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# Recommended Methods for Population Monitoring at Raptor-migration Watchsites

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Abstract.—We provide recommendations for the optimal operation of raptor-migration watchsites, with the goal of reducing and controlling for variation in counts from sources unrelated to population change. Each site must ensure consistency in the seasonal coverage period, length of the daily count period, the number and skill of observers, and the location of observation points. A written protocol must give clear instructions on what and how to count and what to record, so that different observers will collect data as consistently as possible. We outline the contents of a field protocol and emphasize the need to archive the specifics of the protocol in use each field season. Changes in protocols should be avoided, but if absolutely necessary, there are procedures for changeover, described herein, that allow data from both before and after a change to be pooled for analyses. Following the recommended procedures will greatly reduce the variation in counts that can bias annual indexes and resulting trends.

Every experienced hawk counter is well aware that numbers of migrating raptors recorded daily are affected by weather, number and skill of observers, and numerous other factors that affect detectability of birds, such as behavior and altitude of flying birds or volume of migration. When counts are made with the aim of tracking long-term changes in population

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levels, concern arises that daily count variability from these sources will interfere with detection of true changes in annual population size.

This chapter provides specific instruction to count organizers on means of reducing fluctuation in daily counts that is caused by variation in observation effort. Although directed primarily at hawk counters, this paper also provides important information to users of trend results, illustrating the issues of data quality and methodology that should be taken into account when considering the quality of trends from specific sites.

No amount of standardization in count effort can ensure that all migrants passing a site are observed, and hawk counts are only an index of true abundance. (For a detailed discussion of proportion of migrants counted, see Dunn 2005.) The assumption underlying trend analyses based on index counts is that count indexes fluctuate in parallel with true numbers. However, there is active debate in the bird-monitoring community about the validity of this assumption, and numerous count methods are being tested for estimating the proportion of birds available to be detected that are actually recorded (Thompson 2002). Estimating detectability is important for accurate comparisons of breeding-bird densities between habitats (e.g., Bibby and Buckland 1987). That said, at a site where detectability is not changing systematically over time, long-term trends based on index counts should not differ importantly in magnitude from those based on counts adjusted for detectability. Systematic change in detectability is less likely to be a problem in standardized counts of migrating raptors than in those of breeding birds, because migrants passing over a particular site are presumably little affected by habitat change on the ground. Nonetheless, continued research is needed, and the double-observer method (Nichols et al. 2000) is the most suitable approach for migrant raptor counts. In the meantime, it should be understood that all results of long-term trends in raptor migration to date are based on index counts and that most hawk-watch sites are operated by amateur enthusiasts who are likely to continue with index counts in the foreseeable future. Therefore, we concentrate here on recommendations that will minimize changes in detectability as a result of changes in watch effort.

A simple example of how change in effort can affect counts is given in Table 1, which shows hypothetical counts of a species at each of three nearby sites. Let us assume that sites A and B used the same methods in both years, whereas at site C, a tower was built between the two years to improve visibility. Sites A and B each detected a 10% decline in numbers between the two years, even though total numbers at the two sites were very different. At site C, however, numbers rose by 10%. Assuming that all three sites were sampling the same population, we are drawn to the conclusion that the change in methods at site C was the probable cause of the increase at that location.

Table 1. Hypothetical example illustrating the importance of consistency in counts.

| Site | Count in year 1 | Count in year 2 | Percentage of change in numbers | Consistent count |
|---|---|---|---|---|
| A | 200 | 180 | –10 | Yes |
| B | 1000 | 900 | –10 | Yes |
| C | 500 | 550 | +10 | No |

The key to making index counts reliable is to count consistently at each site, both within and among years. Most organizers will want to maximize counts to maintain volunteer interest and enthusiasm, and the site and methods can be selected to afford that opportunity. What must be avoided are subsequent changes in procedures that alter the number of birds recorded independent of any change in actual numbers passing the site.

Consistency of counts within and among years requires each watchsite to set standards for the ways in which data are collected and to ensure adherence to those standards. That said, there is no need for standard methods to be exactly the same for every watchsite, and dates of coverage, length of daily watch period, etc., can be set as most appropriate for each location. As long as counts are conducted consistently within each site, the count index at all sites sampling the same population should change in parallel, even if observation protocols differ between sites.

Key elements of data collection that require consistency include timing of seasonal and daily coverage, timing and length of daily observations, observer numbers and skill, count locations, and details of count instructions. Each of these factors is discussed below.

### Seasonal Coverage

For a species to be well monitored, observations should be taken across most of the migration period, not only during peak passage (Lewis and Gould 2000). For a species to qualify for analysis, counts should be made on a minimum of 75% of days during the species' migration "window" (the period during which 95% of migrants pass by that particular site). For species with migration windows of less than one month, we recommend covering at least 20 days (preferably more) within the migration window. These recommendations are based, in part, on studies modeling the effects of less intense coverage on statistical power for detection of population change (Thomas et al. 2004, Farmer et al. 2007).

Each watchsite should set the coverage period to include the migration windows of as many species as possible. Alternatively, watchsite personnel may decide to focus on one or more target species and limit coverage even though other species could be monitored at that site with additional effort. It is desirable that the same dates be covered each year, but this is

not essential, provided that at least 75% of the migration windows of target species is covered.

### Daily Count Period

A standardized daily counting period should be defined with a specified start time and number of hours of counting. The official Hawk Migration Association of North America count forms are printed for recording hourly counts, so it is simplest to set the official period to start and end on the hour. Start time should be specified as to time zone and standard versus daylight time (e.g., Eastern Daylight Savings Time, Mountain Standard Time).

It is recommended that the daily counts cover 8–9 h, with a minimum of 6 h. The start time and length of the daily count period should be set to maximize coverage of target species (i.e., targeting the times of day when peak movement occurs). However, consistency is more important than total proportional coverage. For example, if most counters can spend only 6 h at the site, the standard count period should not be 8 h, even if that would better cover the period of daily migration activity. Start time and length of count period may differ according to time of year (e.g., shorter count period in December when there is less daylight), but only so long as the same within-season changes in count length are followed consistently year after year. Counters may start before the official starting period and end later if they wish, so long as data collected during the standard period can be separated easily for analysis.

Counts should be continued through the entire standardized period even when few birds are present, and counters should not select days for counting based on expectation of large numbers. Because low counts can be boring for counters, it is important to stress in instructions that such counts are as important for detecting population trends as are "big flight days." If observers come only on days when good migratory movement is expected, the data cannot be used for monitoring population trends.

Instructions also should clarify the conditions under which a count may be suspended. Observer safety should be paramount (e.g., stop and take shelter during thunderstorms or vacate the site if wildfire smoke makes conditions unhealthy); observer comfort should be a secondary concern. Taking short breaks to shelter during heavy showers is fine, but intermittent showers, unfavorable migration conditions, high winds, etc., should not be cause for terminating observations prior to the end of the standard period. Decisions to skip an entire day should be based only on forecasts of hurricane-strength winds, steady rain, snow, or other factors that are unlikely to allow any periods of visibility or safe observation conditions. Whereas the target always should be to cover the full standard-length daily

period, inevitably there will be times when counts are cut short or full days are missed. In such cases, the reason for lack of coverage should be recorded directly onto the daily report form. For instance, "rain-thunderstorm" might be written across 0900 through 1100 hours if a person was absent for those hours because of a thunderstorm. If an entire day is missed, a daily record sheet nonetheless should be completed, giving the date and the cause of there being no coverage, and it should be added to the collection of daily report forms for the season. This is, by far, the best means of ensuring that causes of gaps make it into the permanent database. There are various ways of treating missing data in trend analysis, and the method chosen depends on the cause of the gap.

### Numbers of Observers

Having a single official counter can be acceptable and may be the only feasible option for many watchsites. That said, population trend analyses may be compromised when the same observer takes most of the counts in a given season. Most people feel instinctively that having a single person conducting all counts will reduce day-to-day variation and therefore be "good." However, observers vary in skill levels. When a single observer does all the counting in a single season and there are different single observers in different years, the "observer effect" cannot be separated from the "year effect," which is the signal of population change. If, for example, a particularly gifted counter collects most of the data in a given year, counts in that particular year will be higher, on average, than those in years with observers of more typical skill.

The best way to address this problem is to have several observers who regularly rotate count duties (e.g., taking turns daily or every second or third day). That way, if any one observer drops out of the team in one year and is replaced by a new observer in the next, the overall impact on trend analysis will be negligible. Purposely introducing daily variation in observer skill will, in fact, ensure that annual abundance indexes are less influenced by "observer effect" and more representative of the population signal.

Another way to avoid confounding year effect with observer effect is to have two official counters working together (or three, if flight volume is normally high). This is the recommended option, as long as sufficient personnel are routinely available, for the following reasons:

- The average skills of two (or three) observers are more likely to be similar from year to year than the skills of individual observers.
- When two (or three) observers are present, one can be assigned to record data, which allows the primary observer(s) to work with less distraction. The extra observer(s) can call attention to birds that appear to have been missed, and can serve this function even if not

highly skilled. If the primary observer is of average skill, the second may be kept busier than with a highly skilled counter, but in both cases the total birds detected should be relatively similar, compared with solo counts by unassisted observers of different skill levels. Duties as primary counter should be regularly rotated, even if one observer (e.g., a paid employee) is present daily or is more skilled than other counters.

- Multiple counters offer the opportunity for estimating detectability using the double-observer method (Nichols et al. 2000).
- When two (or three) observers are present, there is more flexibility for taking short breaks, which increases comfort and promotes continued alertness throughout the entire count period.
- Adding an extra counter allows the count to be used for training and evaluating future principal counters.

Regardless of the number of official observers, that number should remain constant day to day and year to year. In theory, a variable can be added to analyses to take account of the effect of extra observers on number of birds detected, but the statistical model would treat the number of observers present as uncorrelated with number of migrants, and that is almost never the case. Instead, more people typically come to nonremote watchsites on days and under weather conditions when good flights are expected. That correlation introduces a bias that cannot be addressed at the analysis stage.

For this reason, visitors to the site should be discouraged from contributing to the official count (although this may be difficult to control). Having some volunteers on hand to talk with visitors can be very helpful, and can also fulfill public-education goals. Physical separation of the official lookout from visitor traffic also can be helpful. Visitor numbers per hour should be recorded whenever possible.

## Observer Skill

The observers responsible for bird identification should be able to identify essentially all raptors (in all plumages) that pass by close enough for a good look, and some target proportion of more distant birds. Standards should be high enough to ensure that identifications are accurate and that the proportion identified is high enough to provide a good sample, but not so high as to exclude all but the most exceptional observers. We recommend, as a rule of thumb, that observers be able to identify to species at least 90% of migrating raptors at the site on any given day. As noted in the previous section, counts will be more consistent if exceptionally skilled observers share or rotate duties with other observers. When possible, watchsites should provide training opportunities to ensure a good supply

of future counters. Allowable optical equipment and its use also should be standardized. Typically, hawk watches call for use of binoculars with ≤10× magnification for scanning and most identification, whereas telescopes should be used only to verify identification of and count individuals that already have been detected. Watchsites also should strive for consistency in the quality of optical equipment used.

### What to Record

Instructions should stress that every raptor detected should be reported, even if it is not identified. There are techniques for including unidentified individuals in analyses, and if they are not reported, volume of migration will be underestimated. Daily report forms should include options for reporting numbers of unidentified falcons, accipiters, buteos, eagles, kites, vultures, and raptors, as appropriate for the site.

Observers should be given clear guidelines for excluding from counts birds that are not migrating past the site (local residents, or migrants that are milling around rather than moving past steadily). One way to do this is to tally only those individuals moving past some fixed reference point along the direction of expected migratory flow. At watchsites where large numbers of migrants may turn back after appearing to move past the site (as occurs at some sites at the edge of water barriers), it may be best to make counts of birds moving past the reference point in the direction opposite to the main migratory flow. Although hourly counts recorded on official data sheets may be the difference between these two figures, field tallies of the original numbers passing in each direction should also be retained. These data are interesting in themselves for research purposes, and analysts looking at population trends may wish to treat the data differently than has been recorded in hourly totals. If this is done, there should be a separate, dated tally sheet, designed for easy and unambiguous recording of the numbers going in each direction each hour.

Age and sex of raptors can be determined in some species, and such data are valuable for interpreting population trends and for research. Because age and sex classes may differ in timing of migration, samples should be taken at regular intervals throughout the season. In some circumstances, every individual of a species may be aged and sexed. For species that are more difficult to identify or more abundant, instructions might call for age, sex, or both to be recorded only during special, short-term counts, such as for 10 min each hour, or for one particular hour of the day or day of the week. These special tallies should be conducted on a regular schedule throughout the season (e.g., daily or every second day).

When numbers of migrants are too high for exact counts, clear instructions should be given to counters on how to record estimated

numbers, such as counting small groups of estimated size instead of individuals (e.g., count groups of about 5 or 10). Hand-held tally devices help in rapidly counting large numbers. When an estimation is very inexact, observers keeping field notes should not record the lowest possible number (e.g., "100+") but should record the probable range (100–150). When tallies are added to produce the official hourly total, use the middle point of each probable range (e.g., 125 for a range of 100–150, or 300 for a range of 100–500).

At some watchsites, regular passage of diurnal migrants other than raptors—such as waterbirds, various small birds (e.g., hummingbirds, jays, finches, swallows) or even dragonflies and butterflies—may occur. Some of these species may be regular and abundant enough for trend analysis. If organizers want these data collected, they should select species that can be easily identified and counted without distracting from raptor counts, provide instructions to observers, and add the species to the field data sheets. Better yet, recruit additional observers to count non-raptor migrants.

It greatly aids analysts if daily weather variables are recorded at the site and are included as part of the database. Important weather variables include wind speed and direction, precipitation type and duration, cloud cover, visibility, barometric pressure, and temperature. Daily report forms should provide for entry of the required data. Instructions should indicate when measurements should be taken (e.g., many sites do this at the start of each hour) and should clearly specify equipment and procedures to be used.

## Watchsite Location

The locations of most watchsites are selected because they are accessible and are known to have good raptor flights. That said, it will be easier to sustain observations over many years if other factors also are considered before a watchsite is established. The recommended minimum duration for contributing to trend analysis is 10 years (Hussell and Ralph 2005). Assurance of long-term access by counters is an important attribute, and count organizers should negotiate long-term access agreements with public and private landowners. Sites that are relatively close to populated areas and readily accessible to counters will be more likely to have a steady supply of volunteer personnel, which contributes to sustainability. Remote sites may be needed to ensure adequate regional sampling of migrant populations, but it is more likely that personnel will have to be hired and accommodations provided to ensure long-term coverage.

At many sites, flights can be observed from multiple lookouts, and it is important to fix the official lookout location once it has been selected, even though more birds may be seen on certain days from a different viewing

site. To promote long-term consistency of counts, factors to consider in selecting an official watchsite should include the following:

- The field of vision should be such that growth of vegetation near the viewing point will not obscure the view over time. Building an observation tower when the watchsite is established can help reduce this concern.
- It should be possible to control visitors from distracting official counters and to avoid extra people contributing to the count. An observation tower or platform for official counters may be useful for this purpose.
- The site should have adequate room for safe and comfortable seating for observers.

### Number of Official Lookouts at a Given Watchsite

Some watchsites have several observation points from which counts could be made. There are two sets of circumstances in which multiple lookouts can be used as part of the standard protocol.

One involves the case in which the birds counted at each lookout are fairly certain to be different individuals. Assuming that sufficient personnel are available, each lookout can be operated as an independent watchsite, with each following its own standardized protocols (which can differ between lookouts) for daily coverage. Data from these sites can be analyzed separately or combined for a pooled, multiple-site analysis. The data from each site are equally valuable for trend analysis, regardless of relative numbers of migrants detected. If there are not enough personnel to cover both sites according to recommended standard protocols, one of the lookouts should be selected as the site of the official count, and any secondary lookout should be staffed as an optional extra when there are personnel available. Data collected at optionally-covered secondary lookouts will be unsuitable for trend analysis. Personnel should understand this, and staffing of secondary lookouts must not diminish coverage at the official vantage point.

A second circumstance involving multiple lookouts occurs when a significant proportion of the birds counted at each of two observation points is likely to be seen from both points. In this case, double-counting should be minimized by establishing a dividing line, with personnel at each point recording only those birds on their side of the line. The task is made easier by choosing a line marked by physical features visible from both observation points. Once established, the line should not be altered. If desired, counters can communicate by radio to discuss who should count individual birds close to the dividing line. This technique, if used, must be part of the standard protocol of the watchsite and must not be used intermittently.

At several existing watchsites, one of two observation points is used on each count day, the choice of which point to use depending on weather (mainly wind direction). This is not a recommended procedure, and counts from such sites may be unacceptable for analysis of long-term trends.

Whenever there are sufficient personnel to staff more than one observation point, consideration should be given to setting up a new, more distant site, rather than adding another site close by. Doing so will contribute more to understanding of regional population change.

## Field Protocols

A key factor in ensuring consistency is to have a carefully written protocol with complete instructions on how the counts are to be conducted at the particular site. It is best to keep this separate from other materials that are provided to counters. For example, if trapping and banding takes place at the station, there should be a separate protocol for each aspect of the operation (see Ralph et al. 2004 for recommendations on running a trapping operation for the purpose of population monitoring). Similarly, detailed information on identification tips (species, age, sex, morphs) and other general information on hawk watching unrelated to the specific site, and procedures for observer training, should be put in separate documents. Separating materials will help focus the attention of the reader on the important aspects of the topic at hand (i.e., maintaining consistency of methods at a particular watchsite), rather than on other items of importance (e.g., personal safety, how to band trapped raptors, etc.).

The overarching goal is to have a document that can be given to a qualified hawk counter who has never visited the site, with instructions complete enough to ensure that, without further guidance, that person can conduct counts consistent with all previous work.

A good protocol document should contain the following elements:

- A brief statement of the purpose of the watchsite, emphasizing the need to adhere to standards laid out in the manual to ensure that the counts can be used for trend analysis.
- Location (including precise geographic coordinates and photographs) and instructions for getting to the site.
- A map of the watchsite (with indication of scale and direction of north) showing the exact location of the official lookout(s) and identifying common landmarks and distances to those landmarks used in quantifying visibility or communicating among observers about the location of migrants.
- Details regarding dates of operation.

- Start and end time of the standard daily count period (specifying time zone and daylight or standard time), and instructions for reporting time (with all details) on each daily report form (e.g., 9 a.m. EDT, or 0900 EDT).
- Instructions for recording data collected outside of standard periods.
- Number and required skill of observers.
- Instructions and schedules for rotating observers.
- What species should be counted (including non-raptors), and guidelines for dealing with probable nonmigrating individuals.
- When and for which species to record age, sex, and color morphs.
- If useful as an aid to observers, brief descriptions of standard flight lines and behavioral patterns of migrants passing through the site, emphasizing variations in relation to different wind and other weather conditions (place in separate document or in an appendix if lengthy).
- Instructions on recording estimated numbers (place in a separate document or in an appendix if lengthy).
- Instructions for filling in all data forms, with quick reference keys to all codes used.
- Instructions for collecting and recording ancillary data, such as weather variables, rare-species reports, height of migration, etc.
- Guidelines for interrupting or ending counts before the standard period is completed, for determining when it is acceptable to skip complete days of observation, and how to report gaps (regardless of length or cause) on daily report forms.
- Required and allowed equipment, including that used for recording weather.
- Instructions on how to reduce visitor impacts on counts.

In an appendix or separate document, add brief miscellaneous instructions, such as where to park at the site, location of nearest restrooms, emergency numbers, what personal items to bring, where to get data forms and what to do with them after the count, duties of observers with respect to site-maintenance, and general safety and injury procedures. Each year, a copy of the field protocol should be labeled with the year and safely stored as a record of the way the operation was run that year. Any changes to protocols or instructions (see below) should be added immediately to the written document, not only to keep observers abreast of change, but also to ensure that there is a complete annual record as to how the station was operated. Analysts working with decades-old data usually have no other way to learn how the counts were conducted. Data on changes at the site, such as periodic dated photographs showing the view in 360º from the lookout(s), are also helpful to analysts.

## Changes to Protocols

On occasion, there may be a good reason or an unavoidable need to change the protocol; for example, if the lookout has become untenable and must be moved, if a tower is needed to reduce visitor interference, or if there is a need to increase or decrease the number of people working together on official counts. Such changes can seriously compromise the value of the data set for long-term monitoring, effectively ending one data series and starting a new one.

To ensure that pre- and post-change data can be combined as a single, long-term data set, it is essential that the old and new protocols be used on alternate days (or, better yet, run simultaneously) for at least one and preferably for two or three seasons. If the two protocols are run simultaneously, great care must be taken to ensure that the data are collected independently by the two procedures (i.e., each protocol should be run as though the other were not being done, and without communication among personnel involved in each). Each count form must have a notation on which protocol was used for collecting the data recorded there. Using this phase-in procedure allows the effect of the protocol change to be modeled in analyses, which allows the population signal to be separated from the effect of the change in methods.

## Field Forms

In addition to having instructions in a written protocol, it is important that data forms be unambiguous, so that observers will not vary in what they record. This is yet another factor that contributes to consistency in the data set. Keys to codes used for recording weather or other extra data, estimated numbers, etc., should be printed on the forms or on a weather-proof page for posting at the field site.

## Conclusions

No watchsite can run a program that will be perfectly free of variation in effort and observer skill. However, it is quite feasible to collect data in a standardized, consistent manner that will greatly increase the value of the data for tracking population change and contributing to research and conservation objectives. Doing so can enhance the satisfaction of participants, whose pleasure comes not only from observing raptor migration, but from knowing that their extensive time commitment and careful recording has produced data that can be put to good use.

## Literature Cited

Bibby, C. J., and S. T. Buckland. 1987. Bias of bird census results due to detectablity varying with habitat. Acta Oecologica 8:103–112.

Dunn, E. H. 2005. Counting migrants to monitor bird populations: State of the art. Pages 712–717 *in* Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference, vol. 2 (C. J. Ralph and T. D. Rich, Eds.). U.S. Department of Agriculture, Forest Service General Technical Report PSW-GTR-191, Pacific Southwest Research Station, Albany, California. [Online.] Available at www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/712-717.pdf

Farmer, C. J., D. J. T. Hussell, and D. Mizrahi. 2007. Detecting population trends in migratory birds of prey. Auk 124:1047–1062.

Hussell, D. J. T., and C. J. Ralph. 2005. Recommended methods for monitoring change in landbird populations by counting and capturing migrants. North American Bird Bander 30:6–20.

Lewis, S. A., and W. R. Gould. 2000. Survey effort effects on power to detect trends in raptor migration counts. Wildlife Society Bulletin 28:317–329.

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

Ralph, C. J., E. H. Dunn, W. Peach, and C. M. Handel. 2004. Recommendations for the use of mist nets for inventory and monitoring of bird populations. Pages 187–196 *in* Monitoring Bird Populations Using Mist Nets (C. J. Ralph and E. H. Dunn, Eds.). Studies in Avian Biology, no. 29.

Thomas, L., G. R. Geupel, N. Nur, and G. Ballard. 2004. Optimizing the allocation of count days in a migration monitoring program. Pages 97–111 *in* Monitoring Bird Populations Using Mist Nets (C. J. Ralph and E. H. Dunn, Eds.). Studies in Avian Biology, no. 29.

Thompson, W. L. 2002. Towards reliable bird surveys: Accounting for individuals present but not detected. Auk 119:18–25.