table 2 is a summary of the distribution pattern detailed by Rappole et al. (1983), and shows whether each species winters primarily in Central America (including Mexico), continental South America, the Caribbean Islands, or a combination of these major categories. These distribution patterns refer to the species as a whole; there are no data referring specifically to populations breeding in Canada. Such information could come only from banding recoveries, so banding effort and the number of banding recoveries (from Diamond and Brewer (in prep.)) are shown as an indication of the contribution of banding studies to determining more precisely the wintering localities of Canadian populations. The very low recovery rates of these species are typical of small songbirds, and clearly offer little potential in this respect.

Table 2. HABITAT, WINTER DISTRIBUTION AND BANDING INFORMATION.

SPECIES	Breeding Habitat	Winter Habitat	Winter Range	Banding Effort	No. Recovered in Tropics
Turkey Vulture	O	B,G	C	vs	
Broad-winged Hawk	M,O	PB,G	S	s	1
Black-billed Cuckoo	O	S	S	s	1
Yellow-bellied Sapsucker	M,O,B	PC,PB,G	C	m	
Whip-poor-Will	M,O	PC,PB	C	s	
Chimney Swift	O	B,G	S	m	
Vaux's Swift	O	B	C	O	
Ruby-throated Hummingbird	M,O	B	C	s	
Black-chinned Hummingbird	O	S,O	C	O	
Rufous Hummingbird	O	C,S	C	vs	
Calliope Hummingbird	O	C	C	O	
Eastern Kingbird	O	B,O,G	S	m	
Great-Crested Flycatcher	M	PB,G	Cs	s	
Olive-sided Flycatcher	S	B,G	Sc	s	
Eastern Wood Pewee	M,O	C,B,S,G	S	m	
Western Wood Pewee	M,O	PC,PB	S	s	
Yellow-bellied Flycatcher	M	PB,G	C	m	
Western Flycatcher	M	PC,PB,G	C	vs	
Traill's Flycatcher	S,B	S,G	C	m	1
* Alder Flycatcher				s	
* Willow Flycatcher				vs	
Least Flycatcher	O	S,O,G	C	vc	1
Hammond's Flycatcher	M	C,G	C	vs	
Dusky Flycatcher	O,S	S,G	C	vs	
Northern Oriole	O	B,O,G	Cs	c	1
Lincoln's Sparrow	O	C,O	C	c	
Rose-breasted Grosbeak	M,O,S	C,B,G	CS	c	2
Black-headed Grosbeak	O,S	C,B,G	C	vs	
Western Tanager	O	PC,G	C	s	
Scarlet Tanager	M	PB,G	S	m	
Violet-green Swallow	O	C	C	vs	
Rough-winged Swallow	O	B,G,O	C	s	
Red-eyed Vireo	M,O,S	PB,G	S	vc	
Philadelphia Vireo	O,S	PB,G	C	m	
Warbling Vireo	M,O	C	C	m	
Solitary Vireo	O	PC	C	m	
Black-and-White Warbler	O	S,C,B,G	CSI	m	1
Golden-winged Warbler	O,S	PB,G	SC	s	
Nashville Warbler	S,B	S,C	C	c	
Orange-crowned Warbler	O,S,D	S,C,B,G	C	m	
Tennessee Warbler	M,O,S	PB,G	CS	vc	
Northern Parula	O	S,B,G	CI	s	
Cape May Warbler	O	S,B	CI	c	
Yellow Warbler	O,S	O,G	SC	vc	
Black-throated Blue Warbler	M,R	S,B	CI	m	1
Yellow-rumped Warbler	M,S,C	S,C,B	CI	vc	
Magnolia Warbler	M,S,C	PC,PB,G	CI	vc	1
Chestnut-sided Warbler	S,B	PB,G	C	m	
Bay-breasted Warbler	M,S,C	PB,G	SC	c	1

Table 2 (contd.)

SPECIES	BH	WH	WR	BE	NRT
Blackpoll Warbler	O,R,S	PB	S	vc	
Blackburnian Warbler	M,C	PB,G	S	m	
Black-throated Gray Warbler	M,O	C	C	vs	
Black-throated Green Warbler	M,C	S,C,B,G	CI	m	1
Townsend's Warbler	M,C	PC,PB	C	vs	
Palm Warbler	O	B,O	CI	m	
Ovenbird	M,B	S,B,G	CSI	c	
Northern Waterthrush	O	G,M	SCI	c	1
Connecticut Warbler	O,S	G	S	s	
Mourning Warbler	O,S	G	S	m	
Common Yellowthroat	O,S	G,M	CI	c	
Wilson's Warbler	O,S	S,B,G	C	c	
Canada Warbler	O,B	PB	S	c	
American Redstart	O,S,B	S,B,G	SCI	vc	
Gray Catbird	O,S,B	S,G	CI	c	2
Wood Thrush	M,B	PB,G	C	m	
Veery	M,O,B	PB	S	m	
Gray-cheeked Thrush	C	PB	S	m	
Swainson's Thrush	M,O	PB	SC	vc	

Key:

Breeding habitat: M = mature forest, B = broadleaf, C = coniferous, O = open and forest edge, R = cutovers and burns, S = second-growth. From Erskine (1977 and in litt.) and Godfrey (1966).

Winter habitat: P = primary, B = broadleaf, C = conifer, S = scrub, O = open (savannah), G = gallery, M = mangrove. From Rappole et al. (1983) and Terborgh (1980).

Winter range: C = Central America (including Mexico), S = continental South America, I = Caribbean Islands. Order of mention reflects relative importance; lower case symbols denote minor areas. From Rappole et al. (1983).

Banding effort: O = nil, vs = very small (,100), s = small (100-1000), m = moderate (1 001 - 5 000), c = considerable (5001-10000), vc = very considerable (. 10 000). From Diamond and Brewer (in prep.).

Number recovered in tropics includes birds banded in tropics and recovered in Canada.

* "Alder" and "Willow" Flycatchers shown separately to include banding records compiled before these taxa were merged in "Traill's" Flycatcher.

Chapter 3 - HABITATS AT RISK

BREEDING HABITATS

Although this report is concerned with changes in winter habitat, it cannot entirely ignore the influence of breeding habitats in Canada. In order to establish that a particular population trend is caused by changes to the winter habitat, it would be necessary to eliminate the possibility that it was caused by changes in breeding habitat. A brief description of forest types in Canada is followed by a discussion of the relationship between these habitats and the distribution of neotropical migrants.

Canadian forests were classified by Rowe (1959, 1972), modifying an earlier system of Halliday's, in what has become known as the Rowe-Halliday system (Bickerstaff et al. 1981). This system recognises the following major forest regions:

Boreal: characterised by White and Black Spruces, Jack Pine, and Tamarack, with much mixture of White Birch, Trembling Aspen and Balsam Poplar.

Subalpine: in the montane uplands of western Alberta and British Columbia; characterised by Engelmann Spruce, Subalpine Fir and Lodgepole Pine.

Montane: occurs in the dry parts of the central plateau of British Columbia, and characterised by the interior "blue" form of Douglas Fir; Lodgepole Pine and Trembling Aspen are also usually present.

Coast (i.e. West coast): Western Red Cedar, Douglas Fir and Western Hemlock are characteristic.

Columbia: Typically contains Western Red Cedar and Western Hemlock, often with the "interior" form of Douglas Fir; occurs in the Kootenay, Upper Fraser and Thompson River valleys, and the Quesnel Lake area, and is similar to the coast forest but rather less rich.

Great Lakes-St.Lawrence: Very mixed - typified by Eastern White Pine, Red Pine, Eastern Hemlock, Sugar and Red Maples, Beech and Yellow Birch, but also with Red Oak, Basswood and White Elm.

Deciduous: restricted to S.W.Ontario, where few remnants have been left; contains the same broad-leaved species as the Great Lakes-St.Lawrence forest, but characterised by others which reach no further north such as Black Walnut, Sycamore and Swamp White Oak.

Acadian: confined to the Maritime Provinces, characterised by Red Spruce, with Balsam Fir, Yellow Birch and Sugar Maple. Beech was formerly more important, and forest invading abandoned farmland is dominated by White Spruce rather than Red.

The Rowe-Halliday forest regions have been used as a basis for bird survey work (e.g. Erskine 1977, 1978), but several have been combined in the regions used by Erskine (1978) and Collins and Wendt (in prep.) in their analyses of the Breeding Bird Survey (Table 3, Figure 1; see also Chapter 5). The limits of these bird-survey regions are normally quite concordant with forest-region boundaries, but there are some important exceptions:

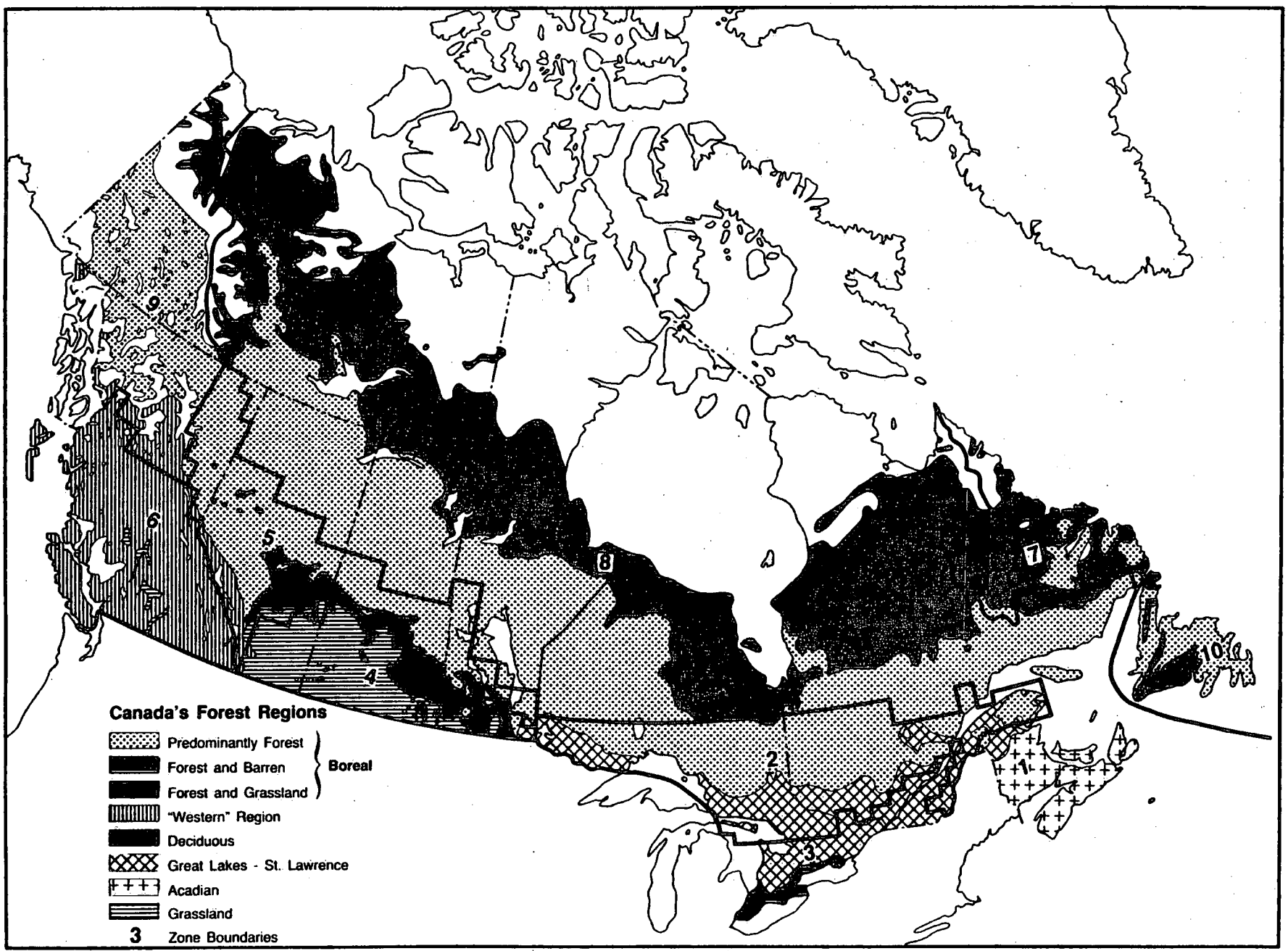


FIGURE 1. Rowe-Halliday Forest Regions of Canada, in relation to Breeding Bird Survey "regions." From Bickerstaff et al. (1981) and Erskine (1978).

Table 3. THE ROWE-HALLIDAY CLASSIFICATION OF FOREST REGIONS OF CANADA AND ITS MODIFICATIONS IN BIRD SURVEY PROGRAMMES.

1 Rowe-Halliday forest region	2 Erskine's region	3 BBS region
Boreal	boreal and subarctic	7,8,9,10; northern parts of 2 and 5
Subalpine	part of BC forest	part of 6
Montane	part of BC	part of 6
(west) Coast	part of BC	part of 6
Columbia	part of BC	part of 6
Great Lakes-St. Lawrence	farmland and northern hardwoods forest	south and west parts of 2; north and east parts of 3; extreme S.E. of 4
Deciduous	southern part of northern hardwoods	southern part of 3
Acadian	Acadian	1

1 As shown in Bickerstaff et.al. (1981, Map 1)

2 As shown in Erskine (1978) and used in that analysis of the results of the Breeding Bird Survey in Canada, and in catalogues of plots in the Bird Census Plot scheme up to 1976 (Erskine 1971, 1972, 1976) but subsequently replaced by two different, partially-overlapping habitat schemes (Erskine 1980, 1984).

3 As currently used by the Breeding Bird Survey scheme in Canada (Collins and Wendt, in prep.).

Several forest types - determined chiefly by altitude - in B.C. are combined (four forest regions combined into one bird region), clearly for practical reasons;

bird region 2 includes both Boreal and Great Lakes-St.Lawrence forests;

bird region 3 includes Great Lakes-St.Lawrence and Deciduous forest;

bird region 5 includes Forest and Grassland (i.e. "parkland") as well as Boreal Forest;

bird region 4 includes Grassland, Boreal forest and grassland, and also Great Lakes-St.Lawrence Forest in its extreme south-eastern corner;

prairie parkland is included with grassland by Erskine (1978), but in bird region 4 is treated as grassland in Saskatchewan and forest in Alberta.

Thus a single Rowe-Halliday forest region may occur in as many as three different bird regions (e.g. Great Lakes-St.Lawrence Forest in bird regions 2, 3 and 4).

Erskine (1978, p.8) has discussed the reasons for these changes; most were made to reflect the distribution patterns of selected species of bird (Regions 4 and 5, 2 and 3) or else differences in land use, such as the almost total clearance of natural forest in southern Ontario south of the boundary between bird regions 2 and 3.

The information relating bird distribution and density to habitat characteristics of Canadian forests is, at present, largely descriptive in nature. Yet substantial changes in forest take place

each year, to logging, fire, clearance for agriculture, and pest infestations, as well as successional development. Many of these changes are described in some detail by Reed and Associates (1978) and Weetman (1983).

There have been relatively few attempts to quantify these relationships; there are notable exceptions on local or regional scales (Martin 1960, Freedman et al. 1981, Lofroth and Wetmore 1985, Welsh in press) but no national-scale attempt to relate bird distribution and density to habitat characteristics. The Breeding Bird Census Plot data could be used in this way, and the Atlas schemes under way in several provinces promise the opportunity to incorporate a variety of data describing habitats and land-use in a systematic fashion. At present, however, the most that can be attempted in a project of this size is to compare maps of bird distribution and density with maps showing selected forest features that might be expected to influence some bird species. Maps of Canadian forests kindly prepared by the FORSTATS programme of the Canadian Forestry Service (see also Bonnor (1982)) are shown as Figures 2a,b etc; they can be compared with maps derived from Breeding Bird Survey data of selected species in Figures 3a, b etc.

(The FORSTAT maps were not available at the time this report was revised. Figures 2 and 3 and accompanying text will be produced as an Appendix to this report when the FORSTAT maps become available).

FIGURE 2. FORSTAT maps of the distribution of forest types in Canada;

FIGURE 3. Compared with distribution of selected bird species as indicated by the Breeding Bird Survey.

(To follow: see Appendix)

WINTER HABITATS

This study refers to birds wintering in "forest" in the tropics. Many species which use forest also use a variety of other types of woody vegetation, so to provide a realistic picture of their habitat needs in winter the definition of "forest" must be a broad one. It must also allow the ornithologists' divisions of habitat types given by Rappole et. al. (1983) to be reconciled with the foresters' divisions used by FAO (FAO 1981, Lanly 1982). Fortunately, the FAO habitat categories were set up with more general needs in mind, and are described sufficiently fully in relation to the more ecologically-oriented classification of vegetation compiled by UNESCO (1973) that the ornithological and foresters' habitat categories can usually be reconciled.

The habitat divisions used are described below. Only those major categories used by Rappole et. al. (1983) that refer to some kind of forest are listed; within each, the corresponding FAO forest types are listed and briefly described.

Savannah

FAO categories NHc/NHO ("mixed broadleaved forest-grassland").

Scrub

Dense, low cover of woody vegetation. FAO categories nH/nS ("shrub formations" of broadleaf and conifers respectively), plus NHCa/NSa ("forest fallow", broadleaf / conifer).

Coniferous

FAO category NS and sub-sets thereof.

Mixed coniferous-broadleaf

There is no corresponding FAO category; all bird species included in this category by Rappole et al. (1983) occur also in decidous, broadleaf or coniferous forest.

Deciduous (seasonal) broadleaf

Again, there is no corresponding FAO category, but most species also use broadleaf forest.

Broadleaf evergreen (aseasonal)

FAO category NHCf and subsets thereof.

Gallery - woody vegetation bordering fresh water

No corresponding FAO category, but FAO (1981) gives areas in 1985 in continental South America extracted from Hueck (1978) or ICITV (1980) as available. There are no figures either for deforestation rates, or for Central America and the West Indies. This is an essentially linear habitat, often only a few trees wide and so of very limited area, so the errors introduced by the inavailability of figures are likely to be very small. The deforestation models in this study assume either that deforestation in this habitat is similar to that in other kinds of forest (models 1 and 3) or that it is negligible (models 2 and 4).

Brackish wetlands - salt marsh, lagoon, mangrove

When combined with a forest category, clearly refers to mangrove. FAO gave no figures in its tables, but data for most countries were included in the text. There are no figures for rates of deforestation, which is unfortunate because in many countries this habitat is under

severe pressure, and it can be an important habitat for some species (e.g. Northern Waterthrush, Common Yellowthroat, Prothonotary Warbler). Deforestation assumptions as for gallery forest.

Rappole et al. (1983) do not distinguish primary forest as a separate category, but a number of workers have drawn attention to the dependence of some species of migrant on primary - or at any rate "mature" - forest. Such species have been identified in this study by reference to Terborgh's (1980) Table 2, and have been assumed to occupy primary forest in winter - whether broadleaf or coniferous is decided by reference both to Rappole et al.'s habitat table, and to the annotations to Terborgh's table. FAO categories NHCf1uv and NS1uv apply respectively to broadleaf and coniferous primary forests, though they also include secondary forest in which there has been no logging for the last 60-80 years.

Chapter 4 - THE SPECIES IN THEIR WINTER HABITATS

The distribution in Latin America of the main vegetation types recognised by UNESCO (1978) is shown in Figure 4. This map was chosen because it is covers more of the neotropics than any other recent vegetation map, though even this does not include the West Indies. Of the other vegetation maps of Latin America that are available, those by Hueck (1978) and the Institut de la Carte Internationale du Tapis Vegetal (1980) cover only continental South America, and that by Anon (1951) covers the whole region but is very much out of date. All these maps show the areas they cover in much more detail than the very generalised map shown here, but Figure 4 does give a sufficiently clear picture, for present purposes, of the distribution of major forest types. A more detailed breakdown, showing the areas of each forest type used in the analyses in this report, is given in Table 4.

The geographical area covered by this report requires some explanation. The northern boundary is that between Mexico and the United States (at ca. 32° N), even though this includes parts of Mexico which are outside the tropics. This was unavoidable, because the FAO data on forest areas and deforestation rates in Mexico are for the whole country, not just the tropical part. Thus although bird distributions within Mexico can be defined in much more detail (e.g. by the physiographic regions used by Edwards (1972)), the same cannot be done for forests. The southern boundary of the map is at 30° S, but the analysis includes all of Brazil including the southernmost part, as well as all of Paraguay; it does not include Argentina or Chile because very little of either country extends into the tropics.

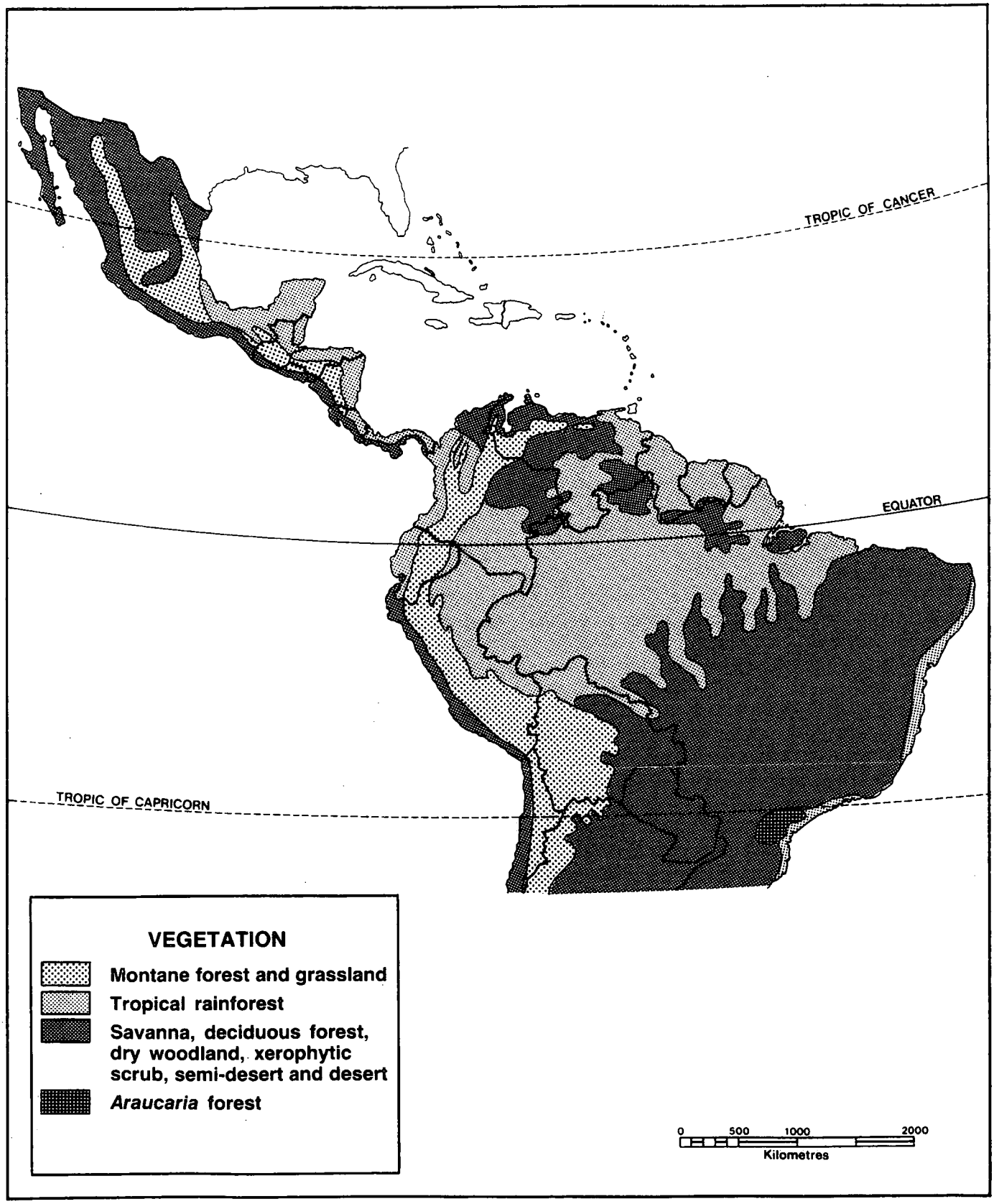


FIGURE 4. Vegetation map of the Neotropics. From UNESCO (1978), Fig.2.

Table 4. AREAS OF HABITATS IN LATIN AMERICA IN 1985.

Units are thousands of hectares. From FAO (1981); "Broadleaf" corrected for logging (see Ch.3). No data available for Lesser Antilles, Puerto Rico or Bahamas. See Ch.3 for definitions of habitat categories.

COUNTRY	HABITAT							
	Broadleaf	Primary broadleaf	Conifer	Primary conifer	Scrub	Savannah	Gallery	Mangrove
Belize	1212	436	209	7	491	92		75
Bolivia	43185	30965	0	0	10400	24630	670	
Brazil	342830	329330	720	720	106870	207250	12460	2500
Colombia	41895	41065	0	0	15500	5400	660	440
Costa Rica	1163	403	0	0	300	160		39
Cuba	1245	455	0	0	935	0		400
Dominican Rep.	432	243	321	45	192	0		9
Ecuador	12125	12025	20	20	4450	550		235
El Salvador	81	78	37	19	318	0		45
French Guayana	8840	8635	0	0	87	70	210	55
Guatemala	3350	2200	642	30	1845	100		50
Guayana	18415	17030	0	0	325	25		150
Haiti	30	20	44	8	67	0		18
Honduras	1595	521	1864	541	1740	200		145
Jamaica	58	56	0	0	387	0		7
Mexico	24064	23764	28025	8115	78050	2000		660
Nicaragua	42614	3320	130	0	1620	0		60
Panama	3945	3155	0	0	159	0		486
Paraguay	2830	910	0	0	3650	28600	140	
Peru	67220	60770	310	310	9070	1120	3250	28
Suriname	14728	14228	0	0	480	690	150	115
Trinidad	190	59	0	0	61	0		4
Venezuela	31195	19760	0	0	12610	2700		260

Several features of Figure 4 deserve emphasis. Most of Mexico consists not of tropical rainforest, but of drier and more open types of forest and woodland, including scrub, and montane forest; only in the south-east is there much lowland rainforest. The pattern shown in southern Mexico - drier open vegetation on the Pacific coast, montane forest along the central mountains, and lush rainforest on the Caribbean slope - is repeated throughout Central America, except that the central ridge of Panama is lower and supports mainly rainforest rather than montane forest.

Vegetation patterns are more complex in continental South America; lowland rainforest lies both east and west of the Andes, and there are extensive areas of drier and more open forest types in most of the northern countries as well as over most of eastern and southern Brazil.

Much of the literature on North American migrants in the neotropics concerns two related aspects of their biology: their interactions with the resident avifauna (do they compete - or do the migrants occupy habitats or ecological niches that the resident species do not fill?); and their habitat choice (do they occupy mature rainforest, or other habitats such as edges, successions, seasonal forests, scrub and savannah?). These topics have been thoroughly reviewed recently (Keast and Morton 1980, Rappole et al. 1983, Morse 1985, Robinson and Terborgh in press, Rappole in press). They will not be explored further here; instead, the winter ranges and chosen habitats of each species are taken from Rappole et al. (1983), whose data represent the results of the most thorough recent review of these topics.

Procedure

Following selection of the species to be considered (see Chapter 2), the habitats in which each species winters were tabulated, together with the countries in which they are known to winter. For each country, the area of each habitat (defined in relation to Rappole et al.'s categories as described in Chapter 3) was entered, using the figures for 1985 given by FAO (1981).

This basic database needed some modification for the larger countries, to take account of the fact that few species winter throughout the whole country. The area actually occupied by each species was determined in most cases by inspection of the range maps in Rappole et al. (1983); for Mexico, the more detailed information in Edwards (1972) was used. Edwards recorded species' occurrence in each of 11 physiographic regions; I weighted these according to their relative areas, and allotted a weighting factor to each species according to the proportion of the total area of the country which it occupies in winter. Thus each species wintering in the larger countries - Mexico, Brazil, Colombia, Venezuela, Ecuador, Peru and Bolivia - was given a weighting factor (from 0.1 to 1.0) according to the approximate proportion of the country in which it winters (Table 5). The total area of each habitat occupied by that species in those countries was then multiplied by the weighting factor for that species in that country, to estimate the total area of habitat used by the species. This database, containing the total area of each type of habitat available to each species in each country of its winter range

Table 5. WEIGHTING FACTORS USED IN MEASURING AREAS OF HABITAT AVAILABLE TO SPECIES IN EACH COUNTRY.

	COUNTRY *						
SPECIES	MEX	COL	VEN	BRA	ECU	PER	BOL
Turkey Vulture	.10						
Broad-winged Hawk	.40	.10	1.0			.50	.70
Black-billed Cuckoo		.40	.50			.20	
Yellow-bellied Sapsucker	1.0						
Whip-poor-Will	.18						
Chimney Swift				.30		.20	
Vaux's Swift	.54						
Ruby-throated Hummingbird	.90						
Black-chinned Hummingbird	.52						
Rufous Hummingbird	.72						
Calliope Hummingbird	.62						
Eastern Kingbird		.60	.10	.01		1.0	.60
Great Crested Flycatcher	.26	.20					
Olive-sided Flycatcher	.08	1.0	.50	.01		.50	
Eastern Wood Pewee		1.0	.30	.01		.60	
Western Wood Pewee		1.0	.30	.01		.60	
Yellow-bellied Flycatcher	.22						
Western Flycatcher	.10						
Traill's Flycatcher		.40	.01			.50	
Least Flycatcher							
Hammond's Flycatcher	.88						
Dusky Flycatcher	.72						
Northern Oriole	.30	.01	.01				
Lincoln's Sparrow	1.0						
Rose-breasted Grosbeak	.46	1.0	.60			.30	
Black-headed Grosbeak	.18						
Western Tanager	.78						
Scarlet Tanager		.40			.50	.01	
Violet-green Swallow	.12						
Rough-winged Swallow	1.0						
Red-eyed Vireo	.30	1.0	1.0		1.0	1.0	
Philadelphia Vireo							
Warbling Vireo	.38						
Solitary Vireo	.38						
Black-and-White Warbler	.56	.50	.40		.05		
Golden-winged Warbler		.30	.20				
Nashville Warbler	.94						
Orange-crowned Warbler	.84						
Tennessee Warbler	.46	.30	.20				
Northern Parula	.24						
Cape May Warbler	.06						
Yellow Warbler	1.0	1.0	.02		.30		
Black-throated Blue Warbler	.06						
Yellow-rumped Warbler	.90						
Magnolia Warbler	.46						

Table 5 (contd.)

SPECIES	COUNTRY *						
	MEX	COL	VEN	BRA	ECU	PER	BOL
Chestnut-sided Warbler	.34						
Bay-breasted Warbler		.30	.10				
Blackpoll Warbler		.50	1.0	.01		.20	
Blackburnian Warbler		.80	.20			.30	
Black-throated Gray Warbler	.52						
Black-throated Green Warbler	.46						
Townsend's Warbler	.66						
Palm Warbler	.06						
Ovenbird	.34	.20	.20				
Northern Waterthrush	.64	.90	1.0				
Connecticut Warbler		.40	.50	.10			
Mourning Warbler	.20	1.0	.10				
Common Yellowthroat	.78						
Wilson's Warbler	.94						
Canada Warbler		0.6	0.8			0.4	
American Redstart	.60	.80		.01			
Gray Catbird	.32						
Wood Thrush	.18						
Veery		.40					
Gray-cheeked Thrush						.20	
Swainson's Thrush	1.0	.70				.20	.70

* MEX = Mexico, COL = Colombia, VEN = Venezuela, BRA = Brazil, ECU = Ecuador, PER = Peru, BOL = Bolivia.

in Latin America, is the basis for the maps of winter distribution patterns (Figures 8 - 76) .

Overall patterns of migrant distribution

The distribution of each species is shown by country in Table 6. The simplest view of the overall distribution of Canadian migrants to tropical forest is shown in Figure 5. This maps the number of species of Canadian migrant wintering in each country, uncorrected for area of country, or area or choice of habitat. It emphasises the importance of Mexico, in which 75% of Canadian species winter, and shows a general decrease from north to south in numbers of species except for Belize, El Salvador and Guatemala, which all host fewer species than Costa Rica and Panama to the south. Belize and El Salvador are both smaller and probably less well-studied than other Central American countries, and also have less varied habitats because both lie on only one coast and have very small montane areas. Colombia and Venezuela host more species of migrant than any other South American countries and Brazil, in spite of its huge area, is relatively unimportant as a wintering site in terms of the number of species using it. Cuba and the Bahamas are the most important of the Caribbean Islands.

Figure 6 shows a different aspect of the overall distribution of migrants, taking into account each country's area of habitat used by migrants. It shows the number of species wintering there, divided by the total area of habitat used by migrants; it is a measure of the density of species per unit area of forest of migrants. This view of the data attempts to correct for one of the biases in Figure 5, due to the very different geographic areas - and hence areas of habitat - of

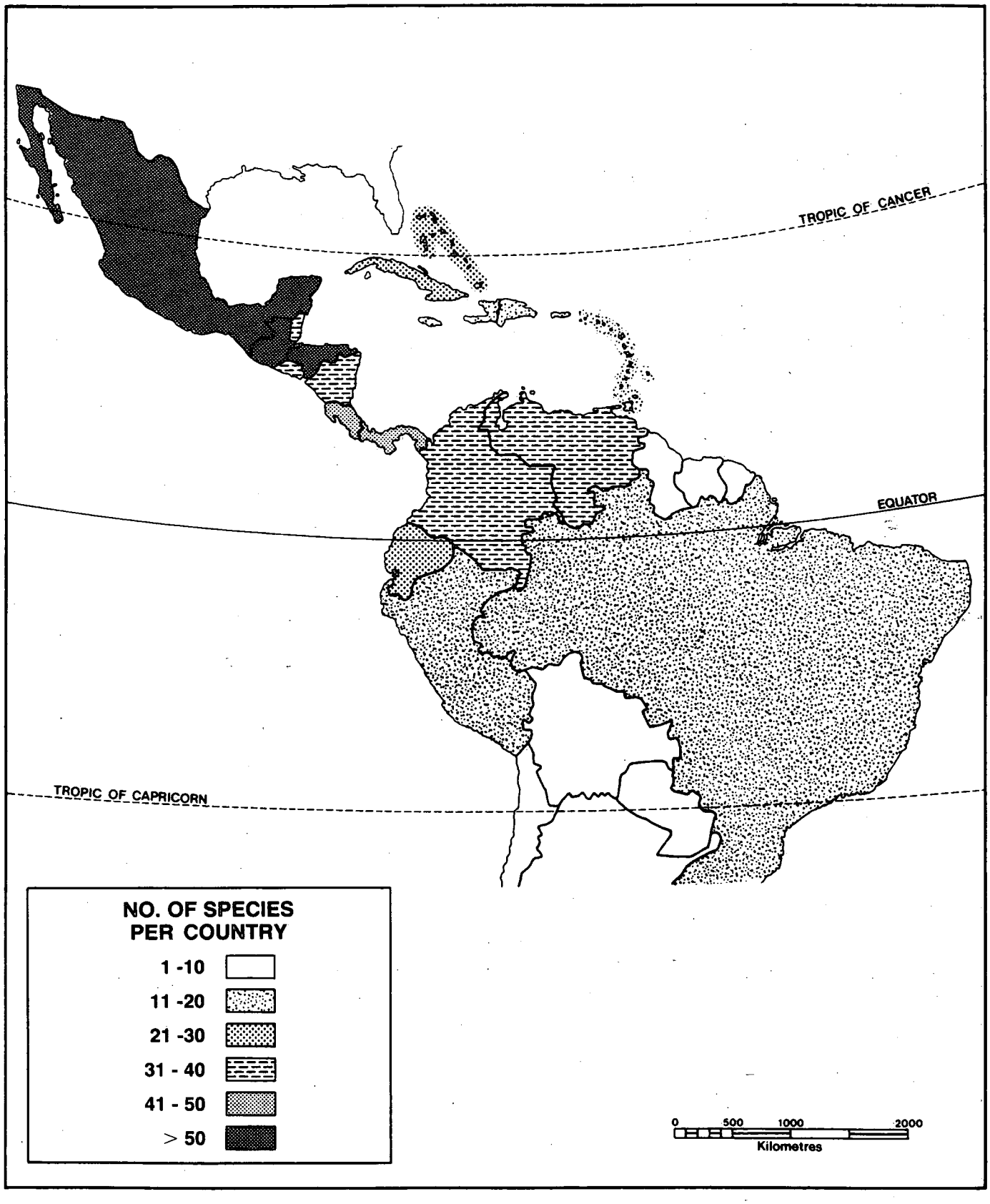


FIGURE 5. The number of Canadian bird species wintering in forest in each country of the Neotropics. Data from Rappole et al. (1983).

Table 6. WINTER DISTRIBUTION OF CANADIAN FOREST BIRDS IN COUNTRIES OF THE NEOTROPICS.

(a) Central America

	COUNTRY *							
SPECIES	MEX	GUA	BEL	HON	ELS	NIC	COS	PAN
Turkey Vulture	X	X	X	X	X		X	X
Broad-winged Hawk	X	X		X	X		X	X
Black-billed Cuckoo								
Yellow-bellied Sapsucker	X	X	X	X	X	X	X	X
Whip-poor-Will	X	X	X	X	X			
Chimney Swift								
Vaux's Swift	X	X	X	X				
Ruby-throated Hummingbird	X	X	X	X	X	X	X	X
Black-chinned Hummingbird	X							
Rufous Hummingbird	X							
Calliope Hummingbird	X							
Eastern Kingbird				X				
Olive-sided Flycatcher	X	X	X			X	X	X
Eastern Wood Pewee								
Western Wood Pewee								X
Yellow-bellied Flycatcher	X	X	X	X	X	X	X	X
Western Flycatcher	X	X						
Traill's Flycatcher		X		X	X		X	X
Least Flycatcher	X	X	X	X	X	X	X	X
Hammond's Flycatcher	X	X		X	X			
Dusky Flycatcher	X							
Northern Oriole	X	X	X	X	X	X	X	X
Lincoln's Sparrow	X	X		X	X			
Rose-breasted Grosbeak	X	X	X	X	X	X	X	X
Black-headed Grosbeak	X							
Western Tanager	X	X		X	X	X	X	
Scarlet Tanager								X
Violet-green Swallow	X	X		X	X			
Rough-winged Swallow	X	X	X	X	X	X	X	X
Red-eyed Vireo							X	
Philadelphia Vireo	X	X		X	X		X	X
Warbling Vireo	X	X		X	X			
Solitary Vireo	X	X		X	X			
Black and White Warbler	X	X	X	X	X	X	X	X
Golden-winged Warbler		X	X	X			X	X
Nashville Warbler	X	X	X					
Orange-crowned Warbler	X	X	X					
Tennessee Warbler	X	X	X	X	X	X	X	X
Northern Parula	X	X	X					
Cape May Warbler	X							
Yellow Warbler	X	X	X	X	X	X	X	X
Black-throated Blue Warbler	X	X	X					
Yellow-rumped Warbler	X	X	X	X	X	X	X	X
Magnolia Warbler	X	X	X	X	X	X	X	X
Chestnut-sided Warbler	X	X		X		X	X	X
Bay-breasted Warbler							X	X

Table 6(a) continued

	COUNTRY *							
SPECIES	MEX	GUA	BEL	HON	ELS	NIC	COS	PAN
Blackpoll Warbler								
Blackburnian Warbler					X		X	X
Black-throated Gray Warbler	X							
Black-throated Green Warbler	X	X	X	X	X	X	X	X
Townsend's Warbler	X	X		X	X	X	X	
Palm Warbler	X			X		X		
Ovenbird	X	X	X	X	X	X	X	X
Northern Waterthrush	X	X	X	X	X	X	X	X
Connecticut Warbler								
Mourning Warbler	X	X		X	X	X	X	X
Common Yellowthroat	X	X	X	X	X	X	X	X
Wilson's Warbler	X	X	X	X	X	X	X	
Canada Warbler				X				X
American Redstart	X	X	X	X	X	X	X	X
Gray Catbird	X	X	X	X		X	X	X
Wood Thrush	X	X	X	X	X	X	X	X
Veery								
Gray-cheeked Thrush							X	
Swainson's Thrush	X	X		X	X		X	X

* MEX = Mexico, GUA = Guatemala, BEL = Belize, HON = Honduras, ELS = El Salvador, NIC = Nicaragua, COS = Costa Rica, PAN = Panama.

Table 6(b) Continental South America

SPECIES	COUNTRY *										
	COL	VEN	GUY	SUR	FRG	BRA	ECU	PER	BOL	PAR	URU
Turkey Vulture											
Broad-winged Hawk	X	X			X	X	X	X	X		
Black-billed Cuckoo	X	X					X	X			
Yellow-bellied Sapsucker											
Whip-poor-Will											
Chimney Swift						X		X			
Vaux's Swift											
Ruby-throated Hummingbird											
Black-chinned Hummingbird											
Rufous Hummingbird											
Cal Hummingbird											
Eastern Kingbird	X	X	X			X	X	X	X		
Olive-sided Flycatcher	X	X				X	X	X			
Eastern Wood Pewee	X	X				X	X	X			
Western Wood Pewee	X	X				X	X	X			
Yellow-bellied Flycatcher											
Western Flycatcher											
Traill's Flycatcher	X	X					X	X	X		
Least Flycatcher											
Hammond's Flycatcher											
Dusky Flycatcher											
Northern Oriole	X	X									
Lincoln's Sparrow											
Rose-breasted Grosbeak	X	X					X	X			
Black-headed Grosbeak											
Western Tanager											
Scarlet Tanager	X						X	X	X		
Violet-green Swallow											
Rough-winged Swallow											
Red-eyed Vireo	X	X				X	X	X	X		X
Philadelphia Vireo											
Warbling Vireo											
Solitary Vireo											
Black and White Warbler	X	X					X				
Golden-winged Warbler	X	X									
Nashville Warbler											
Orange-crowned Warbler											
Tennessee Warbler	X	X									
Northern Parula											
Cape May Warbler											
Yellow Warbler	X	X	X	X	X	X	X	X			
Black-throated Blue Warbler											
Yellow-rumped Warbler											
Magnolia Warbler											
Chestnut-sided Warbler											
Bay-breasted Warbler	X	X									
Blackpoll Warbler	X	X	X	X	X	X	X	X			
Blackburnian Warbler	X	X					X	X			
Black-throated Gray Warbler											

Table 6(b) continued

SPECIES	COUNTRY *										
	COL	VEN	GUY	SUR	FRG	BRA	ECU	PER	BOL	PAR	URU
Black-throated Green Warbler											
Townsend's Warbler											
Palm Warbler											
Ovenbird	X	X					X	X			
Northern Waterthrush	X	X	X	X	X						
Connecticut Warbler	X	X				X					
Mourning Warbler	X	X					X				
Common Yellowthroat											
Wilson's Warbler											
Canada Warbler	X	X				X	X	X			
American Redstart	X	X	X	X		X	X				
Gray Catbird											
Wood Thrush											
Veery	X	X	X				X				
Gray-cheeked Thrush	X	X	X				X	X	X		
Swainson's Thrush	X	X	X				X	X	X	X	X

* COL = Colombia, VEN = Venezuela, GUY = Guyana, FRG = French Guiana, BRA = Brazil, ECU = Ecuador, PER = Peru, BOL = Bolivia, PAR = Paraguay, URU = Uruguay.

Table 6(c) Caribbean Islands

SPECIES	COUNTRY * BAH	CUB	JAM	HIS	PRI	LAN	TRT
Turkey Vulture							
Broad-winged Hawk							
Black-billed Cuckoo							
Yellow-bellied Sapsucker	X	X	X	X	X		
Whip-poor-Will							
Chimney Swift							
Vaux's Swift							
Ruby-throated Hummingbird							
Black-chinned Hummingbird							
Rufous Hummingbird							
Calliope Hummingbird							
Eastern Kingbird							
Olive-sided Flycatcher							
Eastern Wood Pewee							
Western Wood Pewee							
Yellow-bellied Flycatcher							
Western Flycatcher							
Traill's Flycatcher							
Least Flycatcher							
Hammond's Flycatcher							
Dusky Flycatcher							
Northern Oriole		X	X				
Lincoln's Sparrow							
Rose-breasted Grosbeak		X					
Black-headed Grosbeak							
Western Tanager							
Scarlet Tanager							
Violet-green Swallow							
Rough-winged Swallow		X	X				
Red-eyed Vireo							X
Philadelphia Vireo							
Warbling Vireo							
Solitary Vireo		X	X				
Black and White Warbler	X	X	X	X	X	X	X
Golden-winged Warbler							
Nashville Warbler							
Orange-crowned Warbler							
Tennessee Warbler							
Northern Parula	X	X	X	X	X	X	X
Cape May Warbler	X	X	X	X	X	X	
Yellow Warbler							X
Black-throated Blue Warbler	X	X	X	X	X	X	
Yellow-rumped Warbler	X	X	X	X	X	X	
Magnolia Warbler	X	X	X	X	X	X	
Chestnut-sided Warbler							
Bay-breasted Warbler							
Blackpoll Warbler							
Blackburnian Warbler							
Black-throated Gray Warbler							
Black-throated Green Warbler	X	X	X	X	X		

Table 6(c) continued

SPECIES	COUNTRY *						
	BAH	CUB	JAM	HIS	PRI	LAN	TRT
Townsend's Warbler							
Palm Warbler	X	X	X	X	X		
Ovenbird	X	X	X	X	X	X	X
Northern Waterthrush	X	X	X	X	X	X	X
Connecticut Warbler							
Mourning Warbler							
Common Yellowthroat	X	X	X	X	X		
Wilson's Warbler							
Canada Warbler							
American Redstart	X	X	X	X	X	X	X
Gray Catbird	X	X	X	X			
Wood Thrush							
Veery							
Gray-cheeked Thrush				X			
Swainson's Thrush							

* BAH = Bahamas, CUB = Cuba, JAM = Jamaica, HIS = Hispaniola, PRI = Puerto Rico, LAN = Lesser Antilles, TRT = Trinidad and Tobago.

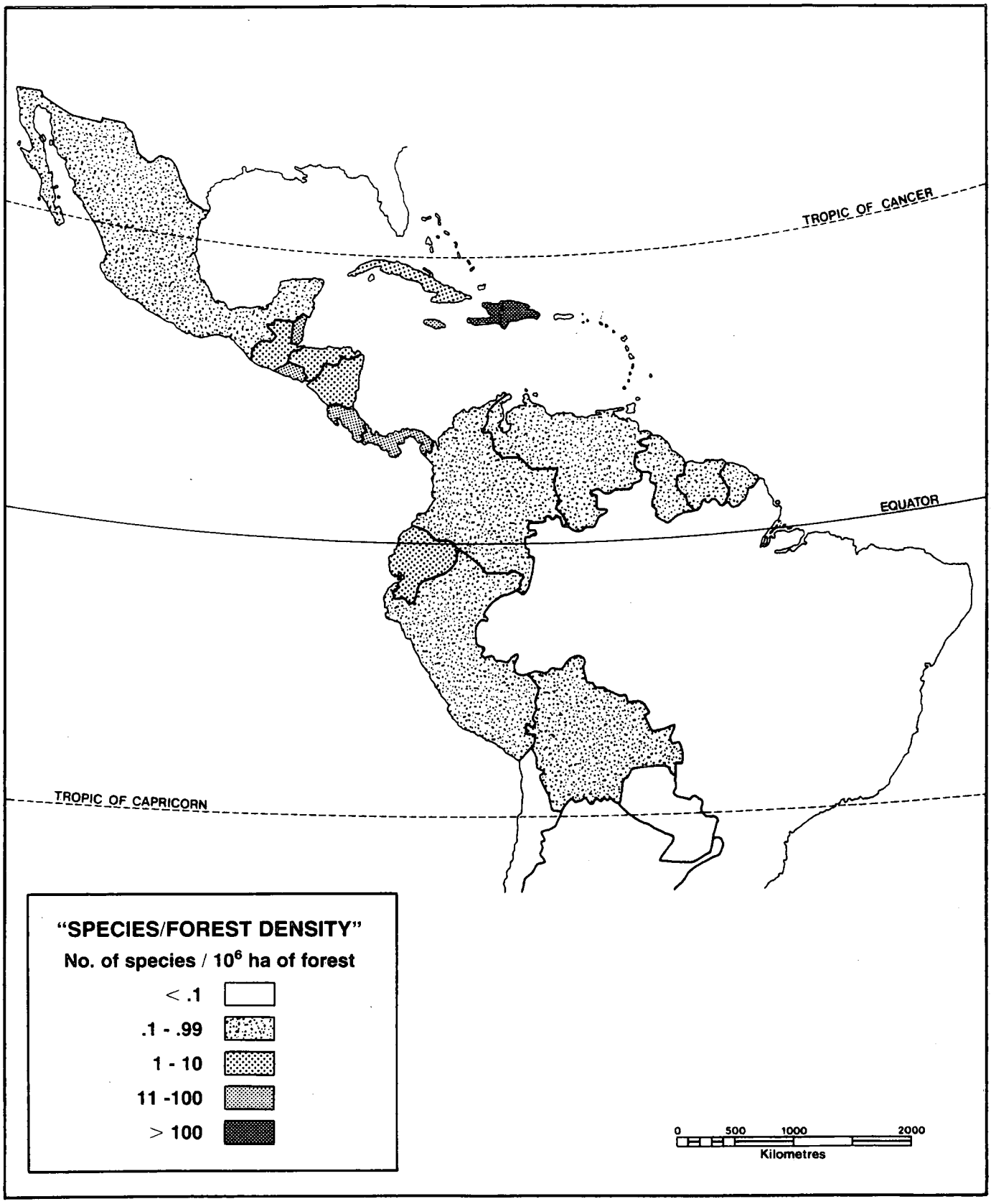


FIGURE 6. The number of species wintering in each country in relation to the area of forest.

different countries. It shows that the island of Hispaniola has the greatest number of species in relation to its forest area, and that other small countries - notably Belize, El Salvador, Costa Rica and Panama - host disproportionately high numbers of migrant species in relation to their areas of forest. By this measure, Mexico ranks as low as Bolivia and French Guayana in its species density.

Perhaps the most realistic view of migrant distribution is shown in Figure 7. The data for this map were computed as follows. For each country, the total area of habitat used by migrant species was summed over all species, giving a figure equivalent to number of species times mean area of habitat available to each species. This total was then summed over all countries, and each country's total was divided by that overall total to give the proportion of the habitat-use by Canadian migrants throughout the neotropics that is accounted for by that country. This measure re-emphasises the importance of Mexico, as does Figure 5, but also gives Brazil and Colombia greater importance than previous treatments, because of the large areas of habitat which they contain.

None of these maps, by itself, can be said to show which countries are most "important" to Canadian migrants. Each shows a different aspect of "importance"; Mexico hosts more species than any other country (Figure 5), and also has one of the largest areas of habitat so it accounts for the highest proportion of total "species-habitat" use (Figure 7), but because it has so much habitat, the concentration of migrant species within it is much less than in many other countries with many fewer species but also very much less habitat (Figure 6). The largest country of all - Brazil - is

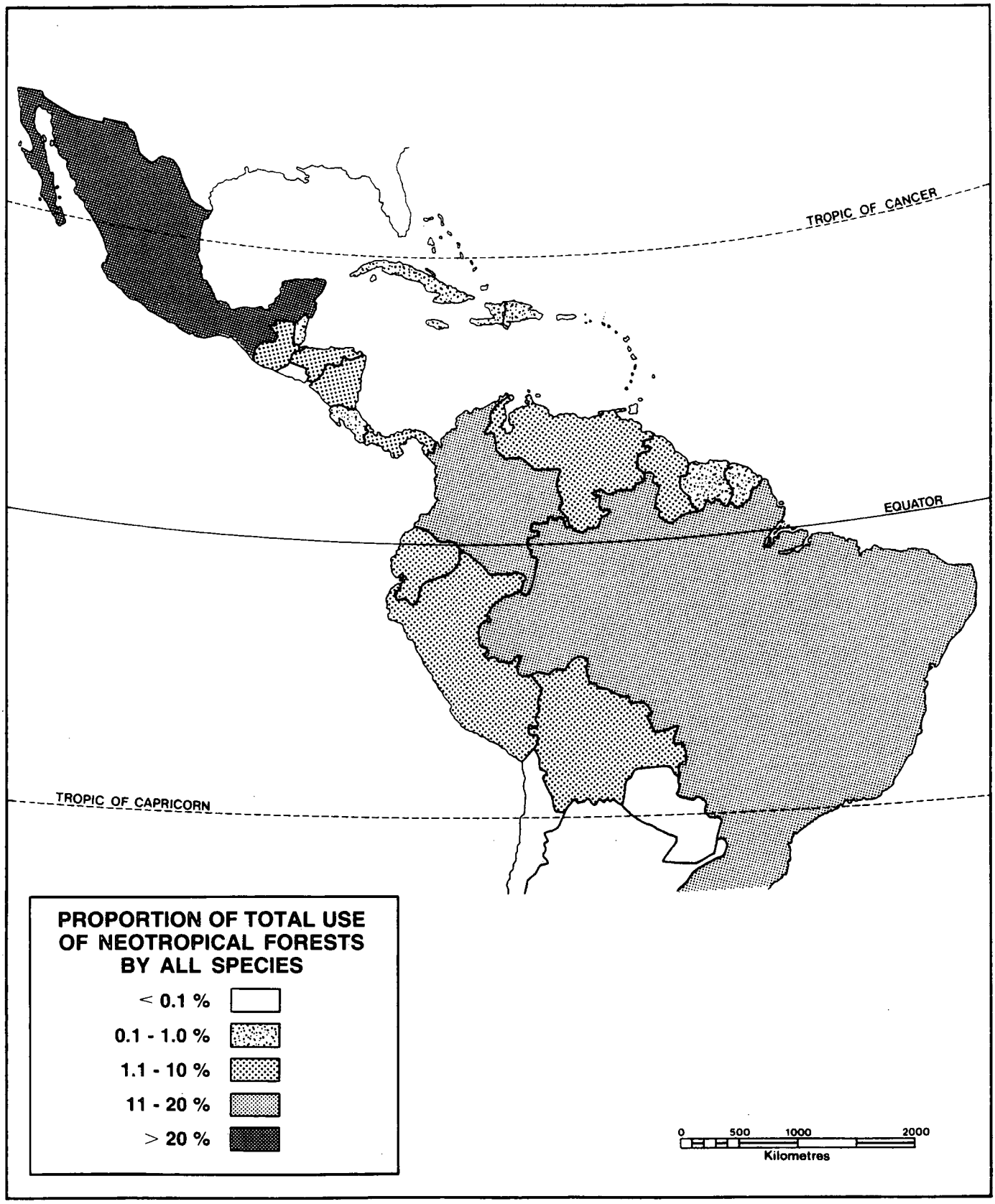


FIGURE 7. The proportion of total habitat-use by Canadian migrants accounted for by each country.

unimportant in terms of numbers of species (Figure 5), and hence in their concentration per unit area of habitat (Figure 6), but looms larger in Figure 7 where its enormous area of habitat is more clearly reflected.

Distribution of individual species

The maps of individual species' distributions (Figures 8 - 76) were compiled from the database described previously. The height of the column in each country shows the proportion of all that species' winter habitat which occurs in that country. It is important to repeat here that these maps do not show the proportion of the population that winters in each country (see Chapters 1 and 7 for more detailed discussion of this point).

Inspection of these maps shows four main groups of distribution patterns. The commonest (31 species, or 47%, show this pattern, e.g. Yellow-bellied Flycatcher) is confined to Mexico and Central America; in some (hummingbirds, Western Flycatcher) the species occurs only in Mexico or one other country. The second major distribution pattern (e.g. Blackpoll Warbler) is South American (15 species, or 23%). In the third group (nine species), the Caribbean Islands contribute significant proportions of the total tropical habitat (e.g. Northern Parula, Cape May and Black-throated Blue Warblers). The fourth group consists of 11 species which are centred primarily in either Central or South America but in which significant proportions of their winter range lie in one of the other major groups (including the Caribbean islands).

Later in this report, each species is allotted a category of "distribution type" (e.g. Table 12). This is based on the region (Central America, continental South America, or West Indies) which contributes most of the total area of winter habitat, as shown on the appropriate species map (see Table 2 and Chapter 2).

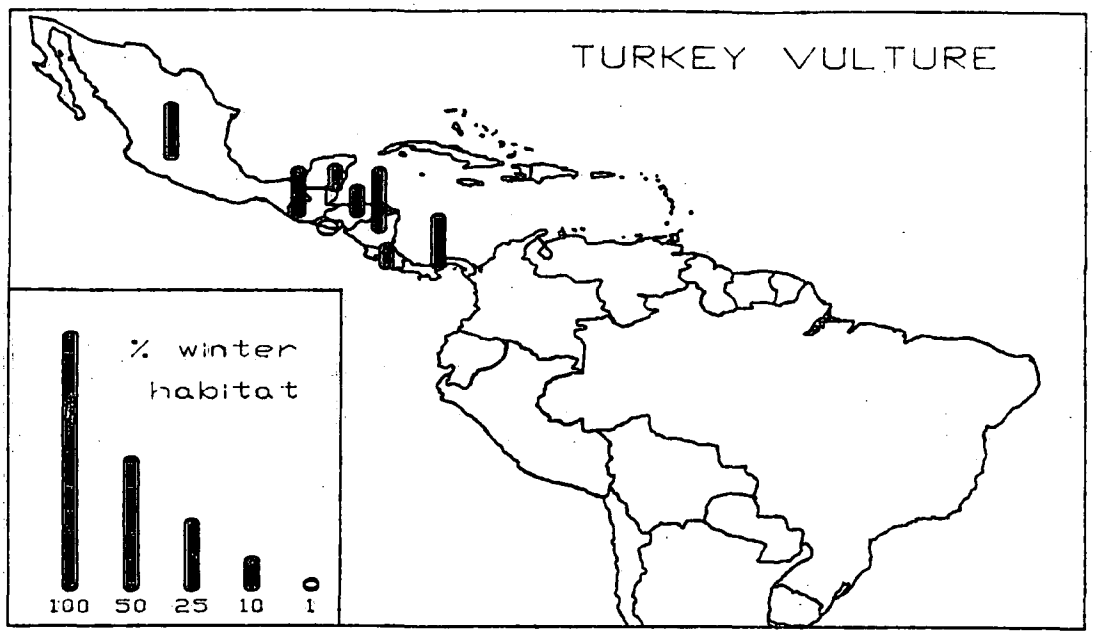
Use of habitat types

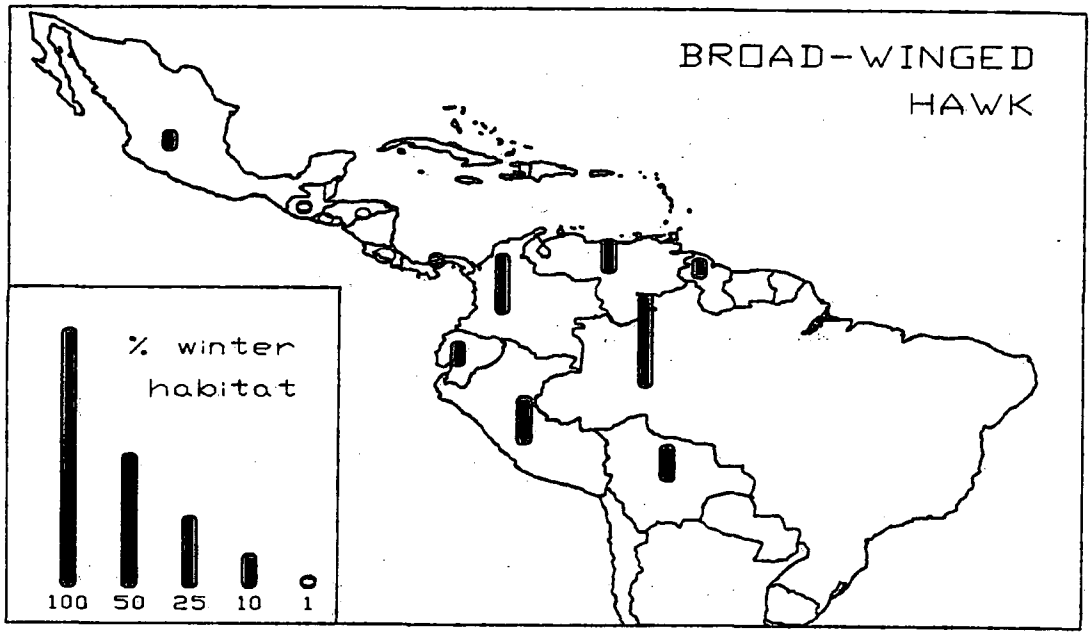
The habitat which is used by most species (Table 2) is gallery forest (42 species or nearly two-thirds of all species). This is unfortunate because FAO gives no figures for the area of this habitat, nor for its rate of deforestation. Since it is an essentially linear habitat (along the edges of rivers) its total area must be relatively small, compared with those of other forest types. In Amazonia, the "transitional" forest between rivers and mature "bottomland" forest on dry ground is a very important habitat for nearctic migrants; Robinson and Terborgh (in press) found migrants to be about 100 times more abundant there than in bottomland forest, and one species - Connecticut Warbler (with a very small winter range) - occurred nowhere else.

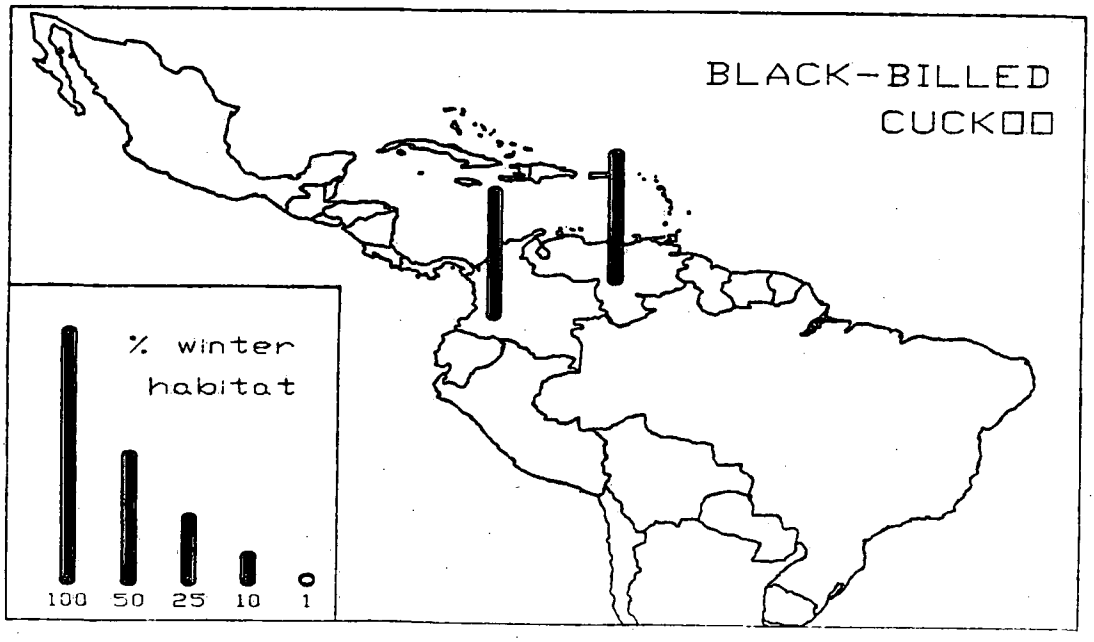
Broadleaf and primary broadleaf forest (treated as separate habitats in this study (see Chapter 3)) are used by 21 and 23 species, respectively. Of these, five species occur only in primary broadleaf forest, and nine (including those five) only in primary forest (including conifers). Scrub is used by 19 species (i.e. nearly as many as use broadleaf or primary broadleaf forest), savannah by eight and mangrove by two. Thus many more species use secondary, scrubby or open kinds of broadleaf habitat than are dependent on primary broadleaf forest (but see Chapter 8 for dangers in interpreting these solely

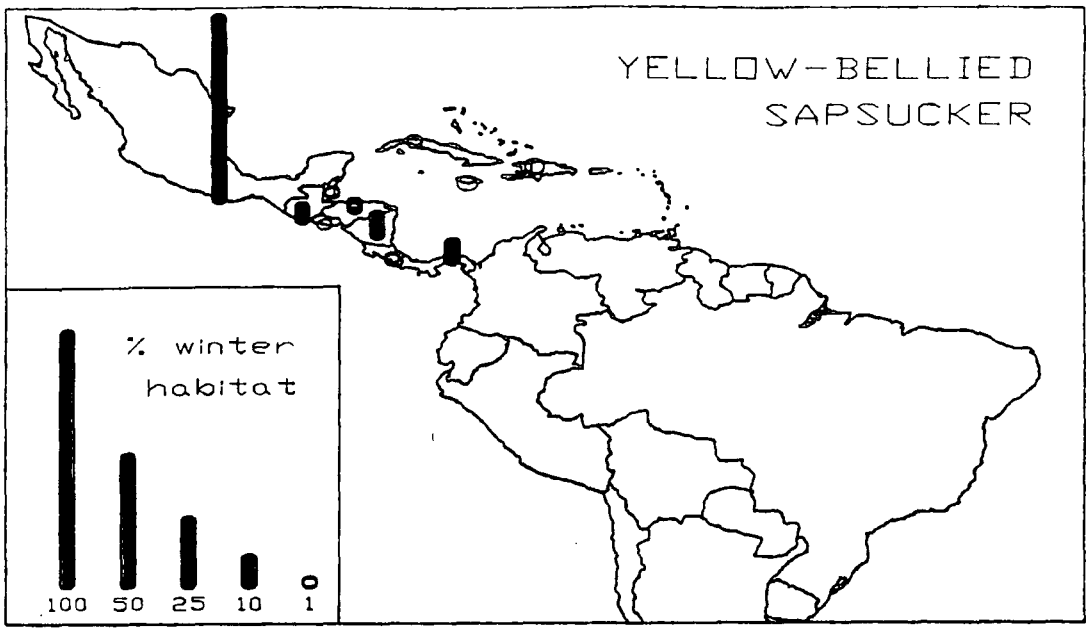
distributional data). Coniferous forest is used by 15 species, and primary conifers by a further eight; these are confined very largely to Mexico, often outside the strictly tropical zone.

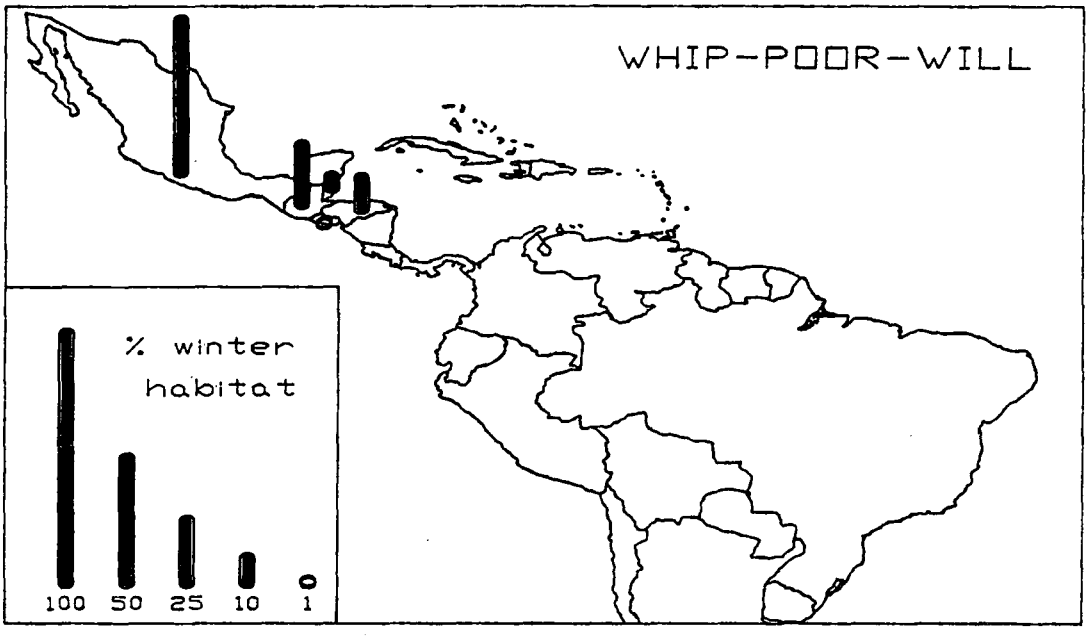
FIGURES 8-69. The proportion of its tropical habitat found in each country of the Neotropics, for each species (in A.O.U. number order). Eastern Wood Pewee is identical with Western Wood Pewee; Rufous and Calliope Hummingbirds with Black-chinned Hummingbird. No map can be drawn for Mourning Warbler because there are no suitable data on the area of its habitat.

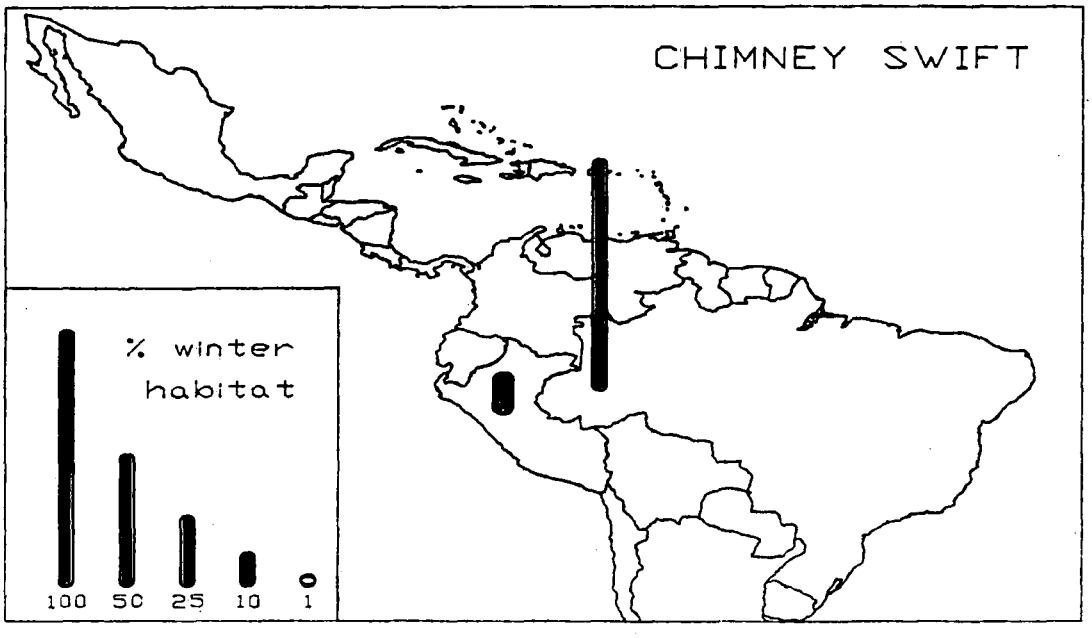

TURKEY VULTURE
% winter habitat
100 50 25 10 1

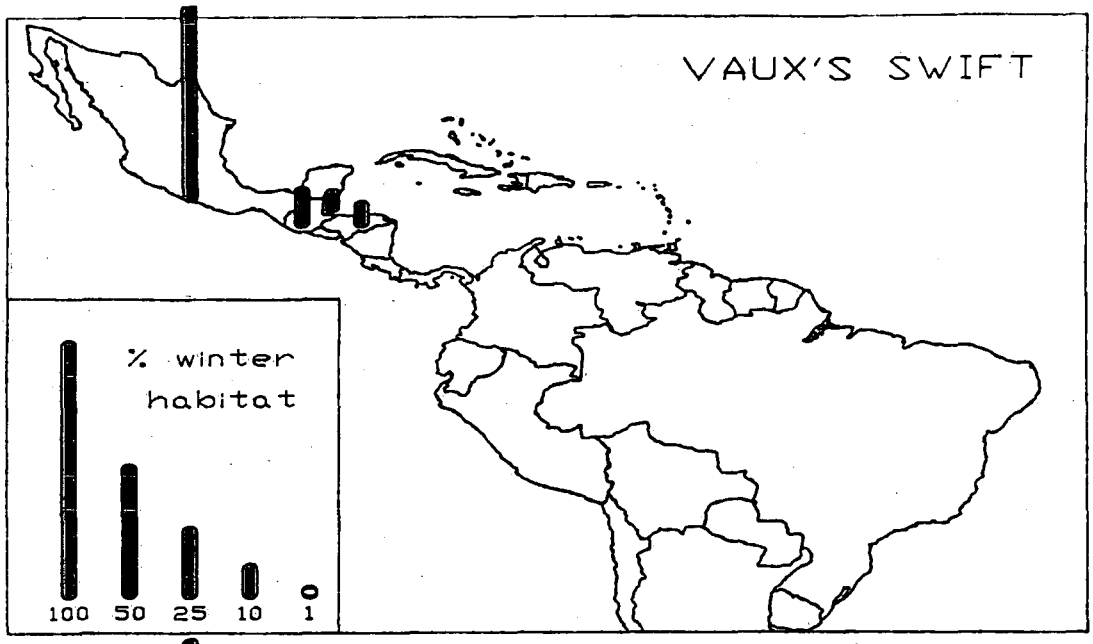

BROAD-WINGED HAWK
% winter habitat
100 50 25 10 1

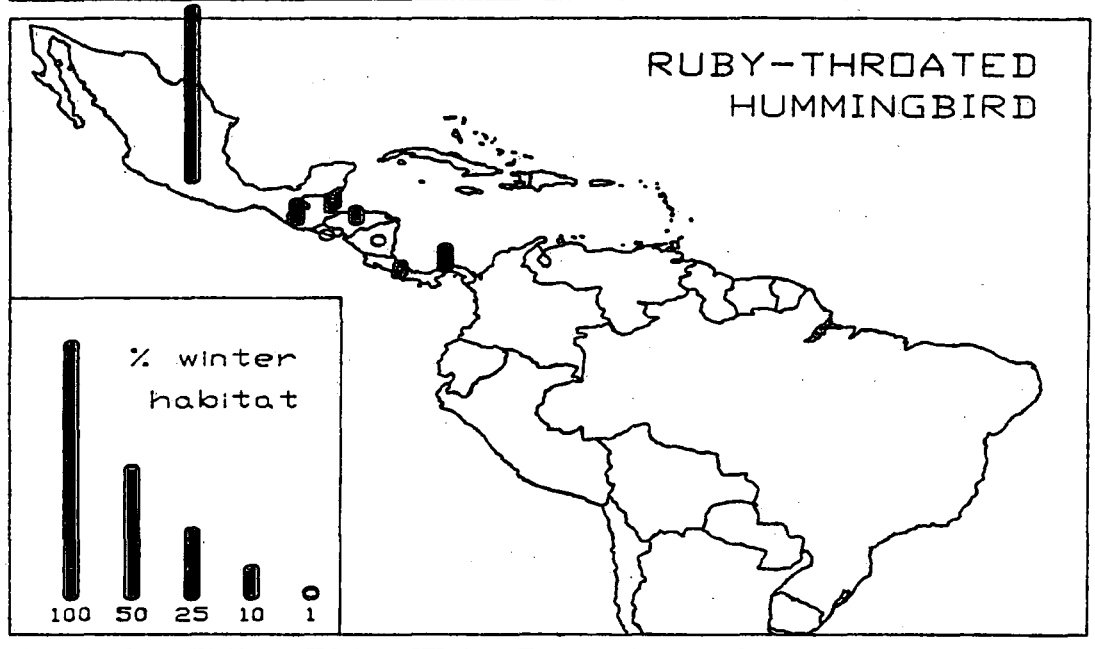

BLACK-BILLED CUCKOO
% winter habitat
100 50 25 10 1

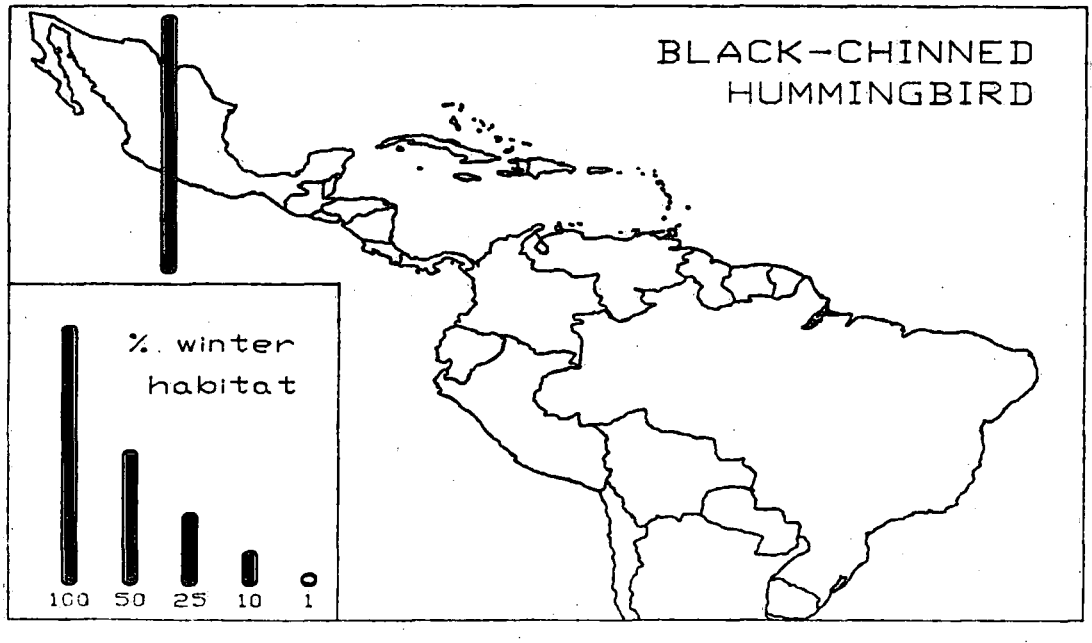

YELLOW-BELLIED
SAPSUCKER
% winter
habitat
100
50
25
10
1

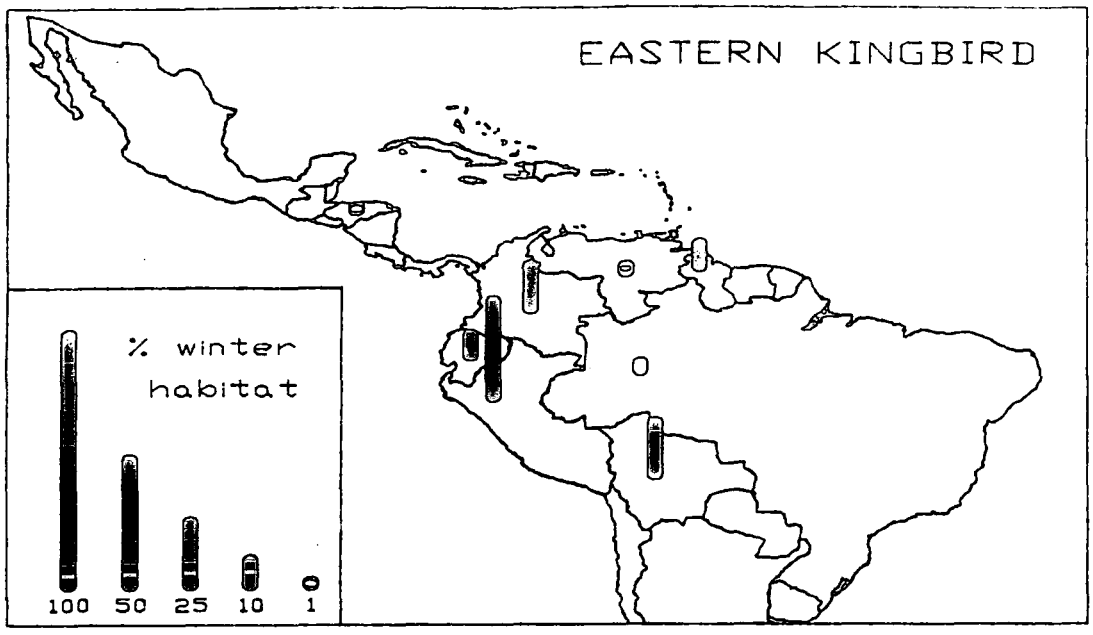

WHIP-POOR-WILL
% winter
habitat
100
50
25
10
1

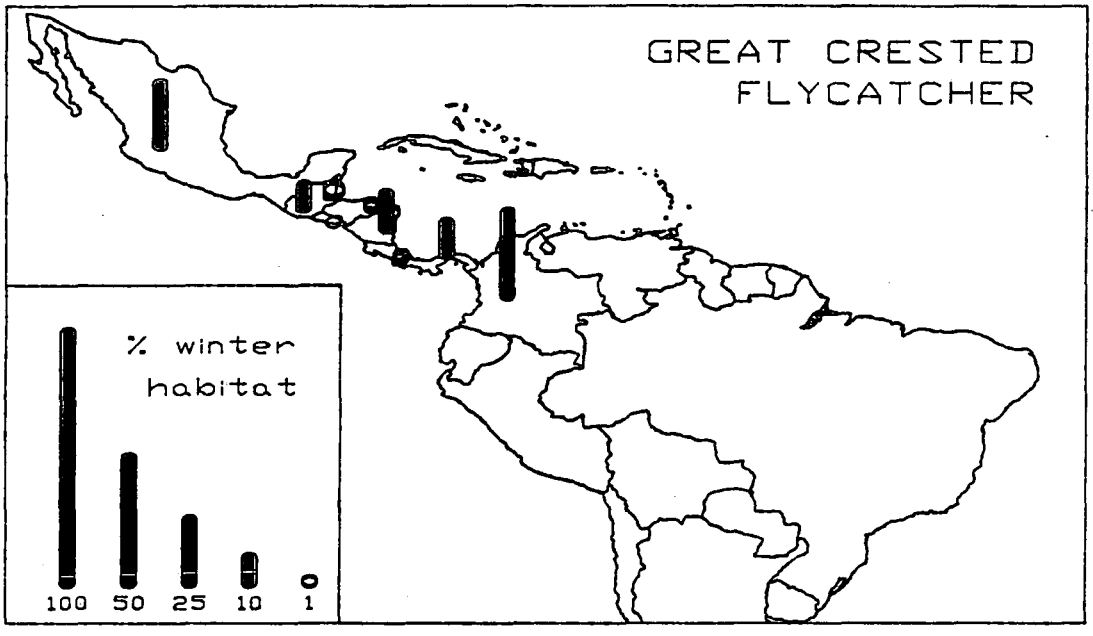

CHIMNEY SWIFT
% winter
habitat
100
50
25
10
1

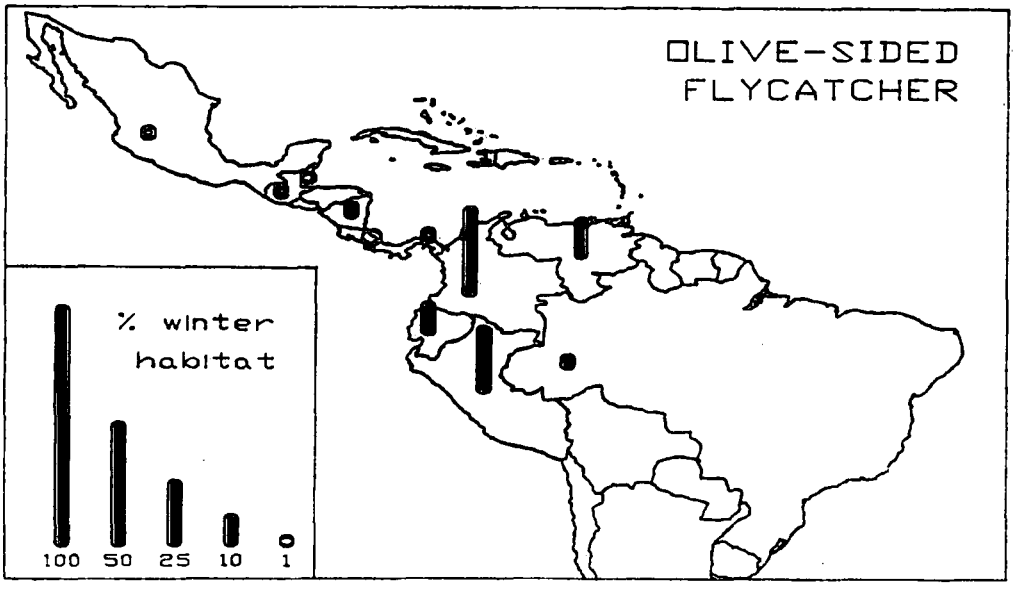

VAUX'S SWIFT
% winter habitat
100 50 25 10 1

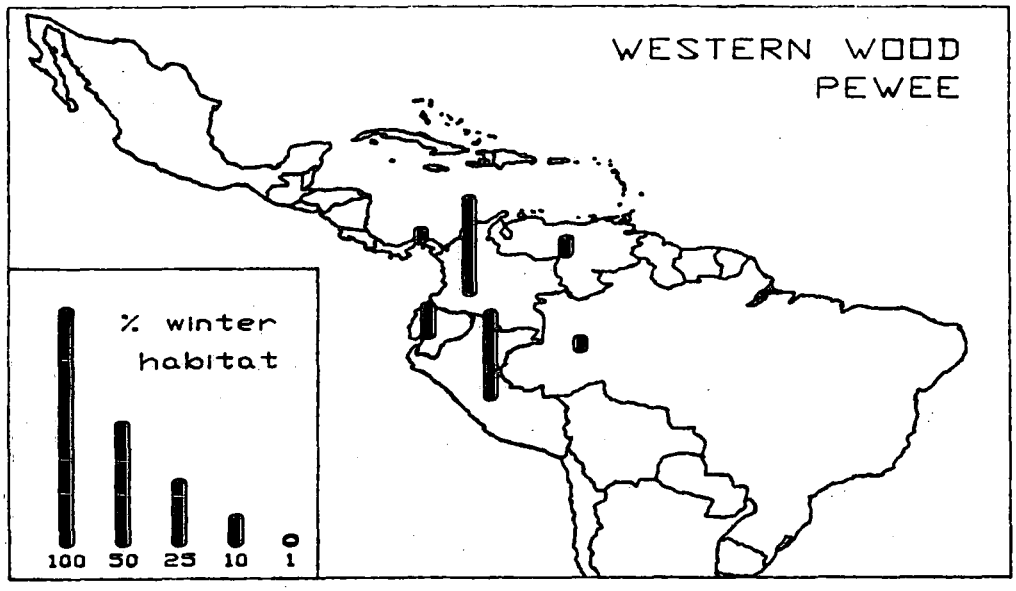

RUBY-THROATED HUMMINGBIRD
% winter habitat
100 50 25 10 1

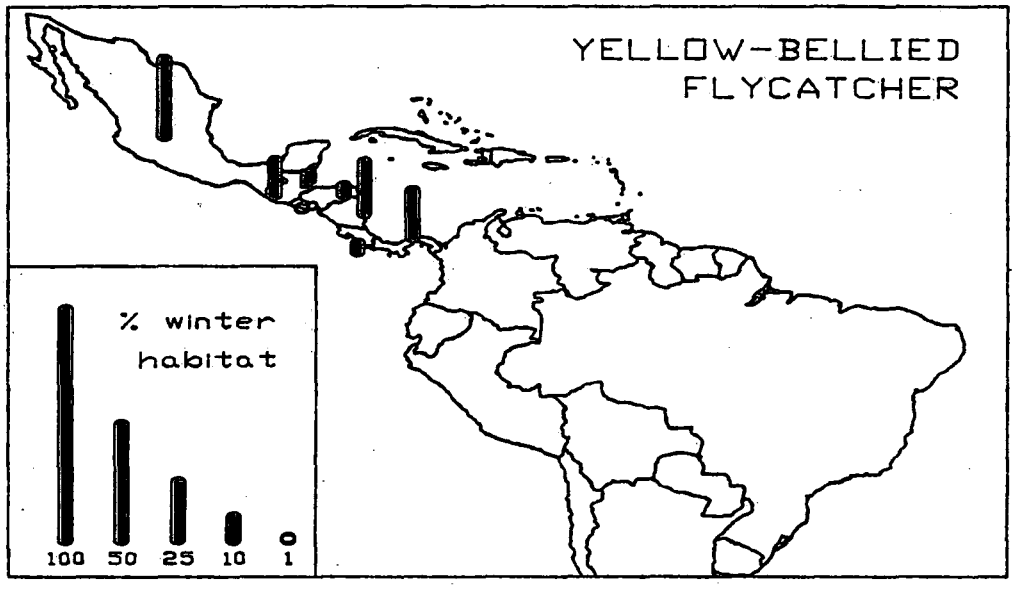

BLACK-CHINNED HUMMINGBIRD
% winter habitat
100 50 25 10 1

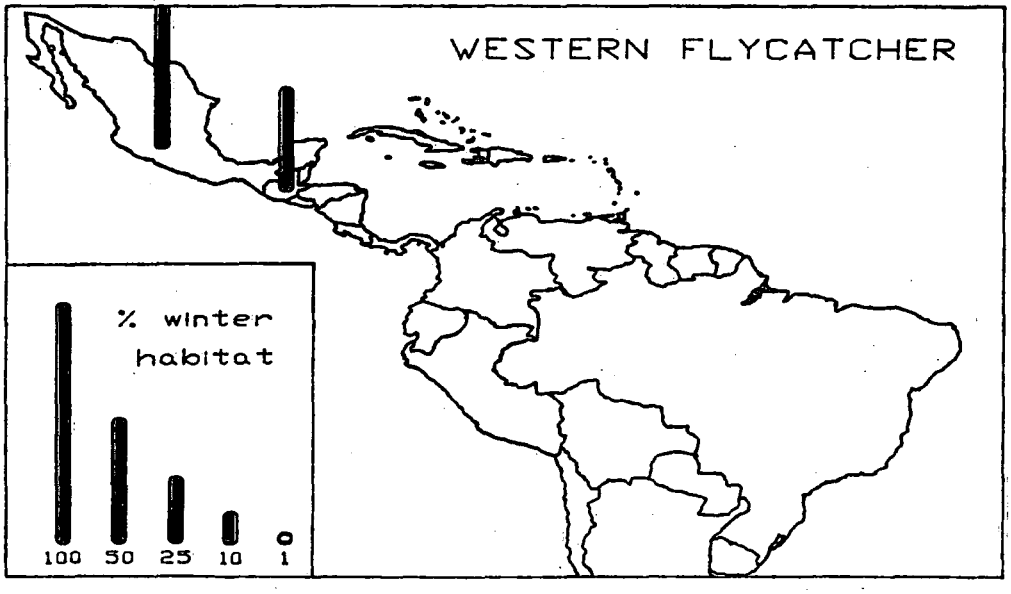

EASTERN KINGBIRD
% winter habitat
100 50 25 10 1

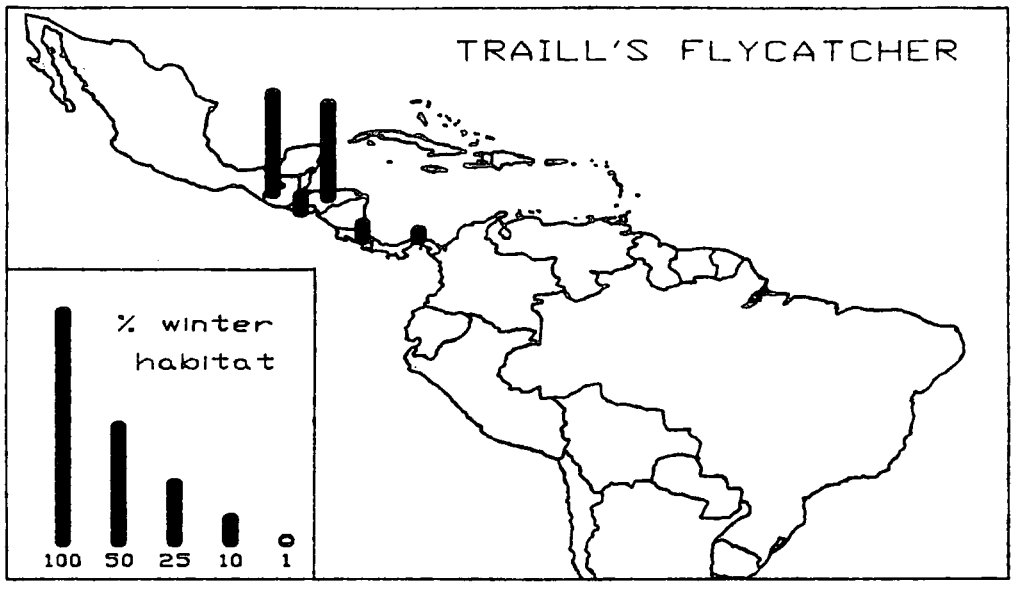

GREAT CRESTED FLYCATCHER
% winter habitat
100 50 25 10 1

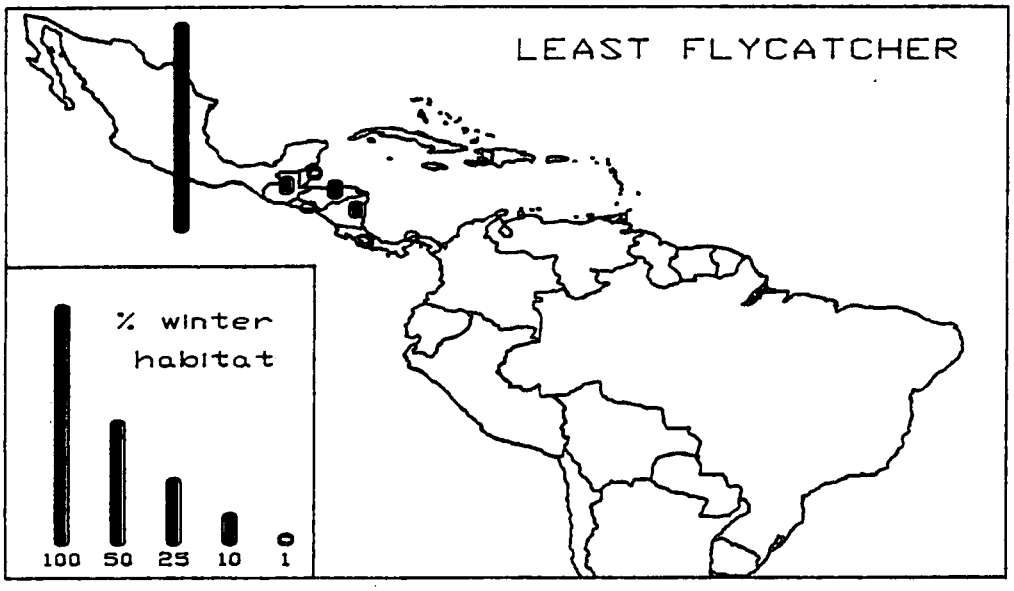

OLIVE-SIDED FLYCATCHER
% winter habitat
100 50 25 10 1

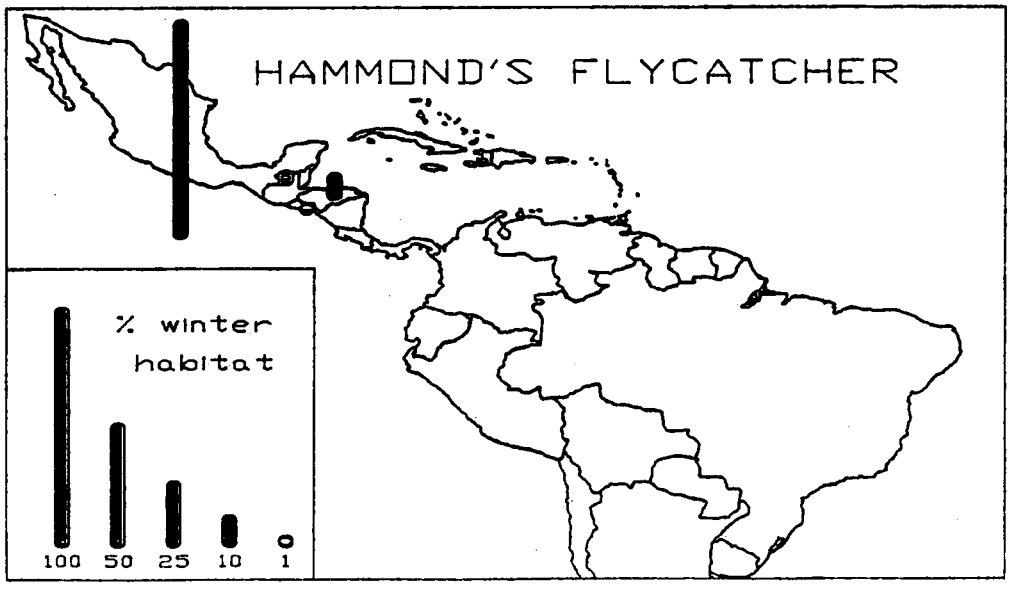

WESTERN WOOD
PEWEE
% winter
habitat
100 50 25 10 0
1

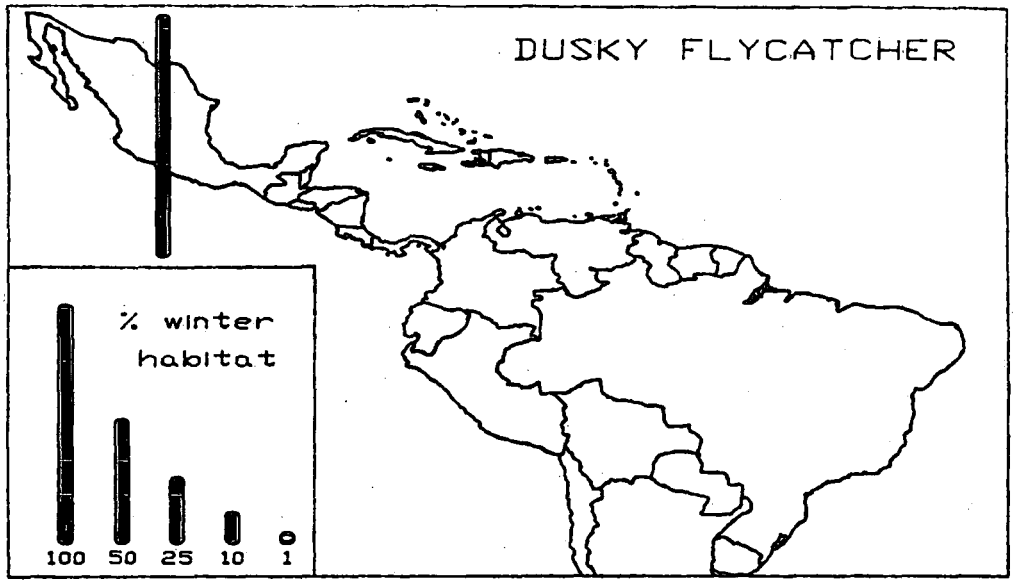

YELLOW-BELLIED
FLYCATCHER
% winter
habitat
100 50 25 10 0
1

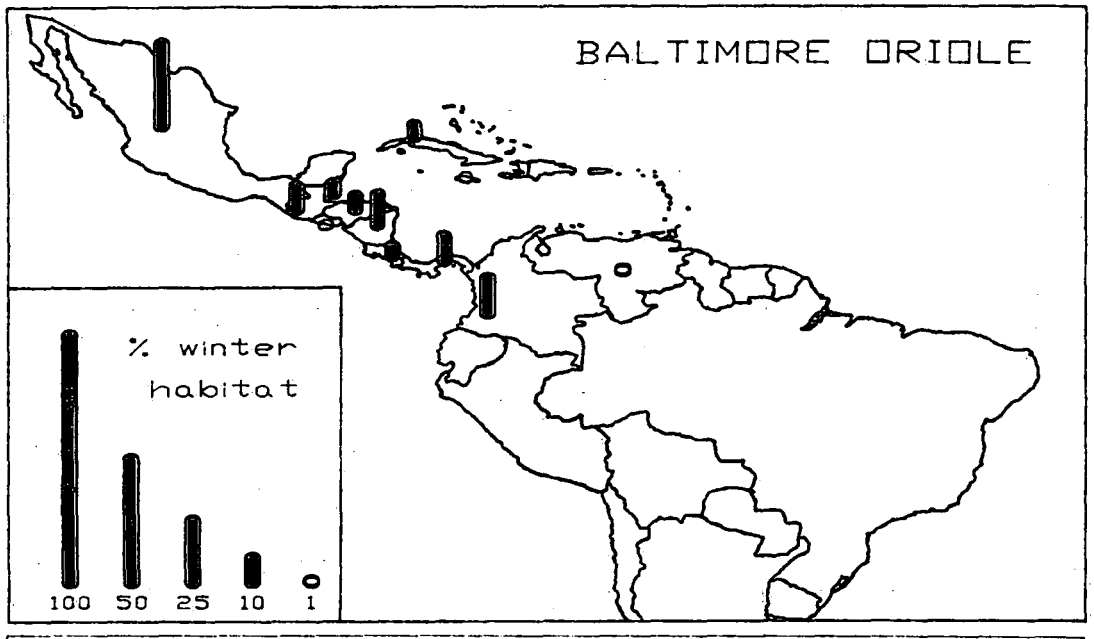

WESTERN FLYCATCHER
% winter
habitat
100 50 25 10 0
1

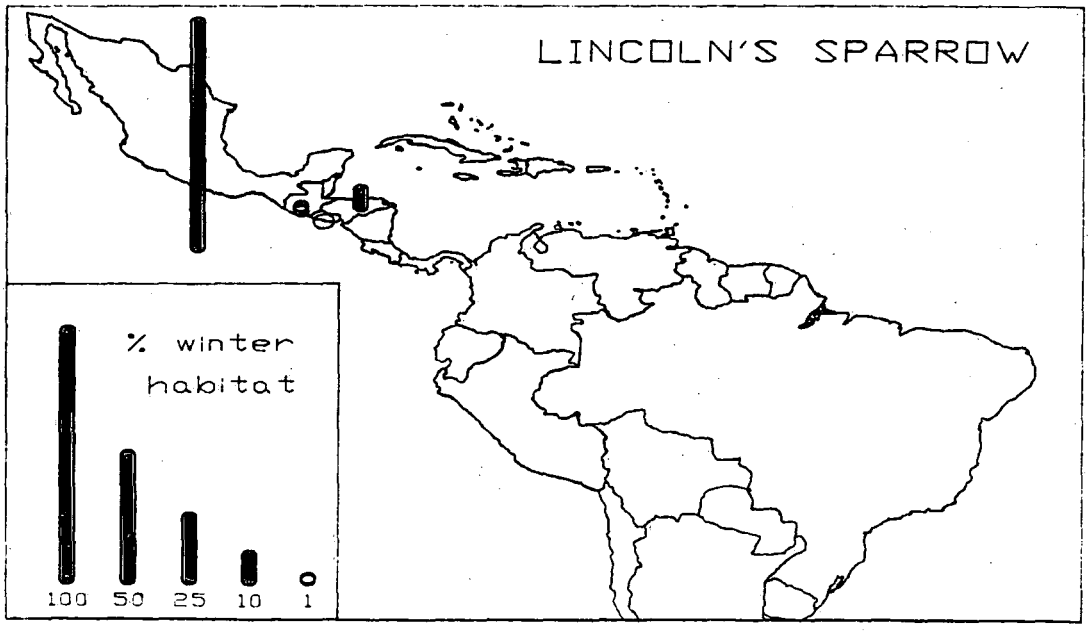

TRAILL'S FLYCATCHER
% winter habitat
100 50 25 10 0 1

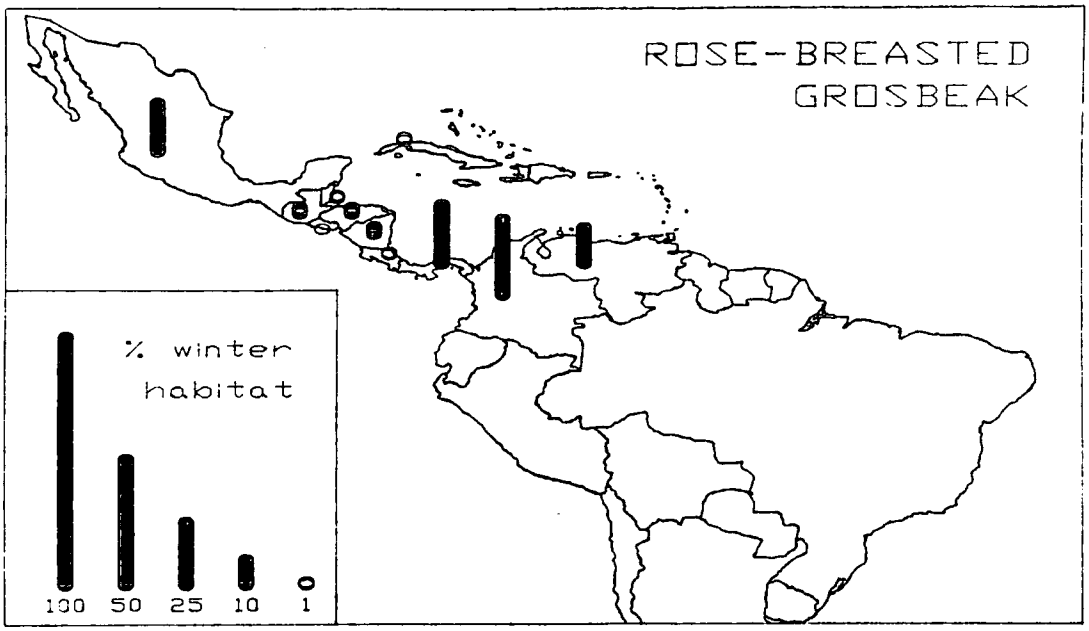

LEAST FLYCATCHER
% winter habitat
100 50 25 10 0 1

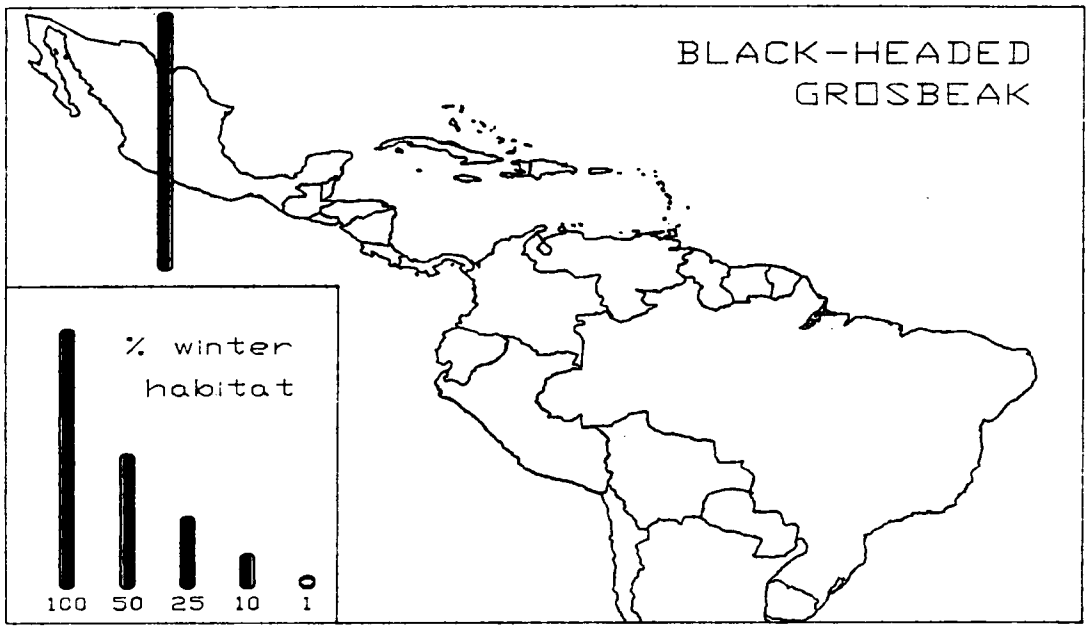

HAMMOND'S FLYCATCHER
% winter habitat
100 50 25 10 0 1

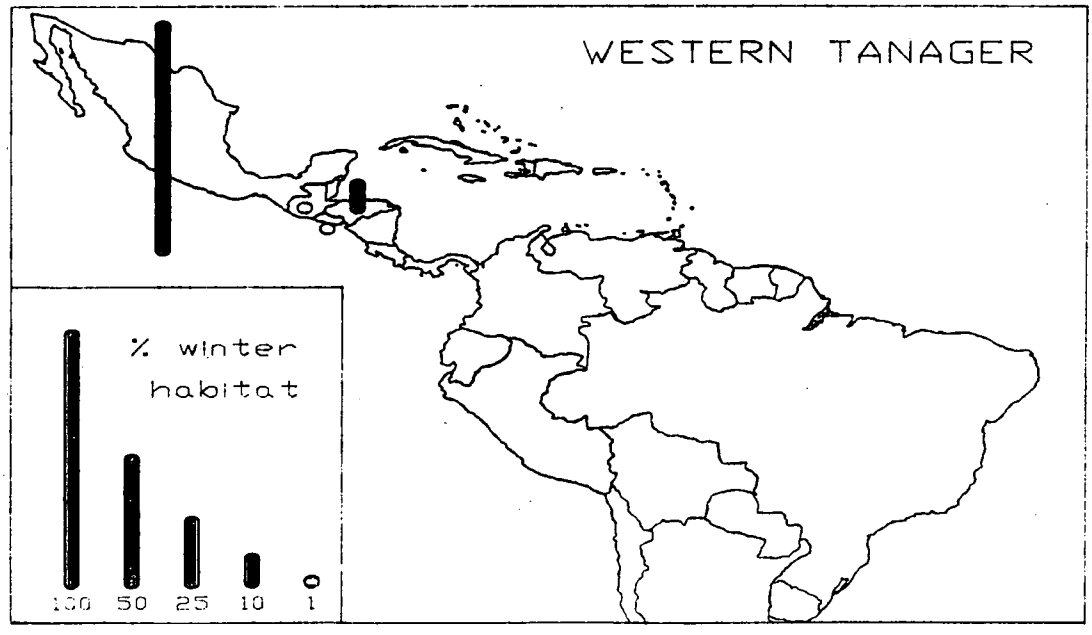

DUSKY FLYCATCHER
% winter habitat
100 50 25 10 1


BALTIMORE ORIOLE
% winter habitat
100 50 25 10 1


LINCOLN'S SPARROW
% winter habitat
100 50 25 10 1


ROSE-BREASTED
GROSBEAK
% winter
habitat
100 50 25 10 1


BLACK-HEADED
GROSBEAK
% winter
habitat
100 50 25 10 1


WESTERN TANAGER
% winter
habitat
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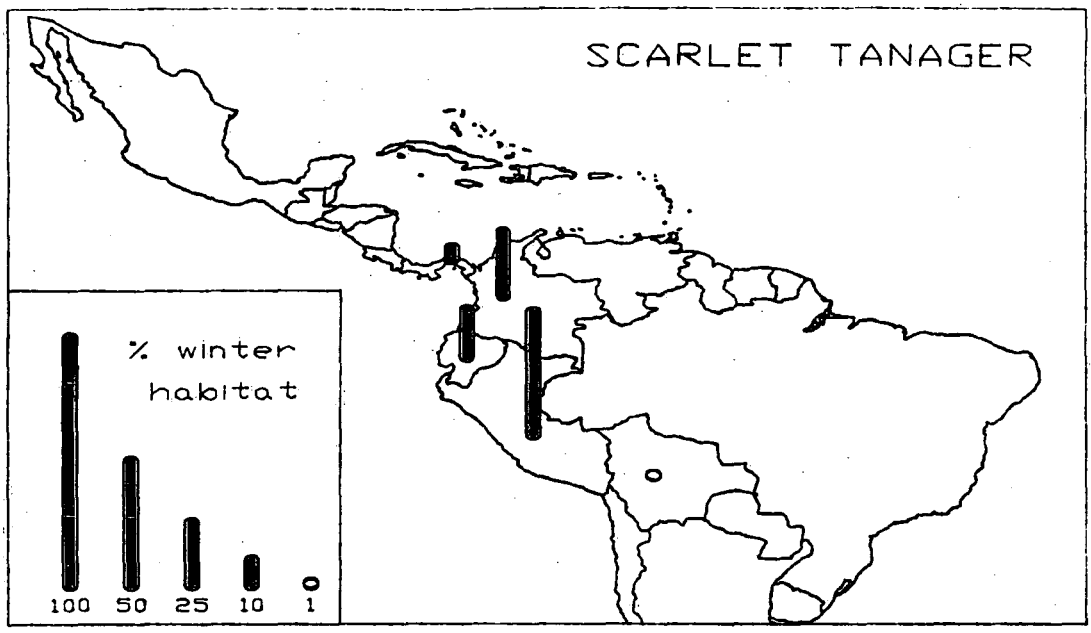
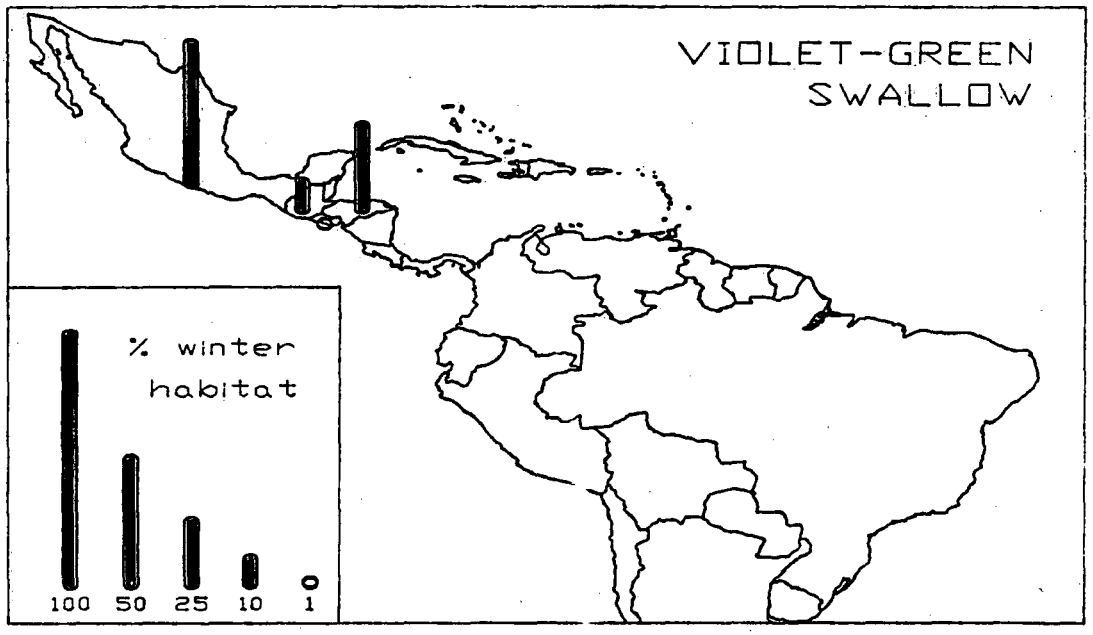
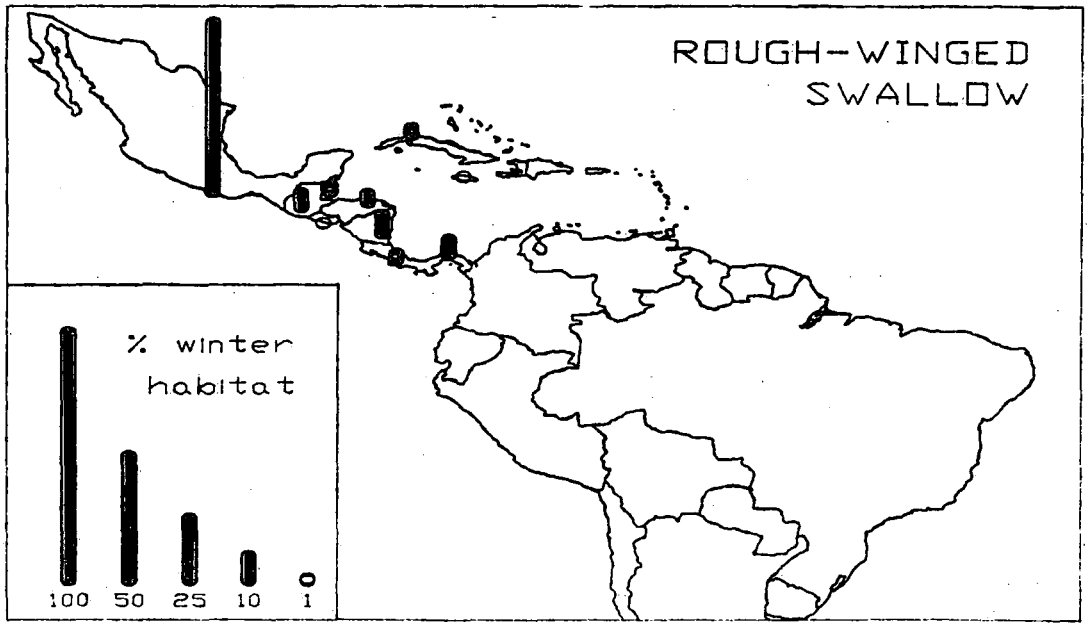
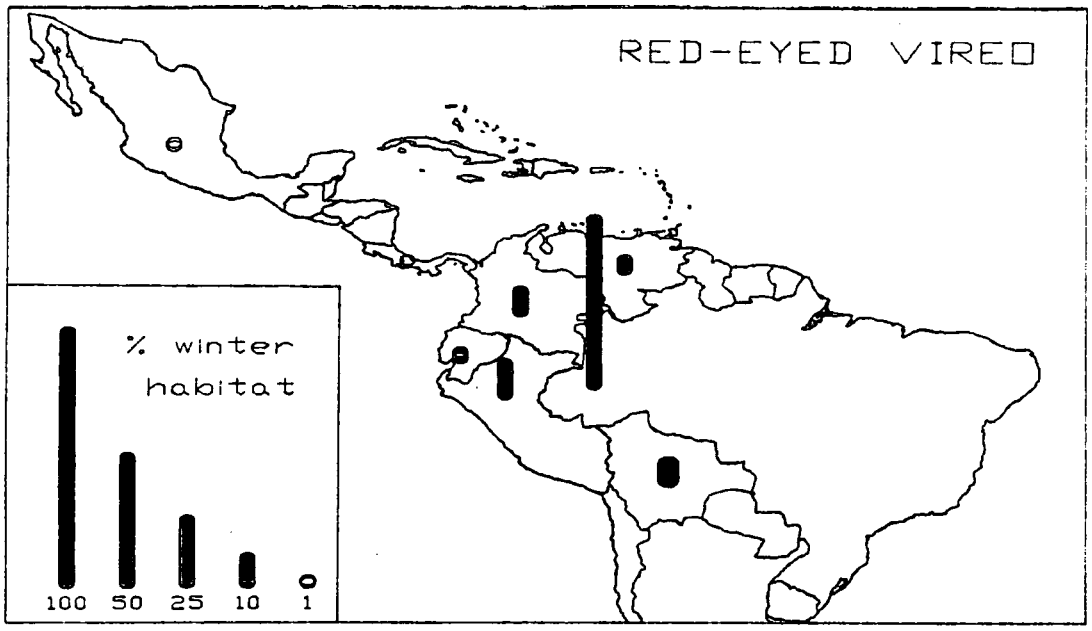
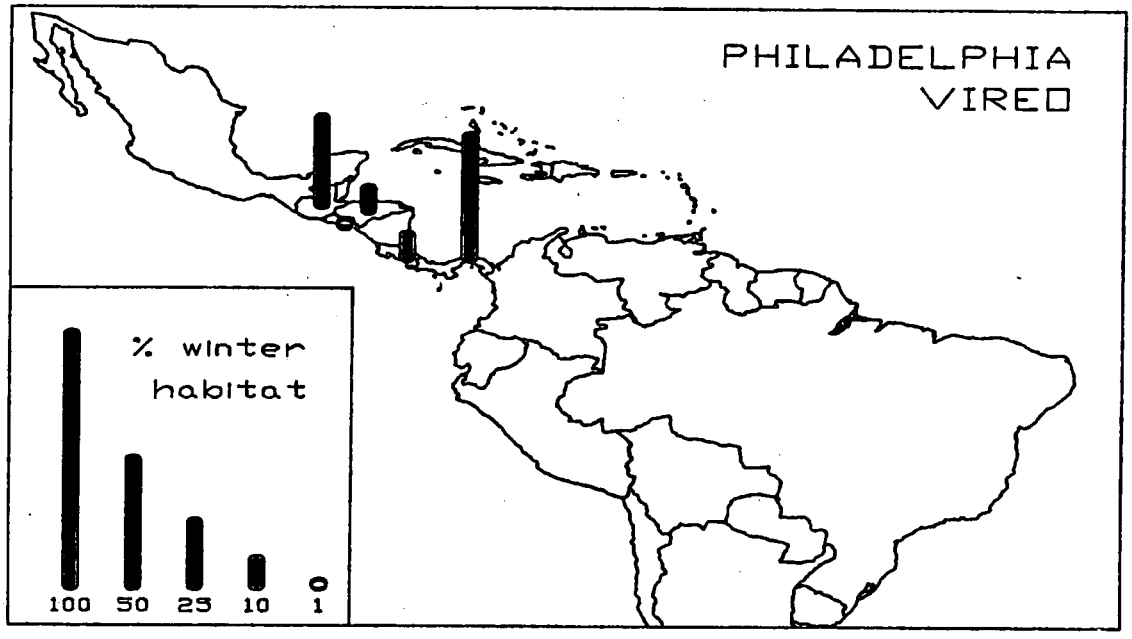
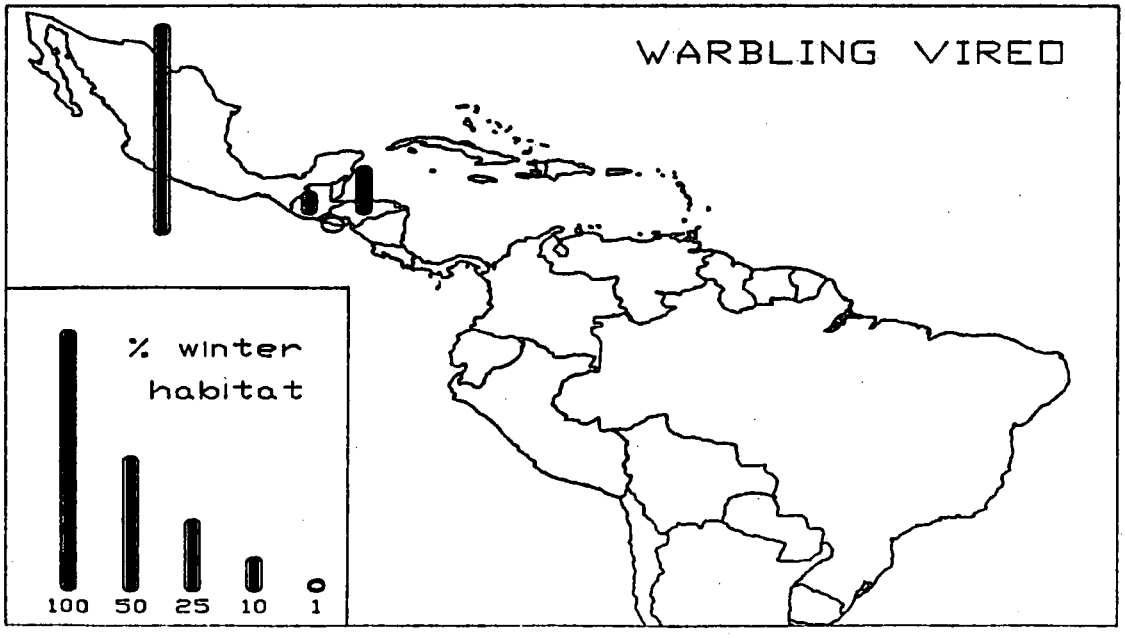

SCARLET TANAGER
% winter habitat
100 50 25 10 1

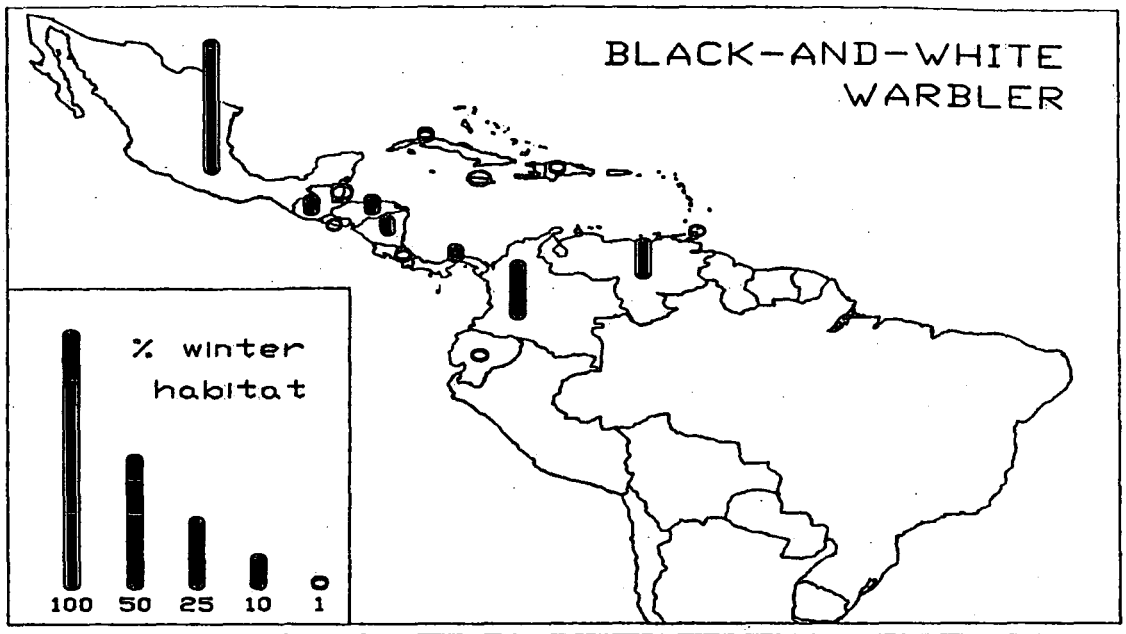

VIOLET-GREEN SWALLOW
% winter habitat
100 50 25 10 1

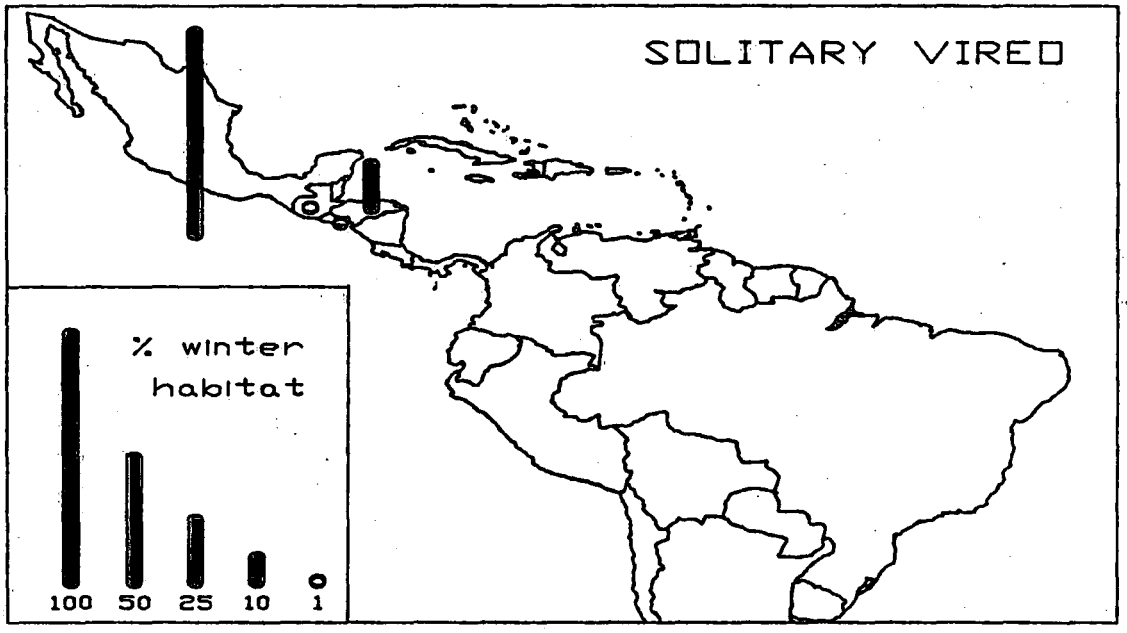

ROUGH-WINGED SWALLOW
% winter habitat
100 50 25 10 1

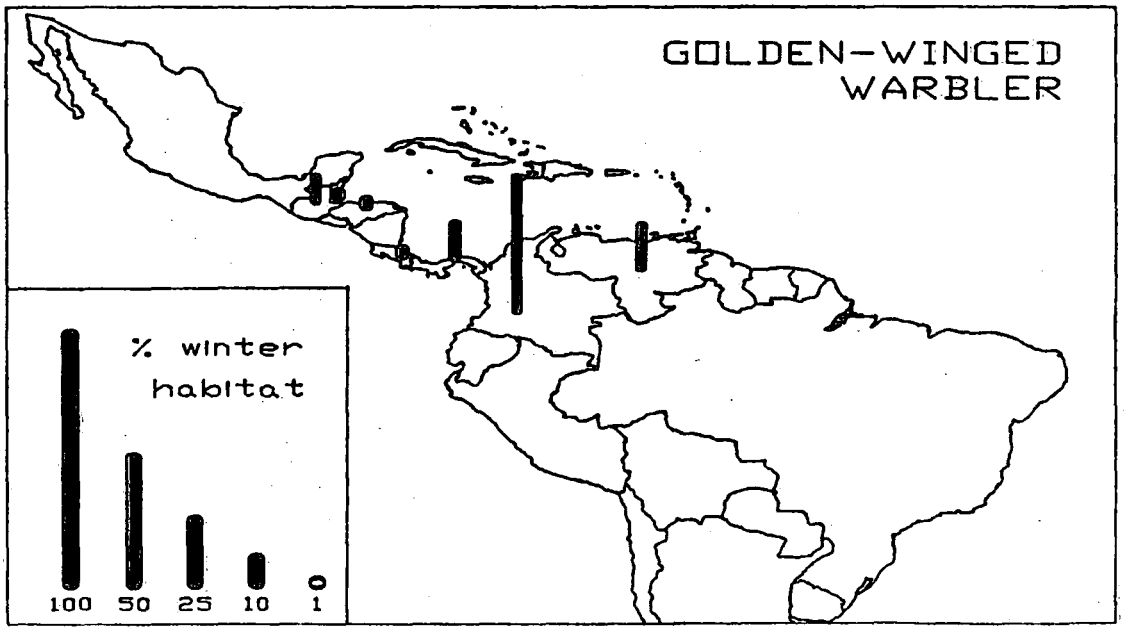

RED-EYED VIREO
% winter habitat
100 50 25 10 1

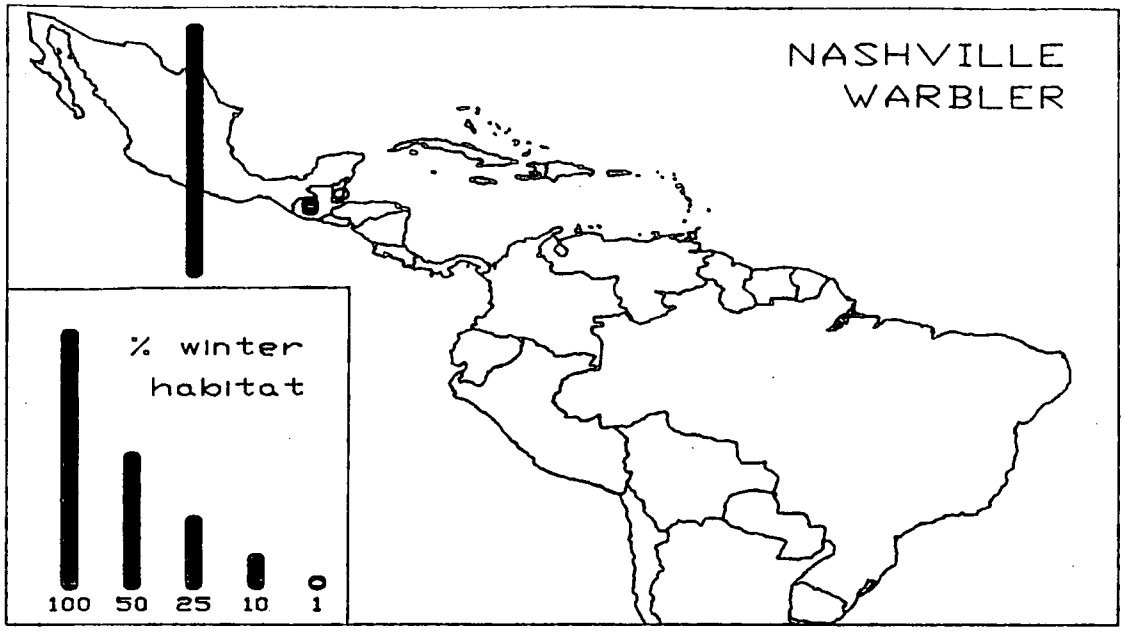

PHILADELPHIA VIREO
% winter habitat
100 50 25 10 1

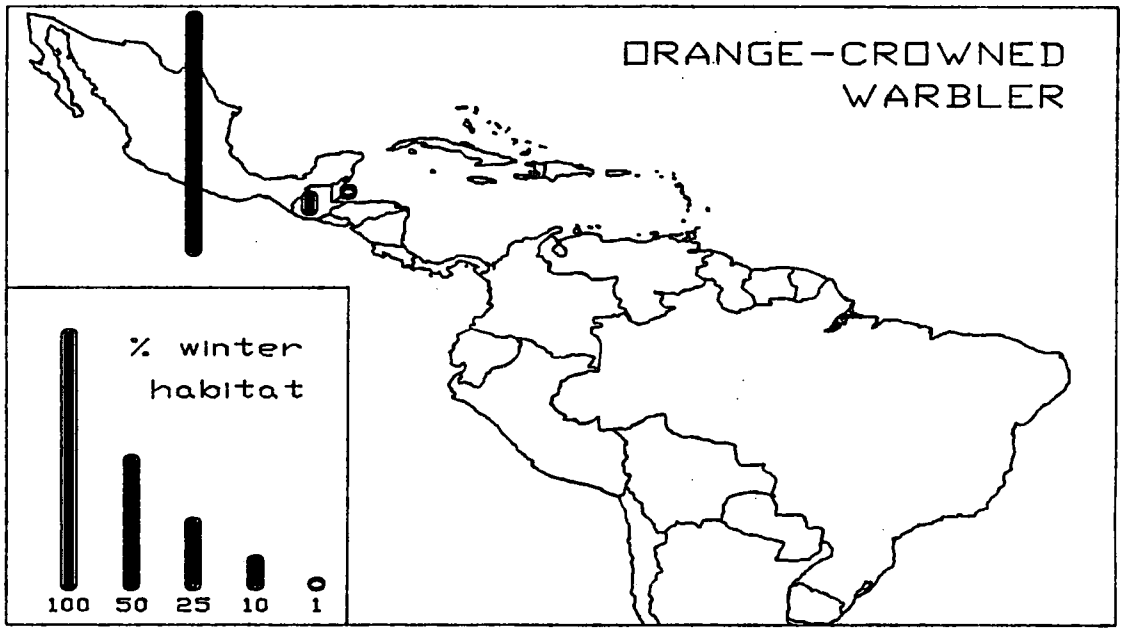

WARBLING VIREO
% winter habitat
100 50 25 10 1

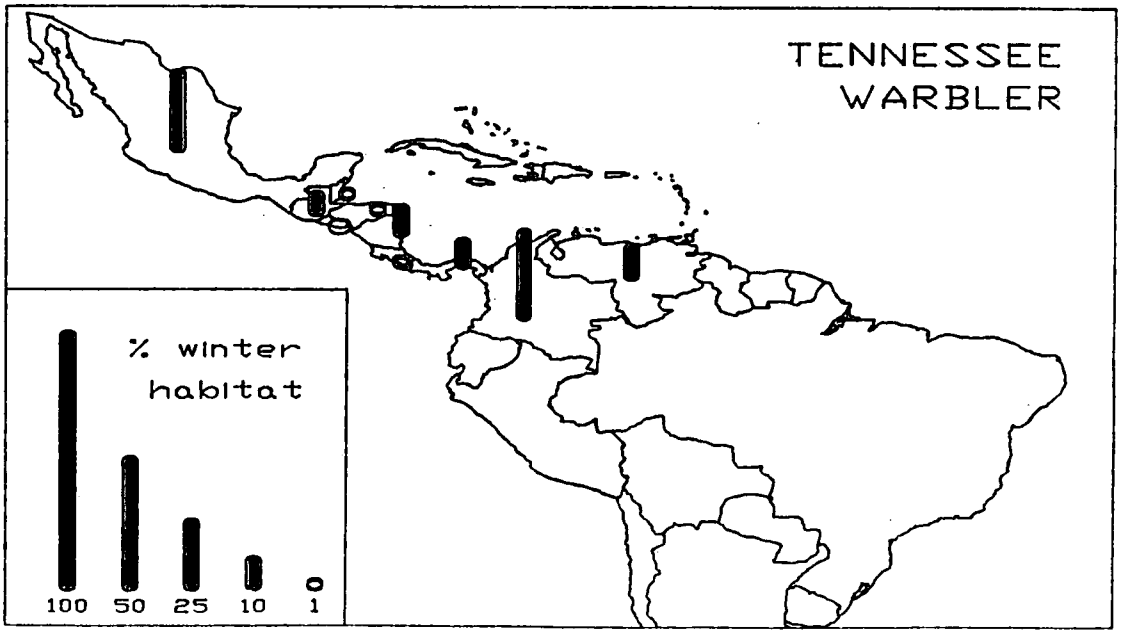

BLACK-AND-WHITE
WARBLER
% winter
habitat
100
50
25
10
1

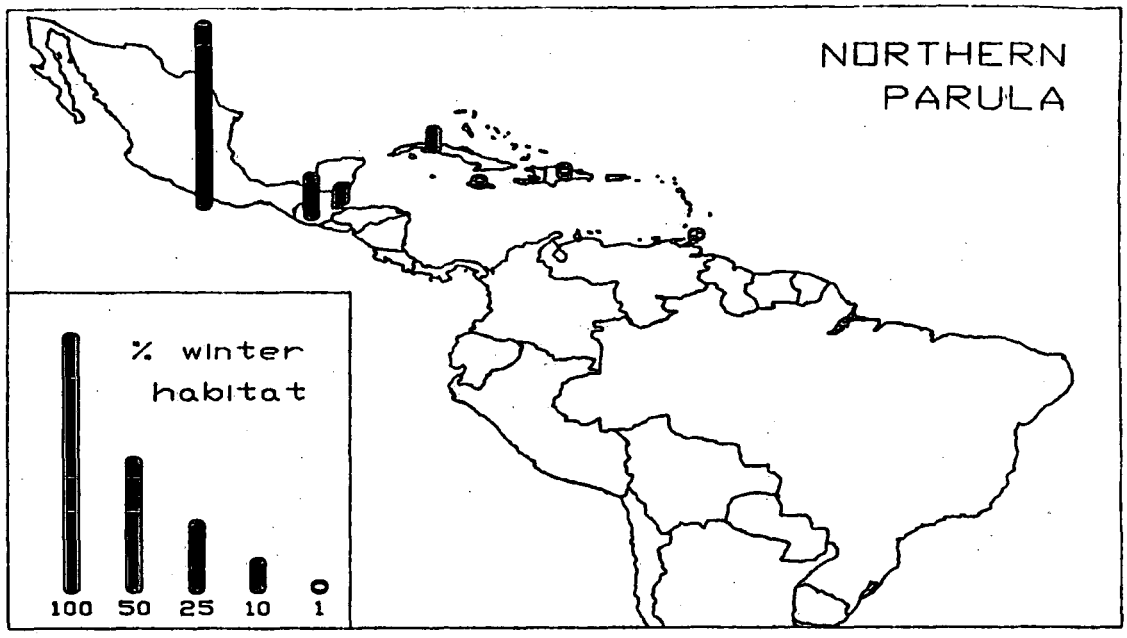

SOLITARY VIREO
% winter
habitat
100
50
25
10
1

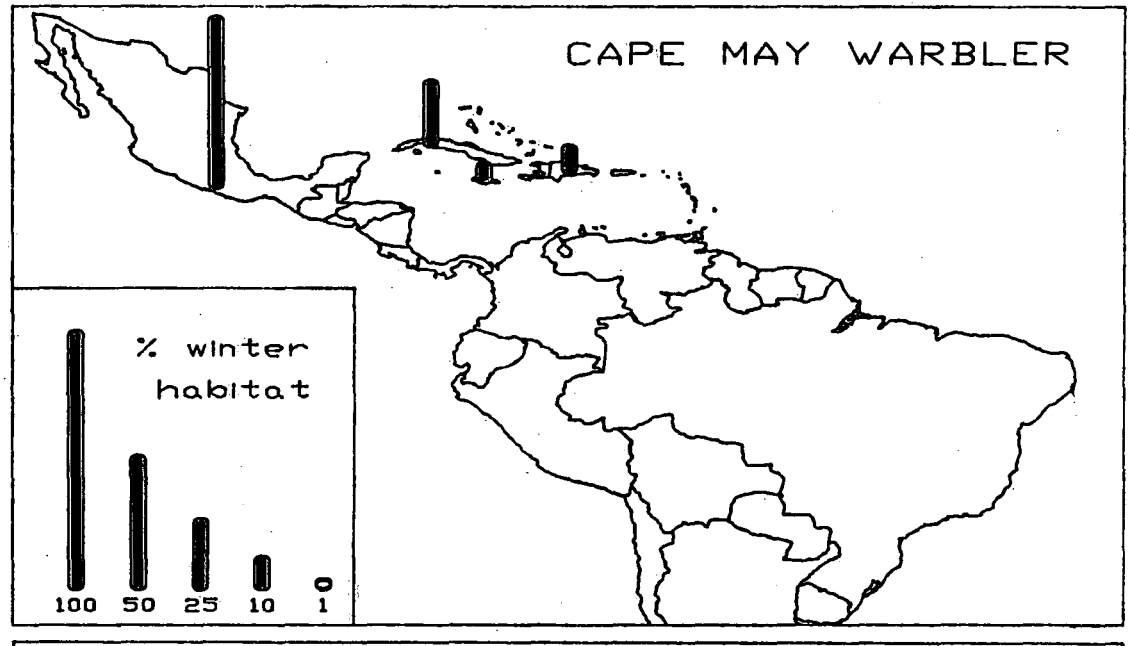

GOLDEN-WINGED
WARBLER
% winter
habitat
100
50
25
10
1

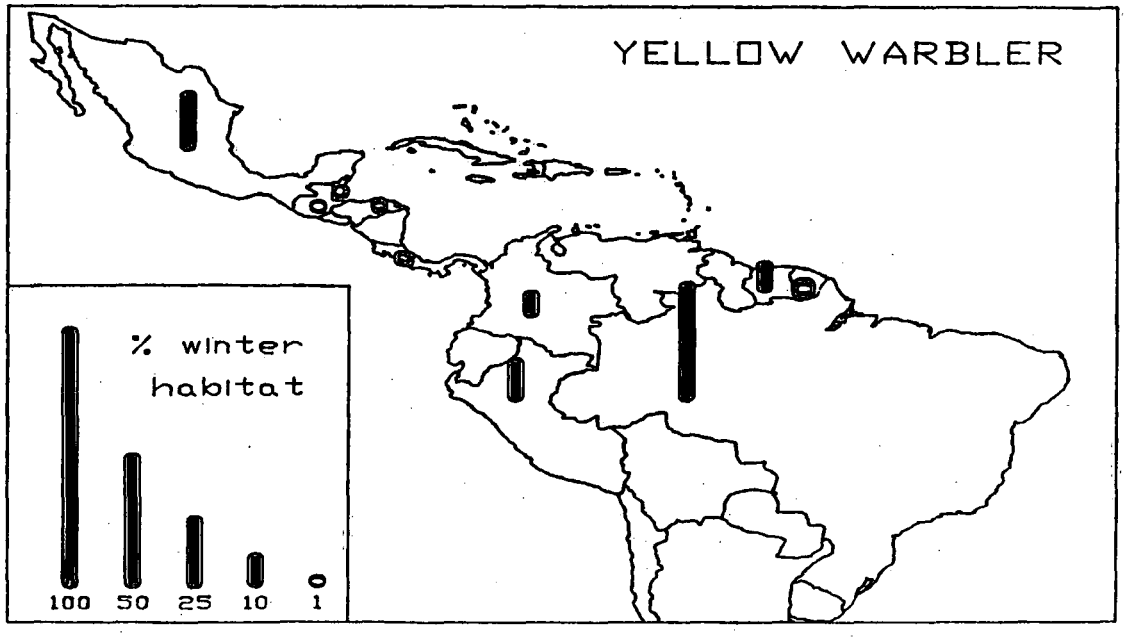

NASHVILLE
WARBLER
% winter
habitat
100 50 25 10 1

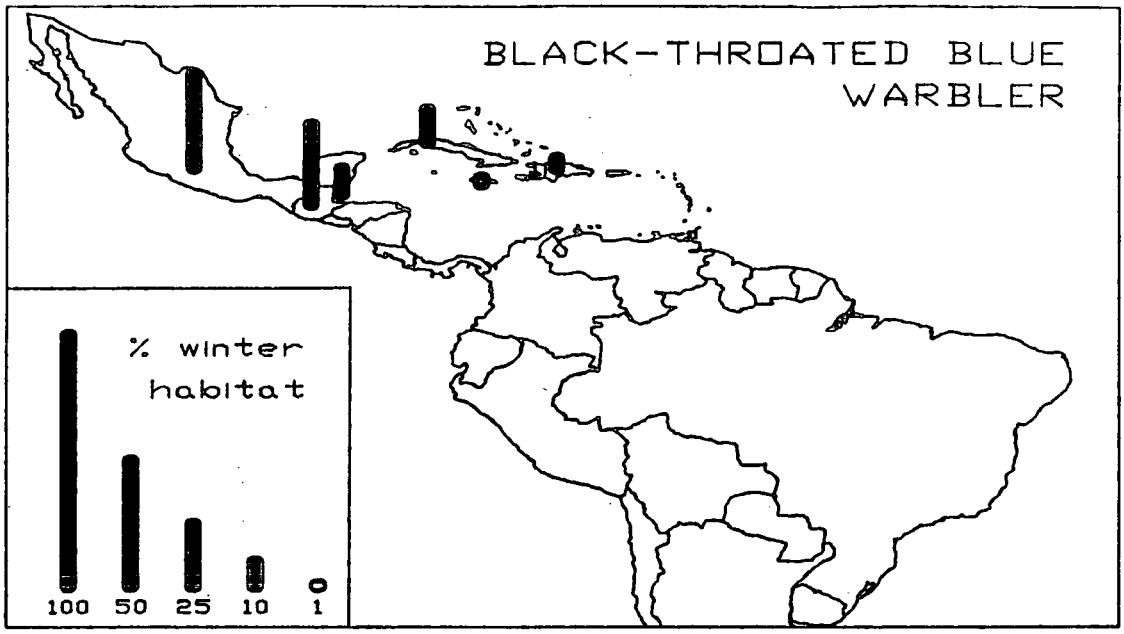

ORANGE-CROWNED
WARBLER
% winter
habitat
100 50 25 10 1

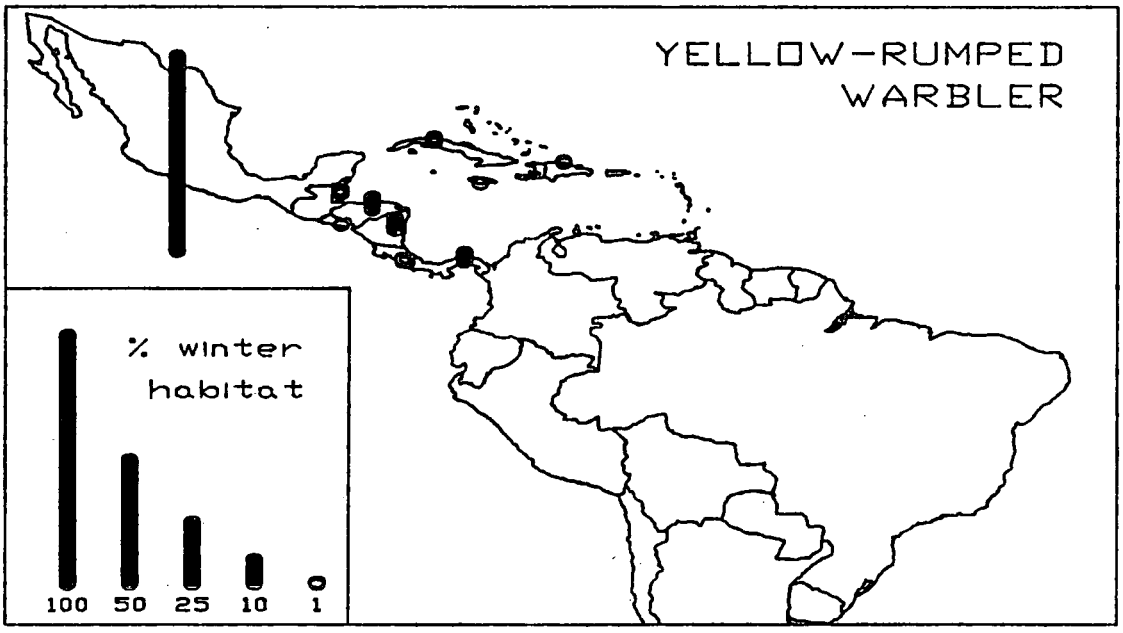

TENNESSEE
WARBLER
% winter
habitat
100 50 25 10 1

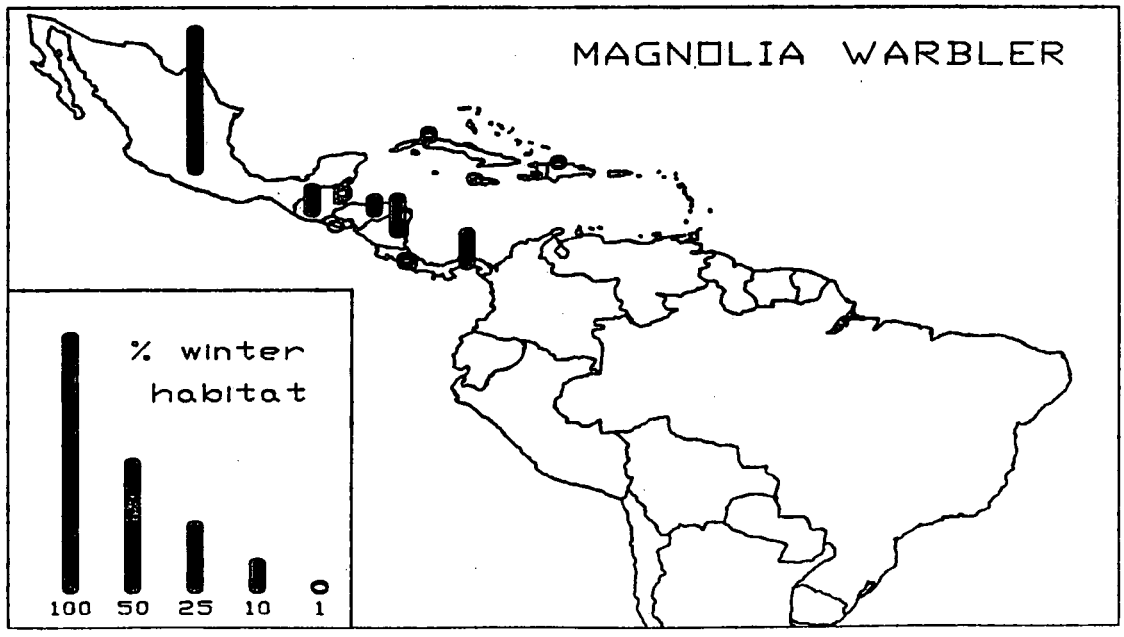

NORTHERN
PARULA
% winter
habitat
100
50
25
10
1

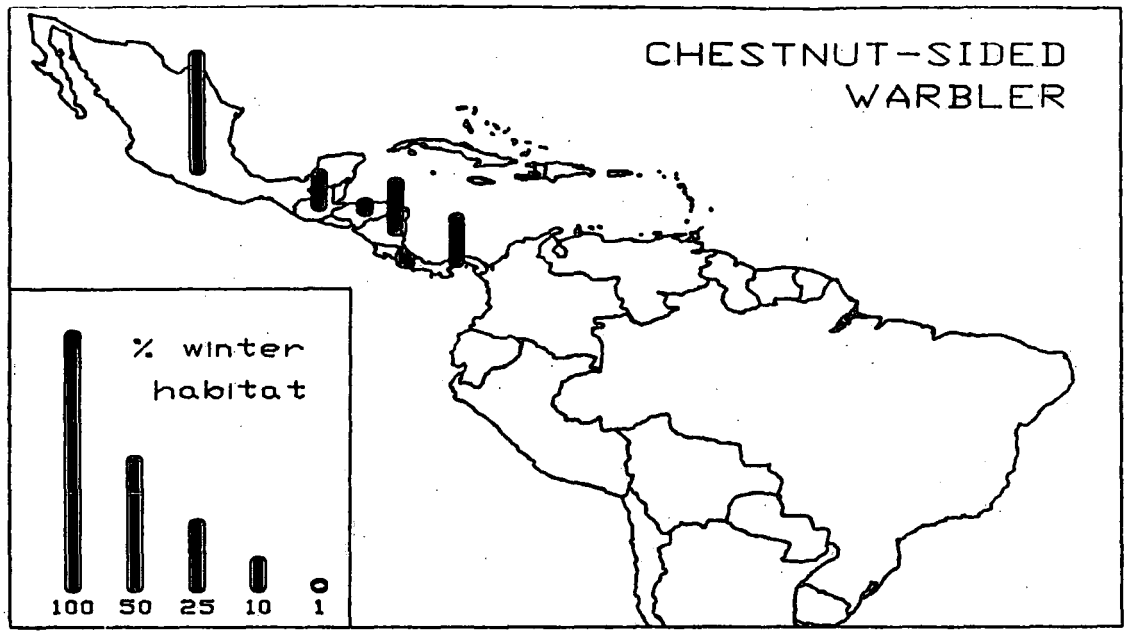

CAPE MAY WARBLER
% winter
habitat
100
50
25
10
1

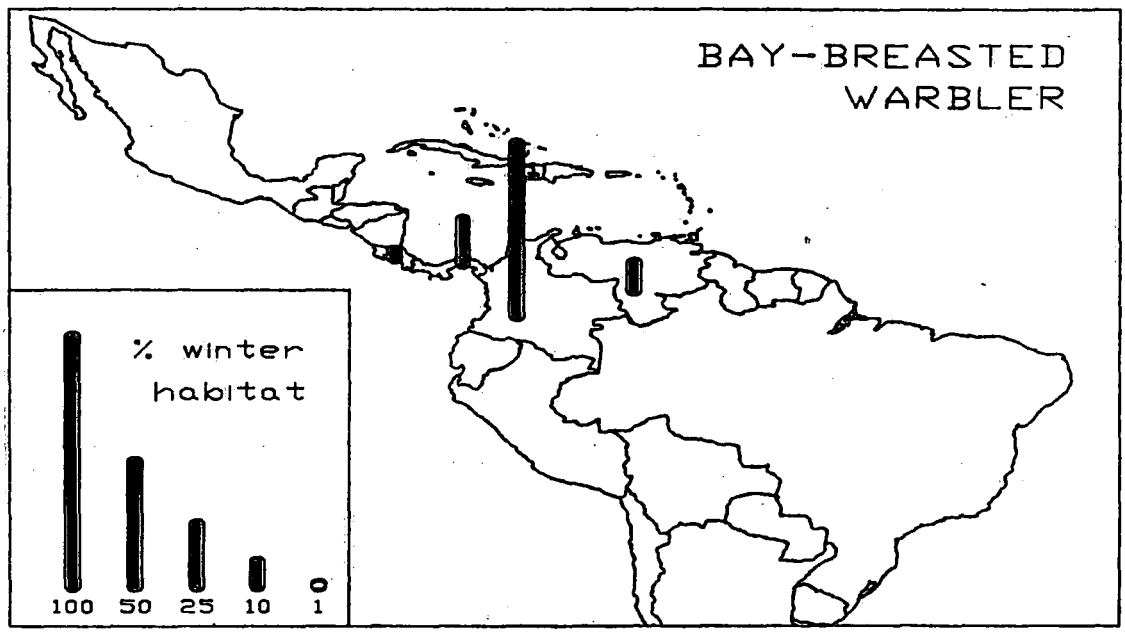

YELLOW WARBLER
% winter
habitat
100
50
25
10
1

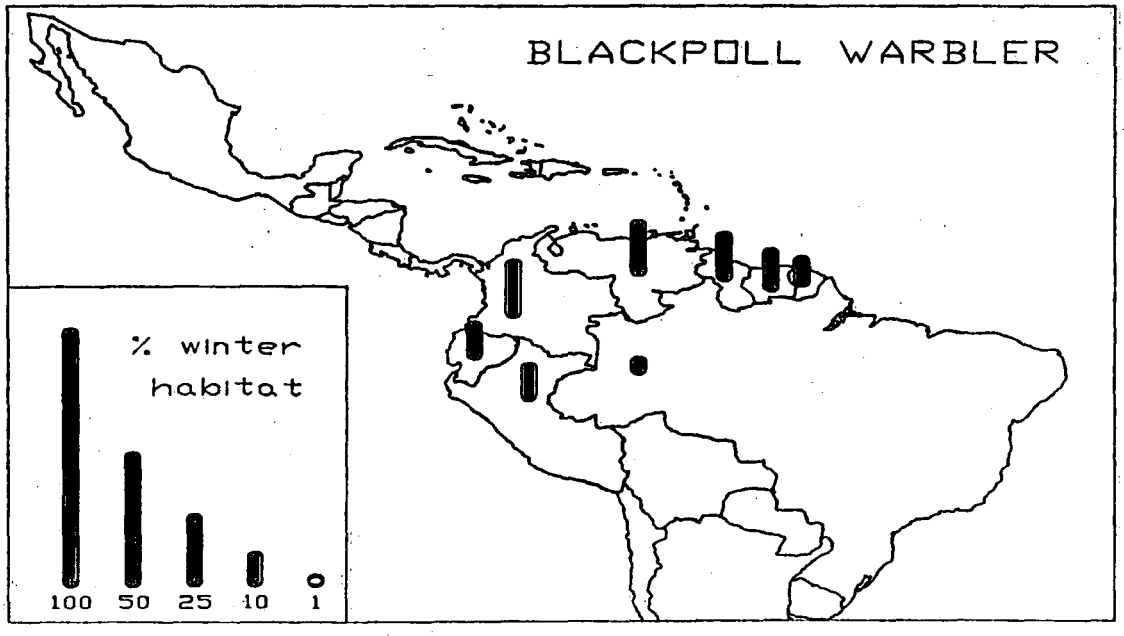

BLACK-THROATED BLUE WARBLER
% winter habitat
100 50 25 10 1

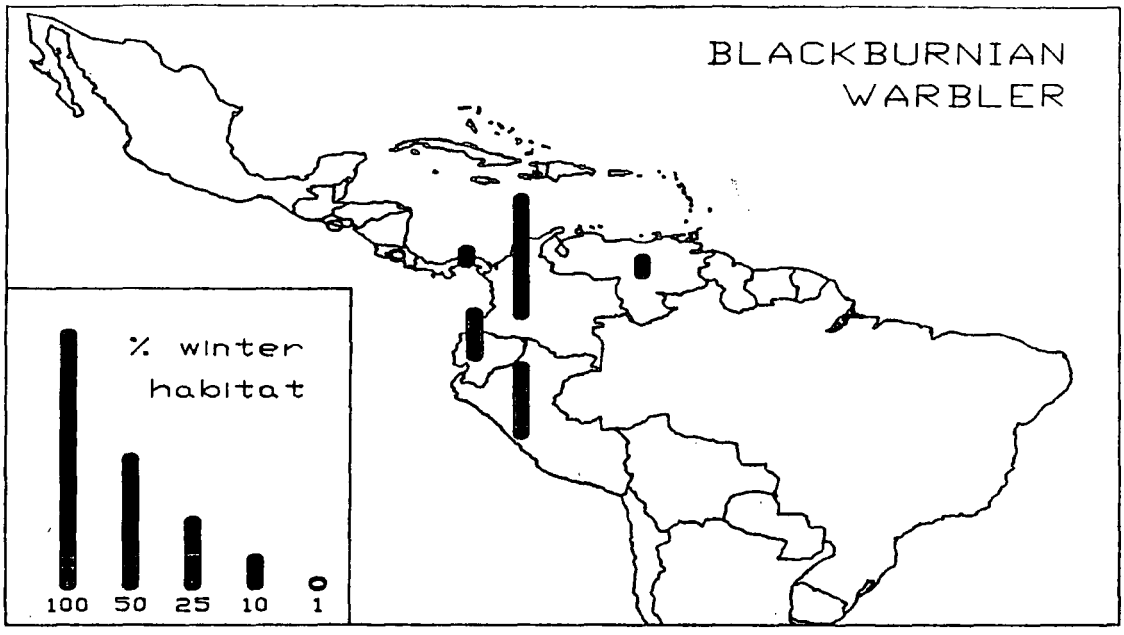

YELLOW-RUMPED WARBLER
% winter habitat
100 50 25 10 1

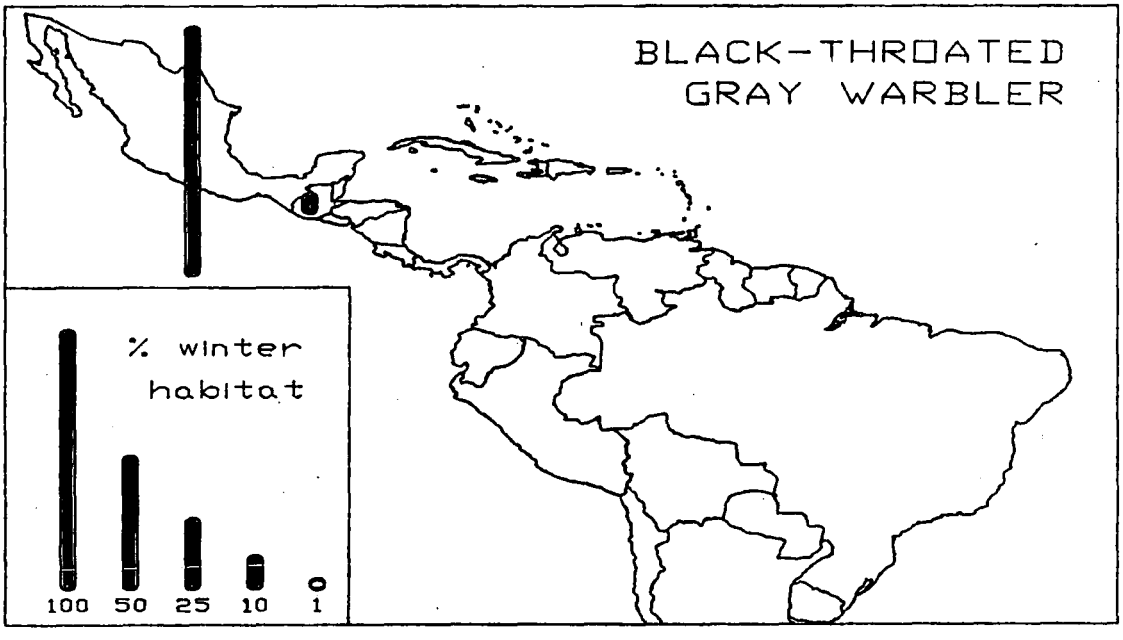

MAGNOLIA WARBLER
% winter habitat
100 50 25 10 1

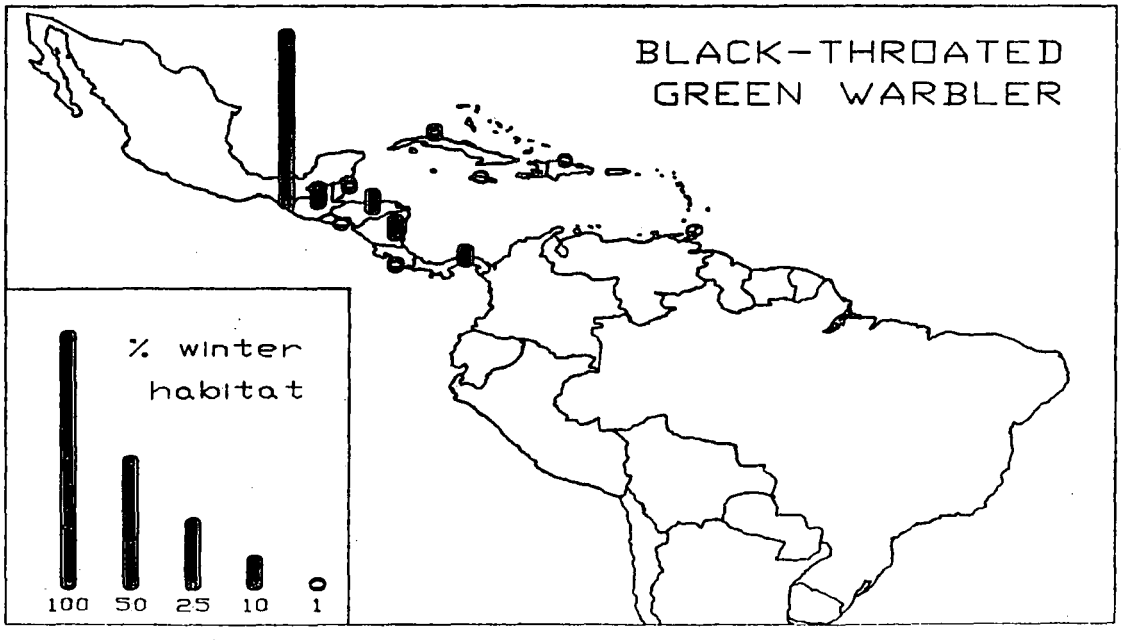

CHESTNUT-SIDED
WARBLER
% winter
habitat
100 50 25 10 1

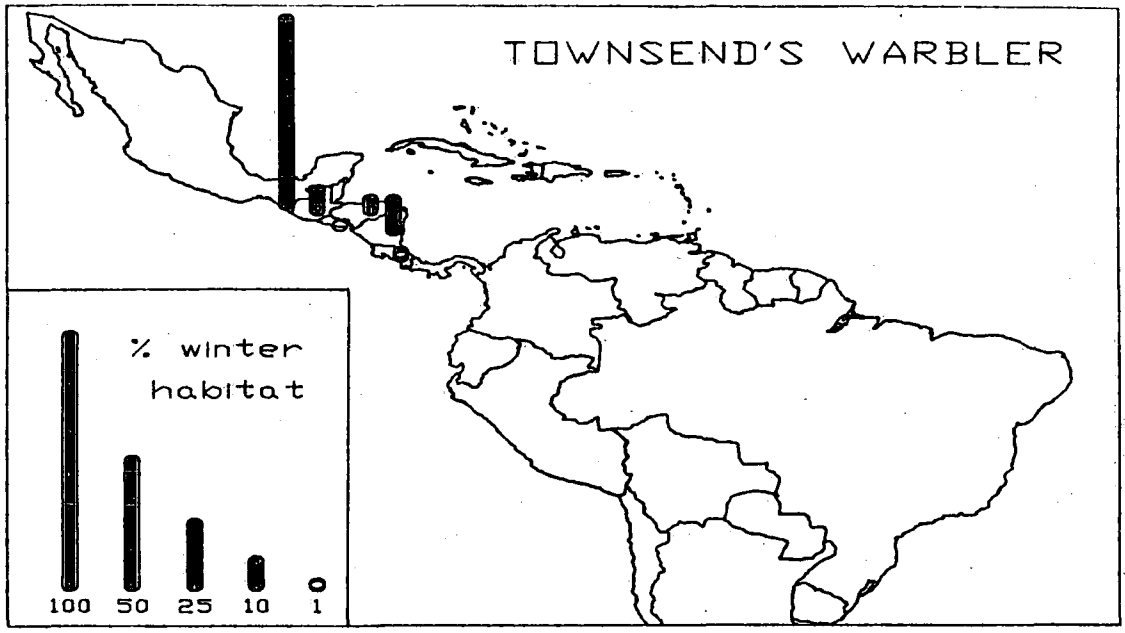

BAY-BREASTED
WARBLER
% winter
habitat
100 50 25 10 1

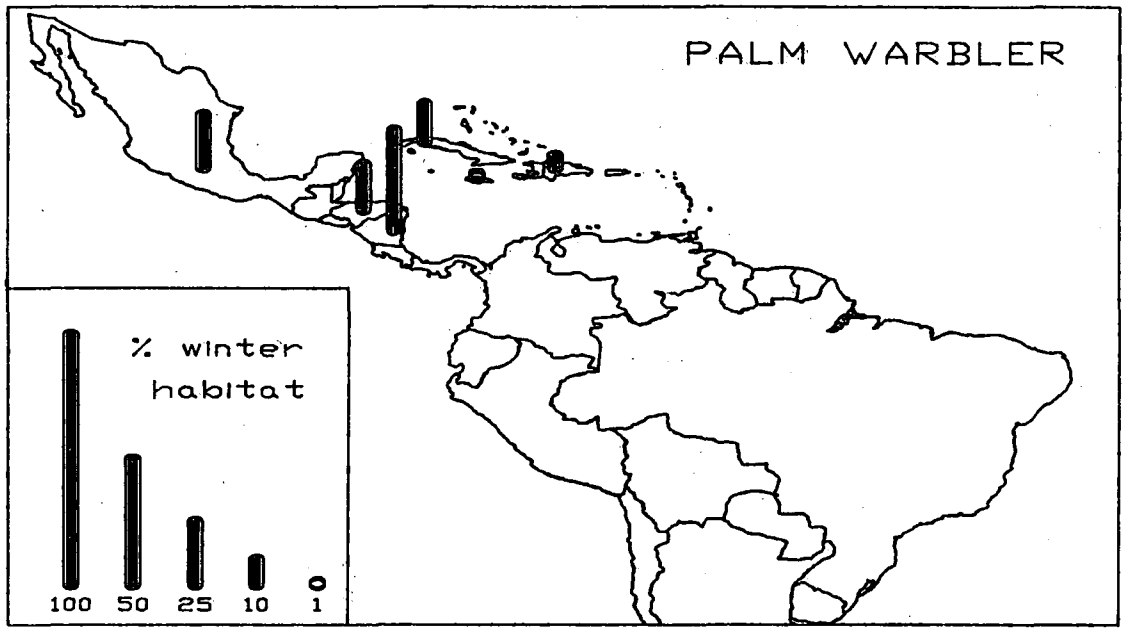

BLACKPOLL WARBLER
% winter
habitat
100 50 25 10 1

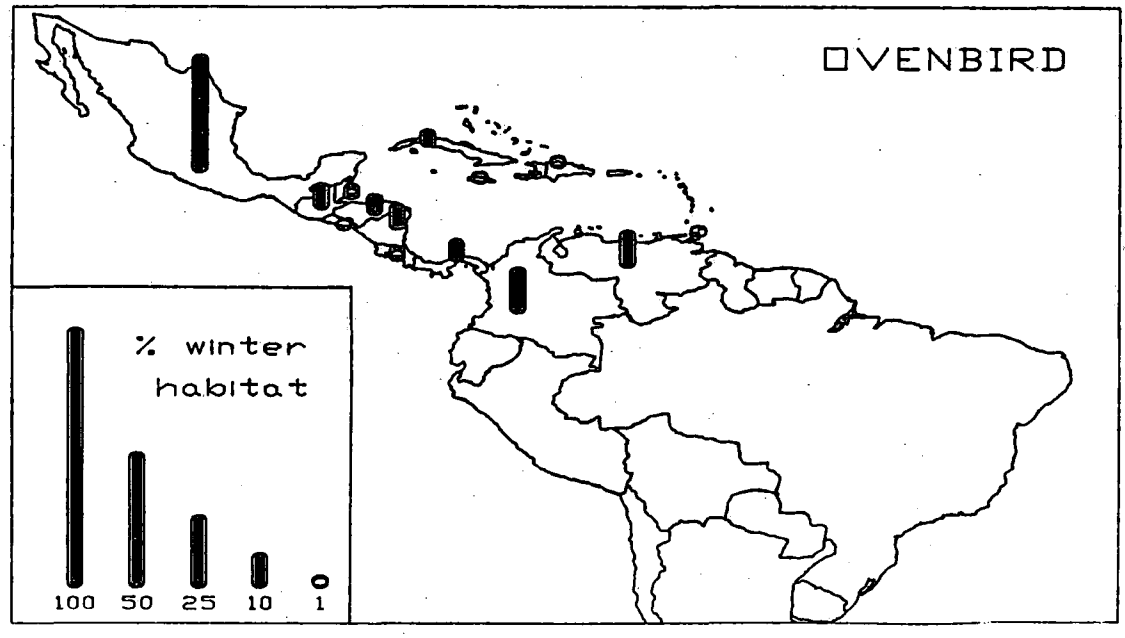

BLACKBURNIAN
WARBLER
% winter
habitat
100 50 25 10 1

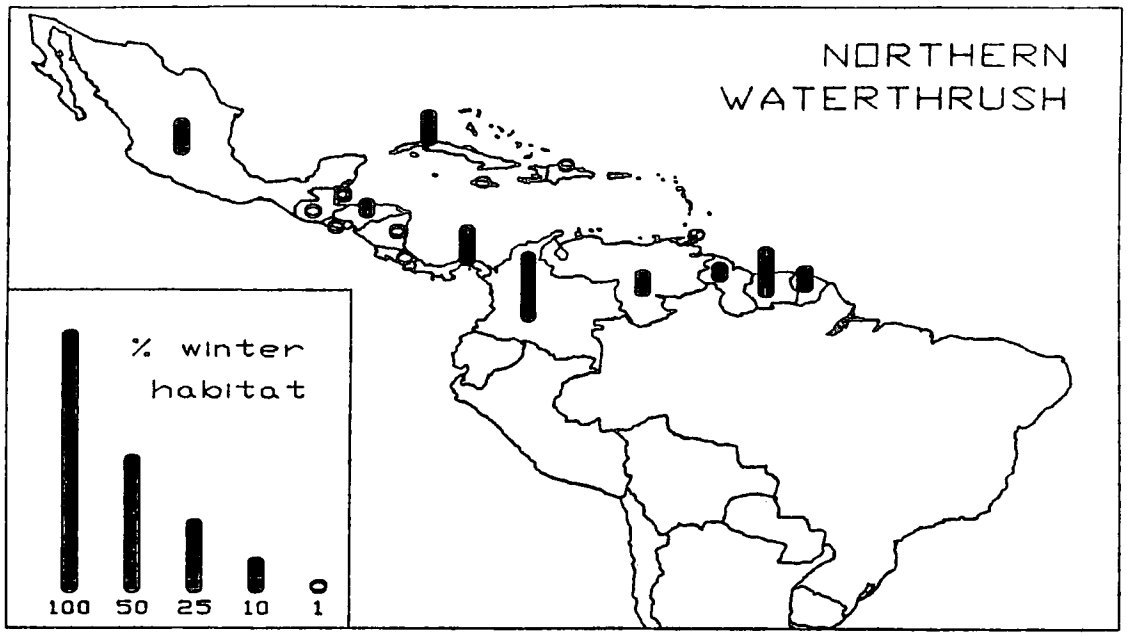

BLACK-THROATED
GRAY WARBLER
% winter
habitat
100 50 25 10 1

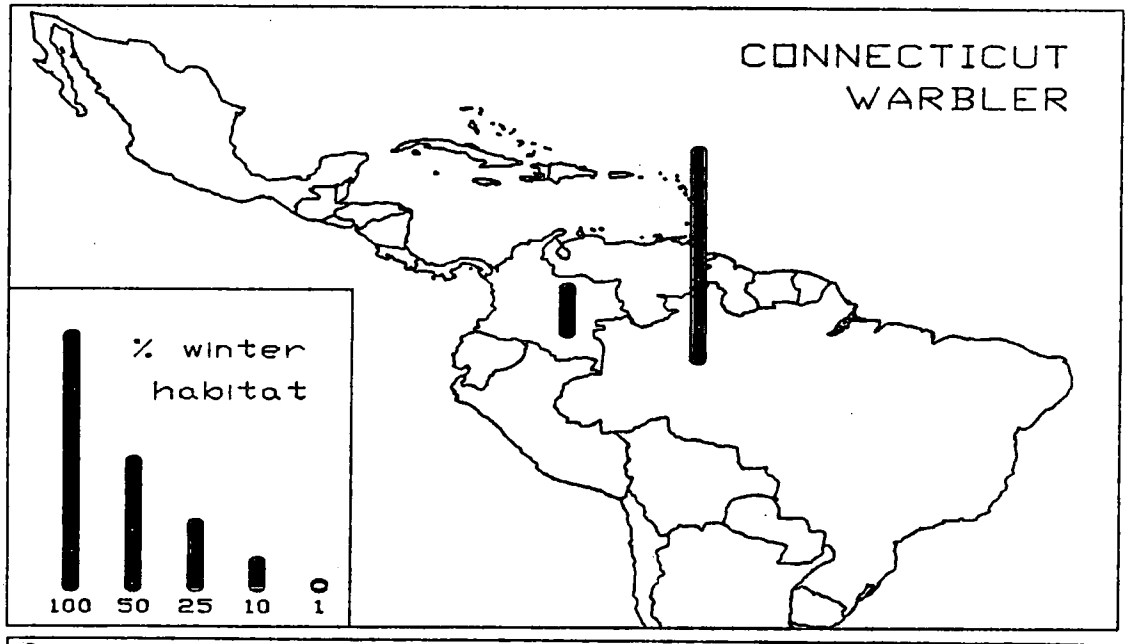

BLACK-THROATED
GREEN WARBLER
% winter
habitat
100 50 25 10 1

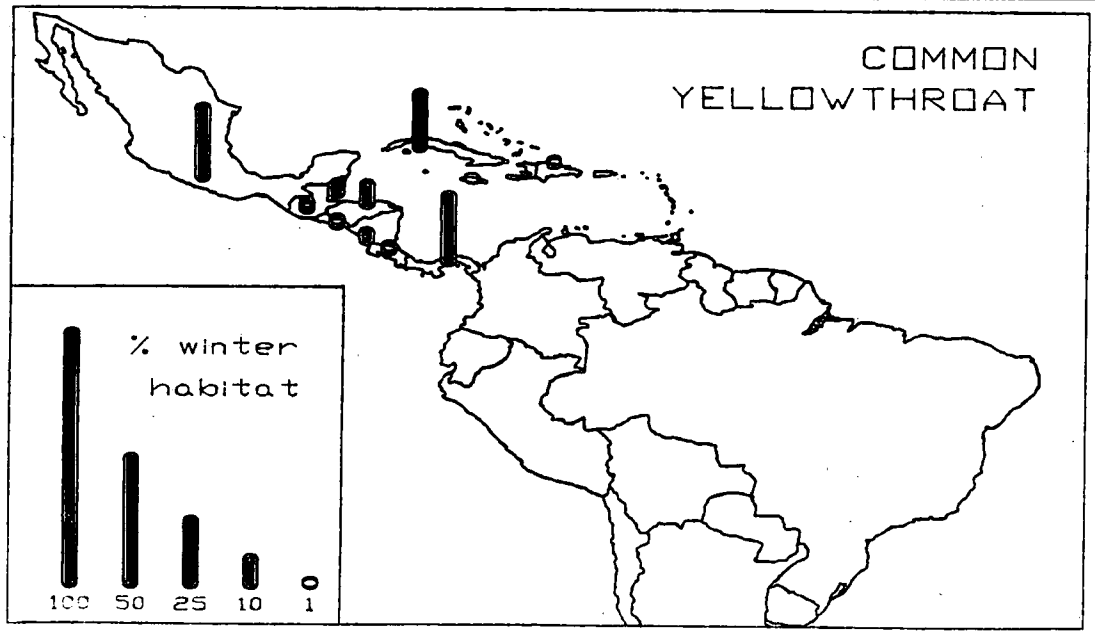

TOWNSEND'S WARBLER
% winter habitat
100 50 25 10 1


PALM WARBLER
% winter habitat
100 50 25 10 1

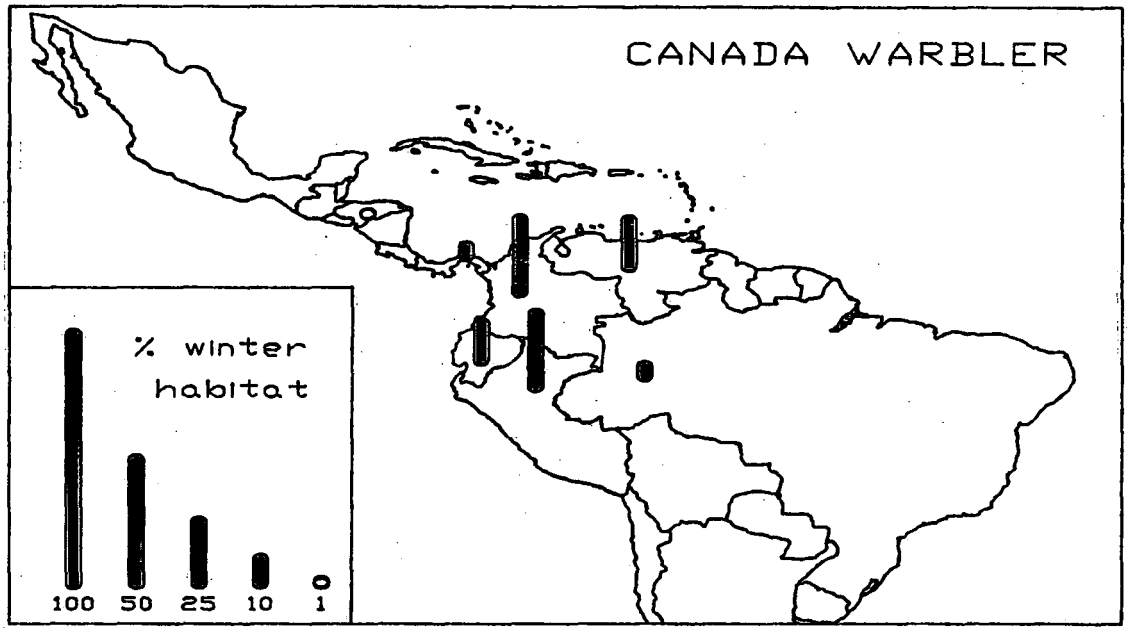

OVENBIRD
% winter habitat
100 50 25 10 1

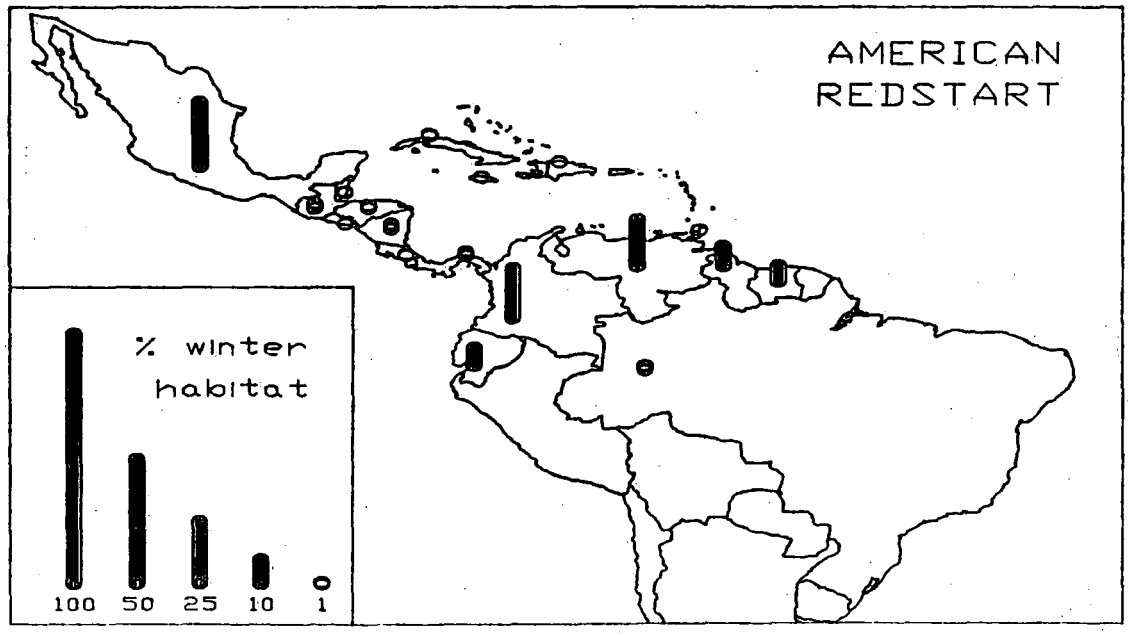

NORTHERN
WATERTHRUSH
% winter
habitat
100
50
25
10
1

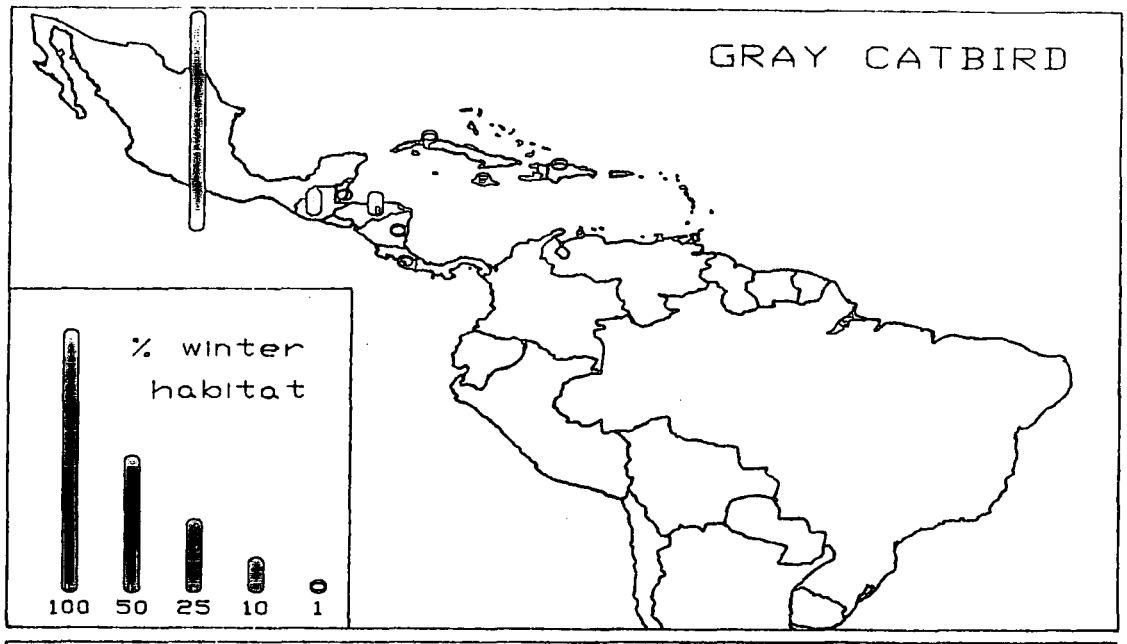

CONNECTICUT
WARBLER
% winter
habitat
100
50
25
10
1

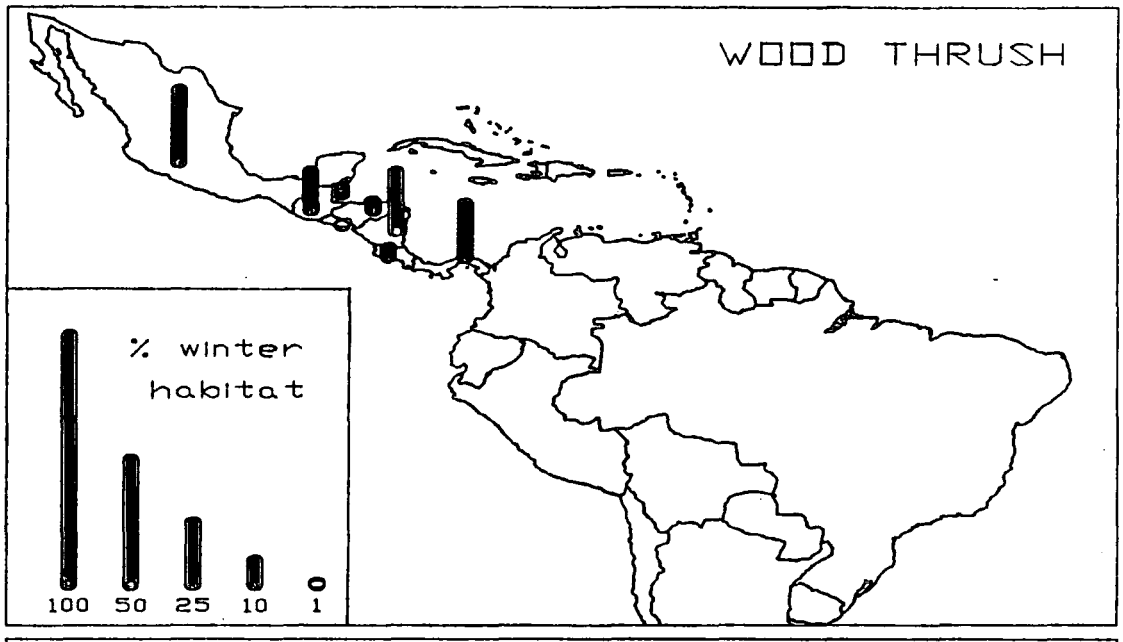

COMMON
YELLOWTHROAT
% winter
habitat
100
50
25
10
1

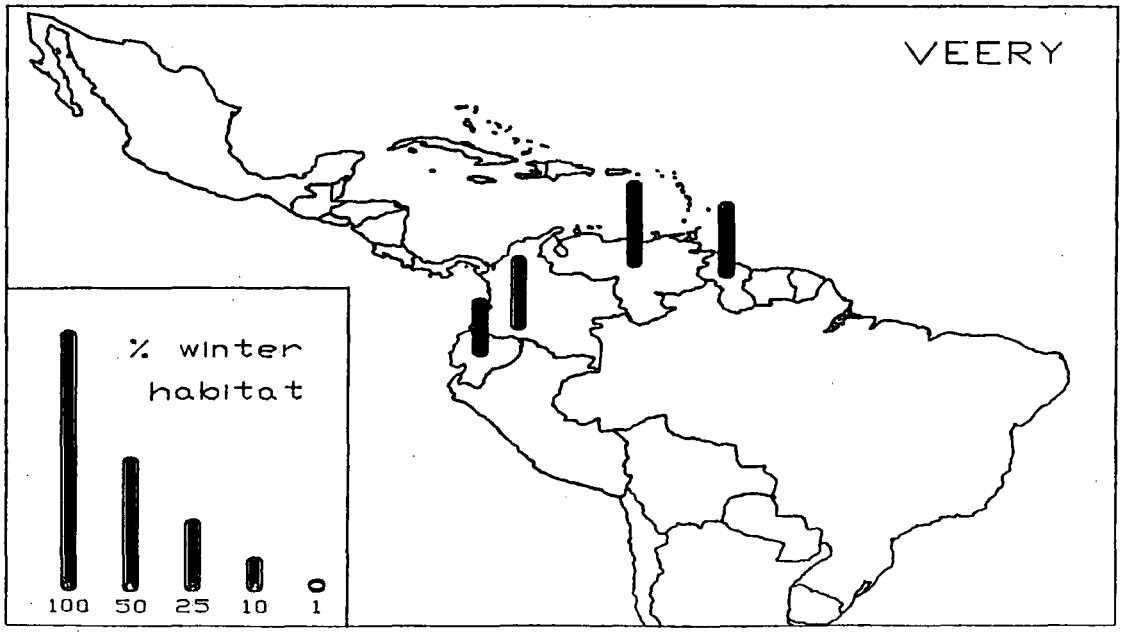

WILSON'S WARBLER
% winter habitat
100 50 25 10 1

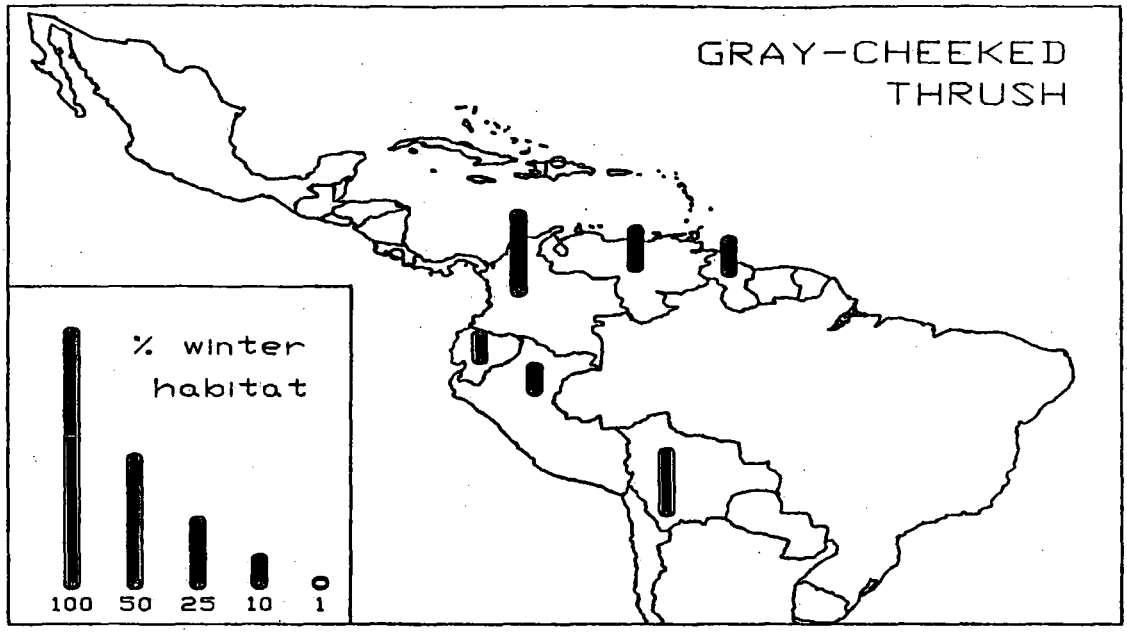

CANADA WARBLER
% winter habitat
100 50 25 10 1

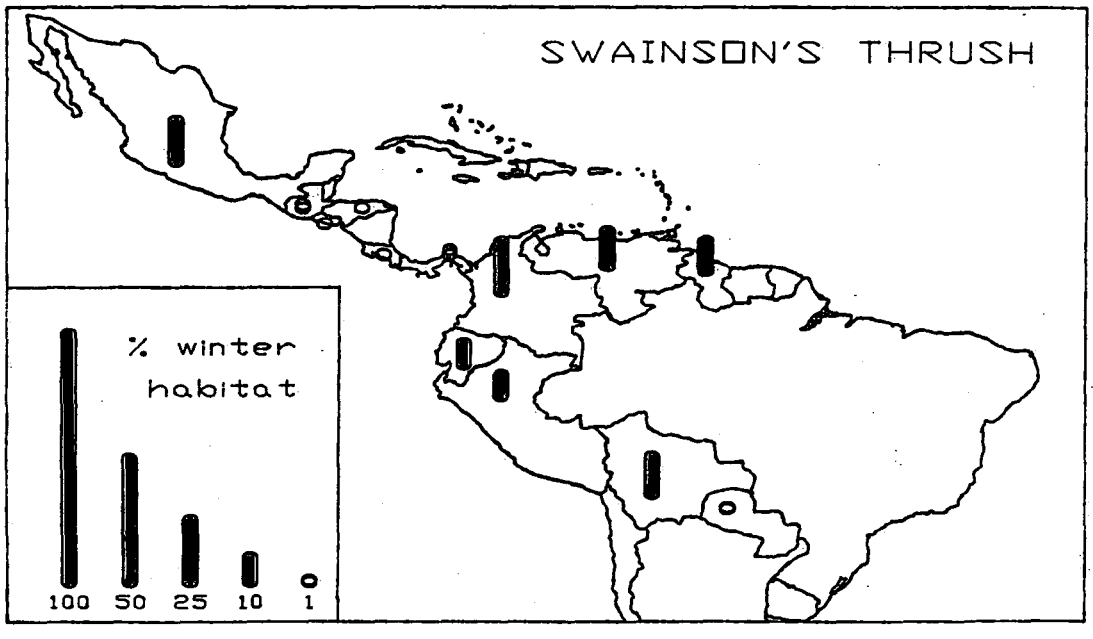

AMERICAN REDSTART
% winter habitat
100 50 25 10 1


GRAY CATBIRD
% winter habitat
100
50
25
10
1


WOOD THRUSH
% winter habitat
100
50
25
10
1


VEERY
% winter habitat
100
50
25
10
1


GRAY-CHEEKED
THRUSH
% winter
habitat
100
50
25
10
1


SWAINSON'S THRUSH
% winter
habitat
100
50
25
10
1

Chapter 5 - TRENDS IN SPECIES' POPULATIONS

There are five possible sources of data which might reflect trends in the breeding populations of Canadian forest birds. Three of these sources are schemes which were not intended to monitor population sizes but might nonetheless have some value in this context. Two - the Breeding Bird Survey, and the Breeding Bird Census Plot scheme - were designed and are used as population surveys; these are examined first.

i) Breeding Bird Survey

This survey consists of roadside counts (thus inevitably missing many forest birds), mainly of singing males, carried out at the height of the breeding season in a highly standardised way, along pre-defined routes of 40 km. A full description of the survey and its history is given by Robbins *et al.* (1982, 1986) (see also Bystrak 1981, Robbins *et al.* 1980, Robbins 1978). The first ten years of the scheme in Canada were described and analysed by Erskine (1978).

Although the survey itself has been carried out in a rigorously standardised fashion since its inception in 1965 (1966 in Canada), several different analytical methods have been used to detect trends (Robbins *et al.* 1980, 1982, 1986). The original method compared counts in pairs of successive years on the same route, and computed trends from annual indices, by applying annual ratios in relation to a selected "base" year. The only existing analysis of Canadian population trends (Erskine 1978) uses this method of "proportional base year adjustment". The method gives somewhat different trends depending on which year is selected as the base year for computing

ratios, and can give misleading trends (Robbins et. al. 1980, Geissler and Noon 1981). It has been replaced by calculations of the average annual proportional change for each route, using linear regression to estimate the slope of the logarithm of the annual count (Robbins et al. 1982) - the "weighted parametric slope" method of Geissler and Noon (1981). This is the method used by Robbins et al. (1982) in their analysis of trends for the whole of North America (see below). A modification of this method, testing trends by a permutation test rather than the "jacknife" test used by Geissler and Noon (1981), has been used to analyse trends within Canada (Collins and Wendt, in prep.).

Two independent analyses of trends shown by the Breeding Birds Survey in Canada are available. The first, by Robbins et. al. (1982), covers the whole of North America and uses Geissler and Noon's (1981) methods of analysis. It is a comprehensive study, analysing trends from the smallest geographical areas possible within the system (the areas of each physiographic stratum within each State or Province) and combining these geographically up to the level of the whole continent. The physiographic strata within Canada follow Aldrich's (1963) "life areas" as refined by Dr.A.J.Erskine (Robbins et al. 1982). Trends were analysed in strata within each State or Province; within an entire State or Province; within large geographical Regions (Eastern, Central and Western); separately for the whole of Canada (i.e. treating the entire country as one "region"); and for the continent as a whole. Species showing statistically significant trends within Canada, and the geographic divisions within which those trends occurred, are shown in Table 7. (These results were taken from Robbins et al.

(1982); this is a draft version of Robbins et al. (1986), which appeared during the final revision of this report).

The second analysis is of Canadian data only (Collins and Wendt (in prep.)). Their analysis covers six of 10 Canadian Breeding Bird Survey "Regions," some of whose borders coincide with those of the physiographic strata used by Robbins et al. (1982), some with the Rowe-Halliday forest regions, and some with neither (see Chapter 3).

Table 7 summarises the trends found by these two studies. They cover similar periods of time (1965 or 1966 - 1979 in Robbins et al., 1966- or 1967 - 1979 in Collins and Wendt), and in both cases, only those trends found to be statistically significant are shown. Trends are mentioned only when they occur within Canada, or in a geographic area which includes part of Canada. Collins and Wendt (in prep.) analysed several different time periods separately, and found several cases where trends were significant over one time period but not over another; the time period used here is chosen to be as close as possible to that used by Robbins et al. to facilitate comparison between the two studies.

Some of the increases noted in Table 7 - for example Turkey Vulture, Rough-winged Swallow - arise from range expansions into the region concerned. Robbins et al. (1982, 1986) were able to interpret all the population changes that they documented in terms of either weather or habitat changes within the continental United States. Long-range neotropical migrants were identified as being particularly susceptible to the fragmentation of forests on the breeding grounds; such fragmentation, combined with periodic outbreaks of spruce budworm

Table 7. TRENDS IN BREEDING BIRD SURVEYS OF CANADIAN NEOTROPICAL FOREST MIGRANTS.

SPECIES	REGION(S)	STUDY* R	STUDY* CW
Turkey Vulture	Great Lakes	+	NA
Broad-winged Hawk	Central; continent	+	NA
Black-billed Cuckoo	Gt. Lakes; eastern; Canada; continent	+	NA
Chimney Swift	Great Lakes; Continent	+	NA
	New Brunswick	–	
Yellow-bellied Sapsucker	New Brunswick; Nova Scotia; St.Lawrence; eastern; Canada; continent	–	0
	Aspen parklands; western	+	0
Eastern Kingbird	Ontario; Quebec; Canada	+	0
Yellow-bellied Flycatcher	Eastern	+	NA
Dusky Flycatcher	B.C.	+	NA
Traill's Flycatcher	Western	–	0
Least Flycatcher	Alberta; Saskatchewan; Quebec	+	0
Western Wood Pewee	Continent	–	
	Southern B.C. (Reg.6)		–
Olive-sided Flycatcher	Western; Quebec	–	NA
Northern Oriole	Saskatchewan; Ontario; eastern; central; continent	+	NA
Lincoln's Sparrow	New Brunswick	+	NA
Rose-breasted Grosbeak	Ontario; Quebec; Maritimes; eastern; continent	+	
	Maritimes; central (Reg.2); southern Ont. (Reg.3)		+

Table 7 continued.

SPECIES	REGION(S)	STUDY* R	STUDY* CW
Black-headed Grosbeak	B.C.	+	NA
Scarlet Tanager	Eastern	+	NA
Western Tanager	B.C.; Canada	+	
	Southern B.C. (Reg.6)		+
Rough-winged Swallow	Ontario	+	NA
Red-eyed Vireo	Maritimes; cent. prairies (Reg.5)	O	+
Warbling Vireo	B.C.	–	O
	Ontario	+	
Solitary Vireo	Quebec; New Brunswick	+	NA
Black-and-white Warbler	Nova Scotia	+	NA
Nashville Warbler	Eastern	–	O
	B.C.	+	NA
Tennessee Warbler	Eastern	+	
	Maritimes	O	+
Northern Parula	New Brunswick; Canada	+	
	Maritimes		+
Yellow Warbler	Maritimes	O	+
Yellow-rumped Warbler	Nova Scotia; continent	+	NA
Chestnut-sided Warbler	St.Lawrence Plains	+	NA
Blackburnian Warbler	New Brunswick	+	NA
Ovenbird	New Brunswick; eastern Canada	+	
	Maritimes		+
Northern Waterthrush	New Brunswick; eastern	+	NA
Mourning Warbler	St. Lawrence Plain	+	NA
Common Yellowthroat	Saskatchewan; eastern; continent	+	O
	Maritimes	O	–

Table 7 continued.

SPECIES	REGION(S)	STUDY* R	STUDY* CW
Wilson's Warbler	Quebec	+	NA
	B.C.	−	NA
American Redstart	New Brunswick; Nova Scotia	+	
	Maritimes		+
Gray Catbird	New Brunswick; Nova Scotia; St.Lawrence Plain	+	0
Wood Thrush	Eastern; Canada; continent	+	NA
Veery	New Brunswick	+	
	Maritimes		+
	Southern Ont.		−
Swainson's Thrush	Ontario; Quebec; Nova Scotia	+	
	Maritimes		+

Notes:
*

R = Robbins et al. (1982), CW = Collins and Wendt (in prep.).
+ = increase; − = decrease; 0 = no trend; NA = not analysed due to insufficient sample size.

in eastern Canada and the reduced use of DDT in North America, were identified as the chief factors contributing to population changes in neotropical migrants.

Many of the strata analysed by Robbins et al. include American territory as well as Canadian; since more observers participate in the B.B.S. scheme in the U.S. than in Canada (J.S.Wendt, pers. comm.), sample sizes tend to be larger in the U.S. than in Canada, so Collins and Wendt's analysis, being confined to Canadian territory, often has smaller sample sizes with which to work. This might explain some of the cases (e.g. Traill's Flycatcher) where the U.S. analysis of regions or strata including Canadian territory found significant trends, but the Canadian study did not. It does not explain the more common cases (e.g. Yellow-bellied Sapsucker, Swainson's Thrush, Gray Catbird) where Robbins et al. found trends, in solely Canadian territory, that Collins and Wendt did not detect; nor those (e.g. Western Wood Pewee in Region 6, Red-eyed Vireo, Yellow Warbler) of which the converse is true.

Whatever the reasons, it is important to be aware that analyses of population trends within Canada from Breeding Bird Survey data can give substantially different results depending on the strata used in the analysis, on the time scales used, on the method used to assess statistical significance of trends, and on the geographic perspective from which the analyses are carried out. In particular, analyses from a "North American" viewpoint, even of Canadian strata, may indicate trends which are not found by analyses based solely upon Canadian samples.

The two sources agree in finding widespread changes in three species of neotropical migrant: Rose-breasted Grosbeak (increase in

central and eastern Canada), Western Wood Pewee (decline, probably throughout its range), and Western Tanager (increase). There must however be serious doubts as to the ability of a roadside survey to detect even substantial changes in the populations of forest-interior birds; one indication of this is that no less than 22 species were recorded so rarely on Breeding Bird Surveys in Canada that their sample sizes did not reach the minimum size chosen by Collins and Wendt for statistical testing (Table 7).

ii) Breeding Bird Census Plots

Detailed censuses of breeding birds on small study plots have been made in a variety of habitats since the 1940s; many of these were published in the journal "American Birds" (and its predecessor "Audubon Field Notes") until 1984. Catalogues of "BBC" plots have been published regularly by Erskine (1971, 1972, 1976, 1980, 1984). These catalogues do not give the full results of the census, only the densities of the five commonest species in each plot, together with the biome or habitat type in which it lies.

A full analysis of these data for population trends would calculate mean densities in each habitat type in each year. An unbiased measure of mean densities would have to include data from all the species in each plot - not just the 5 most abundant - and a habitat-related analysis would require a consistent classification of habitat between years, whereas those used in Erskine's catalogues have changed three times between 1971 and 1984. To correct for these problems would require using the original data (many of which were never published) and would take much more time than this project allowed.

I have therefore confined my analysis to the summaries catalogued by Erskine; but because these give only the "top five" species in each plot, it would be misleading to compare mean densities between years or other time periods. Each of Erskine's catalogues contains censuses carried out over several years, but since they were prepared several years apart, and included mainly censuses performed since the previous catalogue, data contained in the successive catalogues are arranged in a temporal sequence which should reveal any marked population trends.

My procedure was first to allot each census described by Erskine (1976, 1980, 1984) to one of the Breeding Bird Survey "regions" already described, so that the two sources of data could be compared directly. Only those censuses referring to forest were included. Each successive catalogue was treated as a successive time period; dividing the data into the individual year in which each plot was counted would have been unwarrantedly laborious and would have reduced the sample size for any one year to unusably low levels. Within each catalogue, species were scored according to the proportion of plots in which they occurred within the "top five." Thus if ten plots were counted in Region 1 in Time period 1, and Least Flycatcher was recorded in the top five in four of those plots, Least Flycatcher would be scored 0.4 for that time and region. The full analysis is set out in Table 8, for all those species scoring at least 0.2 in one cell of the table. Within each region, three successive time periods are shown (only two are available for Region 10), one from each successive catalogue.

Inspection of Table 8 shows that the number of plots completed in a particular time period in any region is highly variable, and often clearly too small for meaningful analysis. This arises from the fact that this scheme is much less highly organised than the Breeding Bird Survey; plots which people census for their own purposes are included, but no attempt is made to ensure a consistent pattern of censusing in relation to years, regions or habitats (Dr.A.J. Erskine, pers. comm.). The surveys are conducted for specific purposes and so are strongly biased towards the particular habitats and species involved in that particular study. Thus the pattern of census activity is highly irregular and reflects the waxing and waning of a variety of different projects.

Possible trends apparent from Table 8 can be compared with those already described from the roadside counts of the Breeding Bird Survey. They include a decline in Nashville Warblers in Regions 2, 3, 4 and 5, which was also found by Robbins et al. (1982) in strata roughly equivalent to Regions 2 and 5; and a decrease in Tennessee Warblers in Region 2, directly opposite to the increase in that region found by Collins and Wendt (in prep.) but contained within the Eastern Region decline found by Robbins et al. (1982). None of the other possible trends in this data set (e.g. Yellow-rumped and Magnolia Warblers, Region 2; Orange-crowned Warbler, Regions 4 and 6; Townsend's Warbler, Region 6; Ovenbird, Region 4; Black-throated Green Warbler, Region 8) has any counterpart in either analysis of Breeding Bird Survey roadside counts. It is not possible to decide whether these disparities reflect the different biases of the two monitoring

Table 8. THE PROPORTION OF BREEDING BIRD CENSUS PLOTS IN WHICH A SPECIES WAS RECORDED AS ONE OF THE FIVE MOST ABUNDANT.

SPECIES	REGION 1 *			REGION 2			REGION 3		
N=	7	4	25	4	70	17	33	6	43
	time 1	time 2	time 3	time 1	time 2	time 3	time 1	time 2	time 3
Eastern Wood Pewee	0	0.25	0	0	0	0	0.30	0.50	0.19
Yellow-bellied Flycatcher	0	0.25	0.12	0	0.01	0	0	0	0.02
Least Flycatcher	0.29	0.25	0.28	0	0.03	0.12	0.09	0.17	0.16
Rose-breasted Grosbeak	0	0	0	0	0.01	0	0.09	0.33	0.16
Red-eyed Vireo	0.43	0.25	0.40	0	0.07	0.35	0.42	0.17	0.39
Solitary Vireo	0.14	0	0	0.25	0.04	0	0	0	0.05
Black and White Warbler	0.14	0	0.28	0	0	0.12	0.18	0	0.07
Nashville Warbler	0.14	0	0	0.25	0.09	0	0.21	0	0
Tennessee Warbler	0.14	0.50	0.20	0	0.73	0.65	0	0	0
Northern Parula	0.43	0	0.08	0	0	0	0	0	0
Cape May Warbler	0	0.50	0.04	0	0.21	0.18	0.03	0	0
Yellow-rumped Warbler	0.14	0	0.12	1.00	0.24	0.06	0.03	0	0.09
Magnolia Warbler	0.43	0	0.36	0.25	0.43	0.71	0.06	0	0
Chestnut-sided Warbler	0	0	0.16	0	0.01	0.29	0.12	0	0
Bay-breasted Warbler	0.29	0.75	0.12	0	0.59	0	0.06	0	0.02
Blackpoll Warbler	0	0.25	0	0	0.46	0	0	0	0.02
Blackburnian Warbler	0.14	0.25	0	0	0.06	0.06	0.03	0	0.16
Black-throated Green Warbler	0.43	0.25	0.20	0	0.34	0.12	0.18	0	0.09
Ovenbird	0.57	0.25	0.44	0	0.09	0.18	0.58	0.17	0.56
Common Yellowthroat	0	0	0.28	0.25	0	0.24	0	0.17	0.07
American Redstart	0.29	0	0.48	0	0.30	0.06	0.06	0	0.26
Wood Thrush	0	0	0	0	0.09	0	0.15	0.33	0.09
Veery	0.14	0	0.28	0	0.04	0.12	0.36	0	0.33
Swainson's Thrush	0.29	0.75	0.24	0.25	0.51	0.18	0.09	0	0.09

Table 8 (contd.)

SPECIES	REGION 4			REGION 5			REGION 6		
N =	11	3	4	11	13	22	12	10	6
	time 1	time 2	time 3	time 1	time 2	time 3	time 1	time 2	time 3
Great Crested Flycatcher	0	0.33	0.25	0	0	0	0	0	0
Least Flycatcher	0.18	1.00	0.75	0	0.40	0.14	0.08	0	0
Baltimore Oriole	0	0.67	0.25	0.09	0.15	0	0	0	0
Rose-breasted Grosbeak	0	0.33	0	0	0	0	0	0	0
Red-eyed Vireo	0.27	1.00	0.50	0.55	0.77	0.27	0	0	0
Warbling Vireo	0	0.67	0.50	0.09	0	0.09	0.25	0	0
Nashville Warbler	0.27	0	0	0.36	0	0	0	0	0
Orange-crowned Warbler	0.45	0	0	0	0	0.09	0.33	0.30	0
Tennessee Warbler	0.27	0	0	0.45	0	0.18	0	0	0
Yellow Warbler	0	0.30	0	0	0.31	0.14	0	0	0
Yellow-rumped Warbler	0.45	0	0.25	0.36	0.08	0.36	0	0.40	0
Townsend's Warbler	0	0	0	0	0.08	0.05	0.08	0.20	0.50
Ovenbird	0.09	0.33	0.50	0.27	0.15	0.18	0	0	0
Mourning Warbler	0	0	0.25	0	0.15	0.18	0	0	0
Common Yellowthroat	0.27	0.33	0	0.09	0.08	0	0	0	0
Wilson's Warbler	0	0	0	0	0	0	0.17	0.20	0
American Redstart	0.09	0.33	0	0.18	0.08	0.09	0.25	0	0
Swainson's Thrush	0.09	0	0.25	0.36	0.15	0.23	0.75	0.40	0.50

Table 8 (concluded)

SPECIES	REGION 8			REGION 10	
N =	4	11	12	5	3
	time 1	time 2	time 3	time 2	time 3
Yellow-bellied Flycatcher	0	0	0	0.40	0.33
Least Flycatcher	0.25	0.27	0.17	0	0
Lincoln's Sparrow	0	0	0	0.20	0
Red-eyed Vireo	0.50	0.36	0.17	0	0
Solitary Vireo	0.25	0	0.08	0	0
Black and White Warbler	0.25	0.28	0.08	0.20	0.33
Tennessee Warbler	0.50	0.45	0.67	0	0
Yellow-rumped Warbler	0.25	0.18	0.50	0.40	0.67
Magnolia Warbler	0.25	0.18	0	0	0
Blackpoll Warbler	0	0.27	0	1.00	0
Black-throated Green Warbler	0.50	0	0	0.10	0
Ovenbird	0.50	0.36	0.50	0.20	0.10
Northern Waterthrush	0	0.09	0.17	0.40	0.10
Canada Warbler	0.25	0	0	0	0
Gray-cheeked Thrush	0.25	0	0	0.20	0
Swainson's Thrush	0.75	0.36	0.58	0	0

Notes:

* Regions as described under "Habitats at risk" and shown in Figure 1.

Time 1 = approx. 1962-75 (mainly 1973-74) (Erskine 1976); Time 2 = approx. 1972-79 (mainly 1976-77) (Erskine 1980); Time 3 = approx. 1975-82 (mainly 1977-79) (Erskine 1984). Data shown only for species in which at least one cell scored 0.2 or greater.

schemes, or whether there may be real changes in these species which are not detected by the BBS scheme.

iii) Nest Record Scheme

The program of regional Nest Record Card schemes is described by Erskine (1971). Like the Breeding Bird Survey and the Breeding Bird Censuses, volunteers carry out most of the fieldwork. Very little analysis of the results has been carried out (though see, e.g., Peck and James 1983).

If nest-recording activity were random with respect to both year and species, the number of cards completed for each species might be expected to follow any trend in the population. The records of the Ontario Nest Record Scheme were therefore examined to see if any trends can be detected. (Similar schemes exist in other provinces and regions, but their data are not available centrally; the Ontario Scheme was chosen for this exercise because it contains among the largest sample sizes of any Canadian scheme, and its annual totals were available and accessible. If Nest Record Scheme data do reflect trends in breeding populations, a comparison of Ontario Nest Record totals with Breeding Bird Survey results from Ontario should reveal this).

The total numbers of cards submitted to the Ontario Nest Record scheme (from their reports 8-18, 1971-84) are shown in Table 9 for migrant species for which at least 200 cards had been received by the end of 1982. The years 1968-1982 only are tabulated; after then, many volunteers switched their effort to the Breeding Bird Atlas (Cadman et

al. in press)).

Only 17 species have accumulated 200 cards or more over the 15 years involved. Most of these show irregular fluctuations from year to year, possibly reflecting the activities of individual recorders specialising in particular species. Eastern Kingbird, Red-eyed Vireo, Wood Thrush and Veery all appear to show somewhat higher totals in the late 1970s than at other times; these apparent trends mirror increases at that time in a number of other insectivorous species in eastern Canada (but chiefly in the Maritimes), attributed to the recovery of populations reduced by pesticides (Erskine 1978, Robbins et al. 1982). In Chestnut-sided Warblers, on the other hand, the highest totals are found in the early, rather than late, 1970s.

The interpretation of these raw totals is complicated by the likelihood that the completion of cards is neither random nor consistent with respect to species; not only are the nests of some species easier to find than others, but individual recorders tend to specialise on favourite species. Nest recording is also non-random with respect to time; in Ontario, for example, nest-recording activity was evidently neglected during the years of field work for the Ontario Breeding Bird Atlas (though these years were excluded from the present analysis), although it increased immediately before the Atlas project (D.Welsh, pers. comm.).

One of the strongest apparent trends in Table 9 is for most species' totals to decline immediately after the first year of the scheme, no doubt reflecting a decline from the initial burst of enthusiasm on the part of recorders. Detailed analysis of the original

Table 9. NUMBER OF CARDS RECEIVED EACH YEAR BY THE ONTARIO NEST RECORD SCHEME for species for which at least 100 cards had been received by 1983.

SPECIES	YEAR														
	1968	69	70	71	72	73	74	75	76	77	78	79	80	81	82
Broad-winged Hawk	2	5	2	4	5	5	6	4	8	6	13	20	4	4	7
Black-billed Cuckoo	19	15	6	8	8	11	4	16	5	15	3	22	8	9	8
Yellow-bellied Sapsucker	20	14	9	5	10	14	10	16	20	38	27	21	14	8	19
Ruby-throated Hummingbird	1	3	2	1	1	1	7	4	2	7	9	2	2	3	5
Eastern Kingbird	47	38	48	32	53	56	44	88	115	97	80	76	55	70	65
Great Crested Flycatcher	8	9	9	7	4	15	9	13	14	16	12	11	11	19	15
Eastern Wood-Pewee	2	4	3	3	4	1	2	3	5	7	3	8	4	8	9
Traill's Flycatcher	17	9	11	1	3	11	2	10	7	31	29	3	6	11	5
Least Flycatcher	3	4	9	4	3	4	2	4	8	11	6	4	3	11	15
Northern Oriole	27	28	27	11	19	15	20	16	12	51	39	32	16	34	17
Rose-breasted Grosbeak	25	6	6	8	9	21	11	11	19	22	14	10	16	25	17
Rough-winged Swallow	9	7	11	8	11	15	16	21	16	18	25	13	12	18	15
Red-eyed Vireo	10	6	6	6	8	5	11	17	28	47	20	11	9	7	8
Warbling Vireo	3	12	6	3	4	0	1	7	7	10	8	5	2	3	4
Yellow Warbler	101	83	74	41	21	34	20	62	69	73	77	80	58	52	60
Yellow-rumped Warbler	3	1	0	1	1	3	7	3	14	13	8	1	8	9	2
Magnolia Warbler	0	2	2	1	4	2	7	0	4	4	0	3	4	3	4
Chestnut-sided Warbler	4	1	4	11	22	22	15	2	8	12	10	6	3	6	2
Ovenbird	4	5	4	6	6	3	6	2	8	11	6	7	10	9	3
Common Yellowthroat	9	2	3	4	1	2	3	2	8	14	8	3	8	8	4
American Redstart	9	4	2	8	16	20	11	7	18	20	13	9	12	7	6
Gray Catbird	112	65	45	22	12	14	30	75	79	69	31	48	26	42	30
Wood Thrush	4	4	7	8	1	4	6	3	15	14	4	8	10	5	8
Veery	6	5	4	3	7	4	10	10	11	27	15	5	13	9	12
Swainson's Thrush	6	4	2	2	2	1	2	2	8	4	1	7	0	2	6

records themselves (rather than the annual totals used here), especially in relation to the activities of individual recorders, might be able to correct for some of these biases but were outside the scope of this report.

Direct comparison of these results with those from the Breeding Bird Survey is made very difficult by the time periods selected for analysis by Collins and Wendt (1967-1979; 1979-1983; 1967-1974; 1974-1983; and 1967-1983). None of these coincides with any of the groups of years within which markedly high or low Nest Record Card totals appear to be concentrated (1975-1979, and 1971-1974). The potential monitoring value of Nest Record Cards must remain uncertain until BBS trends can be examined year by year, or at least over time periods selected in relation to apparent trends in Nest Record Card totals.

iv) Banding totals

The number of birds banded at regularly-manned bird-banding stations might be expected to reflect trends in breeding populations. The only banding station which has been operating in Canada on a sufficiently large scale, over a long enough period, is Long Point Bird Observatory on the Ontario shore of Lake Erie. The raw totals of numbers banded each year from 1960 to 1984 (kindly supplied by D.Shepherd) show, in most species, irregular year-to-year fluctuations superimposed on a general long-term increase in numbers banded which reflects a steady increase in banding effort as the Observatory expanded over that period. This increasing trend is common to resident species and short-distance migrants as well as those wintering in the tropics. It is unfortunately not possible to correct these data for banding effort since that has not been recorded systematically.

A detailed computer analysis of the numbers (uncorrected for banding effort) of four species of Catharus thrushes banded during fall migration at six North American banding stations, including Long Point, found no long-term trends in numbers at any of the stations (Smith and Schneider (unpub.)).

Banding totals from a single banding station can reflect population trends only in the populations which migrate through that station. Banding totals for the whole of Canada are likely to be much less sensitive to changes in local populations, and more to large-scale trends, though in Canada the national totals of many of the species with which this report is concerned are dominated by the totals from Long Point Bird Observatory which in most years has been the largest single contributor to small-bird banding. The national totals for relevant species, separated into five successive 5-year time periods, are shown in Table 10. The main trend which is apparent from these data is a large increase in many of the passerine species after 1976, which is due partly to projects concentrating on particular species (e.g. Baltimore Oriole, Least Flycatcher) but mainly to a general increase in banding effort directed towards small passerines, most notably at Prince Edward Point, Ontario.

v) Migration counts

Long Point Bird Observatory keeps records of the numbers of migrants seen, as well as those banded. The raw totals themselves reflect weather conditions, which greatly influence the numbers of migrants that are recorded at the Observatory; but Hussell (1981) developed a migration "index" using multivariate regression techniques

Table 10. BANDING TOTALS OF CANADIAN MIGRANTS TO TROPICAL FOREST

SPECIES	YEAR				
	1955 -1960	1961 -1965	1966 -1970	1971 -1975	1976 -1980
Turkey Vulture	3	2	1	6	5
Broad-winged Hawk	16	24	27	86	63
Black-billed Cuckoo	74	178	111	74	297
Yellow-bellied Sapsucker	217	744	525	339	700
Whip-poor-Will	33	34	58	29	46
Chimney Swift	17	7	104	0	4
Vaux's Swift	0	0	0	0	0
Ruby-throated Hummingbird	23	2	0	2	74
Black-chinned Hummingbird	0	0	0	0	0
Rufous Hummingbird	1	0	0	0	0
Calliope Hummingbird	0	0	0	0	0
Eastern Kingbird	200	232	265	223	1221
Great-Crested Flycatcher	90	111	115	94	571
Olive-sided Flycatcher	8	16	10	15	60
Eastern Wood Pewee	320	412	347	261	1168
Western Wood Pewee	33	18	14	22	35
Yellow-bellied Flycatcher	464	555	510	342	2193
Western Flycatcher	28	17	25	1	5
Traill's Flycatcher	220	447	517	590	2095
Least Flycatcher	554	2045	2485	2059	7037
Hammond's Flycatcher	0	4	0	7	1
Dusky Flycatcher	3	4	2	18	21
Baltimore Oriole	563	746	764	576	4028
Lincoln's Sparrow	968	1562	1180	534	2364
Rose-breasted Grosbeak	286	691	1185	843	3190
Black-headed Grosbeak	3	8	0	0	6
Western Tanager	20	99	21	14	73
Scarlet Tanager	149	192	353	192	686
Violet-green Swallow	57	23	6	0	7
Rough-winged Swallow	312	89	45	55	226
Red-eyed Vireo	1154	1197	1153	1182	5663
Philadelphia Vireo	153	183	129	253	871
Warbling Vireo	143	166	127	125	1031
Solitary Vireo	143	237	188	219	852
Black and White Warbler	517	617	504	606	2513
Golden-winged Warbler	13	11	18	19	72
Nashville Warbler	1022	1410	998	1673	3417
Orange-crowned Warbler	242	205	461	285	567
Tennessee Warbler	3205	1391	1280	2922	11680
Northern Parula	43	47	35	40	360
Cape May Warbler	536	594	238	742	5088
Yellow Warbler	2203	1407	999	3295	10613
Black-throated Blue Warbl	278	434	405	353	1349
Yellow-rumped Warbler	3930	6239	5457	5087	12987

Table 10 continued

SPECIES	YEAR				
	1955 -1960	1961 -1965	1966 -1970	1971 -1975	1976 -1980
Magnolia Warbler	1444	2599	1613	1895	9356
Chestnut-sided Warbler	513	767	538	578	1766
Bay-breasted Warbler	739	751	341	1014	6756
Blackpoll Warbler	1232	2374	1598	1435	3911
Blackburnian Warbler	366	329	233	267	1824
Black-throated Gray Warbler	36	1	0	0	2
Black-throated Green Warbler	654	633	403	507	2006
Townsend's Warbler	1	1	1	0	3
Palm Warbler	494	962	866	319	771
Ovenbird	1034	1222	1043	1026	2759
Northern Waterthrush	544	518	648	602	3252
Louisiana Waterthrush	4	4	4	0	12
Connecticut Warbler	73	89	91	40	73
Mourning Warbler	192	301	205	211	916
Common Yellowthroat	897	1745	1482	990	3775
Wilson's Warbler	594	736	703	655	2436
Canada Warbler	539	685	581	521	2996
American Redstart	983	1262	1051	1213	5758
Gray Catbird	1721	2298	1240	1014	3520
Wood Thrush	123	234	268	169	680
Veery	477	718	794	675	2121
Gray-cheeked Thrush	720	1745	874	542	1097
Swainson's Thrush	2758	4142	2695	3147	8633

which assigned variance in spring migration counts to year, date and a variety of weather variables. Hussell (1981) compared the annual index so obtained with Breeding Bird Survey indices from Ontario and Quebec in the same years (1968-79); of ten comparisons involving six species, the correlation coefficient between migration and BBS indices was positive in nine cases, though the correlation was statistically significant in only three. In the only species of neotropical migrant included in Hussell's analysis (Yellow-rumped Warbler), the correlation between the two indices was unfortunately negative, though not significantly so.

Discussion

This comparison of the various possible indicators of population trends in neotropical migrants is inconclusive in that considerable uncertainty remains as to the reality of the trends suggested. This is due partly to problems inherent in the data themselves, and partly to problems in analysing them.

Taking the intrinsic problems first, the Breeding Bird Survey might not be expected to be an accurate monitor of the breeding populations of forest birds for several reasons. First, being a roadside survey, it can rarely include species confined to - or most abundant in - the forest interior. Second, BBS routes can be analysed according to the biome or eco-geographic "stratum" in which they occur, but finer-scale analysis in relation to the actual distribution of habitat along the route cannot be made because such habitat records are not included in the survey. Third, an unknown proportion of the singing males which make up the bulk of the survey's records, may not be breeding birds, but "floaters" looking for a territory (Stewart and

Aldrich 1951, Wilcove and Terborgh 1984). The demography of small forest passerines (short life-span, high population turnover) is such that a high proportion of the males alive in spring and early summer must be first-year birds in search of their first breeding territory. Many species may have a substantial reserve population of such "floaters," which are likely to be less selective about the habitats in which they occur than are breeders. Further, intensive studies of wood-warblers (family Parulidae) have shown that habitat choice, as expressed in habitats actually used in any particular area, is very much influenced both by the availability of resources and by competition from other species (Morse 1985 and references therein). Wilcove and Terborgh (1984) have discussed a variety of ways in which population declines might be manifested in different parts of a species' range, and in habitats of different attractiveness to the species, and concluded that real declines might be very difficult to detect especially in studies covering large geographic areas.

In support of this conclusion is the evidence that the most convincing recent examples of declines in such species in North America have come not from Breeding Bird Surveys alone, but either from combinations of BBS data with more detailed long-term studies of individual plots, forests or small geographic areas, usually using mapping of individual birds, or from such intensive studies alone (e.g. Temple and Temple 1976, Briggs and Criswell 1979, Robbins 1979, 1980, Whitcomb et al. 1981, Ambuel and Temple 1982, 1983, Hall 1984). There have been no such long-term studies in Canada (A.J.Erskine, D.A.Welsh, pers. comm.). These factors combine to suggest that the Breeding Bird Survey is unlikely to detect any but the very largest

changes in breeding populations of neotropical migrant, especially those that breed in the forest interior.

Data from Breeding Bird Census Plots seem intrinsically more likely to reveal trends in breeding populations, especially as many of the censuses include habitat data measured by consistent and systematic methods (James and Shugart 1970). One difficulty with this scheme is that surveys are carried out for the purpose of particular projects, and the mix of habitats and regions included therefore varies considerably from year to year. Another difficulty lies not with the data themselves, but in their accessibility to analysis. For North America as a whole, many of the censuses published in "American Birds" have been computerised, but only the most abundant species in each plot have been entered, and only a selection of the habitat measures are included (Robbins 1977). As already described, analysis of the Canadian material at present must either be extremely laborious, or must be limited to the data included in Erskine's catalogues because the full data have not been computerised.

Difficulties with the other sources of trend data have been discussed under the description of each source. All in all, the lack of a suitably computerised archive for these various sources leaves their potential for population monitoring unfulfilled, and leaves us uncertain as to the existence or reality of such trends.

Supposing, however, that the trends within Canada that have been identified by Collins and Wendt (in prep.) are real ones, we can at least examine the relationship between those trends and the habitats of the species showing them. Table 11 compares the breeding and

wintering habitats of those species showing upward and downward trends in Collins and Wendt's analysis, with the habitats used by the whole species pool of neotropical migrants. Species showing downward trends are distributed among breeding habitats in almost exactly the same proportion as is the whole species pool; winter habitats are divided into more categories so the patterns are less clear, but they do suggest that there are fewer declining species than expected in broadleaf and scrub habitats, and the complete absence of any species showing an upward trend and wintering in primary forest is also striking.

In conclusion, Table 11, while not conclusive, does suggest a tendency for population trends to reflect habitat availability in the winter quarters more than that on the breeding grounds.

Table 11. THE USE OF BREEDING AND WINTERING HABITATS BY SPECIES SHOWING INCREASING AND DECREASING TRENDS ON BREEDING BIRD SURVEYS IN CANADA, COMPARED WITH HABITAT USE BY THE WHOLE SPECIES POOL OF NEOTROPICAL MIGRANTS.

TREND	BREEDING HABITAT				WINTERING HABITAT							
	M	MO	B	S	B	C	PC	PB	G	S	O	M
Decrease	5	10	2	5	1	0	2	6	7	2	2	1
Increase	3	4	1	2	4	3	0	0	4	2	0	0
All species	24	50	9	27	25	15	8	25	48	23	9	2

Note:

Each occurrence of a species in a particular habitat scores equally, irrespective of any other other habitats used by that species; the sample size is therefore not the number of species, but the number of species multiplied by the number of habitats used by each.

For Key to breeding and wintering habitats, see Table 2.

Chapter 6 - TRENDS IN WINTER HABITAT

One aim of this study is to estimate the changes in the area of winter habitat that are likely to take place in the foreseeable future. This is done by applying various methods of estimating rates of deforestation to the FAO figures for each habitat and using them to recalculate the total area of habitat available to each species at a future time. I have arbitrarily chosen the year 2000 as the future reference point for this study.

MEASUREMENTS OF DEFORESTATION RATES

Deforestation rates, derived by unspecified methods (rarely if ever including satellite imagery), are given by FAO (1981, Table 6). These are the only figures available that cover the whole region in habitat-specific detail, and I have used them as the basis for projecting the likely areas of habitat available in the year 2000. However, I have amended them in several ways to counteract biases incorporated in them, which reflect the purposes for which they were originally drawn up (see also Diamond 1985 for a discussion of this problem).

The FAO study uses the term "deforestation" in a special sense which is specific to FAO's area of interest, and which does not overlap completely with the concept of deforestation in use by ecologists and conservationists. FAO's interest in forest lies in the forest's "productivity," which in their use of the word refers to the capability to produce commercial timber. Consequently, their concept of "deforestation" focuses on the alienation of forested land to some

other land use in which commercial timber can no longer be produced. The chief form of "deforestation" which they measure is the transfer of forest land to agriculture; they specifically exclude logging because "the selective logging that is practiced in the large majority of tropical countries has a relatively slight effect on the forest" (Lanly 1982).

However, the logging of previously-uncut forest - whether "selective" or not - is of fundamental concern to this study, because it involves the loss of (or changes to) the only habitat category whose area can be only reduced, not increased, i.e. "virgin" or previously-uncut forest. The areas recorded by FAO (1981, Table 3) as having been "logged" are often very substantial, averaging 1.6 times the areas "deforested" (FAO 1981, Table 6). In order to measure more accurately the loss of primary forest, I have therefore added the areas logged annually (FAO 1981, Table 3) to the areas recorded by FAO as "deforested" (FAO 1981, Table 6). This correction applies only to previously-uncut forest.

The FAO deforestation rates exclude not only logging (as described, and corrected for, above), but also "degradation," e.g. by overgrazing and collecting fuelwood (Lanly 1982). Myers (1980) pointed this out and included degradation in his estimates of forest "conversion" rates, but unfortunately he did not give separate figures for each country or habitat so his data cannot be used to correct for this bias.

The estimates of deforestation rates given by FAO are probably the weakest part of their data; "probably," because the methods by

which they were derived are not clearly stated, though since LANDSAT coverage was incomplete and very recent at that time, it is clear that satellite imagery could have been used very little in estimating deforestation rates. They give separate estimates of the area of each major forest type "deforested," one for 1976–1980 (measured in unspecified ways) and another - predicted, again using unspecified methods - estimated for 1981–85. I have used the second of these figures, since it is the more likely to apply to the period 1985–2000; for forest types not included in FAO's deforestation tables, figures can be derived by comparing their tables of areas of forest types in 1980 and 1985.

MODELS OF CHANGES IN AREA OF WINTER HABITAT

Projections into the future, even from the recent past as in this case, are fraught with difficulties, especially when the past data are of uncertain reliability (as is true of deforestation rates in this case). An extra source of uncertainty is involved here, where the root causes of the changes to habitats lie in pressures on land caused by human populations which are increasing exponentially (at an average rate of 2.9% in Latin America as a whole (Myers 1980)) such that they will be twice the size in the year 2000 that they were in the mid-1970s when most of the FAO data on forest areas were collected. These general and particular uncertainties make it impossible to make firm predictions of future forest areas, or to assign confidence limits to such predictions. The most approporiate approach to this problem is to make several different projections, based on different assumptions which are likely to "bracket" the real situation. Here I make four

such projections; in all cases the data base is the same, i.e. the areas of each forest type in each country in 1985 as predicted by FAO from measurements of areas existing in 1980. These are the only data which are available for the entire region, in sufficient detail for the forest types described to be matched reasonably closely with the wintering habitats described for migratory birds.

1) The extreme "best case" would be to assume that the changes in area predicted by FAO to take place between 1980 and 1985, will continue in a linear fashion from 1985 to 2000. This model does not include the corrections for logging described earlier. According to this model, the total forest area in Latin America in 2000 would be 95% of that in 1985, ranging from 73% in primary coniferous forest (which accounts for a very small proportion of the total area of forest) to 119% in secondary broadleaf and 118% in all secondary forest. Such changes would likely have trivial consequences for migratory Canadian birds wintering in forest.

2) The extreme "worst case" can be estimated from measurements of deforestation in the Rondonia region of Brazilian Amazonia, where colonisation and development have proceeded with the benefit of massive government aid. LANDSAT images have been used to measure the loss of forest cover between 1975 and 1983 (Fearnside and Salati 1985) in the part of Brazilian Amazonia which has been most rapidly deforested in that time (Fearnside 1986). This estimate therefore is up-to-date, uses the best and most objective technique available (satellite imagery), and refers to a geographical area which is being deforested probably as rapidly as any in Latin America.

During 1970-1983, deforestation in Rondonia increased explosively from zero to a cumulative total of nearly 6% (Fearnside and Salati 1985, Fig. 1). The mean annual rate of deforestation over this period was 1.4% (see model 3), but the rate was itself still increasing between 1980 and 1983. If the virtually exponential rate of increase in the rate of deforestation were to continue after 1983 at the same rate as before that year, the forest would be cleared entirely by the year 1992. The entire loss of wintering habitat by this time would obviously have catastrophic consequences for all neotropical migrants.

3) One intermediate model can be derived by using the mean rate of deforestation recorded in Rondonia, i.e. assuming that the rate of deforestation will not increase but will remain at the average level of the last decade. This rate of 1.4% p.a. predicts that 72% of all forest types will remain in the year 2000; since the same rate is applied to all forest types this is not a habitat-specific model and so gives the same result for all migrant species (28% habitat loss by 2000).

4) A second intermediate model can be derived by projecting the rates of deforestation estimated by FAO from 1981-85 in a linear fashion to the year 2000, but using figures for forest areas in 1985 that are "corrected" for their inherent biases as described earlier. Using areas for primary forest in 1985 that treat logging from 1980-1985 as deforestation (as in model 3), but otherwise applying FAO's habitat-specific rates of deforestation in each country, gives new estimates for the area of habitat available to each species in the year 2000. These are shown in Table 12; they average about 72% of the 1985 area and range from a decline of 83% for Philadelphia Vireo to an

increase of 28% for Gray Catbird. I stress again that these estimates are for areas of habitat, not population sizes.

I have calculated the predicted areas of winter habitat for each species only for model 4, because the other models yield estimates of areas which are either too trivial (model 1) or the same for all species (i.e. total loss for all species well before 2000 (model 2), or a consistent loss of 28% of habitat (model 3)).

Models 3 and 4 give identical estimates of the average loss of tropical winter habitat to each species (28%). Model 4 is more useful in the present context because it is habitat-specific and so enables the consequences of habitat loss to be assessed separately for each species; model 3's chief value is probably as a check on the average value generated by model 4.

Correlations between predicted changes in areas of habitat and other aspects of the species' winter distributions, are discussed in Chapter 7.

Table 12. DISTRIBUTION TYPE, HABITAT-DISTRIBUTION DIVERSITY, AND DEFORESTATION UNDER MODEL 4.

Species	Distribution type	H'	Habitat area 1985+	Habitat area 2000+	2000 as % of 1985
Turkey Vulture	C	0.815	22570	10188	45
Broad-winged Hawk	S	0.888	223692	176324	78
Black-billed Cuckoo	S	0.301	28110	32130	114
Yellow-bellied Sapsucker	C	0.451	44272	26873	60
Whip-poor-will	C	0.459	9847	5777	58
Chimney Swift	S	0.151	138452	107322	78
Vaux's Swift	C	0.352	30598	12872	42
Ruby-throated Hummingbird	C	0.513	56786	23424	41
Black-chinned Hummingbird	C	0.000	72045	74745	104
Rufous Hummingbird	C	0.000	20376	20959	102
Calliope Hummingbird	C	0.000	17422	16994	97
Eastern Kingbird	S	0.720	203594	158489	78
Great Crested Flycatcher	C	0.745	25243	12683	50
Olive-sided Flycatcher	S	0.767	152125	93405	61
Eastern Wood Pewee	S	0.580	148623	123802	83
Western Wood Pewee	S	0.595	103631	73796	71
Yellow-bellied Flycatcher	C	0.720	15860	6349	40
Western Flycatcher	C	0.295	5516	2333	42
Traill's Flycatcher	C	0.532	4362	5166	100
Least Flycatcher	C	0.222	57571	54832	95
Hammond's Flycatcher	C	0.164	27411	25500	93
Dusky Flycatcher	C	0.000	56196	58572	104
Northern Oriole	CS	0.879	40687	19430	48
Lincoln's Sparrow	C	0.155	33083	30789	93
Rose-breasted Grosbeak	CS	0.642	173194	102925	59
Black-headed Grosbeak	C	0.000	12757	7912	62
Western Tanager	C	0.157	7118	5538	77
Scarlet Tanager	S	0.516	65198	45596	69
Violet-green Swallow	C	0.417	6055	4668	77
Rough-winged Swallow	C	0.538	65743	28577	43
Red-eyed Vireo	S	0.515	527759	439404	83
Philadelphia Vireo	C	0.513	6642	1179	17
Warbling Vireo	C	0.272	13361	11795	88
Solitary Vireo	C	0.236	3842	2706	70
Black and White Warbler	CSI	0.725	149034	132652	89
Golden-winged Warbler	SC	0.595	23601	13709	58
Nashville Warbler	C	0.060	102898	105412	102
Orange-crowned Warbler	C	0.122	117335	43223	37
Tennessee Warbler	CS	0.755	38202	22426	59
Northern Parula	CI	0.455	35115	36441	104
Cape May Warbler	CI	0.417	9482	9938	105
(Yellow Warbler	SC	0.708	10037	10075	100) *
Black-throated Blue Warbler	CI	0.638	16455	15838	96

Table 12 continued.

Species	Distribution type	H'	Habitat area 1985+	Habitat area 2000+	2000 as % of 1985
Yellow-rumped Warbler	CI	0.409	103211	56379	55
Magnolia Warbler	CI	0.653	26932	14277	53
Chestnut-sided Warbler	C	0.631	18217	13423	74
Bay-breasted Warbler	SC	0.394	18368	10352	56
Blackpoll Warbler	S	0.863	108733	90057	82
Blackburnian Warbler	S	0.586	73362	49072	66
Black-throated Gray Warbler	C	0.076	15254	14640	95
Black-throated Green Warbler	CI	0.565	88704	99111	112
Townsend's Warbler	C	0.396	28889	17810	61
Palm Warbler	CI	0.652	12783	6047	47
Ovenbird	CSI	0.825	80586	76222	95
(Northern Waterthrush	SCI	0.992	4090	4090	100) *
(Connecticut Warbler	S	0.201	1510	1510	100) *
(Mourning Warbler	CS	9.000	660	660	100) *
(Common Yellowthroat	CI	0.796	1849	1849	100) *
Wilson's Warbler	C	0.292	113744	120331	106
Canada Warbler	S	0.693	84876	61189	72
American Redstart	SCI	0.915	233243	161084	69
Gray Catbird	CI	0.305	28749	36722	128
Wood Thrush	C	0.733	14904	8623	58
Veery	S	0.560	65908	51834	78
Gray-cheeked Thrush	S	0.745	135266	107456	79
Swainson's Thrush	SC	0.908	144366	107863	74

Notes:

Distribution type: C = Central America, S = continental South America, I = Caribbean islands.

H' = index of range and habitat diversity (see text).

* These species are confined to gallery or mangrove forest, for which FAO gives no deforestation rates; their apparent stability is therefore spurious.

\+ thousands of hectares.

Chapter 7 - FUTURE TRENDS IN SPECIES' POPULATIONS

Table 12 presents several aspects of the winter distribution of Canadian migrants to neotropical forest, which can be examined to look for possible relationships with likely future trends in the area of winter habitat.

The distribution type of a bird species - i.e. whether predominantly Central American, or continental South American - is evidently not a good predictor of the predicted area of habitat in the year 2000 compared with that in 1985 (the last column in Table 12). This is a little surprising, since species wintering in South America generally have much larger total areas of habitat available to them (mean areas 134,283 and 32,916 thousand hectares for South and Central American winterers, respectively); it presumably reflects the similarity of deforestation rates throughout Latin America.

Table 12 includes an index of diversity, the Shannon-Weiner function ($H' = -\sum p_i \log p_i$) (Tramer 1969), where p_i = the proportion of each species' total area of winter habitat that is found in each habitat used in each country of the winter range; it thus reflects the variety of habitats used as well as the number of countries occupied.

This index has been calculated to see whether a broad tolerance of habitats, and wide geographic range, in winter is related to the possible future trends in habitat area. However, this proves not to be so; H' is slightly negatively correlated with the percentage of 1985 habitat remaining in 2000, but the correlation coefficient is not statistically significant.

The strongest relationship with the relative loss of habitat proves to be with habitat; species wintering primarily in primary forest can expect to retain, on average, about 62% of their 1985 habitat by 2000, whereas those wintering mainly in scrub (i.e. occupying scrub and no more than two other habitats, none of them primary forest) can expect to retain nearly 99% of their habitat; this difference is highly significant (t-test, p , .01). This difference of course reflects the sharp losses predicted in primary forest, compared with likely increases in the area of scrub habitats as more mature forests are progressively degraded; it also reflects FAO's likely under-estimates of rates of scrub clearance (see below)

It has already been stressed (Chapter 1) that changes in the area of winter habitat are most unlikely to be linearly related to changes in the size of breeding populations. Morse (1980) and Wilcove and Terborgh (1984), as briefly summarised in Chapter 1, address some of the reasons for this "uncoupling" of habitat-area and population-size. In addition, Rappole (in press) has shown that although many species of migrant do make considerable use of scrubby and second-growth habitats as well as mature forest, it is primarily immature birds behaving gregariously and as transients which use scrub, while adults take up resident territories within mature forest. It is therefore dangerous to conclude, as one might easily do from the mere figures of areas of habitat presented here, that the future for species "inhabiting" scrub in winter is relatively rosy. It may well not be, if such species' populations are divided as sharply into scrub-haunting immature transient "floaters", and forest-dwelling territorial adults, as Rappole suggests. At the very least, the

increase of scrub at the expense of mature forest is likely to cause a shift in the age-structure of breeding populations, if not an overall decline. Morton (in press) has also shown that in some species (e.g. Hooded Warbler), the two sexes differ in habitat choice, males in this case inhabiting forest and females scrub; in Hooded Warblers it has been shown by laboratory studies that this sexual difference in habitat choice has a genetic basis, suggesting that it may prove inflexible to change in response to changing distributions of habitat.

There are two further important points to be borne in mind with regard to scrubby vegetation as a habitat for migrants:

First, the FAO data are strongly biased towards over-estimating the area of scrub, and under-estimating its rate of loss; this is because the FAO figures include no estimate of the fate of "forest fallow" (i.e. the vegetation arising from the clearing of forest by shifting cultivation) which contributes a large proportion of this habitat category. The rate of clearance of this component of scrubby vegetation is considerable, but unmeasured (Salati and Vose 1983, Houghton et al. 1985, Melillo et al. 1985);

Second, scrub represents a stage in a man-made succession, from mature forest to open agricultural land, and back again as forest regenerates on abandoned land; but as human population pressure increases the demand for fuelwood and cropland, that succession is likely to be arrested at earlier and earlier stages, so that ultimately there will be very little scrub or forest left.

The increase in scrub and secondary forest which is predicted to take place between now and the year 2000 can thus be regarded, at best, as a breathing space for migrants that use it; during that time, scrubby habitats will afford a refuge for those species that can use it, but the respite will likely be short-lived. Since the FAO figures underestimate the clearance of scrub, to an unknown extent, even that respite might not occur.

It remains to identify more precisely the species that are most at risk in the immediate future. The data summarised in Table 13 help to do this. Here, species are allotted a ranking, relative to each other, in terms of the the number of countries they now occupy; the total area of habitat available to them "now" (i.e., according to FAO's (1981) predictions of the areas of habitats in 1985); an index of the "diversity" of their winter range, combining the previous two features; the area of habitat available in 2000, as predicted by model 4 in this study; and the mean rank of all these criteria. In each case, "high" rank refers to low numbers, i.e. greatest vulnerability; a species ranking 1 is the most vulnerable, 66 the least.

(i) Number of countries; this is an approximate measure of the extent of the range. The political connotation is not wholly inappropriate, because patterns of land-use differ considerably from country to country, and a species which occupies many countries is less vulnerable to degradation of its entire habitat by extreme policies in a single country. The species which are most vulnerable by this criterion include the hummingbirds and several other species which are virtually confined to Mexico, but note also the high rank of species

Table 13. SPECIES RANKED ACCORDING TO NUMBER OF COUNTRIES USED IN WINTER, AREA OF WINTER HABITAT AVAILABLE IN 1985, DIVERSITY INDEX, PERCENT OF 1985 AREA OF HABITAT PREDICTED TO REMAIN IN 2000, AND COMBINED MEAN RANK.

SPECIES in order of mean overall rank	RANK ACCORDING TO: 1985 area	No. of countries	Diversity index	2000 area as % of 1985
1. Connecticut Warbler	6	2	13	*
2. Western Flycatcher	6	7	18	5
3. Black-headed Grosbeak	1	15	1	23
4. Solitary Vireo	13	4	15	27
5. Philadelphia Vireo	23	9	30	1
6. Western Tanager	13	10	11	32
7. Vaux's Swift	13	33	21	5
8. Bay-breasted Warbler	13	24	22	14
9. Calliope Hummingbird	1	22	1	50
10. Orange-crowned Warbler	11	55	8	2
11. Violet-Green Swallow	13	8	25	32
12. Black-throated Gray Warbler	6	19	7	46
13. Whip-poor-Will	23	12	29	15
14. Rufous Hummingbird	1	25	1	57
15. Warbling Vireo	13	17	16	42
16. Palm Warbler	28	16	45	9
17. Hammond's Flycatcher	13	31	12	44
17. Dusky Flycatcher	1	39	1	59
19. Lincoln's Sparrow	13	34	10	44
20. Black-billed Cuckoo	6	14	19	65
20. Townsend's Warbler	28	32	23	21
20. Traill's Flycatcher	23	6	34	51
23. Chimney Swift	6	57	9	34
23. Black-chinned Hummingbird	1	45	1	59
25. Cape May Warbler	13	11	25	62
26. Yellow-bellied Flycatcher	40	20	49	3
27. Ruby-throated Hummingbird	40	40	30	4
28. Golden-winged Warbler	33	28	40	15
29. Nashville Warbler	11	48	6	57
30. Scarlet Tanager	23	42	33	25
30. Chestnut-sided Warbler	28	23	42	30
32. Wood Thrush	40	18	52	15
33. Veery	13	44	36	44
34. Turkey Vulture	40	26	58	8
35. Mourning Warbler	33	1	66	*
36. Yellow Warbler	13	50	48	*
37. Rough-winged Swallow	50	43	35	7
38. Yellow-rumped Warbler	50	51	24	13
39. Yellow-bellied Sapsucker	55	38	27	20
40. Black-throated Blue Warbler	28	21	43	49
40. Great Crested Flycatcher	48	29	53	11
40. Least Flycatcher	40	41	14	46
43. Blackburnian Warbler	33	46	39	24
44. Magnolia Warbler	55	30	46	12

Table 13 continued

SPECIES in order of mean overall rank	1985 area	RANK ACCORDING TO: No. of countries	Diversity index	2000 area as % of 1985
45. Western Wood Pewee	28	52	40	28
46. Common Yellowthroat	3	55	57	*
47. Northern Parula	35	33	28	59
48. Canada Warbler	49	33	47	29
49. Baltimore Oriole	37	50	61	10
50. Tennessee Warbler	36	50	55	18
51. Eastern Wood Pewee	59	23	38	40
52. Gray Catbird	27	48	20	66
53. Wilson's Warbler	54	33	17	63
54. Red-eyed Vireo	66	40	32	40
55. Rose-breasted Grosbeak	62	55	44	18
56. Gray-cheeked Thrush	56	33	53	38
56. Northern Waterthrush	5	65	65	*
58. Eastern Kingbird	63	40	39	34
59. Blackpoll Warbler	53	40	63	49
60. Olive-sided Flycatcher	61	55	56	21
61. Black-throated Green Warbler	50	60	37	64
62. Swainson's Thrush	58	61	63	30
63. Ovenbird	47	63	59	46
64. Black and White Warbler	60	64	51	43
65. American Redstart	65	66	64	25
66. Broad-winged Hawk	64	61	62	34

Notes:

* = species confined to gallery or mangrove forest, for which FAO gives no deforestation rates, so these ranks cannot be calculated; the mean ranks given here are those calculated from the first three columns only.

such as Connecticut Warbler, Black-billed Cuckoo and Chimney Swift whose winter ranges are confined to small parts of continental South America.

(ii) The total area of habitat available in 1985 gives a rather different ranking, especially for species confined to Mexico because this is a very large country with plenty of suitable habitat; thus, the hummingbirds do not appear vulnerable by this measure. Note that the highest ranks are confounded by the lack of data on the area of gallery forest in Central America (and some South American countries - see Table 4); the most vulnerable species here include several that are confined to this habitat, or this and mangrove (e.g. Mourning and Connecticut Warblers, Northern Waterthrush). The ranks have nevertheless been retained because gallery forest, by its nature, generally covers relatively small areas (Chapter 3), so this bias introduced by lack of data is not likely to be quantitatively very great.

(iii) The diversity index combines the previous two aspects of a species' distribution, though the ranks tend to be closer to those of "number of countries" than "total area." Again, species confined to Mexico rank most vulnerable, in spite of that country's large areas of habitat.

(iv) The predicted area in 2000, as a percentage of that in 1985, is the criterion that reflects vulnerability to future deforestation. The species ranking highest here are those whose winter distribution is predominantly in the isthmus of Central America, with only a small proportion in Mexico; these species sometimes (but by no means always)

have small areas of winter habitat to start with, but the countries in which they occur are also experiencing the most rapid rates of deforestation. Thus Canadian migrants in general show a similar pattern of vulnerability to that suggested by Fitzpatrick (1982) for a subset of them, the North American tyrant-flycatchers (Tyrannidae).

The geography of this pattern of vulnerability is particularly inconvenient, because the most suitable technology for monitoring the progress of deforestation is not available here. The remote sensing satellite "LANDSAT," which is the most widely used for monitoring changes in vegetation cover on a regional scale, now operates by transmitting signals directly to receiving stations on the ground (no longer, as in the past, by storing data on tape-recorders until in range of a ground station). Unfortunately, the isthmus of Central America lies between the areas covered by receiving stations in California, Maryland and Brazil. There are thus no data being gathered by LANDSAT on this region. However the French satellite SPOT may be able to fill this gap, at least in the future, and this possibility is one to be investigated urgently.

The 11 species ranking highest here, all of which are predicted to lose half or more of their winter habitat by the year 2000, are listed in Table 14, together with a further 20 species which are likely to lose between 25% and 50% of their winter habitat by 2000.

Table 14. SPECIES OF NEOTROPICAL MIGRANT PREDICTED TO LOSE MOST WINTER HABITAT BY THE YEAR 2 000.

SPECIES	PERCENT LOSS BY 2 000
(a) Species expected to lose half or more	
Philadelphia Vireo	83
Orange-crowned Warbler	63
Yellow-bellied Flycatcher	60
Ruby-throated Hummingbird	59
Vaux's Swift	58
Western Flycatcher	58
Rough-winged Swallow	57
Turkey Vulture	55
Palm Warbler	53
Baltimore (Northern) Oriole;	52
Great Crested Flycatcher	50
(b) Species expected to lose between one-quarter and one-half	
Magnolia Warbler	47
Yellow-rumped Warbler	45
Bay-breasted Warbler	44
Whip-poor-will	42
Golden-winged Warbler	42
Wood Thrush	42
Rose-breasted Grosbeak	41
Tennessee Warbler	41
Yellow-bellied Sapsucker	40
Olive-sided Flycatcher	39
Townsend's Warbler	39
Black-headed Grosbeak	38
Blackburnian Warbler	34
Scarlet Tanager	31
American Redstart	31
Solitary Vireo	30
Western Wood Pewee	29
Canada Warbler	28
Chestnut-sided Warbler	26
Swainson's Thrush	26

Chapter 8 - DISCUSSION AND CONCLUSIONS

DISCUSSION

Throughout this report I have been careful to point out that the information at hand allows us to make quantitative estimates of the likely changes in the area of forest habitats available to migrants, but not to extrapolate these to effects on the populations of the migrants. We cannot make such extrapolations with any precision until we have much more information on habitat-specific densities and population structure in each species (see Chapter 7). When such information is available, it will be possible to construct a multiple-regression model relating each species' density to the type of winter habitat, similar to that developed by Lofroth and Wetmore (1985) for forest birds breeding in British Columbia. Until the data ara available to construct such a model, we cannot predict the quantitative extent of population declines; but the extent of the predicted loss of habitat in as many as half the species involved is so great that we can predict qualitatively that substantial declines are inevitable in the dozen species which are set to lose half or more of their winter habitat by the year 2000, and are very likely in the more than twenty other species which will lose more than a quarter of their habitat. The remainder of this chapter proceeds on this assumption, i.e. that the predicted losses of winter habitat for neotropical migrants are of sufficient magnitude to be expected to lead to substantial population declines in the next 15 years.

Before summarising the scientific conclusions and recommendations arising out of this study, it would be misleading not to attempt to place the subject in a broader perspective. This is particularly necessary in a topic dealing with environmental problems in overseas countries, since these involve questions not only of international relations, but of the quite different mix of economic, social, cultural and political factors which are responsible for the specific ecological problems with which this study is concerned.

All the species concerned breed in Canadian forests, which are one of the country's major economic resources; some species are known to play important ecological roles as predators of insect pests (the "budworm" specialists - Cape May, Blackburnian, Tennessee and Bay-breasted Warblers (Erskine 1978) - see also pp.40, 44), and others may well play important roles in forest ecology that have not yet been investigated. Their likely decline in the near future thus has unknown but possibly significant consequences for one of Canada's major natural resources. Forest birds are also an important component of the country's wildlife resources whose non-consumptive exploitation has a major socio-economic impact throughout the nation (Jacquemot and Filion in press). Thus the likely decline in some of these species' populations in the very near future may have significant repercussions on other components of the environment, and on the national economy.

Like other conservation problems, this one arises out of interactions between people and their environment. Although it is often treated as a biological problem, the causes are not biological. Forest is being cut down in Latin America for two chief reasons: creation of pasture for raising cattle, and shifting agriculture

(Myers 1980, Lanly 1982). The cattle industry exports beef to North America and Europe, while shifting agriculture is carried out by susbsistence farmers; most of these are landless peasants forced into the forest because the best agricultural land (particularly in Central America) is used to grow cash crops for export, rather than growing food for the local population. Both these patterns of land-use are encouraged by development policies of foreign and multinational corporations and aid and development agencies, as well as by the social, political and economic policies of the governments of Central and South America.

The detailed interrelationships of these human factors in the tropical conservation story are beyond the scope of this report, but it would be remiss to conclude without drawing attention to their importance in this context. Recent treatments of the subject can be found in Plumwood and Routley (1982), Mares (1986), and Shane (1986).

CONCLUSIONS

(i) More than half of the species of bird which breed in Canadian forests and migrate to Latin America for the winter are likely to lose more than 25% of their wintering habitat by the year 2000, and 12 of these are expected to lose half or more.

(ii) The most vulnerable species winter mainly in the isthmus of Central America (i.e. between Mexico and Colombia), many of them chiefly in broadleaved forest. Species inhabiting more open types of woody vegetation seem to be less immediately vulnerable, but the available figures for the area of these vegetation types are serious

over-estimates, and predicted increases in these kinds of vegetation - at the expense of mature broadleaved forest - are likely to be exaggerated. Any real increases in second-growth forest will anyway be short-lived as human pressure on the land increases.

(iii) There is no convincing evidence that species vulnerable to tropical deforestation are yet declining on their breeding grounds in Canada. Nor is there any convincing evidence that they are not. Several of the data sources which are potentially capable of monitoring these trends cannot be evaluated satisfactorily because they are inaccessible or inappropriately stored; this situation needs urgent attention if the predicted trends in vulnerable species are to be detected. It also seems likely that the most intensive programme designed to monitor such trends - the Breeding Bird Survey - may not be able to do so, at least for many of the forest-interior species in Canada; this problem also needs further investigation.

(iv) The interpretation of the effects on breeding populations of the predicted changes in habitat is hampered by lack of the necessary data on ecology and behaviour of the species in their winter quarters. There is an immediate need for fieldwork to establish not only the densities of species in each major habitat type of the winter quarters, but also the use by different habitats of different age- and sex-classes of the population. These data can then be used to develop a multiple-regession model relating species density to winter habitat, adding predictive power to the simple deforestation models presented here. These data could be obtained by concentrating fieldwork in a few countries with sufficient areas of the relevant forest habitats, and where host institutions or resident specialists are active and co-

operative.

(v) Any programme on Canadian forest birds should incorporate quantitative studies of their population trends and habitat preferences on the breeding grounds, and on migration, as well as in their winter quarters. While the subject of this report concerns the relationship between winter habitat and population trends, future research into this subject would be seriously flawed if it did not pay full attention to trends (in habitat availability as well as bird populations) on the breeding grounds in Canadian forests as well as to the wintering habitats in Latin America.

(vi) The lack of remote-sensing capability to measure areas of habitat in the most vulnerable area - the Central American isthmus - is a serious obstacle to monitoring changes. Possible ways to overcome this problem - for example through the French SPOT satellite system - should be investigated.

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