In November of 2003, Audubon convened an international panel of bird survey experts to undertake a thorough and independent review of the Christmas Bird Count (CBC). The panel's charge was to review the current and potential scientific value of the CBC, and to determine whether such value could be enhanced without completely changing the character of the survey and causing its traditional educational and social benefits to be lost. If the panel felt scientific value could be increased while also retaining the traditional nature of the CBC, then it was to make specific recommendations on how best to achieve those dual goals. The review covered all aspects of CBC design, data collection procedures, day-to-day project management, output products, and education/outreach. This paper, based on two days of meetings and subsequent discussion, constitutes the report of recommendations of the Review Panel to the National Audubon Society. In addition, a more thorough discussion of scientific aspects of the CBC will appear in early 2005 in the journal *The Auk*.

Improving the Christmas Bird Count: Report of a Review Panel

In the late 1800s, people engaged in a holiday tradition known as the Christmas "Side Hunt": They would choose sides and go afield with their guns; whoever brought in the biggest pile of feathered (and furred) quarry won. Conservation was in its beginning stages around the turn of the 20th century, and many observers and scientists were becoming concerned about declining bird populations. Beginning on Christmas Day 1900, ornithologist Frank Chapman, an early officer in the then budding Audubon Society, proposed a new holiday tradition—a "Christmas Bird Census"—that would count birds rather than hunt them. So began the Christmas Bird Count. Thanks to the inspiration of Chapman and the enthusiasm of 27 dedicated birders, 25 Christmas Bird Counts were held that day. The locations ranged from Toronto, Ontario, to Pacific Grove, California, with most counts in or near the population centers of northeastern North America. Those original counters tallied a total of 90 species and about 18,500 birds on all the counts combined.

First CBC:	**December 25, 1900**
Total Participants:	**27**
Species Identified:	**90**
Birds Counted:	**18,500**

History of the CBC

The Christmas Bird Count began in 1900 as a way to engage citizens in an outdoor birding activity during the Christmas period that did not involve hunting. The concept quickly caught on, and the CBC steadily grew in popularity throughout the 20th century. Expansion continues to this day, with 20–30 new counts initiated each year, and the total number of count circles is nearing 2,000. More than 50 of these are outside the United States and Canada, dotted throughout Central and South America and on Caribbean and Pacific islands.

The current CBC protocol calls for the tally of all birds detected within a 24.1 km (15-mile) diameter circle on a single day each winter between 14 December and 5 January. There are no hard rules about the number of counters, hours of searching (beyond requiring a minimum of eight hours in the field), means of travel, or strategies for counting. However, most circles have traditional styles of coverage that are moderately consistent from year to year. Circles are commonly divided into sectors, each of which is assigned to a single party of observers, to ensure sampling of all portions of the circle and to reduce chances of double counting. Typically participants meet at the end of the day for a social gathering and to compile the day's results.

The educational, social, and public relations values of the CBC are great. Many participants are seasoned birders who enjoy the challenge of improving on previous records, and who are curious about changes in birdlife taking place within their count areas. Other participants are keen beginners who may be getting their first exposure to organized birding. For them, the CBC provides an entrée into the world of birding-for-a-purpose, and an opportunity to meet potential birding mentors. The CBC generates much media attention each year, and local count results are published in many community newspapers. The high participation and public awareness of the CBC provides the National Audubon Society with visibility, a powerful tool for public education, and a talking point for conservation.

Because the CBC is the longest running bird survey in North America, covers all of the United States and southern Canada, and is repeated annually in the same locations, an invaluable data set has been accumulated on winter birdlife. There is a large literature that has mined CBC data for research and conservation purposes (see a bibliography of several hundred citations at www.audubon.org/bird/cbc/biblio.html). Examples include publications on biogeographic patterns (Root 1988), changes in distribution and

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abundance (Root and Weckstein 1994, Hagen 1993, Sauer et al. 1996), irregular irruptions (Bock and Lepthien 1976), and effects of disease on bird populations (Hochachka and Dhondt 2000), to list only a few. Long-term population trends based on the CBC have been shown to correspond in a general way with independent information from other sources (Dunn and Sauer 1997, Lepage and Francis 2002). For about 30 short-distance migrants whose breeding grounds are primarily in northern Canada and the Arctic, CBC data are the best available source of information on range-wide population trends during the 20th century (Rich et al. 2004).

Challenges for Scientific Use of CBC Data

While CBC data have been widely used in scientific publications, the survey was not designed for statistical analysis of population change (i.e., rigorous monitoring), and the data set presents serious challenges that analysts must address if appropriate inferences about populations are to be drawn. As noted by Bock and Root (1981:17): "The Christmas Bird Count (CBC) is an enormous but weakly standardized avian count…CBC data are an inappropriate substitute for more controlled census work associated with local projects. Scientists would ignore CBC data altogether, were it not for their potential application to large scale studies."

The Christmas Bird Count holds great value as an educational tool. Photo/Joel Sartore

Why is it that scientists are wary of using CBC data? The two key issues are as follows.

1) Within circles, counts are not complete censuses, but rather are incomplete samples. Because count effort is not uniform or standardized, the proportion of the true population that is counted each year and in each location is highly variable. A particular problem is that the number and expertise of participants in most circles has grown substantially over time (www.audubon.org/bird/cbc/ho.html), such that the number of birds recorded has increased independently of any real change in bird populations. Adjustment of bird counts for effort is required in order to minimize bias,

but is not a simple matter. For example, the number of birds detected per unit effort differs among counts made by people walking, driving among locations, or traveling on boats; and among counts made at roosts, waterfowl concentration sites, during nocturnal owling, or at bird feeders observed from indoors. As a result, separate adjustment is required for the number of birds detected by each effort type (Dunn 1995). Separate adjustment is also required for each species, because the relationship between effort and numbers seen differs among species (Sauer and Link 2002). Simple approaches to effort adjustment are commonly used, such as calculating birds per party-hour, but are known to be inadequate for most species because the number of birds seen does not increase with effort in a linear fashion (Butcher and McCulloch 1990, Link and Sauer 1999a,b).

2) Count circles are not randomly selected, but rather are purposefully chosen; often to be near urban areas or in protected and bird-rich locations such as parks or nature preserves. Density of count locations is correlated with human population density. Many data analysts of the past have taken minimal steps to avoid over-representation of geographic areas where count circles are most dense, and it is often an unspoken assumption (as yet untested) that habitat and bird populations within circles are representative of the landscape as a whole.

Addressing the challenges

There are two basic approaches to improving the scientific and population monitoring value of the CBC. One is to change the way that data are collected on CBCs to increase the scientific value of data collected in the future. The second is to maximize the scientific value of the existing, historic data set. We discuss each of these in turn.

The Review Panel could have recommended making new rules for selecting CBC locations and for data collection that would overcome the challenges described above. However, to do this would require designing what would effectively be a brand new winter survey. Participation would almost certainly be drastically lower than is currently the case, resulting in the loss of many of the educational and social benefits of the CBC. Future data would not be comparable to the 100-year CBC data set already in hand. In fact, chances are very high that the CBC would continue as it currently does even if a new winter monitoring survey were developed, simply because there is such a broad constituency that supports the CBC and enjoys participating. While the Review Panel recognized that having a standardized winter bird survey would be valuable, they agreed unanimously that the CBC should not be forced into that mold, and that the basic CBC structure should be retained. At the same time, the panel felt that modest changes to the way data are collected, which would only minimally alter the way participants currently make their observations, could substantially increase the scientific value of data collected in the future without compromising historic comparability.

The second main avenue to improving the scientific value of the CBC is to minimize the problems associated with using the historic data set. This involves cleaning up the database, providing state-of-the art analysis products, and making all data and products easily available to users. In this age of computers, it is now practical to develop species-specific effort-correction factors to better adjust for unstandardized effort within count circles, based on modeling of effects across many count sites (Sauer and Link 2002). To address the challenge of uneven geographic distribution of count circles, analysts need to weight the data from each location appropriately, and determine through GIS analyses whether habitat inside CBC circles is representative of the larger landscape. While such approaches cannot change the CBC from an unstandardized survey into a high-quality monitoring program, they can greatly reduce the chances of inappropriate interpretation of results, and increase the credibility of inferences based on CBC data.

Such post hoc adjustments of CBC data are not easy to calculate, and few potential users of the data set will be willing or able to undertake them. Therefore, unless some special effort is undertaken to overcome this obstacle, the CBC data set is likely to remain under-appreciated and under-utilized.

The CBC Review Panel recommends that Audubon implement the following strategy to improve scientific value and public use of the CBC, in partnership with others as needed and appropriate. The full list of recommendations is given in an appendix, but most of them constitute steps toward accomplishing the following.

The Christmas Bird Count engages citizens in birding for a purpose. Photo/Sally Conyne

The Strategy for Improvement

Recommendations for Audubon Action

Increase the scientific value of future CBC data

- *Require separate recording of the numbers of birds detected by particular types of effort* (home feeder-watching, owling, and roost counts), for the purpose of improved effort adjustment. Store these data separately in the database (as well as incorporate them into overall count totals).
- *Encourage establishment of standardized sampling components within count circles.* These could include standard routes or designated portions of the count circle that are thoroughly covered in a consistent manner each year. The particular sampling methods may vary among count circles, but the location and sampling method (including effort expended) for each sample component should be specified and well documented so that it can be repeated consistently over time. Counts from standard routes should be stored separately in the database (as well as incorporated into overall count totals). These data could greatly improve the population monitoring value of the CBC, and would also be useful for other research purposes, such as understanding bird/habitat relationships.

Increase the scientific value of the historic database

- *Analyze CBC data using the best available statistical methods.* Calculate effort-adjusted annual indices and trends based on species-specific, non-linear modeling of the relationship between effort and numbers of birds counted (Link and Sauer 1999a,b; Sauer and Link 2002) and using appropriate weighting to adjust for uneven density of count circles. Indices should be calculated for various geographic scales, from individual circles to broad regions such as states, provinces, or Bird Conservation Regions. Future iterations might also include adjustments for habitat and/or weather effects.
- *Make the adjusted indices and trends as widely and as easily accessible as possible.* Use the effort-adjusted annual indices and trends for summaries and graphs displayed on the CBC web site, and make them available for downloading to facilitate continued data mining and research by others. Presentation of effort-adjusted counts will increase scientific credibility of CBC results. Making data available for download will also encourage greater use, and reduce CBC staff time spent on filling requests (currently two to three data requests per month).
- *Develop institutional science capacity for the CBC program.* Ensure that there are resources available to routinely analyze incoming data, to update effort-adjustment factors and trends, and to keep the web site current.

Further develop the potential of the CBC for education and outreach that promote citizen science

- *Tailor the web site for use by a variety of constituencies,* including scientific users, conservation practitioners, CBC participants, the birding community, and educators. Develop separate areas of the web site that present results, interpretation, and additional materials that are primarily of interest to a particular user group.

The Review Panel believes that completion of this work will have several important benefits. It will enhance the scientific value of the CBC both past and future, and encourage use of the CBC by third parties for novel analyses and presentations far beyond what could be accomplished by Audubon staff alone. The use of data from the North American Breeding Bird Survey (BBS) rose steeply once they were made readily available on a web site, and this is likely to be the case with the CBC, as well. It is only because of the computer age that greater use of CBC data has become a realistic possibility, and in turn, the full scientific potential of the CBC will only be realized if the data set is made as widely and easily available as possible via the Internet.

Another potential benefit of implementing the Review Panel recommendations is that organizers of independent counts who currently do not submit results to the CBC database will be given incentive to begin doing so, to ensure that their results will be included in the data set used by researchers. Finally, Audubon will benefit from greater visibility and credibility as the sponsor of the CBC and as a leader in citizen science. Improved scientific credibility should in turn aid efforts to develop a more stable financial base for the CBC.

Acknowledgments

Review Panel members thank the Acopian Center for Conservation Learning for hosting our meeting, and Geoff LeBaron and Greg Butcher for providing background material and patiently answering questions. We salute the National Audubon Society for inviting us to undertake this review and join them in looking forward to the next 100 years of Christmas Bird Counts.

Appendix

Recommendations of the CBC Review Panel to the National Audubon Society

Recommendations are grouped by subject matter, then by priority level. Priority level indicates the sequence in which recommendations should be addressed within each topic, and resources should be sought to address high priority items as soon as possible. Implementation of medium and lower priority recommendations could be delayed, but are not necessarily of lower importance in the long run.

Database Cleanup

High priority

- Clean up the database to address changes in taxonomic names, circle location, and circle name, with priority back to 1966. This date was chosen as highest priority to expedite comparisons between CBC and BBS trends.
- Plot CBC circles onto high resolution maps. Ask compilers to confirm whether the circle is placed correctly, and to estimate past placement of the circle if changes have been made. Use this information to identify and correct errors in the database.
- Ensure that each time a circle location is changed, the circle is given a new identifier in the database, but also retain a mechanism for linking all versions of counts with the same name. This would allow data analysts to decide whether to treat each as a separate count location or not.
- Continue developing automated tools to alert count compilers and regional editors of unusual records (e.g., flags for unusually high or low counts, or species not previously recorded in a given count circle).
- As soon as there is institutional capacity to correct database errors in a timely manner, develop an error reporting page on the CBC web site, with a prominent request that suspected errors be reported.

Medium priority

- Clean up the database (name and location changes) for years prior to 1966. Add all data from Latin American circles, and weather data for all years back to 1966.
- Correct the "December 25" dates that were entered into the database for certain years, for counts that were actually done on different dates.
- As opportunity arises, add data from participating U.S. and Canadian counts for the years missing from the data set. (For recommendations on non-participating counts, see "Overall Project Management.")

Lower priority

- Add weather data collected prior to 1966 to the database.
- Add wild food abundance data to the database.
- Run consistency checks on historical records to flag unusual or improbable records, and organize count compilers or other volunteers to verify, from the published versions or their own records, that these records have been correctly entered.
- Replace rounded counts with actual counts for the set of years in which large counts were rounded off.

Data Collection and Database Entry

High priority

- Instruct counters and compilers to report separately the numbers of birds seen (as well as effort expended) by each of the following: feeder-watching from indoors, owling, roost counting, and any other specialized counting (such as gull counts). Data from these activities should be incorporated into the total count for the circle in the traditional way (i.e. eliminating probable duplicates), but should be recorded separately in the database as well, to allow better adjustment of counts for effort.
- Encourage participants and compilers, via articles in the CBC annual, on the web page, and through other means, to establish some standard sampling components within each circle. These could include standard routes, designated areas (e.g. a particular woodlot) that can be thoroughly searched, or lookout points for waterfowl. The aim is to cover each standard route in as consistent a way as possible each year (same number of counters, approximately same time of day, and speed of coverage), and to continue such coverage indefinitely into the future, regardless of changes in habitat or birdlife along the route. As with the previous recommendation, standard route counts should be incorporated into the total count for

the circle in the traditional way, but should also be recorded separately in the database. Many observers already cover their sectors, or portions thereof, as described here, such that establishing a standard route may only be a matter of officially recording the details and separately recording the observations made on that route. Results can greatly increase value of the CBC for monitoring population change within a particular circle and will enhance understanding of the relationships between effort, habitat, and count totals to improve overall monitoring.

- Develop field sheets (possibly including species lists appropriate to different parts of the continent) that direct separate recording of counts made using special types of effort and in standardized sampling areas (as described above), including the effort spent on each of these endeavors. Make electronic versions available to compilers for printing and distributing to participants for use in the field, to encourage compliance with separate recording and to raise interest in establishing standard routes.
- Develop data entry tools for the separately recorded data discussed above (counts made using special types of effort, and counts taken on any standard routes). The same tool could be used for separate recording of data from individual sectors within circles, even if not designated as standard sampling components, both for research purposes and for permanent archiving of data that are of local interest.
- Develop a strategy for collecting "metadata" on standard sample components, such as their locations and instructions for coverage. Instructions should be sufficiently detailed to allow a new person to find and follow the route and to conduct counts as done previously, without any additional guidance. For the near future, such data might best be collected via text files and scanning of maps that have been mailed in. Copy the instructions to compilers each year for distribution to participants who will cover the standard routes. If sector data are recorded separately in the database, then the compiler should send in a map showing sector boundaries for purposes of documentation.
- Provide each count compiler annually a map showing the official boundaries of the circle, roads, and major habitats, onto which sector boundaries can be drawn. Instruct compilers to give a copy to each field party.
- Maintain permanently the current range of permissible CBC dates (14 December–5 January). Do not expand the period simply because it starts or ends midway through a weekend, as this could lead to a never-ending expansion of the count period over time.
- Add a section to the Compiler's Manual on strategies for ensuring good and consistent coverage, which stresses the importance of consistency for making the data most useful for scientific purposes. Tips should include:
  - Try to have at least 10 people participating, split into at least five parties;
  - Try to hold the count each year on approximately the same date;
  - Do not shift CBC circle boundaries even a little, as this requires treatment of the data as a new count circle and destroys the link between current and past data;
  - Divide circle into sectors and assign parties to sectors to encourage coverage of all parts of the circle and to minimize double counting. Include some nice bird areas in each sector, so that no one gets stuck with awful habitat;
  - Strive for consistency of coverage every year (send count parties to the same places, use the same count strategies);
  - Provide each party with a map showing sector boundaries, roads, and major habitats, and a tip sheet for good coverage (materials to be provided by Audubon);
  - Consider establishing permanent standard sampling routes or areas within the circle (perhaps one per sector), to be covered with similar effort every year. Annually, provide the designated observers for these routes with details on location and instructions for coverage.
- Provide count compilers with "tip sheets" on attaining good CBC coverage, for giving out to each field party annually to help improve consistency of counts from year to year. Instruction should be included on:
  - Which birds should be counted (e.g. rules for counting birds seen crossing sector boundaries, birds that could not be identified with certainty to species);
  - Avoidance of double counting within birding parties;
  - Importance of making at least short visits to all parts of the assigned area, even if few birds are expected in some habitats;
  - Requirement to keep a separate tally of birds counted in the field, at roosts, at feeders watched from indoors, and during nocturnal owling (as well as of time spent in each of these endeavors);
  - How to record effort if party size varies during the count;
  - What the value is of establishing permanent standard routes or sample areas. (Direct the observer to ask the compiler about this if interested.)

Medium priority

- As technology and resources allow, develop a tool that electronically captures information on location of permanent standard sampling areas. Such a tool could also be used to archive annual sector boundaries.
- Encourage establishment of new counts to fill important geographic gaps in the United States and southern Canada (see section below on research needs). Accept applications for new counts where many already exist, because the marginal cost of

adding counts is very small, and higher count density reduces potential for count circles to be unrepresentative of the wider landscape.

- Consider asking count compilers to annually record the abundance of wild seeds, fruits, and cones, using simple scales such as those used by the Cornell Laboratory of Ornithology in some of its surveys. Develop appropriate field instructions, record forms, and data-entry tools. These data have great potential for research in combination with CBC data, and are not available on a broad geographic scale from any other source.
- Hold periodic regional meetings of count compilers. Sessions could be used to discuss tips, such as for making counts run smoothly, recruiting participants, developing strategies for good coverage, or establishing permanent standard routes. Gather feedback on problems, needs for better information or forms, improvements to web site tools, etc.
- Improve the design of the Compiler's Manual to make it more user-friendly and to make the most important information stand out.
- Offer a comment field in the data entry tools that allows count compilers to enter brief notes on factors thought to have had a major impact on counts in that year (e.g., extremely bad weather, gross changes in habitat within the circle since the previous count).
- Develop tools for archiving, and display on the web site, of rare bird documentation, including digital photographs, scanned images of drawings or notes, or other forms of digital documents.

Lower priority

- Scan any historic original notes, drawings, and other documentation of rare birds into image files for archival purposes and incorporation into the web database.
- Work with personnel running existing owl monitoring programs to develop a standardized owl counting protocol that could be used by CBC participants on a voluntary basis, including development of owl call tapes appropriate for use in each region of the continent.

Web Site Products

High priority

- Calculate and post on the Christmas Bird Count web site both for display and for downloading:
  - CBC annual indices and trends at continental and regional scales (including Bird Conservation Regions, given the value of these data for Partners in Flight conservation applications), calculated using the best available methods for species-specific adjustment of counts for effort (Link and Sauer 1999a, b), and with appropriate weighting to adjust for uneven geographic distribution of count circles. Highest priority is for United States and Canada and sub-divisions thereof, for years since 1966, to allow comparison with BBS results.
  - Count data for individual circles adjusted for effort based on regionally modeled effort adjustments (as well as the raw data and effort information that currently are provided).
- Provide tools that allow easy download of both the raw data and effort-adjusted counts for any combination of years or circles, ranging from the complete data set to all routes within one or more regions to data for individual circles.
- Post appropriate metadata on the web site, including information on how CBCs are conducted, how analyses were done (including details of individual species-effort corrections), how data from the web site should be cited in publication, and appropriate cautions on the interpretation and use of the data.
- Provide options for viewing graphical displays of data as total numbers, birds/circle, birds/party-hour, or effort-adjusted counts based on regional modeling, but make it clear that the latter is the recommended option for most uses of the data.
- Communicate with people who write summary articles on annual CBC results, to determine what data summaries would be of most use to them.

Medium priority

- Produce effort-adjusted Christmas Bird Count indices and trends for time periods prior to 1966.
- Use digital land-cover data, derived from remote sensing or other sources, relevant to the time of year, to determine the proportion of each circle made up of standard habitat types. Include results in the CBC database, so they can be downloaded along with counts for research purposes. Consider repeating habitat assessment periodically (e.g., every 5-10 years, as technology and resources permit) as an aid to interpreting trends in bird numbers.
- Provide a comment feature on the web site inviting suggestions for improved presentation and usability features for the web site.
- While initial web site products likely will consist of pre-calculated results, work toward adding a feature for custom analyses (as on the BBS web site, with user-selected region and span of years). If feasible, offer an option for the user to select non-standard groupings of circles to be included in analysis.

Education/Outreach

High priority

- Continue providing the CBC annual publication to every participant, and consider providing an option for receiving it electronically only. Consider changing the name of this publication from *American Birds* to something more clearly identified with the CBC and Audubon, such as *Audubon Christmas Bird Count*

Annual. (The current name is easily confused with *North American Birds,* published by the American Birding Association.) In every issue, provide volume number and other information needed for citation (information that is missing from recent volumes).

- Continue annual cycle of press releases announcing upcoming count seasons and post-count results.
- Establish more direct communication between CBC organizers, participants, and count compilers, making appropriate use of listserves and email.
- Structure the web site to meet the needs of various user groups: scientists, lay birders, conservation personnel, and the general public. Most of the products described above are of interest to all groups, but separate sections of the web site could be developed to provide additional material for particular groups (examples given below).
- At appropriate spots on the web site, and in language appropriate to each target user group, explain the strengths and limitations of CBC data. This is important for promoting appropriate use and interpretation of the data, but also as an educational lesson on how imperfect data can lead to incorrect conclusions. Emphasize that trends from CBC data will generally be more reliable for broad-scale analyses than for a single count circle, particularly if effort has been changing over time (because the effect of changing effort on a single count cannot be reliably estimated).
- Provide links from the CBC web page to other stable and useful sites on the CBC (e.g., www.mbr-pwrc.usgs.gov/bbs/cbc.html, and http://home.pacifier.com/~mpatters/cbc/acbc.html).
- Use the web site to post news updates related to the CBC, and summaries of research on the CBC or using CBC data (both current and historic).
- Develop new educational resources on the CBC web site, including providing links to other large-scale citizen science projects (such as eBird or Project FeederWatch) and to other sites offering educational units or classroom projects based on birds.

Medium priority

- Invite Audubon education/outreach staff (perhaps including state societies) to develop education units based on using the CBC web site, which could be made available for classroom use.

Lower priority

- Develop a photo gallery of bird pictures taken by CBC participants during counts.
- Once effort-adjusted CBC data are available on the web site, consider inviting youngsters or classes to submit articles to a CBC kid's page, based on their own uses of the data.
- Encourage CBC partners (such as Bird Studies Canada, or any others that may sign on in future) to develop web sites that present photos, regionally-interesting articles on the CBC, regional results (based on appropriately cited, effort-adjusted data obtained from the main CBC web site), etc. Provide links in both directions between such sites and the main CBC web site.

Research

High priority

- Use digital land-classification data, such as those derived from remote sensing, to investigate the degree to which CBC circles represent the wider landscape. Determine whether habitat stratification and/or modeling of habitat effects should be incorporated into certain kinds of CBC analyses. Repeat analyses periodically (e.g., every 10 or 20 years).
- Conduct a survey of count compilers to find out how many (if any) standardized sample areas are currently being surveyed, how long they have been surveyed, and whether the data are still available. Carry out research on these data (or on newly collected data) to determine the value both of standardized sample components, as well as count data from individual sectors within circles, for assessing count/effort relationships, bird/habitat relations, and local population changes. Results will provide guidance on the emphasis that should be placed on promoting establishment of standard routes, as well as the merits of collecting sector-specific data from all counts.

Medium priority

- Encourage additional research that could help to improve analysis methods for CBC data, or interpretation of CBC results. For example:
  - The effect of count date on bird numbers, with the aim of determining whether date should be included in modeling of adjusted annual indices.
  - The extent of regional variation in the relationships between counts and effort adjustment, and whether such variation should routinely be incorporated into effort adjustments.
  - The importance of incorporating weather covariates into routine analyses (both compiler-recorded local weather and broader scale weather patterns recorded by the weather office).
- Carry out a survey on the characteristics of CBC participants (e.g., age distribution, birding experience, computer literacy, etc.) to help guide recruitment programs and development of outreach materials.
- Conduct research into typical coverage of count circles, by asking compilers from selected circles to map the routes actually traveled by each party. Determine whether coverage (actual proportion of ground covered) is biased with respect to habitat coverage, or changes consistently with number of participants.

■ Encourage the development of short-term (e.g., 1–3 years) research projects that take advantage of the infrastructure provided by the CBC (e.g., to carry out counts of selected mammals, or separate counts of certain bird species by sex). Such projects could be developed by Audubon, or independent researchers could submit proposals and commit to analyzing the data, covering any costs (e.g., new data entry tools), and reporting back to participants.

Lower priority

■ Evaluate CBC data in relation to data from other, winter-long surveys, such as Project FeederWatch and eBird, to determine how counts during the CBC period compare with those at other times during the winter in terms of variance and geographic distribution, and how shifts in phenology, e.g., due to climate change, might influence interpretation of trends in CBC data.

■ Conduct an investigation of the best means of monitoring flocking species that wander in winter, using simulations as appropriate, to determine whether the CBC may have advantages over a standardized monitoring program that would sample far smaller areas.

Overall Project Management

High priority

■ Develop staff and financial infrastructure, either in-house or with partners, to ensure that routine analysis and updating of CBC results can be conducted annually and that effort adjustments can be recalculated as warranted. This will probably require a CBC scientist/analyst, in addition to database management and project organization personnel.

■ Incorporate annual publicity related to the CBC and the carrying out of a campaign every few years to recruit new participants, into the regular duties of Audubon's public relations and outreach staff.

■ Support efforts to expand the CBC into Latin America, recognizing that there is keen interest in many countries, and that the social and educational benefits and the basic knowledge of bird distribution that the CBC provides may be especially valuable for Latin Americans. Urge adoption in Latin America of features known to provide better CBC data (establish permanent standard routes within circles; establish one stratum of randomly selected circles and another for areas of special interest). At the same time, make it clear that the CBC is not a good choice of program for achieving standardized population monitoring, and that in many cases other programs may be more appropriate.

■ Participant fees are currently crucial to continuation of the CBC (with annual staff and printing expenses of $200,000), but can be an irritant and deterrent to participation. We recommend various approaches to alleviating the situation.

- Continue to develop online pre-registration and pre-payment for counts, to lessen the burden of fee collection on count compilers.
- Add text to the CBC web site displays and publications noting that analyses were paid for in part by participant fees, to educate participants about use of their money.
- Offer the CBC annual publication in an electronic version, to reduce printing and mailing costs.
- The National Audubon Society (beyond CBC staff alone) should be actively involved in developing permanent, long-term funding for the CBC, to eliminate or reduce dependence on participant fees. Completion and dissemination of up-to-date, effort-adjusted analyses via the CBC web site will greatly increase usability and scientific credibility of the CBC, which should facilitate funding.

■ Develop strategies for bringing counts conducted independently of Audubon into the fold and capturing their past data, particularly to fill geographic gaps in coverage.

- Meet with organizers of independent counts to determine why they do not report to Audubon, and discuss whether these impediments can be overcome. Demonstrate the benefits of joining the Audubon program (e.g., data will be incorporated into future analyses displayed on the CBC web site; counts will be adjusted for effort in a way that few people could do on their own; easy data entry tools are available; the database provides a permanent archive for local data; online pre-payment system removes collection duties from count compiler).
- Investigate avenues for getting historic data from independent counts into the CBC database. These could include working with organizers of these counts to obtain sponsorship to offset the costs of the historical data entry.

■ Establish a CBC Scientific Advisory Committee that can be called on for advice as needed, to periodically review the CBC web site, and to review progress on implementing the recommendations contained in this report.

Medium priority

■ Consider developing additional regional partners, along the lines of the current partnership with Bird Studies Canada (e.g., in Latin America or in U.S. states that already have a strong statewide system for collating CBC data).

The Painted Bunting *(Passerina ciris)* is one of the bird species being tracked by CBC data. Photo/Charles Lee

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Seasoned birders as well as beginners participate on Christmas Bird Counts. Photo/Deborah Phillips

Plans for Implementing the Panel's Recommendations

Audubon has received many suggestions over the years for ways to improve the Christmas Bird Count to increase its value to science without destroying its history or its fun. To address these questions, Audubon convened a scientific peer review panel to provide an independent assessment of the scientific value of the Christmas Bird Count and to make recommendations for ways to improve data collection methods while retaining the essential flavor of the event. The accompanying report is the result.

The review offers strong support for the use of CBC data to study population dynamics of North American birds. It also gives suggestions for making significant improvements in the way data are collected, stored, analyzed, and made available for public use. Audubon's aim is to implement these recommendations in a timely and prioritized manner. Many will be time-consuming and costly, and some will involve minor changes to the way CBCs are done. To achieve these goals, Audubon is committed to raising the necessary funds, beyond participant fees. In fact, the development of electronic data entry and storage over the past 10 years has been financed with money received from grants.

The most important background activity of the Christmas Bird Count currently is the application of new methods in the analysis of population trends (and annual indices) of all birds that have consistently appeared on CBCs from 1966 to the present. In an article that appears in this issue (page 10), Audubon's Senior Scientist for Bird Conservation, Dan Niven, along with scientists from the U.S. Geological Survey, explain the first step in the process. This progress greatly increases the value of the information you have been gathering as a CBC participant, and we thank you for your role in this important effort.

We encourage you to read the review panel's report and its recommendations for improving the CBC, and to send us your comments. Please email us at gbutcher@audubon.org, pgreen@audubon.org, or glebaron@audubon.org, or write to us at: Audubon Science, 545 Almshouse Road, Ivyland, PA 18974.

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