THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY

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BACKGROUNDER

A Matter of Timing: Climate Change Impacts on Bird Migration

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Migratory birds that travel short distances between their breeding and wintering grounds are better able to respond to seasonal shifts due to climate change and, consequently, may be able to breed more successfully than birds traveling longer distances.

HOT RESEARCH QUESTIONS

How and why are some species of bird better able than others to change their migratory patterns in response to global climate change? What happens when a migrating bird species can't adequately compensate for climatic shifts? What relationships among birds and other species may change due to changes in migratory patterns?

When the days grow warmer in the temperate places of the world, trees unfurl new leaves, insects awaken, and birds arrive en masse to fill the air with song. When the days grow cool again, the leaves fall, the insects disappear, and the birds fly south, leaving the world quiet once more.

But what happens when the leaves unfurl earlier than they used to because the forest is warmer earlier in the spring (Figs. 1 and 2)? Do birds miss out on those leaf-eating insects, so abundant when the buds burst, but ever scarcer as the leaves mature? Or do those birds migrate earlier to keep up with changing availability of food? The answer to both questions is yes, depending on the species of bird and where they winter.

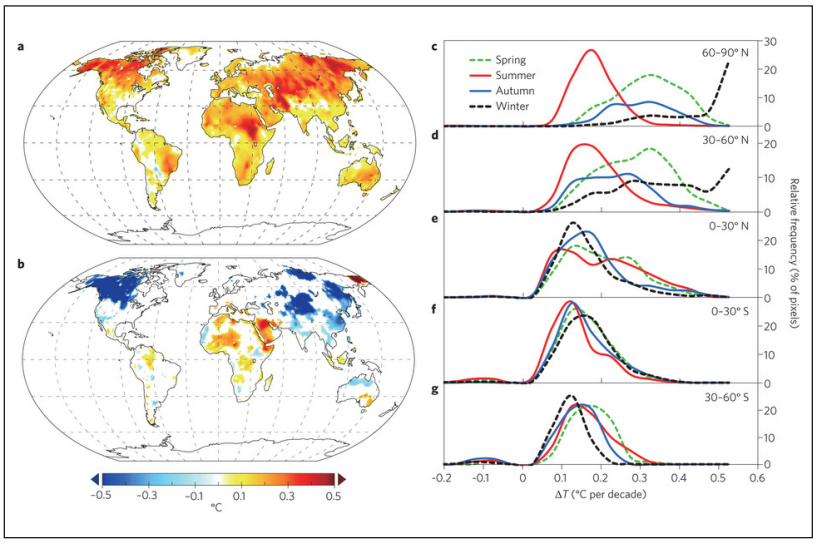

Figure 1. Annual mean air temperature (a) and annual temperature range (b) have changed significantly from 1948 to 2010, with changes varying geographically. The degree of seasonal warming has differed by latitude (c–g), with warming most pronounced at high northern latitudes, particularly in winter and spring. Source: Xia, et al. 2014, "Terrestrial carbon cycle affected by non-uniform climate warming." Reprinted by permission from Macmillan Publishers Ltd.: *Nature Geoscience* 7:173–180, ©2014; http://www.nature.com/ngeo/index.html

Migratory birds rely on multiple plant, insect, and other animal communities for their livelihoods, and not all species are able to adapt readily to changes in those communities. Researchers agree that spring migration is occurring earlier than in decades past, that birds' laying dates have advanced, and that the breeding season has lengthened for many species. However, research

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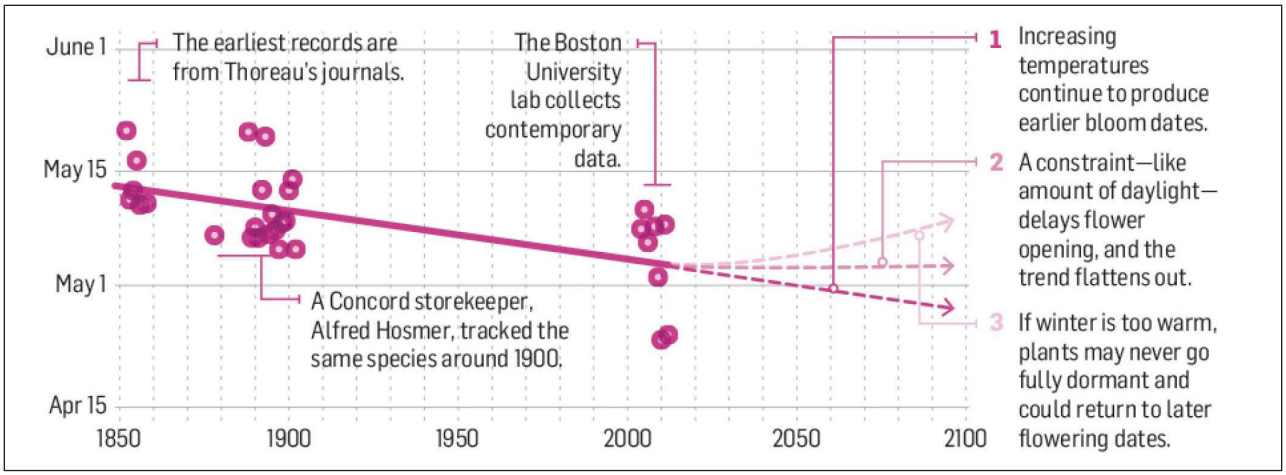


Figure 2. The timing of plant growth in temperate regions is changing in response to increasing spring temperatures. Researchers at Boston University have shown, for example, that flowering dates have advanced in Massachusetts, USA, by comparing contemporary studies with historical records. Image: © 2014 Popular Science, from the article "The New Spring, Brought to You by Climate Change, in Five Charts," by Katie Peek, based on data from Elizabeth Ellwood et al., Boston University; http://www.popsci.com/article/science/new-spring-brought-you-climate-change-five-charts. Reprinted by permission from Drs. Peek and Ellwood.

shows that individual species vary widely in how they respond to these changes (Fig. 3, Table 1).[1–6] There is mounting evidence that migratory birds who travel short distances between their breeding and wintering grounds are better able to respond to seasonal shifts under climate change conditions than birds who travel long distances. These differences have repercussions for population numbers and for the ecological relationships among species.[7–10] This backgrounder will explore why and how short-distance migrants are suffering less under climate change than long-distance migrants.

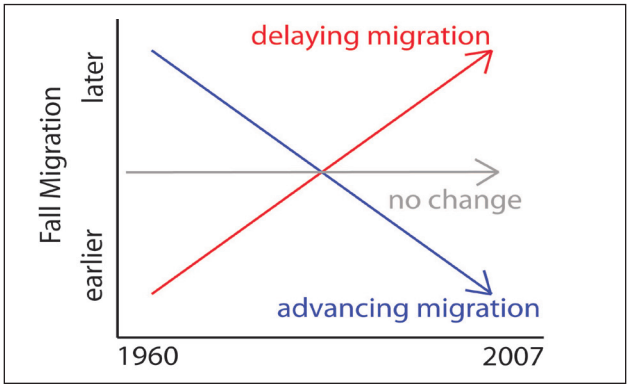


Figure 3. Banding studies spanning decades have shown that species of North American migrants have changed the timing of their autumn migration; see Table 1. Image: Megan Skrip

BREEDING SEASONS

More short-distance migrants have increased the length of their breeding seasons than long-distance migrants.

Researchers consistently find short distance (SD) migrants have responded to climate change by starting their spring migrations earlier, whereas long distance (LD) migrants have not. This may be because SD migrants are better able to respond to changing conditions in areas that are geographically closer and more similar to their wintering areas.[1, 8, 9] While the timing of autumn migration is more variable than in spring, there is evidence that SD migrants delay flying south after breeding more often than LD migrants do.[2, 5]

Long-distance Migrants		Short-distance Migrants	
American Redstart	no change	Dark-eyed Junco	no change
Blue-winged Warbler	no change	Swamp Sparrow	no change
Northern Waterthrush	no change	Eastern Towhee	delaying
Ovenbird	no change	Hermit Thrush	delaying
Wood Thrush	no change	Song Sparrow	delaying
Black-and-white Warbler	delaying	Yellow-rumped Warbler	delaying
Blackpoll Warbler	delaying	Ruby-crowned Kinglet	nonlinear delay
Red-eyed Vireo	delaying	White-throated Sparrow	nonlinear delay & advance
Common Yellowthroat	nonlinear delay		
Gray Catbird	nonlinear delay & advance		
Veery	nonlinear delay & advance		

Table 1. Species breeding in the same region can vary widely in their responses to climate change; some show no changes in migration timing, while others show linear or nonlinear trends over decades. Linear trends (such as those represented by the straight lines in Figure 3) show a consistent rate of delay or advance over time; while nonlinear trends indicate variable rates of change, perhaps even in opposite directions within one species. For example, between 1960 and 2007, Gray Catbirds, Veeries, and White-throated Sparrows have switched from delaying migration to advancing migration. Image: Megan Skrip, based on data presented in Smith and Paton 2011, "Long-term shifts in autumn migration by songbirds at a coastal eastern North American stopover site," *The Wilson Journal of Ornithology* 123(3):557-566.

SHORT-DISTANCE v. LONG-DISTANCE

Scientists group migratory birds that breed in temperate climates into two broad categories: long-distance (LD) and short-distance (SD) (Fig. 4). Migrants that breed in temperate North America and winter in the southern portions of the continent are considered SD, while those that winter primarily in South America are LD.[4] Temperate migrants that breed in northern, central, and western Europe are SD if they winter in southern Europe and northern Africa and LD migrants if they winter in sub-Saharan Africa.[11]

LD migrants in the Americas and Europe/Africa face large migration barriers during their journeys, such as deserts and seas, whereas SD migrants seldom encounter such inhospitable terrain, and can respond more readily to changing weather conditions in breeding grounds relatively close to where they winter. The cumulative findings of many researchers have painted very different pictures of the future for SD and LD migratory birds. To date, much of this work has been conducted in Europe (e.g., Germany, Switzerland, the Netherlands), where warming is more pronounced than in the Americas.[4, 5]

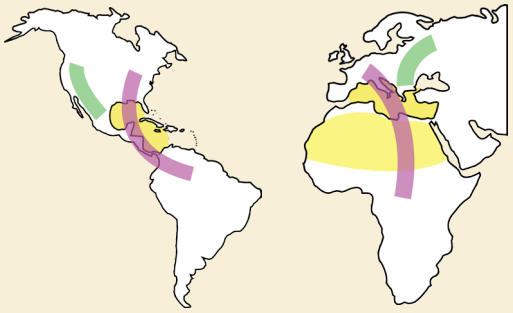
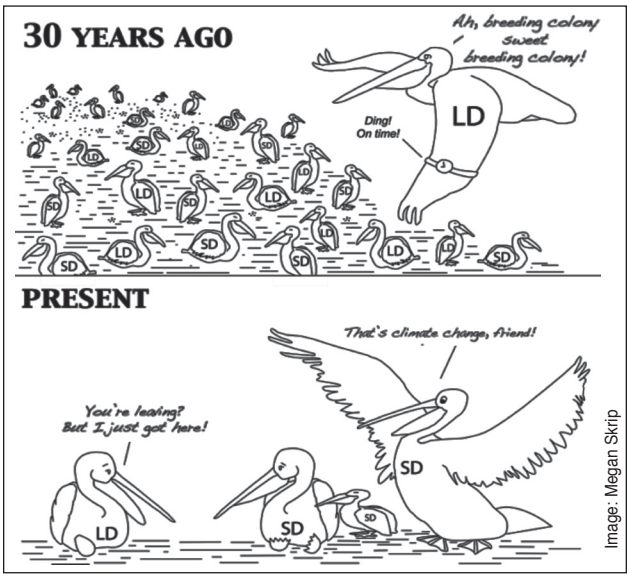


Figure 4. Long-distance migratory bird species (purple lines) often must cross migration barriers like seas and deserts (yellow) during their flights, while short-distance migrant species (green lines) do not. Image: Megan Skrip

Simply put, SD migrants arrive at breeding grounds earlier and leave later—lengthening the breeding season. While many studies have examined these phenomena in songbirds—warblers, sparrows, flycatchers, cuckoos, and other, generally small, perching birds—these trends also hold for birds of prey.[5] Presumably, a longer stay in North America during the breeding season means higher predation pressure on the animals these raptors hunt; the extent of this impact, though, remains unknown.

While SD migrants are better able to lengthen their breeding season than LD migrants, can the breeding season of LD migrants actually be shortened



by climate change? In Greece, two closely related species of pelican form large joint breeding colonies to protect themselves from predation and other disturbances—the larger the colony, the safer the nests. Yet, one of these pelicans is an SD species, and the other is LD. As the climate has warmed, the SD species, but not the LD species, has started laying eggs earlier in the year.[10] The LD birds arrive to the colonies later than the SD, but to derive the benefit from the larger, established SD breeding colonies, they stop laying when the SD birds do. As climate change has advanced the breeding schedule of the SD pelicans, LD pelicans that arrive later to the breeding colonies have truncated their own breeding season, likely limiting the number of chicks they can produce.

FOOD MISMATCH

Short-distance migrants suffer less from "food mismatch" caused by climate change than long-distance migrants.

Migrants face another detrimental consequence of climate change: a mismatch in timing between their arrival/nesting and the peak availability of insect prey. With earlier leaf-out, leaf-eating insects peak in abundance earlier in the year than in decades past.[7] Birds rely on this resource to feed their nestlings and therefore must adjust their arrival and/or laying times to keep up with the temporal shift in this important resource. Failure to do so can have serious consequences for successful reproduction.[7, 8]

In a landmark study of one hundred European bird species in 2008, researchers demonstrated[8] that species with falling numbers were those that had failed to respond to earlier food peaks resulting from climate change, while species that did advance their migration timetables showed stable or increasing populations (Fig. 5).

Even within migratory species, different levels of mismatch can occur in different geographic locations, causing some populations to decline more rapidly than others. A 20-year study of nine Dutch populations of Pied Flycatcher found that areas with late peaks in caterpillar prey exhibited population declines of 10%, while areas with early food peaks showed population declines of over 90%.[7] A follow-up study showed that LD species displayed greater population declines than SD species in temperate forests, suggesting that LD populations had not responded adequately to changes in the timing of their available food source.[11] As the researchers point out, "consistent with the mismatch hypothesis, the effect was strongest in species arriving latest in spring."[11] Again, these results demonstrate the advantages of short migration distances and the potential for climate change to alter ecological relationships by benefiting SD migrants over LD migrants.

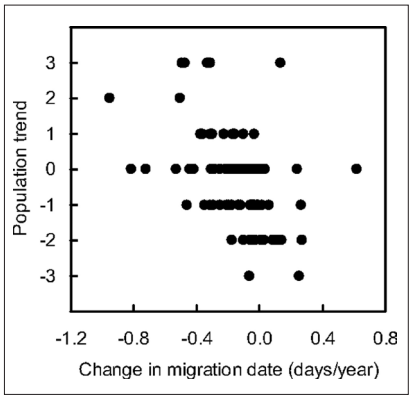


Figure 5. Between 1960 and 2006, European migratory bird species that began spring migrations earlier showed increasing population trends, while species that failed to adjust showed decreasing population trends. Source: Figure 1 from Møller et al. 2008. "Populations of migratory bird species that did not show a phenological response to climate change are declining." *Proceedings of the National Academy of Sciences*. 105(42)16195-1600; © National Academy of Sciences. Reprinted by permission.

Researchers use long-term datasets to track the arrival and departure dates of migratory species, like this Song Sparrow, at particular geographic locations. They can relate those data to environmental variables such as temperature and abundance of food.

MIGRATION DISTANCES

Short-distance migrants can shorten their migration distance more readily than long-distance migrants can.

Not only are SD migrants, by nature of their migration strategy, closer to their breeding grounds than LD migrants during winter, they can also shorten their migration distance more than LD migrants can by wintering even closer to their traditional breeding territories as conditions there become more hospitable. European SD migrants have shortened their migration distances over the past thirty years,[3] undoubtedly benefitting from reduced travel time and potentially further extending the duration of their breeding seasons. Some North American birds have also shifted their wintering ranges northward (Fig. 6).

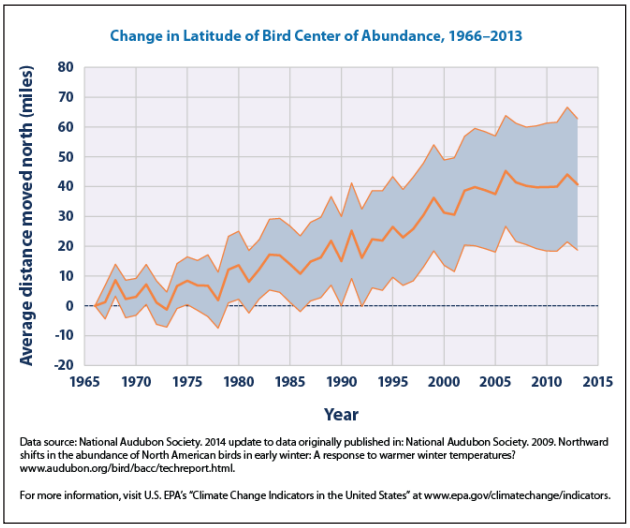


Figure 6. Between 1966 and 2013, 305 species of birds wintering in North America shifted their winter ranges northward. Image source: US EPA, based on National Audubon Society data, Climate Change Indicators in the United States: Bird Wintering Ranges. http://www.epa.gov/climatechange/science/indicators/ecosystems/bird-ranges.html

Laboratory studies show that SD migrants may not only change individual behavior but also evolve, as populations, to reside closer to their breeding grounds. Over the course of thirteen years, researchers observed a significant decline in the migratory activity of wild SD European Blackcaps.[3] In captivity, researchers selectively bred individuals with low migratory activity and found that within four generations, 14 individuals hatched that had no migratory tendency at all. To date, no equivalent experiments have been performed to evaluate whether LD migrants might also become resident in their breeding grounds. Yet, researchers point out that the gradual, natural evolution of shortened migratory distance in LD is likely unrealistic, particularly when unsuitable, or even inhospitable, habitat lies between the breeding and wintering grounds (Fig. 4).[3]

BROOD PARASITISM

Brood parasitism may increase in long-distance migrants relative to short-distance migrants under climate change conditions.

The Blue-headed Vireo is a short-distance migrant that summers and winters in North America, and therefore is more capable of shortening its migration distance than a closely related species, the Red-eyed Vireo, which winters in the Amazon Basin of South America.

Research has shown that LD migrants' reproduction may be further compromised by climate change more than that of SD migrants due to heavier pressure from brood parasites. The migration timing of brood parasites—birds that lay their eggs in the nests of other species—is becoming more synchronized with long-distance hosts than with short-distance hosts, at least in Europe.[9] The Common Cuckoo lays its eggs in the nests of over one hundred European songbirds, both LD and SD, reducing the number of eggs that the parasitized parents can produce in a season. Yet, the Common Cuckoo is itself a LD migrant, and researchers found that while SD hosts arrive to breeding grounds approximately fifteen days earlier than in the past, LD hosts arrive only six days earlier and Common Cuckoos only five days earlier.[9] These data suggest that Common Cuckoos may shift from SD to LD hosts as the timing of LD migrants' breeding becomes a better match with theirs. Already, evidence suggests that brood parasitism in one LD species, the Reed Warbler, is increasing.[9]

Parasitism among European SD species, meanwhile, has declined.[9] Chick production in LD migrants may be doubly affected, therefore, by both a mismatch with food availability and greater risk of parasitism.

Whether brood parasitism also differentially affects LD migrants in the Americas is currently an open question.

FUTURE DIRECTIONS

As research continues to examine how migratory birds respond—or fail to respond—to a changing climate, further explanation of the differences between LD and SD migrants is likely to emerge.

The ways that researchers design their studies will yield new insights into SD and LD migraton timing. Most studies so far have focused on one geographic area with datasets spanning long periods of time. More and more studies are following long time periods over a wide geographic area to help researchers understand how birds are changing not only their timing but also how that timing varies in space. For example, a study of spring migration by Ruby-throated Hummingbirds found that birds arrived about fifteen days earlier at lower latitudes of the United States and about eleven days earlier at higher latitudes, indicating that the pace of migration has slowed considerably (Fig. 7).[6] Birds have species-specific reasons for their behavior[4] and not only the temporal but also the geographic variability of their responses will be important to consider in future management.

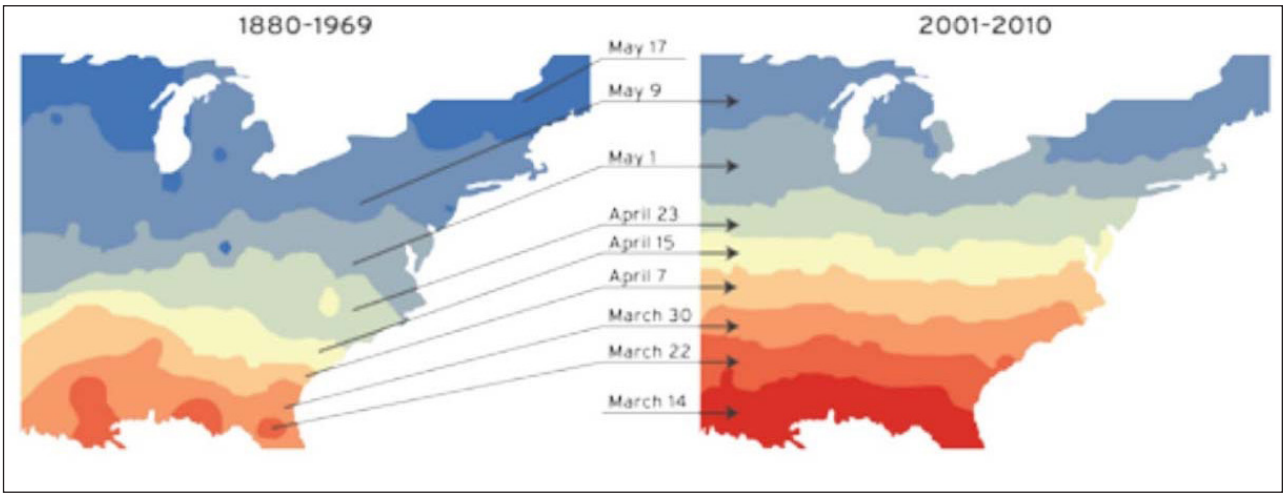


Figure 7. The arrival of Ruby-throated Hummingbirds to eastern North America in spring has shifted in time and space since the last century. Source: Figure 2 from Courter et al. 2013, "Assessing migration of Ruby-throated Hummingbirds (Archilochus colubris) at broad spatial and temporal scales," *The Auk* 130(1):107–117; published by the American Ornithologists' Union, aoucospubs.org. Reprinted by permission.

Photos: Megan Skrip

Migratory birds, like this Ruby-throated Hummingbird (right), rely on multiple stopover sites to rest and refuel during their journeys. Climate change may alter how and when they use these sites, and the overall pace of migration.

SUGGESTED SOURCES

General

David King, Research Wildlife Biologist, http://www.nrs.fs.fed.us/people/dking

Deborah Finch, Program Manager and Supervisory Biologist, http://www.fs.fed.us/rm/albuq/dfinch.php

Seasonal (Phenological) and Distributional Changes

Peter Paton (Timing of migration) Professor, University of Rhode Island http://www.uri.edu/nrs/peter-paton/

Benjamin Zuckerberg (Changes in distribution) Associate Professor, University of Wisconsin-Madison http://forestandwildlifeecology.wisc.edu/zuckerberg-benjamin-current-faculty-profile

Connecting Science and Public Audiences

Janis Dickinson, Director, Citizen Science, Cornell Lab of Ornithology. http://www.birds.cornell.edu/Page.aspx?pid=1735&id=65

Gary Langham (@garylangham) Chief Scientist, National Audubon Society. http://getoutside.audubon.org/audubon-leader-gary-langham

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