ARRIVAL DATES OF MIGRATORY BREEDING BIRDS IN MAINE: RESULTS FROM A VOLUNTEER NETWORK

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Abstract - First arrival dates for 115 species of migratory breeding birds were gathered by 89 observers across the state of Maine during the spring migration of 1994. Arrival dates in the 15 Biophysical Regions of Maine, regions based on vegetational, climatic, and physiographic patterns, yielded insight into the timing of spring migration. Unexpectedly, few species showed significant differences in their average arrival dates among the Biophysical Regions. Most significant differences involved later arrivals in the far northern portion of Maine. Birds were not late in arriving in the Western Mountains compared to lowland areas of the state. The study provides the most intensive data for a single year on arrival dates of migratory breeding birds in Maine.

INTRODUCTION

The state of Maine spans a pronounced gradient in temperature, snowfall, rainfall and other abiotic features. This climatic variability results in distinctive and predictable changes in plant communities. Climatic and vegetational patterns were combined by McMahon (1991) to produce a map of Biophysical Regions of Maine, each with a unique combination of climate and vegetation (Fig. 1).

It is reasonable to expect that the distribution of animals will be determined in part by climate and vegetational characteristics of a habitat. In this contribution, we examine patterns of arrival dates for 115 species of Maine breeding birds that winter south of Maine, and relate them to climatic differences across the state. In Maine, the greatest climatic difference between Biophysical Zones occurs between the relatively mild South Coastal Region (frost-free period of 140-160 days, average July maximum temperature of 81 °F, average January minimum temperature 14 °F) and the Boundary Plateau Region (frost-free period of 80 days, average July maximum temperature of 75 °F, average January minimum temperature -3 °F) (McMahon 1991). Migratory birds may respond directly to temperature or to temperature-related physical factors such as frozen ground or ice on bodies of water. However, food is likely to be a more important variable influencing the

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arrival of migratory birds. All of these factors improve as the season progresses up the state. Arrival dates of migratory breeding birds may reflect some or all of these climate-related factors.

As an example, many species of Maine breeding birds (e.g., vireos, wood-warblers, tanagers) obtain much of their food by gleaning insects from the leaves of deciduous trees. One would predict that such leaf-gleaning species would not arrive on their breeding grounds until leaves and their folivores were beginning to appear.

Insects and other folivores probably appear earlier in southern Maine than in other Biophysical Regions in the state. The likelihood of this pattern is suggested by a phenological study of balsam fir (*Abies balsamea)* which indicated that plant growth in southern Maine was initiated 12 days before growth in northwestern Maine (Boundary Plateau Biophysical Region) (Mingo and Diamond 1979). It is possible that bird migration might mirror these phenological differences. We predicted that bird species arrivals would fan out to the north and west from relatively mild southern coastal regions, following the progression of changes in climate and biological variables.

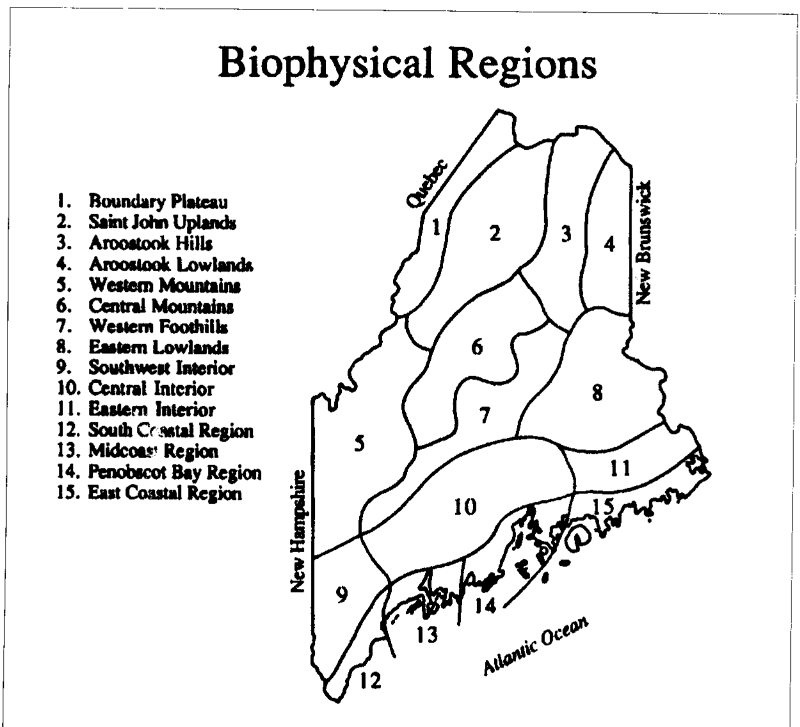

Figure 1. Biophysical Regions of Maine (McMahon 1991).

MATERIALS AND METHODS

In late February, 1994, a data sheet was sent out to 200 Maine birders. The mailing list was compiled from Maine members of the American Birding Association and the Ornithological Societies of North America, and Maine volunteers in the Breeding Bird Survey. Announcements of the project appeared in newsletters of Maine Audubon and National Audubon chapters, the Guillemot and on the recorded Maine Audubon Society Bird Hotline and the Downeast Maine Bird Hotline. The data sheet had the 115 migratory breeding species listed along with a column for each of the 15 Biophysical Regions. Cooperators were asked to record the first date of observation of each species in as many Biophysical Zones as they visited. A total of 89 people contributed data to the project. Most observers had observations for a single Biophysical Region.

We asked observers to simply record first arrival of each species. As Richardson (1978) points out, the first arrivals of species may not provide an accurate indication of migration phenology. However, the species studied here are breeding birds, so the variance in arrival date is likely to be less than in more southerly stop-over areas. Furthermore, volunteers are more likely to participate if the requested data are not difficult to collect. We believe that the first arrival dates, averaged over a Biophysical Region, provide a reasonable measure of migration phenology in different parts of the state.

A total of 4,847 arrival dates were gathered by the 89 observers. The data were entered into a FileMaker Pro database which included fields for bird species, day of week of sighting, arrival date, Biophysical Region and observer. Minimal editing of the data was done. We deleted 42 records either because of highly improbable early arrivals (more than 21 days earlier than the mean for a Biophysical Region) or because of extraordinarily late first arrivals (greater than 21 days later than the mean for a Region) compared to other observers in the same Biophysical Region.

Coverage of the different Biophysical Regions was roughly proportional to human population density. The four coastal Regions (12,13,14,15) received thorough coverage along with Regions 9, 10 and 11. No records from Region 6 and a single record from Region 8 were received. The four regions in the northern tier of Maine received sparse coverage (eight observers). To facilitate statistical analysis, Biophysical Region 1 (Boundary Plateau) and Region 2 (St. Johns Highlands) were combined. Regions 3 (Aroostook Highlands) and Region 4 (Aroostook Lowlands) were combined as well.

We converted each arrival date in the database to the day of the year (e.g., April 1 is the 90th day of the year). For each species, a one-way analysis of variance was performed on the data using Biophysical Region as the factor to test for differences in arrival dates among Biophysical Regions. If the ANOVA indicated that there were significant differences among Regions ($p \leq 0.05$), Bonferroni-Dunn post hoc comparisons were performed to determine where significant differences lay (Sokal and Rohlf 1981). Statistical tests were performed using Statview II and SuperANOVA on a Macintosh computer.

To determine if cold fronts might have influenced migration by causing fall-outs of northbound migrants, Daily Weather Maps from the National Data Analysis Center were examined to determine when large cold fronts passed through Maine. Eighteen fronts passed through Maine between March 21 and May 31, 1994. The number of first arrival dates before the front was compared to the number recorded on the day when the front passed through. If weather-related fall-outs occurred, one expects that the arrival dates after the front will be higher than the number recorded just before the front passed through. Similarly, we compared the number of arrival dates on the day of the front passage to the number of arrival dates a day later. For both of these analyses, χ^2 analysis was used to compare the number of times the arrival dates on the date of front passage exceeded the day being compared (before or after the front). Front-related effects are episodic in nature unlike the gradual amelioration of climate in the spring from south to north. We believe it is necessary to attempt to tease apart these two potential impacts of arrival data.

The precision of the arrival data could be reduced if most observations are made on weekends. A preponderance of weekend observations might detect the arrival date of a given species in different regions on the same day when one species might have arrived earlier during the week in one region. The number of arrival dates for each day of the week was calculated and differences were tested for significance using χ^2 analysis.

Between April 15 and May 31, 1994, the ten dates with the most arrival dates were identified. Each was classified according to weekend or weekday observation and cross-classified according to the presence or absence of a cold front. Expected values were determined on the basis that 11 out of the 47 days in the period were weekend days and 10 out of the 47 days experienced a cold-front. A two-factor (weekend versus weekday; cold front versus clear weather) χ^2 analysis tested for significant deviations from random.

RESULTS

Arrival Dates

Contrary to expectation, the majority of bird species showed no significant differences in arrival date across the state of Maine. The mean arrival dates for 115 species among Biophysical Regions are given in Table 1 in phylogenetic order. The earliest arrival date in the state is also given. Finally, the standard deviation for arrival date is provided as a measure of variability in arrival date.

From Table 1, the ten species with the highest standard deviations in arrival date, in decreasing order, are piping plover, eastern meadowlark, yellow-bellied sapsucker, blue-winged teal, common snipe, pied-billed grebe, common loon, northern harrier, American bittern and green-winged teal. The lowest standard deviations, in increasing order, are Philadelphia vireo, mourning warbler, chestnut-sided warbler, yellow-bellied flycatcher, ovenbird, black-billed cuckoo, common nighthawk, olive-sided flycatcher, Wilson's warbler and grasshopper sparrow.

Table 2 presents arrival dates by Biophysical Regions for which an ANOVA indicated there were significant differences among the means ($p \leq 0.05$). The right-most column of Table 2 indicates the results of Bonferroni-Dunn post hoc pair-wise contrasts. We will not list each significant difference in the text but will point out that most of the significant differences involve a significantly late arrival date into northern Aroostook County (Regions 1 and 2, or Regions 3 and 4) or into the Central Highlands (Region 5).

Day of the week bias

To obtain the most accurate data on arrival dates, constant observation efforts for each day of the spring migration period are desirable. However, many observers have difficulty finding time during weekdays for ornithological observation and hence provide more weekend observations. Weekend observations were more frequent than weekday observations (1,842 observations on weekends (mean of 921/day)) compared to 3,005 on weekdays (mean of 601/day). A χ^2 test showed that there was significant deviation from random in the reporting of first arrival dates ($\chi^2 = 168.1$, $p < 0.001$).

Weather effects

Between March 25 and May 31, 1994, 18 strong cold fronts passed across the state of Maine (National Climatic Research Center data). For eight of those dates, the number of first arrivals on the date of passage was greater than the number on the previous day before the front passed through. There is no significant difference in the number of days where the front date had more arrivals than the following dates compared to the number of days where the difference was reversed ($\chi^2 = 0.111$, $p > 0.75$). Comparing the arrival dates on the front date versus the day afterward, greater arrival dates were reported on the front date for 12 of the 18 dates. This frequency was not different from random ($\chi^2 = 1.03$, $p > 0.31$).

For the period April 15 until May 31, the ten dates with the most

Table 1. Average 1994 arrival date in the state of Maine for 115 migratory breeding birds. The mean arrival date and the earliest arrival date are given for each species along with the sample size for that species and standard deviation of arrival date as a measure of the synchrony of the migration of each species. Species followed by an asterisk showed significant differences in arrivals in different portions of the state (see Table 2). The species are arranged in the phylogenetic order adopted by the American Ornithologists' Union.

Species	Mean First Arrival	Earliest First Arrival	Sample Size	Standard Deviation
Common Loon (inland only) (*Gavia immer* (Brünnich))	4/26	4/2	24	16.618
Pied-billed Grebe (*Podilymbus podiceps* (Linnaeus))*	4/17	3/25	26	17.103
American Bittern (*Botaurus lentiginosus* (Rackett))	4/27	3/25	24	16.434
Great Blue Heron(*Ardea herodias* Linnaeus)	4/10	3/3	87	15.200
Green Heron (*Butorides virescens* (Linnaeus))	5/11	4/25	20	8.647
Black-cr. Night-Heron (*Nycticorax nycticorax* (Linnaeus))	5/4	4/10	14	13.113
Glossy Ibis (*Plegadis falcinellus* (Linnaeus))	4/17	4/1	19	11.517
Wood Duck (*Aix sponsa* (Linnaeus))	4/14	3/21	48	15.783
Green-winged Teal (*Anas carolinensis* Gmelin)	4/11	2/25	41	16.406
Blue-winged Teal (*Anas discors* Linneaus)*	4/19	3/24	32	18.069
Ring-necked Duck (*Aythya collaris* (Donovan))*	4/9	3/24	47	13.821
Turkey Vulture (*Cathartes aura* (Linnaeus))	3/31	2/28	74	13.578
Osprey (*Pandion haliaetus* (Linneaus))*	4/16	3/16	80	11.734
Northern Harrier (*Circus cyaneus* (Linnaeus))	4/14	3/24	67	16.447
Broad-winged Hawk (*Buteo platypterus* (Vieillot))*	4/27	3/31	62	13.805
American Kestrel (*Falco sparverius* Linnaeus)*	4/4	2/19	86	16.108
Virginia Rail (*Rallus limicola* Viellot)	5/4	4/9	14	13.725
Sora (*Porzana carolina* (Linnaeus))	5/15	4/25	17	11.769
Piping Plover (*Charadrius melodus* Ord)	5/3	3/24	14	25.379
Killdeer (*Charadrius vociferus* Linnaeus)	4/4	2/21	86	16.116
Willet (*Catoptrophorus semipalmatus* (Gmelin))	5/8	4/2	20	11.412
Upland Sandpiper (*Bartramia longicauda* (Bechstein))	5/4	3/22	15	14.856
Spotted Sandpiper (*Actitis macularia* (Linnaeus))*	5/11	4/24	40	8.753
Common Snipe (*Capella gallinago* (Linnaeus))*	4/23	4/4	35	17.855
American Woodcock (*Scolopax minor* (Gmelin))*	4/3	3/18	63	11.773
Roseate Tern (*Sterna dougallii* Montagu)	6/7	6/7	1	
Common Tern (*Sterna hirundo* Linnaeus)	5/21	5/5	15	9.093
Arctic Tern (*Sterna paradisaea* Pontoppidan)	5/28	5/14	4	10.456
Least Tern (*Sterna albifrons* Pallas)	5/17	5/3	5	8.503
Black Tern (*Chlidonias niger* (Linnaeus))	5/22	5/10	7	6.997
Black-billed Cuckoo (*Coccyzus erythropthalmus* (Wilson))	5/27	5/12	13	5.221
Yellow-billed Cuckoo (*Coccyzus americanus* (Linnaeus))	6/4	6/4	1	
Common Nighthawk (*Chordeiles minor* (Forster))	5/27	5/21	22	5.473
Whip-poor-will (*Caprimulgus vociferus* (Wilson))	5/16	4/20	15	13.143
Chimney Swift (*Chaetura pelagica* (Linnaeus))	5/13	5/1	47	9.131
Ruby-thr. Hummingbird (*Archilochus colubris* (Linnaeus))	5/15	4/11	77	8.02
Belted Kingfisher (*Megaceryle alcyon* (Linnaeus))	4/19	3/23	73	16.221
Yellow-bellied Sapsucker (*Sphyrapicus varius* (Linnaeus))	4/29	4/2	39	18.447
Northern Flicker (*Colaptes auratus* (Linnaeus))	4/14	2/19	87	13.349
Olive-sided Flycatcher (*Nuttallornis borealis* (Swainson))	4/23	4/16	17	5.669
Eastern Wood-Pewee (*Contopus virens* (Linnaeus))	4/26	5/11	45	7.302
Yellow-bellied Flycatcher (*Empidonax flaviventris* (Baird and Baird))	5/26	5/21	21	4.567
Alder Flycatcher (*Empidonax alnorum* (Audubon))	4/25	4/7	30	6.754
Willow Flycatcher (*Empidonax traillii* (Audubon))	5/24	4/27	16	9.044
Least Flycatcher (*Empidonax minimus* (Baird and Baird))	5/18	4/15	44	10.471
Eastern Phoebe (*Sayornis phoebe* (Latham))	4/6	3/22	83	8.347
Great Crested Flycatcher (*Myiarchus crinitus* (Linnaeus))	5/15	4/25	57	10.666
Eastern Kingbird (*Tyrannus tyrannus* (Linnaeus))	5/13	5/1	61	8.842
Purple Martin (*Progne subis* (Linnaeus))	5/20	4/30	15	11.412
Tree Swallow (*Iridoprocne bicolor* (Vieillot))	4/17	3/25	98	14.299
N. Rough-winged Swallow (*Stelgidopteryx ruficollis* (Vieillot))	5/6	4/10	29	10.579
Bank Swallow (*Riparia riparia* (Linnaeus))	5/13	4/13	24	12.513
Cliff Swallow (*Hirundo pyrrhonota* (Vieillot))	5/10	4/13	40	11.639
Barn Swallow (*Hirundo rustica* Linnaeus)	5/5	4/2	73	12.938

House Wren (*Troglodytes aedon* Vieillot)	5/10	4/24	26	7.345
Winter Wren (*Troglodytes troglodytes* (Linnaeus))	4/14	4/8	8	8.237
Marsh Wren (*Cistothorus palustris* (Wilson))	5/18	4/30	12	11.107
Ruby-crowned Kinglet (*Regulus calendula* (Linnaeus))	4/22	4/8	55	10.932
Blue-gray Gnatcatcher (*Polioptila caerulea* (Linnaeus))	5/2	4/20	21	10.469
Eastern Bluebird (*Sialia sialis* (Linnaeus))	4/14	3/7	60	14.903
Veery (*Catharus fuscescens* (Stephens))	5/16	4/18	53	11.244
Bicknell's Thrush (*Catharus bicknellii* (Ridgway))	5/20	5/2	8	8.643
Swainson's Thrush (*Catharus ustulatus* (Nuttall))	5/22	5/12	22	6.238
Hermit Thrush (*Catharus guttatus* (Pallas))	4/22	3/13	67	13.145
Wood Thrush (*Hylocichla mustelin* (Gmelin))	5/11	4/22	57	7.899
Gray Catbird (*Dumatella carolinensis* (Linnaeus))	5/10	4/2	78	10.539
Brown Thrasher (*Toxostoma rufum* (Linnaeus))	5/11	4/23	43	10.055
Solitary Vireo (*Vireo solitarius* (Wilson))	5/3	4/16	60	8.599
Yellow-throated Vireo (*Vireo flavifrons* Vieillot)	5/21	4/28	11	12.186
Warbling Vireo (*Vireo gilvus* (Vieillot))	5/17	5/2	30	9.441
Philadelphia Vireo (*Vireo philadelphicus* (Cassin))	5/25	5/22	9	3.492
Red-eyed Vireo (*Vireo olivaceus* (Linnaeus))*	5/20	5/1	55	8.081
Tennessee Warbler (*Vermivora peregrina* (Wilson))	5/18	5/4	29	6.483
Nashville Warbler (*Vermivora ruficapilla* (Wilson))	5/8	4/30	50	6.938
Northern Parula (*Parula americana* (Linnaeus))	5/10	4/23	65	7.698
Yellow Warbler (*Dendroica petechia* (Linnaeus))*	5/10	4/12	74	8.792
Chestnut-sided Warbler (*Dendroica pensylvanica* (Linnaeus))	5/12	4/18	69	7.569
Magnolia Warbler (*Dendroica magnolia* (Wilson))	5/13	4/25	59	6.394
Cape May Warbler (*Dendroica tigrina* (Gmelin))	5/15	5/2	39	6.855
Black-thr. Blue Warbler (*Dendroica caerulescens* (Gmelin))	5/13	5/2	44	7.198
Yellow-rumped Warbler (*Dendroica coronota* (Linnaeus))	4/29	3/28	80	11.227
Black-thr. Green Warbler (*Dendroica virens* (Gmelin))	4/7	4/25	73	6.684
Blackburnian Warbler (*Dendroica fusca* (Müller))	5/17	4/28	53	7.928
Pine Warbler (*Dendroica pinus* (Wilson))	4/23	4/1	44	9.095
Prairie Warbler (*Dendroica discolor* (Vieillot))	5/14	4/23	14	13.579
Palm Warbler (*Dendroica palmarum* (Gmelin))	4/21	4/8	45	8.034
Bay-breasted Warbler (*Dendroica castanea* (Wilson))	5/17	5/9	32	4.563
Blackpoll Warbler (*Dendroica striata* (Foster))	5/20	4/23	38	7.807
Black-and-white Warbler (*Mniotilta varia* (Linnaeus))	5/4	4/20	73	6.548
American Redstart (*Setophaga ruticilla* (Linnaeus))	5/15	4/30	68	6.878
Ovenbird (*Seiurus aurocapillus* (Linnaeus))	5/9	4/27	71	4.958
Northern Waterthrush (*Seiurus noveboracensis* (Gmelin))	5/9	4/24	37	8.305
Louisiana Waterthrush (*Seiurus motacilla* (Vieillot))*	5/1	4/20	9	13.122
Mourning Warbler (*Oporornis philadelphia* (Wilson))*	5/26	5/20	20	4.303
Common Yellowthroat (*Geothlypis trichas* (Linnaeus))*	5/12	4/29	77	. 7.494
Wilson's Warbler (*Wilsonia pusilla* (Wilson))*	5/17	4/7	32	5.743
Canada Warbler (*Wilsonia canadensis* (Linnaeus))	5/19	5/5	41	6.493
Scarlet Tanager (*Piranga olivacea* (Gmelin))	5/18	5/6	49	6.191
Rose-breasted Grosbeak (*Pheucticus ludovicianus* (Linnaeus))	5/11	4/28	72	6.288
Indigo Bunting (*Passerina cyanea* (Linnaeus))*	5/18	4/22	33	10.266
Eastern Towhee (*Pipilo erythrophthalmus* (Linnaeus))	5/4	3/28	42	11.778
Chipping Sparrow (*Spizella passerina* (Bechstein))	4/25	3/31	75	11.930
Field Sparrow (*Spizella pusilla* (Wilson))	5/2	4/8	23	13.110
Vesper Sparrow (*Pooecetes gramineus* (Gmelin))	4/23	3/25	21	10.845
Savannah Sparrow (*Passerculus sandwichensis* (Gmelin))	4/28	4/6	53	12.832
Grasshopper Sparrow (*Ammodramus savannarum* (Gmelin))	6/1	5/21	8	5.952
‡Sharp-tailed Sparrow (*Ammospiza caudacuta* (Gmelin))	5/26	5/17	4	8.461
Lincoln's Sparrow (*Melospiza lincolnii* (Audubon))	5/14	4/4	21	12.482
Swamp Sparrow (*Melospiza georgiana* (Latham))	4/27	4/5	40	12.619
White-throated Sparrow (*Zonotrichia albicollis* (Gmelin))	4/20	3/25	79	8.944
Bobolink (*Dolichonyx oryzivorus* (Linnaeus))	5/15	4/25	68	7.135
Red-winged Blackbird (*Agelaius phoeniceus* (Linnaeus))	3/27	3/4	99	13.021
Eastern Meadowlark (*Sturnella magna* (Linnaeus))	4/19	2/28	51	21.046
Rusty Blackbird (*Euphagus carolinus* (Muller))	4/6	3/13	27	14.316
Common Grackle (*Quiscalus quiscula* (Linnaeus))*	3/27	2/24	89	13.385
Northern Oriole (*Icterus galbula* (Linnaeus))	5/12	3/26	71	8.339

‡Sharp-tailed Sparrow (*Ammodramus caudacutus*) has recently been split into two species: Nelson's Sharp-tailed Sparrow (*A. nelsoni*) and Salt Marsh Sharp-tailed Sparrow (*A. caudacutus*) (American Ornithologists' Union 1995). Both species breed in Maine but are not distinguished in this study.

Table 2. 1994 arrival dates by Biophysical Region of all migratory breeding birds which showed sigificant differences in arrival across the state. ">" indicates that the arrival date is later than the arrival dates for all regions to the right of the sign. "<" indicates that the arrival date in a particular region is earlier than all regions listed to the right. All contrasts were done with Bonferroni-Dunn post hoc tests ($p \leq 0.05$). All pair-wise comparisons not listed are not statistically different ($p > 0.05$).

	Biophysical Region											Significant Differences among Biophysical Regions
	1&2	3&4	5	7	9	10	11	12	13	14	15	
Pied-billed Grebe	5/15	6/11		5/6		4/15		4/12	4/8	4/10	4/11	3&4>10,12,13,14,15
Blue-winged Teal		6/11				4/19	4/23	4/12	4/16	4/8	4/30	3&4>10,12,13,14
Ring-necked Duck	5/2	4/26	5/7	5/3	4/10	4/5	4/2	4/10	3/29	3/28	4/16	5>13,14
Osprey	5/8	4/29	4/26	4/24	4/30	4/15	4/2	4/12	4/6	4/17	4/13	1&2>11,12.13 3&4>11; 9>11,13
Broad-winged Hawk	5/13	4/19	5/1	4/13	5/4	4/24	5/28	5/1	4/25	4/15	4/26	11>7,14
American Kestrel	5/9	4/18	4/7	4/3	4/16	3/31	4/16	4/4	3/29	3/29	4/6	1&2>10,13,14
Spotted Sandpiper	5/17	6/11	5/14	4/28	5/6	5/10		5/11	5/9	5/17	5/10	3&4>1&2,5,7,9,10 12,13,14,15
Common Snipe	5/18	6/11	5/15	4/15		4/16	5/28	4/23	4/15	4/11	4/26	3&4>7,10,12,13,14; 11>14
American Woodcock	5/6		3/30	4/12	4/6	4/2	3/29	4/2	4/1	3/31	3/28	1&2>5,9,10,11 12,13,14,15
Red-eyed Vireo	5/24	6/11	5/15	5/18	5/17	5/16	5/15	5/23	5/19	5/29	5/19	3&4>5,9,10,11
Yellow Warbler	6/4	5/29	5/17	5/8	5/14	5/5	5/21	5/9	5/9	5/13	5/16	1&2>7,10,12,13
Louisiana Waterthrush					5/31	4/30		4/29	4/23			9>13
Mourning Warbler	6/6		5/23			5/22		5/28	5/28		5/24	1&2>5,10,12,13,15
Common Yellowthroat	5/25	5/30	5/16	5/8	5/14	5/11	5/15	5/9	5/9	5/17	5/15	3&4>7,12,13
Wilson's Warbler	5/31		5/21	5/19	5/17	5/17		5/15	5/14		5/22	1&2>12,13
Indigo Bunting		6/3	5/16	5/18	5/20	5/21		5/17	5/21	5/10	4/24	3&4>15
Common Grackle	4/20	4/2	4/4	4/3	3/19	3/26	4/16	3/22	3/22	3/23	3/27	1&2>9,12

arrival dates reported were cross-classified into day of the week (weekend versus weekday) and weather pattern (front versus clear). Over this period, 11 fronts passed through. A 2 x 2 contingency table (weekend versus weekday, front versus clear) showed that three dates occurred on clear weekends, three on clear weekdays, two on stormy weekend days and two on stormy weekdays. χ^2 analysis indicated that there was no significant effect of either day (weekend versus weekday) or cold fronts on the reporting of arrival dates ($\chi^2 = 1.54$, $p > 0.67$).

DISCUSSION

Over 4,800 records of first arrival dates for 115 species of migratory breeding birds were obtained from observers across the state of Maine. Classified according to Biophysical Region (McMahon 1991), the arrival dates in large part failed to conform to our expectations of earlier arrrivals in southern Biophysical Regions. For 98 of the 115 species, no significant differences in different Biophysical Regions were detected. Given that the phenology of plants is such that York County (South Coastal Region) can be as much as two weeks earlier in leaf-out than the

Boundary Plateau (Mingo and Dimond 1979), this lack of significant results is surprising, particularly for leaf-gleaning birds like red-eyed vireos, yellow warblers and other insectivores. For the 17 species that did show a significant difference in arrival date across the state, the northern tier of zones usually had later arrivals (Table 2). These species conform to the predictions that arrival dates are a function of the progressive amelioration of weather and vegetational change from southern coastal/lowland areas to northern inland areas. However, the data cannot differentiate between two possible hypotheses for arrivals: south to north migration or coastal to inland migration.

Consideration of the standard deviations of arrival dates reveals some intriguing patterns (Table 1). The species that are most variable in their arrival dates are non-passerines, often associated with water or marshes. As open water appears earlier in southern portions of the state, variation in arrival date of waterbirds is likely because of those temporal differences in open aquatic habitat across the state. The species that are least variable are primarily passerine birds. One of these species, the grasshopper sparrow, has a restricted distribution in Maine (Adamus 1989), perhaps explaining its tight arrival schedule.

Passerines appear to migrate in broad waves, dropping out across wide expanses of Maine. Their relatively high abundance and hence likelihood of being sighted compared to hawks, shorebirds and ducks may also help explain the relatively low standard deviations of the passerines.

The precision of the data may be influenced by the bias toward weekend observations; 1,842 of the reported first arrivals out of a total of 4,858 (37.9%) were made on weekends. This bias is unavoidable as the data collection depended on the cooperation of volunteers, many of whom did not have time available during the week for bird observations. It is inevitable that some migratory breeders may have arrived locally during a weekday but were not detected until a local birder got into the field on a weekend. However, a considerable number of sightings of first arrivals were made on weekdays, indicating good coverage during the whole period.

It is well known that cold fronts cause migrating passerines and other birds to cease their migrations, producing a fall-out (Richardson 1978). Low pressure systems with their counterclockwise rotations have northerly winds on the advancing side; these are favorable winds for migration. As the front passes through, winds shift to a southerly direction, sometimes producing spectacular groundings of migrants (Imhof 1953, Proescholdt 1961, Richardson 1966, Forsyth and James 1971). Eighteen such fronts occurred during the spring of 1994. However, fronts seemed to play only a minor role in the timing of bird arrivals into the state because no significant effects of fronts were documented. Consideration of the patterns of migatory arrival for the 17 species in Table 2 are consistent with a south to north pattern, reflecting the progressive improvement of climate through the spring. We expect that more intensive coverage is needed to clarify the patterns for the remaining 98 species in which no significant differences in arrival date could be documented across the state.

Despite the fact that Maine spans a wide range of climatic conditions, our breeding birds seem to arrive largely in massive waves that spread quickly over the state. The cooperation of the 89 volunteers has produced the most ambitious effort to document the phenology of bird migration in a single year. The data are far more precise than the general arrival dates given by Knight (1908) and Palmer (1949). We intend to continue this project for a number of years and welcome additional participants to this long-term project. Anyone interested in participating should contact the senior author.

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