THE INCIDENCE OF VAGRANT LANDBIRDS ON NOVA SCOTIAN ISLANDS

IAN A. MCLAREN

Biology Department, Dalhousie University, Halifax, Nova Scotia B3H 4J1, Canada

ABSTRACT.—Many vagrant landbirds have occurred on Brier, Sable, and Seal islands, Nova Scotia and have produced first records for Nova Scotia or Canada. In counts made on these islands for more than a decade, individuals of western species were relatively more common than in similar counts on islands off northeastern Florida in spring and North Carolina in fall. Western vagrants were more frequent, but much less diverse, on the Florida islands in fall. Recent checklists substantiate the conclusion that vagrant species from remote ranges are more diverse on the Nova Scotian islands than in other localities in eastern North America. The diversity and high incidence of vagrants may be related partly to the convergence of continental windstreams on Nova Scotia during migration seasons. Regional species, however, evidently avoid Sable Island, which is farthest offshore, whereas vagrants from remote ranges are relatively more common there than on the other two islands. This suggests that navigational error by "lost" vagrants is paramount. Weather patterns are examined in association with the earliest vagrants of each season, as these vagrants may have come most rapidly and directly. Southern vagrants may fly past their normal ranges in spring, unassisted by winds. Western species in spring are probably not generally deflected from their normal routes by winds. Western *Dendroica* spp. in spring in the east may come because of mirror-image disorientation. Southern vagrants are proportionately as common in fall as in spring, and individuals may or may not be wind-assisted in their reverse migrations. Western vagrants are relatively more common in fall than in spring. Some may come directly down-wind on fall westerlies, but their relatively high incidence in Nova Scotia may result from their being swept up the east coast by prevailing southwesterlies. Turn-of-the-century records from Sable Island suggest that vagrancy may have increased among species that have expanded their populations or ranges, especially those of disturbed habitats. *Received 16 May 1978, accepted 5 July 1980.*

LIKE some other places at the edges of continents, certain islands off Nova Scotia are visited by a remarkable variety of birds. Here I argue that the incidence of vagrants among these birds is higher than elsewhere in eastern North America and offer some explanations. The analysis is confined to landbirds, as seabirds and waterfowl need not use the islands, and the relative abundances of herons, shorebirds, and marsh birds may reflect available habitats. Three islands off Nova Scotia (Fig. 1) are the main sources of information. Brier Island is virtually connected to the mainland through another island and a long peninsula. Seal Island is about 25 km off the south end of the province, and Sable Island is about 150 km from the mainland.

Sable Island has long been known for its birds. Although there are casual earlier accounts, Dwight's (1895) visit in 1894 stimulated the interest in birds of the children of R. J. Bouteillier, Superintendent of the Life Saving Establishment on the island. One result is 219 bird skins, some unusual and hitherto undocumented, now in the Dwight collections at the American Museum of Natural History, New York and the Science Museum, Springfield, Massachusetts. Between 1900 and 1908, James and Richard Bouteillier also sent out lists of birds they recorded. Some were published (Boutelier 1901; Bouteiller 1905, 1906, 1908; Bouteiler 1908; their name is persistently misspelt in these papers and in references to them, but their holographic version is Bouteillier). Their unpublished lists and some of their published ones are on file at the Nova Scotia Museum of Science, Halifax. There is also on file an

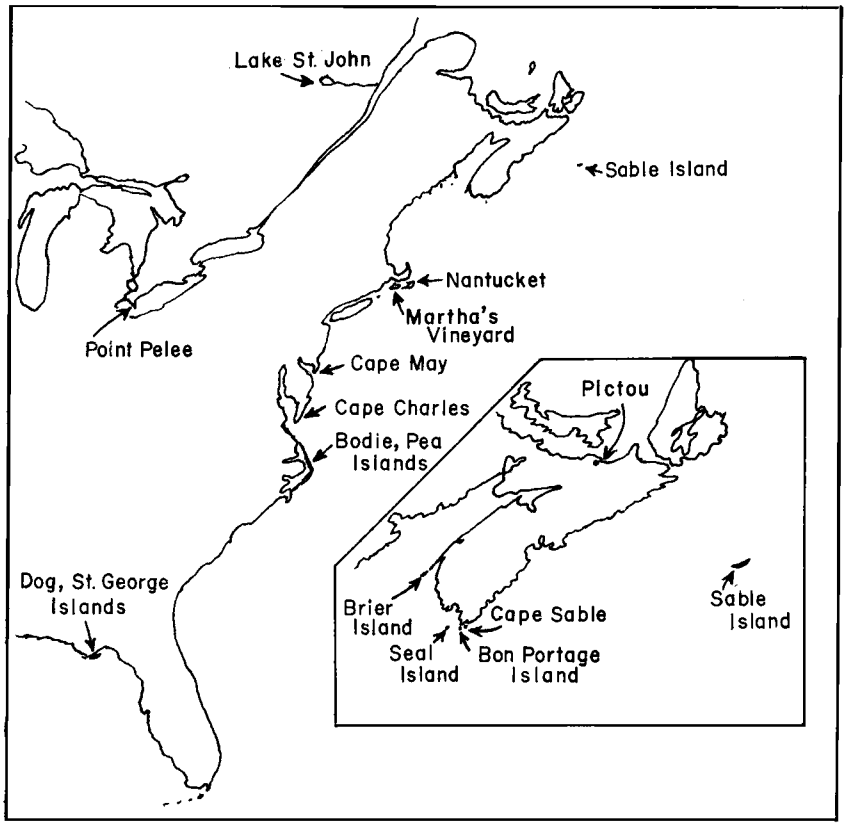

Fig. 1. Locations, excluding states and provinces, referred to in the text.

annotated list of birds of the island by Harry Piers, then Curator of the Provincial Museum, based on an interview with Richard Bouteillier on 10 June 1902 and stated to be the "results of about 10 years' observations."

Extensive records were begun again when Mrs. C. Bell, whose husband was employed on the island, began noting seasonal arrivals and unusual species in June 1963. Between December 1966 and her departure in March 1970 she kept daily records of all birds seen around the West Light. Since 1967, while on the island doing other research, my students, colleagues, and I have kept daily bird lists. Beginning in May 1974, regular lists have been made by Alban Richard, a government employee on the island.

Two seasonal lists (with no unusual species) from Seal Island in 1901 and 1902 were made by James Crowell, Lightkeeper, and are on file at the Nova Scotia Museum, and there was some subsequent interest in breeding birds (references in Tufts 1973). The first visits undertaken in order to observe and count migrants and vagrants, however, began in 1963 (Macpherson 1970).

Although Brier Island is most accessible, there appears to have been no early study of the birds there. A visit to observe birds was made in 1955 (Lewis 1956), and W. Lent, a lightkeeper on the island, subsequently reported and collected unusual species there. Complete daily lists were begun by E. L. Mills in 1969.

TABLE 1. Landbird vagrants recorded on Nova Scotian islands.

Species	Normal range[a]	Island records[b]		
		Brier	Seal	Sable
Swainson's Hawk (*Buteo swainsoni*)	W	X		
Band-tailed Pigeon (*Columba fasciata*)	W		P	
White-winged Dove (*Zenaida asiatica*)	W		P	X
Chuck-will's-Widow (*Caprimulgus carolinensis*)	S	2		
Red-bellied Woodpecker (*Melanerpes carolinus*)	S	4		
Gray Kingbird (*Tyrannus dominicensis*)	S			X
Western Kingbird (*Tyrannus verticalis*)	W	2,4	P	X
Fork-tailed Flycatcher (*Muscivora tyrannus*)	S		P	
Say's Pheobe (*Sayornis saya*)	W		1	P
Cave Swallow (*Petrochelidon fulva*)	S		1	1
Black-billed Magpie (*Pica pica*)	W	P		
Fish Crow (*Corvus ossifragus*)	S			X
Varied Thrush (*Ixoreus naevius*)	W			X
Blue-gray Gnatcatcher (*Polioptila caerulea*)	S	X	P	
White-eyed Vireo (*Vireo griseus*)	S	P	X	P
Prothonotary Warbler (*Protonotaria citrea*)	S	X	P	P,1
Swainson's Warbler (*Limnothlypis swainsonii*)	S		1	
Blue-winged Warbler (*Vermivora pinus*)	S	P	P	X
Yellow-rumped ("Audubon's") Warbler (*Dendroica coronata* ssp.)	W			X
Black-throated Gray Warbler (*Dendroica nigrescens*)	W	X	P	X
Townsend's Warbler (*Dendroica townsendi*)	W			P
Hermit Warbler (*Dendroica occidentalis*)	W			P
Cerulean Warbler (*Dendroica cerulea*)	S	X	X	X
Yellow-throated Warbler (*Dendroica dominica*)	S	X	P	P
Kentucky Warbler (*Oporornis formosus*)	S	1	P	P,3
Hooded Warbler (*Wilsonia citrina*)	S	2	P	P
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	W	X	X	P
Northern ("Bullock's") Oriole (*Icterus galbula bullockii*)	W		P	
Black-cowled Oriole (*Icterus dominicensis*)	S		X	
Brewer's Blackbird (*Euphagus cyanocephalus*)	W	X	X	X
Boat-tailed Grackle (*Quiscalus major*)	S			X
Summer Tanager (*Piranga rubra*)	S	X	P	P
Western Tanager (*Piranga ludoviciana*)	W	P		
Black-headed Grosbeak (*Pheucticus melanocephalus*)	W			X
Blue Grosbeak (*Guiraca caerulea*)	S		X	X
Painted Bunting (*Passerina ciris*)	S			X
Green-tailed Towhee (*Pipilo chlorurus*)	W		P	P
Lark Bunting (*Calamospiza melanocorys*)	W	4	P	
Le Conte's Sparrow (*Ammospiza leconteii*)	W		X	
Cassin's Sparrow (*Aimophila cassinii*)	W		P	
Dark-eyed ("Oregon") Junco (*Junco hyemalis* ssp.)	W		X	X
Clay-colored Sparrow (*Spizella pallida*)	W		P	
Harris's Sparrow (*Zonotrichia querula*)	W		P	
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	W			X
Chestnut-collared Longspur (*Calcarius ornatus*)	W			X

[a] Definitions of "western" (W) and "southern" (S) in text.

[b] Symbols are X = sight record only; P = photo on file, National Museum of Canada, Ottawa; specimens in: 1, National Museum of Canada; 2, Nova Scotia Museum of Science, Halifax; 3, American Museum of Natural History, New York; 4, collection of C. Coldwell, Wolfville, Nova Scotia.

OCCURRENCE OF VAGRANTS

For present purposes, I define as vagrant any landbird species that, according to Tufts (1973), does not nest in Nova Scotia or that does not normally migrate or "erupt" into the province from farther north and west, however rarely. A vagrant thus must show displacement eastward or northward from its normal breeding or migratory range. I include as vagrants three well-marked subspecies that were until recently given species status and that are still counted by observers on the islands.

It will be useful to distinguish between two groups from more distant regions (Table 1), as defined from maps in Robbins et al. (1966). "Southern" species are

mapped as not breeding north of Cape Cod, Massachusetts on the east coast, although they may nest farther north in the Midwest. "Western" species are mapped as breeding west of the longitude of Lake Michigan. Some of these may not nest as far north as do some southern species, but I have not placed them in a separate category of southwestern species.

The remaining vagrant species include some that breed as near as in Maine, and even New Brunswick, and two have nested in Nova Scotia since Tufts' (1973) book. Some, however, are less frequent than certain species in Table 1. The species are: Turkey Vulture (*Cathartes aura*); Red-shouldered Hawk (*Buteo lineatus*); Yellow-billed Cuckoo (*Coccyzus americanus*); Red-headed Woodpecker (*Melanerpes erythrocephalus*); Rough-winged Swallow (*Stelgidopteryx ruficollis*); House Wren (*Troglodytes aedon*); Carolina Wren (*Thryothorus ludovicianus*); Long-billed Marsh Wren (*Cistothorus palustris*); Short-billed Marsh Wren (*Cistothorus platensis*); Brown Thrasher (*Toxostoma rufum*); Wood Thrush (*Hylocichla mustelina*), which has recently nested in Nova Scotia; Yellow-throated Vireo (*Vireo flavifrons*); Warbling Vireo (*Vireo gilvus*); Worm-eating Warbler (*Helmitheros vermivorus*); Golden-winged Warbler (*Vermivora chrysoptera*); Pine Warbler (*Dendroica pinus*); Prairie Warbler (*Dendroica discolor*); Lousiana Waterthrush (*Seiurus motacilla*); Yellow-breasted Chat (*Icteria virens*); Orchard Oriole (*Icterus spurius*); Scarlet Tanager (*Piranga olivacea*); Cardinal (*Cardinalis cardinalis*), which has recently nested; Indigo Bunting (*Passerina cyanea*); Dickcissel (*Spiza americana*); Rufous-sided Towhee (*Pipilo erythrophthalmus*); Henslow's Sparrow (*Ammodramus henslowii*); Grasshopper Sparrow (*Ammodramus savannarum*); Seaside Sparrow (*Ammospiza maritima*); Lark Sparrow (*Chondestes grammacus*); and Field Sparrow (*Spizella pusilla*).

Although some island vagrants have been recorded earlier elsewhere in Nova Scotia, others are first records for the province or for Canada. Those first records that are not in Tufts (1973), together with some very unusual records, are reviewed briefly here.

The province's only Swainson's Hawk, in light phase, was seen during a major hawk flight on Brier Island in September 1964 (W. Lent, B. K. MacKay).

The first Nova Scotian White-winged Dove was on Sable Island on 10 August 1979 (A. Richard), and another was authenticated on Seal Island on 27 August 1979 (photo I. McLaren).

The only provincial record of a Band-tailed Pigeon was one on Seal Island between 23 September and 19 October 1974 (photo, S. Tingley).

A Gray Kingbird on Sable Island 20–23 October 1973 (A. Richard) was a well-described second provincial record (first record on Bon Portage Island; see below).

An Acadian Flycatcher (*Empidonax virescens*) reported by the Bouteilliers (MS) on Sable Island is suspect. Recent tentative sightings from Seal and Sable Islands are not included in Table 1 or in subsequent analyses.

In addition to the first Canadian records of Cave Swallows on Sable Island in Tufts (1973), a specimen (also of the Cuban population, W. E. Godfrey pers. comm.) was taken from Seal Island on 16 May 1971.

A Black-billed Magpie seen between 14 and 18 May 1973 on Brier Island (photo, W. Neilly) was a provincial first, although conceivably an "escape" from somewhere in the east.

Supposed first provincial sightings of House Wrens (Bouteiler 1908 and Bouteillier MSS) on Sable Island are suspect, as no reports of Winter Wrens (*Troglodytes troglodytes*) were made.

The first provincial Carolina Wren was sighted on Seal Island on 6 October 1974 (J. and S. Cohrs).

Although the Blue-gray Gnatcatcher had been widely reported earlier, it was first authenticated on Seal Island on 25 May 1975 (photo S. Tingley).

"Several" Prothonotary Warblers on Sable Island on 7 September 1903 (Bouteillier MS) were first provincial sightings.

The specimen of Worm-eating Warbler from Sable Island taken on 3 October 1902 is evidently a first from Canada, hitherto unreported.

A specimen of Swainson's Warbler from Seal Island taken on 9 October 1972 was a first from Canada.

A first authenticated Blue-winged Warbler in the province was on Seal Island on 24 August 1971 (photo D. W. Finch).

Male Black-throated Gray Warblers on 9 May 1966 and 1 May 1967 on Sable Island were firsts for the province. The species was confirmed on Seal Island on 10 October 1972 (photo J. Boulva).

A female Townsend's Warbler on Sable Island 9–10 June 1973 (photo D. W. Finch) is the only provicial record.

Two female Hermit Warblers on Sable Island on 26–27 May and 4 June 1975 (photos D. W. Finch, I. McLaren) are first Canadian records.

Yellow-throated Warblers on Sable Island on 7 June 1968 (C. Bell) and 22 August 1968 (photo D. Higgins) are first provincial records.

First provincial sightings of Pine Warblers by the Bouteilliers (published and MSS) on Sable Island are dubious, as autumn Blackpoll Warblers (*Dendroica striata*) are not listed.

The first authenticated Prairie Warbler in Nova Scotia was on Sable Island in late August 1969 (photo A. Lock).

A Louisiana Waterthrush on Sable Island on 2 July 1966 (C. Bell) was a first provincial sighting, and it was confirmed there on 9 August 1970 (photo J. Burton).

An apparent Black-cowled Oriole on Seal Island on 24 May 1971 (Doane 1971) may have been, from the description, of the Bahamian population.

An adult male Painted Bunting was seen on Sable Island on 31 July 1965 (C. Bell). Two females have been tentatively identified (not included in the present analyses) on Sable and Seal Islands. Earlier sight records in Canada are considered to be "escapes" by James et al. (1976).

Early sightings of Henslow's Sparrows on Sable Island (Bouteiller 1905, 1908) are open to doubt. The first well-described provincial occurrence was one on Seal Island on 10 October 1976 (B. Mactavish, S. Tingley).

A LeConte's Sparrow on Seal Island on 6 October 1974 (B. Mactavish et al.) was a provincial first.

Nova Scotia's first (and Canada's second; see James et al. 1976) Cassin's Sparrow was seen by several observers (photo S. Fullerton) on 18 May 1974.

A Clay-colored Sparrow on Seal Island on 18 May 1975 was the first authenticated in Nova Scotia (photo S. Tingley).

Although often seen earlier, the first authenticated Field Sparrow in the province was on Seal Island on 8 November 1971 (photo I. McLaren).

The first confirmed Harris's Sparrow in the province was on Seal Island between 29 September and 1 October 1973 (photo S. Fullerton).

An adult Golden-crowned Sparrow on Sable Island on 9 October 1967 (C. Bell) was a first in Nova Scotia.

For comparisons with other localities, this paper uses records from the three above-mentioned islands. Many of these vagrants and a few additional ones, however, have also been seen on two other islands off the south end of the province—Bon Portage Island and Cape Sable (Fig. 1). Unusual species were recorded over the years on Bon Portage Island by Evelyn Richardson, and some of these are documented only in her book "Living island" (Richardson 1965). Additions from among her sightings to the list of remote vagrants in Table 1 are a Scissor-tailed Flycatcher (*Muscivora forficata*) and a Bahama Swallow (*Callichelidon cyaneoviridis*). Her second-hand reports of two Mangrove Cuckoos (*Coccyzus minor*) and two Vermilion Flycatchers (*Pyrocephalus rubinus*) are at least suggestive. An unannotated list (Smith and Smith 1972) of the birds of Cape Sable (a small island off Cape Sable Island proper) includes a Black Vulture (*Coragyps atratus*) and a Bachman's Sparrow (*Aimophila aestivalis*); the latter has been tentatively identified on Seal Island but is not included in Table 1 or subsequent analyses. Birds authenticated on Cape Sable Island, but not on the three islands of Table 1, are Scissor-tailed

Flycatcher (photo S. and B.-J. Smith) and Chestnut-collared Longspur (see Tufts 1973).

RELATIVE ABUNDANCE OF VAGRANTS

Methods.—The species that have occurred on the Nova Scotian islands, and particularly the first records for the province or Canada, certainly imply an unusual incidence of vagrancy. This claim is better documented, however, from quantitative surveys on the islands. Here I use only those lists, usually daily, in which observers counted or estimated numbers of all landbird species seen. Occasional minimal estimates were not amplified (e.g. 100+ was taken as 100). The periods analyzed were between 1 April and 30 June ("spring" hereafter) and between 15 July and 30 November ("fall").

Some birds were identifiable as individuals on successive dates, but this was generally not possible with more frequent species. For these some estimate of residence time was needed. I examined records from Sable Island, where there were many sustained periods of observation of the open terrain and the area around buildings near the west end. I used daily lists made by at least two active observers for at least 2 weeks, discarding birds seen on first or last days of the periods. I used species that are conspicuous because of size or habits: hawks, large flycatchers, swallows, jays, nuthatches (generally on buildings), mimids, thrushes, icterids, tanagers, grosbeaks, buntings, and towhees. To reduce confusion I chose only those species that were relatively infrequent (<30 individuals, 1967–1979, in uncorrected lists; most were vagrants). Many of these birds were in fact recorded as individuals on successive days by observers. Altogether, 114 individuals of 25 species satisfied all criteria, and these were observed for an average of 3.7 days. This accords with the conclusion of DeSante (1973) that individual passerines might migrate about every fourth night.

I assumed, therefore, that a species (or sex or age category, etc.) was new if not seen during the previous 4 days. Also, when a species was recorded in larger numbers than had been recorded during the previous 4 days, the increment was assumed to be new individuals. I made no attempt to correct for "turnover" in species that were continuously present in similar numbers for more than 4 days; for these, a single peak count often stood as a total for the period. Against this tendency toward possible underestimation, there were periods of inactivity or bad weather that could have led to the recounting of birds present but not seen for 4 or more days. Most of the counts from Brier and Seal islands were made on weekend visits, so that (except for some identifiable individuals) counts of birds from two successive weekends could be added.

Resident birds on the islands could not be treated according to the above 4-day rule and, furthermore, were not always listed by observers on all days. For these, peak counts made during each season were used as estimates of abundances. Some judgement was used in discriminating influxes of migrants of the same species as the residents.

Lists of birds from other localities were not treated in the same way as those from Nova Scotian islands. Extensive counts were supplied by H. M. Stevenson from observations made by him and his colleagues between 1950 and 1978 on (generally monthly) visits to Dog, St. George, and Little St. George islands off northwest Florida (Fig. 1). Rarities were certainly sought and noted, but the intent was to count all species. I made no attempt to distinguish residents from migrants on these islands and simply summed all individuals counted in March–May and August–December, seasons considered to be comparable with times of spring and fall migration in Nova Scotia.

Another comparable list of species from east-coast islands is that made by Sykes (1967) between 21 August and 30 November 1965 on Bodie and Pea islands, North Carolina (Fig. 1). Similar lists seem unavailable for other east-coast islands, but some species counts and checklists will be referred to briefly.

Comparisons between Nova Scotia and other regions.—In a comparison of the incidence of vagrants in Nova Scotia and other regions farther south, obviously only western species can be considered (Table 2). The incidence of western species in spring was clearly greater in Nova Scotia than in Florida. Although proportionately more western individuals occurred in Florida in fall, these were dominated by the "routine" Western Kingbird (15 of 22 individuals). The 24 fall vagrants on Bodie and Pea islands were also dominated by Western Kingbirds (10) and the equally "routine" Clay-colored Sparrow. Western Kingbirds were also the most common western vagrant in fall in Nova Scotia but made up only 18 of 61 individuals (next

TABLE 2. Relative abundance and diversity of western on islands in three regions.

Season	Region	Species		Individuals		
		Total	Western	Total	Western (%)	*J* Western[a]
Spring	Nova Scotia	173	11	37,157	0.040	1.00
	Florida	125	0	10,145	0	—
Fall	Nova Scotia	186	15	123,648	0.049	0.78
	North Carolina	148	7	108,894	0.022	0.71
	Florida	148	7	18,225	0.121	0.58

[a] *J* is a measure of evenness, H/H_{max}, where H is calculated by the Brillouin formula.

were 17 Yellow-headed Blackbirds and 6 Clay-colored Sparrows). These differences among the localities are evident in the evenness values of Table 2.

A list of landbird migrants made by Rusling (unpublished MS, 1936, National Audubon Society) on Cape Charles, Virginia (Fig. 1) between 22 September and 11 November 1936 includes *no* western vagrants among 121,350 individuals of 103 species. Even given the greater difficulties in field identification at that time, this survey adds to the impression that there is unusual frequency and diversity of vagrants in Nova Scotia.

A list by Browne (1967) from a 7-yr survey of birds near Lake St. John, Quebec (Fig. 1) reveals the paucity of vagrants at an inland site, somewhat closer to the range of most western species. Among 103,309 individuals of 123 species of landbirds (all seasons, and thus not wholly comparable with Nova Scotia), Browne recorded only a single Burrowing Owl (*Athene cunicularia*) as a vagrant by the definitions used in Table 1.

Some checklists from east-coast localities are sufficiently local or sufficiently annotated to allow comparisons with Table 1. A "complete" checklist for Maryland (Robbins and Bystrak 1977) includes "hypotheticals" and has 21 western species, compared with 20 (excluding the 3 subspecies) in Table 1. Moreover, only 13 of the western vagrants in Maryland were in Atlantic coastal localities (including those given as "Eastern Shore Section"). A checklist for Cape May County, New Jersey (Fig. 1), updated to 1980 (Cape May Bird Observatory n.d.), contains only 12 western species. A checklist for Nantucket, Massachusetts (Fig. 1) by Andrews and Blackshaw (1979) has eight western species. One from nearby Martha's Vineyard, Massachusetts (Sargent 1975) has 12. An annotated checklist for Maine (Vickery 1978), which like Table 1 has some single-observer "hypotheticals," has 24 western species, of which 22 are from coastal or near-coastal localities. This number is similar to the count from Nova Scotia (Table 1) but of course comes from a much larger region.

Point Pelee, Ontario (Fig. 1) is an inland locality where vagrants have been intensively sought for a long time (checklists in Stirett 1973a,b,c,d; supplemented from James et al. 1976). For comparative purposes I exclude species that are defined (Table 1) as southern or western but that also nest in Ontario (per James et al. 1976). Point Pelee is closer to the ranges of all remaining vagrants, yet only 19 such western and 10 southern species (including the subspecies of Table 1) have been recorded there, compared with 18 and 11, respectively, in Nova Scotia. Lest it be thought that the two lists represent the same near-asymptotic limit of potential western and southern vagrants, it can be noted that 13 species from Point Pelee are not in Table 1, and 14 species from Table 1 have not occurred at Point Pelee.

TABLE 3. Relative abundance and diversity of vagrant species on three Nova Scotian islands.

Season	Island	Number of species			Individuals			
		Total	Vagrant	Remote[a]	Total	Vagrant (%)	Remote (%)	*J* Remote[b]
Spring	Brier	126	14	1	9,272	0.669	0.011	—
	Seal	140	30	11	16,023	1.590	0.150	0.77
	Sable	149	34	17	11,862	1.240	0.346	0.83
Fall	Brier	155	30	8	34,720	0.421	0.055	0.87
	Seal	173	49	22	70,893	1.405	0.117	0.89
	Sable	152	36	17	22,964	1.206	0.266	0.82

[a] Western and southern species as in Table 1.
[b] *J* is evenness measure; see Table 2.

In summary, the Nova Scotian islands are visited by an unusually large number and great diversity of vagrants, possibly more so than any other areas of comparable size in eastern North America.

Comparisons among the Nova Scotian islands.—There were marked differences in the incidence and diversity of vagrants on the three Nova Scotian islands (Table 3). Seal Island had the highest abundance of vagrant individuals, both spring and fall, but there were proportionately many more remote vagrants on Sable Island. Although the evenness component of diversity of these remote vagrants (Table 3, both seasons combined) was lower on Sable Island ($J = 0.822$) than on Seal Island ($J = 0.868$), a comparison of the most abundant species (which strongly influence evenness measures) is instructive. Among 108 individuals, the 5 most abundant species on Seal Island were: Blue-gray Gnatcatcher (16), Blue Grosbeak (12), Western Kingbird (10), Hooded Warbler (9), and (tied at 8 each) Clay-colored Sparrow and White-eyed Vireo. Among 102 individuals on Sable Island, the most common were: Hooded Warbler (20), Cave Swallow (14), Prothonotary Warbler (12), Yellow-headed Blackbird (12), and Yellow-throated Warbler (8). Clearly the lower diversity on Sable Island is induced by some less "routine" species.

Some counts made during the same time periods on pairs of islands (Table 4) indicate that population densities differ. As might be expected from their geographical settings, Brier Island at times has very heavy waves of migrants, and Sable Island often has very few migrants present.

The island results can also be compared with a 10-yr survey near Pictou, Nova Scotia (Fig. 1) by Holdway (1967). During April–November he counted some 17,500 individuals of 110 species. (Some species were incompletely counted, and others are given only as yearly totals; these two features may partly cancel out in using his counts for comparison with Table 3). The only spring and fall vagrants near Pictou were a Blue Grosbeak and a Rufous-sided Towhee.

TABLE 4. Relative abundance of birds from counts on the same days on two islands.

Number of days	Mean number of individuals per day		
	Brier	Seal	Sable
40	—	637	158
11	839	820	—
5	618	—	105

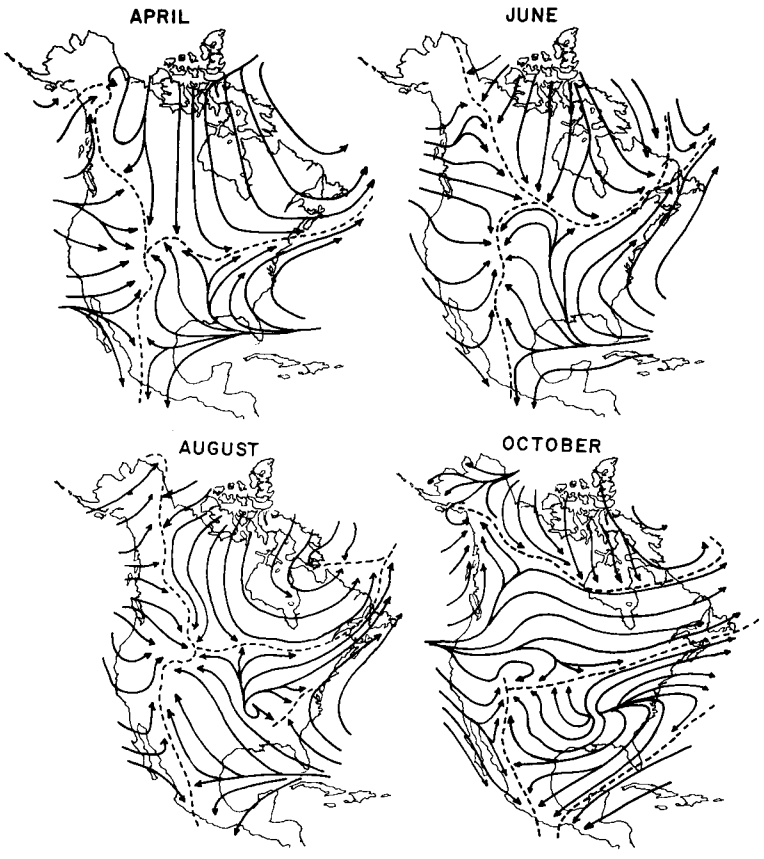

Fig. 2. Streamlines of resultant airflow at the surface or 1,000 mbar, whichever is higher, together with boundaries (dashed) between major airmasses, over North America (after Bryson and Hare 1974).

In summary, Brier Island is dominated by regional migrants, although with a greater proportion of vagrants than occurs near Pictou, on mainland Nova Scotia. Seal Island may have a somewhat lower density of regional migrants, but with a substantially greater admixture of vagrants. On Sable Island, birds are much less common during migration, but relatively many more are from remote regions.

Patterns and Explanations

Effect of geographical location.—Nova Scotia is particularly well situated to receive vagrant birds from other parts of North America. Thrusting out into the Atlantic, half-way between the equator and the pole, its islands may offer last possible landfalls for birds coming from the west and first landfalls for birds moving north but displaced over the ocean. These features of shape and position, however, do not in themselves explain why so many vagrants should arrive in the general vicinity of the province.

General role of weather.—There is an extraordinary convergence of air masses and wind streamlines in the vicinity of Nova Scotia during seasons of migration (Fig. 2). The mean boundary between arctic and tropical air massess passes north-

ward in May and southward in September across the province. During spring, southwesterly flow predominates. During early autumn, streamlines from the midwestern to southeastern United States converge on Nova Scotia and carry out to the sea beyond. Later, before polar outbreaks become very strong, westerlies dominate southern Canada from coast to coast. Stagnant anticyclonic eddies of tropical air then return to the southeastern United States.

Storm tracks from the south and west of the United States, whence come most of the birds I have designated as vagrants, also converge in the vicinity of Nova Scotia. At the average speeds of storms in May and September depicted by Visher (1954), storms would take about 3 days to move from southern Florida or Minnesota to Nova Scotia.

Vagrants, especially in older works, are often said to have been brought by "storms." If this implies that birds are entrained in moving low-pressure systems, it is misleading. That hurricanes displace seabirds is of course well known, but few of the landbird vagrants considered here have appeared on the islands after the nearby passage of intense storms. It is the general impression of observers on Nova Scotian islands that vagrants appear, along with numbers of migrant landbirds, generally during fine weather, often after the passage of cold fronts offshore, and with westerly or northwesterly winds. The prior displacement of birds to the vicinity of Nova Scotia, however, may involve the variety of trajectories implied in Fig. 2. That the general role of weather is through geostrophic wind patterns rather than through storms, as such, agrees with other analyses of migration and vagrancy in North America (e.g. Gauthreaux and LeGrand 1975 and references therein).

General role of navigational error.—Kaufman (1977) and others have argued that disorientation is more important than weather in causing vagrancy, the winds merely abetting the progress of disoriented individuals. I believe that navigational error is primarily responsible for the high incidence of vagrants on the Nova Scotian islands. It should be noted that islands, especially offshore ones like Sable Island, may concentrate landbirds from large surrounding airspace, thus giving a misleading impression of their abundance. This alone should not affect arguments about the *relative* abundance of regional and remote vagrant species. The importance of navigational error would rather seem to follow from the marked differences among the three Nova Scotian islands, for it appears that regional species avoid and remote species accumulate on Sable Island (Table 3). There are two possible explanations. First, regional birds in general may have started out from more nearby localities and thus be less obliged to put down on Sable Island out of exhaustion. Second, selection may have acted more strongly against offshore drift in regional populations, whereas remote species, lacking any inherent "knowledge" of the region, carry on to the limits of their disorientations. Many may pause in coastal regions, where vagrants are well known but where, as on Brier Island, they are greatly outnumbered by regional birds making safe landfalls. I conclude that islands, including the western American "oases" discussed by Gauthreaux and LeGrand (1975), may generally be bypassed by regional birds while at the same time attracting "lost" vagrants.

This selective concentration of vagrants may be largely responsible for their high relative abundance on the Nova Scotian islands (Table 2), for the more southern islands examined are not as isolated as are Sable and Seal islands. I also showed, however, that the list of western vagrants in Table 1 exceeds those from a number of large, long-studied regions closer to the sources or normal flight paths of such

birds. I therefore believe that the geographical and meterological factors considered earlier are an important part of the overall explanation of the phenomenon.

Southern species in spring.—Richardson (1971) found from radar studies that the predominant spring movement of small birds near the Maritime Provinces is to the northeast, east-northeast, and even east. These directions are readily related to the occurrence of vagrancy. Most vagrants to the islands are species that nest in New England or southern Canada; the five most abundant in the quantitative lists were Brown Thrasher (106), Field Sparrow (54), Rufous-sided Towhee (51), Indigo Bunting (45), and Wood Thrush (28). The southern species (per Table 1) may give more insight into the relative roles of winds and navigational error. These appeared (all available records) as early as 14 April and as late as 24 June (median 19 May).

Some southern individuals may have come haltingly or deviously north, so that their associations with recent weather might be misleading. Accordingly, I examined weather maps on the 3 days prior to the dates of the five earliest occurrences on the islands, on the assumption that such birds were more likely to have come most recently and directly from their normal ranges to the southwest. The following were on Sable Island: a Blue-winged Warbler along with a very early Yellow Warbler (*Dendroica petechia*) on 14 April 1975; a Prothonotary Warbler along with a very early Wilson's Warbler (*Wilsonia pusilla*) and an Ovenbird (*Seiurus aurocapillus*) on 18 April 1971; a female Blue Grosbeak on 28 April and two males on 4 May 1971. On Seal Island, a Hooded Warbler appeared on 28 April 1975. The general wind pattern that emerges is not one of propulsion northeastward by winds, but rather of fine weather and slack winds occasioned by high pressure moving to the southeast or eastern United States, although there were offshore winds from New England or the Maritimes or both on or before days of appearances. Only the Blue Grosbeaks on 4 May 1971 were associated with southwesterly flow up the coast during the 3 previous days, although the Hooded Warbler in 1975 could have experienced such winds 4 days earlier. In appears, then, that most of these individuals were displaced by winds only in the northeast, if at all, and only after considerable "voluntary" overshooting of their normal range limits.

The two Caribbean species in Table 1 deserve further consideration. The five Cave Swallows on Sable Island on 9 May 1968 (C. Bell) were in the vanguard of swallows that year. Again, their appearance was not preceded by strong southerly or southwesterly winds, but by fine weather in the southeastern States and offshore flow in the Maritimes. Their appearance the next year on 13 June was perhaps too late to assume recent arrival in the region. The Cave Swallow on Seal Island on 16 May 1971 and the apparent Black-cowled Oriole there on 24 May, however, were both preceded by the movement of frontal troughs off the Atlantic coast from the Caribbean to the Maritimes, with southerly flow most marked prior to 16 May. These conditions could have deflected migrants in the Caribbean to the east and perhaps caused them to carry on north offshore. Even so, such extreme displacements must surely be viewed as navigational error. In spite of much awareness and searching, no Cave Swallows have been recorded since in Nova Scotia. Perhaps an abnormal flight-path tradition became briefly established by a group of these birds, but soon became selectively eliminated.

Western species in spring.—Western species are well known on the east coast in fall, but a surprising number have been found in spring on the Nova Scotian islands, when 19 of 82 remote vagrants (all available records) were western. These individ-

uals may have been deflected by westerly winds or may have come largely through disorientation. The fact that they appeared (all available records) over the same time period (10 April–10 June, median 19 May) as did the southern vagrants (see previous section) is an indication that they did not in general come circuitously from western sources.

Again the five earliest occurrences on the islands are more likely to reflect the patterns of displacement. Such birds on Sable Island were: a Black-throated Gray Warbler on 1 May 1967 and an "Audubon's" Warbler 3 days later; a Yellow-headed Blackbird on 8 May 1970; a Black-throated Grey Warbler on 9 May 1966. A Brewer's Blackbird appeared on Seal Island on 14 May 1978. Only the Black-throated Gray Warbler in 1966 appeared after a period of westerlies in southern Canada and the Northern United States, driven by a deep low over James Bay. The two western warblers in 1967 could have been influenced by appropriate winds from the Gulf States if they "chose" to come from the southwest. The others came after periods of high-pressure calm in eastern North America or after periods of flow up the Atlantic coast, like most southern species in spring (above). There is no general indication that these early western individuals were deflected by winds from their normal migration routes.

Several kinds of navigational error might impel western birds to Nova Scotia in spring. The Western Kingbird, Brewer's and Yellow-headed blackbirds, and Clay-colored Sparrows may have been relatively slightly disoriented eastward from potentially midwestern extremities of their ranges. The Cassin's Sparrow and Green-tailed Towhees on Seal and Sable islands in spring 1974 (the other Nova Scotian record of the towhee is also from spring; see Tufts 1973) could have continued to fly on a northeast bearing beyond the extremities of their normal ranges. It seems inexplicable, however, that all four records of Chestnut-collared Longspur in Nova Scotia (Tufts 1973, plus a bird on 4 June 1974 on Sable Island), as well as one each from New Brunswick and Newfoundland, are from spring.

The western *Dendroica* warblers are of interest, because six of eight individuals on the islands occurred in spring. DeSante (1973) concluded that the high frequencies of some eastern wood warblers in coastal California in fall is because they are prone to "mirror-image orientation." Instead of migrating normally to the left of a north-south axis of reference, they deviate by the same angle to the right and end up in California. The west coast of northern Mexico, where most of the western *Dendroica* winter or migrate (see e.g. maps in Robbins et al. 1966), runs almost northwest-southeast. A mirror-image disorientation would thus be expected to run northeast (45°). Between 1965 and 1980 there have been 38 spring records of these warblers east of the 100°W meridian, as reported in the journal *American Birds*. Most of the reports come from the northeastern United States and southern Ontario. The points of observation cannot be properly analyzed by regression to obtain a mean track of vagrancy, for the distribution is highly biased by lack of possible points in the Gulf of Mexico and in the uninhabited northeast of Canada. If an origin is *assumed* in about the middle of the Mexican range (say at 105°W and the Tropic of Cancer), however, individual tracks can be postulated for each of the 38 birds recorded (Mercator projection for true rhumb lines). The 95% confidence interval for the mean track is 39.3°–47.3°. This is in good agreement with the supposition that these birds were mirror-image disoriented and not extreme deviants in some normal distribution of tracks around the proper migratory direction.

Southern species in fall.—As in spring, most of the vagrants on the islands in fall

are those that nest closer to Nova Scotia. The five most abundant were: Brown Thrasher (164), Field Sparrow (139), Dickcissel (119), Indigo Bunting (102), and Prairie Warbler (99). Such vagrants were about as common among regional migrants in fall as in spring (ca. 1.01% vs. 1.19% of all individuals, respectively). Remote southern individuals (all records) appeared between 7 August and 15 November (median 20 September) and made up 0.08% of total counts in fall compared with 0.12% in spring. It thus appears that "reverse migration" of southern species to Nova Scotia is about as regular as "overshooting" the normal range in spring. Such reverse migration is well documented by radar for small birds near Nova Scotia (Richardson 1972) and Cape Cod (Williams et al. 1977). Able (1977) found that nocturnal migrants that had flown or drifted beyond the mainland off New England showed diurnal reorientation northward. This is presumably adaptive, but could lead to net displacement northeastward on westerly winds. It is also possible that southern vagrants make one of two kinds of navigational error: they could be persistently 180°-disoriented, or they may tend to fly downwind (promoted as a general tendency by Gauthreaux and Able 1970).

Again insights may come from five seasonally early examples. Although I previously chose 15 July as the beginning of the fall migration for analyses of island records, there were two earlier occurrences on Sable Island (not considered on Table 3): three Hooded Warblers on 2 July 1967 and a Prothonotary Warbler on 4 July 1965. Also on this island were a Painted Bunting on 31 July 1965, a Hooded Warbler on 7 August 1970 and a Prothonotary Warbler 3 days later, and a Yellow-throated Warbler on 22 August 1968. The first three occurrences were after periods of strong surface flow up the eastern seaboard, but the later arrivals followed at least 2 days of relatively slack conditions in the southeastern United States and along the east coast. This seems to support the possibility that persistent 180°-disorientation was involved in some of these birds.

Western species in fall.—Western species were slightly more abundant among all species in fall than in spring on the Nova Scotian islands (Table 2). They also made up a larger proportion (72 of 184 individuals; all available records) of remote vagrants at this season, compared with spring (see above; $\chi^2 = 6.42$, df = 1, $P \sim 0.01$). Dates of appearances (all records) were between 10 August and 30 November, the median date of 1 October being somewhat later than for southern vagrants (see above; median test, $\chi^2 = 3.17$, df = 1, $P \sim 0.08$). This difference, if real, may weakly reflect the more remote origins of most western species and possibly the switch to westerlies later in the season (Fig. 2).

Again, the five earliest vagrants (on Sable Island except as indicated) were: a White-winged Dove on 10 August 1979; young male Yellow-headed Blackbirds on 15 August 1975 and 16 August 1977; a White-winged Dove on Seal Island on 27 August 1979; a young male and female Yellow-headed Blackbird on 27 August 1978. The two doves in 1979 and the blackbirds in 1978 appeared after some days of relatively slack winds in the eastern United States and southern Canada, but the two earlier blackbirds both occurred after deep lows farther north had caused strong westerlies across southeastern Canada for 2 or 3 days.

Southwestern birds that normally withdraw southwestward from their breeding ranges (e.g. White-winged Dove and southwestern populations of Band-tailed Pigeon) could come to Nova Scotia as a result of persistent 180°-disorientation. Disorientation alone, however, is unlikely to explain the high incidence in Nova Scotia of western species that nest father north, as this would imply a modal disorientation

at about right angles to the normal track. It seems inescapable that wind must play some role in bringing such birds to Nova Scotia. Some species, like the relatively nonmigratory Varied Thrush with a corridor of fall and winter records across mid-continent (Keith 1968), may move rapidly downwind on late-fall westerlies (Fig. 2). Downwind displacement, however, need be only weak or sporadic. Any navigational error that leads to the east coast of North America may be amplified in Nova Scotia and perhaps, as checklists suggest (see *Comparisons between Nova Scotia and other regions*), in Maine as well, by prevailing southwesterly winds along the coast.

Has vagrancy increased?—Certainly vagrant birds are being sought more in recent years. Able (1972), however, has speculated on a suggestion that has been made by others, that vagrancy has actually increased, possibly implicating toxic chemicals in the biosphere. Although such a notion is difficult to test rigorously, records from Sable Island at the turn of the century are probably as good as can be found anywhere for this purpose.

The Bouteilliers recorded 14 species of landbirds (some perhaps doubtful) that I have classed as vagrants. Eight of these are species that are uncommon today (<10 between 1967 and 1979 on the island), along with four (Yellow-billed Cuckoo, Prothonotary Warbler, Orchard Oriole, Yellow-headed Blackbird) that have occurred more regularly (11–16 individuals 1967–1979). It is more instructive to consider the most abundant of today's vagrants to Sable Island, with greater than 20 individuals recorded during 1967–1979. In order of abundance, these are: Dickcissel (51), Prairie Warbler (46), Rufous-sided Towhee (32), Brown Thrasher (29), Yellow-breasted Chat (27), Indigo Bunting (25), and Scarlet Tanager (21). Of these, the Bouteilliers recorded in more than a decade only the Indigo Bunting (1 specimen) and Dickcissel (2 reports, 1 specimen). It is hard to believe that they could have overlooked all the others, some very conscpicuous, if they were as regular as they are today. Indeed, all have shown range expansions in recent years, and the tanager possibly now nests in Nova Scotia. It is also noteworthy that all except the first and last are species that benefit from the proliferation of second growth and shrub in human-disturbed habitats.

Therefore I conclude that vagrancy may indeed have increased among some species since the turn of the century. This can be related to increased abundance and range expansion, however, and not to secular trends in the tendency of individuals to wander.

ACKNOWLEDGMENTS

I am indebted to Christel Bell for her very extensive notes on birds on Sable Island and to Alban Richard for keeping records in more recent years. Others who have supplied daily lists of their findings on one or more islands were: Jean Boulva, Dick Brown, Shirley Cohrs, Davis Finch (who also "discovered" the extent of the Dwight collections), Sylvia Fullerton, Tony Lock, Bruce Mactavish, Ted Miller, Eric Mills, Howard Ross, Wayne Stobo, Stuart Tingley, and Dan Welsh. H. M. Stevenson kindly supplied extensive lists of birds from the Florida islands, and the North Carolina list was kindly made available from his MS thesis by Paul Sykes, Jr. Eric Mills and Chandler Robbins commented usefully on earlier drafts. Other studies by the author and his students on Sable Island, during which bird records were kept, were supported by the Natural Sciences and Engineering Research Council Canada, Canadian Wildlife Service, and the Canadian National Sportsmen's Fund.

LITERATURE CITED

ABLE, K. T. 1972. The changing seasons. Amer. Birds 26: 25–30.

———. 1977. The orientation of passerine nocturnal migrants following offshore drift. Auk 94: 320–330.

ANDREWS, E., & K. T. BLACKSHAW. 1979. Check list of Nantucket birds. Nantucket, Massachusetts Edith Andrews.

BOUTEILER, J. 1908. List of birds seen on Sable Island, N.S., from March 28th, 1906, to Jan. 1st, 1907. Ottawa Natur. 21: 189–191.

BOUTEILLER, J. 1905. Bird migration, 1904. Observations made at Sable Island, Nova Scotia. Ottawa Natur. 19: 119–120.

———. 1906. Bird migration, 1905. Observations made on Sable Island, Nova Scotia. Ottawa Natur. 20: 127–129.

———. 1908. Bird migration, 1907. Observations made on Sable Island, Nova Scotia. Ottawa Natur. 22: 96–97.

BOUTELIER, R. 1901. Autumn notes on birds, Sable Island, N.S., 1901. Ottawa Natur. 15: 199–200.

BROWNE, P. 1967. Status of birds, Lake St. John region, Quebec. Canad. Field-Naturalist 81: 50–62.

BRYSON, R. A., & F. K. HARE. 1974. The climates of North America. Pp. 1–47 *in* World survey of climatology, vol. 2. New York, Elsevier.

CAPE MAY BIRD OBSERVATORY. n.d. A checklist for the birds of Cape May, N.J. New Jersey Audubon Soc.

DESANTE, D. F. 1973. An analysis of the fall occurrences and nocturnal orientations of vagrant wood warblers (Parulidae) in California. Unpublished Ph.D. dissertation, Stanford, California, Stanford Univ.

DOANE, B. K. 1971. A Black-cowled Oriole? Nova Scotia Bird Soc. Newsletter 13: 79–81.

DWIGHT, J. 1895. The Ipswich Sparrow (*Ammodramus princeps*) and its summer home. Mem. Nuttall Ornithol. Club No. 1.

GAUTHREAUX, S. A., & K. P. ABLE. 1970. Wind and the direction of nocturnal songbird migration. Nature 228: 476–477.

———, & H. E. LEGRAND. 1975. The changing seasons. Amer. Birds 29: 820–826.

HOLDWAY, E. 1967. Birds of the Pictou area, Nova Scotia: 1957–1966. Occ. Paper 5, Sci. Ser., Halifax, Nova Scotia, Nova Scotia Mus. (mimeo).

JAMES, R. D., P. L. MCLAREN, & J. C. BARLOW. 1976. Annotated checklist of the birds of Ontario. Royal Ontario Mus. Life Sci. Misc. Publ.

KAUFMAN, K. 1977. The changing seasons. Amer. Birds 31: 142–152.

KEITH, A. R. 1968. A summary of extralimital records of the Varied Thrush, 1848 to 1966. Bird-Banding 39: 245–276.

LEWIS, H. F. 1956. Nova Scotia Bird Society expedition to Brier Island. Newsletter Nova Scotia Mus. Sci. 4: 35–37.

MACPHERSON, L. B. 1970. Seal Island birds in the fall. Nova Scotia Bird Soc. Newsletter 12: 116–119.

RICHARDSON, E. 1965. Living island. Toronto, Ontario, Ryerson.

RICHARDSON, W. J. 1971. Spring migration and weather in eastern Canada: a radar study. Amer. Birds 25: 684–690.

———. 1972. Autumn migration and weather in eastern Canada: a radar study. Amer. Birds 26: 10–17.

ROBBINS, C. S., B. BRUUN, & H. S. ZIM. 1966. Birds of North America. New York, Golden Press.

———, & D. BYSTRAK. 1977. Field list of the birds of Maryland. Maryland Avifauna No. 2, Maryland Ornithol. Soc.

SARGENT, R. M. 1975. Check list—birds of Martha's Vineyard. Martha's Vineyard, Massachusetts, Vineyard Gazette.

SMITH, B.-J., & S. SMITH. 1972. [List of birds of Cape Sable Island, N.S.]. Nova Scotia Bird Soc. Newsletter 14: 76–78.

STIRRETT, G. M. 1973a. The spring birds of Point Pelee National Park. Ottawa, Ontario, Parks Canada.

———. 1973b. The summer birds of Point Pelee National Park. Ottawa, Ontario, Parks Canada.

———. 1973c. The autumn birds of Point Pelee National Park. Ottawa, Ontario, Parks Canada.

———. 1973d. The winter birds of Point Pelee National Park. Ottawa, Ontario, Parks Canada.

SYKES, P. W., JR. 1967. The fall migration of land birds along the Bodie Island-Pea Island region of the Outer Banks of northeastern North Carolina. Unpublished M.S. thesis, Raleigh, North Carolina, North Carolina State Univ.

TUFTS, R. W. 1973. The birds of Nova Scotia, 2nd ed. Halifax, Nova Scotia, Nova Scotia Mus.

VICKERY, P. D. 1978. Annotated checklist of the birds of Maine. Maine Audubon Soc.

VISHER, S. S. 1954. Climatic atlas of the United States. Cambridge, Massachusetts, Harvard Univ. Press.

WILLIAMS, T. C., J. M. WILLIAMS, L. C. IRELAND, & J. M. TEAL. 1977. Autumnal bird migration over the western North Atlantic Ocean. Amer. Birds. 31: 251–267.