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RECOMMENDED METHODS FOR MONITORING BIRD POPULATIONS BY COUNTING AND CAPTURE OF MIGRANTS

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for the Intensive Sites Technical Committee of the Migration Monitoring Council

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PREFACE

In September 1993, a workshop was held to evaluate the potential of migration monitoring as a means of assessing population changes in migrant landbirds (organized by the Canadian Wildlife Service and a branch of the U.S. Fish and Wildlife Service, the latter now the Biological Resources Division, a branch of the U.S. Geological Survey). The workshop recommended establishment of a continental migration monitoring program, including "a series of intensive long-term monitoring sites to monitor the maximum number of species with emphasis on populations breeding in northern Canada and Alaska" (Blancher et al. 1994).

A "Migration Monitoring Council" (Appendix 1), appointed to implement the recommendations of the workshop, met in March 1994. It appointed two technical committees charged with establishing standards and guidelines for the operation of monitoring programs. One committee dealt with extensive monitoring (such as checklist programs). The second technical committee was responsible for the requirements of intensively operated sites, such as bird observatories and bird-banding capture stations. This document was drafted in February 1996 and was widely circulated; it is a report of the Intensive Sites Technical Committee. Below we detail the current recommendations for field methods for population monitoring of landbird migrants at intensively operated sites.

INTRODUCTION AND OBJECTIVES

We describe options and recommendations for field methods for monitoring population changes of small landbirds during migration. 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 on birds during migration in a scientifically rigorous manner. These data would be suitable for analyses of both long-term trends in populations and for comparisons among sites throughout North America. These methods can also be used to good advantage during other seasons, including breeding and winter, with minor changes.

The goals of a migration monitoring station are to contribute data to an international effort to determine what changes are taking place in populations of migratory birds, as well as to document migration at the station itself. The primary method of attaining these goals is to generate what we term a "Migration Count," a count of migrant birds that can be used for long-term population monitoring.

Migration monitoring stations can also gather data relevant to a wide variety of other important population parameters on migrating birds. These parameters, such as condition, timing of movements, age and sex ratios, are derived from capture of individual birds. They may indicate the basis of changes in migrant populations and generate hypotheses of specific causes of changes, including declines.

Our recommendations for monitoring changes in population size are based on methods that have been shown in at least one study to generate population trends which correspond well with trends from the Breeding Bird Survey (BBS). Other approaches may also prove to be valid as migration monitoring is an active field of research.

The recommendations are primarily aimed at a single station working daily through the migration season, because such stations have been shown to produce trends that correspond to BBS trends. Therefore, our current emphasis is on stations that can sustain near daily coverage of one or both migration seasons over at least 10 years. However, it has been suggested that population trends and composition could also be monitored from a network of stations each operated on one or two days per week. The efficacy of this approach has not been fully tested. Ideally, they would be coordinated such that most or all days are covered by at least one station. We encourage stations that can only manage intermittent coverage to consider following our guidelines in all other respects, and to coordinate their efforts with other, nearby stations to form a network.

This is not intended to be a detailed field manual, as several exist (see list of existing manuals and sources in Appendix 2). The key recommendation we make is that each station develop its own field protocol of standard operating procedures, which will be used in the same manner from day to day and from year to year. We do NOT recommend that every station use identical methods; the guidelines presented here are meant to establish the methodological bounds within which we suggest that data useful for monitoring 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 in the calculation of population changes. Standardization of counting methods can make a major contribution to removing extraneous variation derived from variable observer effort and sampling procedures. Nevertheless, migration counts will still be subject to uncontrollable variation from weather, observer differences, and unavoidable changes in the level of effort. Some of these problems can be addressed by the use of appropriate analytical procedures. We do not directly address these statistical issues in this document, although we do allude to them in support of a given recommendation. Those interested in details should see Hussell (1981), Hagan et al. (1992), Hussell et al. (1992), Pyle et al. (1994), Dunn and Hussell (1995).

THE MIGRATION COUNT

A "migration count" is any tally or count of birds, usually directed towards those on spring or fall passage (Dunn and Hussell 1995). This definition could include birds counted at a 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. For monitoring small landbirds, particularly nocturnal migrants, we will be concerned mainly with birds observed or captured at short-term 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.

Obviously, the more standardized the method, the more consistent and useful the counts will be. Regardless of the method used, 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. Therefore, standardization helps ensure the proportion of the population counted remains similar from day to day and year to year.

The ideal that we should strive for is a separate tally each day of three groups: (1) newly-arrived migrants, (2) resident individuals, and (3) stopovers that arrived on earlier days. Inclusion of the latter two groups in successive counts are inevitable in most methods. The number of newly-arrived migrants is required for some analyses of the data. Recommendations for this separation are detailed later (p. 6).

METHODS TO BE CONSIDERED

There are several options for producing a useful migration count of small landbirds. More than one type of data can be collected simultaneously, which can be useful to facilitate assessment of each method. These options include: visible migration count; area search or route census counts; banding captures by net or trap; incidental observations; and daily estimated totals.

Visible migration counts

A count of migrants can be conducted at sites where an important feature of migration is diurnal movement of birds (including day-time movement of primarily nocturnal migrants, and/or movements of strictly diurnal migrants such as swallows). This count is usually from a fixed point, and tallies those species that can be identified in flight. This method is widely used for recording migrations of hawks in North America (Fuller and Titus 1990), as well as waterbirds, and has also been used for recording diurnal flights of landbirds (some normally nocturnal migrants) in Europe, and at a site on the shore of Lake Superior at Duluth (Eckert 1990).

A standardized visible migration count may be adopted in addition, or as an alternative, to a census (see below), and as a component of an estimated total. 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.

Advantages of visible migration counts are:

1. Birds involved in unidirectional flights are clearly in migration, are new arrivals, and are unlikely to be counted more than once.
2. Counts are unlikely to be affected by year-to-year changes in food abundance or other local site changes.
3. Procedures can be highly standardized.
4. Counts are relatively unselective with respect to species, in that potentially all birds seen can be counted (but see Disadvantage #1).
5. No special skills for handling birds are needed, and birders like to participate in these counts.
6. Although count accuracy may be influenced by weather, visible migration counts can be conducted in any weather, including conditions when it is impossible to use traps or nets.

Disadvantages of visible migration counts are:

1. Many small birds may be hard to identify at the range and speed that they pass the observation point, and successful counting may require personnel with exceptional abilities to identify birds in flight.
2. If large numbers of birds are involved, it may be difficult to count or estimate their numbers accurately and consistently.
3. Because birds are not handled, age and sex composition of the migrants will be unavailable for most species.
4. Variation in skill level of observers will be reflected in the counts more than with some of the other methods of data collection.

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 1981b), and is most effective if taken at the same time each day. It may involve an "area search" of the entire study site, or of selected plots within the area (Ralph et al. 1993:35), usually in multiples of 20 minutes. A survey along a predetermined linear route within the entire study area can also be used as a census. A census route should be 1-2 km, so that it can be walked at a slow pace in about 1 hour. 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.

A census has the following advantages:

1. It is relatively unselective with regard to species (except that secretive species are likely to be missed).
2. Although census accuracy may be influenced by weather, counts can be conducted in any weather, including conditions when it is impossible to use traps or nets.

3. Procedures can be highly standardized.
4. It can be completed in a relatively short time, by one person.
5. No special skills for handling birds are needed, and birders like to participate in censuses.

Disadvantages of a census are:

1. Some individual birds may be missed, especially in heavy cover, and others may be counted twice.
2. Observers must be skilled in identification and detection of birds. Training necessary to bring observers up to acceptable standards can be time-consuming.
3. The ability of observers to detect birds accurately varies.
4. The census sample may represent a relatively small proportion of the total birds present in or passing through an area on a particular day, especially when the census duration is short.
5. Small birds moving rapidly through an area may be difficult to detect and identify.
6. Secretive species are likely to be missed.
7. Residents and migrants may be difficult to separate and turnover hard to assess (i.e., the same individuals may be counted on more than one day).

Banding Captures

Captures of birds during migration have been used 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. MS; Dunn and Hussell 1995) and composition (Dunn and Nol 1980, Ralph 1981a). Most standardized capture procedures will involve only the use of mist nets. However, Heligoland traps 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 an estimated total.

While standardization of effort is very important, at some sites, such as some exposed coastal locations, it may be difficult to maintain an adequately standardized trapping or netting procedure, due to frequent adverse weather, wide fluctuations in bird numbers, and/or habitat changes. In these circumstances, we do not recommend banding captures as the only, independent count method (Dunn et al., in press), but they can still be used as a component of a daily estimated total and to determine age and sex composition of the population.

To further standardization, net and trap sites should be clearly identified and marked and set in exactly the same positions each year, if at all possible. The array of nets and traps should allow the participants to visit them within 10-15 minutes when no birds are present. 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 and may influence stopover behavior of migrants. 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, starting at a constant clock time or at a constant time relative to

sunrise. 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 the birds (e.g., severe weather, more birds captured than can be safely handled, predator problems). Non-standard opening and closure times of nets and traps should be recorded. Partial closure and opening of the array of nets and traps should be avoided whenever possible.

Attention should be given to the possible need to manage 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).

As discussed in Ralph et al. (1993), the minimum data taken at a capture station are: species; band number; age and sex of the birds; and a measure of the effort expended (e.g. net hours). How aged and sexed, wing chord, body mass and/or fat condition, and molt condition are highly recommended, but are at the discretion of the individual stations. It is essential that knowledge and experience of principal banders be at a very high level to ensure accurate identification, use of plumage criteria for age and sex, and especially use of skull ossification for ageing. We suggest that a permanent and fully-equipped banding laboratory or shelter should be conveniently located within the trapping/netting area of all major stations to enable banders to process birds accurately and efficiently.

A standardized netting or trapping procedure has the following advantages:

1. It is objective (all birds caught are identified and counted).
2. It is relatively unaffected by differences among the operators' abilities.
3. It will produce a random sample within each species, and will do this more effectively than other methods at sites with heavy cover or in other situations where birds are not easily observed or counted.
4. Previously-banded stopover migrants or residents can be identified as individuals and separated.
5. It provides detailed demographic information on age and sex classes which can be used to formulate hypotheses about causes of changes of population levels.
6. Condition of brood patch, cloacal protuberance, subcutaneous fat, and molt can be used to separate at least some residents from migrants and generate further hypotheses about causation of changes in populations.

Disadvantages of trapping or netting are:

1. It is relatively selective with regard to species, and many individuals present in the area that might be included in a visual count will not be captured.
2. Its efficiency is likely to be adversely affected by severe weather conditions, and weather will dictate complete closure of the operation on some days.
3. Since habitat change, such as height of the canopy, can affect capture totals more than in other methods, habitat maintenance at the sites may be necessary.

4. Large day-to-day variation in numbers of birds at some sites may make it difficult to operate nets in consistent numbers or locations.
5. Netting and banding requires special skills, training, and permits.

Incidental Observations

Incidental observations of birds seen or heard by observers or banders in the course of their work at a site can be tallied. This method is particularly 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. This is inherently an unstandardized method. 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 because this is the least standardized method that we describe and we do not recommend it except when used in combination with other methods. It 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.

Incidental observations have the following advantages:

1. They are relatively unselective as to species and can be made in any weather.
2. They provide a measure of species which are rare at the site or at a particular time of year.
3. They can detect presence and/or numbers of birds at a time of day or in a part of the site not covered by standardized procedures.
4. They add interest for volunteers and keep them focused on birds throughout the day (or shorter observation period), as they are aware that all observations will become part of the permanent record.
5. No special skills for handling birds are needed.

Disadvantages of incidental observations:

1. Many individual birds may be missed and others may be counted twice or more.
2. Observers must be skilled in identification and their abilities to detect and identify birds will vary.
3. Incidental observations are not suitable for obtaining consistent estimates or samples of total numbers, but only for detecting presence and absence and for providing supplementary information on levels of abundance.
4. Because they are not well standardized, they cannot be used as a sole migration count.

Daily Estimated Totals

The "Daily Estimated Total" (or 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), and Southeast Farallon Island, California (Pyle et al. 1994). The ET method should combine data from the at least two of the four methods described above (Appendix 4).

Regardless of the components used as input, the objective is to integrate all available information to estimate the 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 4.

ETs are likely to be most successful in small areas with relatively open habitat, where personnel housed on-site are making more or less continuous observations. New stations planning to use ETs should develop procedures that are standardized to the maximum practicable extent. Nevertheless, when incompletely standardized procedures are used to collect data that form a component of the ET input (e.g. unstandardized banding captures, incidental observations), then the ET procedure might be helpful in overcoming those deficiencies in standardization.

At sites that experience fairly wide fluctuations in numbers of migrants (particularly at exposed coastal sites), the ET procedure might be preferable to visual counts or banding captures alone. We recommend that each component of the ET (census, visible migration count, banding, other observations) be standardized to the maximum extent feasible and be recorded separately (in addition to the ET), so that each can be analyzed separately. A procedure should be included for estimating the numbers of stopovers and residents.

The ET method has the following advantages:

1. It is based on 2 or more separate sampling procedures and attempts to take advantage of the strengths of each while mitigating their weaknesses, by compensating for variation in effort and day-to-day variation in the effectiveness of each procedure.
2. It usually covers a longer period of the day than is allocated to a census, visible migration count, or banding alone and is therefore likely to detect more species and individuals.
3. It attempts to include all individuals of all species that were detected in the count area in a specified time; a procedure that is intuitively appealing and a challenge to many birders and volunteers.
4. Because an ET is often larger and never smaller than counts derived by other methods, ETs may conform more closely to the assumptions required by analysis methods used to estimate population indices and trends.

Disadvantages of the ET:

1. Preparation of the daily totals is comparatively subjective, rather than strictly objective and standardized. Rules for preparation of daily totals must be devised and followed. Nevertheless, such rules will be open to subjective interpretation, making it difficult to ensure a fully consistent estimation procedure.
2. Variation in effort devoted to any of the component procedures may introduce a bias into the estimates.
3. When birds are moving quickly around or through the site, ETs will be particularly subject to

error unless effort devoted to incidental observations is standardized, or standardized visible migration counts are part of the regular procedure.

4. In heavily vegetated sites, the ET for many species is likely to be based mainly on capture samples, and will be affected by any variation in trapping or netting effort.

COUNT AREA

The site should include or encompass a defined Count Area that has features that are 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 capture is to occur 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 easily seen. An area with natural edges, such that birds moving in and out can be readily detected, may be preferable to an area without such boundaries.

Depending on method used, the area should include census routes for one or more 20-minute 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 is defined by the array of nets and traps. If parts of the count area are not regularly covered by the netting and trapping operation, they should be included in a route census or a standardized area search.

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

Normally, any birds seen or heard in or over the count area may be included in any census or other 'visual' count. However, special rules may be made for including or excluding birds seen from the count area that are beyond its boundaries or are very high above it. Any techniques involving nocturnal counts should be separated from the more usual diurnal counts.

The size and configuration of the area selected as the Count Area should be such that it can be adequately covered by available personnel (usually 2-3 people) to consistently generate an acceptable Migration Count using the chosen methods. A pilot project should be used to experiment with the size of area that can be thoroughly covered and with locations of nets, traps, census route, etc.

COUNT PERIOD

No matter the type of method, organizers should define the total daily "count period", as well as the standard daily time periods during which the various component activities of bird sampling procedures

occur. 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 6 hours after sunrise; or from dawn to 2 p.m. Length of count period should take into account the normal numbers of personnel and the hours that they are available.

The early morning hours after dawn must always be included in the count period to ensure that newly-arriving nocturnal migrants are included, and because bird activity is generally greater at that time of day.

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 PROBLEM OF RESIDENTS AND STOPOVERS

Here and elsewhere in this document, the resident birds that we wish to separate from migrants are 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 young of the year). Year-round residents of non-migratory species, or of non-targeted migrants, are of less concern because these will not be included in an analysis that concerns only migrants. We would prefer to not include 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.

In practice, it will often be impossible to exclude all earlier arriving migrants and residents from the count, 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 tend not to hold stopover migrants for more than a day or two would minimize this factor. Finally, it must be emphasized that the residents and non-target species or individuals all may have importance for other management or research considerations, and should always be recorded.

At sites with few stopovers and residents, failure to distinguish these individuals from newly-arrived migrants will not create serious problems in the analysis. However, the daily counts should separate likely stopovers and residents whenever possible. We do not recommend modifying the basic count procedure to accomplish this. Rather, we recommend recording additional information that will allow stopovers and residents to be deducted from the total counts at the analysis stage.

Retraps of birds banded on previous days are obviously stopovers, and can later be separated from the ET or capture totals. The retrap rate, 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, birds of rare or scarce species that are highly unlikely to be represented by new individuals each day, other birds that can be identified as individuals, and birds of known resident species regularly present in specific locations.

Observers in an area soon become aware of these regular residents and also of the known or presumed stopovers. From this, they are then able to estimate their 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 "PKS" (Probable and Known Stopovers; see McCracken et al. 1993). Only individuals judged to be residents or stopovers with at least 80% certainty are recorded as such. A similar procedure is used on Southeast Farallon Island, where separate daily estimates are made of total present and number of arrivals (P. Pyle, personal communication).

Operation of traps or nets outside the standard count period could introduce a bias if birds captured in extra hours subsequently tend to avoid traps or nets, as has been demonstrated for some breeding birds. If this occurs at sites where significant numbers of stopovers occur regularly, netting and trapping should be limited to the standard period. 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 seriously bias subsequent data and might be permitted. Extra trapping and netting may then help to show how much (or little) stopping over occurs and to distinguish newly-arrived migrants from stopovers on subsequent days. We would suggest, however, that operation of nets and traps outside of the standard hours be given careful consideration before being undertaken. 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.

FACTORS IN SITE SELECTION

Coverage of species

A key recommendation of the Migration Monitoring Workshop was that a series of intensive monitoring sites be established to monitor the maximum number of species, with emphasis on species and populations breeding in northern Canada and Alaska that are not currently adequately covered by the Breeding Bird Survey. Therefore, newly-established migration monitoring stations will contribute most to monitoring North American bird populations if they monitor populations or species that are not currently well-monitored by the Breeding Bird Survey (Appendix 3), particularly those species breeding

in northern Canada or Alaska, and are at geographic locations that enhance development of a continental network of stations that effectively intercepts all populations of northern-breeding migrants.

Selection procedure

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 adequately monitored. In order to monitor a species at a migration station, it has to be present in numbers that are adequate for analysis. We think it desirable that an average of at least 10, and preferably more than 20, individuals of a species are recorded per season. In addition, we suggest that coverage of at least 75% of the days in the species' migratory period is desirable (i.e., the period when the middle 95% of the individuals normally occur). For the purpose of assessing whether or not a species can be monitored at a site, species recorded at a lower rate, or over a lower percentage of its migratory period, should be regarded as unmonitored.

Number of sites

Most migration monitoring station operators aiming for daily coverage will probably work at only one site, while others work at a cluster of two or more sites, each operated daily, in the same local area. Addition of sites will add extra counts and will increase the reliability of population monitoring, but will add to the costs, as well as the task of maintaining consistent, long-term daily coverage. Sites operated in tandem 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 such sites should normally be within 5-30 km of others, but they could be closer if there is evidence that the same individuals are unlikely to be encountered at more than one site.

An alternative strategy is a network of cooperating sites, each operated on a regular, but not daily, basis. This strategy may be more effective at monitoring a range of species than a single site. Each site in the network may observe or capture only a few individuals of rarer species, but the combined counts from sites within a region may provide an adequate sample of these species. The region covered should be a reasonably homogeneous bioregion, perhaps covering an area of a few to several hundred kilometers on a side.

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.

1. The site should be a concentration area for migrants. Coastal (especially peninsular) sites are apt to "funnel" or attract migrants, but attention should also be paid to concentration sites such as river valleys, off-shore islands, and "islands" of habitat (e.g. a brushy area in the middle of a larger prairie or an oasis of greenery in a desert). Among other considerations, it will be difficult to attract volunteer personnel over long periods of time to sites that consistently have low numbers of migrants.

2. There are advantages to a site that does not regularly "hold" large numbers of individuals stopping over for more than a day, and that has relatively few resident species.

3. Working and inexpensive living quarters for participants (especially for volunteers) should be on-site. One reason for this is that the first hours of daylight can be readily covered, when most nocturnal migrants have not yet dispersed. Another is that on-site facilities provide a focal point for the program and tend to lead to a stronger volunteer commitment.

4. The area must be reasonably accessible. However, a degree of isolation is an attractive feature for many volunteer participants. If stations are to be operated in tandem, then they should be no more than 30 km apart. Ideally, major stations should be reasonably close (within 150 km) to a major population centre that can provide a supply of volunteers to assist in the operation and administration of the station. Stations that are remote from population centres may be best operated as a satellite of, or in partnership with, an existing major station.

5. Preferably, the site should not be frequented regularly by the public and it should be well protected from any sources of development and disturbance.

6. In order for the monitoring program to yield useful results, some kind of secure tenure is virtually essential. Ideally, the area should be owned outright by the organization. Alternatively, a long-term commitment should be available from the owner (preferably a government or conservation agency).

7. Migration counts have less chance of long-term bias from change in vegetation if the site has climax vegetation or is naturally maintained at an early successional stage. If vegetation is going to grow up, the site should be one where there are minimal restrictions on cutting, trimming and mowing as necessary to maintain the habitat at about the same stage (especially where netting is to be the sole means of counting).

8. We suggest that stations should plan on continuing monitoring for a minimum of 5, and preferably beyond 10 years. Such a commitment normally requires institutional sponsorship, and site selection should take into account whether a suitable institution exists to take on the migration monitoring as a project. A monitoring program with such an organizational sponsorship is more likely to continue despite turnover in personnel, and may provide a route to financial support.

HABITAT MANAGEMENT

Vegetation changes may affect the numbers present in an area, as well as their detectability. We recommend that sites with reasonably stable habitat conditions be selected whenever possible. Coastal areas that are held in an early or mid-stage of succession by local conditions are likely to be ideal for this

and other reasons. Alternatively, the habitat should be quantitatively monitored, and, if necessary, managed to prevent major changes from occurring. A habitat management plan should be included in the Field Protocol.

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. 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, but we do recommend that acceptable levels of knowledge and experience be specified in the station manual or field protocol.

Between-year changes in personnel can lead to between year bias in population monitoring results, because people differ in their abilities to observe and count birds. 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 who may have superior skills but who change from year to year.

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. Wherever possible use several qualified people within the season. Estimated totals 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 site, rotate observers among sites within each season.

Recommendations 2 and 3 contrast with those of some multi-site monitoring programs, including the Breeding Bird Survey, which prefer continuity of observers at the same site between years. Migration count requirements differ because usually only one or a few sites are sampled in a region, making it more difficult to distinguish observer effects from year to year population changes in the statistical analysis of trends.

FIELD PROTOCOL AND MANUAL

Once a site has been chosen and pilot studies conducted, each migration monitoring station should write a protocol or 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 methods adopted should follow the recommendations proposed here. The manual should enable people who are unfamiliar with the station to collect data in a manner that is consistent with procedures followed previously. In addition it should form a guide and reference for current field personnel. As a minimum, the manual should include the following:

1. 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, etc. A list of high priority species that can be monitored should be included (Appendix 3).
2. A definition of the area being monitored, including a map or maps showing (if applicable) the boundaries of the area, census route(s), visible migration observation points, and sites of nets and traps.
3. Definition of the daily time period(s) during which the count(s) are to be conducted (see Count Period).
4. A description of the methods used to produce a migration count, with particular attention to any procedures that are specific to the site (e.g. site-specific rules for deriving ETs, as in McCracken et al. 1993:16-18). Also, for visual counts, include rules about which birds may be counted that are flying over or beyond the boundaries of the count area.
5. A description of procedures for recording stopover and resident individuals. It should include site-specific rules for determining which individuals are to be recorded as stopovers and residents.
6. A description of record-keeping procedures.
7. Statements specifying the knowledge, skills and experience required of participants and descriptions of training programs to bring inexperienced personnel up to the required levels.
8. 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 (Appendix 2) and many of these procedures will be directly applicable to other stations. Nevertheless, each station should adapt these procedures to its needs and 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.

Some changes to the field protocol may be unavoidable. If so, the change and its timing should be fully

recorded, so that its possible impacts can be assessed at the analysis stage. The potential effects on the value of the data for population monitoring should be carefully considered before optional changes are adopted. In general, the best way to mitigate negative effects is to phase in the changes over 2 or 3 years. Ideally, the new and the old protocols should be run simultaneously (i.e. on the same day) or on alternate days during the phase-in period. This will enable the effects of the two protocols to be detected (and corrected for) in the analysis. Avoid making major changes in the protocol between years.

SUMMARY OF RECOMMENDATIONS

To contribute useful information to the North American Migration Monitoring Program, stations or networks should monitor several priority species (Appendix 3) and should attempt to be in operation for an indefinite period beyond a minimum of 10 years. Single stations should sustain daily or near daily coverage through one or both migration seasons. Coordinated regional networks, as discussed above (p. 2), may involve less intense coverage at individual sites, but should aim to maintain daily coverage across the network by alternating operation of individual sites. A summary of our recommendations for selection of sites and operation of migration monitoring stations follow.

- 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 at a site.
- Count Area.--The count area should be clearly defined and identified on a map in the field protocol.
- Count Period.--The total daily count period must be clearly defined, together with time periods in which various component activities should be carried out.
- Site Selection.--The site(s) should be capable of monitoring several of the priority species listed in Appendix 3. Habitat and other site conditions should be reasonably stable. Sites should meet as many as possible of the other site selection criteria.
- Habitat Management.--Major changes in the vegetation and other aspects of habitat at the sites should be avoided or managed to maintain a reasonably stable environment.
- 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 and Manual.--This is a mandatory requirement 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

MIGRATION MONITORING COUNCIL AND TECHNICAL COMMITTEES

Migration Monitoring Council
*Peter Blancher, CWS, National Wildlife Research Centre
Michael Bradstreet, Long Point Bird Observatory
Greg Butcher, American Birding Association
André Cyr, University of Sherbrooke
Loney Dickson, CWS, Edmonton
*Sam Droege, U.S. National Biological Service
Bill Murphy, Ottawa Banding Group
Nadav Nur, Point Reyes Bird Observatory
C. John Ralph, U.S. Forest Service
Stan Temple, University of Wisconsin

Intensive Sites Technical Committee
John Hagan III, Manomet Bird Observatory
Keith Hobson, CWS, Saskatoon
*David Hussell, Ontario Ministry of Natural Resources
Nadav Nur, Point Reyes Bird Observatory
*C. John Ralph, U.S. Forest Service

Extensive Sites Technical Committee
*Greg Butcher, American Birding Association
Jim Cox, Florida Fish and Game
Brenda Dale, CWS, Edmonton
*Erica Dunn, CWS, National Wildlife Research Centre
Jeff Price, U.S. National Biological Service, North Dakota
Ken Rosenberg, Cornell Laboratory of Ornithology
Rick West, Delaware Spring Bird Count

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* = Co-chairs of Council or Committee
CWS = Canadian Wildlife Service, Environment Canada.

Appendix 2

MIGRATION MONITORING MANUALS

A manual for monitoring bird migration, by J.D. McCracken, D.J. T. Hussell and E.H. Dunn (1993). Source: Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0.

A manual for monitoring bird migration at Last Mountain Lake, by Alan R. Smith (1994). Source: Alan R. Smith, Canadian Wildlife Service, 115 Perimeter Road, Saskatoon, Saskatchewan, Canada S7N 0X4.

A manual for monitoring bird migration, Beaverhill Bird Observatory (1994). Source: Beaverhill Bird Observatory, P.O. Box 1418, Edmonton, Alberta, Canada T5J 2N5.

A revised field protocol for monitoring bird migration at Thunder Cape Bird Observatory, by Jul K. Wojnocoski and David J.T. Hussell (1995). Source: Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario N0E 1M0.

A manual for monitoring bird migration at the Delta Marsh Bird Observatory, by Heidi den Haan and Paula Grieef (revised 1998). Source: Delta Marsh Bird Observatory, R.R.#1, Box 1, Portage la Prairie, Manitoba, Canada R1N 3A1.

Coyote Creek Riparian Station Bird Bander's Handbook. Source: Coyote Creek Riparian Station, P.O. Box 1027, Alviso, California 95002.

The Lesser Slave Lake Bird Observatory Operation Manual (1995). Source: Beaverhill Bird Observatory, P.O. Box 1418, Edmonton, Alberta, Canada T5J 2N5.

Appendix 3.

A PRELIMINARY ASSESSMENT OF
SPECIES COVERAGE PRIORITIES
FOR MIGRATION MONITORING PROGRAMS

prepared by Erica H. Dunn
[From Appendix D in Blancher et al. (1994)]

Note: Priorities may be lower if breeding density in inaccessible northern breeding populations is very low. Regional lists might include more species. Recent analyses indicate that Christmas Bird Counts may provide good trends for those species that winter largely in the United States (lists 2. and 4. below); if so, those species may be lower priority than suggested here.

1. 50+% of North American breeding range is north of Breeding Bird Survey coverage and 50+% of winter range is south of U.S.

Peregrine Falcon
Merlin
Least Flycatcher
Alder Flycatcher
Yellow-bellied Flycatcher
Swainson's Thrush
Gray-cheeked Thrush
Philadelphia Vireo
Tennessee Warbler
Orange-crowned Warbler
Cape May Warbler
Magnolia Warbler
Bay-breasted Warbler
Blackpoll Warbler
Palm Warbler
Connecticut Warbler
Wilson's Warbler
Northern Waterthrush

2. 50+% of North American breeding range is north of Breeding Bird Survey coverage but much of winter range is in U.S.

Rough-legged Hawk
Winter Wren
Ruby-crowned Kinglet
Varied Thrush
Northern Shrike
Water Pipit
Yellow-rumped Warbler
LeConte's Sparrow
American Tree Sparrow
Harris' Sparrow
White-throated Sparrow
White-crowned Sparrow
Golden-crowned Sparrow
Fox Sparrow
Smith's Longspur
Lapland Longspur
Snow Bunting
Rusty Blackbird

3. 50+% of Canadian (but not North American) breeding range is north of Breeding Bird Survey coverage and 50+% of winter range is south of U.S.

Osprey
Common Nighthawk
Olive-sided Flycatcher
Western Wood Pewee
Say's Phoebe
Tree Swallow
Violet-green Swallow
Bank Swallow
Cliff Swallow
Barn Swallow
Solitary Vireo
Red-eyed Vireo
Black-and-white Warbler
Black-throated Green Warbler
Yellow Warbler
Ovenbird
American Redstart
Lincoln's Sparrow
Western Tanager

4. 50+% of Canadian (but not North American) breeding range is north of Breeding Bird Survey coverage but much of winter range is in U.S.

Bald Eagle
Northern Harrier
Sharp-shin. Hawk
Red-tailed Hawk
Short-eared Owl
Long-eared Owl
Northern Flicker
Yellow-bellied Sapsucker
Eastern Phoebe
Horned Lark
American Crow
Golden-crowned Kinglet
Townsend's Solitaire
Hermit Thrush
American Robin
Savannah Sparrow
Swamp Sparrow
Song Sparrow
Chipping Sparrow
Dark-eyed Junco

Appendix 4

Daily Estimated Totals: additional information

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 (including species that are rare at a particular site or time of year). 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 particularly well-suited for incorporating incidental observations made while operating nets and traps.

The method adopted by Long Point Bird Observatory (LPBO) (McCracken et al. 1993) 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 6-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 2 procedures or by 2 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 judgements about overlap and numbers will likely result in some day-to-day variability in the accuracy of ETs, but this should not greatly affect year-to-year consistency if the same procedure for deriving ETs is followed consistently from year to year (see McCracken et al. 1993: 16-18).

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 judgements 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 judgements 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.