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ANALYSIS OF UNUSUAL BIRD MIGRATION IN NORTH AMERICA DURING THE STORM OF APRIL 4–7, 1947

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INTRODUCTION

THE occurrence of a phenomenally early wave of insectivorous migrant birds at Toledo, Ohio, on April 5 and 6, 1947, was reported by Mayfield (1947). He suggested that there might be a meteorological explanation for this event, for "on April 5 an intense low-pressure area developed in Kansas and moved northeastward, marked by tornadoes in Oklahoma and Missouri and accompanied by strong south winds in the eastern Mississippi Valley and Lake region."

Baillie (1947) and Saunders (1947) recorded the equally unusual wave of migrants which was noted at Toronto, Ontario, on April 5, 6, and 7, 1947, virtually simultaneously with the one at Toledo. Similar reports from observers in extreme southern Ontario made it evident that the two waves were really part of the same phenomenon.

While there are numerous instances of birds in North America being transported far off-course by maritime and oceanic storms, this has not been the case for continental disturbances. The authors of the present paper, therefore, felt that it would be of value to bring together published and unpublished records pertinent to this particular occurrence and to analyse them in relation to the meteorological conditions prevailing over the continent at that time.

The difficulty with such an analysis lies in the scattered and fragmentary nature of the data on birds. If more were known about bird distribution and movements during migration, the correlation with weather data would probably be much more evident. Such factors as irregularity in time and duration of observation-periods, the attendant emphasis on week-ends, and the lack of a central clearing-house for the detailed information collected make it impossible to reduce the data on birds to figures that may be compared quantitatively with those obtained by the network of weather stations.

Photograph by Karl H. Maslowski

BARN OWL, *Tyto alba pratincola*, BRINGING YOUNG COTTONTAIL RABBIT TO ITS NEST. DURING THE PERIOD OF MAY TO AUGUST, 1947, I SPENT AN ESTIMATED THREE TO TEN HOURS PER NIGHT OBSERVING BARN OWLS AT THEIR NESTS ALONG THE LITTLE MIAMI RIVER NEAR CINCINNATI, OHIO. THEIR PREY CONSISTED ALMOST ENTIRELY OF RATS AND MICE, BUT ON THREE OCCASIONS VERY YOUNG RABBITS WERE BROUGHT TO ONE PARTICULAR NEST. JUDGING BY THE RABBIT FUR ON THE OWL'S TALONS I ASSUME THE RABBIT WAS TAKEN DIRECTLY FROM THE NEST. BUT HOW DID THE OWL FIND THE RABBIT; BY SEEING THE FUR LINING OF THE NEST MOVE, OR BY WATCHING THE MOTHER RABBIT? WOULD THE BONES OF SO YOUNG A RABBIT BE SUFFICIENTLY OSSIFIED TO BE FOUND IN THE PELLETS OF YOUNG OWLS?—Karl H. Maslowski, Cincinnati, Ohio.

However, within these limitations, it is believed that the accumulated information does present an interesting picture, even though many blank spaces remain in it. It is hoped that this paper may be the means of bringing to light some of the information necessary to fill these blanks.

Acknowledgments.—This study was made possible only because a great many ornithologists were kind enough to locate and compile for their particular region the records which had to be assembled in order to provide a composite, over-all picture for analysis.

Persons who contributed such information or gave assistance in tracing it to its source are: Mr. Emmet R. Blake of Chicago Natural History Museum; Dr. Donald J. Borror of Ohio State University; Professor Maurice Brooks of West Virginia University; Mr. Louis W. Campbell of Toledo, Ohio; Mr. Ben B. Coffey, Jr., of Memphis, Tenn.; Mr. Philip A. DuMont of the Fish and Wildlife Service, Washington D. C.; Mr. William Girling of London, Ont.; Mr. Ludlow Griscom of Museum of Comparative Zoology, Cambridge, Mass.; Mr. James W. Hancock of Madisonville, Ky.; Dr. Lee Roy Herndon of Elizabethton, Tenn.; Dr. Joseph C. Howell of University of Tennessee; Mr. Monroe Landon of Simcoe, Ont.; Dr. Harvey B. Lovell of University of Louisville; Dr. George H. Lowery, Jr., of Louisiana State University; Mr. Harold Mayfield of Toledo, Ohio; Mrs. D. S. Miller of Detroit, Mich.; Mr. Harold D. Mitchell of Buffalo, N. Y.; Messrs. Burt Monroe, Sr. and Jr., of Louisville, Ky.; Mrs. Robert A. Monroe of Knoxville, Tenn.; Mr. George W. North of University of Toronto; Mr. Henry M. Parker of Cambridge, Mass.; Mr. Chandler S. Robbins of Fish and Wildlife Service, Laurel, Md.; Dr. R. M. Saunders of University of Toronto; Mrs. E. R. Smith of Two Rivers, Wisc.; Mr. Jerry Stillwell of Dallas, Tex.; Mr. Arthur Stupka, Park Naturalist at Great Smoky Mountain National Park, Tenn.; Mr. Milton B. Trautman of Stone Laboratory, Put-in-Bay, Ohio; Mr. M. G. Vaiden of Rosedale, Miss.; Mr. Francis M. Weston of Pensacola, Fla.; Professor George G. Williams of Rice Institute, Houston, Tex.; Mr. Gordon Wilson of Western Kentucky State Teachers College, Ky.; Mrs. T. E. Winford of Dallas, Tex.; and Mr. A. A. Wood of Chatham, Ont.

The authors are particularly indebted to Mr. James L. Baillie, Research Assistant of the Royal Ontario Museum of Zoology; Mr. Baillie made a starting point for this study by compiling the pertinent records from Toronto and southern Ontario. He provided data from his journals covering arrival dates in the Toronto region for the past 27 years and gave enthusiastic assistance throughout the preparation of the manuscript.

Helpful criticism of the manuscript was kindly offered by Mr. Aaron M. Bagg of Holyoke, Mass., and by Mr. L. L. Snyder, Curator of Ornithology, Royal Ontario Museum of Zoology.

Thanks are due to Mr. Andrew Thomson, Controller of the Meteorological Division of the Department of Transport (Canada) for permission to consult the official meteorological records and the original synoptic charts in the preparation of Figures 1 to 4. These figures were prepared by Mr. Eric Thorn of the Royal Ontario Museum of Zoology.

RECORDS FROM SOUTHERN ONTARIO

At Toronto, local manifestations of the cyclonic disturbance were rain and fog on April 5 and, on April 6, a strong southwest wind

accompanied by a rise in temperature. Even before the windstorm had subsided, observers at Toronto began to report the occurrence of migrant birds which may be grouped into two classes: 1) species appearing regularly in this region each spring, but in this instance reported many days before their previous earliest recorded arrival date; 2) species considered rare in the region at any time.

As reports from various parts of southern Ontario were accumulated, the coincidence of irregular occurrences became known and it was recognized that something of an unusual nature had occurred to displace so many individuals and species in both time and space.

Table 1 is a compilation of rare and/or early migrants reported from southern Ontario for the period April 1–25, 1947. For birds observed later than, say, April 9, it may be supposed that: a) they reached the region during the period of the storm, but remained unnoticed until the date on which they were reported; or b) they were carried beyond their normal route-pattern by the storm, but did not reach southern Ontario until they made a further advance, perhaps during periods favorable to northward migration such as occurred on April 10–11 and April 17; or c) their appearance in the region was unrelated to the storm of April 4–7.

Some comment should be made in regard to the following species mentioned in Table 1:

WHITE-EYED VIREO, *Vireo griseus*.—An individual was found dead at Westboro, a suburb of Ottawa, on April 7. It appears to have been farther off course than any other and constitutes a remarkable record. Mowat (1947) and Lewis (1948) list a total of seven previous records in Ontario, so that this would seem to be the eighth. However, the previous records were either from the Toronto region or the Lake Erie region of extreme southern Ontario.

RED-EYED VIREO, *Vireo olivaceus*.—The Red-eyed Vireo from Meaford (Georgian Bay region of Lake Huron) and the above-mentioned White-eyed Vireo together constitute the two most northern records in the table. It is of interest to note that both were found dead.

HOODED WARBLER, *Wilsonia citrina*.—Six individuals are listed for various areas in the Toronto region. An additional five, not listed, were seen in the Toronto region between April 26 and May 3. While some of these may represent duplications, it is nevertheless probable that more were present during April and early May than had been reported previously at Toronto for all seasons and for all the time that local records have been kept.

SUMMER TANAGER, *Piranga rubra*.—The individual discovered by Mr. F. H. Emery in the vicinity of his home at Toronto remained

TABLE 1

UNUSUAL OBSERVATIONS REPORTED FROM SOUTHERN ONTARIO DURING APRIL 1–25, 1947

April	*Species*	*Locality*	*County*	*Observers*	*Significance of record*
1–4	None	——	——	——	——
5	Blue-headed Vireo	Toronto	York	Waters	Abnormally early
6	Nighthawk	Toronto	York	Lambert	Abnormally early
6	Chimney Swift	Turkey Point	Norfolk	North	Abnormally early
6	Wood Pewee	Toronto	York	Stark	Abnormally early
6	Parula Warbler	Toronto	York	Baillie *et al.*	Abnormally early
6	Blackburnian Warbler	Toronto	York	Douglas, Allworth	Abnormally early
6	Hooded Warbler	Port Dover	Norfolk	Parkinson	Exceptionally rare
6	Hooded Warbler, male	Toronto (Strathgowan)	York	Field, Dwight	Exceptionally rare
7	Chimney Swift	Toronto	York	Cook, Gunn	Abnormally early
7	Least Flycatcher	Toronto	York	Cook, Gunn	Abnormally early
7	White-eyed Vireo (dead)	Westboro	Carleton	Valois	Entirely extralimital
7	Red-eyed Vireo	Toronto	York	Waters	Abnormally early
8	Catbird	Ancaster	Wentworth	Halladay	Abnormally early
9	Red-eyed Vireo (dead)	Meaford	Grey	Beamer	Abnormally early
9	Hooded Warbler, male	Toronto (Baby Point)	York	Gough	Exceptionally rare
9	Hooded Warbler, female (dead)	Toronto (Runnymede)	York	Mrs. Sines	Exceptionally rare
10	Blue-gray Gnatcatcher	Cedar Springs	Kent	Stirrett	Abnormally early
11	Black and White Warbler	Toronto (Sherwood Park)	York	Miss Hambleton	Abnormally early
11	Black and White Warbler	Toronto (Grenadier Pond)	York	Shortt	Abnormally early
12	Oven-bird	Toronto	York	Sherrin	Abnormally early
13	Blue-gray Gnatcatcher	Point Pelee	Essex	Lancaster	Abnormally early
13	Hooded Warbler, male	Toronto (Glencairn Ave.)	York	MacArthur	Exceptionally rare
13	Summer Tanager, male	Toronto (Beech Ave.)	York	Bodsworth	Entirely extralimital
13	Harris's Sparrow	Toronto	York	Lamsa	Entirely extralimital
17	Blue-gray Gnatcatcher, male	Toronto	York	Cook, Gunn	Exceptionally rare
18	Summer Tanager, male	Toronto (Old Mill Terr.)	York	Emery	Entirely extralimital
18	American Redstart	Port Hope	Durham	Ness	Abnormally early
19	Blue-gray Gnatcatcher	Hamilton	Wentworth	North	Exceptionally rare
19	American Redstart	Toronto	York	Halladay, Helleiner	Abnormally early
20	Yellow-throated Vireo	Toronto	York	Miss Lawrence	Abnormally early
24	Worm-eating Warbler	Toronto	York	Scovell, Swift	Entirely extralimital
24	Hooded Warbler, male	Toronto (High Park)	York	Scovell	Exceptionally rare
24	Hooded Warbler, male	Toronto (High Park)	York	W. Martin	Exceptionally rare

there long enough to afford a great many people their first opportunity to observe this species. It was a male which had not yet attained its full breeding plumage, having green wings and a green band on the head. Only four previous records are known for Toronto.

WORM-EATING WARBLER, *Helmitheros vermivorus*, and HARRIS SPARROW, *Zonotrichia querula*.—There are no specimens for the Toronto region, but there have been a few previous sight records for these two species.

With the exception of the Harris's Sparrow, which migrates northward west of southern Ontario, species indicated as being rare or extralimital in Table 1 invariably have their center of abundance south and/or southwest of southern Ontario.

COMPARISON OF ARRIVAL DATES FOR THE TORONTO REGION

Table 2 is designed to illustrate the wide disparity in time between the first dates for species included in Table 1 as observed at Toronto and the earliest and mean arrival dates for the same species in the same region in previous years. The dates for previous years are compiled from observations made by one observer only (Baillie), but they cover a period of 27 years of active observation in the field and it is believed that they present an accurate picture for the Toronto region.

TABLE 2

ARRIVAL DATES IN 1947 FOR 17 SPECIES IN THE TORONTO REGION, COMPARED WITH EARLIEST AND MEAN ARRIVAL DATES RECORDED BY MR. JAMES L. BAILLIE IN THE TORONTO REGION DURING THE PERIOD 1920–1946, INCLUSIVE

Species	*Number years recorded, 1920–1946*	*Earliest arrival date*	*Mean arrival date*	*Earliest date in 1947*	*Number days in advance of:*	
					Earliest date	*Mean date*
Nighthawk	27	May 5	May 14	April 6	29	38
Chimney Swift	27	April 28	May 9	April 7	21	32
Least Flycatcher	26	April 28	May 10	April 7	21	33
Wood Pewee	26	May 13	May 21	April 6	37	45
Blue-gray Gnatcatcher	3	April 22	May 5	April 17	6	18
Yellow-throated Vireo	12	May 13	May 23	April 20	23	33
Blue-headed Vireo	20	May 1	May 9	April 5	26	34
Red-eyed Vireo	25	May 12	May 16	April 7	35	39
Black and White Warbler	26	April 26	May 4	April 11	15	23
Worm-eating Warbler	0	—	—	April 23	—	—
Parula Warbler	21	May 6	May 13	April 6	30	37
Blackburnian Warbler	26	May 2	May 12	April 6	26	36
Oven-bird	26	May 3	May 10	April 12	21	28
Hooded Warbler	0	—	—	April 6	—	—
American Redstart	26	May 2	May 11	April 19	13	22
Summer Tanager	0	—	—	April 13	—	—
Harris's Sparrow	0	—	—	April 13	—	—
	Mean number of days (13 species)				23	32

An indication of the regularity with which a species occurs at Toronto is given in column 2 which shows, out of a possible 27, the number of years in which Baillie observed the species in the Toronto region.

Calculations derived from columns 6 and 7 show that the 13 species listed therein were, on the average, 23 days earlier than Baillie's earliest arrival dates and 32 days earlier than his mean arrival dates.

RECORDS FROM EASTERN UNITED STATES

In the light of the observations from Toledo (Mayfield) and southern Ontario (Table 1), certain records among those mentioned by DuMont (1947) for the Chicago region, Black and Wallace (1947) for the Detroit region, and Beardslee (1947) for the Buffalo region assume particular importance.

In order to supplement the data available from the literature, the authors wrote to ornithologists in a number of sections of the eastern United States. By the use of information provided through the kindness and co-operation of these contributors, it has been possible to augment the data for Table 3. This table is, therefore, a compilation of unpublished reports and published records. It presents spring arrival dates, where available, for 31 species from 24 localities, ranging from the Gulf of Mexico to the Great Lakes. While it provides a fairly good coverage of the whole area, there are still large gaps in important regions such as, for example, western Pennsylvania, Indiana, Missouri, Arkansas, Alabama, and Georgia.

It was hoped that such a table might bring out some or all of the following information: 1) the scope and incidence of the early wave(s) of April 3–7, 1947; 2) dates on which those of the species which migrate from Central or South America first reached North America; and 3) some clues as to the probable starting point of the flight which ended at the Great Lakes on April 5–7. While the table leaves some of these questions unanswered, it does provide, in summarized form, a good deal of information about the problem.

Along the Great Lakes, unusual occurrences were first reported on April 5 and were numerous from April 6 through April 8. The largest number of such occurrences was reported from urban or suburban areas where the density of human observers was greatest, but there was a striking difference in that far more were reported from Toledo and Toronto than from Detroit and Buffalo. In rural areas where human observers were fewer, these occurrences were reported chiefly from the north shore of Lake Erie, on or close to a line representing the shortest distance between Toledo and Toronto.

TABLE 3

RECORDS OF SPRING ARRIVAL IN 1947 FROM 24 LOCALITIES RANGING FROM THE GREAT LAKES AND NEW ENGLAND TO THE GULF OF MEXICO. OCCURRENCES WITHIN THE SEVEN-DAY PERIOD APRIL 3–9 ARE SHOWN IN BOLDFACE TYPE; THOSE EARLIER THAN APRIL 3 ARE ITALICIZED

Species	*Northern Illinois*	*Southern Michigan*	*Toledo, Ohio*	*Southern Ontario except Toronto*	*Toronto, Ontario*	*Buffalo, New York*	*Central Ohio*	*Wheeling, W. Va.*
Whip-poor-will	April 20	May 1	**April 6**	April 19	April 26	April 12	May 17	
Nighthawk		May 10	May 17	May 13	**April 6**	May 19	May 4	
Chimney Swift	April 10	April 24	**April 6**	**April 6**	**April 7**	April 30	**April 6**	
Least Flycatcher		May 1	April 26	May 2	**April 7**	April 26	May 4	
Wood Pewee		May 14	May 13	May 12	**April 6**	May 14	May 14	
Cliff Swallow	April 27	April 24	May 18	May 13	?	May 1	—	
Catbird	April 30	April 29	April 23	**April 8**	May 4	**April 7**	April 24	
Blue-gray Gnatcatcher	April 17	April 26	**April 6**	April 10	April 17	**April 7**	**April 6**	
White-eyed Vireo		—	April 27	**April 7**	—	—	April 27	
Yellow-throated Vireo		May 3	**April 6**	May 11	April 20	May 2	May 3	
Blue-headed Vireo		May 14	May 1	May 2	**April 5**	April 28	May 10	
Red-eyed Vireo		May 1	**April 5**	**April 9**	**April 7**	May 4	May 3	
Black and White Warbler	**April 7**	**April 8**	**April 6**	April 30	April 11	April 26	**April 5**	
Prothonotary Warbler		May 5		?	—	May 10	**April 6**	
Worm-eating Warbler		—	**April 6**	—	April 24	—	May 10	
Golden-winged Warbler		May 10	April 26	May 15	—	May 11	May 14	
Parula Warbler		May 13	May 2	May 3	**April 6**	May 2	May 10	
Magnolia Warbler		May 2	April 29	May 12	May 14	May 4	May 10	
Black-throated Green Warbler		April 26	April 27	May 2	May 3	April 26	April 26	
Blackburnian Warbler		**April 6**	May 3	April 24	**April 6**	April 16	May 14	
Palm Warbler	April 26	**April 6**	April 26	April 26	May 1	April 30	April 26	
Oven-bird		April 19	May 4	May 2	April 12	May 3	April 30	
Northern Water-thrush	April 29	May 11	**April 6**	April 27	May 1	April 30	—	
Louisiana Water-thrush	April 17	May 11	**April 6**	May 4	—	May 3	April 10	
Kentucky Warbler	April 30	—	May 3	—	—	—	May 10	**April 5**
Yellow-throat		April 29	April 29	May 3	May 3	May 2	April 20	
Hooded Warbler	**April 6**	**April 6**	**April 8**	**April 6**	**April 6**	**April 6**	May 10	**April 5**
American Redstart	April 30	May 10	April 29	April 19	April 18	May 2	May 14	
Orchard Oriole		May 18	?	May 13	—	April 30	—	
Scarlet Tanager		**April 6**	May 11	May 12	May 15	May 12	May 10	
Summer Tanager		—	—	—	April 13	—	May 10	

TABLE 3—(*Continued*)

Species	*Morgantown, W. Va.*	*Charleston, W. Va.*	*Washington, D. C.*	*Massachusetts*	*Louisville, Kentucky*	*Bowling Green, Kentucky*	*Madisonville, Kentucky*	*Memphis, Tenn.*
Whip-poor-will			**April 6**	April 19	**April 6**	April 27	—	—
Nighthawk			May 10	April 30	May 8	April 24	April 30	April 23
Chimney Swift			**April 6**	April 12	*March 31*	*March 31*	**April 3**	*March 30*
Least Flycatcher			May 6	April 29	May 10	—	May 5	—
Wood Pewee			April 27	May 3	May 4	April 25	April 27	—
Cliff Swallow			April 17	**April 7**	May 5	—	—	—
Catbird			April 20	April 25	April 25	April 22	April 20	April 20
Blue-gray Gnatcatcher			April 12	**April 9**	**April 4**	**April 5**	**April 6**	*March 30*
White-eyed Vireo			April 19	—	April 23	April 20	**April 9**	April 10
Yellow-throated Vireo			April 20	May 7	May 2	April 26	April 20	**April 7**
Blue-headed Vireo			April 20	April 11	—	April 28	—	—
Red-eyed Vireo			April 27	May 2	April 26	April 26	April 17	**April 7**
Black and White Warbler	**April 3**	**April 4**	April 10	April 22	**April 5**	*March 13*	April 14	*March 30*
Prothonotary Warbler			—	—				
Worm-eating Warbler			April 27	May 14	May 3	April 26	—	—
Golden-winged Warbler	**April 5**		April 30	May 7	May 5	May 11	May 5	April 12
Parula Warbler			April 12	April 24	May 3	May 10	May 8	April 13
Magnolia Warbler		**April 5**	May 3	May 8	May 9	May 11	May 16	May 2
Black-throated Green Warbler	**April 3**		April 24	April 29	**April 5**	April 24	April 24	April 16
Blackburnian Warbler		**April 5**	April 30	April 29	May 3	May 3	April 28	April 12
Palm Warbler			*March 29*	April 10	May 5	?	April 21	April 19
Oven-bird			April 19	May 2	May 3	April 27	—	**April 7**
Northern Water-thrush			April 13	April 29	May 5	May 5	May 2	—
Louisiana Water-thrush			**April 5**	April 10	**April 5**	April 13	?	April 13
Kentucky Warbler		**April 6**	April 30	May 15	April 30	April 27	April 20	April 12
Yellow-throat	**April 6**		April 19	April 30	April 26	April 20	April 11	April 13
Hooded Warbler		**April 4**	April 13	May 7	May 3	April 13	**April 7**	**April 8**
American Redstart	**April 4**	**April 6**	April 12	April 30	May 3	April 13	May 4	April 15
Orchard Oriole			**April 7**	—				
Scarlet Tanager			April 23	May 3	April 22	April 26	April 25	April 23
Summer Tanager			May 14	May 7	April 24	April 26	April 23	April 15

TABLE 3—(*Continued*)

Species	*Knoxville, Tenn.*	*Great Smoky Mountain National Park*	*Elizabethton, Tenn.*	*Texas Coastal Region*	*Dallas, Texas*	*Rosedale, Miss.*	*Pensacola, Florida*	*Carolinas Region*
Whip-poor-will	—	April 17	May 3	winters	—	—	winters	
Nighthawk	—	June 3	April 25	April 13	?	April 13	**April 8**	**April 6**
Chimney Swift	**April 7**	**April 5**	**April 6**	*March 22*	**April 8**	*March 29*	*March 16*	**April 3–7**
Least Flycatcher	—	May 3	May 2	April 15	April 30	—	—	
Wood Pewee	April 30	April 26	April 13	April 13	—	**April 3**	April 17	
Cliff Swallow	—	—	April 27	April 16	May 4	*March 29*	—	
Catbird	April 30	April 22	April 22	winters	May 7	April 13	winters	
Blue-gray Gnatcatcher	**April 5**	**April 6**	**April 6**	winters	*March 27*	—	winters	
White-eyed Vireo	April 10	**April 7**	**April 6**	*March 20**	*March 30*	*March 29*	winters	
Yellow-throated Vireo	April 22	**April 7**	April 12	*March 23*	—	—	*March 26*	
Blue-headed Vireo	—	—	April 27	winters	May 12	winters	winters	
Red-eyed Vireo	April 21	April 22	April 24	*March 30*	April 26	**April 3**	*March 24*	
Black and White Warbler	April 13	**April 4**	April 13	*March 13**	May 10	*March 29*	*March 16**	
Prothonotary Warbler							*March 23*	
Worm-eating Warbler	April 30	April 26	May 2	*March 21*	—	—	*March 26*	
Golden-winged Warbler	May 4	April 20	April 26	April 13	—	—	—	
Parula Warbler	—	April 22	April 20	*March 3*	—	**April 3**	*March 16*	
Magnolia Warbler	May 3	—	April 26	April 25	May 12	—	May 4	
Black-throated Green Warbler	**April 6**	April 24	April 24	*March 24*	May 9	April 13	—	
Blackburnian Warbler	May 1	April 22	April 26	April 20	May 9	—	—	
Palm Warbler	*March 10*	April 22	April 26	—	—	—	winters	
Oven-bird	April 13	April 20	April 24	April 13	—	—	April 16	*March 30*
Northern Water-thrush	—	*March 30*	—	*March 29*	—	—	—	
Louisiana Water-thrush	April 23	—	**April 6**	*March 30*	—	—	—	
Kentucky Warbler	April 21	April 26	April 30	*March 24*	—	**April 3**	April 17	**April 7**
Yellow-throat	April 20	April 20	April 13	winters	April 25	**April 3**	winters	
Hooded Warbler	April 17	April 12	April 20	*March 29*	—	**April 3**	*March 16*	
American Redstart	April 18	April 15	April 20	April 13	May 7	April 13	April 14	
Orchard Oriole								
Scarlet Tanager	April 17	April 18	April 26	April 13	—	—	April 14	April 19
Summer Tanager	April 16	April 16	April 27	*March 30*	?	April 25	*April 2*	**April 6**

* One or more records during the winter of 1946–1947.

Thus, as far as the Great Lakes Region is concerned, the area of flight termination appeared to center along a relatively narrow belt connecting Toledo and Toronto, barely broad enough to include Detroit and Buffalo, but excluding Rochester where Edson (1947) reported no similar occurrences. However, beyond that belt, there were isolated occurrences as far west as Chicago, north to Georgian Bay and northeast to Ottawa.

It is interesting to note that virtually all these occurrences took place at, or close to, the edge of a large body of water. The sparsity of comparable observations from inland points is indicated by the reports from London, Ontario, a city lying close to the Toledo-Toronto line, but about 20–25 miles inland from Lake Erie. There an active group of field ornithologists found no comparable occurrences during the period in question. To the south, as will further be shown, it is necessary to go far inland before any comparable occurrences are encountered.

Unusual species observed at three or more points in the Great Lakes Region were: Chimney Swift, *Chaetura pelagica;* Blue-gray Gnatcatcher, *Polioptila caerulea;* Red-eyed Vireo; Black and White Warbler, *Mniotilta varia;* and Hooded Warbler. The Hooded Warbler was reported on April 6 at Chicago, Detroit, Port Dover, Ont., Buffalo, and Toronto (April 8 at Toledo) and appears to have been an important component of the wave. Warblers (8 species) and vireos (4 species) comprise 12 of the 20 species listed in Table 3 for the Great Lakes Region within the period April 5–9.

Table 3 does not indicate the number of individuals of a species seen on the date given. In many instances, the records represent single individuals, seldom more than three or four. Thus the wave in the Great Lakes Region, for all its diversity, need not necessarily have been larger than a few score to a few hundred birds.

A further point of interest is that the Toledo birds were no longer to be found two or three days after they were first observed. This was not universally the case at Toronto, where Hooded Warblers, for instance, were seen almost daily until early June in High Park.

South of Lake Erie, one might have expected numerous records of a similar nature in Ohio, but they were in fact remarkably scarce. However, the following four relevant occurrences are listed for central Ohio in Table 3: Blue-gray Gnatcatcher, April 6; Black and White Warbler, April 5; Chimney Swift, April 6; and Prothonotary Warbler, *Protonotaria citrea*, April 6. Borror (1950) has listed the last three dates as being the earliest spring arrival occurrences for these species on local record.

An outstanding feature of Table 3 is the early wave of warblers reported in West Virginia. It is important to note that some of these arrival dates are earlier than those for the Great Lakes by a clear margin of two days. Further, this wave was distinctive in that it was restricted primarily to warblers and included several species not seen along the Great Lakes.

Eastward from West Virginia, Robbins (1949) has shown that Washington, D. C., experienced a heavy migration wave on April 6 and 7, but it consisted chiefly of species arriving at normal or near normal dates. In addition, however, the recording of Whip-poor-will, *Caprimulgus vociferus*, Chimney Swift, Louisiana Water-thrush, *Seiurus motacilla*, and an adult male Orchard Oriole, *Icterus spurius*, showed a positive relationship with the unusual observations to the west and northwest.

Northeast of Washington, along the Atlantic seaboard, where Massachusetts records are fairly representative, a heavy wave of migrants was similarly reported April 6 to 9, but again these were chiefly species which were to be expected at this date and included only two of the species listed in Table 3.

Table 3 lists arrival dates for three locations in Kentucky and four in Tennessee. These are remarkable in that they show that seven of the nine species of warblers encountered in West Virginia on April 3–6 were still conspicuously absent from Kentucky and Tennessee at that time. However, there was a scattering of records for April 4–7 (principally on April 6 and 7) in which the species figuring most prominently were: Chimney Swift, Blue-gray Gnatcatcher, White-eyed Vireo, Black and White Warbler, Black-throated Green Warbler, *Dendroica virens*, and Louisiana Water-thrush. Of the seven locations in the two states, only the most southwesterly one, Memphis, reported a small influx on March 30, when the Chimney Swift, Blue-gray Gnatcatcher, and Black and White Warbler were noted.

Of the warblers which were not reported in Kentucky and Tennessee until after April 6, the most interesting case is undoubtedly that of the Hooded Warbler. It was seen at Madisonville on April 7 and at Memphis on April 8, but the other five stations did not report it until April 12 or even considerably later.

Table 3 lists some particularly significant observations from Rosedale, Mississippi, in the Mississippi valley some 350 miles north of the Gulf. Four of the species in Table 3 were first observed there on March 29 and an additional six, including the Hooded Warbler, were added on April 3. These were the records of a single observer, Mr. M. G. Vaiden, and it is of some interest that he was able to note a

third of the species given for the Great Lakes Region and West Virginia a very few days before they were reported far to the north.

On the Gulf itself, all observers are agreed that only the early records are of any particular significance, late records indicating merely that the birds have flown inland without stopping. At Pensacola, Florida, Weston (1947) indicated a brief flurry in which four of the listed species, including the Hooded Warbler, were observed on March 16. In the case of the Hooded Warbler, this date was three days earlier than recorded in any previous year. Williams (1947) ably analysed the arrival of the early waves along the Texas coastal region and their relation to weather conditions. The Hooded Warbler was first seen there on March 29 and a number of the other species were recorded either on March 20–22 or March 29–30. The situation along the Gulf is complicated by the fact that individuals of at least eight of the species in Table 3 winter there.

When considered as a whole, then, the observations summarized here for the early April period of 1947 from eastern North America reveal a chronological and geographical dispersal of migrants which is not only unusual, but apparently unique as far as the published literature on ornithology is concerned. That being the case, it is pertinent, as Williams (1950) has stressed, to examine the day-to-day meteorological conditions of the period to determine what correlation exists between the two.

METEOROLOGICAL DATA

In order that non-meteorologists may comprehend the discussion and diagrams, a brief explanation of meteorological terms and symbols is given here.

Explanation of Meteorological Terms and Symbols.—The analysis of modern weather maps recognizes the existence of large bodies of air which approximate horizontal homogeneity. Any one of these large bodies of air covers thousands of square miles of the earth's surface and is referred to as an *air mass.* Between two different types of air masses, each of which is itself quasi-homogeneous at any fixed level, there is a sloping surface of discontinuity known as a *frontal surface.* The intersection of a frontal surface with the surface of the earth is termed a *front.*

Air masses acquire their characteristic properties of temperature and moisture content according to the section of the earth's surface with which they have been in contact. They naturally divide themselves, for classification purposes, into two main types: (a) *Tropical air masses* in which the air remains at low latitudes for a considerable period of time; and (b) *Polar air masses* in which the air remains at

high latitudes for a considerable period of time. Air masses are further classified according to whether they originated over land or water surfaces.

In accordance with the above, it may be stated that the air masses usually to be found on the North American continent are: 1) Maritime Tropical; 2) Maritime Polar; and 3) Continental Polar. In Figures 1–4 and Table 4, these air masses are respectively represented by the following symbols: mT, mP, and cP.

Weather maps commonly indicate the position of moving areas of high and low barometric pressure. The *millibar* is the unit now commonly used to express atmospheric pressures. One hundred millibars are almost equal to the pressure exerted by three inches of mercury. Winds blow in a clockwise direction around centers of high pressure and counter-clockwise around centers of low pressure.

On the weather maps of Figures 1–4, solid lines represent *isobars* or lines of equal pressure. A line with triangular points represents a *cold front*—the leading edge at the surface of the earth of a moving air mass which is colder than the air it is displacing. A line with half circles represents a *warm front*—the retreating edge of a moving mass of relatively cold air. A line with alternate triangular points and half circles represents a *quasi-stationary front*—the forward edge of a relatively stationary cold air mass.

It is a common occurrence for a center of low pressure to develop at the junction of a warm and a cold front. The pronounced sector of a low pressure area between a warm front and a cold front is termed the *warm sector.*

Wind direction at 2,000 feet above mean sea level (as distinct from surface level) is indicated on the figures by shafts which extend outwards from the station in the direction from which the wind is blowing. Wind strength is indicated by full barbs and half barbs attached to the end of the wind shaft; each full barb represents 10 miles per hour of wind and each half-barb represents 5 miles per hour of wind. The strength of the wind is inversely proportional to the distance apart of the isobars. It may also be noted that the isobars represent the wind direction and speed at approximately 2,000 feet above ground level. At the surface of the earth, the winds are frequently only about 70 per cent of the wind strength indicated by the spacing of the isobars and turn by approximately 30 degrees to blow in towards a trough of low pressure.

Recent Concepts Relating Migration and Barometric Pressure Patterns. —In considering the actual meteorological conditions prevailing during the particular period under consideration, it is important to

bear in mind certain recently-stated concepts relating migration and weather fronts in eastern North America, and for this reason they are briefly re-stated here:

(1) Both Williams (1945) and Lowery (1945) emphasized the fact that, in the Gulf Coast Region, migrants in motion are precipitated to earth by the arrival of a cold front. Lowery (1945) also indicated that, in favorable weather, migrants may travel several hundred miles inland before alighting.

(2) Bagg (1948) stated that "There is a particular barometric pressure-pattern in North American weather which stimulates spring migration into New England and adjacent sections of the Northeast." (It is of interest to note that Bagg selected as an example of "the ideal pattern" the exact situation considered in this paper. He specifically cited the weather map illustrated here as Figure 4).

"The ideal pattern is well indicated on the U. S. Weather Bureau's map for 1:30 a. m. on April 6, 1947, wherein a high pressure area is moving eastward off the southeast U. S. coast, while a low pressure area is moving into the Great Lakes region after having originated in the vicinity of Kansas and Colorado.

"The favorable situation prevailing on April 6, 1947 (and other dates during that spring) was initiated by the clock-wise effect of the 'high' which set up a northeastward flow of warm air from the Gulf to New England. This flow subsequently was intensified by the counter-clockwise effect of the adjacent 'low'."

Bagg and collaborators (1950) have subsequently set forth the more general hypothesis that, while some spring migration may be expected in and through regions covered by the westward side of a high pressure area, pronounced migration will take place into or through regions covered by the warm sector of a low pressure area.

(3) Robbins (1949) showed that the arrival of spring migrants at Washington, D. C., was closely correlated with southwest winds and a rising minimum temperature, this being particularly applicable when considering the spring advent of Mississippi flyway species to the Washington region.

(4) Williams (1950) made the point that migrants probably find it difficult to land safely on a dark night, particularly if the wind velocity is high, and that when the adverse flying conditions of a cold front are then encountered, they may be forced to fly as much as hundreds of miles off-course before there is sufficient visibility to permit a safe landing.

Periods of Influx of Tropical Air in March, 1947.—Since many of the species under consideration normally reach the southern United

States in March, it is worth noting that there were three periods in March, 1947, during which there was a northward flow of tropical air from the Gulf, bringing southerly winds, warmer temperatures and, presumably, migrants from South and Central America. These three periods occurred on *March 12–14*, *March 22–25*, and *March 27–28*. In the first and third periods, weak northward thrusts of tropical air reached the Gulf states but did not penetrate north of latitude 35° N. (southern Tennessee) while over this continent. During the second period, an extensive area of the eastern United States was covered by tropical air, but this originated primarily from a flow of air from the Pacific Ocean which supplanted the northward flow from the Gulf, leaving the latter to persist only in Louisiana and southern Alabama.

Meteorological Conditions, April 1 to 7, 1947.—The beginnings of the storm of April 4–7 were not much in evidence before April 3 but, because of the early West Virginia records, it was thought best to review the meteorological conditions from April 1 until the dissipation of the storm on April 7. Limitations of space make it impractical to deal in detail with the meteorological aspects of the entire period. However, the relationship between the rapidly changing weather conditions of the period and the degree of migration that might theoretically be expected is indicated in Table 4. In a subsequent section, some comparisons are made to see whether theory fits the known facts. Simplified versions of synoptic weather maps for important stages of this period are presented in Figures 1–4.

An analysis of the development and course of the storm itself is here briefly summarized.

On April 3, almost the entire continent was covered by polar air. A center of high pressure, located in central Ontario, was moving slowly eastward, and a second similar center was located in the Yukon. The only center of low pressure was situated in Utah. It was the subsequent motion and development of these centers of high and low pressure areas which resulted in the storm.

On April 4, as the deepening low center moved eastward, a warm sector of tropical air was gaining prominence as it moved northeast over Texas and Oklahoma. By 1:30 a. m., E. S. T., on April 5, the low pressure area exhibited a complex double center over the state of Kansas (Fig. 2).

With the passing of the Ontario high pressure area to the southeast, the direction of the winds in the lower levels of the atmosphere changed from easterly to southerly over the eastern sections of the continent and at the same time increased greatly in strength. Winds of 40 m. p. h. at 2,000 feet above mean sea level are common in Figure 2.

TABLE 4

DISTRIBUTION AND MOVEMENT OF AIR MASSES OVER SECTIONS OF SOUTH-CENTRAL AND SOUTHEASTERN NORTH AMERICA DURING THE PERIOD APRIL 1–7, 1947, AND THEIR PROBABLE RELATION TO BIRD MIGRATION

Date	*Region*	*Air mass*	*Meteorological synopsis*	*Conditions for migration*
April 1	Eastern U. S., Lake Erie to Fla.	cP	west side of High	moderately favorable
	E. Texas, part Okla. and La.	mT	warm sector of southern Low	very favorable
	Mid-west, Minn. to w. Texas	cP	behind cold fronts	unfavorable
April 2	West Va. and neighboring states (Fig. 1)	mP	warm sector of northern Low, followed by cold front	favorable till mid-afternoon, then unfavorable?
	Lakes Erie and Ontario (Fig. 1)	cP	cold air north of Low center	unfavorable
April 3	U. S. east of Miss. Valley	cP	se. part of High	unfavorable
	Texas and w. Oklahoma	mT	warm sector of developing Low	favorable
April 4	U. S. east of Ohio-Florida line	mP	south to southwestern part of High	becoming somewhat favorable
	Texas, La., Ark., Miss., and s. Mo.	mT	warm sector of Low	very favorable
April 5 1:30 a. m., E. S. T.	Ill., Ind., Ohio, West Va., Ky., and most of Tenn. (Fig. 2)	mP	southerly winds ahead of warm sector; rain.	favorable
	S. Mo. south to Gulf from e. Texas to Ala. (Fig. 2)	mT	warm sector of Low	very favorable
April 5 1:30 p. m., E. S. T.	S. Mich. and from s. Ontario se. to Md. and Va. (Fig. 3)	mP	southerly winds ahead of warm sector; rain	favorable
	E. Ill., Ind., Ohio, West Va., Ky., Tenn., Miss., Ala. (Fig. 3)	mT	warm sector of Low	very favorable
	Okla., Ark. and w. La. (Fig. 3)	mP	cooler air; high winds	???
April 6 1:30 a. m., E. S. T.	C. New York, e. Penn., e. West Va. and Atlantic seaboard from N. Jersey to S. Carolina (Fig. 4)	mT	warm sector of Low	very favorable
	Mich., s. Ont., w. New York, and sw. in a broad arc to Ark. and La. (Fig. 4)	mP	cooler air; high winds	???
	Ill., Mo., Wis. (Fig. 4)	cP	cold air	unfavorable
April 6 1:30 p. m., E. S. T.	Vermont, N. Hampshire, and Atlantic seaboard, Mass. to Ga.	mT	warm sector of Low	very favorable
	S. Ontario, Ind., Ohio, West Va., and s. to Ala. and La.	mP	cooler air between 1st and 2nd cold fronts	???
	Wis., Ill., Mo.	cP	cold air behind 2nd cold front	unfavorable
April 7, 1:30 a. m., E. S. T.	Atlantic seaboard, N. Jersey to Carolinas	mP	cooler air between 1st and 2nd cold fronts	???
	NE. U. S. n. of line from Mass. to Okla.	cP	cold air behind 2nd cold front	unfavorable

On the night of April 4–5, as is shown in Figure 2, a warm front from the more easterly center of low pressure in Kansas lay through Missouri, western Tennessee, and Alabama. North and east of the warm front, such states as Tennessee, Kentucky, and much of Indiana and Ohio were covered by a mass of maritime polar air bringing rising temperatures along with the strong southerly winds. Throughout most of this region, clouds at the 1,000- to 2,000-foot level created an overcast condition which reduced or nullified the increased visibility that would otherwise have been provided by the full moon. The air was clear, however, and visibility in the region was officially recorded as ranging from six to 30 miles. To the west and southwest of the warm front lay the region covered by tropical air, by then including Arkansas, Louisiana, Mississippi, and southern Missouri. Cloud cover there was at the same level but less dense and broken in places.

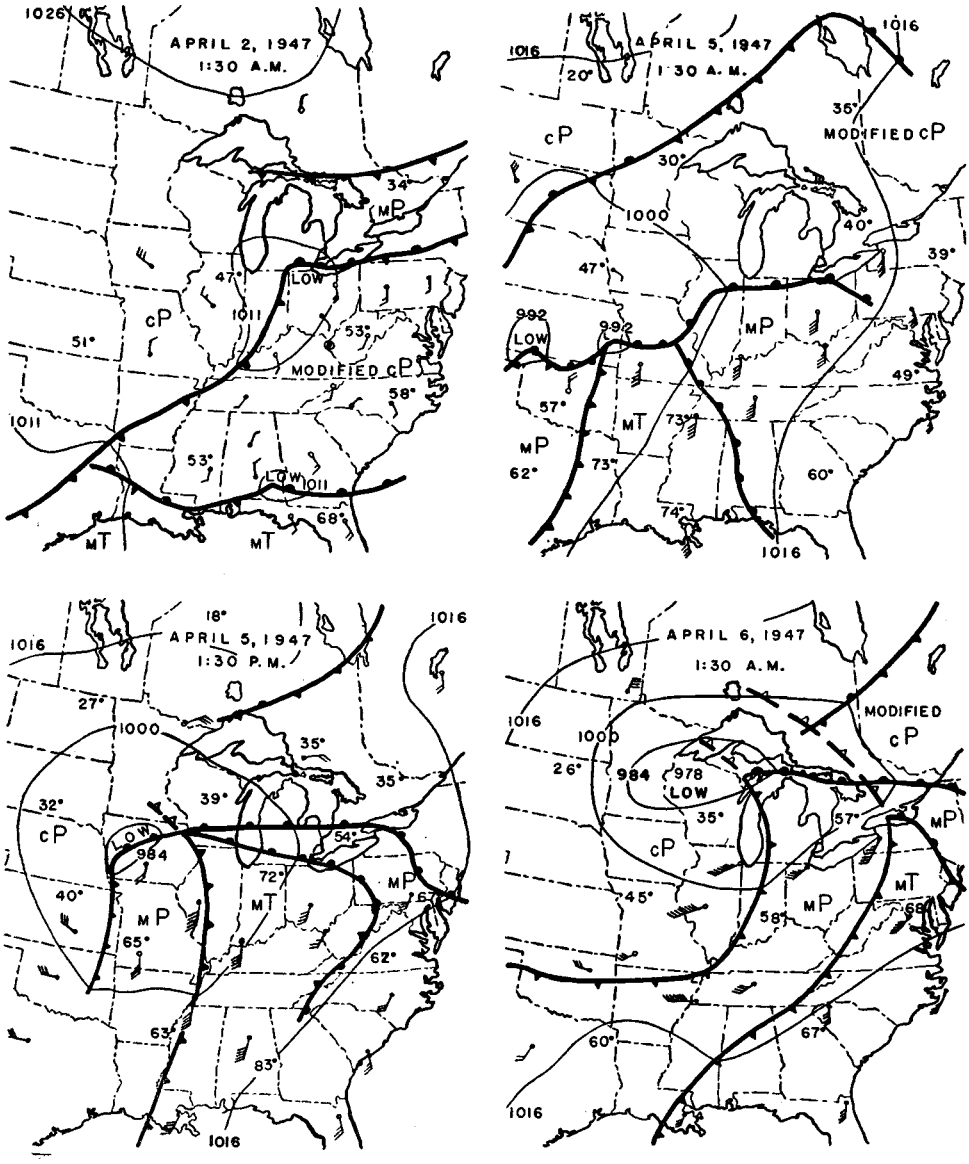
As may be seen by comparing Figure 2 with Figure 3, the center of low pressure showed marked intensification between 1:30 a. m. and 1:30 p. m., E. S. T., on April 5. The pressure at the center of the low had decreased by nine millibars and was accompanied by a corresponding increase in wind strength.

Two cold fronts were associated with the storm center of Figure 3. A mass of maritime polar air lay between these two cold fronts and a continental polar air mass lay to the west of the more westerly cold front. Temperatures plotted in Figure 3 show that the maritime polar air mass was approximately 10–15° F. colder than the tropical air mass, while the continental polar air mass was approximately 20-25° colder than the maritime polar air mass.

The warm tropical air arrived at Toledo at ground level between 10:30 a. m. and 1:30 p. m., E. S. T., on April 5. At the earlier hour there was a layer of maritime polar air over Toledo to a depth of 6,000 feet. At 10:30 a. m. the temperature at the surface was 54°. Three hours later, the cold air mass had retreated to the northeast of Toledo and was replaced by tropical air of 71° temperature.

Moderate to heavy precipitation in the form of rain and thunderstorms occurred in advance of the warm front, with little or no rain reported in the warm sector itself. Amount of precipitation, for the six-hour period ending at 1:30 p. m. April 5, at stations in advance of the warm front were: London, Ontario, 0.98 inches; Erie, Penn., 1.80; and Buffalo, N. Y., 0.62 inches.

Visibility in the warm sector at 1:30 p. m. April 5 was of the order of 15 miles or better. Ahead of the warm front, visibilities of two to five miles were common and locally ranged as low as zero.



FIGURES 1–4. Maps to show weather conditions from April 2 to April 6, 1947.

Toledo remained within the warm sector until about 8:30 p. m. April 5, at which time the maritime polar air mass reached Toledo from the west. The warm front was meanwhile moving slowly northeastward and passed Toronto at about 1:00 a. m. April 6. It was followed almost immediately by the cold front which had passed Toledo in the early evening. Thus, Toronto remained in the warm sector very briefly—for a matter of minutes only.

The position of the warm sector at 1:30 a. m., E. S. T., April 6, is shown in Figure 4. It will be noted that the slowly moving warm front has reached its most northerly position prior to or at the time of this map, since the cold front east of Toronto is moving rapidly eastward and is displacing the tropical air at the ground.

The storm had reached its full intensity by 1:30 a. m. April 6. During the morning of April 6, the winds at Toronto reached 75–80 m. p. h. at a height of 2,000 feet above mean sea level. The storm center itself had moved at a fairly constant speed of 30–35 m. p. h. from 1:30 a. m. April 5 until it reached its lowest pressure (and greatest intensity) in Wisconsin during the early hours of April 6, after which it moved more slowly.

During April 6 the storm gradually diminished in intensity and it lost its identity on the following day. The Atlantic seaboard remained in tropical air until the first cold front swept across the coastline late on April 6. It was closely followed by the second cold front which, as it moved southeastward across the eastern part of the continent, brought in its wake low temperatures and northwesterly winds.

DISCUSSION

Dealing first with the March invasions of tropical air, it will be noted that the early records established on March 16 at Pensacola, at the base of the Florida peninsula, coincide well with the arrival of tropical air over the southern part of Florida on March 14.

The extended warm period experienced in the eastern United States on March 22–25 was brought about primarily by an eastward flow of air from the Pacific which cut off a northward flow from the Gulf; this may have discouraged migration far inland from the Gulf, but arrival of migrants on the Gulf coast itself was to be expected and was duly reported by Williams (1947).

The brief influx of tropical air on March 27–28 and the ensuing cold front are reflected in arrivals along the Texas coast reported on March 28–29 by Williams (1947) and by Mr. M. G. Vaiden at Rosedale, Miss., on March 29.

The very similar influx of tropical air on April 1 and 2 is reflected in Mr. Vaiden's additional arrivals reported on April 3. Again, the tropical air penetrated no farther north than the southern border of Tennessee, but on this occasion the contemporary eastward movement of another rather weak low to the north created quite favorable conditions for migration in *its* warm sector (Fig. 1).

It is the action of this more northerly low that may have brought about the five observations made in West Virginia on April 3 and 4. From a meteorological viewpoint, these are the hardest to interpret, for migration conditions were decidedly unfavorable along the approach to West Virginia from the night of April 2–3 until April 4. However, birds moving northeastward in the warm sector of this low on either the night of April 1–2 or during the day on April 2 might logically reach West Virginia, which was close to the apex of the warm sector on April 2.

Because of both the distance involved and the fact that there were two separate systems of low pressure present between the Gulf and the Great Lakes, it is unlikely that the early West Virginia birds reached there directly from points south of the United States. On the whole, the data in Table 3 support this view. Of the four species involved, there are records for the Black and White Warbler as follows: coastal Texas and Louisville, Ky., on March 13; Pensacola on March 16; Rosedale, Miss., on March 29; and Memphis, Tenn., on March 30; thus for this species the two West Virginia records are not so surprising under the circumstances. The arrival dates of March 16 and 29 for the Hooded Warbler on the Gulf coast have already been mentioned. The Black-throated Green Warbler was reported from coastal Texas on March 24, but there are no other dates in Table 3 as early as that from Morgantown on April 3. For the American Redstart, seen at Morgantown on April 4 and Charleston on April 6, Table 3 shows no other record until more than a week later.

The observations from West Virginia on April 5 and 6 coincided with the improved migration conditions on the night of April 4–5 and the very favorable conditions on April 5–6. While these birds may have arrived earlier, along with those reported on April 3 and 4, the observations from Washington, D. C., on April 5–7 indicate a marked influx of migrants into the general region during this latter period.

Turning now to the wave which reached the southern Great Lakes, the evidence gives little reason to doubt that the intense storm of the period was a basic factor in causing it to end where and when it did. But some doubt remains as to where it began. Inasmuch as the region of precipitation of migrants coincided fairly closely with the

northern limit of the tropical warm front, it might at first be supposed that birds flying from the southeast from some region such as West Virginia were precipitated along an extended line running southwest–northeast across Lake Erie and Lake Ontario. However, in following the movement of the relevant air masses and the wind directions, it seems much more logical that the birds came from the southwest and that the extension of the flight from Toledo east-northeast to Toronto was the result of the high winds which were blowing in exactly that direction on the night of April 5–6.

While the dates in Table 3 do not definitely indicate the starting point or points of the flight, many of the lists are of value in supplying negative information, indicating areas from which it is unlikely that the flight originated. This has tended to narrow down the possibilities. It seems fairly evident that on, say April 4, most of the birds in question were south of Tennessee. Only the Chimney Swift, Blue-gray Gnatcatcher, Black and White Warbler and Palm Warbler, *Dendroica palmarum*, had been reported north of this line. It is also unlikely that they were as far west as Oklahoma or central Texas. Dallas data (Table 3) show that few of these species are regularly recorded there and very few had been seen by that date. On the other hand, the records from Rosedale, Mississippi, show a very fair representation of the species concerned by that date. Therefore, on the basis of the slender evidence available, it seems most likely that many of the birds began their flight from the Mississippi valley south of the southern border of Tennessee. Alabama and Georgia remain as possibilities, but no arrival dates were obtained from these states.

Assuming the region of the state of Mississippi as a starting point for many of the birds, it remains to calculate the period of time and the rate involved. The distance amounts to some 700 miles to Toledo and another 200 miles to Toronto.

The tropical air mass had covered Mississippi by the evening of April 4, producing favorable conditions for a northward flight, but its leading edge did not reach Toledo until about noon on April 5. As the evidence indicates that the birds did not reach Toledo prior to the arrival of the warm front, it can be concluded that the flight was not completed overnight on April 4–5.

Birds travelling partway on the night of April 4–5 and continuing on in the tropical air mass during some part of April 5 could have reached Toledo between noon and 8:30 p. m., while that city was in the warm sector. The single record for April 5 from Toledo, that of a Red-eyed Vireo, suggests that it, at least, arrived within this time period. The bird was observed by Mr. Louis W. Campbell who wrote

that he saw it on Cedar Point, between Maumee Bay and Lake Erie, late in the afternoon when "under the trees the light was beginning to grow dim." However, this was apparently an exceptional case, fo the reports indicate that the great majority of the birds reached the Great Lakes Region subsequent to the end of daylight on April 5.

The route could have been covered under purely nocturnal conditions by northward movement on the nights of April 4–5 and 5–6. This may well have been the case in some instances, although data from intermediate points do not support a diurnal stop-over of relevant species in significant numbers on April 5.

A flight begun in the south during daylight on April 5 and carried on into the night of April 5–6 seems rather unlikely for most species listed in Table 3, although it should be considered for such normally diurnal migrants as the Chimney Swift and the Nighthawk, *Chordeiles minor*.

The remaining possibility is that of the journey having been accomplished in a single overnight flight on April 5–6. Although the distance is great, there is considerable support for this theory. Conceding the birds a flying speed of 30 m. p. h. and a favorable wind of 40 m. p. h. (a conservative estimate for that night), these would together realize a net ground speed of 70 m. p. h. Toledo could then have been reached in 10 hours, but it would have taken another 2.5 to 3.0 hours to reach Toronto. Most, if not all, of such a flight would necessarily have taken place in the maritime polar air mass which replaced the tropical air mass over the Mississippi valley during the afternoon of April 5. After exposure to the high temperatures of the tropical air mass during the day, a migration flight in the following polar air mass need not be too surprising, for the temperature of the latter was a still relatively warm 58–60° at 1:30 a. m. on April 6. Wind direction and velocity may well have been the decisive factors. There was little difference in wind direction on either side of the cold front. Once the flight was begun, high winds may have prolonged its duration, for with surface winds reaching 60 m. p. h. or more during the night the dangers involved in landing were undoubtedly high.

One point clearly indicated by the records is that the birds were almost invariably seen within a relatively short distance of a large body of water. The occurrences are clustered on or close to the shores of Lakes Erie and Ontario, with outlying reports from Lake Michigan and Georgian Bay. There are remarkably few inland reports. The significance of this is not clear, but it is possible that the water may have presented a visual barrier or, more likely, that a landing at its edge may have been an easier matter in a high wind.

As a matter of speculation, it is possible that the concentration of records about the cities and towns may have been partly the result of the local influence of the glow of light, reflected from cloud and water, permitting sufficient visibility for a landing under difficult conditions.

Also in Table 3, the heavy movement of Blue-gray Gnatcatchers into Tennessee and Kentucky on April 4–5–6 is clearly shown. These winter chiefly in Florida but westward as far as Texas; the intensity of the storm does not appear to have upset their migration pattern. However, some did turn up at the Great Lakes and these, it is suspected, originated from the southwest rather than the southeast. Later in the month they reached the northern Atlantic states in unusual numbers, as was reported by Griscom (1947).

By contrast, the Hooded Warbler, so conspicuously a feature of the Great Lakes flight, was notably absent from Missouri, Tennessee, and Kentucky during the April 4–6 period. Perhaps these latter regions might well have been the destination of the flight had not the intensity of the storm brought about different results.

In reviewing the relation of the storm to the flight, it can be said that the flight was of a much more unusual nature than the storm. The storm was unusual chiefly in the rapidity with which it developed, in the exceptional depth of the low pressure center, and in the correspondingly high wind velocity. The track of the storm was a common and predictable one. On April 11–12, less than a week later, a similar storm followed a similar path across the continent, although it did not have as deep a low pressure center and wind velocities were not as high. There was no comparable flight of birds to the Great Lakes, and in fact the literature does not indicate any previous flight of a similar nature.

This leads to the speculation that, while the storm undoubtedly had a direct influence in transporting birds so far north and east, some birds of different species were already "reacting" ahead of normal migration pattern, perhaps due to unusual tropical or sub-tropical meteorological conditions. Two facts support this: 1) the warbler flight into West Virginia which was unprecedentedly early and yet which, in its earlier stages at least, was not accompanied by a particularly intense storm such as might readily have accounted for the exceptional northward advance; and 2) a few exceptionally early March records from Pensacola, Florida, hint that some individuals were already migrating ahead of normal schedule.

SUMMARY

On April 5–7, 1947, a phenomenally early flight of insectivorous migrants, chiefly warblers and vireos, was recorded along the southern Great Lakes. The greatest number of reports came from Toledo and

Toronto, with lesser numbers from Chicago, Detroit, the north shore of Lake Erie, and Buffalo. These birds arrived, on the average, about three weeks earlier than the previous earliest spring date. The reports are tabulated and compared.

For further comparison, spring arrival dates in 1947 were gathered from some 24 different localities between the Great Lakes and the Gulf of Mexico. An equally surprising flight of warblers showed up in various parts of West Virginia on April 3–6.

The species making up these two flights were, for the most part, still unreported at that time in Kentucky and Tennessee, and it was necessary to go as far south as Mississippi before finding a number of arrival dates prior to April 4. It seems most likely, therefore, that these flights began south of the southern border of Tennessee and that at least the Great Lakes flight originated in the lower Mississippi Valley.

During the period of April 5–7, an intense storm moved northeastward across the continent, bringing with it high wind velocities and, in its warm sector, an invasion of tropical air from the Gulf of Mexico. There seems little doubt that this storm caused the flight to the Great Lakes to end where and when it did. From both the distances involved and the timing of frontal passages, it seems evident that a flight of exceptionally long duration took place on the night of April 5–6 or, alternatively, that part of the flight was diurnal in character. While some birds may have made much of the flight within the warm sector, it is probable that many flew all or most of the distance in the cooler maritime polar air mass which followed the warm sector.

The observations made in West Virginia on April 3 and 4 could not be explained in terms of this storm, but they may have been related to a relatively weak low pressure area which brought light southerly winds and mild temperatures to West Virginia on April 2.

As some exceptionally early migration was taking place even before the storm occurred, it is possible that unusual tropical or sub-tropical influences may have been a prior factor, tending to accelerate migration before the birds reached the United States.

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