Recommended Protocols for Monitoring Impacts of Wind Turbines on Birds

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Environment Canada
Canadian Wildlife Service

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prepared by
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Environment Canada

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Introduction

Uses of this document

To fulfil the requirements of a federal environmental assessment (EA), the proponent of a wind-powered generating station (whether a large wind energy installation or a single turbine) may be required to gather baseline information on the birds that use and move through the area to be developed, and to provide follow-up information on the actual impact of the installation on the birds of the area (for more details see Environment Canada's *Wind Turbines and Birds: a Guidance Document for Environmental Assessment*, available at: http://www.cws-scf.ec.gc.ca/publications/eval/index_e.cfm).

The current document has been developed to provide proponents with information on the types of protocols likely to be useful for baseline studies and follow-up monitoring at proposed wind energy sites to evaluate impacts of wind turbines on birds.

However, proponents should not use this document on its own without consulting biologists from the Canadian Wildlife Service of Environment Canada (CWS). The most appropriate protocols for a project depend on the particular location and the risk factors at that location. Only some of the protocols in this document are likely to be required at any given site; conversely, some circumstances (e.g., offshore installations) may require protocols not covered in this document.

Pre-construction monitoring typically can be completed in one year, except in areas with particularly high uncertainty such as offshore installations. However, at any site, additional monitoring may be required if inappropriate protocols are used and inadequate data are collected in the first year. This could cause delays in approval. CWS biologists, if consulted in the early planning stages of a project, can help determine which protocols are most appropriate for a particular installation, and the appropriate level of effort to invest in each, thus greatly reducing the risk that data will not be adequate for the assessment.

While only those species of birds specified in the *Migratory Birds Convention Act, 1994* (MBCA) are under federal jurisdiction, this guide suggests study methods that are suitable for gathering information on all bird species. Some protocols, particularly post-construction mortality monitoring studies, may also be appropriate for monitoring impacts to bats. Bats have been found to be particularly vulnerable to wind energy installations in some areas. However, this document does not specifically address monitoring requirements for bats, and in particular does not address pre-construction monitoring for bats. Proponents are reminded that bats and all non-MBCA bird species are under provincial or territorial jurisdiction; the protocols suggested in this document are not meant to replace information provided by provincial or territorial authorities. Proponents are urged to contact the relevant provincial or territorial authorities to determine what requirements or expectations they may have with respect to bat monitoring pre- or post-construction.

Field data collection

It is very important that field workers hired to perform surveys outlined in this document are skilled at identifying birds by song and call and by sight. This requires knowledge of all the bird species that might be found in any particular habitat and the skill to identify individual bird songs from a chorus of mixed-species bird songs. Generally, if a person is a regular participant in the annual Breeding Bird Survey (a continental bird survey programme administered in Canada by the CWS) or any other national bird survey programme that requires an equivalent or better ability, and is familiar with birds in the region where the survey is being undertaken, then he or she is probably capable of undertaking this work. Proponents are responsible for ensuring that field staff carrying out bird surveys have adequate skills.

If a skilled field worker familiar with songs is not available, it may be possible to use electronic recording devices to record bird songs for later analysis. This approach has been adopted by a number of monitoring programs, including the Alberta Biodiversity Monitoring Program and is described in further detail under "**microphone point counts"** in Appendix 1. With present technology, this still requires a person skilled in identifying bird songs to do the final identification, but the interpretation can be done outside of the breeding season when field experts may be more readily available, and does not require the expert to travel to the field site. A field worker must still be available who is able to identify birds visually for surveys of species that are rarely detected by song, such as waterbirds or raptors, or for surveys outside of the breeding season when most birds are not singing.

Using the same field workers to carry out the pre-construction baseline studies and the follow-up surveys is recommended as a means to help standardise comparisons. Even a highly skilled observer will not manage to detect every bird that is singing at the same time, and the proportion of birds detected varies among observers. As a result, many trend analysis programs, including those for the Breeding Bird Survey, only analyse trends in data collected by the same observers. Proponents should be aware that the personnel used by a contracting company may vary from year to year, and that using the same company does not guarantee the same personnel. Furthermore, despite initial intentions, it may sometimes happen that the same personnel are not available for follow-up surveys.

For this reason, it is desirable for field work to include a means of estimating detection probabilities or observer validation in the protocols. For surveys based on bird songs (such as point counts), one way to do this is to make recordings of some or all of the point counts using appropriate equipment, and have the recordings analysed independently (see **microphone point counts** in Appendix 1). Digital copies of any recordings should be submitted with the EA and deposited with the monitoring database (see next section) along with appropriate documentation on the date, time, location, weather conditions, and equipment used. These can later be interpreted by one or more additional experts if it is necessary to compare observers.

This is most likely to be a concern if the site contains habitat that supports significant numbers of breeding songbirds. CWS biologists can advise whether this is likely to be the case.

Reporting requirements

Proponents are required to include the results of pre-construction surveys in their Environmental Impact Assessments. Post-construction survey and monitoring results are required to be written up and submitted to the CWS as part of follow-up.

Proponents are also asked to make available raw survey data from standardized protocols for both pre- and post-construction monitoring. The Canadian Wind Energy Association (CanWEA) and the CWS are collaborating to develop a database for the collection of bird-related data from Canadian wind energy projects, particularly for data collected using protocols recommended in this document. This national database will be used by CWS researchers to increase understanding of environmental effects of turbines on birds including the potential for cumulative effects related to habitat displacement or direct mortality. The results of these analyses will be particularly valuable for informing future monitoring requirements, in particular determining which monitoring data are most useful for predicting impacts (by comparing pre- and post-construction data), and Environment Canada will also use the results to update these protocols and the companion document *Wind Turbines and Birds: a Guidance Document for Environmental Assessment*, to make the EA process as efficient as possible. Analyses can also provide information on potential mitigation measures if significant adverse impacts are detected.

Provisions will be made to ensure that proprietary interests are protected for all data submitted. While it is desirable to provide some results for the public, this will be at a very general level, to protect the concerns of individual proponents. Any released data will not be linked to particular projects and will not provide sensitive information without the consent of the proponent.

Normally, data from pre-construction baseline studies would not be deposited into the shared database until after EA approval and the start of construction, even though the results and data are required to be a part of the information submitted through the EA process[1]. Post-construction raw data and results should be deposited annually into the shared database and thereby reported to the CWS.

During the initial development phase, provision of data to this database by proponents will be on a voluntary basis, though it is hoped that most companies will participate. Once the database is fully operational and all parties (CanWEA, CWS and industry) are satisfied that it meets their needs for information storage and security, then it may become an expectation of EA approval that all companies would submit their data. Proponents may want to consider including data entry into the database as part of the contracted requirements of the company or persons hired to perform the studies.

[1] This database will not be ready until the middle of 2007. In the meantime, proponents should retain all their raw data so that they can be entered in the database once it is available.

Pre-construction (baseline) sampling methods

This section provides an overview of the types of sampling that might be expected pre-construction as part of the Environmental Impact Assessment process. For sampling methods highlighted in **bold**, further details on protocols are given in Appendix I.

Note that the amount of sampling required will vary considerably among sites, depending on the size of the site, the nature of the habitats at the site, and the numbers and species of birds expected, as reflected in the Level of Concern scores (see Environment Canada's *Wind Turbines and Birds: a Guidance Document for Environmental Assessment* for details on the Level of Concern scores). For some sites, very little sampling will be required. As noted in the introduction, proponents should consult with the CWS prior to commencing surveys to determine the appropriate choice of protocols and level of effort.

Breeding season

Breeding season surveys should be designed to determine which species regularly use the area for nesting, for foraging during the breeding season, or for raising their young, and to obtain measures of abundance of bird species using the area. Such data will be used to predict the potential impact to breeding birds of developing turbines on a site and (when combined with post-assessment monitoring) to quantify the actual impact, if construction proceeds, in order to test the predictions.

Area searches are an effective means for developing a species list for a site. This method involves visiting all of the different habitat types in an area, at various times of day and year when different species are most readily detected. A list is kept of all bird species encountered, preferably with an estimate of numbers and information on any breeding evidence found (e.g., nests, carrying food, territorial behaviour, etc.). This is essentially the same approach as is used for regional Breeding Bird Atlases which have been used to map the distribution of breeding birds in several provinces of Canada (for example, see the Ontario Breeding Bird Atlas guide to participants available on: http://www.birdsontario.org/atlas/atlasmain.html). In its simplest form, an area search does not require standardized effort, although the amount of effort should be recorded.

Quantitative estimates of bird abundance can involve a variety of protocols. For most songbirds, the most widely used method involves **point counts**. For monitoring turbine sites, 10-minute point counts are recommended, spread through the project area. For projects with more than 10 turbines proposed, this would normally require at least 20 point counts in each major natural habitat type; this can be scaled back for small projects (< 10 turbines) or if the area of natural habitat likely to be affected is small. Point counts should be repeated twice over the course of the breeding season to ensure that both early and late breeders are detected. Some bird surveys involve shorter point counts (3 minutes or 5 minutes) but those are generally more appropriate for large scale surveys (e.g., province-wide) rather than for specific sites of interest such as wind energy installations. Because of minimum spacing requirements between point count

stations, 20 stations may not fit within either the entire project area or within a particular habitat type, in which case the sampling can be reduced accordingly. Particularly if the project involves any potentially important habitats for songbirds, it is highly recommended that at least some of the point counts be concurrently recorded using microphones and digital recorders so that later analysis of recordings can be used to adjust for variation among observers (see section on **microphone point counts** for more information on benefits and limitations of this approach).

For surveys involving birds not readily detected by song (such as waterfowl or shorebirds or birds on migration), an alternative quantitative measure is a **standardized area search.** This involves selecting a particular area (which may be the complete study area or carefully selected smaller plots) and recording all individuals of each species encountered during a standardized visit. This is most effective for species readily detected visually (such as waterfowl or shorebirds) or if the study area is relatively small. A variation on this method involves **line transects** which can be of either fixed width or variable width.

Colonial species often require special survey methods to count, or estimate, the total number of nests in the colony. However, contractors should be aware that many colonial waterbirds are quite sensitive to disturbance, and it is usually inadvisable to enter colonies during the nesting season. If a waterbird colony is present at the site (e.g., gulls, terns, herons, cormorants, seabirds) the contractor should make a rough estimate of numbers without actually entering the colony and then contact the CWS for advice on how to proceed. The appropriate advice will depend on the location of the colony, the area it covers, the species present in the colony, and the estimated number of birds in the colony.

For some secretive bird species, such as marsh birds and some raptors, especially owls, **playback methods** may be required to determine presence/absence or to estimate numbers. These involve playing recordings of the birds' territorial calls at the edge of suitable habitat during the appropriate time of day and year, and listening for a response. In most cases, such surveys can be qualitative, to determine presence or breeding evidence, unless the project area includes a large wetland or important habitat for a species at risk that is difficult to detect. In that case, a more quantitative survey may be recommended: contact the CWS for more details on designing a study to suit a particular area.

Non-breeding season

Areas that contain habitats that may be important for migrants as stopover sites or wintering areas should be surveyed to determine whether they support large numbers of birds in these seasons. Some areas may also have high concentrations of birds flying through them, in which case there is a concern whether they may be flying at heights comparable to the blades of the wind turbines. Depending on the habitats present in an area, the geographic location of the area, and prior knowledge of when birds travel through the general area, this may involve surveys during both spring and autumn migration as well as in winter.

Passage migration
Birds flying through the project site on migration may be at risk of colliding with turbines. **Passage migration counts** are done to determine the number of birds flying through or over an area. Quantitative monitoring of passage migration will normally only be required if there is particular reason to believe migration will be concentrated at a site (e.g., large numbers of migrants known to pass through, wind energy installation is on a ridge top or within mountain passes, or data from similar areas elsewhere suggest migrants may be concentrated). For diurnal migrants, such as raptors, some songbirds, or some waterbirds, this can involve standing at a suitable vantage point and recording the numbers of each species passing by, taking note of whether they are flying through areas where turbines are proposed to be built. Many songbirds, as well as owls and some waterbirds, migrate mainly at night. Full quantification of nocturnal migration typically requires **radar** but an index of migration activity can often be obtained by **acoustic monitoring**.

Migration rates vary considerably from one day to the next, depending on weather conditions, so fairly intensive surveys (several days per week) are required to get a quantitative understanding of migration at a site. If daily coverage is not possible then efforts should be concentrated on days when weather conditions are favourable for large-scale migration. Information on migration volume, derived from analyses of weather radar data may help to calibrate local studies.

Migration stopover
For quantitative surveys of stopover use, a variation on an area search called a **stopover count** is usually recommended in which one or more standardized transects are walked, and all birds seen or heard within a specified distance of the transect are recorded. The distance should be chosen such that birds can be readily identified within that distance, and will not be counted twice from different transects or different parts of the transect. In some areas or for some species (e.g., birds), it may be appropriate to also count birds beyond that distance. Transect(s) should be selected to sample all major habitats present on the site. Time of day and time of tide (for coastal areas) should be standardized to the time when birds are most readily counted. For songbirds, early morning is generally preferable, although raptors may be more readily detected later in the day.

In most cases, these surveys should be made approximately once a week throughout the spring and autumn migration season. In some circumstances, it may be necessary to modify this protocol to involve more intensive (e.g., daily) surveys during peak migration periods for particular species of concern.

If significant concentrations of birds are present (such as migrating raptors or large flocks of waterbirds), **behavioural studies** should also be undertaken to assess whether the behaviour of birds using the area leads to a risk of collision with turbines. One approach, sometimes called a watch count, requires the observer to be stationed

at a particular vantage point and to count the number of times birds move through potential turbine locations or other areas of concern.

Overwintering
Counts during the winter (e.g., November to March) should be carried out if the habitat characteristics lead to an expectation of, or if there is a history of, significant use of the area by overwintering birds (e.g., songbirds, raptors, waterfowl). **Standardized area searches** are the most effective survey methods, using protocols similar to those recommended for migration stopover studies. As with migration stopover studies, if significant numbers of birds are present, searches should be complemented with **behavioural studies** to determine whether birds flying through areas will be within the future blade-swept area if turbines are built.

Winter visits should be done once or twice per month to estimate numbers of birds using an area, although more frequent visits may be needed for behavioural studies in areas with known concentrations of birds.

Offshore locations

At offshore locations, specialized survey methods may be required. Although there is some concern about direct mortality from turbines, the greatest problem, at least based on the European experience, appears to be displacement of seabirds from areas that may be important for feeding or commuting. This could potentially have population level consequences if large portions of a population are excluded from high quality habitat or forced to fly much longer distances around a site. Surveys must be designed to assess usage of the area throughout the year, for commuting, migration and foraging. In addition to monitoring bird activity, this may require monitoring of food supplies. Appropriate survey methods may include shipboard line transects, platform-based observations, and radar monitoring. The preferred combination will depend upon how much is known about the area and what risks are anticipated. Given limited knowledge about most sites, two years of pre-construction monitoring may be necessary to assess annual variation. Because offshore wind energy installations have not yet been developed in Canada, standard guidelines are not yet available on the amount of monitoring required—this will need to be determined on a case by case basis. Once further experience has been obtained, standards for these surveys will be included in future updates to this document. Whichever methods are chosen, data should be recorded in a standardized fashion for that method, as described below, to ensure the data can be compared with results from other locations, and stored in the standardized database.

Bats

There is increasing evidence that some wind energy installation, even in agricultural settings, can intercept and kill large numbers of bats. As a result, it may be important to monitor prospective wind energy installation sites to determine whether any of the sites present an elevated risk for substantial bat mortality.

Bats fall outside of federal jurisdiction unless they are a species at risk, and proponents should contact the relevant provincial or territorial wildlife department to determine what requirements they may have for monitoring of bats or bat activity. Several provinces are in the process of developing written guidelines. Links will be provided to these documents as they become available. Alberta has completed a document:

Lausen, C. E. Baerwald, J. Gruver, R. Barclay. March 2006. Bats and Wind Turbines. Pre-siting and pre-construction survey protocols. Appendix 5 *In*: Vonhof, M. 2002. Handbook of Inventory Methods and Standard Protocols for Surveying Bats in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, Alberta. Revised 2005.

Information on obtaining this document is available at http://www.srd.gov.ab.ca/fw/bats/ABAT.html.

Some of these protocols may also be relevant in other jurisdictions, but this must be determined in consultation with the relevant authorities.

Some monitoring techniques relevant for birds will also provide information on bats, especially **radar monitoring** and post-construction **carcass searches**. These are mentioned under the respective sections outlining those techniques.

Overview of post-construction follow-up studies

This section provides an overview of the types of sampling that can be expected post-construction as part of the Environmental Impact Assessment process. The precise requirements will be determined as a condition of the approval process. For sampling methods highlighted in **bold**, further details on protocols are given in Appendix 1.

Breeding season

At sites that support reasonable densities of native breeding birds (as demonstrated by pre-construction assessment), follow-up monitoring should be undertaken using the same techniques to those used during pre-construction assessment. The purpose of these surveys is to determine the consequences of the turbines to species diversity, to evaluate the predictions made during the EA process, to evaluate the cumulative effects of the industry on bird diversity and numbers, and to detect significant changes in numbers at single sites. If baseline studies indicated a very low level of native bird diversity and numbers (as might be expected of installations within industrial parks or intensive row crops), then follow-up breeding season studies are unlikely to be required. This should be determined through consultation with the CWS.

If post-construction surveys are required, then normally at least two or three years of breeding season surveys would be needed to differentiate any possible effects of the turbines from natural year-to-year variation, and to separate short-term from long-term effects. In areas of lower concern, it may be appropriate to start these surveys the second year after construction, and limit surveys to two years. If results appear to be significant, but vary substantially among years, then in some cases additional surveys

may be requested to consider longer term effects (e.g., repeat surveys 5 or 10 years later). Breeding season surveys are not especially onerous, and could be expected to require no more than 4-10 person-days of field work each year, except on very large sites.

Non-breeding season

If baseline studies during the non-breeding season suggest that the area is important for birds at these times of the year (determined through consultation with the CWS), then similar studies to those performed in the baseline work should be repeated to gauge the consequences of the turbines' presence on birds during these times.

Carcass searches

Carcass searches are important, even on sites determined to be of a low level of concern, to evaluate the correctness of the predictions, and to test for the possibility of unexpected risk factors. For example, on some sites where pre-construction surveys suggested a low-risk area, there nevertheless was substantial unanticipated mortality observed for bats.

As a minimum standard, 6 to 8 weeks of carcass searches during the spring migration period and 8 to 10 weeks during the fall migration period should be planned for. At sites with a low level of concern, one year of data would normally be sufficient, but at sites in the highest levels of concern, two or three years of monitoring might be required. These requirements may be extended if substantial mortality is observed, particularly to evaluate any mitigation measures that may have been introduced. If turbines are in areas that support significant breeding or wintering populations of species with an elevated risk of mortality from turbines (e.g., raptors or Species at Risk with aerial displays), then carcass searches may be required during the breeding season or in winter.

Collision studies

In some areas (offshore, bogs, marshes, etc.) carcass searches are impossible or highly impracticable, and alternative methods for estimating collision mortality may be required. **Radar** has been proposed as one approach. Another approach combines microphones attached to turbines (to detect the sound of collisions) with infra-red video (to identify the species colliding). Protocols for such techniques have been developed in Europe, but have not been widely tested. As a result, an overview of these approaches is included here, but proponents requiring these approaches will need to develop an appropriate protocol, in consultation with the CWS. Proponents constructing a wind energy installation in an area that would require radar-based or other technological approaches to estimating collision rates should be aware that the costs of post-construction monitoring may be significantly higher than in areas where carcass searches are possible.

Appendix 1. Details of selected sampling protocols

This Appendix provides further details on some of the sampling protocols that are likely to be appropriate for bird monitoring in the context of wind energy EA.

Note that, whichever sampling methods are used, a complete written field protocol describing the exact sampling methods should be provided as part of the documentation and reporting. This documentation should include precise coordinates of all locations surveyed (preferably from GPS).

Area searches

- Area searches are intensive searches with the goal of finding as many bird species as possible present in an area and providing very general information on bird abundance and status.
- Area searches must be undertaken by a qualified biologist or contractor skilled at recognition by song (during the breeding season) and by sight (at all times of year) of all bird species likely to occur in an area.
- The minimum searching effort for obtaining a list of breeding species in an area would normally be a few hours for a small wind energy installation, ten or more hours for a medium wind energy installation, twenty or more for a large, and more than twenty for a very large wind energy installation (for details on what constitutes a small, medium, etc., wind energy installation see Environment Canada's *Wind Turbines and Birds: a Guidance Document for Environmental Assessment*). For very large wind energy installations, a useful rule of thumb is to determine, from bird range maps or breeding bird atlas data, combined with habitat information, the number of species that might be expected in the area. Searching should continue for at least 20 hours, or until at least 80% of the expected number of species have been found (on the assumption that remaining species are probably present in very low numbers).
- For breeding season studies in areas with a variety of natural habitats, multiple visits increase the chances of detecting species that breed early or late in the season. Searches can be made more efficient by concentrating at times of peak bird activity (early morning for most songbirds, late morning or early afternoon for soaring raptors, early evening for owls and other nocturnal species).
- The procedure is to search through all the main habitat types in the area and record all birds seen and heard and to estimate the number of individuals detected on each visit. In addition, for breeding season studies, any evidence of breeding should be recorded.
- Data recorded should include:
    - The level of effort for each visit (date, start time, finish time, hours of searching, and some measure of the area searched, such as the distance covered, or a map of the area that was searched).
    - A complete list of species detected on each visit/each day.

- If possible (especially for standardized searches–see below), an estimate of the number of individuals actually detected (by sound or by sight).
- For breeding season surveys, data on any breeding evidence detected, using standard breeding bird atlas codes (Appendix 2).
- A basic description of the habitats covered.
- These data should be retained for entry into the database.
- In addition, summary data should be calculated for the EA report that indicate all species detected at each season, with estimates of peak numbers, and total sampling effort.

Standardized area searches

- Standardized area searches are a quantitative variation on an area search in which the area being searched and the search effort are strictly standardized and the number of individuals of each species detected during the sampling period is recorded to provide an index of abundance.
- For recording songbirds during the breeding season, especially in forested habitats, these are harder to standardize than **point counts**. However, they may be the best available option for counts outside the breeding season, for sampling species that are not readily detected by song, or when surveying sites that are too small to fit more than a few point counts.
- Usually these involve sampling only a portion of the study area, unless the study area or the particular habitats of concern (e.g., wetlands or tidal mudflats) can all be sampled on a single survey session. One variation on standardized area searches is a fixed width transect, in which a route (transect) is selected, and all birds within a fixed distance of the transect are recorded. The appropriate transect width depends on habitat and species of interest: for songbirds in heavily vegetated areas, few birds are detected more than 100 m away; for raptors or waterbirds in open areas, birds may be detected and identified at distances of 1 km or more with good optical equipment. Square, circular or rectangular plots up to 1 km^2 have also been used in various circumstances; the area(s) to be surveyed can be any shape, provided that the shape is clearly documented, the effort is standardized, and the same areas are surveyed on each occasion.
- Data recorded should be the same as for other area searches (see above).

Line transects (distance sampling)

- A line transect is a form of distance sampling which, if assumptions are met, can be used to provide density estimates.
- The most important assumptions are that transects are placed randomly with respect to habitat, that distance between the transect line and the bird can be accurately estimated, that all birds very close to the transect are detected, that the birds do not move before being detected, and that they are not counted more than once.
- Random placement of transects is usually only possible in fairly uniform areas. In terrestrial habitats, this is most likely to be possible in grasslands or low shrub areas, but can also sometimes be done in forested areas.

- Line transect sampling can be a particularly useful technique for shipboard surveys in marine environments (but distance sampling methods can not be used to estimate density for water bird surveys conducted from a beach or shoreline, because the distribution of birds with respect to the coast is usually not random).
- Transects may be any length that can be conveniently surveyed within the optimal survey times (which would be early morning for songbirds, but may be more flexible for marine birds).
- This method involves travelling along the transect at a fairly uniform speed, and recording the shortest (perpendicular) distance from the transect to the position where each bird was first detected (note that this would normally be less than the distance between the observer and the bird).
- Data can be grouped into distance categories (e.g., 25 m distance bands), but if possible, it is preferable to estimate actual distances. If necessary, these can always be grouped during data analysis. If birds are present in flocks or groups, then the distance to the centre of each flock should be recorded, along with the estimated number of birds in the flock.
- The position of birds along the transect should be recorded as well, usually by dividing the transect into segments, and recording which segment each bird was observed. Segments could be from 100–500 m long depending on the total transect length and range of habitats traversed.
- Data recorded for each transect survey should include:
    - Start location and ending location for each segment on the transect as well as the whole transect (or details, preferably in the form of a Geographic Information System (GIS) shape file, of the complete path of the transect if it is not a straight line).
    - Date, start time, and end time for each individual survey.
    - Individual records for each bird (or flock) with its distance from the transect, segment number, and flock size.
        - Alternatively, records can be kept of the total number of birds of each species in each distance band for each segment along the transect.

Behavioural studies (watch counts)

- These may be required when species at risk, raptor concentrations, or flocks of other birds are present in or around a site, to determine whether their behaviour might lead to a significant risk of mortality from wind energy installations.
- Behavioural studies are intended primarily to determine how birds are using the area, especially to determine whether they are regularly flying through areas that will be swept by blades after the turbines are built, or are using sites or habitats that will be directly affected by the construction process.
- The optimal protocols depend on the species being observed as well as the topography of the site; a customized design will be required in most cases. This design should be developed by the contractor and submitted to the CWS for review before implementation. A typical study might involve finding a suitable vantage point from which birds can be observed and recording the movements of

birds and the major habitats that they are using at different times throughout the day.

- Observations should only be undertaken at the appropriate season, on days when significant numbers of the species of interest are present in the area, and should typically be undertaken on multiple days to assess day-to-day variation in activity.
- Data recorded will depend on details of the sampling protocol but, as a minimum, should include information on dates and times when surveys were undertaken, as well as summary statistics on how often birds, and how many birds flew through potential turbine locations, whether they were flying within, above or below the blade height of turbines to be installed, and how often they used sites that would be disturbed by construction.

Point counts

- To be effective, point counts must be placed at well-chosen locations, carried out by experienced observers (unless microphones are being used to record them – see next section) and performed at the appropriate time of day in appropriate weather conditions.
- Point Count Placement:
  - Point count locations may be chosen either randomly or systematically (e.g., at regular intervals along a route) within the target habitats. If they are placed systematically, then the starting point of the route should be randomly chosen, if possible. Point count locations should be chosen to emphasize areas near prospective turbine sites as much as possible. Point counts should generally not be placed on roadsides, but it is acceptable to select a starting point for a route along an access road.
  - If the area consists of relatively large areas of homogeneous habitat, then point counts should be placed within each major habitat type, ideally with the centre point at least 100 m from the habitat edge.
  - If the project area consists of a fragmented mosaic of habitats (e.g., small fields interspersed with hedgerows and small woodlots) such that it would be hard to place many points >100 m from a habitat edge, it may be more effective to consider the whole landscape as one “habitat” and place point counts randomly or systematically within it.
  - Every major habitat type within the project area (pine forest, hardwood forest, scrub, grassland, field, etc.) likely to support significant numbers of breeding birds should be included.
  - At least 20 stations are normally required to sample a habitat adequately, spaced at least 250 m apart in forest, or 500 m apart in open habitat. These stations may be distributed among several different blocks of habitat.
  - The number of stations per habitat can be reduced if the total area of a particular habitat within the project site is too small to support 20 stations.
  - If the project is in the large to very large category (see Environment Canada’s *Wind Turbines and Birds: a Guidance Document for Environmental Assessment*) and is situated primarily in one major habitat

type, or if the habitat is very heterogeneous, then 20 stations may be insufficient to cover the breadth of the geographic area and sample the diversity of microhabitat types; for small projects, with limited areas of natural habitat, 20 stations per habitat type may be unnecessary – contact the CWS for guidance on sample size in all of these cases.

- Once station locations have been selected, they can be grouped into routes in a way that allows for maximum efficiency of visits – it is not necessary to visit all stations for a particular habitat type on the same day.
- Post-construction monitoring seeks to assess the impact of turbines on bird abundance and distribution.
    - Two alternative designs for point count placement can be considered:
        - One approach is to survey the exact same locations as were surveyed during pre-construction. This approach gives information on the overall, landscape-level impact of the turbines, but less information on the specific impact of the turbines.
        - Another approach is to select new point count locations in relation to the turbines (e.g., points close to turbines, 250 m away from turbines and 500 m away from turbines). The number of points and number of turbines sampled would depend on their configuration and on the diversity of habitats in which they are located. Stations should be selected so that some are downwind of turbines, based on prevailing wind direction, while others are upwind, as the noise impacts, and hence disturbance effects on birds may differ.
    - An ideal design would incorporate both approaches, by selecting pre-construction point count locations in relation to proposed turbine sites based on the above design. However, this may not always be possible for various reasons, including uncertainty at the time of the initial surveys in the eventual location of the turbines.
    - The appropriate design for a particular site should be determined at the time of EA approval, in consultation with the CWS.
    - The extent and intensity of monitoring expected will depend on the species richness and densities present in the site pre-construction.
- Each station must be georeferenced by GPS.
- The habitat within 100 m of the station should be described in qualitative terms, unless a complete habitat map for the area has been prepared and the points can be placed on that habitat map. The habitat description should incorporate summary information on habitat structure (e.g., forest, marsh, field), dominant vegetation types within the habitat (e.g., major tree species), and, for forest or shrub habitats, an estimate of stand age and average stand height.
- The habitat coding system used by the Ontario Nest Records Scheme is recommended for coding the major structural habitat types in most parts of

Canada. It is described in the Scheme's manual at http://www.birdsontario.org/onrs/instructions.html.

- Point count timing and survey conditions:
  - Point counts must be performed in the early morning during the breeding season, between dawn (one half hour before sunrise) and about 4 hours after sunrise. Later in the season, singing drops off more quickly – surveys in late June and early July should usually be completed within 3 hours of sunrise.
  - The peak breeding season varies geographically, but in most parts of Canada it extends from late May to early July. Consult the CWS for the optimal dates for a particular region.
  - Each station should be surveyed twice, once early in the season, and once later in the season (at least 10 days after the first survey at a particular station).
  - Point counts should be performed when there is as little wind as possible, because wind affects the observer's ability to hear birds. Usually, this means that wind speeds should be 3 or less on the Beaufort scale. However, in areas where the wind rarely drops below 4, even in the early morning (e.g., in some parts of the prairies or mountain ridges) this restriction may have to be relaxed.
  - It is important to always begin point counts as early as possible in the morning (but not earlier than one half-hour before local sunrise), when the wind is generally calm so that windy conditions that may arise later in the morning can be avoided.
  - Point counts should not be if it is raining unless precipitation is not more than a light drizzle (birds tend to stop singing in the rain).
  - During post-construction point counts, in some areas, the sound of the turbines may affect the ability to hear birds. If this is a problem, it may be necessary to stop turbines near the point location while the point count is being undertaken; if wind conditions are low enough for point counts, then energy production from the turbine is likely to be minimal at that time anyway. Failure to control turbine noise during post-construction surveys may lead to under-detection of birds and over-emphasis of the impact of turbines on bird communities.
  - If turbine noise is a problem and can not be adequately controlled, then the CWS should be consulted to determine whether an alternative point placement design may be feasible.
- Data recording:
  - At each station, the surveyor should listen for ten minutes, recording all species seen or heard, along with an estimate of the number of individuals of each species.
  - The surveyor should estimate the distance to each bird using a scale of 0–50 m, 50–100 m and further than 100 m. Birds that move during the survey should be recorded in the closest distance category that they entered during the survey. Distances can often be difficult to judge when a bird is only heard singing in dense habitats, in which case the observer

should provide a best estimate. This will still be valuable for differentiating birds that are close from those that are very distant.

- Data that need to be reported are the number of birds of each species detected in each distance band. It is often easiest to track individual birds if they are first mapped onto a circular diagram using a standard set of symbols, and then the number of individuals counted up afterwards.
- Birds that fly over without stopping should be recorded separately as "fly-overs".
- Additional information that should be recorded include:
  - Weather conditions (temperature, wind speed (on a Beaufort scale), % cloud cover, and presence of any precipitation should be recorded).
  - Date and time of day.
  - GPS coordinates of the point location.
  - Name of the observer doing field work.
- A sample data form is included as Appendix 3 of this document, but it is not necessary to use this form provided that all of the relevant data are recorded. Use of some sort of data form is desirable to ensure that all required data are recorded in the appropriate format, thus facilitating later computer data entry.

Microphone point counts

- Use of stereo microphones and digital recorders to record bird songs on point counts has several advantages:
  - When skilled birders able to identify all the bird songs in the region are not available, microphones can be used to record birds on the point counts, and these can later be interpreted by a skilled birder after the field season.
  - Recordings allow evaluation of observer effects, especially if there are changes in observers between pre- and post-construction monitoring. Even skilled birders differ in the proportion of birds present at a point count that they detect and it is important to calibrate among observers if the observers change.
  - In addition, if any bird songs are heard during a count that cannot be identified by the primary observer, the recordings can be compared with reference material or sent to another skilled birder for validation.
- Tests of these approaches are discussed in Rempel, Hobson, Holborn, Van Wilgenburg, and Elliott. 2005. Bioacoustic monitoring of forest songbirds: interpreter variability and effects of configuration and digital processing methods in the laboratory. J. Field Ornithol. 76(1):1–11.
- This approach has been adopted by a number of standardized programs, including the Alberta Biodiversity Monitoring Program (protocol details are available in their terrestrial monitoring methods document, available on their web site: http://www.abmp.arc.ab.ca/ReportsDocuments/Protocols.htm).
- For these reasons, especially in areas expected to have significant numbers of breeding birds (e.g., native habitats such as forest or prairie), it may be desirable to use recordings as a standard approach for point counts. This can either be

done on a subset of points, concurrently with a skilled observer, to allow for measuring observer variability or can be done for all point counts, in which case observers can be used who are less skilled in bird song identification.

- However, it is also important to be aware of some of the limitations of microphones. In particular, as described below, they are very sensitive to external noise, such as wind (especially in areas with a lot of trembling aspen), vehicle noise, etc.
- If point counts must be conducted under windy or noisy conditions (e.g., there are few mornings during the breeding season with wind speeds below 3 on the Beaufort scale, or there is substantial traffic noise even in the very early morning) then microphones may not be an effective solution.
- A variety of recording units are potentially suitable for recording point counts. The key features are that the unit should have stereo microphones with sufficient sensitivity to detect birds singing at approximately the same distance that a skilled observer would be able to hear them. Each microphone should be partially directional (to enhance the stereo effect, thus facilitating counts of the number of individuals), but between them, the microphones should have an omnidirectional pickup, so that birds in all directions can be detected.
- Recordings should be made onto a digital recorder, in either high quality format (e.g., uncompressed CD quality), or in compressed formats (e.g., MP3) which seem to be generally adequate; recordings can also be made directly to computers by connecting microphones through sound cards.
- Digital recordings have the advantage that copies are readily made, and computer software for visualizing sonograms can be used to facilitate data analysis (although, unfortunately, software has not yet been developed for reliable automated identification).
- Two companies in Canada currently produce complete packages designed for field work that meet these standards (Riverforks: http://www.riverforks.com and Environment Audio Recording Systems (E.A.R.S.): http://www.earscanada.com/). Both of their systems are designed to be weather resistant.
- However, other systems could be readily designed for less cost using separately purchased components that would have suitable characteristics. Because the actual characteristics of different systems may vary, it is important that pre- and post-construction monitoring be carried out using comparable equipment.
- Record levels should be adjusted to avoid saturation (which leads to distortion). A high pass filter should be incorporated into the system to reduce noise from very low frequencies, which usually represent environmental noise rather than bird songs (only a few species such as grouse produce low frequency sounds). If possible, a standard volume calibration tone should be recorded, to allow standardization of playback volumes.
- For recording, microphones must be mounted on a tripod approximately 1–2 m above the ground in such a way that no vegetation will rub against them. The recorder should normally be positioned a few metres away from the microphones to avoid interference, and to minimize the impact of incidental noise. The operator should check that everything is properly connected by listening through headphones connected to the system prior to the start of the point count.

- At the start of each recording, the operator should announce the date, start time, and GPS coordinates of the station, followed by “start” or something similar. At the end of the 10-minute period, the operator should announce “stop” before turning off the recording (beeps from a stop watch can serve the same purpose). This will assist the analyst, and ensure that the time period of the recording matches that of the field operator, if a standard point count is being undertaken at the same time.
- The operator must minimize making any noise during the recording. Microphones are particularly sensitive to noise from crunching of gravel, leaves or other vegetation underfoot. If the operator is simultaneously conducting a point count, it is best to stand at least 5 m, and preferably 10 m away from the microphones, to minimize noise on the recording while observing birds.
- If insect noise is a major problem on the recordings, it may help to spray an insect repellent on the wind shields of the microphones.
- Microphones are generally more sensitive to environmental noise than human ears, especially at higher frequencies. Rustling of leaves, particularly trembling aspen, as well as vehicle noise can be particularly problematic. In areas with a lot of aspens, this may require conducting recordings under lower wind conditions than would be acceptable for a human listener.
- When analyzing recordings from a stereo microphone setup, it is not possible to determine reliably the distance away from each bird, so it is necessary to group all birds into an unlimited distance category. Otherwise, data recorded for a microphone recording should be the same as those recorded for a regular point count.
- If point counts are conducted by an observer, as well as by recording, the data from both the observer and the recording should be entered separately into the database. It is very important that the recordings be interpreted by somebody who does not know (or remember) what was recorded by the observer. Conversely, the observer should NOT modify what he reported on a point count in the field based on interpretation of the recordings. Otherwise, it is not possible to use the recordings to calibrate observers, and the results will not be comparable among observers. The only exception is if an observer heard a call that could not be identified in the field, and the recording was used to determine the identity, or if an observer realizes that he/she clearly mis-identified a song, in which case the identification can be corrected.
- Proponents are responsible for analysis of all recordings by a skilled analyst and for providing data on the species detected on the recording. In future, it may also be possible to store copies of the digital recordings with the database—copies should be kept on file, on a hard drive or other storage medium (e.g., CD or DVD), for later addition to the database, and in case they are required for re-analysis for comparison with post-construction data.

Playback counts

- Playback of recordings is used primarily to detect secretive species, such as owls or marsh birds, or to obtain more information on particular species, such as

Species at Risk, where the presence of even a few individuals of a species may be of concern.

- In many cases, it is sufficient to do this qualitatively, to detect the presence of particular species, through integration into an area search protocol.
- Quantitative surveys may be expected in some areas, such as if an area contains extensive wetlands that might contain significant numbers of marsh birds. Nationally standardized protocols for marsh bird monitoring, using playback, are currently being developed. A number of regionally appropriate standard protocols exist for nocturnal owls.
- If a Species at Risk is expected in an area, the most appropriate protocols should be discussed with the CWS before initiating surveys. Quantitative playback surveys for a Species at Risk may be required if the area is known to contain significant habitat for the species – these would need to be designed in conjunction with a CWS biologist and/or the appropriate recovery team for the species.
- Playback counts involve:
    - Playback of recordings of territorial songs or calls of target species that are of particular concern and may be expected in the habitat. Each playback should be followed by a period of silent listening to detect responses. Multiple recordings may be played (either repeats of the same species, or different species), followed by silent listening.
    - Playback must be done at the appropriate time of day:
        - Early morning for most songbirds.
        - Early morning or evening for marsh birds.
        - After dark for most owls.
    - Playback should also be done at the appropriate time of year, depending on the species and region. The peak calling period for many owls can be one to two months earlier than the main breeding season for songbirds. Marsh birds tend to be most vocal early in the breeding season.
    - Playback can be attempted in any patches of habitat suitable for the target species. The appropriate spacing will depend on the distribution of habitats. For habitats that are difficult to enter (e.g., wetlands), it is usually acceptable to use playback from the edge of the habitat.
    - Unless following a protocol that has been previously approved specifically for a quantitative survey, playback of calls for a Species at Risk should be stopped as soon as the species presence has been confirmed, to minimize disturbance to the species.

Stopover counts

- The purpose of stopover counts is to estimate the abundance of birds using the project area as a stopover site on migration, whether for resting or for foraging. The optimal design of a stopover count will depend on the nature of the habitats in the area, and the types of species that might be expected.
- The usual sampling method will be a variation on the **standardized area search** methods.

- For large open area birds (waterfowl, shorebirds, other waterbirds, etc.), a route should be developed that provides a vantage point over all of the major habitat areas where birds might be expected.
    - In a large project area, this may involve a route of several kilometres, with driving in between observation sites.
    - The objective of this survey should be to estimate the total number of individuals of each species present in the area on a particular visit.
    - If the study area consists of several discrete patches of important habitat, then the number of individual birds of each species on each site should be recorded separately. This information may be important for turbine placement.
    - Data recorded for these surveys should include a map of the route and the major observation sites, the date, the start and end time of each visit.
    - Most waterbirds can be counted at any time during the day. However, in some areas birds may make daily movements from a roost site in one area to a foraging site in another area. Similarly, in tidal areas, birds may move among locations in response to tidal cycles. In these cases, counts should be timed to coincide with peak numbers present within the study area.
    - If significant numbers of birds are located, then **behavioural studies** (see relevant section) should be considered to determine whether the behaviour of these birds is likely to put them at risk from the wind turbines.
- For songbirds, routes should be selected that sample the major habitats likely to be used by songbirds in the region.
    - Routes can be placed along existing trails or roads. Foraging migrants are most readily detected at edges of habitats, in hedgerows, etc.
    - A good quantitative design is to set out transects approximately 500 m long along trails or roads, placing at least two per major habitat type (e.g., forests, shrubland, grassland, etc.). Individual transects may traverse multiple habitats. However, transects can be any length, provided that the same routes are visited each time.
    - Transects should be walked approximately twice a week in the early morning (sunrise to up to no more than 4 hours after sunrise) during the peak migration period for the species of interest.
    - In most cases, it is sufficient to record the total number of birds of each species detected along the transect, using **standardized area search** methodology.
    - In some habitats, it may be appropriate to use **line transect** methodology and record the distance to each bird, or the number of birds in fixed distance categories (e.g., 25 m distance bands), separately counting different segments of the transect.

Passage migration counts

- Passage migration counts are used to estimate the numbers of birds flying through an area during migration periods. These will normally only be needed when there is a clear risk factor or significant unknowns.

- For most songbirds, the spring migration period runs from early April to late May, the fall period from the end of August to the middle of October, although this varies by region, latitude and altitude. Migration of waterfowl may commence in March, while migration of eagles and some northern migrants extends into November.
- For raptors and other diurnal migrating birds the following protocol is recommended:
    - Select an observation point from which a clear view is available of one or more potential turbine locations in areas that may represent migration concentration sites (e.g., ridge tops).
    - Record the species and heights of all passing birds in relation to the height of the proposed turbines. Codes can be used for incompletely identified species (e.g., *Accipiter* sp.).
    - Start at about 9 a.m. and record continuously for 6 hours, dividing the observations into one hour blocks. This will make the data comparable to most raptor monitoring stations.
    - If daily observations are not possible, then observations should be carried out for at least 10 days spread over the peak migration period for species thought to be at risk (consult local naturalists for this information). Within this period, dates should be chosen with weather conditions favourable for migration (e.g., no precipitation, light to moderate tail winds).
    - Record weather conditions (temperature, wind speed and direction, sky cover, precipitation), date, time of day, GPS coordinates of the observation point, and the approximate area and direction over which most observations were made.
- For night-migrating birds or bats, passage migration counts require technological approaches including either radar or acoustic monitoring or both. These are described in further detail in subsequent sections.

Acoustic monitoring of migrating birds

- Many species of songbirds regularly make flight calls during nocturnal migration; many calls can be identified to species. Microphones and digital recorders can be used to monitor these species during migration. However, not all species call during migration, and little is known about how often individual birds call and how much this varies from night to night or with weather conditions. To get a complete picture of the number of birds migrating through another area, acoustic monitoring may need to be combined with other techniques such as **radar**, infrared video devices, or observations with a ceilometer (a bright light pointed straight up into the sky). Nevertheless, acoustic monitoring alone may sometimes be sufficient for understanding regional variation in the concentrations of migrating birds or the heights of birds.
- A variety of systems have been used for monitoring nocturnal migrants ranging from single microphones connected to a digital recorder that provide an index of bird activity, to arrays of 4 or more microphones connected to a computer that can be used to calculate the height and position of each bird's call.

- Note that acoustic systems used for monitoring birds are not suitable for monitoring bats, because of the difference in frequency range of their calls.
- In general, systems that monitor height are likely to be more relevant to wind energy installation monitoring than systems that only provide an index of total numbers.
- National standards have not yet been developed for acoustic monitoring. At present this technique is most likely to be required only in the context of a research project. If nocturnal flight call monitoring is required for a particular project, then a protocol should be worked out in conjunction with the CWS.

Radar monitoring

- Marine radar units can be used to monitor activity of birds and bats within a relatively large area (a few kilometres radius) from a single location.
- However, radar has the disadvantage that targets can rarely be positively identified to species. Methods for distinguishing birds from bats, based on flight patterns, are being developed, but have not been fully tested.
- A variety of systems have been developed for automated data collection and processing. This is particularly important for monitoring over longer time periods, such as a complete migration season. However, most of these automated systems are relatively expensive, and only a few consulting companies have expertise with this technology. Each company uses different approaches for automated processing of data and estimating trajectories and/or heights of flying birds and bats. Most of these approaches have not yet been compared and cross-validated; it is not yet possible to recommend one system over another.
- As such, radar is not generally being required for monitoring unless there are particular risk factors involved, such as a suspected migration corridor for bats or birds, concerns about particular Species at Risk, or concerns about waterbird movements at proposed offshore installations.
- If radar is required, the ideal sampling scheme would involve monitoring on a daily basis through the main migration period for species of concern, especially if a fully automated system can be deployed.
- If this is not possible, because of limited availability of technology or other logistic constraints, then less intensive sampling may be acceptable. Various sampling schemes can be considered, depending on logistical constraints such as the remoteness of the site and the availability of radar. If daily coverage is not possible, the next most preferred option would involve monitoring at regular intervals throughout the season (e.g., one or two nights per week, preferably concentrated on nights when weather conditions are favourable for migration—tail winds that are not too strong, no precipitation). Another option would involve sampling for a few days in a row at longer intervals, e.g., for 2-3 days every two weeks. If data are available on the likely peak migration period for species of concern, then continuous monitoring for 1 or 2 weeks during this period may also be acceptable.
- Regardless of the sampling scheme, monitoring should continue through the night, either recording continuously (preferred) or for periodic intervals such as 15-30 minutes per hour.

- Data that are recorded should include:
  - Technical information on the equipment used, including information on maximum range, minimum and maximum altitude at which targets can be detected at various distances, methods used for data analysis, etc.
  - For each bird or bat target detected, data should include information on its identity to the extent possible (e.g., bird vs. bat), its trajectory (including direction of travel and position in relation to potential turbine sites), and altitude (if known).
  - Data can then be summarized in various ways to indicate overall bird and bat activity, how this changes over the night and the season, and how it varies across the study area.
  - Summary data should be provided as part of the Environmental Impact Assessment. Raw data (i.e., information on individual tracks) should be retained for inclusion in a central database, once appropriate data standards have been developed.
- As with acoustic monitoring, the uncertainty in protocols is such that this technique is most likely to be required only in the context of a research project. If radar monitoring is required for a particular project, then the most suitable protocol should be worked out in conjunction with the CWS.

Carcass searches

- These can be expected to be the most intensive and potentially costly part of the follow-up programme, involving many hours of work.
- To calculate total mortality associated with a turbine, in addition to searching for carcasses, it is necessary to estimate:
  - The proportion of carcasses that fell outside the search area.
  - The proportion of carcasses within the search area that are removed by scavengers between visits.
  - The proportion of carcasses remaining that was found by the observer.
- In most cases, carcass searches should be conducted every 3 days at a site, to minimize loss of carcasses due to scavenging, and to estimate more reliably the actual date/weather conditions when mortality took place. In some circumstances (e.g., presence of many, very efficient scavengers) it may be necessary to increase the frequency. Conversely, if carcass removal trials indicate that most carcasses persist for a week or more, then less frequent searches may be acceptable. For this reason, scavenging rate should be estimated early in the process (see below).
- The minimal duration of carcass searches for passage migrants would typically be 6 weeks during the spring migration period and 8 weeks during the fall migration period.
  - The peak period of migration varies by region, but generally most spring migration is from early April to the end of May, while the fall season extends from early August to the middle of October. Migration of waterfowl or some raptors may extend outside these seasons.
- If significant numbers of raptors, species with aerial mating displays, or other birds that during baseline behavioural studies showed a propensity for flying at

the height of the blades are present at other times of year (e.g., breeding season or over-winter), then additional carcass searching should be undertaken during the period these birds are present. For breeding season, this would normally be a 6-week period. In winter, this would depend on when birds are present in the area, and could be anywhere from 4–12 weeks. Optimal search intervals may vary with time of year and weather conditions.

- Carcass searching does not generally require bird experts and can usually be done by well-trained technicians, who could be locally-hired personnel.
- Trained dogs can greatly increase the efficiency of carcass searches, particularly if the search area has significant vegetation. Dogs can search a larger area more rapidly than human observers, and tend to find a higher percentage of carcasses. This will make for more accurate and more reliable estimates of total mortality. Particularly at large wind energy installations, proponents should always consider the use of dogs, if possible.
- Visual carcass searching tends to be most efficient in bright light conditions, with a light breeze (which can cause feathers to flutter), and when it has not rained recently (rain tends to flatten feathers).
- Carcass searches should focus on the area where the search is most efficient – this will usually be the gravel pad at the base of the turbine, roads extending from it, and any areas of ground nearby that are either covered with short vegetation (e.g., grasses or low forbs) or are bare. Finding carcasses in forests or scrub is extremely difficult, even with dogs.
- Once a search area has been selected, searching should be undertaken uniformly throughout the search area, so that all parts of it are searched equally intensively.
- If necessary, a stratified design can be undertaken in which searching is most intensive in areas where carcasses are most likely to be detected, with less intensive searching farther away. For a typical 80 m turbine, with 40 m blades, most birds seem to fall within 80 m of the towers, while most bats fall within 50 m; however, the intensive survey area could be smaller still, especially if this would allow increasing the numbers of turbines visited, or if the stratum near the turbine is much easier to search.
- One form of stratified design is to search a small intensive area on every visit, and to search a larger, less intensive area only on occasions when a greater-than-typical number of carcasses is discovered in the intensive area (in some cases this may mean a single carcass). This design is suitable for migrants, because most birds may be killed only under specific weather conditions, which could lead to many birds being killed on a single night.
- For smaller sites (1–10 turbines), every turbine should be searched. For larger sites, a subset of turbines should be selected to cover representative areas throughout the wind energy installation, and searched in a similar fashion.
- It is not necessary to search every turbine on the same day. For example, a third of the selected turbines could be visited each day, such that each turbine is sampled every 3 days. The order of visits should be the same each cycle, so that the sampling interval (e.g., 3 days) is the same for each turbine.

- It is generally preferable to search a larger number of turbines, but with a smaller search area at the base of each turbine, than to search intensively at only a few turbines. This is because it is possible that only a few turbines may cause problems for birds.
- In some areas, it may be appropriate to sample some turbines every 3 days, and others at longer intervals, on a rotating schedule, to ensure that mortality at selected turbines is not being overlooked.
- Whenever possible, searches should begin as soon after sunrise as practical, to minimize carcass loss from early morning scavengers.
- Regardless of the area searched, it will almost always be necessary to calculate a correction factor to allow for carcasses that fall in areas that were not searched. Statistically sound corrections must take into account the fact that the expected number of carcasses varies in relation to distance from the turbine as well as prevailing wind directions on every night since the last carcass search.
- To make these calculations, the following data must be recorded:
    - The area in which searching was undertaken at each turbine, as well as the date, start time and end time for each search (separately for each turbine). If the search area was symmetrical around the turbine, this can be easily recorded as the diameter of the circle around the turbine. If the search area was irregular in shape (e.g., the base pad plus part of an access road), then a scale diagram of the search area must be prepared. If a stratified search was undertaken, the area of each stratum must be recorded.
    - For every carcass found, record:
        - The date and time it was found.
        - The state of decomposition, to help estimate the number of days since death.
        - The extent and type of injury sustained (if identifiable).
        - The species (or the best estimate of species, if it is in too poor condition to identify completely).
        - The distance and direction from the nearest turbine as well as GPS coordinates of the carcass (to serve as a verification check).
        - The substrate on which the victim was found.
    - Information on average wind strength and direction on each night since the last search is also required.
- **Scavenger trials:** It is also necessary to correct for carcasses that were scavenged before the search period.
- Carcass removal experiments to estimate scavenging rates must be conducted:
    - At least twice during each season when searches are being undertaken, as the suite of scavengers is likely to change through the year; and
    - With carcasses that resemble native birds and are freshly dead or were frozen when freshly dead.
        - Examples are blackbirds and starlings from provincial control programmes, turbine victims, quails and quail chicks from farmers, and dark chicks from industrial chicken farms or breeders (the dark chicks are unsuitable as meat chickens because their skin is also

darkly coloured; the chicks may be given away or sold for a reduced price).
        - Bats are normally only available as turbine victims.
    - Carcasses should be laid out in the search area, georeferenced by GPS, and then looked for on the day of the next carcass search. Carcass persistence should be examined over various intervals, either by setting out carcasses at different intervals before the search (e.g., some immediately after the previous search, others the day before), or by setting them out the night before a search, but then leaving all carcasses in place for up to 2 weeks, checking them on each search occasion for their persistence.
    - Carcasses should be distributed at all turbines where searches are undertaken, with no more than one or two carcasses per turbine. Carcasses should be distributed across the range of different substrates being searched, roughly in proportion to their proportions in the search area (e.g., if 20% of the search area is a gravel pad and 80% is grass, then 20% of the carcasses should be placed on the gravel pad, and 80% in grass).
    - Scavenger trials should be repeated annually, as the numbers and efficiency of scavengers, especially vertebrates such as raccoons, foxes, crows, etc., may change among years.
- **Searcher efficiency trials:** All observers, even those with trained dogs, will overlook some carcasses. This percentage will vary depending on the observer, the habitat and the area being searched, etc.
- Searcher efficiency must be tested for every individual or team involved in searching for carcasses (including teams using dogs). Searcher efficiency values are not transferable to a different individual or team or to a different substrate.
    - Unknown to the searcher, another person sets out carcasses on the previous evening within the area to be searched the following day.
        - Carcasses should be placed at random locations within the search area. The location of the carcasses must be recorded, so that they can be retrieved if they were not located by the searcher.
        - If a stratified design is in use, then separate trials must be undertaken in areas being intensively searched and those with lower intensity searching.
        - If bats have been found as victims they should be included as test carcasses. Whenever possible, use carcasses of native species that may be expected at the turbine site, so that the searcher will not recognize them as being part of a trial. If they remain in good condition, carcasses may be re-used for multiple trials.
        - No more than one or two carcasses should be placed in the search area of any given turbine on a single visit.
        - Trials need not cover every turbine, but should be distributed across substrates as for scavenger trials.
    - At least 20 carcasses should be used when testing observers.

- These should be spread over multiple visits, so that the observer does not become aware that a test is underway. The best design involves testing that is undertaken continuously, with one or a few carcasses placed prior to each visit. This is most practical if more than one observer is involved in carcass searching, in which case each observer can place one or more carcasses within the areas being searched by the other observer. This has the advantage that it keeps human searcher efficiency high, because the searcher will be "on guard" during every search session.
- Any carcasses that were not found should be retrieved immediately after the search to determine whether they were scavenged or overlooked. Optionally, they may then be left in place as part of a scavenger efficiency trial, unless they are required for further searcher efficiency trials.
- Data recorded for searcher efficiency trials should include, for each bird:
  - Date, time and location it was placed, along with the species.
  - Date and time it was searched for and whether it was found, overlooked or scavenged, along with the name of the searcher. If the carcass remained, record its condition (intact, partially scavenged or decomposed).
- It may also be possible to develop a design that combines searcher efficiency and scavenger trials, provided that these trials involve at least some birds placed the night before (so they are still fresh) and some placed on the previous visit.

- A variety of statistical approaches have been used to estimate total mortality, incorporating all necessary correction factors. Because these are likely to improve over time, as further data are accumulated, all proponents are asked to retain all raw data to allow for flexible reanalysis in future.
- The shared database being developed by the CanWEA and the CWS will incorporate routines to estimate total mortality from each site using the best available statistical methods, provided that all raw data (not averages or lumped data) are deposited in the database. This would include all information described in this section (information on search effort, search area, each carcass found, scavenger trials, observer efficiency trials and daily weather conditions). Proponents are strongly encouraged to deposit their data in this database to ensure that these calculations can be adequately standardized across projects. This will also allow for simple reanalysis if better statistical techniques become available in the future.
- Provincial/territorial and federal permits are required to handle and collect dead birds or parts thereof. Please apply for these permits well before the carcass counts are to be done.
- The CWS can provide additional help with design of carcass searches.

Estimating collisions using other methods

- In some cases, where carcass searches are not practical (e.g., sites over water or wetlands), other techniques may be necessary to estimate mortality.
- Some of these techniques include radar, thermal imaging equipment, video equipment, or direct observations of birds.

- In most cases, neither radar nor thermal imaging equipment can be used to identify the species of birds involved, unless there are only a few species of concern with very different flight patterns or sizes.
- Effective use of any high tech approach requires sophisticated computer algorithms to process large amounts of data automatically, because many hundreds of hours of recordings may need to be scanned to detect collisions.
- For this same reason, visual observations are unlikely to be effective except in very unusual circumstances, or as part of a research project to understand bird behaviour around turbines.
- With radar, detecting collisions depends on following a track that disappears when it reaches the turbines – but it is not known how often tracks may disappear for other reasons, or whether all incoming birds will necessarily be detected.
- Thermal imaging methods may be able to observe collisions directly, but can only view a limited area, usually only a portion of one turbine.
- A system specifically designed to measure bird collision rates has been developed that combines microphones placed in the turbine structure (to detect the sounds of a collision) with a video camera (to record what hit the turbine). A computer is programmed to store video images from shortly before and after any unusual sounds (which may represent a collision). Tests have shown that it can effectively detect artificial collisions (e.g., tennis balls), but further testing is required to determine how well it will detect actual bird collisions (Verhoef, Westra, Korterink, and Curvers. 2003. *WT-Bird, a novel bird impact detection system*. Unpublished report. Available at: http://www.ecn.nl/docs/library/report/2002/rx02055.pdf). Replacing the video camera with a thermal imaging system may be required to detect nocturnal collisions.
- At present, none of these technologies is sufficiently developed to provide standardized protocols. These techniques would normally only be required under exceptional circumstances (e.g., offshore installations), or as part of a special research project.
- As the technologies are developed, it may be appropriate to recommend their use more widely in the future.

Appendix 2. Codes for breeding evidence

The following codes should be used for breeding evidence, in association with breeding season area searches. These codes are those used for the Ontario or Maritimes breeding bird atlases. Further details are available from their web sites:
Ontario Breeding Bird Atlas (http://www.birdsontario.org/atlas/atlasmain.html) and Maritimes Breeding Bird Atlas (http://www.mba-aom.ca/english/index.html). These were selected to allow for consistency in the national database.

OBSERVED

X Species observed in its breeding season (no evidence of breeding). Presumed migrants should not be recorded.

POSSIBLE BREEDING

H Species observed in its breeding season in suitable nesting habitat.

S Singing male present, or breeding calls heard, in its breeding season in suitable nesting habitat.

PROBABLE BREEDING

P Pair observed in their breeding season in suitable nesting habitat.

T Permanent territory presumed through registration of territorial song on at least 2 days, a week or more apart, at the same place.

D Courtship or display between a male and a female or 2 males, including courtship feeding or copulation.

V Visiting probable nest site.

A Agitated behaviour or anxiety calls of an adult.

B Brood patch on adult female or cloacal protuberance on adult male.

N Nest-building or excavation of nest hole (woodpeckers and wrens). Both groups may build dummy or roosting nests so nest-building alone is not enough to confirm breeding.

CONFIRMED BREEDING

NB Nest building or adult carrying nesting material (for all species except wrens and woodpeckers).

DD Distraction display or injury feigning.

NU Used nest or egg shell found (occupied or laid within the period of the study).

FY Recently fledged young or downy young, including young incapable of sustained flight.

AE Adults leaving or entering nest site in circumstances indicating occupied nest.

FS Adult carrying faecal sac.

CF Adult carrying food for young.

NE Nest containing eggs.

NY Nest with young seen or heard.

Appendix 3. Sample data sheet for ten-minute point counts

Location (Site Name): _____UTM Map no.: _____

Date: ____/____/20__ Observer: _____

Wind (Beaufort scale): ____ Sky: _____ Precipitation: _____ Temp: ____^{o}C

Comments: _____

_____

Point Count Station

	1	2	3	4	5	6	7	8	9	10
UTM Easting										
UTM Northing										
Time of visit										

		First five minutes			Second five minutes			
Stn	Species Code	0–50 m	51–100 m	>100 m	0–50 m	51–100 m	>100 m	Total

		First five minutes			Second five minutes			
Stn	Species Code	0–50 m	51–100 m	>100 m	0–50 m	51–100 m	>100 m	Total