The Program for Regional and International Shorebird Monitoring (PRISM)[1]

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Abstract

This report describes the "Program for Regional and International Shorebird Monitoring" (PRISM). PRISM is being implemented by a Canada-United States Shorebird Monitoring and Assessment Committee formed in 2001 by the Canadian Shorebird Working Group and the U.S. Shorebird Council. PRISM provides a single blueprint for implementing the shorebird conservation plans recently completed in Canada and the United States. 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 each of 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. PRISM has four main components: arctic and boreal breeding surveys, temperate breeding surveys, temperate non-breeding surveys, and neotropical surveys. Progress on, and action items for, each major component are described. The most important major tasks for immediate action are carrying out the northern surveys, conducting regional analyses to design the program of migration counts, and evaluating aerial photographic surveys for migration and winter counts.

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Introduction

This document describes the Program for Regional and International Shorebird Monitoring (PRISM). PRISM is a single blueprint for monitoring shorebirds in Canada and the United States and is based on the Canadian and United States shorebird conservation plans (Brown 2001, Donaldson 2001). 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.; and (5) assist local managers in meeting their shorebird conservation goals.

Most of this report is focused on the goal of estimating trend in population size because we believe this is technically the most difficult goal. PRISM has adopted goals and standards for comprehensive avian monitoring programs proposed by Bart and Francis (2001). Their general goal, building on earlier work by Butcher et al. (1993), is 80 percent power to detect a 50 percent decline occurring during 20 years, using a two-tailed test with the significance level set at 0.15 and acknowledging effects of potential bias. They analyze existing and feasible levels of accuracy for shorebirds and show that relatively few species meet the proposed standard at present but that if the Canadian and United States bird conservation initiatives are implemented, the standard will probably be met for most shorebird species breeding regularly in North America.

A four-part approach for estimating trends in population size has been developed:

1. Arctic and boreal breeding surveys.
2. Temperate breeding surveys.
3. Temperate non-breeding surveys.
4. Neotropical surveys.

The rationale underlying this scenario is that trends in population size can best be studied during the breeding season, on the breeding grounds. At this time, populations are stable rather than mobile, surveys are relatively straightforward because the birds are dispersed, and extrapolation from sampled plots to the entire population can be made using standard methods from classical sampling theory. This approach works well in temperate latitudes. In northern areas, where gaining access is difficult and costly, we propose an initial survey on the breeding grounds, to obtain estimates of population size, and then opportunistic data collection from these areas and a comprehensive program of surveys in staging, migration, and wintering areas at lower latitudes, where access is reasonably easy, to provide indications of population declines. When such warning signs appear, or at intervals of 10-20 years, the breeding ground surveys can be repeated to get updated population sizes and thus estimates of change in population size. 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.

The U.S. Plan suggested that selected subspecies and distinct populations, in addition to all species that breed regularly in the United States and Canada, should be included in the monitoring and assessment program. The rationale for this suggestion was that many subspecies, and a few populations, have such different breeding and/or non-breeding ranges that separate management efforts would be needed if they declined. For example, the three subspecies of Dunlins (*Calidris alpina*) in North America winter in different parts of the world, and evidence exists that one (*C. a. arcticola*) of them may be declining whereas this is not true for the other two. Computing a single species-wide trend for Dunlins does not provide managers the information they need. Furthermore, it is relatively straightforward to calculate separate trends for the three subspecies since they spend both the breeding and non-breeding periods in almost completely non-overlapping areas. The same rationale holds for a few distinct populations. For example, small populations of Marbled Godwits (*Limosa fedoa*) breed near James Bay and in western Alaska. They are separated from the main population by hundreds of kilometers, and certainly each warrant population-specific conservation actions by managers. It thus seems appropriate to identify them as separate taxa in monitoring and assessment program.

The U.S. shorebird plan identified 72 species, subspecies, or distinct populations that warrant separate monitoring and assessment efforts. With slight modifications following review by Canadian shorebird specialists, this list now covers 74 taxa including 49 species. The complete list is available at http://amap.wr.usgs.gov.

Arctic and Boreal Breeding Surveys

A substantial amount of work has been carried out recently to develop breeding surveys for shorebirds in remote areas in the arctic and boreal regions. The current proposal has three components: (1) an extensive survey, to be carried out at 10-20 year intervals, using random sampling and methods that permit estimating abundance (not just an index to it) across all arctic and boreal 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.

This program is based on the assumption that reliable information on breeding populations, as has been collected on waterfowl for many years, is also needed for shorebirds. Unlike waterfowl, breeding shorebirds cannot be counted by aerial surveys, and annual surveys on the ground of all or a large portion of northern North America would be prohibitively expensive. Thus, periodic surveys, to be carried out at an interval of 10-20 years, are proposed to provide reliable information on population size. This program will be augmented by surveys every 1 to 5 years at a series of sites selected non-randomly on the basis of practical issues such as high quality habitat, frequent visitation by shorebird biologists, and easy access. We expect to define a variety of protocols that would differ in methods, cost, and precision of estimates. The third component is a checklist program. A protocol is being developed that can be used any time qualified observers visit shorebird breeding areas. This component of the program will yield information from many more areas than the regular surveys. Taken together, these components will provide annual data from numerous, but non-randomly selected, sites and periodic comprehensive surveys that will provide essentially unbiased estimates of actual population size and thus of change in size since the last major survey. The program will provide information of value in many ways other than monitoring. For example, new information on distribution and local abundance will be collected as will information on how weather affects shorebird distribution and nesting activity. Providing regular reports on these topics will help ensure continued funding. The three major components of this approach are each described in more detail below.

Continental Survey

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 therefore used to separate the good and less good habitat 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, regularly-shaped, equal-size (10-16 ha) plots are established.

Double sampling, which is being used to estimate bird abundance on the sample plots, is a standard statistical method from the survey sampling literature (Cochran 1977, Thompson 1992). When used to estimate bird density, the method involves one sample surveyed using a rapid method such as area searches, point counts, or variable circular plot counts, 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 – and thus of trend in density – if the subsample 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. In addition to providing unbiased estimates of density, and thus trend in density, double sampling has several other advantages: (1) the rapid method can be changed as new methods become available, (2) domains can be compared even if detection rates differ (though separate estimates of the detection rates are then needed), (3) total population size can be estimated, and (4) valuable ancillary information (e.g., nest success) can be obtained on intensive plots with little additional effort. Double sampling has been used to survey waterfowl for many years (e.g., Eberhardt and Simmons 1987, Prenzlow and Lovvorn 1996) and has also been used occasionally in other wildlife studies (Handel and Gill 1992, Anthony et al. 1999). See Bart and Earnst (2002) for additional description of the method in bird surveys.

Results from the plot surveys are used to build regression models that predict the number of birds that would be recorded on rapid surveys covering each plot in the study area. The sum of these numbers is the estimated number that would be recorded if the entire study area were surveyed using the rapid method. This number is divided by the detection rate obtained from the intensive plots to produce an unbiased estimate of population size. For more details of the approach see Bart et al. (2002).

Regular Surveys at Permanent Sites

These surveys will permit more intensive monitoring in a sample of areas that are of known importance to shorebirds. There are often sharp differences in spring weather from year to year at a given site, and surveys in consecutive years will help avoid erroneous conclusions caused by erratic weather conditions. Preference should be given to sites that are easy to access, or that host ongoing, long-term research programs and facilities, and that have high-quality shorebird habitat. Some sites should also be contained within existing protected areas (where there is reasonable certainty that sites will not be disturbed, and where wildlife-oriented habitat classifications of satellite data often exist). Possible sites for these surveys in arctic regions of Canada include Cambridge Bay, Victoria Island; East Bay Bird Sanctuary, Southampton Island; Polar Bear Pass National Wildlife Area, Bathurst Island; Truelove Lowland, Devon Island; Prince Charles Island, Foxe Basin; Coats Island; Dewey-Soper Bird Sanctuary, Baffin Island; Creswell Bay, Somerset Island; and Bathurst Inlet. In Alaska, possible sites in the arctic include the Arctic National Wildlife Refuge, Prudhoe Bay, the Colville River Delta, Barrow, Wainwright, and one or more locations in each of the six National Wildlife Refuges (Selawik, Yukon Delta, Togiak, Alaska Peninsula, Izembek, Alaska Maritimes) in western Alaska. Potential sites in boreal regions have not yet been identified.

A Checklist Program

In 2001, the Canadian Wildlife Service started work on a network of arctic locations where the NWT/Nunavut Bird Checklist Survey will be conducted each year. Special consideration will be given to shorebirds in site selection. 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. Surveys are easy so the network of survey locations can be extended to other jurisdictions.

Boreal Regions

Seven shorebird species breed extensively (and in four cases largely) in boreal zones. It is not clear what method of monitoring will be most appropriate for boreal North America; different surveys may be needed for different species. In the Northwest Territories the Canadian Wildlife Service will test the use of "mini-Breeding Bird Survey" routes (walking routes that will replace conventional driving routes in roadless portions of the Territory) to monitor population trends of boreal-nesting shorebirds such as

Common Snipe (*Gallinago gallinago*) and Lesser Yellowlegs (*Tringa flavipes*). River Breeding Bird Survey (BBS) routes in Alaska have high encounter rates of boreal-breeding shorebirds. It may be possible to extend the double-sampling survey methodology south of the treeline. Aerial surveys to identify staging lakes might be coupled with breeding ground surveys to identify important areas within the boreal region. More planning is needed before a boreal shorebird monitoring program is implemented. This effort should be coordinated with planning for boreal songbird monitoring as it is desirable to combine monitoring efforts for these two groups of birds.

Other Projects in Support of the Northern Surveys

An extensive literature review is being conducted to capture and summarize all existing information on the distribution and abundance of shorebirds nesting in boreal and arctic regions of North America. A considerable proportion of arctic shorebird data resides in unpublished government and industry reports that are not widely accessible. The literature review will make this information available for such purposes as selecting survey sites and estimating historical and recent population size. A map showing distribution and abundance for each species is being prepared from this database. The database contains the following information: (1) location data (place name, geographic coordinates, habitat type); (2) species presence/absence; (3) species breeding status and general abundance; (4) species densities; and (5) literature citation.

Natural history information of use to field surveyors in deciding how many individuals are nesting on plots they have surveyed is being compiled for each of the northern-nesting species. These "Survey Tips" are being prepared by species specialists following uniform guidelines prepared for this project. All accounts will be posted on a web site, and shorebird specialists will be invited to contribute their own observations to the accounts, which will be updated frequently.

An "Atlas of Beringian Shorebirds" is being created to increase access to the large amount of information collected on shorebird distribution, abundance, biology and migration in Beringia (western Alaska, eastern Siberia and nearby areas) over the past two decades. Beringia is the most significant center of shorebird diversity within the Holarctic region. Numerous species, such as Western Sandpipers (*Calidris mauri*), Baird's Sandpipers (*C. bairdii*), Pectoral Sandpipers (*C. melanotos*), and Rock Sandpipers (*C. ptilocnemis*), occur in both the Alaskan and Russian parts of Beringia. Several Beringian endemics have relatively small ranges in Russia (e.g., Great Knot [*C. tenuirostris*]) or Alaska (e.g., Black Turnstone [*Arenaria melanocephala*]) and several nesting species are rare and may require special protective measures (e.g., Bristle-thighed Curlew [*Numenius tahitiensis*], Spoonbill Sandpiper [*Eurynorhynchus pygmeus*]). In addition, some species that nest in Northeast Asia migrate through Alaska enroute to wintering grounds in Central and South America. The Atlas and accompanying electronic database will be used to assess the status of specific shorebird populations in the region and identify future needs for management, research, and conservation.

Temperate Breeding Surveys

Seventeen shorebird species breed in the temperate region of North America, in areas of Canada and the United States that are generally accessible by roads. A large portion of the breeding range of three species (Spotted Sandpiper [*Actitis macularia*], Upland Sandpiper [*Bartramia longicauda*], Common Snipe) extend into northern areas inaccessible by roads, and this portion of their ranges will be monitored by the northern surveys (see Arctic and Boreal Breeding Surveys, above). Although all shorebird species will eventually be monitored under this plan, current resources should focus on the highest priority species. Setting priorities for the temperate breeding species depends on their conservation status (Brown et al. 2001) and on the adequacy of their coverage under existing surveys. Priorities for designing and implementing new surveys should focus on species with high conservation concerns (scores of 4 or 5) under the United States 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 Imperiled" (score 5) and seven are "High Concern" (score 4; *table 1*; Brown et al. 2001).

One "Highly Imperiled" species, the Piping Plover (*Charadrius melodus*), is listed as threatened under the Endangered Species Act (ESA) and is monitored on the breeding grounds by the International Piping Plover Census (Plissner and Haig 1997). One species of "High Concern", the American Woodcock (*Scolopax minor*), is monitored by the North American Woodcock Singing-ground Survey (Bruggink 1998).

Table 1— *Standard errors (SEs) for annual rates of change (expressed as a percent) for shorebird species breeding in accessible areas calculated from BBS data (Sauer et al. 2000).*

Species	SE < 0.90	SE 0.91 to 1.30	SE 1.31 to 1.86	SE > 1.86
Killdeer	0.23			
Mountain Plover[1]				4.51
Black-necked Stilt[2]				2.00
American Avocet			1.36	
Willet	0.80			
Spotted Sandpiper		0.97		
Upland Sandpiper	0.58			
Long-billed Curlew		1.10		
Marbled Godwit			1.38	
Common Snipe	0.42			
American Woodcock				2.13
Wilson's Phalarope[3]			1.57	

[1] *Charadrius montanus*
[2] *Himantopus mexicanus*
[3] *Phalaropus tricolor*

The Breeding Bird Survey (BBS) may adequately monitor additional species. It has been suggested that species are 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 (Bart and Francis 2001). This SE criterion is met for Killdeer (*Charadrius vociferus*), Willet (*Catoptrophorus semipalmatus*), Upland Sandpiper, and Common Snipe (*table 1*), and is nearly met for Spotted Sandpiper (SE = 0.97; Sauer et al. 2001, Bart and Francis 2001). More evaluation is needed to assess whether roadside or other bias is particularly large for these five species. Upland sandpiper is a priority level 4, but covered by the BBS with a SE = 0.58. Therefore, it would be a lower priority for implementation of a new survey, although a closer analysis of BBS coverage for this species is warranted due to its high level of concern. Spotted Sandpiper is a priority level 2 and covered by the BBS at a level (SE = 0.97) that would result in a lower priority for implementation of a new survey. Coverage by the BBS for these species, as well as for the American Avocet (*Recurvirostra americana*), Long-billed Curlew (*Numenius americanus*), and Marbled Godwit, could be improved by increasing the number of routes and/or by reducing potential survey biases; these options may be worth exploring, although currently the BBS does not adequately monitor these species. Standard errors for all other species are >1.5 percent per year suggesting that even with substantial improvement, the BBS will not provide adequate coverage for them. However, there is an overall need to examine in more detail the usefulness of the BBS for all of the temperate zone breeders, as well as determining which species can be effectively monitored on a regional basis by this method. This is particularly important for subspecies, and for species where significant portions of the breeding range habitat may be treated differently in different geographic regions of their range (e.g. CRP program in United States versus no such program in Canada; eastern versus western Upland Sandpipers).

The United States and Canadian shorebird plans presently suggest survey designs for some species but these survey designs have not been prioritized, analyzed for possible species combinations, or subjected to rigorous peer review. The next step to achieve our goal of monitoring the temperate breeding species should be a formal peer review and analysis of the survey designs in Brown et al. (2001) by researchers familiar with survey design and the particular species. This review should consider: (1) alternative methods, (2) recommend a detailed design and field evaluation, and (3) recommend a plan for eventual implementation. Species with lower conservation scores hopefully could be combined in surveys of the species of high concern.

One aspect that should be considered in the design and review of these new protocols is the use of ‘direct’ or ‘unbiased’ counts. Many specialists in avian population biology recommend that, whenever possible, new monitoring programs should use methods that yield direct or essentially unbiased estimates of population density (e.g., counts when all birds are visible), rather than relying on indirect, or index, methods (Nichols et al. 2000, Bart and Francis 2001). The rationale for this recommendation is that too many sources of bias exist with index methods for a high level of confidence in the trend estimates that they produce. An additional advantage is that direct counts also yield estimates of population size that are essentially unbiased and thus achieve the first PRISM goal. We believe that this recommendation should be followed whenever possible in designing new breeding surveys for accessible species of special concern, although this criterion is not met in existing surveys. See the complete PRISM report at http://amap.wr.usgs.gov for additional recommendations on designing the species-specific surveys.

Temperate Nonbreeding Surveys

Surveys during the nonbreeding period will monitor use at stopover locations, elucidate habitat relationships during this period, and help local managers meet their shorebird management goals. There is some debate at present over whether nonbreeding counts can also provide useful information about population trend, some people believing this is possible for most species, others feeling the potential inaccuracies are so great that such surveys might be misleading too often to be of any value. Most people seem to be agreed that counts during the nonbreeding period in the foreseeable future will not provide sufficient reliability to be the only basis for trend estimation, and will, at a minimum, have to be supplemented by the breeding surveys discussed above. Because nonbreeding surveys will be carried out in many areas for other purposes, and because many people feel that they do have considerable potential as trend estimators, we believe that the issues should be explored in detail by identifying potential problems, designing a comprehensive survey to minimize them, and carrying out a careful assessment of reliability of the resulting program. This section discusses ways to implement this approach.

The rationale, and challenge, in using nonbreeding surveys to estimate trends in population size may be explained as follows. Suppose that each year about the same fraction of birds is in the study area during the study period, apart from random year effects, and that the survey provides a good estimate of this number. In this case, trend in the survey result will be a good estimate of trend in population size. On the other hand, suppose that the ratio of the survey result to population size gradually falls from 0.10 to 0.05 during several years. Then the survey result will suggest a 50 percent decline even if the population is actually stable. The key issue in designing and evaluating nonbreeding surveys is thus whether a long-term trend is likely in the ratio of the survey result to population size (the "index ratio"). Low precision of the survey result is also a possible problem, but investigation of this issue (Bart unpub.) shows that large enough samples can probably be obtained that sampling error will be relatively small (e.g., CVs < 0.10). The potential for bias is thus the major problem to be solved in designing the nonbreeding surveys.

We have identified three potential problems – referred to below as frame bias, selection bias, and measurement bias - that would cause a long-term trend in the index ratio, and thus cause bias in the trend estimate. Frame bias is a long-term trend in the proportion of birds in the population that is 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 is in inaccessible areas. 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.

A detailed procedure has been developed to design the temperate, nonbreeding surveys. "Shorebird monitoring regions" were defined by intersecting a States and Provinces map with a Bird Conservation Regions map and eliminating small polygons (*fig. 1*). A separate sampling plan must 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,

(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, and

(4) describes the monitoring plan including maps and detailed descriptions of areas to be surveyed along with survey protocols.

The potential for selection and measurement bias at the site, stratum, and regionwide level is also discussed, and pilot studies needed before the sampling plan can be completed are identified. The procedures for conducting these assessments, and examples of the products produced during the assessment, are available on the PRISM website http://amap.wr.usgs.gov.

Neotropical 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., Buff-breasted Sandpiper [*Tryngites subruficollis*], American Golden-plover [*Pluvialis dominica*], Baird's Sandpiper), 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 and Ross 1989). Aerial surveys of South America (Morrison and Ross 1989), Panama (Morrison et al. 1998), Central America (Morrison et al., in prep), and Mexico (Morrison et al., in prep.) 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. These areas also support austral shorebird migrants, resident shorebirds, and other rare, endemic birds.

Approaches to estimate densities of wintering migrant shorebirds and residents could be adapted from methods developed for accessible, temperate breeding grounds. An initial step would be to identify sites in South America.

Cooperative shorebird projects are already underway in many parts of Latin America and the Caribbean (e.g., Red Knot project, WHSRN 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. We fully realize that monitoring is but one tool that can be used to accomplish the hemispheric conservation of shorebirds. We hope to use these projects and their underlying philosophies as a foundation to build a comprehensive monitoring strategy for shorebirds across the western hemisphere.

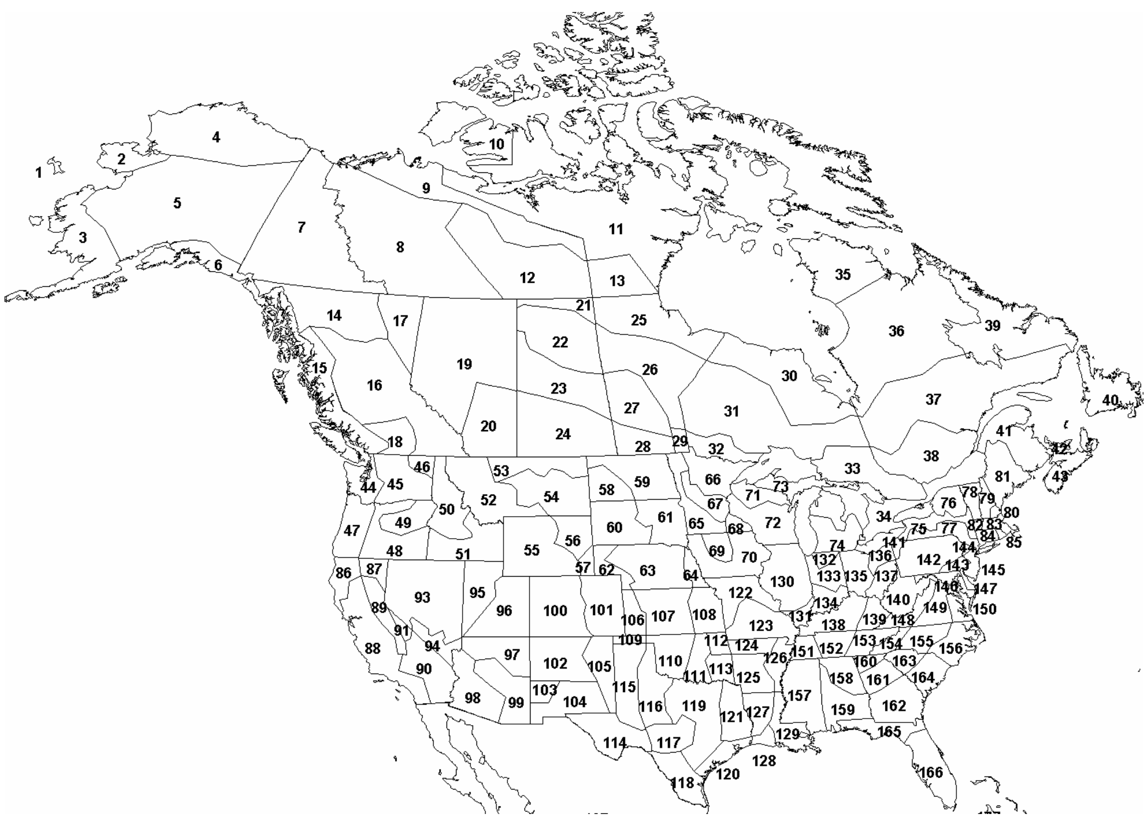

Figure 1— Bird monitoring regions in Canada and the United States.

Many of the theoretical approaches previously outlined in this document are equally applicable to areas south of the United States - Mexico border. Close collaboration among colleagues in North, Central, and South America and the Caribbean is crucial to realistically assess the feasibility of implementing monitoring approaches at sites in Latin America and the Caribbean. Although numerous, effective partnerships currently exist, a wider network of shorebird enthusiasts needs to be encouraged. Conversely, knowledge of programs in other countries needs to be more widely distributed among shorebird workers in the United States.

Assistance to Local Managers

Providing assistance to local managers in meeting their shorebird conservation goals is one of the PRISM goals. Little work has been done on this goal to date because the monitoring program is not yet in place. A few examples, however, are beginning to emerge that illustrate ways in which the monitoring infrastructure can be of use to managers concerned about shorebirds. The South Atlantic Migratory Bird Initiative is coordinating a regionwide program in the southeastern United States to investigate drawdown procedures for shorebirds. The Point Reyes Bird Observatory has hired a shorebird conservation specialist to work with local managers in implementing the Southern Pacific Regional Shorebird Conservation Plan. The Western Shorebird Survey developed an arrangement with the State of Utah to provide analytic assistance for their water bird survey in exchange for assistance in identifying shorebird survey sites and preparing survey protocols. The International Shorebird Survey has a long history of working with local managers on their conservation issues through holding workshops and providing direct technical assistance. Thus, a few cases exist in which people with monitoring and management expertise have joined forces. We hope that many more such collaborative efforts will occur during the next few years; promoting such efforts should be a major goal of the PRISM.

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Literature Cited

Anthony, R. G., M. G. Garrett, and F. B. Isaacs. 1999. **Double-survey estimates of bald eagle populations in Oregon.** Journal of Wildlife Management 63: 794-802.

Bart, J., S. Brown, B. Harrington, R. I. G. Morrison, and S. K. Skagen. In review. **An analysis of shorebird migration monitoring as a method for estimating trend in population size.** Manuscript submitted to the Condor.

Bart, J. and S. L. Earnst. 2002. **Double-sampling to estimate density and population trends in birds.** Auk 119:36-45.

Bart, J. and S. L. Earnst. This volume. **Methods for shorebird surveys in the arctic.**

Bart, J. and C. Francis. In review. **Quantitative Goals for Avian Monitoring Programs.** Manuscript submitted to Conservation Biology.

Bart, J., A. Manning, S. Thomas, and C. Wightman. This volume. **Preparation of regional shorebird monitoring plans.**

Brown, S., C. Hickey, B. Harrington, and R. Gill (editors). 2000. **United States Shorebird Conservation Plan.** Manomet, MA: Manomet Center for Conservation Sciences; 70 p.

Bruggink, J. G. 1998. **American Woodcock harvest bird breeding population status.** U.S. Fish and Wildlife Service Bulletin.

Butcher, G. S., B. G. Peterjohn, and C. J. Ralph. 1993. **Overview of national bird population monitoring programs and databases.** In: D.M. Finch and P.W. Stangel, editors. Status and management of Neotropical migratory birds: Proceedings of the 1992 Partners in Flight National Training Workshop, 21-25 September, Estes Park, Colorado. General Technical Report RM-229. Rocky Mountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture; 192-203.

Cochran, W.G. 1977. **Sampling Techniques.** New York, NY: J. Wiley & Sons.

Donaldson, G., C. Hyslop, R. I. G. Morrison, I. Davidson. In press. **Canadian Shorebird Conservation Plan.** Canadian Wildlife Service Special Publication. Ottawa.

Eberhardt, L. L., and M. A. Simmons. 1987. **Calibrating population indices by double sampling.** Journal of Wildlife Management 51(3): 665-675.

Handel, C. M. and R. E. Gill, Jr. 1992. **Breeding distribution of the black turnstone.** Wilson Bulletin 104: 122-135.

Howe, M. A., P. H. Geissler, and B. A. Harrington. 1989. **Population trends of North American shorebirds based on the International Shorebird Survey.** Biological Conservation 49: 185-199.

Morrison, R. I. G., R. W. Butler, F. S. Delgado, and R. K. Ross. 1998. **Atlas of Nearctic shorebirds and other waterbirds on the coast of Panama.** Canadian Wildlife Service Special Publication. Ottawa, Ontario; 112 p.

Morrison, R. I. G. and R. K. Ross. 1989. **Atlas of Nearctic shorebirds on the coast of South America,** Volume 1, 2. Canadian Wildlife Service Special Publication. Ottawa, Ontario; 325 p.

Nichols, J. D., J. E. Hines, J. R. Sauer, F. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. **A double-observer approach for estimating detection probability and abundance from point counts.** Auk 117: 393-408.

Plissner, J. H. and S. M. Haig. 1997. 1996 **International piping Plover census.** Report to U.S. Geological Survey, Biological Resources Division, Forest and Rangeland Ecosystem Science Center, Corvallis, OR.

Prenzlow, D. M., and J. R. Lovvorn. 1996. **Evaluation of visibility correction factors for waterfowl surveys in Wyoming.** Journal of Wildlife Management 60(2): 286-297.

Sauer, J. R., J. E. Hines, and J. Fallon. 2001. **The North American Breeding Bird Survey, results and analysis 1966-2001.** Version 2001.2, Laurel, MD: Patuxent Wildlife Research Center, Geologic Survey, U.S. Department of the Interior.

Thompson, S. K. 1992. **Sampling.** New York, NY: J. Wiley & Sons.