Monitoring the shorebirds of North America: towards a unified approach

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The Program for Regional and International Shorebird Monitoring (PRISM) has recently developed a single blueprint for monitoring shorebirds in Canada and the United States in response to needs identified by recent shorebird conservation plans. The goals of PRISM are to: (1) estimate the size of breeding populations of 74 shorebird taxa in North America; (2) describe the distribution, abundance, and habitat relationships for these taxa; (3) monitor trends in shorebird population size; (4) monitor shorebird numbers at stopover locations, and; (5) assist local managers in meeting their shorebird conservation goals. The initial focus has been on developing methods to estimate trends in population size. A three-part approach for estimating trends includes: (1) breeding surveys in arctic, boreal, and temperate regions, (2) migration surveys, and (3) wintering surveys.

INTRODUCTION

The recent drafting of shorebird conservation plans in Canada and the United States (Donaldson *et al.* 2000, Brown *et al.* 2001) emphasized the need for coordinated continent-wide monitoring of shorebird species that regularly breed in North America. The U.S. Shorebird Conservation Plan (Brown *et al.* 2001) identified 72 species, subspecies, or distinct populations that warrant monitoring. With slight modifications following review by Canadian shorebird specialists, this list now covers 74 taxa including 49 species. The complete list of taxa is available at http://amap.wr.usgs.gov.

In response to the stated needs of the shorebird conservation plans, the Program for Regional and International Shorebird Monitoring (PRISM) has recently developed a single blueprint for monitoring shorebirds in Canada and the United States. The goals of PRISM are to:

1. Estimate the size of breeding populations of shorebirds in North America.
2. Describe shorebirds' distribution, abundance, and habitat relationships.
3. Monitor trends in shorebird population size.
4. Monitor shorebird numbers at stopover locations.
5. Assist local managers in meeting their shorebird conservation goals.

The initial focus has been on developing methods to achieve the most difficult goal, that of estimating trends in population size. A three-part approach for estimating such trends includes: (1) breeding surveys in arctic, boreal, and temperate regions, (2) migration surveys, and (3) wintering surveys. PRISM's general goal, building on earlier work by Butcher *et al.* (1993), is to achieve 80% power to detect a 50% decline occurring during 20 years, using a two-tailed test with the significance level set at 0.15 and acknowledging effects of potential bias.

Trends in population size can best be studied on the breeding grounds when populations are stable and birds are dispersed. Extrapolation from sampled plots to the entire population can be made using standard methods from classical sampling theory. This approach is ideal for species that breed in temperate latitudes. However, in northern areas, gaining access is difficult and costly. For species that breed in arctic and boreal regions, PRISM proposes initial surveys on the breeding grounds to obtain estimates of population size. Indicators of population declines will then come from a comprehensive program of surveys in staging, migration, and wintering areas at lower latitudes, where access is reasonably easy. When warning signs appear, or at intervals of 10–20 years, arctic and boreal breeding ground surveys can be repeated to get updated population sizes and thus estimates of population trends. This approach avoids the high cost of annual surveys in remote northern areas but also avoids complete reliance on trend estimates from the migration period when several sources of bias are possible. PRISM's intent is to monitor the complete list of 74 taxa using a combination of new and existing comprehensive surveys, such as the arctic breeding survey (below), the Breeding Bird Survey (Sauer *et al.* 2001), the International Shorebird Survey, and the Maritimes Shorebird Survey, when appropriate, and to initiate targeted surveys for individual species when necessary.

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BREEDING SURVEYS

Arctic region

A substantial amount of work has been carried out recently to develop breeding surveys of shorebirds in remote areas in arctic regions. The current approach has three components: (1) an extensive continental survey, to be carried out at 10–20 year intervals, using random sampling and methods that permit estimating abundance (not just an index of it) across all arctic regions of North America; (2) annual or semi-annual surveys at 10–20 non-randomly selected permanent shorebird sites using either index or density methods; and (3) collection of checklist data, using a standard protocol, at as many sites and as often as possible. After three initial years of broad application, these methods are currently undergoing a thorough peer review. It is possible that the first and second components will be combined to permit estimates of population size and trends over a shorter time period (5–10 years). Potentially, these surveys can provide information on 34 species of shorebirds.

The continental surveys use a combination of GIS methods to select plots and double sampling to collect the bird information. In much of the arctic, shorebirds are concentrated in irregularly shaped patches that cover only a small fraction of the landscape. Stratified sampling is used so that sampling effort can be concentrated in the higher-quality areas. When patches are small, plots follow their borders and thus are of unequal size. When patches are large and regularly shaped, equal-size (10–16 ha) plots are established.

Double sampling, used to estimate bird abundance on the sample plots, is a standard statistical method from the survey sampling literature (Cochran 1977, Eberhardt & Simmons 1987, Bart & Earnst 2002). The method involves a sample that is surveyed using a rapid method, such as area search, point count, or variable circular-plot count, and a second subsample of these plots on which actual density is determined through intensive methods. The ratio of the result using the rapid method to actual density is used to adjust the results from the large sample of plots. The method yields unbiased estimates of density if the sub-sample is selected randomly and the intensive methods provide accurate counts. No assumptions are required about how the index ratio in the initial surveys varies with observer, time of day, habitat or other factors. Thus detection rates may vary, even considerably, with these factors.

Annual or semi-annual surveys at permanent sites will permit more intensive monitoring in a non-random sample of areas of known importance to shorebirds and will help avoid erroneous conclusions caused by erratic weather conditions. Preference is given to sites that are easy to access; that host ongoing, long-term research programs and facilities; that have high-quality shorebird habitat; or that are contained within existing protected areas. At these sites, demographic and habitat studies could be carried out along with double-sampling surveys.

A checklist survey was initiated by the Canadian Wildlife Service in 1995 and will be expanded to a network of arctic locations that are covered on an annual basis. Checklist survey data can be used to identify annual variation in shorebird distribution, breeding locations and breeding phenology, and over time it can provide a general indication of trends in distribution and abundance.

Boreal region

More planning is needed before a boreal shorebird monitoring program is implemented. It is not clear what methods will be most appropriate to monitor the 12 shorebird species that breed extensively in the boreal zone. Different surveys may be needed for each. Species life histories and behaviours, and possible survey methods are currently being assessed to determine the best approaches to use. Potential monitoring methods include "mini-BBS" (Breeding Bird Survey) routes (walking routes that could replace conventional BBS driving routes in roadless portions of the northern boreal forest) to monitor population trends of boreal-nesting shorebirds such as Wilson's Snipe *Gallinago delicata* and Lesser Yellowlegs *Tringa flavipes*; aerial helicopter surveys for larger species that are identifiable from the air; and conventional BBS in southern parts of the boreal region where there are adequate road networks.

Temperate region

Seventeen shorebird species breed in the temperate region of North America, in areas of Canada and the U.S. that are generally accessible by roads. Priorities for designing and implementing new surveys focus on species with high conservation concerns under the U.S. and Canadian shorebird plans, and on surveys that can combine species with similar ranges and natural histories. Four of the temperate breeding shorebird species are "highly imperilled" and seven are of "high concern" (Brown *et al.* 2001). Specialized breeding surveys currently cover one highly imperilled species (also a threatened and endangered species under the Endangered Species Act), the Piping Plover *Charadrius melodus* (Plissner & Haig 1997) and one species of high concern, the American Woodcock *Scolopax minor* (Bruggink 1998).

The Breeding Bird Survey (BBS) may adequately monitor additional species. PRISM considers species to be adequately monitored by the BBS if the standard error (SE) of the estimated rangewide trend, expressed as a percent, is less than 0.9 and if there is no reason to believe that bias (e.g., roadside bias) is especially large. This SE criterion is met for Killdeer *Charadrius vociferous*, Willet *Catoptrophorus semipalmatus*, Upland Sandpiper *Bartramia longicauda*, and Wilson's Snipe, and is nearly met for Spotted Sandpiper *Actitis macularia* (SE = 0.97; Sauer *et al.* 2001). More evaluation is needed to assess whether roadside or other bias is particularly large for these five species. Survey designs for the remaining temperate breeding species, initially proposed in Brown *et al.* (2001), have undergone extensive review and evaluation. Already considerable progress has been made towards refining survey protocols for Long-billed Curlew *Numenius americanus* and Marbled Godwit *Limosa fedoa*.

MIGRATION SURVEYS

Surveys during the migration period will monitor use of stopover locations, elucidate habitat relationships during this period, and help local managers meet their shorebird management goals. An additional important role of migration monitoring is to serve as an early warning of population declines; independent data from breeding ground surveys may then support or refute such declines. Counts during the nonbreeding period alone will not provide sufficient reliabil-

ity to be the only basis for trend estimation. Because nonbreeding surveys will be carried out in many areas for other purposes, we believe that their usefulness in trend estimation should be explored in detail. Such an effort would entail identification of potential problems, design of elements in a comprehensive survey to minimize them, and a careful assessment of the reliability of the resulting program.

The potential for bias is the major problem to be solved in designing the nonbreeding surveys. Three sources of bias have been identified. Frame bias is a long-term trend in the proportion of birds in the population that are in the study area during the study period. Selection bias is a long-term trend in the proportion of the birds in the study area during the study period that are in inaccessible areas or are not surveyed. Measurement bias is a long-term trend in the ratio of birds recorded to birds present during surveys. Quantitative expressions for frame, selection, and measurement bias are presented in the complete description of PRISM available at http://amap.wr.usgs.gov.

Existing and emerging temperate nonbreeding surveys across several regions are now being integrated. A major focus of this integration is to reduce potential sources of bias and to re-evaluate site selection procedures. A detailed procedure has been developed to design or re-design the migration surveys. Numerous shorebird monitoring regions have been defined across the United States and Canada. A sampling plan will be developed for each region that

(1) is based on all existing information on shorebird distribution and timing of use in the region;
(2) designates a survey period, usually 6–8 weeks during spring or fall migration, based on when shorebirds are present in the region; and
(3) subdivides the region into (a) "Type 1" habitat that is regularly used by shorebirds and will be surveyed (usually by sampling) 3–6 times annually; (b) "Type 2" habitat that contains few, but some, shorebirds and will be surveyed every several years to document continued low use, and (c) "Type 3" habitat which is assumed to have virtually no shorebirds and will not be surveyed. These designations are based on previous knowledge of the area or pilot studies.

The procedures for conducting these assessments, examples of the products produced during the assessment, and a map of the shorebird monitoring regions are available on the PRISM website, http://amap.wr.usgs.gov. The potential for selection and measurement bias at the site, stratum, and region-wide level is also discussed in more detail.

WINTERING SURVEYS

There is clearly a need to evaluate the efficacy of surveys in Central and South America. Winter surveys may be especially valuable for species that primarily winter in southern South America (e.g., Red Knot *Calidris canutus*, Buff-breasted Sandpiper *Tryngites subruficollis*, American Golden-Plover *Pluvialis dominica*, Baird's Sandpiper *Calidris bairdii*), for species which pose special problems during breeding and migration surveys (yellowlegs and some *Calidris* species), and for species which appear to be concentrated in certain areas in winter (Black-bellied Plover *Pluvialis squatarola*, Ruddy Turnstone *Arenaria interpres*, Whimbrel *Numenius phaeopus*; Morrison & Ross 1989). Aerial surveys of South America (Morrison & Ross 1989), Panama (Morrison *et al.* 1998), Central America, and Mexico have identified major shorebird concentration areas along these coastlines. Additional information is available from some sites in the Caribbean. These sites could be included in the sampling frame for selection of monitoring sites. Specific issues of site access and survey timing would need to be developed for each survey site. Surveys along the coasts of South America would sample several North American breeding species, such as the Hudsonian Godwit *Limosa haemastica*. However, some shorebirds are dispersed among inland wetlands and grasslands. Approaches to estimate densities of wintering migrant shorebirds could be adapted from methods developed for accessible, temperate breeding grounds.

Cooperative shorebird projects are already underway in many parts of Latin America and the Caribbean (e.g., Red Knot project, Western Hemisphere Shorebird Reserve Network sites, Western Sandpiper project, Pan American Shorebird Project, identification of major sites in Baja, Mexico, by the Point Reyes Bird Observatory). In addition, NABCI (North American Bird Conservation Initiative) emphasizes that bird conservation must be addressed internationally and linkages with other countries should be encouraged. Monitoring is but one tool that can be used to accomplish the hemispheric conservation of shorebirds.

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