Bird Wintering Ranges

1 Describe the physical, chemical, or biological measurements upon which this indicator is based. Are these measurements widely accepted as scientifically and technically valid? Explain.

This indicator shows changes in bird wintering ranges over time 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. 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.

Data from the CBC have been used in many peer-reviewed studies. A list of these studies is available on the National Audubon Society's Web site at: www.audubon.org/bird/cbc/biblio.html.

2 Describe the sampling design and/or monitoring plan used to collect the data over time and space. Is it based on sound scientific principles? Explain.

Bird surveys take place each year in approximately 2,000 different locations throughout the contiguous 48 states and the southern regions of Alaska and Canadian provinces. 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 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. Skilled observers are organized by the National Audubon Society, Bird Studies Canada, local Audubon chapters, and other bird clubs.

3 Describe the conceptual model used to transform these measurements into an indicator. Is this model widely accepted as a scientifically sound representation of the phenomenon it indicates? Explain.

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.

Figures 1 and 2 report 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. Figure 1 shows the average latitudinal distance moved northward and Figure 2 shows the average distance moved inland from the coast. In both cases the value for 1966 is set to zero as a baseline.

4 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

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 Web site at: <u>http://birdsandclimate.audubon.org/index.html</u>. For additional information on CBC survey design and methodologies, see the technical reports listed at: www.audubon.org/bird/cbc/biblio.html.

At the time EPA published this indicator, the Audubon report (National Audubon Society, 2009) was still available in draft form, pending publication in the peer-reviewed literature. The draft report does not provide complete citations for references, but these citations will be provided when Audubon publishes the final version of the study.

5 To what extent is the complete data set accessible, including metadata, datadictionaries, and embedded definitions? Are there confidentiality issues that may limit accessibility to the complete data set?

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: www.audubon.org/bird/cbc. 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.

6 Are the descriptions of the study or survey design clear, complete, and sufficient to enable the study or survey to be reproduced? Explain.

Descriptions of the study in National Audubon Society (2009), references therein, and descriptions of CBC on the National Audubon Society's Web site at: www.audubon.org/bird/cbc/index.html are sufficient to allow this study to be reproduced.

7 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

As described in the response to Question 3, quality assurance and quality control (QA/QC) of the CBC data set takes place at several levels. QA/QC measures are followed for individual observations, the compilation of data from each count circle, and the compilation of data across multiple circles. 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.

8 What statistical methods, if any, have been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)? Are these methods scientifically appropriate?

A complete description of statistical methods used to generalize data from count circles to portray continent-wide estimates of change in bird wintering ranges is available in National Audubon Society (2009) and in a variety of methodology reports listed at: www.audubon.org/bird/cbc/biblio.html.

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.

9 What uncertainty measurements or estimates are available for the indicator and/or the underlying data set?

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).

10 To what extent do uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

The sources of uncertainty and variability 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 variability of 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.

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 Describe any limitations or gaps in the data that may mislead a user about fundamental trends in the indicator over space or over the time period for which data are available.

Limitations to this indicator include the following:

- 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 can be 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.

12 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? <<u>www.audubon.org/bird/bacc/techreport.html</u>>