

# Climate Change and Avian Populations: a Review

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**Abstract:** Avian species fulfill many important roles in their respective ecosystems as seed dispersers, pollinators, and predators. Avian populations have previously, currently, and are likely to be affected by climate change. Climate change can cause distribution ranges to shift, migration patterns to alter, and reproductive success to decrease. Climate change may also impact plants and invertebrate prey, thereby modulating food availability and accessibility and likely reproductive potential. The impact of climate change on avian species is difficult to predict given the complexities of bird natural histories and the shifting importance of ecological variables on survival. Given the global biological importance of bird species, conservationists need to be cognizant of these potential changes in avian populations as well as their impacts and design appropriate action plans based on the most accurate available data.

**Keywords:** birds, climate change, range, migration, phenology

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## Introduction

Birds play an essential role in ecosystems as prey and predators. They also help with plant pollination and seed dispersal. Birds are an integral part of food webs and are important indicators of habitat change. Since animals are impacted by their surrounding environment, changes in climate can be expected to heavily influence avian species. For example, population sizes and ranges as well as the timing of migration and breeding behavior may be affected. Previous evidence from the fossil record suggests that historic climate change events have caused changes in bird species distributions. Here, we review some of the pertinent studies investigating the ecological variables important to bird survival and how climate change can be expected to influence bird populations.

### The overall impact of climate change

Over a century (ending 2005), the average temperature of the earth's surface increased by about 0.74°C (IPCC, 2007). Such global warming may alter several biotic and abiotic factors, including the physiology and reproduction of organisms and the manner in which they interact with and behave in their

respective environments. Populations may subsequently increase or decrease in size or diversity.

Furthermore, human impacts on the environment will likely exacerbate the impacts of climate change and put additive pressure on plants and animals, including birds. To this end, there are numerous studies that have been completed investigating and predicting how climate change could impact bird populations, including range shifts, changes in water and food availability, modifications in phenology, variation in migration patterns, and alterations in species population numbers.

### Shifting ranges

Avian species ranges could shift due to climate change. Such alterations could be either beneficial or detrimental depending on the species affected (Trautmann, 2018). Birds in Rwanda, Africa, shifted their elevational ranges by 1.9 meters over 15 years (Neate-Clegg et al., 2020). Temperature changes can interact with habitat fragmentation to the detriment of many species (Neate-Clegg et al., 2023).

Cold-adapted birds with restricted ranges are likely more susceptible to climate change, being less adaptable to warmer conditions caused by global

warming. Research in Finland has shown that Arctic bird species are shifting their range poleward by about 0.8 kilometers a year (Brommer et al., 2012). Higher-elevation species unable to adapt to increasing altitude may eventually face physiological challenges due to the decreased availability of oxygen at greater elevations.

Altitudinal shifts are not the only changes that may happen. Species may also adjust their ranges latitudinally. For instance, ecological models conducted on the endangered black-faced spoonbill, *Platalea minor*, of Asia predict that the species will shift its range northwards by several kilometers by 2080 (Hu et al., 2010).

### **Fossil evidence for range shifts with climate change**

Paleontological studies on birds suggest that bird species have been previously impacted by changes in climate. For instance, turacos, a group of fruit-eating birds, are presently only distributed in sub-Saharan Africa, although a 52 million-year-old fossil of an ancestor of these birds was found in the state of Wyoming (Field and Hsiang, 2018)). The climate of Wyoming today is uninhabitable for extant turaco species, but may have been suitable at one time given the likely drastic climate changes that have occurred in the region.

### **Climate change and water availability**

Shifting climatic conditions can be expected to influence water availability. The question is how this would impact avian species highly dependent on water sources, such as Anseriformes, or waterfowl. There is evidence that waterbirds are already being affected by changes in climate (e.g., Amano et al., 2020).

Climate change will not only induce changes in temperature but also changes in habitat (Nagy et al., 2022). The most important factors to species survival, according to ecological models, are precipitation and temperature, as was found by research done on grassland bird species in North America (Maresh Nelston et al., 2023). Suitable

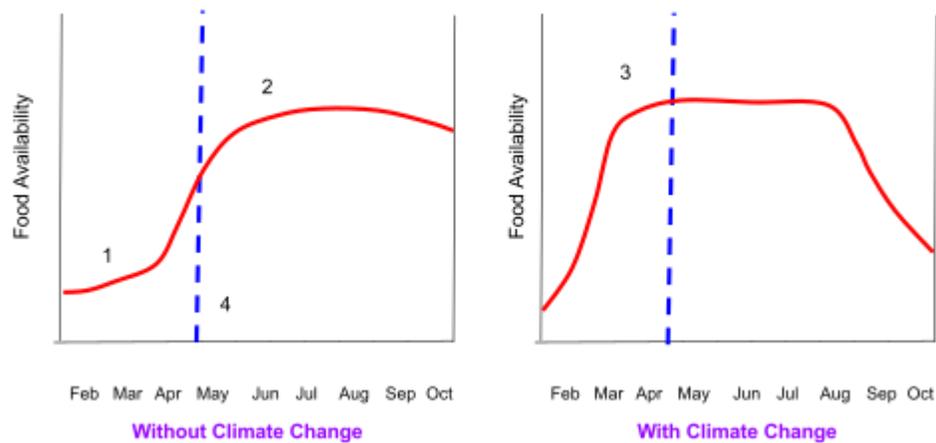
wetland habitats are essential for the survival of migrating waterfowl, and many countries have set aside protected areas to ensure such habitat persists. The problem is knowing if these areas will remain suitable for the birds in the future as conditions change.

Modeling of waterbird species ranges with predicted climate changes suggests a loss of waterbird species in the more arid areas of Southern Africa (Nagy et al., 2022). At the same time, species may spread into Europe as conditions there become more suitable (Nagy et al., 2022). Despite advancements in ecological modeling methods, concrete predictions remain difficult to make given the intricacies of a species natural history. For example, waterbirds also use non-water habitats such as open fields, so the real impact on their populations is difficult to predict.

### **Climate change and food availability**

Plants and other animals, besides birds, will also be impacted by changes in the climate. This includes the abundance and diversity of insects and invertebrates, which form an important component of the avian diet. Invertebrates, including insects, are ectothermic organisms that adjust their activity and breeding in accordance with changing temperatures and rainfall. The consequence of climate change on these organisms is an alteration in their activity and reproduction. The relative diversity and abundance of invertebrates are expected to change with climatic fluctuations.

Changing invertebrate prey availability will impact bird species (Pierce-Higgins, 2010). Climate change has already impacted butterfly populations at higher elevations in Northern California (Halsch et al., 2021). Butterflies are important prey for birds. A decrease in butterfly abundance means a reduced food source for birds. The same pattern will likely occur with other types of insects depending on where they occur and what their physiological and ecological tolerances are. Without a dependable high-quality food source, bird reproductive success will likely decrease.



**Figure 1:** An example of how food availability may shift with changing temperatures and impact bird reproduction in the Northern Hemisphere. 1. Without climate change, insect populations start to increase in numbers as temperatures start to increase in March. 2. Peak insect availability is in June, which is when birds are laying eggs. 3. With climate change, food abundance begins before the peak reproduction of birds. 4. Peak reproduction of birds. From: [https://commons.wikimedia.org/wiki/File:Climate\\_Change\\_and\\_Bird\\_Reproduction.svg](https://commons.wikimedia.org/wiki/File:Climate_Change_and_Bird_Reproduction.svg)

### Impacts on annual cycles and breeding

Appropriate timing of cyclical and seasonal events, or species phenology, is essential for the survival and reproduction of birds. Birds specifically time their breeding efforts to coincide with the season when food and weather conditions are optimal. For example, many bird species breed when days are longer and warmer since this is when they can find more food for their chicks. This increased food availability and longer days during summer in temperate regions means that chicks can develop rapidly, ultimately increasing the odds of offspring surviving.

Climate change impacts how long the reproductive season is for birds (Møller et al., 2010). In Denmark, researchers found that climate change increased the duration of the breeding season for those birds that had many broods in a season. The opposite was true for birds that only had a single brood per season. (Møller et al., 2010). This could drastically alter the population abundance of species, depending on how successful their reproduction is.

### Species with multiple broods

Some species breed multiple times a year. For example, doves and pigeons (Columbiformes) are often multiple-clutch species (Westmoreland et al.,

1986). The impact of climate change on these species is largely unknown and may be partly mitigated by their multiple-clutch reproductive strategy. However, climate change still may indirectly impact these birds if it affects their habitat.

For example, although the mourning dove, *Zenaidura macroura*, in North America is a generalist and very adaptable, reproduction is affected by habitat fragmentation and local weather conditions like precipitation (Dinges et al., 2022). High precipitation is related to the lower breeding success of the species. Even though this is a common and abundant bird, there may still be decreases in population due to climate change.

### Cascading trophic interactions and climate change

Species at different trophic levels have varying physiological requirements that are impacted when climate changes (Zhang et al., 2017). The effects of climate modifications are complex and unpredictable. Changes in food availability can have a cascading effect on food webs in that alterations in the abundance of one species can have an effect on all others. Such trophic cascades may have both a positive and negative impact depending on the species involved (Brose et al., 2012).

Changes in food availability will have an effect on interspecies resource interactions, with birds that feed on insects, other invertebrates and plant material, impacted. Food availability is one of the reasons many bird species migrate when the seasons change. When temperatures drop and food becomes less available, birds migrate to find suitable areas to overwinter. However, in time, climatic conditions may alter conditions, causing changes in what food is present and when this food is present. This may require birds to shift the timing of their migration if they are to survive.

### Impacts on bird migration

Migration is necessary for many bird species all over the world. Migration prompts birds to move away from inclement conditions where food is scarce to better conditions where food availability is suitable. Researchers using modeling suggest that the ranges of long-distance migrants are likely to be negatively affected by alterations in climatic conditions (Deomurari et al., 2023). This is most probably because suitable habitat for such species will likely shift northwards. The birds will then also shift their ranges to match where the suitable habitat is so that they can find enough food to survive.

Climate change may alter where species spend their time during the breeding season within migration. Both the locations where species breed and their wintering grounds can be impacted by climate modifications. Niche modeling suggests this will happen to neotropical thrushes in the family Turdidae (Da Silveira et al., 2021). The results of this study suggested that wintering grounds would decrease for some species of *Turdus* thrushes found in the Neotropics.

### Bird species richness

Changes in land use may interact with climate change to reduce the bird species richness or the number of different species, in some areas (Mantyka-Pringle et al., 2015). In some situations and locations, species richness may actually increase because of climate change. For instance, there has been an increase in the species richness of birds in Mediterranean forest ecosystems at higher elevations (Jiménez-Franco et al., 2023). In this case, new species have moved higher in response to changes in the climate. It is difficult to predict how individual species

will respond to changing climate. Some forest species may shift their range and enter new areas, increasing local species richness, but in other places, species may decline or move out of an area, decreasing species richness. Species moving into new areas may also outcompete current species, thereby decreasing their populations.

Historical data from bird atlas projects could provide useful insights into changing patterns of particular species within a country and across different regions. A bird atlas project is when people record all species observed within a particular grid of a region so as to form an atlas of bird distribution patterns. This can help scientists and conservationists to assess if species ranges and relative abundances are changing, and to what extent.

### Consequences for bird conservation

One of the greatest threats to bird species is habitat change caused by climate change and human modification of landscapes. Increasing urbanization and deforestation have severe consequences for many animal species, including birds. Climate change can be expected to further lead to reduced habitat, placing increased pressure on at-risk bird species. Birds, previously not threatened, may become so with such climate modifications in the future.

Changes in climatic conditions will have consequences for bird populations because it is probable that habitats will be further fragmented or reduced (Friggens and Finch, 2015). For example, modeling of future climate scenarios suggests that suitable habitat would be reduced in the southwestern United States. This could have grave consequences for endangered species such as the southwestern willow flycatcher, *Empidonax traillii eximius*. Another bird of the southwestern United States, Lucy's warbler, *Oreothlypis luciae*, may also be put at risk by changing conditions and habitat.

Animals most susceptible to changes are often specialized (stenotopic) species, which are more vulnerable to environmental perturbations than generalist (eurytopic) species. Stenotopic species typically adapt more slowly, if at all, to changing conditions. Bird conservation will rely on understanding that climate change in the future could put species at further risk and cause more species to become threatened. Such understanding can assist in

designing avian management plans, identifying those species requiring urgent or specialized attention, and assigning conservation status via platforms such as the IUCN Red List.

### Conclusion

Climate change is likely to impact birds in a number of ways. Different species may shift their ranges in accordance with climatic change that causes

habitats to shift. Breeding and annual cycles will be influenced by changes in climate, as will the migratory patterns of birds. A further consequence of climate change is on species richness, where effects may vary. It is critical for conservationists to also understand that climatic variability and change in the future will pose new challenges for birds that are threatened or endangered species.

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### Conflicts of interest

The author states no conflict of interest.