

Recommended Methods for Monitoring Change in Landbird Populations by Counting and Capturing Migrants

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ABSTRACT

Counts and banding captures of spring or fall migrants can generate useful information on the status and trends of the source populations. To do so, the counts and captures must be taken and recorded in a standardized and consistent manner. We present recommendations for field methods for counting and capturing migrants at intensively operated sites, such as bird observatories and banding stations with daily or near daily coverage. Each site should generate a daily "migration count" for each species. One or more methods are acceptable, including a visible migration count, a census or area search, banding captures, and a daily estimated total. All methods should be standardized as far as possible and a written protocol for each site should define the count area, times and locations of count and capture procedures, and other site-specific features designed to maintain consistency from day-to-day and year-to-year. The protocol should also include standards for numbers and skills of personnel and for habitat management. Several factors should be considered when selecting new migration monitoring sites, including specific questions to be addressed, presence of target and/or high priority species, turnover rate of migrants, habitat stability, property ownership and tenure, and accessibility. Sites should be operated for at least 10 years with coverage of 75% or more of the migration period of target species.

INTRODUCTION AND OBJECTIVES

Any species that migrates can be counted during passage or at a stopover site along the migratory path. If the entire population breeding or wintering to the north or south of the site migrates, counts of migrants have the potential to generate useful information on the status of those populations.

Accurate knowledge of population status and trends is fundamental to species conservation. The premier scheme for determining population change in North American birds is the Breeding Bird Survey (BBS; Robbins et al. 1986, Sauer et al. 2004). However, the BBS roadside survey is unsatisfactory for monitoring populations of some species that breed in low densities or are difficult to detect. Also, geographic coverage by the BBS does not fully encompass the breeding ranges of many species, particularly those breeding in northern Canada and Alaska.

A recent analysis, undertaken for the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004), listed 244 species judged to be monitored poorly on a continental scale by BBS, either because the species is too rarely encountered, precision of trend estimation is low, or because BBS covers < 2/3 of the continental breeding range. These are high priority species for monitoring by other methods; many are migrants and potentially amenable to monitoring

during migration. The authors of the plan recommended improved migration monitoring capability in North America, particularly for those migratory species poorly monitored by BBS (Rich et al. 2004). The first step for obtaining reliable population trends from migration data is to ensure that field data are collected in accordance with acceptable standards. Our primary objective in this paper is to provide recommendations for collecting such data.

The potential value of migration monitoring as a means of assessing population changes in migrant landbirds was evaluated in 1993 at an international workshop organized by the Canadian Wildlife Service and the U. S. Fish and Wildlife Service (now the Biological Resources Division of the U.S. Geological Survey). The workshop recommended establishment of a continental migration monitoring program and appointed a technical committee to establish standards and guidelines for station operation (Blancher et al. 1994). Draft recommendations were circulated widely for comment and then were posted on the Internet (Hussell and Ralph 1998). To make this document more widely available, we have updated and revised this version of those recommendations and brought them into conformity with the suggestions contained in Ralph and Dunn (2004).

In the interests of brevity, we have omitted some of the detailed background and rationale for our recommendations. That additional material is in the original document (Hussell and Ralph 1998) which also contains a preliminary list of northern-breeding species judged to be of high priority for migration monitoring. For a more complete and updated list of species priorities, see the North American Landbird Conservation Plan (Rich et al. 2004).

We describe options and recommendations for field methods for documenting numbers of small landbirds during migration, for the purpose of monitoring changes in population size. The recommendations are designed for intensively operated sites, such as bird observatories and bird-banding capture stations, and they apply equally to spring and fall migrations. The target audience is any individual or group who wishes to collect high quality data to estimate trends in migrating

bird populations in a scientifically rigorous manner. These data should be suitable for analyses both of long-term trends in populations and for comparisons among sites throughout North America.

We note that some of the recommendations below would be somewhat different for study objectives other than population trend estimation. Such objectives might include suitability of stopover habitat, or the composition and productivity of local, resident birds or short-distance migrants.

The basic approach to documenting population trends of birds sampled during migration is to generate a daily "Migration Count," using one or more counting techniques as described below (Dunn and Hussell 1995). Migration monitoring stations can also gather data relevant to a wide variety of other important population parameters on migrating birds. Many of these data, such as condition, timing of movements, age and sex ratios, are derived from capture of individual birds. They may indicate the causes of changes in migrant population size and composition or generate hypotheses concerning specific causes of changes, including declines.

Our recommendations are based on methods that have been shown in several studies to generate population trends that correspond well with trends from the BBS (Hussell et al. 1992, Pyle et al. 1994, Dunn et al. 1997, Francis and Hussell 1998, Ballard et al. 2003). Other approaches to data collection and analysis of migration counts may also prove to be valid but have yet to be evaluated.

A key recommendation is that each station develops its own field protocol of standard operating procedures to be used in the same manner from day to day and from year to year. Our recommendations do not require that every station use identical methods. The guidelines presented here are intended to establish the methodological bounds within which data useful for monitoring numbers of migrating birds can be collected. Within these bounds, techniques should be modified to meet constraints imposed by local geographical conditions and the availability of skilled personnel. We also offer suggestions for choosing new

sites and provide guidance on which species are of highest priority for migration monitoring.

Many of our recommendations are designed to maximize the usefulness of migration counts for estimating population changes. Standardization of counting methods can only contribute to removing extraneous variation derived from variable observer effort and sampling procedures. Migration counts will still be subject to uncontrollable variation from factors such as weather, observer differences, unavoidable changes in the level of effort, and habitat change. Some of these problems can be addressed by the use of appropriate analytical procedures. We do not directly address these statistical issues here, although we do allude to them in support of certain recommendations. Those interested in details should see Hussell (1981), Hussell et al. (1992), Dunn and Hussell (1995), Dunn et al. (1997), Francis and Hussell (1998), and Dunn et al. (2004a,b).

THE MIGRATION COUNT

A "migration count" is any tally or count of birds on spring or fall passage (Dunn and Hussell 1995). This definition could include birds counted at a stopover site, observed flying past a fixed point in diurnal migration, captured in nets or traps, seen on radar screens, or whose calls are recorded in nocturnal migration. Here we are concerned primarily with monitoring small landbirds, particularly nocturnal migrants, by counting birds observed or captured at stopover sites immediately following a migratory flight.

Depending on the situation, a migration count may be derived exclusively from observations (as is the case with most hawk migration counts), exclusively from standardized netting of birds, or from a combination of observations and captures. Incidental observations (unstandardized or incompletely standardized) can be a useful component of a daily "estimated total" (ET). Therefore, incidental observations are discussed as an option below, although we do not recommend that they be used alone. Regardless of the method, the migration count can never be a complete tally of every bird present at or passing over a site.

Instead, observers record a sample of the population. Standardization of methods helps ensure that the proportion of the migrating population that is counted remains similar from day to day and year to year. The more standardized the method, the more consistent and useful the counts will be.

The ideal that we should strive for is a separate tally each day (or for each count within a day) of three groups: (1) newly arrived migrants, (2) resident individuals, and (3) stopovers that arrived on earlier days. Inclusion of groups (2) and (3) in successive counts that are intended to represent group (1) may violate assumptions of some analyses. Inaccurate assignment of some individuals is inevitable in most counting methods, although banding contributes to separation of new arrivals from previously captured individuals.

Methods to be Considered

There are several options for producing a useful migration count of small landbirds: banding captures by net or trap; visible migration count; area search or route census counts; incidental observations; and daily estimated totals. A sampling method or combination of methods should be selected that is judged to be effective at the particular monitoring site. More than one type of data can be collected simultaneously, which can be useful in assessing the contribution of each method to results (Dunn et al. 2004b). Combining capture with observational methods can improve the quality of trends in some cases, as well as increase the number of species that can be analyzed.

Pros and cons of each method of sampling migrants should be considered carefully before it is adopted as part of a standard field protocol. We provided a detailed list of potential advantages and disadvantages of each method in Hussell and Ralph (1998). We recommend that persons contemplating design of a migration monitoring program consider those comments.

Visible migration counts - A count of migrants can be conducted at sites where an important feature of migration is diurnal movement of birds (including diurnal movement of primarily nocturnal

migrants, and/or movements of strictly diurnal migrants, such as swallows). The count is usually taken at a fixed point and consists of a tally of those individuals that can be identified as they move through or over the site. This method is used widely for recording migrations of hawks in North America (e.g. Fuller and Titus 1990, Bildstein 1998), as well as waterbirds, and has also been used for recording diurnal flights of landbirds in Europe and the Americas (Eckert 1990, Ralph et al. 2005). A standardized visible migration count may be adopted in addition, or as an alternative, to a census, and as a component of an estimated total (see below). If the count includes individuals that may remain in, or return to, the count area from day to day, then a procedure for estimating such individuals should be adopted.

Area search or route census counts - A census is an attempt to identify and count all of the birds in a specified area within a specific time period (Ralph 1981). For monitoring migrants, it should be conducted at the same time each day, usually within the first 2-4 hours after sunrise. It may involve an "area search" of the entire study site (see 'Count Area,' below), or of selected plots within the area (Ralph et al. 1993:35). A survey along a pre-determined route within the entire study area can also be used as a census. The census route or search area should be of a size that can be covered in about one hour at a slow walking pace (e.g., a 1-2 km route). A census of migrants may be most effective in relatively open sites, where the vegetation is not too dense for birds to be seen easily. For population monitoring, a census can be used independently or as a component of an estimated total. If it is to be used independently, a procedure for estimating stopovers and residents should be included if possible, and the census should perhaps cover a larger area and last correspondingly longer.

Banding captures - Captures of birds during migration have often been used alone as a count method for monitoring changes in population size (Berthold and Schlenker 1975, Berthold et al. 1986, Hagan et al. 1992, Dunn et al. 1997, Lloyd-Evans and Atwood 2004). Banding captures also have the potential to monitor changes in age composition and other demographic factors (Dunn et al. 2004a, Hussell 2004). Most standardized capture

procedures involve only the use of mist nets. However, Heligoland or other traps (including baited traps) could be used for the same purposes. The count of newly arrived birds should be the capture rate (e.g., birds/net-hour) of newly captured individuals. Standardized capture can also be a component of a daily estimated total. Standards for netting are detailed in Ralph et al. (2004a), and are reviewed here only briefly. Net and trap sites should be identified and marked clearly and set in exactly the same positions each year. The array of nets and traps should allow operators to visit all within 10-15 minutes when no birds are present (North American Banding Council 2001a, b). The number and types of nets and traps should remain constant from hour to hour and year to year, as these variables can affect capture totals (Pardieck and Waide 1992). We suggest that bait not be used with a standardized Heligoland trap or mist-netting program, because it is difficult to use consistently (e.g., in consistent quantity), and may influence stopover duration of migrants. Water drip traps are easier to standardize, but still must be used consistently. Unavoidable changes in position, number, or type of nets or traps (e.g., dimensions, mesh size) should be documented. The nets and traps should be operated during the same number of hours during the same standard time period each day. For monitoring nocturnal migrants, an early morning start at the same time relative to sunrise is preferred. Nonetheless, even during the standard period, the trapping or netting operation should be stopped if conditions arise that endanger the safety of birds. Opening and closing times of each net and trap should always be recorded. Partial closure and opening of the array of nets and traps should be avoided whenever possible. Attention should be given to managing the vegetation in the vicinity of net or trap sites to mitigate potential long-term changes in the habitat (e.g., Berthold and Schlenker 1975, Berthold et al. 1986).

While standardization of effort is very important, at some sites, such as certain exposed coastal locations, it may be difficult or impossible to maintain an adequately standardized trapping or netting procedure due to frequent adverse weather or wide fluctuations in bird numbers (requiring frequent closure of some or all nets). At some sites, uncontrollable habitat changes may require re-

location of nets. In either circumstance, we recommend banding capture not be used as the only, independent count method, but it can still be used as a component of a daily estimated total (Dunn et al. 2004b) and to determine age and sex composition of the population.

As discussed in Ralph et al. (2004a), the minimum data taken at a capture station are: species, band number, age and sex of the birds, and a measure of the capture effort expended (e.g., net hours). Recording of information on how birds were aged and sexed, wing chord, body mass and/or fat condition, and molt condition is recommended highly but is not required for population monitoring purposes. It is essential that knowledge and experience of principal banders be at a very high level to ensure accuracy in identification, appropriate use of plumage criteria for age and sex, and, especially, for use of skull ossification for ageing. We suggest that a permanent and fully equipped banding laboratory or shelter be located conveniently within the trapping/netting area of all major stations to enable banders to process birds accurately and efficiently.

Incidental observations - Recording incidental observations of birds seen or heard by observers or banders in the course of their work is important in determining the presence or absence of rare and unusual species not normally observed, not captured by nets or traps, or missed during regular censuses or visible migration counts. However, this is inherently an unstandardized method, and we do not recommend it as a migration count technique, except when used in combination with other methods. Nevertheless, standardization can be improved if consistent procedures or rules are adopted that result in a similar amount of effort being devoted to incidental observation each day, and we recommend that this be done as much as possible. Incidental observations can be an important component of the daily estimated total discussed below, especially if data are collected in a reasonably consistent way from day to day.

Daily estimated totals - The daily ET approach to deriving a daily count has been used at many European and some North American observatories and has been validated as a population monitoring method with data from Long Point, Ontario (Hussell

1981, Hussell et al. 1992, Francis and Hussell 1998), and Southeast Farallon Island, California (Pyle et al. 1994).

The ET method combines data from at least two of the four methods described above. Regardless of the components used as input, the objective is to integrate all available information to estimate the daily numbers of each species in, or passing through, a defined count area during the count period. Because the procedure may be unfamiliar to many readers (and can involve several variations), we include some additional details in Appendix 1. A procedure should be included for estimating the numbers of stopovers and residents (see below).

ETs are likely to be most useful for small areas with relatively open habitat, where personnel housed on-site are making more or less continuous observations. They may add little to netting stations in densely vegetated sites where few birds are visible. Nevertheless, when data-collection procedures that form a component of the ET are incompletely standardized (e.g., variable-effort banding, incidental observations), the ET procedure may be helpful in overcoming those deficiencies in standardization (Dunn et al. 2004b). At sites that experience fairly wide fluctuations in numbers of migrants (particularly at exposed coastal sites), the ET procedure may be preferable to sole reliance on visual counts and/or banding captures. We recommend that each component of the ET (census, visible migration count, banding, other observations) be standardized to the maximum extent feasible, and that birds detected by each activity be recorded separately (in addition to the ET), so that each can be analyzed separately. Any data collected using techniques involving nocturnal counts should also be recorded separately from the more usual diurnal counts.

COUNT AREA

The study area should consist of a defined Count Area that has features compatible with the chosen count procedures. A Count Area of 5-20 ha is likely to be appropriate, but a larger area may be manageable in very open habitats. If birds are to be captured, there must be suitable sites for nets or traps. If visual censuses are to be conducted,

the vegetation should not be too dense for birds to be seen easily. An area with natural edges, such that birds moving in and out can be detected readily, may be preferable to an area without such boundaries.

The size and configuration of the area selected as the Count Area should be such that it can be covered adequately by available personnel (usually 2-3 people) to generate consistently an acceptable Migration Count using the chosen methods. Depending on the method used, the Count Area should include plots for one or more standard area searches, a census count route of up to 2 km in length, and/or a suitable observation point for conducting a visible migration count. If netting or trapping is the exclusive method for obtaining a count, then the Count Area will be defined by the fixed locations of the nets and traps. Although the only birds "counted" will be those captured, the surrounding area (that may be included in a habitat management plan) should be delineated.

Normally, any birds seen or heard in or over the Count Area may be included in any census or other audio-visual count. However, special rules may be needed for including or excluding birds seen from the Count Area that are beyond its boundaries or are very high above it.

The Count Area and key features (such as observation points or net lanes) should be defined clearly and identified on a map included in the field protocol (see below).

DAILY COUNT PERIOD

No matter what methods are used, the protocol should define the total daily Count Period, as well as the standard daily time periods when the various component activities of bird sampling should take place. At some monitoring sites, the Count Period for ETs is all daylight hours. In other situations, it may be desirable to limit the count to a specific, standardized period, e.g., the first six hours after sunrise; or from dawn to 2 p.m. When the target species are nocturnal migrants, the early morning hours after dawn should always be included in the Count Period to ensure that newly arriving birds are sampled, and because bird activity is generally greatest then. Length of Count Period should be

appropriate for the normal numbers of personnel present and the hours that they are available.

If the daily Count Period for the ET or for banding captures is less than all daylight hours, then records of birds seen or captured outside the Count Period should be identified as such in the records and excluded from the standard total used in population trend analyses. In general, trapping or netting should be limited to the standard Count Period, especially if significant numbers of day-to-day stopover migrants occur regularly and trap or net avoidance is suspected or known to occur, as discussed below ("The problems of residents and stopovers in migration counts").

FREQUENCY AND DURATION OF COVERAGE

We suggest that at least 75% of the days in each target species' migratory period should be covered within each migration season of operation (the migratory period being defined as the period when the middle 95% of the individuals normally occur at the study location). Preferably, coverage should be daily, even though current analysis methods can adjust for missing days. Near-daily coverage will improve precision of trends (Thomas et al. 2004), decrease the number of years of data required for analyses to produce good estimation of weather and date effects (Hussell et al. 1992, Dunn et al. 1997), and decrease the number of years before a trend can be detected.

Recommendations in this paper are aimed primarily at single stations where work will be conducted daily through the migration season, because such stations have been shown to produce trends that correspond to BBS trends. However, it has been suggested that population trends could also be monitored by a local or regional network of stations, each operated one or two days per week. While this may be adequate for monitoring age composition of migrating populations (Ralph et al. 2004b), the efficacy of this approach for trend monitoring has not been tested. Ability to identify potentially confounding site-specific variables such as date, weather variables, and moon phase (and to compensate for them in trend analyses), depends to a large extent on the number of days of coverage at each site. To conduct a trend analysis similar to that of Francis and Hussell (1998) over a 10-year period, we estimate that a

single site should have an average of at least 28 days' coverage per migration season; a cluster of five sites should each cover a minimum of 22 days per season, and 20 sites should each cover at least 20 days per season. Reduction of coverage below these levels would require a less sophisticated analysis of the effects of confounding variables, potentially giving less precise estimation of trends. We, nonetheless, encourage stations that can manage only intermittent coverage to consider following our guidelines in all other respects and to coordinate their efforts with other, nearby stations such that most or all days are covered by at least one station in the group.

To generate sufficient data for meaningful trend analyses, migration monitoring stations must be run using a standardized protocol for an absolute minimum of five years, and preferably at least ten. The goal should be indefinite operation, which means that stations should be organized such that their operation is not dependent on participation of one or a few specific individuals.

THE PROBLEM OF RESIDENTS AND STOPOVERS IN MIGRATION COUNTS

It is preferable to exclude multiple counts of the same individuals in population-trend analyses because most analysis methods assume that daily counts are independent of each other. In addition, variability attributable to the effects of weather on counts can be identified most effectively if counts include only newly arrived migrants. Therefore, we wish to identify and separate from migrants those individuals of targeted migrant species that are present at the site on summer or winter territories, or are otherwise present for more than a few days (e.g., post-breeding adults or locally produced young, and migrants making a prolonged stopover). Year-round residents of non-migratory species, or of non-targeted migrant species, are of less concern because these will not be included in an analysis that concerns only migrants.

In practice, it will often be impossible to exclude all earlier-arriving migrants and residents from daily counts, particularly at sites that have many individuals that stop over for more than a day. Various techniques are possible for mitigating the

problem of stopovers and residents, but the major factor is choice of site. Exposed coastal sites that have few residents and generally do not hold stopover migrants for more than a day or two tend to minimize this factor. Of course, it must be emphasized that all resident and non-target species or individuals may have importance for other management or research reasons, and data should always be recorded for all birds detected.

At sites with few stopovers and residents, failure to separate these few individuals from newly arrived migrants will not create serious problems in the analysis. However, likely stopovers and residents should be recorded separately in the daily counts whenever possible. We do not recommend modifying the basic count procedure to accomplish this, but rather recommend recording additional information that will allow stopovers and residents to be subtracted from the total counts at the analysis stage. For example, recaptured birds banded on previous days are obviously stopovers and can later be separated from the ET or capture totals. Each day's recapture rate, for each species, can also be used to estimate the proportion of the total daily count consisting of stopovers.

In addition to these data derived directly from banding and retrapping, other individuals can often be identified with a high level of certainty as stopovers or residents, even though they were not captured on the day in question. Included here are previously banded birds that were seen but not captured, repeated sightings of individuals of rare or scarce species that are highly unlikely to be new individuals each day, other birds that can be identified as individuals, and birds of known resident species that are regularly present at specific locations within the Count Area.

Regular observers quickly become aware of probable resident birds and also of the known or presumed stopovers. Incidental observations are particularly valuable in repeatedly confirming the presence of such individuals. From these observations, observers are then able to estimate resident and stopover numbers as readily as they can the ETs. This is done routinely at Thunder Cape, Ontario, which has an additional column on its ET sheets for Known Stopovers (KS). Only

individuals for which there is *strong evidence* of stopover or residency should be called KS, and this procedure should be applied only to target species for migration monitoring. A similar procedure is used on Southeast Farallon Island, California, where separate daily estimates are made of total present and number of new arrivals (P. Pyle, pers. comm.). Banding of birds on alternate legs on alternate days helps with this separation.

Operation of traps or nets outside the standard count period could introduce a bias to ETs if birds captured in extra hours subsequently tend to avoid traps or nets, as has been demonstrated in some species, although not all, during breeding (Ralph and Dunn 2004). Where significant numbers of stopovers occur regularly, netting and trapping should preferably be limited to the standard time period defined for that activity. Some good migration monitoring sites do not hold large numbers of stopovers, and newly arrived migrants may not react to nets and traps in the same way as breeding birds on territory. If so, capture of migrants in extra hours may not bias subsequent data seriously and, therefore, could be permitted. Indeed, extra trapping and netting may help to show how much (or little) stopover occurs and help to distinguish newly arrived migrants from stopovers on subsequent days. Nonetheless, we suggest that the potential pitfalls of operating nets and traps outside of the standard hours be given careful consideration. At the very least, netting and trapping effort and the birds captured in non-standard hours should be recorded as such and excluded from data used for trend analysis.

MAINTAINING CONSISTENCY

In addition to conducting standardized field methods as described above, there are several other actions required to ensure consistency of coverage. These actions are especially important for long-term trend monitoring, as there is almost certain to be turnover in personnel and changes in the condition of the Count Area over the 10+ years recommended as a minimum operations life for a migration monitoring station.

Habitat management - Vegetation changes may affect the numbers of birds present in the Count Area, as well as their detectability; it will certainly

alter the numbers captured in mist nets (Ralph and Dunn 2004). Habitat change presents the most serious potential bias for trend monitoring of migrants (Dunn 2005). Therefore, we recommend that migration monitoring stations be located where there are reasonably stable habitat conditions, whenever possible. Coastal areas, where early or mid-stage successional vegetation is maintained by environmental conditions, are likely to be ideal. Alternatively, the habitat should be monitored quantitatively or photographically, and managed if necessary, to prevent major changes from occurring and to ensure that vegetation around net-lanes remains at a constant height. A habitat management plan should be included in the Field Protocol (see below).

Personnel - One experienced person should be in charge of the operation of the station at all times. If the regular station manager is absent, another experienced person should be designated as a replacement for the duration of the regular manager's absence. The stations should not be operated if there are not enough experienced personnel on hand to make complete, accurate counts or to capture and handle birds safely. Volunteers should be encouraged to participate, and qualified volunteers can be responsible for station management. An effective way to ensure consistent coverage at major stations, however, is to place a paid employee in charge as station manager.

The skills required of participants in a migration monitoring program will vary with the methods selected. We do not give direction on specific skill levels or training regimes here (see North American Banding Council 2001a, b), but we do recommend that acceptable levels of knowledge and experience be specified in the station manual or field protocol.

Because people differ in their abilities to observe and count birds, between-year changes in personnel can lead to between-year bias in counts and the population monitoring results derived from them. It is better to involve a variety of people (even if their abilities differ somewhat) than to create between-year bias by relying heavily on single observers, especially when a single observer has superior skills.

Three important recommendations follow from this:

- 1) All observers who are responsible for counts (especially censuses and visible migration counts) should meet some high, but reasonably attainable, level of ability to identify and count birds.
- 2) Do not assign sole responsibility for all counts in a year to a single individual. Whenever possible, use several qualified people within the season. ETs should always be a joint responsibility of all qualified participants.
- 3) Rotate qualified personnel whenever possible. If a census or visible migration count is part of the routine, different observers should do it on different days. If you operate more than one station, rotate observers among stations within each season.

Field protocol and manual - Once a study location has been chosen, pilot studies conducted, and data-collection methods selected, each migration monitoring station should write a protocol and operations manual describing its procedures for deriving daily counts and collecting other field data. This is a mandatory requirement for any long-term migration monitoring station or network. The manual forms a guide and reference for current field personnel. It should be sufficiently detailed to enable experienced birders and/or banders who are unfamiliar with the station to collect data in a manner that is consistent with procedures followed previously, without any guidance other than the manual itself.

The contents of the field protocol should provide detailed specifications of the site-specific procedures and equipment that are used to obtain a Migration Count at the site. It should not contain instructions on banding techniques (how to set up nets, handle birds, etc.), as this information is detailed in other manuals that should be available at every banding station (North American Banding Council 2001a, b). Station operating procedures unrelated to bird counts (such as emergency contacts, vehicle operation rules, house-keeping chores) should be kept in a separate document, or at least a separate section of the manual. That is, the protocol should focus on *what* must be done to obtain a Migration Count at the site, not on *how* to do it. Instructions on *how* to conduct the Count should be included only to the extent that they are

specific to the site, essential to obtaining the Count, and not available in standard reference manuals.

As a minimum, the station's field protocol should include the following:

- ◆ A brief statement of the goals and objectives of the program, including the main target species or groups (such as all landbirds, diurnal migrants, Neotropical migrants, species breeding in the forests of northern Canada). A list should be included of the high priority species that can be monitored at that site (See: Rich et al. 2004; Appendix 3 in Hussell and Ralph 1998).
- ◆ A definition of the Count Area, including a map or maps showing (as applicable) the boundaries of the area, census route(s), visible migration observation points, and sites of individual nets and traps.
- ◆ Definition of the daily time periods during which each count method is to be conducted, and of the overall Count Period.
- ◆ A detailed description of site-specific procedures for each count method (e.g., frequency of net rounds and route for checking nets, suggested duration of census, suggestions for regular rotation of census-takers, rules about which birds may be counted that are flying over or beyond the boundaries of the count area, site-specific rules for deriving ETs).
- ◆ A detailed description of the equipment to be used in counting at the station (e.g. net dimensions and mesh size for each net location, rules for use or prohibition of bait or drip traps).
- ◆ A description of site-specific procedures for recording stopover and resident individuals.
- ◆ A description of record-keeping procedures, preferably with sample forms correctly filled in.
- ◆ Statements specifying the knowledge, skills and experience required of participants and descriptions of training programs to bring inexperienced personnel up to the required levels.
- ◆ A discussion of potential changes in the habitat at the site and, if necessary, a management plan designed to maintain a stable situation.

Basic field and data management protocols are available from established stations, which can be contacted through several web sites (<http://www.pwrc.usgs.gov/bbl/manual/birdobs.htm>; <http://www.bsc-eoc.org/cmmn.htm>), and many of these procedures will be applicable directly to other

stations. Nevertheless, all station operators should adapt procedures to their own needs and should provide detailed descriptions of site-specific field procedures, bearing in mind the main objective of obtaining consistent daily counts. Before final adoption, the draft protocol should be reviewed by at least two persons experienced in field procedures and analysis of migration data for population monitoring purposes. At least one such person with experience elsewhere should visit the site for several days to see the proposed protocol in operation and to advise on possible modifications.

Changes in field protocol - Once field procedures have been established, changes should be avoided, as this could alter the numbers of birds recorded independently of any true change in population size. However, some changes to the field protocol may be unavoidable as time goes on (e.g., due to destruction of net sites). If so, the change in protocol and its date of introduction should be recorded fully so that its possible impacts can be assessed in analyses. In general, the best way to mitigate negative effects is to phase in the changes over two or three years, ideally running the new and the old protocols on alternate days during the phase-in period. Alternatively, run both protocols simultaneously, but with separate recording (e.g., add new nets but record numbers of birds caught in the original set and in the new nets separately). Record which protocol was in use each day, so that effects of the two protocols can be detected (and corrected for) in the analysis. If a major change in protocol must be made, it is better to do so in the middle of a season rather than between years, so that its effects can be distinguished more easily from year effects.

FACTORS TO CONSIDER IN ESTABLISHING A NEW STATION

Site selection - To contribute the most to monitoring North American bird populations, new migration monitoring stations should be established at locations where (1) they will monitor populations or species that are not currently well-monitored by the Breeding Bird Survey (species listed as Mo2 and Mo3 in Rich et al. 2004), and where (2) they will contribute to a regional or continental network of stations that effectively intercepts populations of northern-breeding migrants. (Note that northern-

breeding populations can be sampled throughout much of the United States, and some of those species may be sampled most effectively at sites far from the breeding range.)

Three critically important site-selection criteria are:

- 1) The site should be a concentration area for migrants, particularly migrants of the target species.
- 2) A site that does not regularly hold large numbers of individuals stopping over for more than a day, and has relatively few residents of target species, is highly desirable because each daily migration count should represent an independent sample of the monitored population.
- 3) The site should have stable vegetation: either climax vegetation or a naturally maintained, early successional stage. Alternatively or additionally there should be minimal restrictions on habitat maintenance (cutting, trimming, mowing, etc.).

Ideally, a site should be visited several times during the migration seasons before being selected as a potential migration monitoring site. Before making a final selection, a pilot monitoring program should be undertaken, with the objective of determining whether target species are likely to be monitored adequately. We think it desirable for analysis that an average of at least ten, and preferably more than 20, individuals of a species be recorded per season (assuming daily coverage of at least 75% of the species' migration period). Species recorded at a lower rate or over a lower percentage of its migratory period should be regarded as unmonitored at that location.

Pilot work should also be undertaken to experiment with the size of Count Area that can be covered thoroughly and to determine the best locations for nets, traps, census route, etc. Once migration monitoring has begun, changes in protocol should be avoided to the extent possible.

Number and dispersion of sites - Most migration monitoring station operators aiming for daily coverage will probably work at only one site. Another strategy is for several nearby sites to work together, each operating daily or less than daily, and pooling their data for a common analysis (Francis and Hussell 1998, Ralph et al. 2004b).

Note, however, that the efficacy of less-than-daily sampling by cooperating stations has not been evaluated for the purposes of documenting long-term population trend.

Sites operated with the intention of pooling data for trend analyses must be close enough together (or more distant, but along a single migration flight path) that they can be assumed safely to be sampling the same migrant population (i.e., breeding and wintering in the same regions and undergoing the same demographic trends). On the other hand, such sites should be far enough apart to provide independent samples of migrants (i.e., the same individual birds should not normally be available for counting or capture at more than one site). We suggest that sites 5-50 km distant from each other will normally meet these criteria. Data from sites that are closer or farther apart should be examined carefully for evidence that the foregoing criteria apply before proceeding with a pooled analysis, because there are statistical barriers to pooling data from stations sampling birds from different portions of the breeding range (Dunn 2005).

Pooling data from several sites potentially has both advantages and disadvantages that should be considered and balanced carefully when designing a multiple site program.

Potential advantages include:

- ◆ Multiple sites may record a wider range of species, including rare species, than a single site. Sites that do not detect a species in adequate numbers can be discarded from pooled analyses for that species.
- ◆ In general, pooling data from several sites will increase reliability of trend estimates by reducing effects of counting errors and other year-to-year inconsistencies in data collection at single sites. In particular, undocumented or undetected habitat changes at single sites may lead to undetected bias in estimated trends. With multiple sites, habitat-related bias in trends is more likely to be detected, and effects will be reduced in pooled analyses if habitat effects differ among sites.
- ◆ Multiple sites provide insurance against unforeseen circumstances causing closure of sites. Sites can be dropped or added to the program without compromising the long-term trend

estimates, provided that at least one site (preferably more than one) bridges all years.

Potential disadvantages of multiple sites:

- ◆ Adding sites will increase the total person-days, costs, and administrative burden of the program, but may not give a proportionate return in precision of trend estimates, especially after the number of sites pooling data exceeds about five (although this has not been evaluated).
- ◆ For sophisticated trend analyses (taking into account the effects of environmental variables), the coverage required at individual sites does not decline in direct proportion to the number of sites. All sites require a high level of coverage (probably at least 3-4 days per week throughout each migration season) in order to identify effects of environmental variables within a 10-year period.

Other site criteria - Assuming that targeted species are recorded in adequate numbers at a site or a network, there are several other technical and practical factors that should influence the choice of site before a long-term commitment is made. None of these is an absolute requirement, but each contributes strategically to the long-term viability of a migration-monitoring station. Here, we briefly summarize these additional criteria; further elaboration may be found in Hussell and Ralph (1998).

1. Working and inexpensive living quarters for participants (especially for volunteers) should be on-site.
2. The area must be reasonably accessible.
3. The site should be well protected from any sources of development and disturbance.
4. For the monitoring program to yield useful results, some kind of secure tenure is essential.
5. A long-term commitment (>10 years) normally requires institutional sponsorship. Site selection should take into account whether a suitable institution exists to take on the migration-monitoring project.

SUMMARY OF RECOMMENDATIONS

Site Selection: The site(s) should be capable of monitoring several priority species. Habitat and other site conditions should be reasonably stable, or amenable to control. Sites should meet as many as possible of the other site selection criteria discussed above.

Migration Count: The choice of method should be appropriate to the site characteristics. Standardization from day-to-day and year-to-year is the key to obtaining a consistent and reliable count. A census or area search, visible migration count, banding captures, or a daily estimated total are all acceptable procedures. Incidental observations can contribute to a daily estimated total. More than one method can, and where possible should, be used for generating Migration Counts. Count and effort data should be recorded separately for each method.

Count Area: The area covered by all sampling methods combined should be defined clearly and identified on a map in the field protocol.

Count Period: The total daily Count Period must be defined clearly, together with time periods in which various component activities should be carried out.

Count Frequency and Duration: Counts should be made daily or near daily, on at least 75% of the days within each target species' migration period. Sites should be operated for 10+ years.

Personnel: Personnel should have the training, experience, and skills necessary to conduct the counts. Attention should be given to the potential impact of personnel changes on the count. In general, avoid heavy reliance on single observers and avoid between-year changes.

Field Protocol: Preparation of a field manual is mandatory for all long-term migration-monitoring stations and networks. Changes in the field protocol should be avoided, especially between years. Unavoidable changes and their timing should be documented.

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APPENDIX 1. ADDITIONAL INFORMATION ON ESTIMATED TOTALS

The daily "estimated total" (or ET) method for deriving a daily count for population monitoring combines data from incidental observations and from one or more other completely or partially standardized procedures. It can be regarded as a special case of an area search census conducted over an extended count period (part or all of a day) and using more than one procedure (e.g., netting, route census, incidental observations) to make the search. The ET method is useful for obtaining a census (total count) of birds present or passing through an area that reflects observed abundance levels and is as complete as possible. Depending on the site characteristics, we recommend a

combination of either a census or visible migration count and a netting/trapping procedure that is standardized to the maximum extent possible at the particular site, together with incidental observations. At sites where trapping or netting is not possible, an ET based on a census and/or a visible migration count, together with incidental observations, is acceptable; but inclusion of banding is preferred because of the additional useful information it yields. Moreover, the ET procedure is well-suited particularly for incorporating incidental observations made while operating nets and traps.

The method adopted by Long Point Bird Observatory (LPBO) is based on the "daily census" conducted at British bird observatories. The "daily census" attempts to estimate and record the actual number of birds of each species present in or passing through a specified area and detected by observers on a given day. The LPBO procedure includes a standardized hour-long "census" of birds observed along a pre-determined route covering essentially the entire count area. LPBO has adopted the more realistic term "daily estimated total" (or "ET") to replace the British "daily census" and to avoid confusion with the formal hour-long census. The daily census of landbird migrants conducted regularly since 1968 on Southeast Farallon Island, California, by Point Reyes Bird Observatory follows a procedure similar to that at British bird observatories and LPBO; but at that site the ET closely approaches a true census because all or nearly all individuals are detected (DeSante 1983). Input to the daily estimated total at Long Point typically consists of conducting the morning census, at least six hours of intensive trapping and netting starting at dawn (weather permitting), and more or less continuous incidental observation by banders and other observers throughout the day. In other situations, other input to the daily estimated total may be more appropriate. At Thunder Cape, Ontario, for example, it was found that continuous observation of diurnal migration in the morning was essential to coming up with realistic ETs, because the area under observation was relatively small, and there was much movement of birds into and out of the site. These birds were not covered either by the banding totals or by a census of relatively short duration, nor could they be tallied adequately by casual or intermittent observation. Therefore, the morning census was replaced by a standard six-hour visible migration count at Thunder Cape.

Regardless of the components used as input, all observers and banders present at the site should participate in arriving at the consensus ET for each species each day. The objective is to use all available information to estimate the numbers of each species present in or passing through the count area during the count period (including incidental observations, e.g., of fly-bys seen while nets were being checked).

Some subjectivity is involved in making decisions about which birds have been double-counted (by two procedures or by two persons making incidental observations) and in estimating overall abundance. Inclusion of all banders and observers in the process is intended to help resolve such problems and to mitigate any one person's tendency to over- or under-estimate numbers. Such subjective judgments about overlap and numbers will likely result in some day-to-day variability in the accuracy of ETs, but this will not greatly affect year-to-year consistency if the same procedure for deriving ETs is followed consistently from year to year.

Because the components of the ET involve overlap, each of the components is at least partially redundant. For example, some of the birds censused may also be included in the banding total. The procedure for estimating the daily total (ET) involves somewhat subjective judgments about such overlap and redundancy (see above). Nevertheless, the ET procedure also takes advantage of the partial redundancy of methods, in the sense that an individual detected by any of the component methods can be included in the ET. When weather conditions preclude netting, many birds that would have been captured are included in the observation totals. Moreover, additional observation effort can compensate for the smaller sample of captured birds when netting effort is reduced. Redundancy of component methods and compensatory adjustments of effort may contribute to accuracy of ETs as a measure of the actual numbers occurring at a site.

ETs are likely to be most consistent when the component procedures are highly standardized and strict rules are followed for making judgments about overlap. Special attention should also be given to adopting a protocol that avoids excessive variation in the time and effort devoted to incidental observations (Dunn et al. 2004b).

NOTE: Versions of the above document have been available on the World Wide Web for several years (<<http://www.fs.fed.us/psw/topics/wildlife/birdmon/pif/migmon.html>>). *NABB's* editors felt it was important to have this information in printed form and are pleased to make it available to our subscribers at this time.