
Bird Wintering Ranges

Identification

1. Indicator Description

This indicator examines changes in the winter ranges of North American birds from the winter of 1966–1967 to 2005. Changes in climate can affect ecosystems by influencing animal behavior and distribution. Birds are a particularly strong indicator of environmental change for several reasons described in the indicator text.

Components of this indicator include:

- Shifts in the latitude of winter ranges of North American birds over the past half-century (Figure 1)
- Shifts in the distance to the coast of winter ranges of North American birds over the past half-century (Figure 2)

2. Revision History

April 2010: Indicator posted

Data Sources

3. Data Sources

This indicator is based on data collected by the annual Christmas Bird Count (CBC), managed by the National Audubon Society. Data used in this indicator are collected by citizen scientists who systematically survey certain areas and identify and count common bird species. The CBC has been in operation since 1900, but data used in this indicator begin in winter 1966–1967.

4. Data Availability

Complete CBC data are available in both print and electronic formats. Historical CBC data are available in print in the following periodicals: *Audubon Field Notes*, *American Birds*, and *Field Notes*. Annual publications of CBC data were made available beginning in 1998. Additionally, historical, current year, and annual summary CBC data are available online at: <http://birds.audubon.org/christmas-bird-count>. Descriptions of data are available with the data queried online. The appendix to National Audubon Society (2009) provides 40-year trends for each species, but not the full set of data by year. EPA obtained the complete data set for this indicator directly from the National Audubon Society.

A similar analysis is available from an interagency consortium at: www.stateofthebirds.org/2010.

Methodology

5. Data Collection

This indicator is based on data collected by the annual CBC, managed by the National Audubon Society. Data used in this indicator are collected by citizen scientists who systematically survey certain areas and identify and count common bird species. Although the indicator relies on human observation rather than precise measuring instruments, the people who collect the data are skilled observers who follow strict protocols that are consistent across time and space. These data have supported many peer-reviewed studies, a list of which can be found on the National Audubon Society's website at: <http://web4.audubon.org/bird/cbc/biblio.html>.

Bird surveys take place each year in approximately 2,000 different locations throughout the contiguous 48 states and the southern portions of Alaska and Canada. All local counts take place between December 14 and January 5 of each winter. Each local count takes place over a 24-hour period in a defined "count circle" that is 15 miles in diameter. A variable number of volunteer observers separate into field parties, which survey different areas of the count circle and tally the total number of individuals of each species observed (National Audubon Society, 2009). This indicator covers 305 bird species, which are listed in Appendix 1 of National Audubon Society (2009). These species were included because they are widespread and they met specific criteria for data availability.

The entire study description, including sampling methods and analyses performed, can be found in National Audubon Society (2009) and references therein. Information on this study is also available on the National Audubon Society website at: <http://birdsandclimate.audubon.org/index.html>. For additional information on CBC survey design and methodologies, see the technical reports listed at: www.audubon.org/bird/cbc/biblio.html.

6. Indicator Derivation

At the end of the 24-hour observation period, each count circle tallies the total number of individuals of each species seen in the count circle. Audubon scientists then run the data through several levels of analysis and quality control to determine final count numbers from each circle and each region. Population trends over the 40-year period of this indicator and annual indices of abundance were estimated for the entire survey area with hierarchical models in a Bayesian analysis using Markov chain Monte Carlo techniques (National Audubon Society, 2009). Data processing steps also include corrections for different levels of effort—for example, if some count circles had more observers and more person-hours of effort than others.

This indicator is based on the center of abundance for each species, which is the center of the population distribution at any point in time. In terms of latitude, half of the individuals in the population live north of the center of abundance and the other half live to the south. Similarly, in terms of longitude, half of the individuals live west of the center of abundance, and the other half live to the east. The center of abundance is a common way to characterize the general location of a population. For example, if a population were to shift generally northward, the center of abundance would be expected to shift northward as well.

This indicator examines the center of abundance from two perspectives:

- Latitude—testing the hypothesis that bird populations are moving northward along with the observed rise in overall temperatures throughout North America.
- Distance from coast—testing the hypothesis that bird populations are able to move further from the coast as a generally warming climate moderates the inland temperature extremes that would normally occur in the winter.

This indicator reports the position of the center of abundance for each year, relative to the position of the center of abundance in 1966 (winter 1966–1967), averaged across all 305 species. No attempt was made to generate estimates outside the surveyed area. The indicator does not include northern Alaska or Canada because data for these areas were too sparse to support meaningful trend analysis. No attempt was made to estimate trends prior to 1966 (i.e., prior to the availability of complete spatial coverage and standardized methods), and no attempt was made to project trends into the future.

The entire study description, including analyses performed, can be found in National Audubon Society (2009) and references therein. Information on this study is also available on the National Audubon Society website at: <http://birdsandclimate.audubon.org/index.html>.

7. Quality Assurance and Quality Control

As part of the overall data compilation effort, Audubon scientists have performed several statistical analyses to ensure that potential error and variability are adequately addressed. QA/QC procedures are described in National Audubon Society (2009) and in a variety of methodology reports listed at: www.audubon.org/bird/cbc/biblio.html.

Analysis

8. Comparability Over Time and Space

The CBC has been in operation since 1900, but data used in this indicator begin in winter 1966–1967. The National Audubon Society chose this start date to ensure sufficient sample size throughout the survey area as well as consistent methods, as the CBC design and methodology have remained generally consistent since the 1960s. All local counts take place between December 14 and January 5 of each winter, and they follow consistent methods regardless of the location.

9. Sources of Uncertainty

The sources of uncertainty in this indicator have been analyzed, quantified, and accounted for to the extent possible. The statistical significance of the trends suggests that the conclusions one might draw from this indicator are robust.

One potential source of uncertainty in these data is uneven effort among count circles. Various studies that discuss the best ways to account for this source of error have been published in peer-reviewed journals. Link and Sauer (1999) describe the methods that Audubon used to account for variability in effort.

10. Sources of Variability

Rare or difficult-to-observe bird species could lead to increased variability. For this analysis, the National Audubon Society included only 305 widespread birds that met criteria for abundance and the availability of data to enable the detection of meaningful trends.

11. Statistical/Trend Analysis

Appendix 1 of National Audubon Society (2009) documents the statistical significance of trends in the wintering range for each species included in this indicator. National Audubon Society (2009) also presents the statistical significance of each of the aggregate trends (northward distance and distance from the coast across all 305 species) and discusses the uncertainty of these trends. Based on ordinary least-squares regression, the average latitudinal center of abundance shifted significantly to the north by 34.8 miles ($p < 0.0001$) over the period of interest. Populations shifted inward from the coast by an average of 20.5 miles ($p < 0.0001$).

12. Data Limitations

Factors that may impact the confidence, application, or conclusions drawn from this indicator are as follows:

1. Many factors can influence bird ranges, including food availability, habitat alteration, and interactions with other species. Some of the birds covered in this indicator might have moved northward or inland for reasons other than changing temperatures.
2. This indicator does not show how responses to climate change vary among different types of birds. For example, National Audubon Society (2009) found large differences between coastal birds, grassland birds, and birds adapted to feeders, which all have varying abilities to adapt to temperature changes. This Audubon report also shows the large differences between individual species—some of which moved hundreds of miles while others did not move significantly at all.
3. Some data variations are caused by differences between count circles, such as inconsistent level of effort by volunteer observers, but these differences are carefully corrected in Audubon's statistical analysis.
4. While observers attempt to identify and count every bird observed during the 24-hour observation period, rare and nocturnal species may be undersampled.

References

Link, W.A., and J.R. Sauer. 1999. Controlling for varying effort in count surveys: An analysis of Christmas Bird Count data. *J. Agric. Biol. Envir. S.* 4:116–125.

National Audubon Society. 2009. Northward shifts in the abundance of North American birds in early winter: a response to warmer winter temperatures? www.audubon.org/bird/bacc/techreport.html.