Monitoring Goals and Programs of the U.S. Fish and Wildlife Service

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Abstract — The United States Fish and Wildlife Service coordinates several surveys that collect information on the population status of migratory birds in North America. The North American Breeding Bird Survey is the primary source of population information on nongame birds during the breeding season, and waterfowl surveys are conducted during breeding and wintering seasons. The surveys are international in scope, based upon research into sampling methods for birds, and used in management of migratory birds. The Service also maintains the Bird Banding Laboratory in cooperation with the Canada Wildlife Service, and supports demographic monitoring of bird populations.

INTRODUCTION

The United States Fish and Wildlife Service (Service) has a legal mandate under the Fish and Wildlife Conservation Act of 1980 to monitor population status of migratory birds. To fulfill this mandate, the Service (and its predecessor agencies such as the Bureau of Biological Survey) has developed survey methods and statistically designed surveys that provide information regarding population sizes, population trends, productivity rates, and death rates of migratory bird species. Although the Service's goal is the development of adequate survey programs for all migratory bird species, and many species are now monitored with at least population surveys, certain taxa are poorly monitored due to life-history traits or geographic ranges that make them undetectable by existing survey procedures.

The Service has several monitoring programs, each with different goals and products. For example, many surveys collect data on population size or trends in populations, while others collect data on rates of survival or reproduction. The distinction between game and nongame species has important ramifications for monitoring because game species tend to have high band recovery rates that allow for modelling of survival rates from banding and recovery data. Research into population estimation techniques has played a major role in development of surveys. Finally, most Service surveys are international in scale. In this paper, I briefly outline: (1) some fundamental principles of the design of monitoring programs; (2) variables that are monitored; and (3) underlying rationales, procedures, and uses of Service monitoring programs, with special attention to neotropical migrant bird species. Views expressed in this paper reflect my opinions about monitoring and these surveys, and should not be construed as Service policy.

There are many publications that examine Service monitoring programs. The most comprehensive recent work is Martin et al. (1979), which reviews all programs in progress up to that date. Annual reports are produced for most surveys (e.g., Droege and Sauer 1990), and periodic reviews are published in the peer-reviewed literature (e.g., Robbins et al. 1986, Sauer and Bortner 1990). Recently, the Office of Migratory Bird Management has produced a draft monitoring strategy for the lower 48 states (Droege pers. commun.).

WHAT CONSTITUTES A VALID SURVEY?

Existing bird surveys differ greatly in quality of information, varying from anecdotal, which could be defined as nonsystematic collection of data of varying quality, to statistically-designed surveys. In many cases, the population to be surveyed is poorly defined, and may change from year to year.

To have credibility as a sample survey, the population to be sampled must be divided into nonoverlapping units. All units taken together constitute what statisticians call a sampling frame, from which a subset of units is selected as a sample and all birds in each sample unit are counted. If the sampling frame is

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not complete in that some part of the population does not appear in the units and cannot be sampled, or if some units have a higher probability of inclusion than others, then estimates of population attributes from the sample may be biased (Cochran 1977). This form of bias may occur in surveys constrained to roads that do not sample forest interiors, wetlands, and other places where there are few roads.

Wildlife surveys usually have the additional constraint that counts within sampling units are incomplete, and a portion of the animals are missed during a survey. Much Service research has involved development of methods for estimation of the proportion of animals missed. Bias in estimation of population parameters exists due to incomplete nature of counts, as the average counts are not accurate representations of actual populations.

Surveys should be designed to estimate a population parameter with a specified level of precision. For example, for the North American Breeding Bird Survey (BBS), a reasonable goal would be estimation of trends with sufficient precision that a decline of 50 % (trend of -2.74 %/year) over a 25-year period would be detected with probability 90%. In any survey, bias in the parameter estimate must be considered, and sources of bias must be carefully examined. The particular problem of incomplete counts is often disregarded in survey design and analysis, but it can contribute significant bias and imprecision to results (Barker and Sauer 1992). Of course, as a survey progresses, evaluation of precision will provide information of whether the survey is meeting its goals.

Should We Monitor Survival and Productivity in Addition to Population Size of Bird Populations?

Temple and Weins (1989) suggested it is better to monitor survival and productivity rates than population size because the rates provide more insight into mechanisms of population change. However, they point out that population sizes are generally easier to monitor. This distinction between monitoring the vital rates and monitoring population size is extremely important, because surveys for population size of neotropical migrant birds tend to be extensive yet of low intensity. Surveys for survival and productivity tend to require much effort and are more local, but also provide better information that can be used in modelling populations. Generally, the Service has attempted to monitor both vital rates and sizes of bird populations, but success of monitoring differs greatly among bird species.

Game and Nongame Species Monitoring

Because Hunter Harvest Has Historically been a factor that influences bird populations, and the Service has legal authority to regulate hunter harvest, there has long been impetus for extensive monitoring of the population status of game species. Ironically, the harvest provides several opportunities for monitoring using methods not available for nongame species. The tradition of hunters returning bands from shot birds provides significant band-recovery information that can be used to estimate survival and recovery rates (Brownie et al. 1985) and conduct distributional analyses based on geographic patterns in band recoveries (Pendleton and Sauer 1992). Nongame birds have such low recovery rates of bands that recovery information is effectively useless for both survival rate estimation and distributional analyses (S. Droege et al., Unpublished Poster Session, Neotropical Migrant Bird Workshop, Estes Park, Colorado, 21-24 Sept. 1992).

Surveys That Provide Information on Population Sizes and Trends

In this section, I review some of the major surveys that provide population size information. Counting birds during breeding, wintering, and migration has been the focus of Service work since the earliest monitoring projects. The Bureau of Biological Survey, for example, collected observations on bird migration from lighthouse keepers and additional observers located throughout the U.S. starting in the 19th century. From this anecdotal start, other survey methods have been developed with both sampling frames and visibility adjustments to account for incomplete counts. I provide a brief review of the more extensive surveys, omitting some of lesser interest (such as goose surveys) in the context of Neotropical migrant birds.

It is critical to note that some surveys (such as the Spring Breeding-ground Survey) sponsored by the Service directly estimate population size, and are designed to provide precise and unbiased estimates of yearly size. Population changes are modelled from these yearly population sizes. Other surveys (such as the roadside surveys) are not used to estimate yearly population sizes. These surveys are known to yield biased estimators of population size because of their sampling units (a roadside route) and their unadjusted count data. For these surveys, population trends are often the quantity estimated, and yearly indices of abundance are a secondary feature.

GAME BIRD SURVEYS

Aerial Surveys

Spring Breeding-Ground Survey

Each year, the Service coordinates a survey of waterfowl in the north-central U.S., Western Canada, and Alaska. In the survey, pilots and observers in fixed-wing aircraft fly along pre-defined transects and count waterfowl. Selected portions of transects are also intensively searched from the ground, and the ratio of counts from ground to air counts is used to adjust total air counts for visibility differences due to the aerial survey. Because sexes differ greatly in their visibility, for many species age and sex of birds are noted during counts and a derived index to number of indicated pairs is computed and used as an index to abundance. This survey provides a visibility-adjusted index to population size (i.e., an estimate of population size), and results from the survey are used as a primary source of information on yearly breeding populations for setting harvest regulations. The survey has existed in its present form since 1955, and presently provides population estimates and standard errors for 10 species of ducks, including such Neotropical migrants as teal (*Anas* spp.) and Northern Pintails (*A. acuta*). In conjunction with the breeding-ground survey, habitat and pond data are collected to provide insight into causes of changes in these bird populations.

Mid-Winter Inventories

Wintering counts of waterfowl are conducted in cooperation with state wildlife agencies. These counts take many forms, including surveys from fixed-wing aircraft, helicopters, boats, and automobiles. They are all set up as roving surveys, where the survey crew is given an area to survey. As expected within this sampling framework, proportions of birds actually counted can differ greatly among areas and over time. However, this survey has been used to document changes in populations of American Black Ducks (*A. rubripes*).

Roadside surveys

Mourning Dove Call-Count Survey

Begun in 1966, the Call-count Survey is composed of over 1000 permanently-located roadside routes in the continental U.S., with 20 listening stations (stops) located about 1.6 km (1.0 mi) apart. Each May, the route is surveyed by a single observer who records all Mourning Doves (*Zenaida macroura*) heard at 3 minute counts conducted at each stop. The sum of the number of birds heard over all stops used as the yearly index of abundance on the route. Trends in dove populations are estimated each year in time for the Early Season Regulations Meeting in late June (D. D. Dolton, Office of Migratory Bird Management, U. S. Fish and Wildlife Service, Pers. commun.).

American Woodcock Singing-Ground Survey

The Singing-ground Survey is also a roadside survey, but is run at dusk each spring. This survey ranges over the northeastern and northcentral U.S. and southern Canada. Approximately 1500 survey routes are along roadsides, but each 5.79 km-long (3.6 mi) route has only 10 stops. the total number of American woodcock (*Scolopax major*) observed at all stops is used as the index to abundance in this survey, which has been run since 1968. Sauer and Bortner (1990) provide a recent analysis of Singing-ground Survey data.

NONGAME BIRD SURVEYS

North American Breeding Bird Survey

The BBS has been described in several other papers in this volume, and Robbins et al. (1986) provided an extensive summary of the methods of the survey. It is a roadside route survey in the U.S. and southern Canada, and now has over 3000 survey routes. Begun in the eastern U.S. in 1966, it is our primary source of population information for neotropical migrants (Robbins et al. 1989). Using the route-regression method (Geissler and Sauer 1990), I determined which species met the criterion of estimates with sufficient precision to detect a decline of 50 % over a 25 year period with probability 0.9. Of 137 species of neotropical migrant birds, only 13 species did not meet the criteria (Table 1). Although 124 species were estimated with sufficient precision, many of the species were either seen at low abundances on BBS routes or were seen on very few routes (Table 2). Caution is necessary in interpreting trends in species with low abundances, small sample sizes, or with ranges that extend beyond the range of the survey. Due to taxonomic changes, trends were not estimated for Alder Flycatcher (Empidonax alnorum), Willow Flycatcher (E. traillii), and Cordilleran Flycatcher (E. difficilis), and Kirtland's Warblers (Dendroica kirtlandii) did not appear in the survey due to their limited range.

Table 1. — Neotropical migrant bird species not monitored with sufficient intensity to detect a 50 % decline in the population over a 25 year period with probability 0.9. Species that were detected at low relative abundances (superscript a) or at low samples sizes (degrees of freedom < 14, superscript b) are also noted. See the AOU checklist (American Ornithologists' Union 1983) for scientific names of bird species.

BLACK SWIFT
WHITE-THROATED SWIFT[a]
COSTA'S HUMMINGBIRD[a]
GRAY FLYCATCHER[a]
GRAY-CHEEKED THRUSH[a]
BLACK-CAPPED VIREO[a,b]
GRAY VIREO[a]
TENNESSEE WARBLER
TOWNSEND'S WARBLER
GOLDEN-CHEEKED WARBLER[a,b]
GRACE'S WARBLER
BAY-BREASTED WARBLER
BLACKPOLL WARBLER

Table 2. — Neotropical migrant bird species that were monitored with sufficient intensity to detect a 50 % decline in the population over a 25 year period with probability 0.9. Note that some species were detected at low relative abundances (superscript a) or at low samples sizes (degrees of freedom < 14, superscript b), suggesting that caution be used in interpreting trend results. See the AOU checklist (American Ornithologists' Union 1983) for scientific names of bird species.

AM. SWALLOW-TAILED KITE[a]
MISSISSIPPI KITE[a]
BROAD-WINGED HAWK[a]
SWAINSON'S HAWK[a]
MERLIN[a]
PEREGRINE FALCON[a,b]
MOUNTAIN PLOVER[a]
UPLAND SANDPIPER
LONG-BILLED CURLEW
BAND-TAILED PIGEON
BLACK-BILLED CUCKOO[a]
YELLOW-BILLED CUCKOO
FLAMMULATED OWL[a,b]
BURROWING OWL[a]
LESSER NIGHTHAWK
COMMON NIGHTHAWK
CHUCK-WILL'S-WIDOW
WHIP-POOR-WILL[a]
CHIMNEY SWIFT
VAUX'S SWIFT[a]
RUBY-THR. HUMMINGBIRD[a]
BLACK-CHIN. HUMMINGBIRD[a]
CALLIOPE HUMMINGBIRD[a]
BROAD-TAIL. HUMMINGBIRD
RUFOUS HUMMINGBIRD
ALLEN'S HUMMINGBIRD[a]
OLIVE-SIDED FLYCATCHER
WESTERN WOOD-PEWEE
EASTERN WOOD-PEWEE
YELLOW-BELL. FLYCATCHER
ACADIAN FLYCATCHER
LEAST FLYCATCHER
HAMMOND'S FLYCATCHER
DUSKY FLYCATCHER
VERMILION FLYCATCHER[a]
ASH-THROATED FLYCATCHER
GRT. CRESTED FLYCATCHER
CASSIN'S KINGBIRD
WESTERN KINGBIRD
EASTERN KINGBIRD
SCISSOR-TAIL FLYCATCHER
PURPLE MARTIN
VIOLET-GREEN SWALLOW
N. ROUGH-WINGED SWALLOW
BANK SWALLOW
CLIFF SWALLOW
BARN SWALLOW
HOUSE WREN
BLUE-GRAY GNATCATCHER
VEERY
SWAINSON'S THRUSH
WOOD THRUSH
GRAY CATBIRD
PHAINOPEPLA
WHITE-EYED VIREO
BELL'S VIREO[a]
SOLITARY VIREO
YELLOW-THROATED VIREO[a]
WARBLING VIREO
PHILADELPHIA VIREO[a]
RED-EYED VIREO
BLUE-WINGED WARBLER[a]
GOLDEN-WINGED WARBLER[a]
ORANGE-CROWNED WARBLER
NASHVILLE WARBLER
VIRGINIA'S WARBLER
NORTHERN PARULA
YELLOW WARBLER
CHESTNUT-SIDED WARBLER
MAGNOLIA WARBLER
CAPE MAY WARBLER
BLACK-THR. BLUE WARBLER[a]
BLACK-THR. GRAY WARBLER
HERMIT WARBLER
BLACK-TH. GREEN WARBLER
BLACKBURNIAN WARBLER
YELLOW-THROATED WARBLER[a]
PRAIRIE WARBLER
PALM WARBLER[a]
CERULEAN WARBLER[a]
BLACK-&-WHITE WARBLER
AMERICAN REDSTART
PROTHONOTARY WARBLER
WORM-EATING WARBLER[a]
SWAINSON'S WARBLER[a]
OVENBIRD
NORTHERN WATERTHRUSH
LOUISIANA WATERTHRUSH[a]
KENTUCKY WARBLER
CONNECTICUT WARBLER[a]
MOURNING WARBLER
MACGILLIVRAY'S WARBLER
COMMON YELLOWTHROAT
HOODED WARBLER
WILSON'S WARBLER
CANADA WARBLER
YELLOW-BREASTED CHAT
HEPATIC TANAGER[a]
SUMMER TANAGER
SCARLET TANAGER
WESTERN TANAGER
ROSE-BREASTED GROSBEAK
BLACK-HEADED GROSBEAK
BLUE GROSBEAK
LAZULI BUNTING
INDIGO BUNTING
PAINTED BUNTING
DICKCISSEL
GREEN-TAILED TOWHEE
CHIPPING SPARROW
CLAY-COLORED SPARROW
BREWER'S SPARROW
LARK SPARROW
LARK BUNTING
BAIRD'S SPARROW
GRASSHOPPER SPARROW
LINCOLN'S SPARROW
BOBOLINK
YELLOW-HEAD. BLACKBIRD
ORCHARD ORIOLE
HOODED ORIOLE[a]
BULLOCK'S ORIOLE
BALTIMORE ORIOLE
SCOTT'S ORIOLE

Other Surveys

The Service has worked with many other surveys to evaluate their efficiency in estimating population trends of neotropical migrants. Christmas Bird Count and Breeding Bird Census data are presently maintained by the Office of Migratory Bird Management, and preliminary research has been conducted into the comparative efficiency of these surveys. The Service has also collaborated in studies involving International Shorebird Surveys, Hawk Migration Counts, songbird migration counts, colonial bird nest registers, and other bird surveys (See Sauer and Droege 1990 for a description of these surveys). All of these surveys tend to have either poorly defined target populations or poorly designed sampling frames.

PRIMARY DEMOGRAPHIC CHARACTERISTICS

Productivity Studies

July Waterfowl Productivity Studies

Productivity of waterfowl is assessed in July by an aerial survey to estimate brood production. Although covering generally the same area, this survey is slightly less extensive than the breeding-ground survey, and brood counts are not adjusted for visibility.

BBirds Project

A program to assess regional productivity of songbirds has been initiated by the Cooperative Research Centers (Martin, T., U. S. Fish and Wildlife Service, Pers. Comun.). In this project, study sites are established in forested areas, and nest success is monitored by Mayfield methods (Bart and Robson 1982). The program is habitat-specific, and therefore not a valid sample of overall regional nest success, but it will allow comparisons within sampled forested habitats.

Banding Studies

The North American Bird Banding Laboratory (BBL), located in Laurel, MD, houses banding and recovery records for migratory birds that breed in North America. For reasons noted below, the role of the BBL in neotropical migratory bird research and management is quite different from its role in game bird management. Banding studies are of use only when the essential feature of banding, that birds can be uniquely identified when recaptured or found dead in the future, can be used to estimate demographic features of the population. Migration banding studies do not contain this essential feature, as birds banded in migration are almost never recovered or recaptured after they leave the banding site. Hence, banding is not an essential part of migration "banding" studies, and these programs use number of birds banded as an index to yearly population sizes.

Game-Bird Banding

Banding is an important tool for management of migratory game birds. Recovery data provide information that can be used to: (1) estimate survival rates in band-recovery models (Brownie et al. 1985); (2) estimate recovery rates to index harvest rates; (3) estimate harvest rates (if reward bands are used); and (4) address distributional questions.

Non-Game Banding

Banding of nongame birds is apparently not of great use in distributional or band-recovery survival analyses due to the extremely low numbers of returns (S. Droege et al., Unpublished Poster Session, Neotropical Migrant Bird Workshop, Estes Park, Colorado, 21-24 Sept. 1992). Instead, banding is most efficiently used when birds can be recaptured at the same site and mark-recapture methods can be used to estimate survival (e.g., Pollock et al. 1990, Lebreton et al. 1992). Local banding studies using mark-recapture methods have proven to be the only appropriate way to estimate survival rates for songbirds. The MAPS program co-sponsored by the Service (DeSante 1992) uses a network of mark-recapture studies in a pilot program to monitor productivity and survival of songbirds.

THEMES IN SERVICE MONITORING

There are several themes that I note in Service monitoring programs of particular interest to neotropical migrant monitoring:

International Scope

Most Service programs are international in scope. The Canadian Wildlife Service collaborates with the Service on waterfowl surveys, breeding bird surveys and banding projects, and cooperative migratory bird studies are also conducted with Mexico. This close cooperation is essential for reasonable management of migratory species, and the North American Waterfowl Management Plan represents a major international effort to conserve waterfowl resources. Partners-in-flight will also advance international cooperation for migratory bird conservation.

Several active international FWS projects will benefit monitoring and research into populations of Neotropical migrant birds. A pilot study to assess the feasibility of extending the BBS south into northern Mexico is underway, and will begin fieldwork in 1993 (B. G. Peterjohn, Office of Migratory Bird Management, Pers. commun.). Also, FWS research has conducted cooperative banding studies in Mexico, Caribbean countries, Belize, and other Central American countries. All of these efforts emphasize the international cooperation necessary for Neotropical migrant bird conservation.

Used In Management

Service monitoring programs are used in harvest management for game bird species. Although game management procedures may not seem particularly relevant for neotropical migrant landbirds, needs for reliable survey techniques for use in the sometimes adversarial forum of harvest regulations have driven much research and development of new survey methods. For example, the American Woodcock Singing-ground Survey and the Mourning Dove Call-count Survey are roadside surveys similar in design to the North American Breeding Bird Survey used in the yearly regulations process. Because of potential for controversy that exists when survey results are used to affect political decisions regarding land-use and other practices, nongame bird surveys should also be carefully reviewed for statistical rigor.

Research-Based Methods

Statistically valid, unbiased estimation is prerequisite for population management. Because of this need for reliable information in management, the Service has traditionally supported quantitative research into survey design and analysis through Research Centers and Cooperative Wildlife Research Units. Most surveys that presently exist are conducted and analyzed using methods developed at least in part by Service biologists and statisticians, and the Service sponsors workshops on topics of interest to survey biologists (e.g., Sauer and Droege 1990).

CONCLUSIONS

The BBS provides estimates of population changes for many neotropical migrants, but clearly there are groups of species with life history characteristics or ranges that prevent the BBS from adequately covering them. For example, nocturnal birds are generally only noted on the earliest stops on BBS routes, and usually have extremely low average counts and small sample sizes. Also, species that nest to the north of the BBS survey routes tend to be poorly sampled. In 1990, we assessed the efficiency of the BBS in sampling regional populations of all North American bird species (J. R. Sauer and S. Droege, Geographic and temporal aspects of sampling in the North American Breeding Bird Survey, unpubl. manuscript), and this document is available to interested readers. Much of this material will be published in the long-term summary of BBS data (B. G. Peterjohn, C. S. Robbins, and J. R. Sauer, In prep.). For more information on the sample efficiency of Service surveys, I refer readers to the draft monitoring strategy for the lower 48 states (S. Droege, Office of Migratory Bird Management, Pers. commun.).

Service monitoring programs have benefitted from extensive interaction between field biologists motivated to study birds and statisticians interested in special problems of biological sampling. Information from Service monitoring programs are used in management, and are therefore subjected to public and professional review. Because of the use in management, survey goals are well defined, statistically defensible (or at least deficiencies are well known), and produced on schedules that maximize potential use of information. As products of a public agency, survey results are in the public domain and available to researchers and managers regardless of institutional affiliation.

Attention to methodological details has always characterized the Service approach to survey design and analysis. In Partners in Flight, there are many fledgling monitoring programs. It appears that many programs are designed to allow agencies or specific parks to participate in monitoring. The experience of the large-scale monitoring programs of the Service indicate that unless these programs are designed with specific goals and products in mind they are unlikely to succeed. A mandate to count birds without specific uses for results is doomed to produce useless results of unknown validity. To avoid wasted effort on ineffective monitoring programs I suggest that anyone designing such a program first specify the parameter of interest, with a minimal acceptable level of precision. Then, a sampling unit and frame should be carefully selected to avoid bias in the estimates of the parameter. Finally, survey results should be produced through periodic analyses and reports on the program, and the results presented in a form that is of use to managers.

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